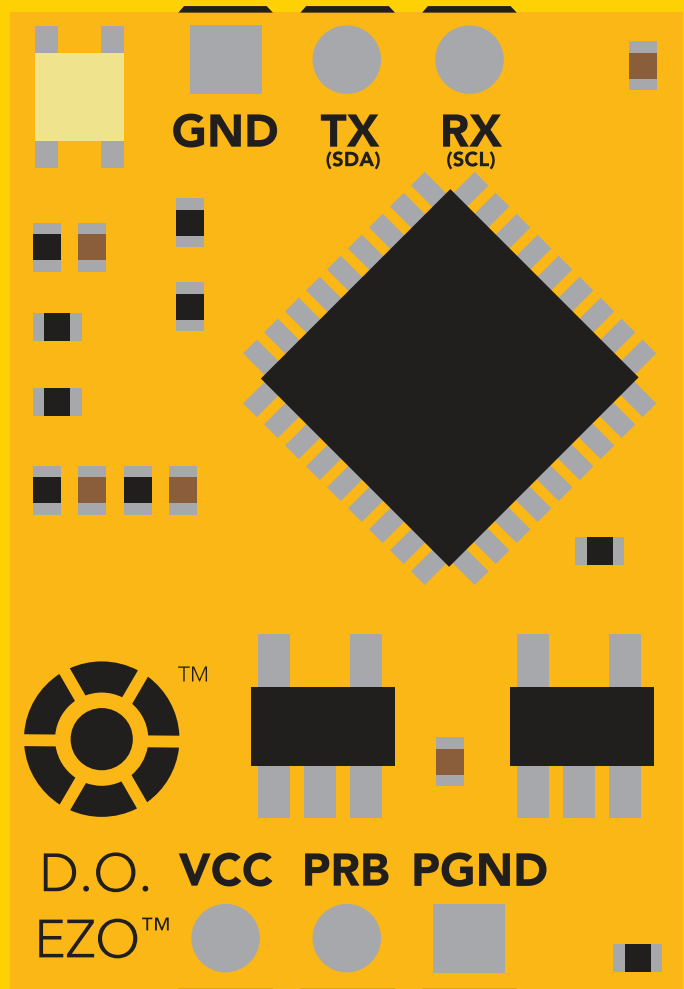


# EZO-DO™

## Embedded Dissolved Oxygen Circuit

Reads	<b>Dissolved Oxygen</b>
Range	<b>0.01 – 100+ mg/L</b> <b>0.1 – 400+ % saturation</b>
Accuracy	<b>+/- 0.05 mg/L</b>
Response time	<b>1 reading per sec</b>
Supported probes	<b>Any galvanic probe</b>
Calibration	<b>1 or 2 point</b>
Temperature, salinity and pressure compensation	<b>Yes</b>
Data protocol	<b>UART &amp; I<sup>2</sup>C</b>
Default I <sup>2</sup> C address	<b>97 (0x61)</b>
Operating voltage	<b>3.3V – 5V</b>
Data format	<b>ASCII</b>



**PATENT PROTECTED**



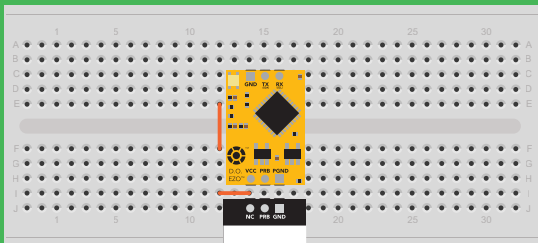
# STOP

**SOLDERING THIS DEVICE VOIDS YOUR WARRANTY.**

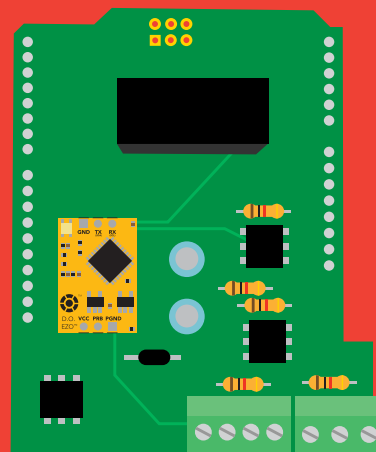
**This is sensitive electronic equipment. Get this device working in a solderless breadboard first. Once this device has been soldered it is no longer covered by our warranty.**

**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.**

**Get this device working in a solderless breadboard first!**



**Do not embed this device without testing it in a solderless breadboard!**



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## UART

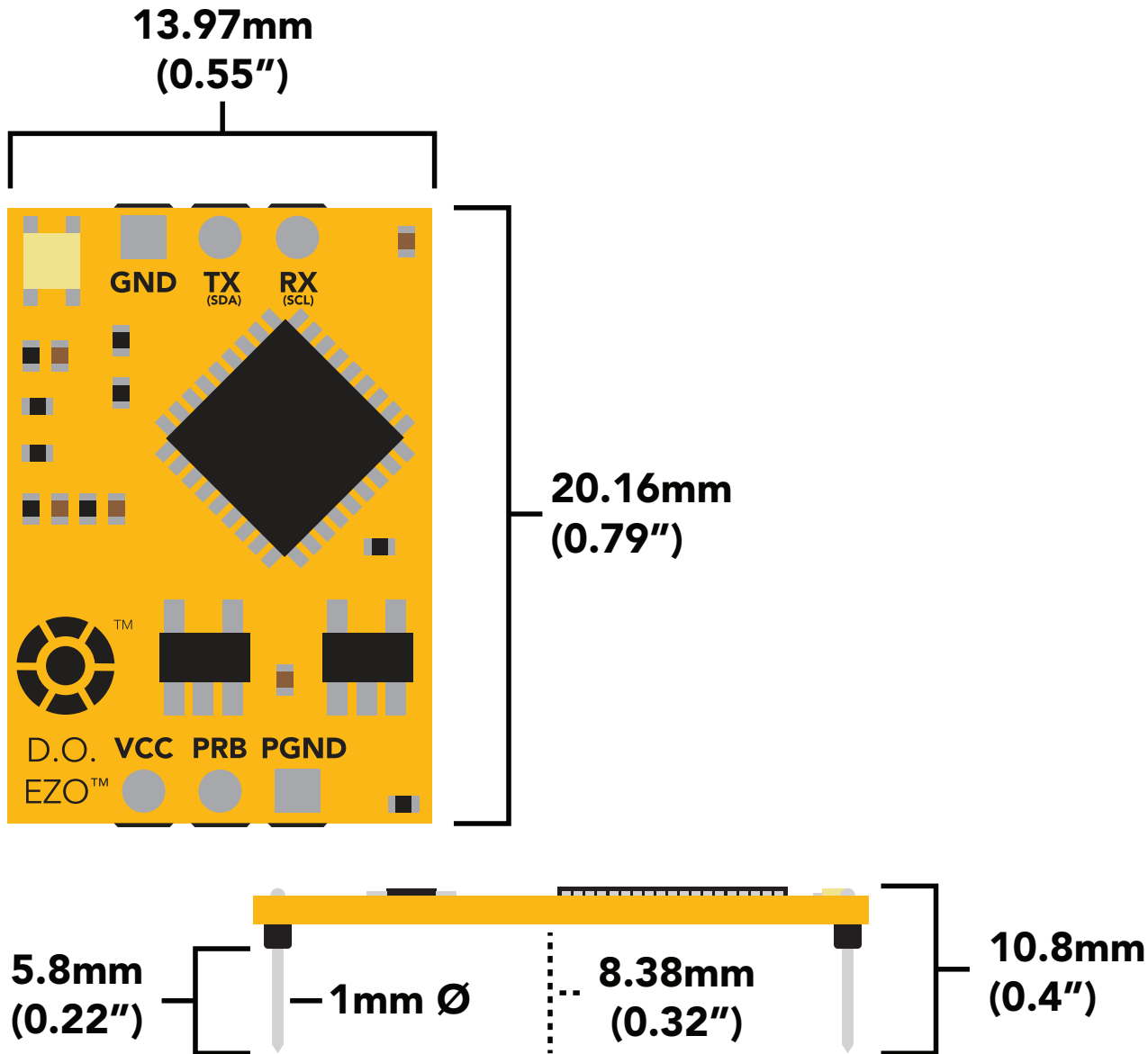
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# EZO™ circuit dimensions



## Power consumption

	LED	MAX	STANDBY	SLEEP
<b>5V</b>	ON	13.5 mA	13.1 mA	0.66 mA
	OFF	12.7 mA	12.7 mA	
<b>3.3V</b>	ON	12.1 mA	12 mA	0.3 mA
	OFF	11.9 mA	11.9 mA	

## Absolute max ratings

Parameter	MIN	TYP	MAX
Storage temperature (EZO™ D.O.)	-65 °C		125 °C
Operational temperature (EZO™ D.O.)	-40 °C	25 °C	85 °C
VCC	3.3V	5V	5.5V

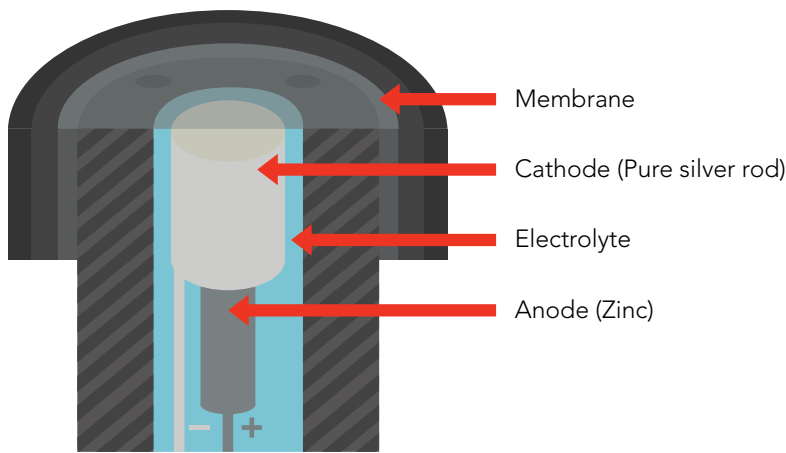


# Operating principle

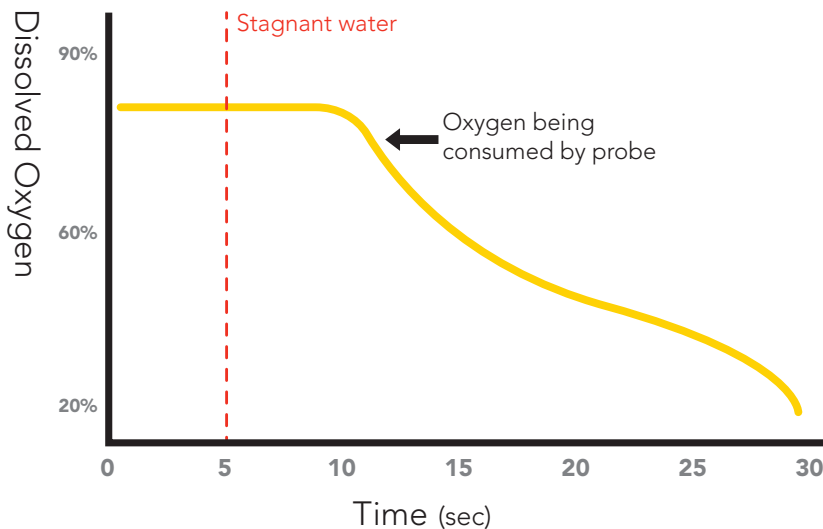
The Atlas Scientific™ EZO™ Dissolved Oxygen circuit works with:

- X Optical probe** Slow response, requires external power, expensive.
- X Polar Graphic probe** Requires external power, output in  $\mu\text{A}$ .
- ✓ Galvanic probe** Requires no external power, output in mV.

A galvanic dissolved oxygen probe consists of a PTFE membrane, an anode bathed in an electrolyte and a cathode. Oxygen molecules diffuse through the probe's membrane at a constant rate (without the membrane the reaction happens too quickly). Once the oxygen molecules have crossed the membrane they are reduced at the cathode and a small voltage is produced. If no oxygen molecules are present, the probe will output 0 mV. As the oxygen increases so does the mV output from the probe. Each probe will output a different voltage in the presence of oxygen. The only thing that is constant is that **0mV = 0 Oxygen**. (A galvanic dissolved oxygen probe can also be used to detect the Oxygen content in gases).



## Flow Dependence



One of the drawbacks from using a galvanic probe is that it consumes a **VERY** small amount of the oxygen it reads. Therefore, a small amount of water movement is necessary to take accurate readings. **Approximately 60 ml/min.**

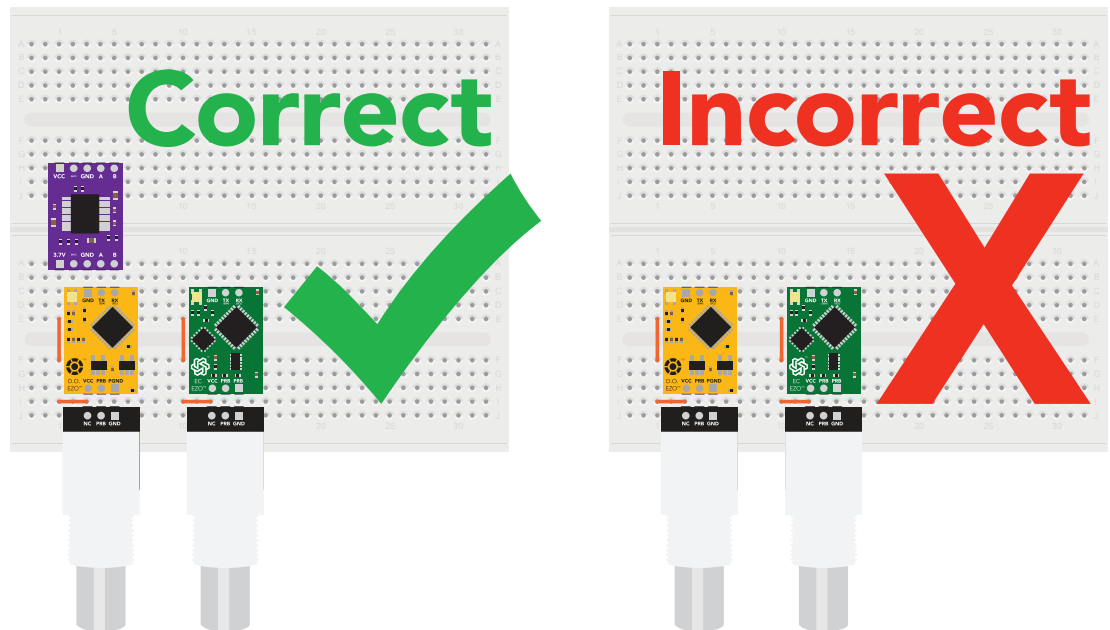
# Power and data isolation

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

When electrical noise is interfering with the Dissolved Oxygen 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 Dissolved Oxygen probe in a cup of water by itself. The readings should stabilize quickly, confirming that electrical noise was the issue.



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



Basic EZO™  
Inline Voltage Isolator

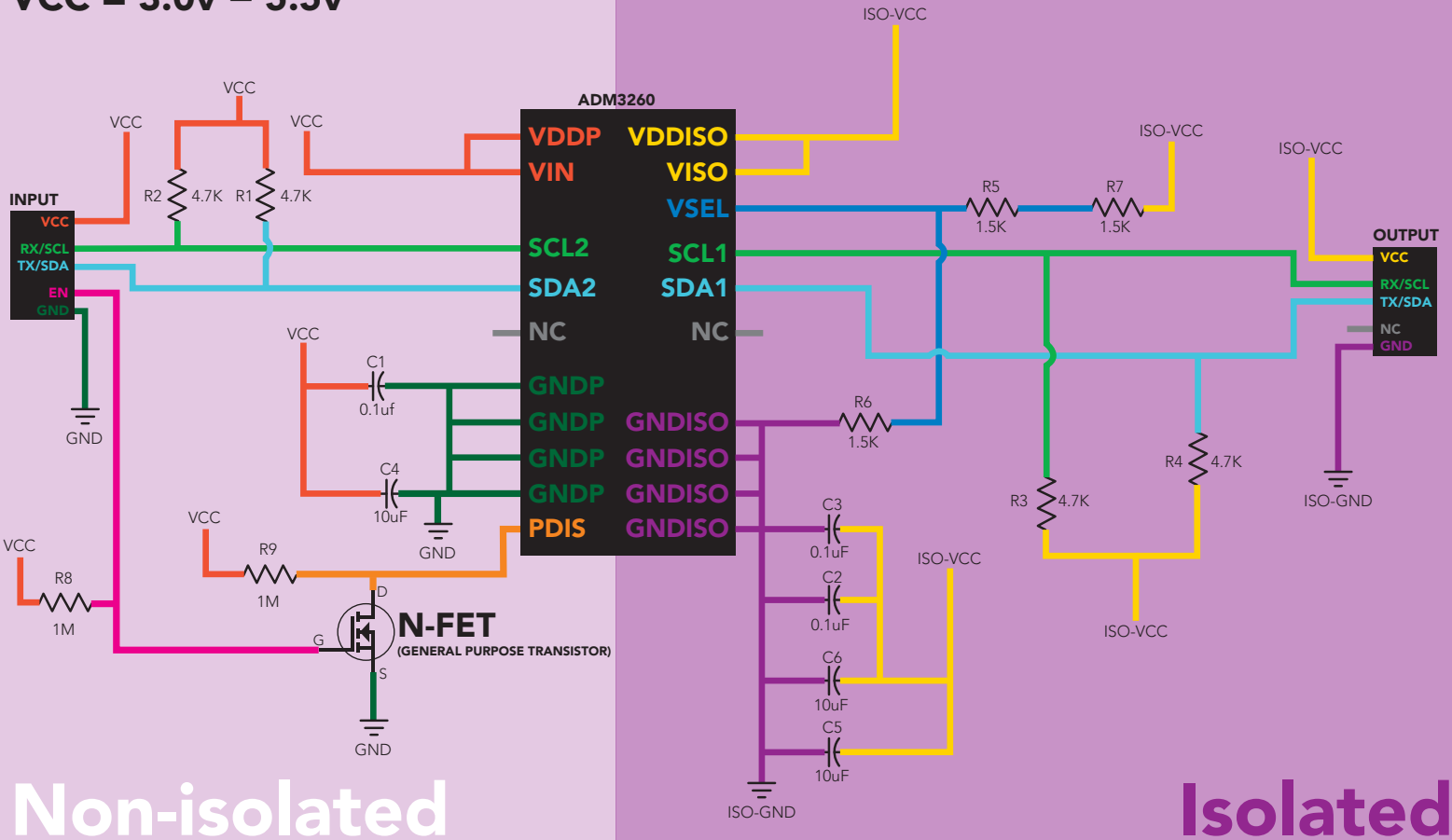
**Without isolation, Conductivity readings will effect Dissolved Oxygen accuracy.**

This schematic shows exactly how we isolate data and power using the and a few passive components. The ADM3260 can output isolated power up to 150 mW and incorporates two bidirectional data channels.

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 (R5, R6, and R7) this produces a voltage of 3.9V regardless of your input voltage.

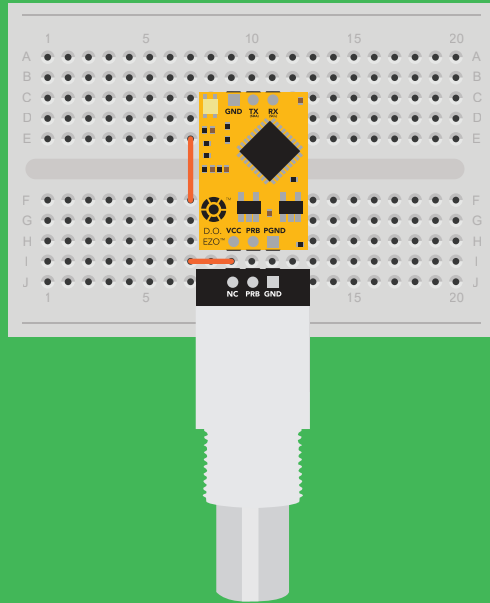
**Isolated ground is different from non-isolated ground, these two lines should not be connected together.**

VCC = 3.0v – 5.5v

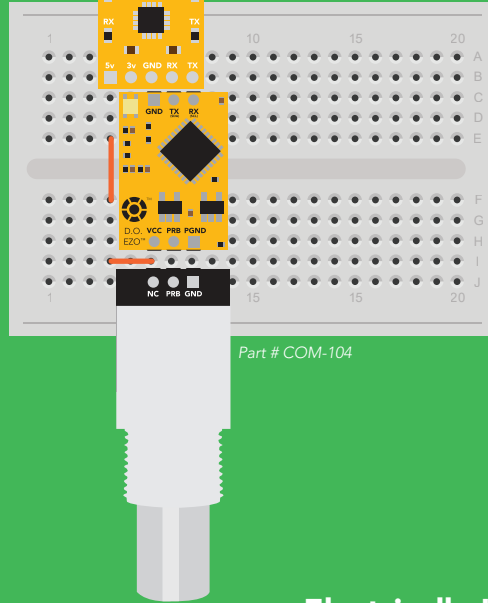


# ✓ Correct wiring

## Bread board

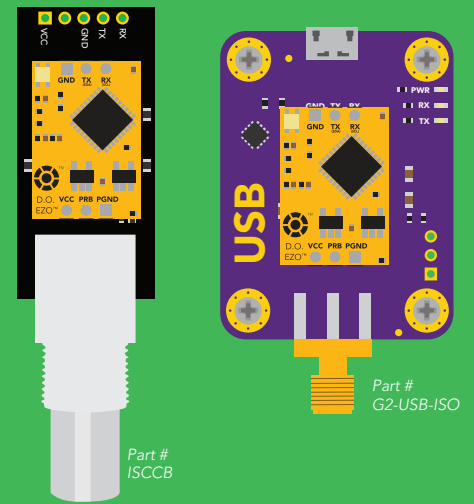


## Bread board via USB



Part # COM-104

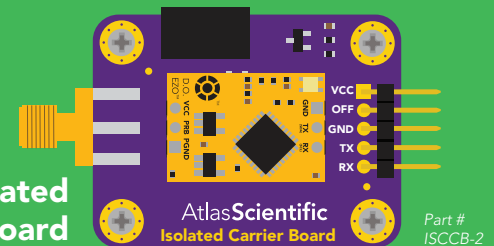
## Carrier board USB carrier board



Part # ISCCB

Part # G2-USB-ISO

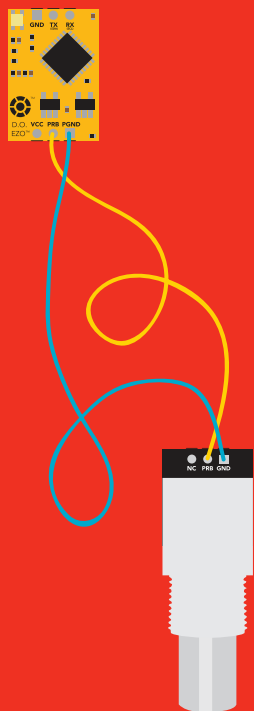
## Electrically Isolated EZO™ Carrier Board



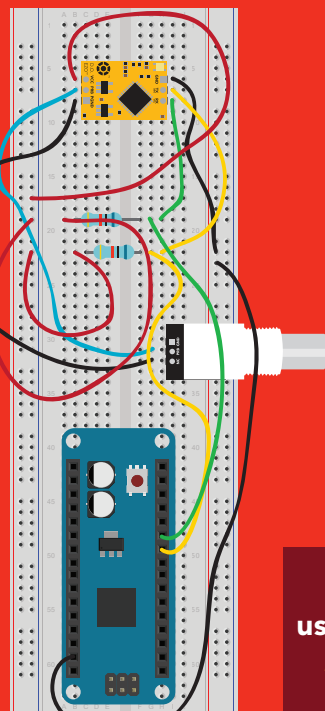
Part # ISCCB-2

# X Incorrect wiring

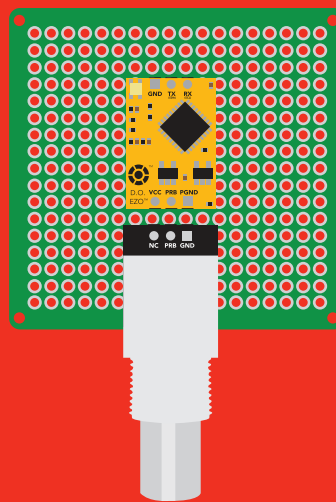
## Extended leads



## Sloppy setup



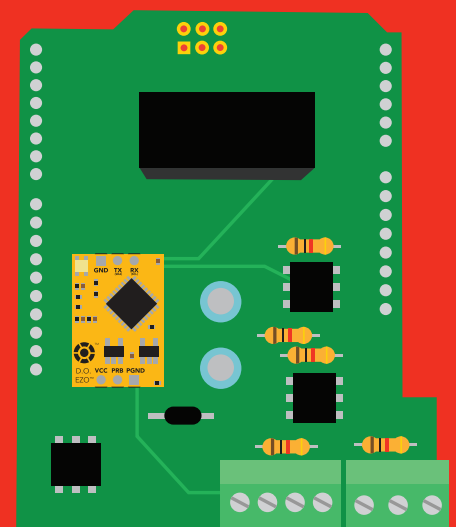
## Perfboards or Protoboards



**NEVER**  
use Perfboards or Protoboards

*Flux residue and shorting wires make it very hard to get accurate readings.*

## \*Embedded into your device



**\*Only after you are familiar with EZO™ circuits operation**

# Calibration theory

Simple calibration

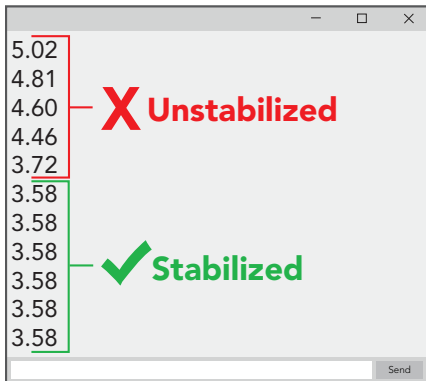
## UART mode

Continuous readings

Advanced calibration

## I<sup>2</sup>C mode

Continuously request readings



The most important part of calibration is watching the readings during the calibration process.

It's easiest to calibrate the device in its default state (UART mode, with continuous readings enabled).

Switching the device to I<sup>2</sup>C mode after calibration **will not** affect the stored calibration. If the device must be calibrated in I<sup>2</sup>C mode be sure to **continuously request readings** so you can see the output from the probe.



The Atlas Scientific EZO™ Dissolved Oxygen circuit, has a flexible calibration protocol, allowing for **single point** or **dual point (optional)** calibration.

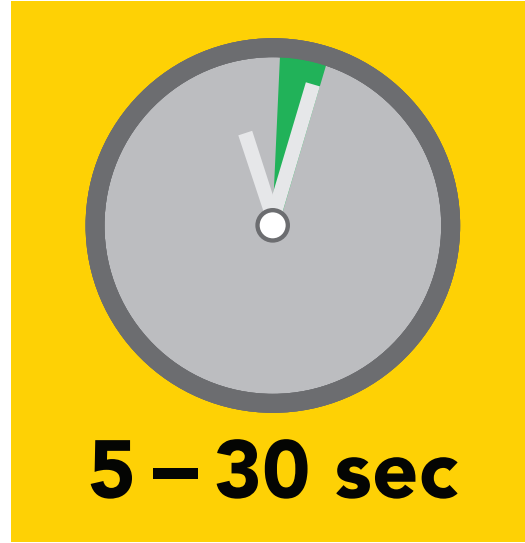
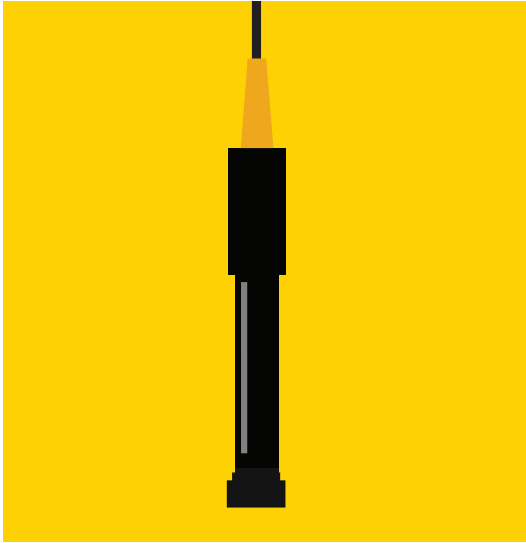
**Calibrate first, compensate later.**

Temperature, salinity and pressure compensation values have no effect on calibration.



# Single point calibration

Let the Dissolved Oxygen probe sit, exposed to air until the readings stabilize. (*small movement from one reading to the next is normal*).



```
15.03
14.45 — X Unstabilized
14.08
13.95
13.95 — ✓ Stabilized
13.95
13.95
cal
*OK
9.09
9.09
```

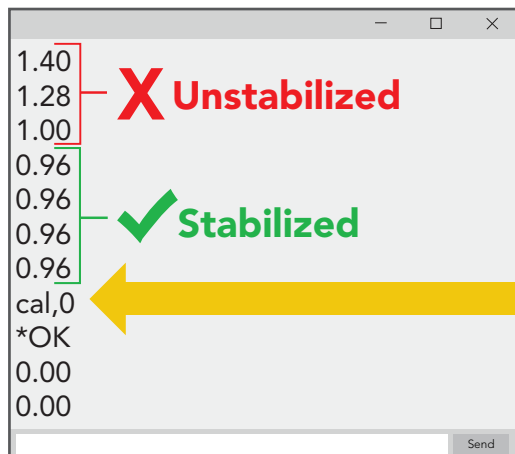
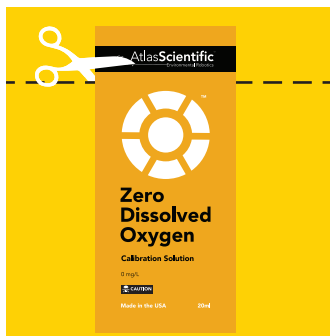
Once the readings have stabilized, issue the calibration command. **"cal"**

After calibration is complete, you should see readings between **9.09 – 9.1X mg/L**.  
*(only if temperature, salinity and pressure compensation are at default values)*

## Dual point calibration (optional)

Only perform this calibration if you require accurate readings *below* 1.0 mg/L

After you have calibrated the EZO™ Dissolved Oxygen circuit using the "Cal" command; Remove the top of the Zero Dissolved Oxygen calibration solution pouch, and Insert the probe and stir it around to remove any trapped air (which could cause readings to go high). Let the probe sit in Zero D.O. calibration solution until readings stabilize. (small movement from one reading to the next is normal).

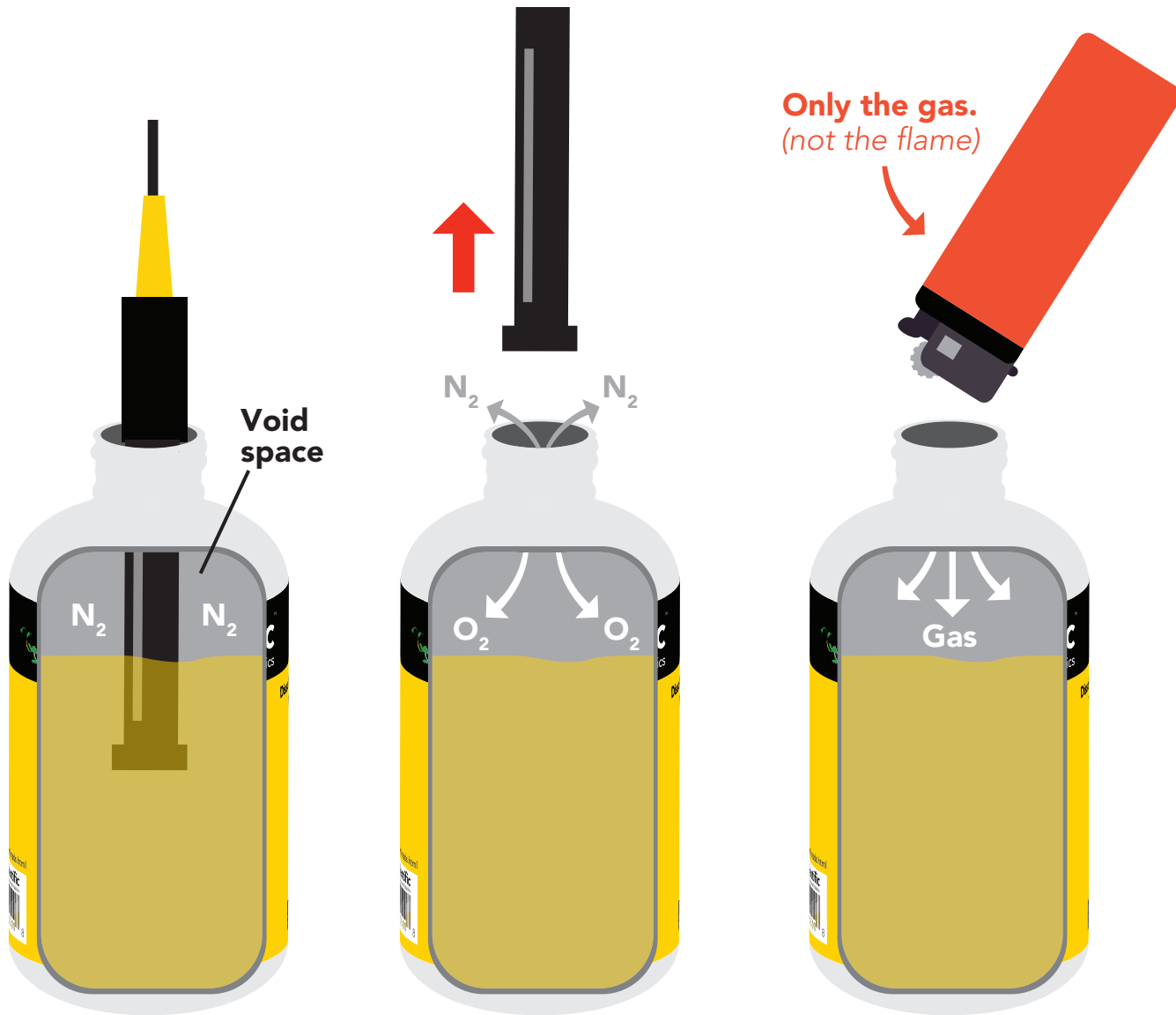


Once the readings have stabilized, issue the calibration command. **"cal,0"**

*After 24 hours, the calibration solution inside an open pouch is no longer considered accurate.*

# How to preserve the Zero D.O. calibration solution

Oxygen is everywhere. The Zero D.O. calibration solution has been designed to chemically absorb oxygen. Once the bottle has been opened the test solution has been exposed to oxygen and will slowly stop working.



Inside each bottle of the calibration solution is a small amount of nitrogen gas that helps displace oxygen out of the bottle during the filling process. When the Dissolved Oxygen probe is removed from the bottle, oxygen will enter the bottle and begin to dissolve into the solution.

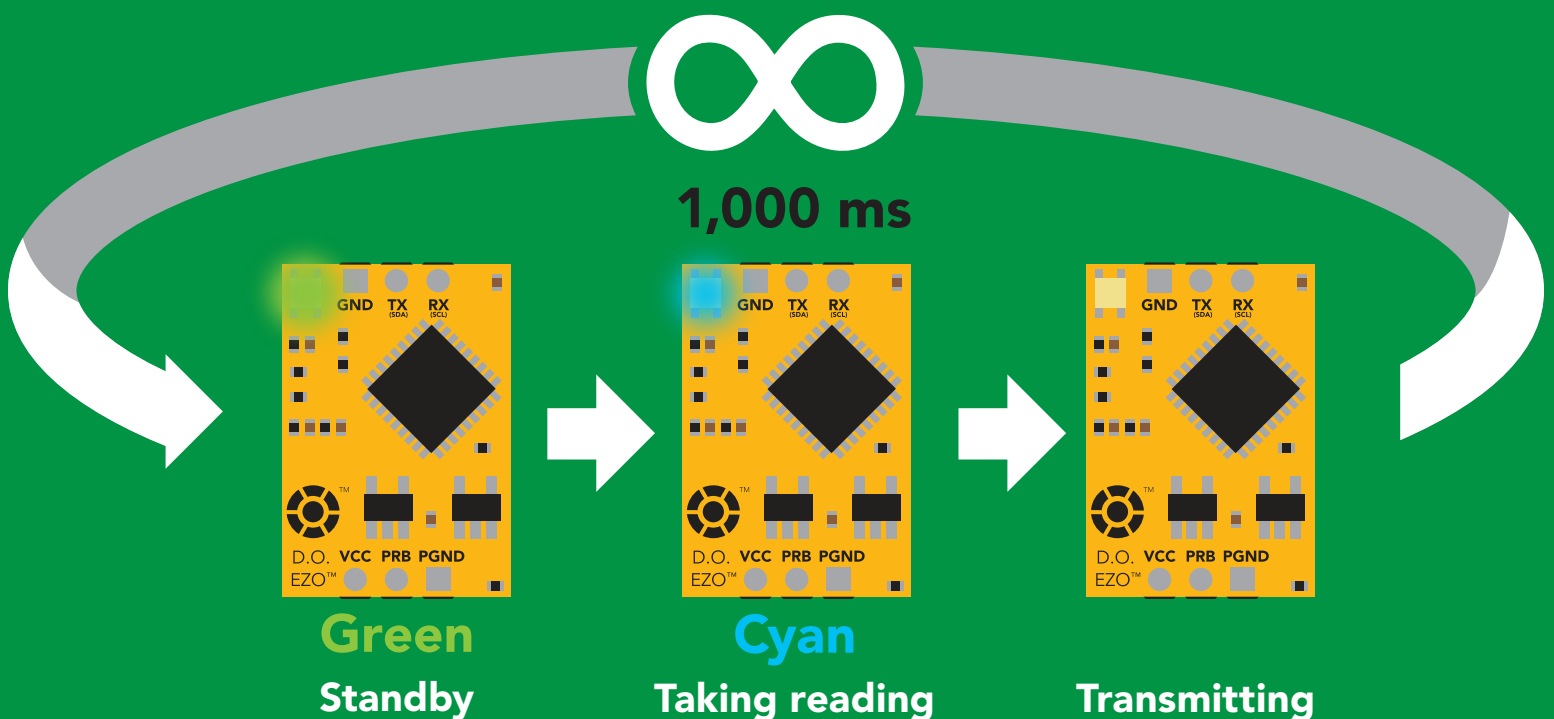
In order slow down this process, fill the void space of the bottle with any gas (*other than oxygen*) to preserve the calibration solution. Gas from a lighter works great if other gases are currently unobtainable.



# Default state

# UART mode

Baud	9,600
Readings	continuous
Speed	1 reading per second
Temperature compensation	20 °C
Salinity compensation	0 (Fresh water)
Pressure compensation	101.3 kPa (Sea level)
LED	on



# ✓ Available data protocols

# UART

Default

# I<sup>2</sup>C

# ✗ Unavailable data protocols

# SPI

# Analog

# RS-485

# Mod Bus

# 4–20mA

# UART mode

## Settings that are retained if power is cut

- Baud rate
- Calibration
- Continuous mode
- Device name
- Enable/disable parameters
- Enable/disable response codes
- Hardware switch to I<sup>2</sup>C mode
- LED control
- Protocol lock
- Software switch to I<sup>2</sup>C mode

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

- Find
- Pressure compensation
- Salinity compensation
- Sleep mode
- Temperature compensation

# UART mode

8 data bits      no parity  
1 stop bit        no flow control

**Baud** 300  
1,200  
2,400  
**9,600 default**  
19,200  
38,400  
57,600  
115,200

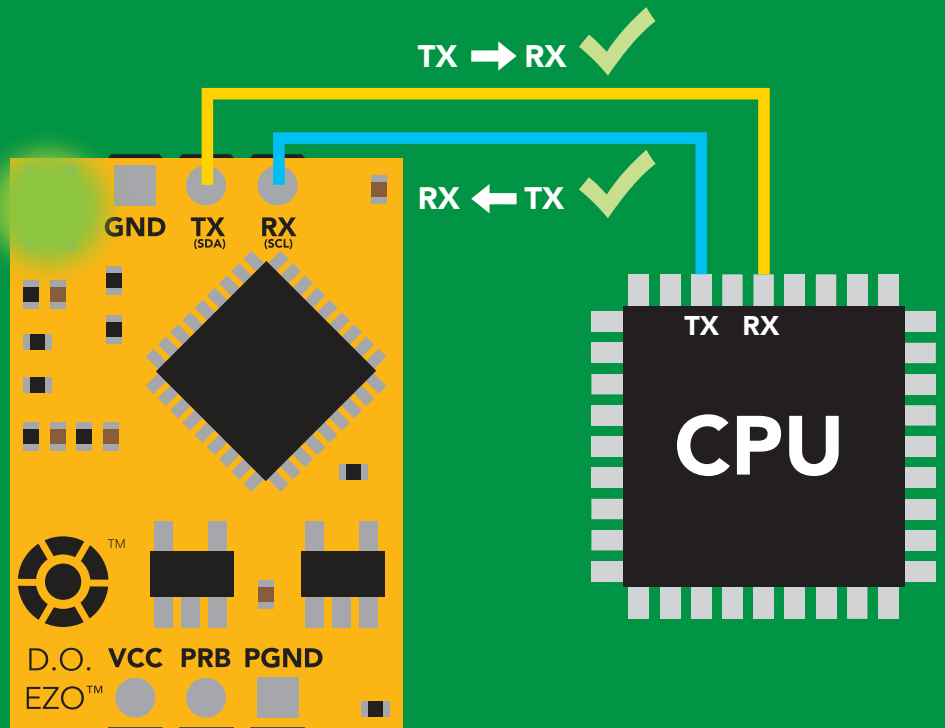
**RX**  
Data in



**TX**  
Data out



**Vcc** 3.3V – 5.5V

## Data format

<b>Reading</b>	Dissolved Oxygen	<b>Data type</b>	floating point
<b>Units</b>	mg/L & (% sat) <small>when enabled</small>	<b>Decimal places</b>	mg/L = 2 % sat = 1
<b>Encoding</b>	ASCII	<b>Smallest string</b>	4 characters
<b>Format</b>	string <small>(CSV string when % sat is enabled)</small>	<b>Largest string</b>	16 characters
<b>Terminator</b>	carriage return		

# Receiving data from device

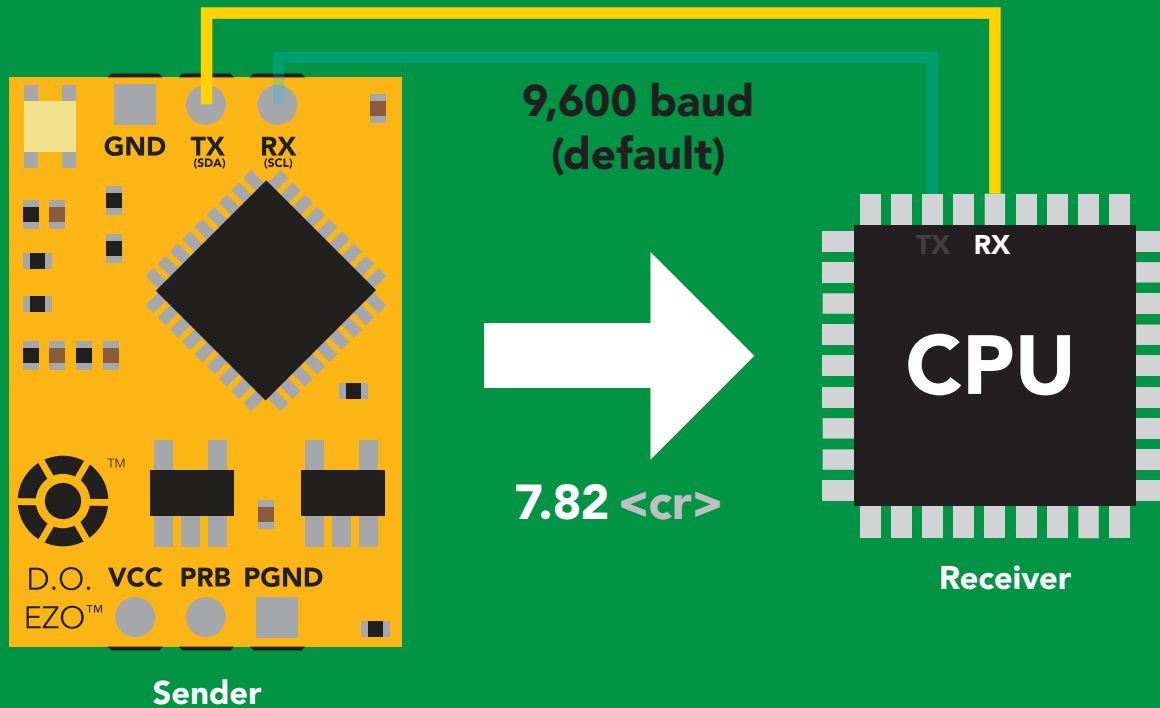
2 parts

ASCII data string

Command

Carriage return <cr>

Terminator



## Advanced

ASCII: 7 . 8 2 <cr>

Hex: 37 2E 38 32 0D

Dec: 55 46 56 50 13

# Sending commands to device

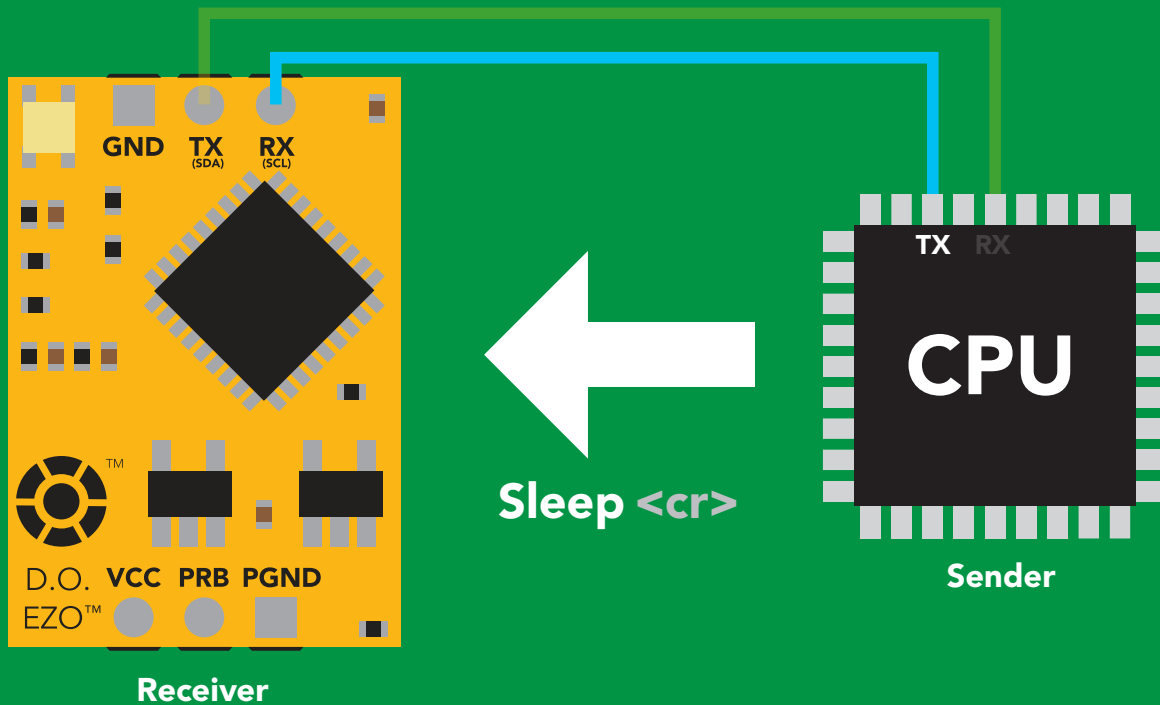
2 parts

**Command (not case sensitive)**

ASCII data string

**Carriage return <cr>**

Terminator



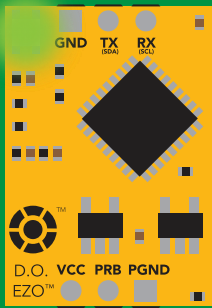
## Advanced

ASCII: **S** **I** **e** **e** **p** **<cr>**

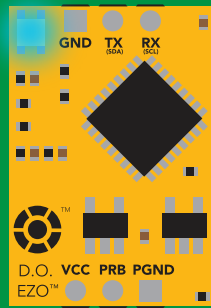
Hex: **53** **6C** **65** **65** **70** **0D**

Dec: **83** **108** **101** **101** **112** **13**

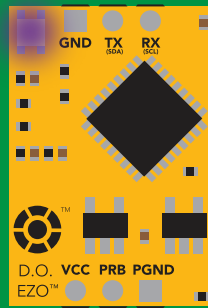
# LED color definition



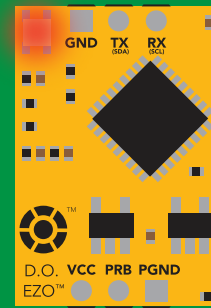
**Green**  
UART standby



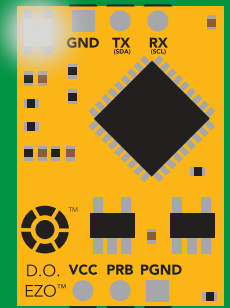
**Cyan**  
Taking reading



**Purple**  
Changing  
baud rate



**Red**  
Command  
not understood



**White**  
Find

**5V**

LED ON  
**+0.4 mA**

**3.3V**

**+0.2 mA**

# UART mode

## command quick reference

All commands are ASCII strings or single ASCII characters.

Command	Function		Default state
Baud	change baud rate	pg. 37	9,600
C	enable/disable continuous reading	pg. 23	enabled
Cal	performs calibration	pg. 25	n/a
Export	export calibration	pg. 26	n/a
Factory	enable factory reset	pg. 39	n/a
Find	finds device with blinking white LED	pg. 22	n/a
i	device information	pg. 33	n/a
I2C	change to I <sup>2</sup> C mode	pg. 40	not set
Import	import calibration	pg. 27	n/a
L	enable/disable LED	pg. 21	enabled
Name	set/show name of device	pg. 32	not set
O	enable/disable parameters	pg. 31	mg/L
P	pressure compensation	pg. 30	101.3 kPa
Plock	enable/disable protocol lock	pg. 38	disabled
R	returns a single reading	pg. 24	n/a
S	salinity compensation	pg. 29	n/a
Sleep	enter sleep mode/low power	pg. 36	n/a
Status	retrieve status information	pg. 35	n/a
T	temperature compensation	pg. 28	20°C
*OK	enable/disable response codes	pg. 34	enable



# LED control

## Command syntax

L,1 <cr> LED on **default**

L,0 <cr> LED off

L,? <cr> LED state on/off?

## Example

## Response

L,1 <cr>

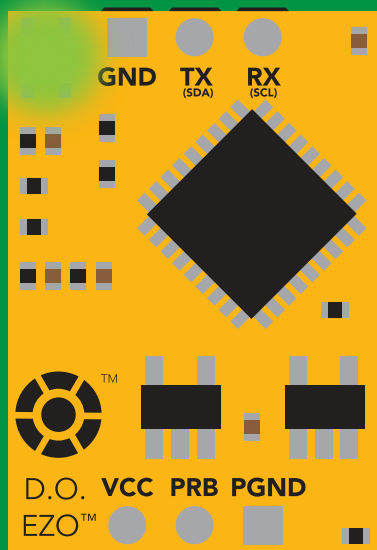
\*OK <cr>

L,0 <cr>

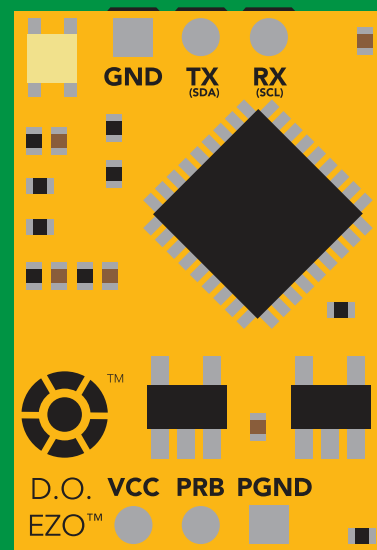
\*OK <cr>

L,? <cr>

?L,1 <cr> or ?L,0 <cr>  
\*OK <cr>



L,1



L,0

# Find

## Command syntax

This command will disable continuous mode  
Send any character or command to terminate find.

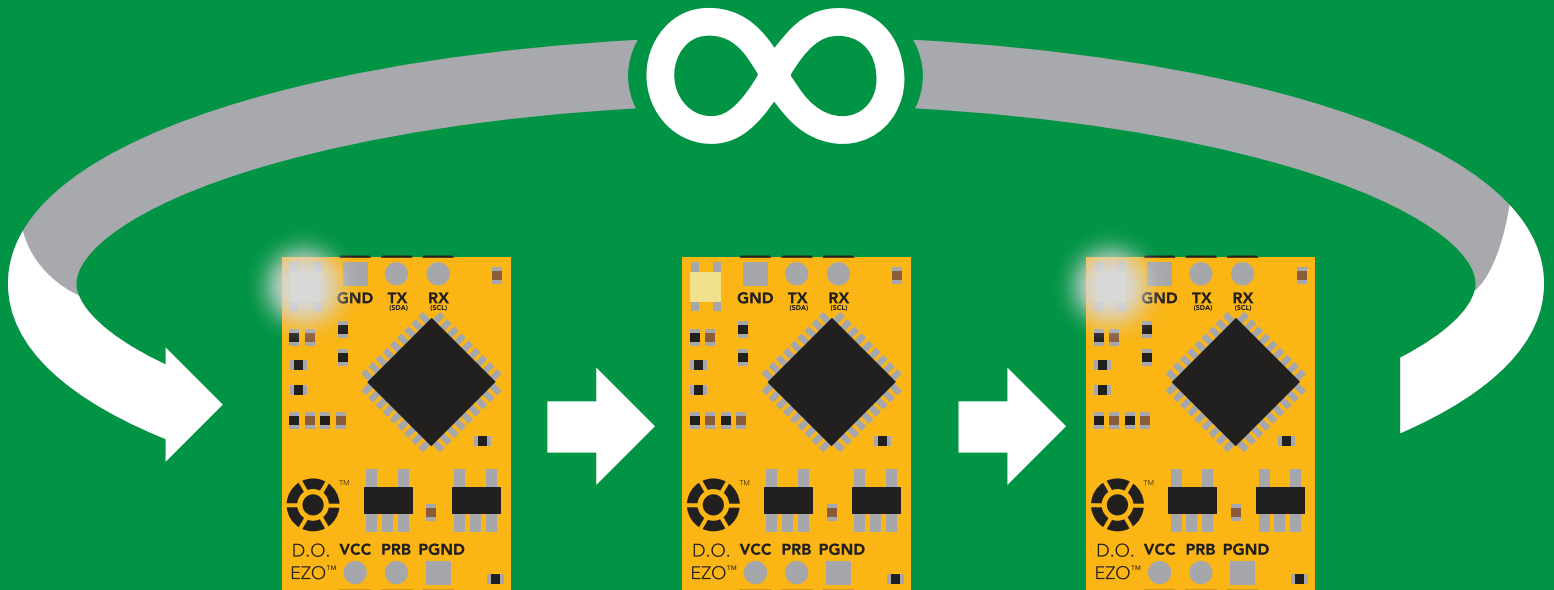
Find <cr> LED rapidly blinks white, used to help find device

## Example

## Response

Find <cr>

\*OK <cr>



# Continuous reading mode

## Command syntax

- C,1 <cr>** enable continuous readings once per second **default**
- C,n <cr>** continuous readings every n seconds (n = 2 to 99 sec)
- C,0 <cr>** disable continuous readings
- C,? <cr>** continuous reading mode on/off?

## Example

## Response

**C,1 <cr>**

**\*OK <cr>**  
**DO (1 sec) <cr>**  
**DO (2 sec) <cr>**  
**DO (3 sec) <cr>**

**C,30 <cr>**

**\*OK <cr>**  
**DO (30 sec) <cr>**  
**DO (60 sec) <cr>**  
**DO (90 sec) <cr>**

**C,0 <cr>**

**\*OK <cr>**

**C,? <cr>**

**?C,1 <cr> or ?C,0 <cr> or ?C,30 <cr>**  
**\*OK <cr>**

# Single reading mode

## Command syntax

R <cr> takes single reading

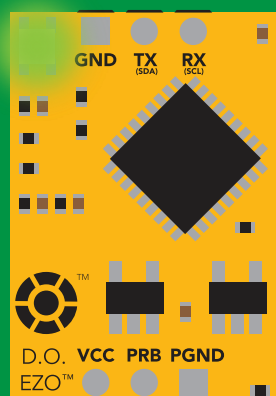
### Example

R <cr>

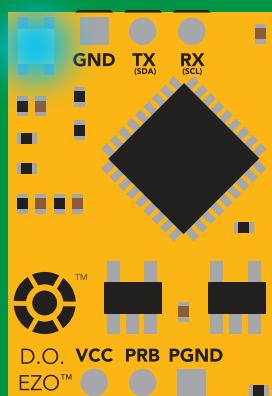
### Response

7.82 <cr>

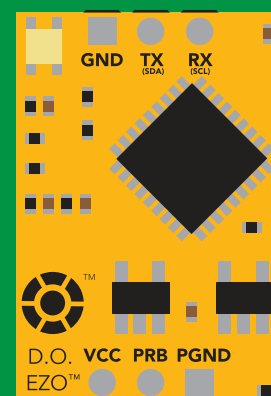
\*OK <cr>



**Green**  
Standby



**Cyan**  
Taking reading



**Yellow**  
Transmitting



600 ms

# Calibration

## Command syntax

The EZO™ Dissolved Oxygen circuit uses single and/or two point calibration

- Cal** <cr> calibrate to atmospheric oxygen levels
- Cal,0** <cr> calibrate device to 0 dissolved oxygen
- Cal,clear** <cr> delete calibration data
- Cal,?** <cr> device calibrated?

## Example

## Response

**Cal** <cr>

**\*OK** <cr>

**Cal,0** <cr>

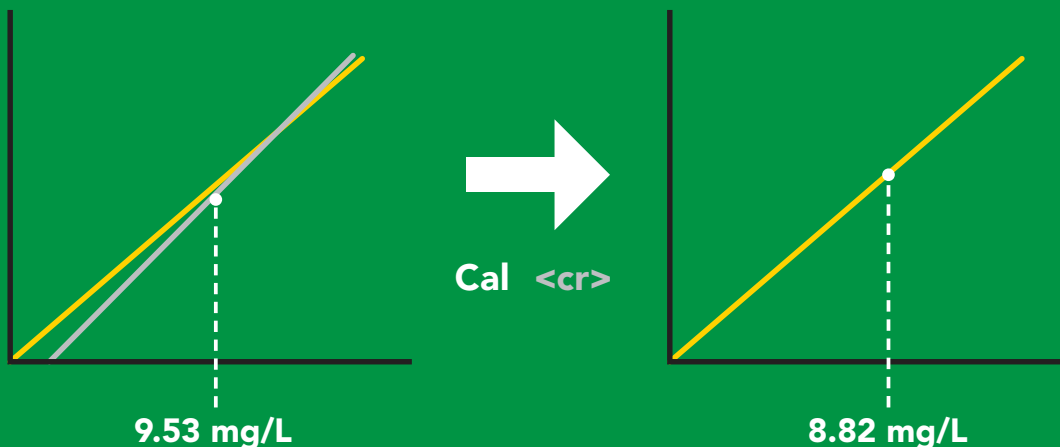
**\*OK** <cr>

**Cal,clear** <cr>

**\*OK** <cr>

**Cal,?** <cr>

**?Cal,0** <cr> or **?Cal,1** <cr> or **?Cal,2** <cr>  
\*OK <cr>                      single point                      two point



# Export calibration

## Command syntax

Export: Use this command to download calibration settings

Export,? <cr> calibration string info

Export <cr> export calibration string from calibrated device

## Example

## Response

Export,? <cr>

10,120 <cr>

### Response breakdown

10, 120

# of strings to export

# of bytes to export

Export strings can be up to 12 characters long, and is always followed by <cr>

Export <cr>

59 6F 75 20 61 72 <cr> (1 of 10)

Export <cr>

65 20 61 20 63 6F <cr> (2 of 10)

(7 more)

⋮

Export <cr>

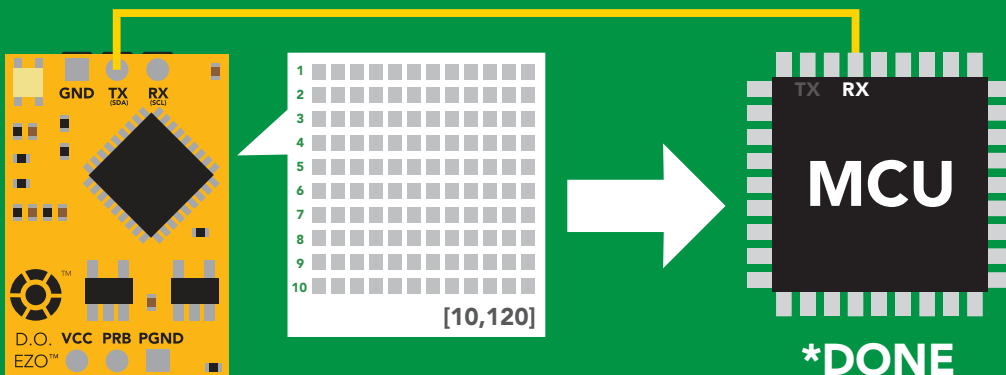
6F 6C 20 67 75 79 <cr> (10 of 10)

Export <cr>

**\*DONE**

Disabling \*OK simplifies this process

Export <cr>



# Import calibration

## Command syntax

Import: Use this command to upload calibration settings to one or more devices.

Import,n <cr> import calibration string to new device

## Example

Import, 59 6F 75 20 61 72 <cr> (1 of 10)

Import, 65 20 61 20 63 6F <cr> (2 of 10)

⋮

Import, 6F 6C 20 67 75 79 <cr> (10 of 10)

## Response

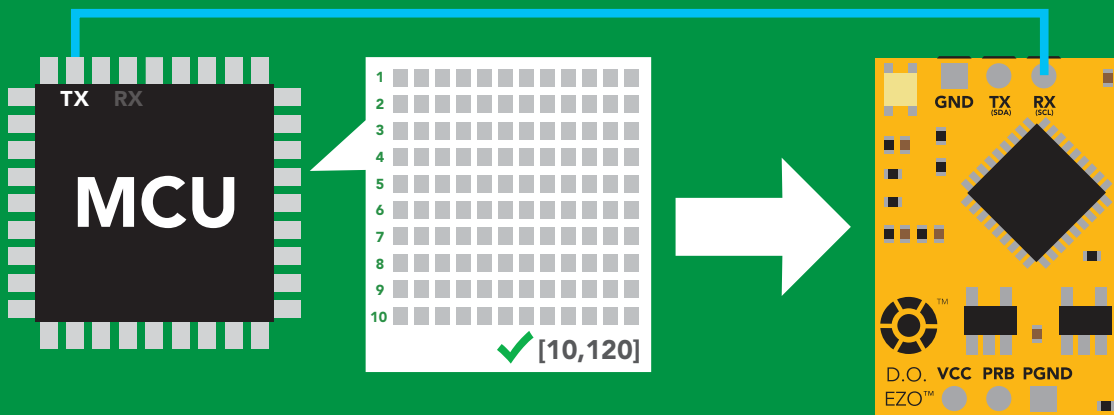
\*OK <cr>

\*OK <cr>

⋮

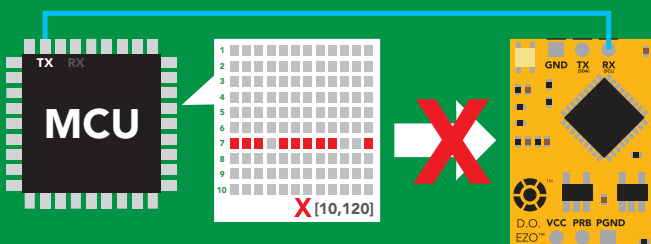
\*OK <cr>

Import,n <cr>



\*OK <cr>

system will reboot



\*ER <cr>

\* If one of the imported strings is not correctly entered, the device will not accept the import, respond with \*ER and reboot.

# Temperature compensation

## Command syntax

Default temperature = 20°C  
Temperature is always in Celsius  
Temperature is not retained if power is cut

**T,n** <cr> n = any value; floating point or int

**T,?** <cr> compensated temperature value?

**RT,n** <cr> set temperature compensation and take a reading\*

This is a new command  
for firmware V2.13

## Example

## Response

**T,19.5** <cr>

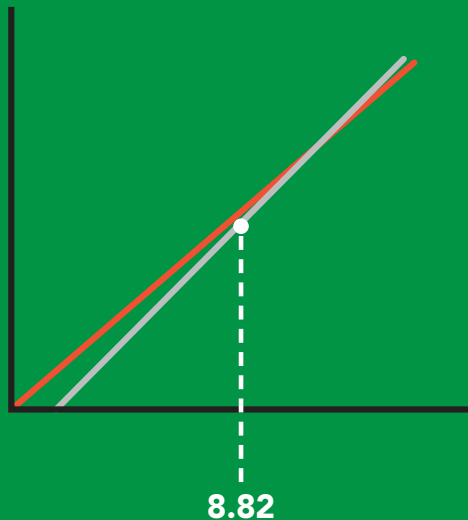
**\*OK** <cr>

**RT,19.5** <cr>

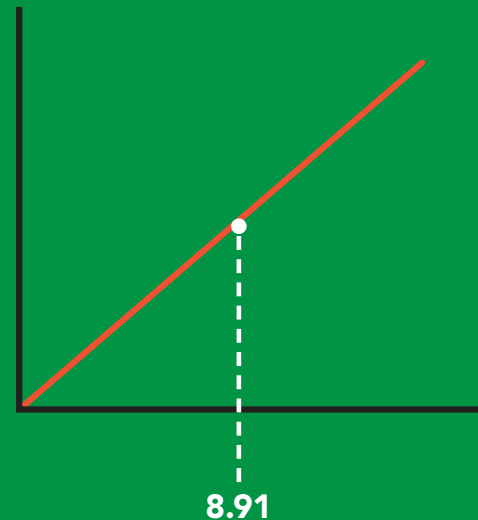
**\*OK** <cr>  
**8.91** <cr>

**T,?** <cr>

**?T,19.5** <cr>  
**\*OK** <cr>



→  
**T,19.5** <cr>





# Salinity compensation

## Command syntax

Default value = 0  $\mu\text{S}$   
If the conductivity of your water is less than 2,500 $\mu\text{S}$  this command is irrelevant

**S,n** <cr> n = any value in microsiemens  
**S,n,ppt** <cr> n = any value in ppt  
**S,?** <cr> compensated salinity value?

## Example

## Response

**S,50000** <cr>

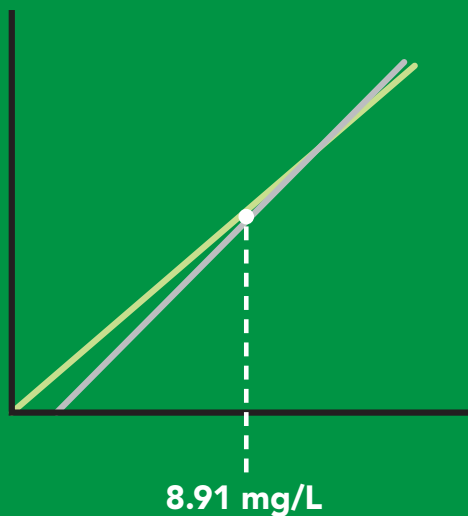
**\*OK** <cr>

**S,37.5,ppt** <cr>

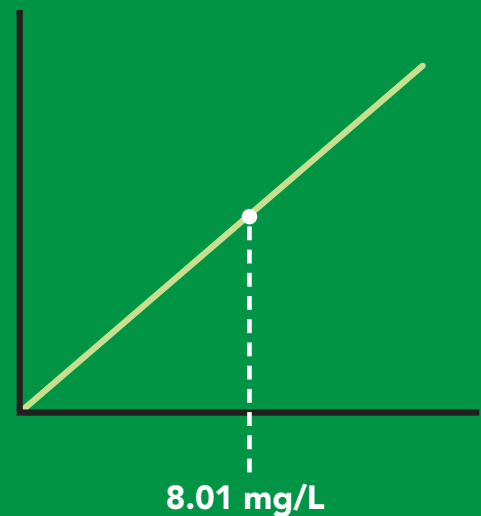
**\*OK** <cr>

**S,?** <cr>

**?S,50000, $\mu\text{S}$**  <cr> **or** **?S,37.5,ppt** <cr>  
**\*OK** <cr>



**S,50000** <cr>



# Pressure compensation

## Command syntax

Default value = 101.3 kPa  
This parameter can be omitted if the water is less than 10 meters deep

`P,n <cr>` n = any value in kPa

`P,? <cr>` compensated pressure value?

## Example

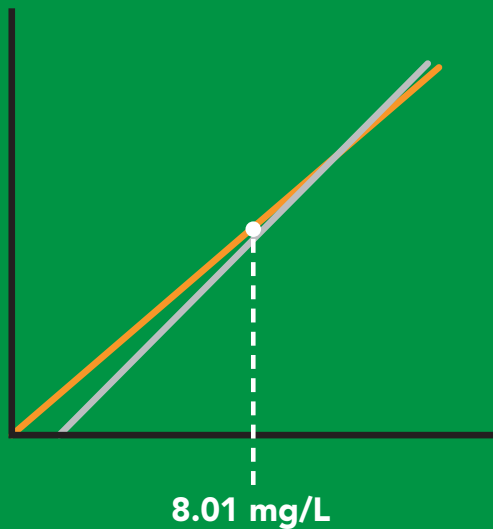
## Response

`P,90.25 <cr>`

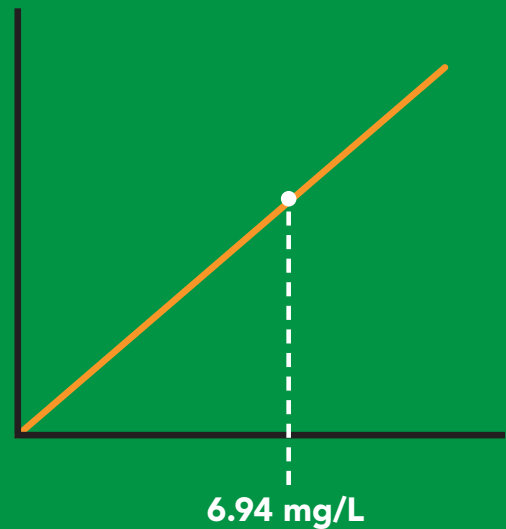
`*OK <cr>`

`P,? <cr>`

`?,P,90.25 <cr>`  
`*OK <cr>`



→  
`P,90.25 <cr>`



# Enable/disable parameters from output string

## Command syntax

O, [parameter],[1,0] <cr> enable or disable output parameter

O,? <cr> enabled parameter?

## Example

O,mg,1 / O,mg,0 <cr>

O,%,1 / O,%,0 <cr>

O,? <cr>

## Response

\*OK <cr> enable / disable mg/L

\*OK <cr> enable / disable percent saturation

?,O,%,mg <cr> if both are enabled

### Parameters

mg mg/L  
% percent saturation

### Followed by 1 or 0

1 enabled  
0 disabled

**\* If you disable all possible data types your readings will display "no output".**

# Naming device

## Command syntax

Do not use spaces in the name

Name,n <cr> set name

Name, <cr> clears name

Name,? <cr> show name

n =

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16

Up to 16 ASCII characters

## Example

## Response

Name, <cr>

\*OK <cr> name has been cleared

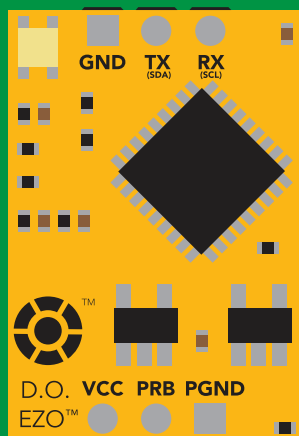
Name,zzt <cr>

\*OK <cr>

Name,? <cr>

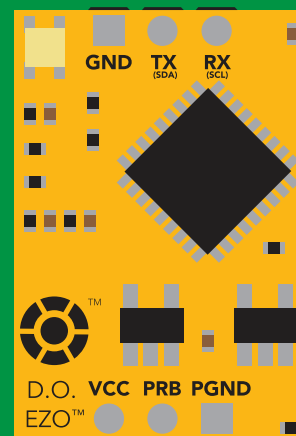
?Name,zzt <cr>  
\*OK <cr>

Name,zzt



\*OK <cr>

Name,?



?Name,zzt <cr>  
\*OK <cr>

# Device information

## Command syntax

```
i <cr> device information
```

### Example

```
i <cr>
```

### Response

```
?i,D.O.,1.98 <cr>  
*OK <cr>
```

## Response breakdown

```
?i, D.O., 1.98  
    ↑      ↑  
  Device Firmware
```

# Response codes

## Command syntax

- \*OK,1** <cr> enable response **default**
- \*OK,0** <cr> disable response
- \*OK,?** <cr> response on/off?

## Example

## Response

**R** <cr>

**7.82** <cr>  
**\*OK** <cr>

**\*OK,0** <cr>

no response, **\*OK** disabled

**R** <cr>

**7.82** <cr> **\*OK** disabled

**\*OK,?** <cr>

**?\*OK,1** <cr> or **?\*OK,0** <cr>

## Other response codes

- \*ER** unknown command
- \*OV** over volt ( $VCC \geq 5.5V$ )
- \*UV** under volt ( $VCC \leq 3.1V$ )
- \*RS** reset
- \*RE** boot up complete, ready
- \*SL** entering sleep mode
- \*WA** wake up

These response codes  
cannot be disabled

# Reading device status

## Command syntax

Status <cr> voltage at Vcc pin and reason for last restart

### Example

```
Status <cr>
```

### Response

```
?Status,P,5.038 <cr>  
*OK <cr>
```

## Response breakdown

```
?Status, P, 5.038  
          ↑      ↑  
          Reason for restart Voltage at Vcc
```

### Restart codes

P	powered off
S	software reset
B	brown out
W	watchdog
U	unknown

# Sleep mode/low power

## Command syntax

Send any character or command to awaken device.

Sleep <cr> enter sleep mode/low power

## Example

## Response

Sleep <cr>

\*OK <cr>

\*SL <cr>

Any command

\*WA <cr> wakes up device

5V

STANDBY

13.1 mA

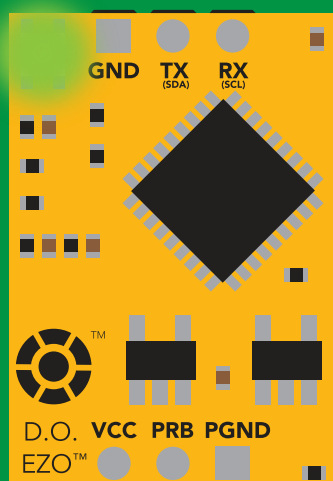
SLEEP

0.66 mA

3.3V

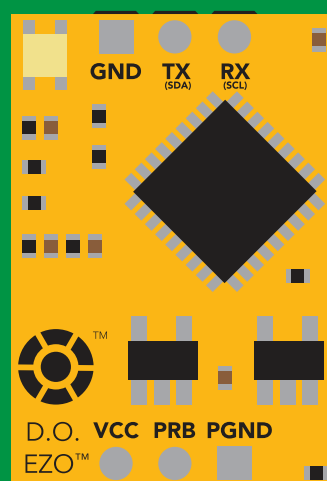
12 mA

0.3 mA



Standby  
13.1 mA

Sleep <cr>



Sleep  
0.66 mA



# Change baud rate

## Command syntax

Baud,n <cr> change baud rate

### Example

Baud,38400 <cr>

\*OK <cr>

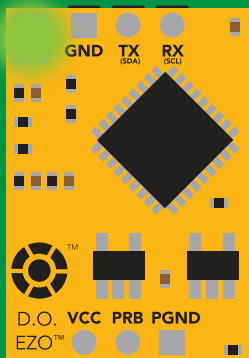
Baud,? <cr>

?Baud,38400 <cr>

\*OK <cr>

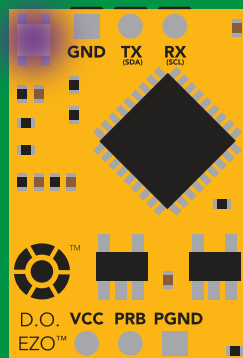
n =

- 300
- 1200
- 2400
- 9600 default**
- 19200
- 38400
- 57600
- 115200



Standby

Baud,38400 <cr>

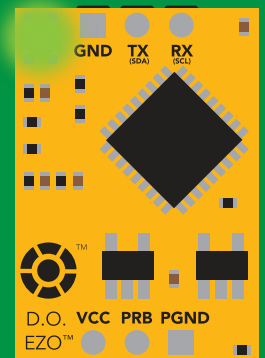


Changing  
baud rate

\*OK <cr>



(reboot)



Standby

# Protocol lock

## Command syntax

Locks device to UART mode.

Plock,1 <cr> enable Plock

Plock,0 <cr> disable Plock **default**

Plock,? <cr> Plock on/off?

## Example

## Response

Plock,1 <cr>

\*OK <cr>

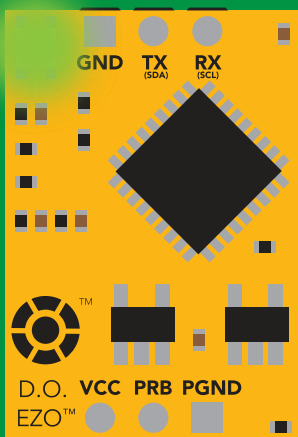
Plock,0 <cr>

\*OK <cr>

Plock,? <cr>

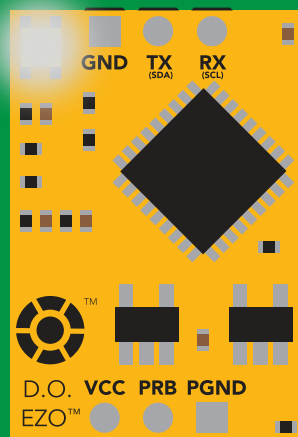
?Plock,1 <cr> **or** ?Plock,0 <cr>

Plock,1



\*OK <cr>

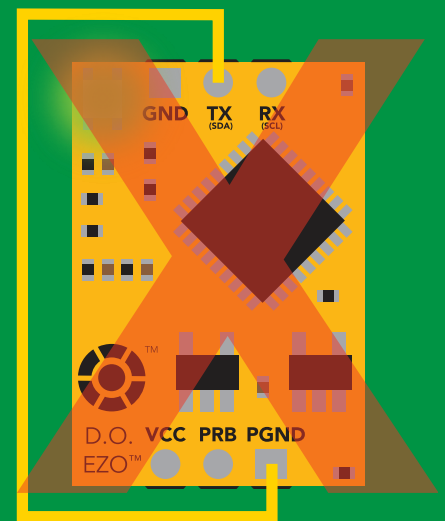
I2C,100



cannot change to I<sup>2</sup>C

\*ER <cr>

Short



cannot change to I<sup>2</sup>C

# Factory reset

## Command syntax

Clears calibration  
LED on  
"\*OK" enabled

Factory <cr> enable factory reset

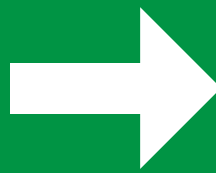
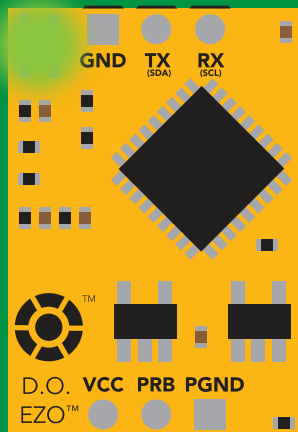
### Example

### Response

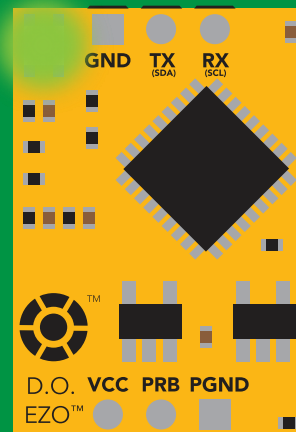
Factory <cr>

\*OK <cr>

Factory <cr>



(reboot)



\*OK <cr>

\*RS <cr>

\*RE <cr>

Baud rate will not change

# Change to I<sup>2</sup>C mode

## Command syntax

Default I<sup>2</sup>C address 97 (0x61)

I2C,n <cr> sets I<sup>2</sup>C address and reboots into I<sup>2</sup>C mode

n = any number 1 – 127

## Example

## Response

I2C,100 <cr>

\*OK (reboot in I<sup>2</sup>C mode)

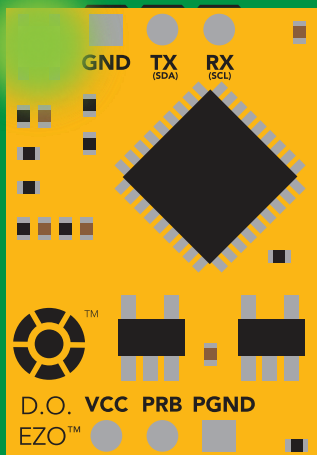
## Wrong example

## Response

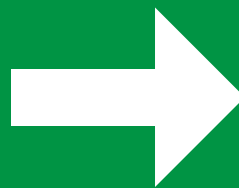
I2C,139 <cr> n ≠ 127

\*ER <cr>

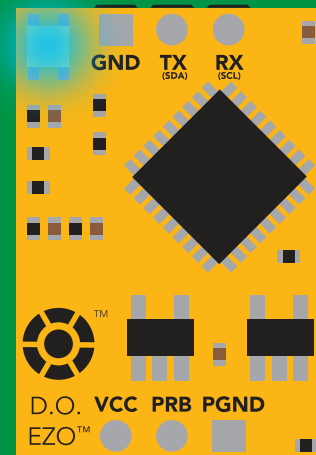
I2C,100



Green  
\*OK <cr>



(reboot)



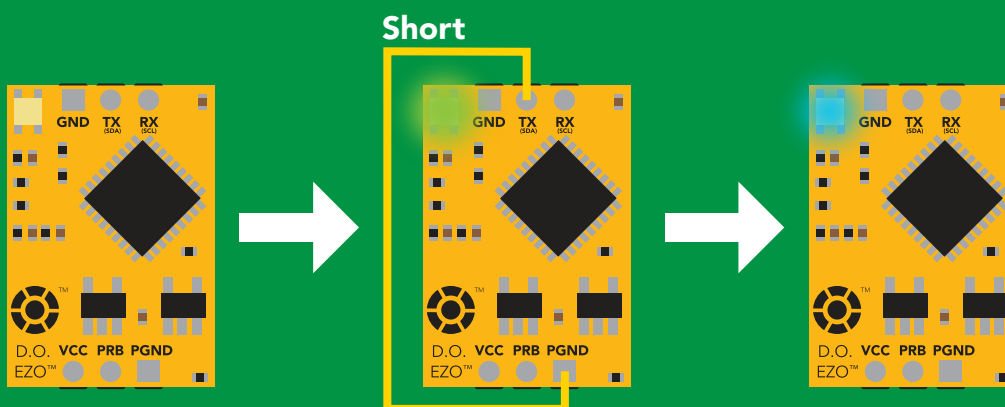
Blue  
now in I<sup>2</sup>C mode

# Manual switching to I<sup>2</sup>C

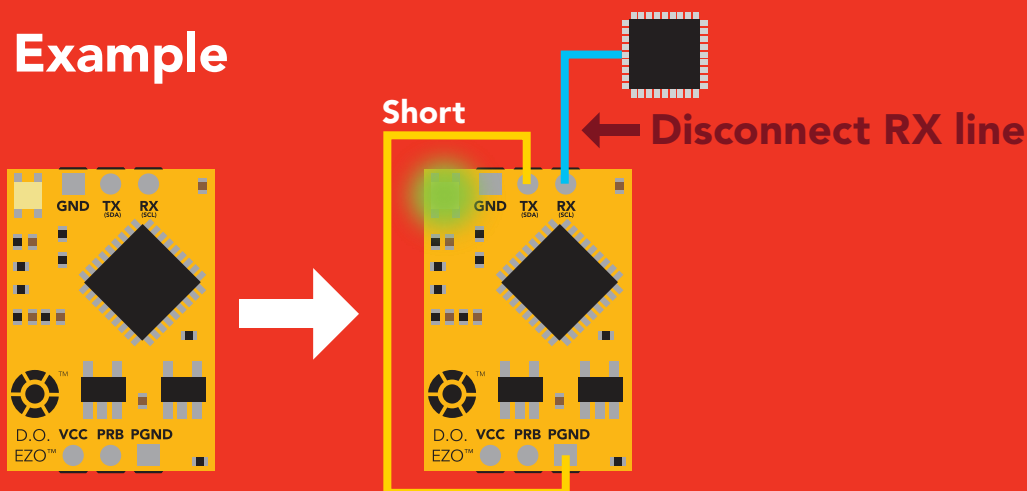
- Disconnect ground (power off)
- Disconnect TX and RX
- Connect TX to PGND
- Confirm RX is disconnected
- Connect ground (power on)
- Wait for LED to change from **Green** to **Blue**
- Disconnect ground (power off)
- Reconnect all data and power

Manually switching to I<sup>2</sup>C will set the I<sup>2</sup>C address to 97 (0x61)

## Example



## Wrong Example



# I<sup>2</sup>C mode

The I<sup>2</sup>C protocol is **considerably more complex** than the UART (RS-232) protocol. Atlas Scientific assumes the embedded systems engineer understands this protocol.

To set your EZO™ device into I<sup>2</sup>C mode click [here](#)

## Settings that are retained if power is cut

- Calibration
- Change I<sup>2</sup>C address
- Enable/disable parameters
- Hardware switch to UART mode
- LED control
- Protocol lock
- Software switch to UART mode

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

- Find
- Pressure compensation
- Salinity compensation
- Sleep mode
- Temperature compensation

# I<sup>2</sup>C mode

I<sup>2</sup>C address (0x01 – 0x7F)  
**97 (0x61) default**

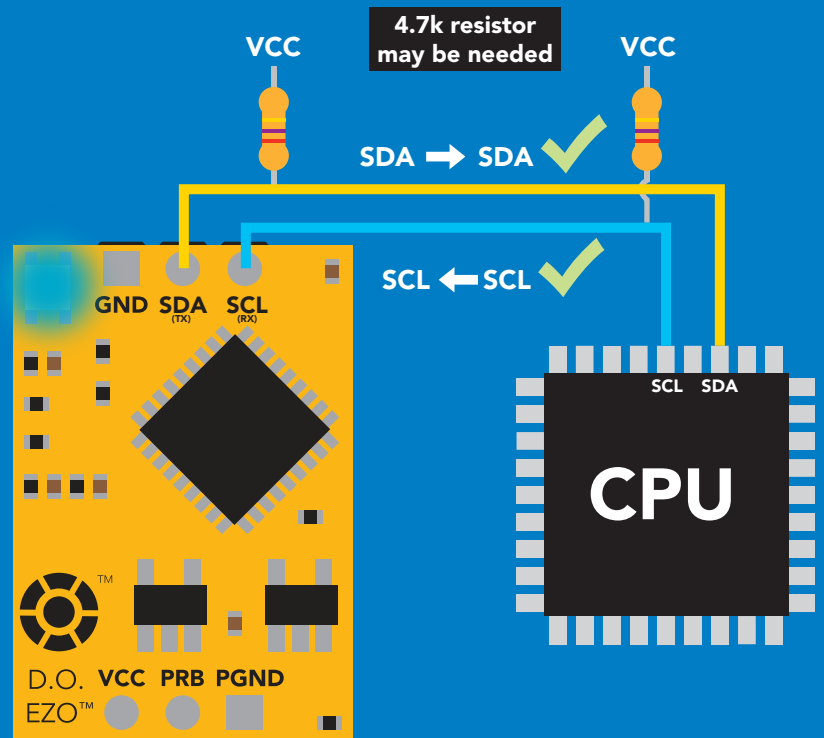
Vcc 3.3V – 5.5V

Clock speed 100 – 400 kHz

SDA 

SCL 

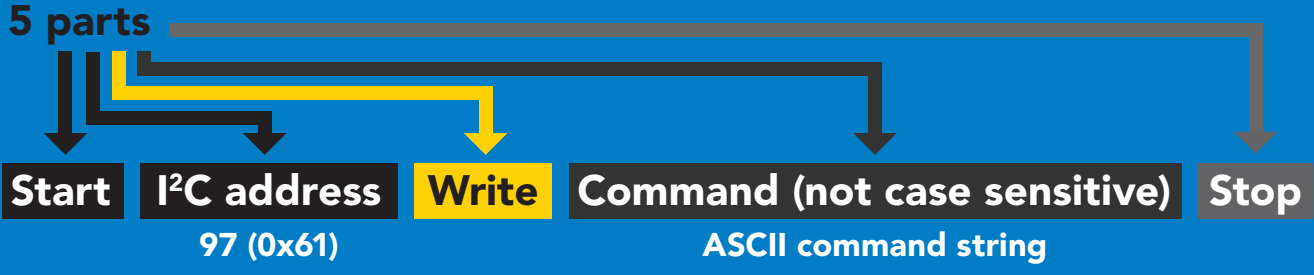




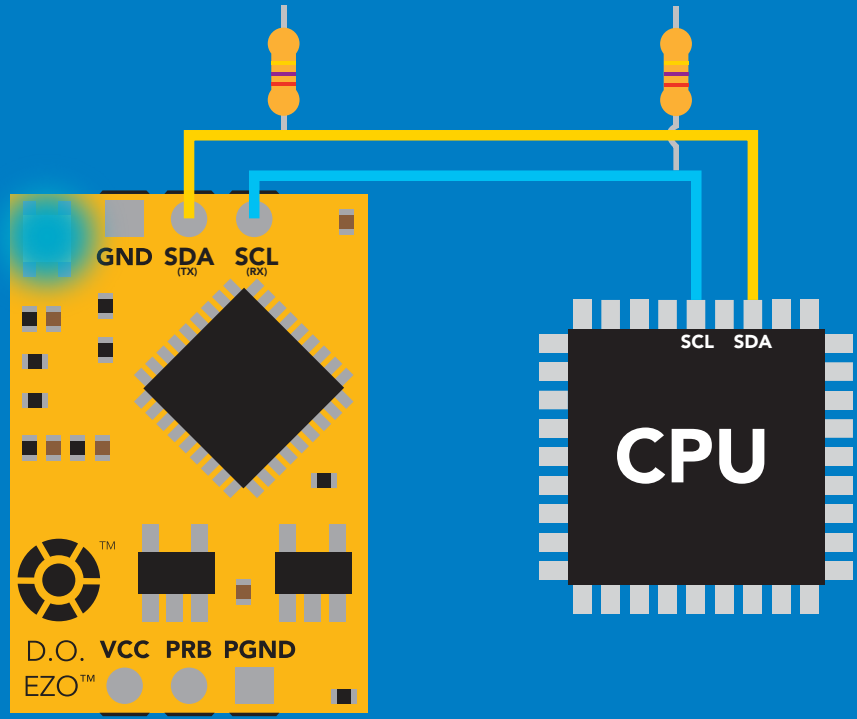
## Data format

Reading	Dissolved Oxygen	Data type	floating point
Units	mg/L & (% sat) <small>when enabled</small>	Decimal places	mg/L = 2 % sat = 1
Encoding	ASCII	Smallest string	4 characters
Format	string <small>(CSV string when % sat is enabled)</small>	Largest string	16 characters

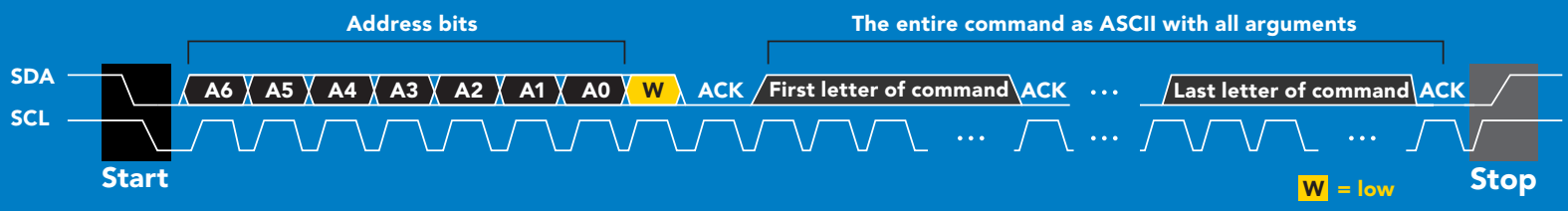
# Sending commands to device



## Example

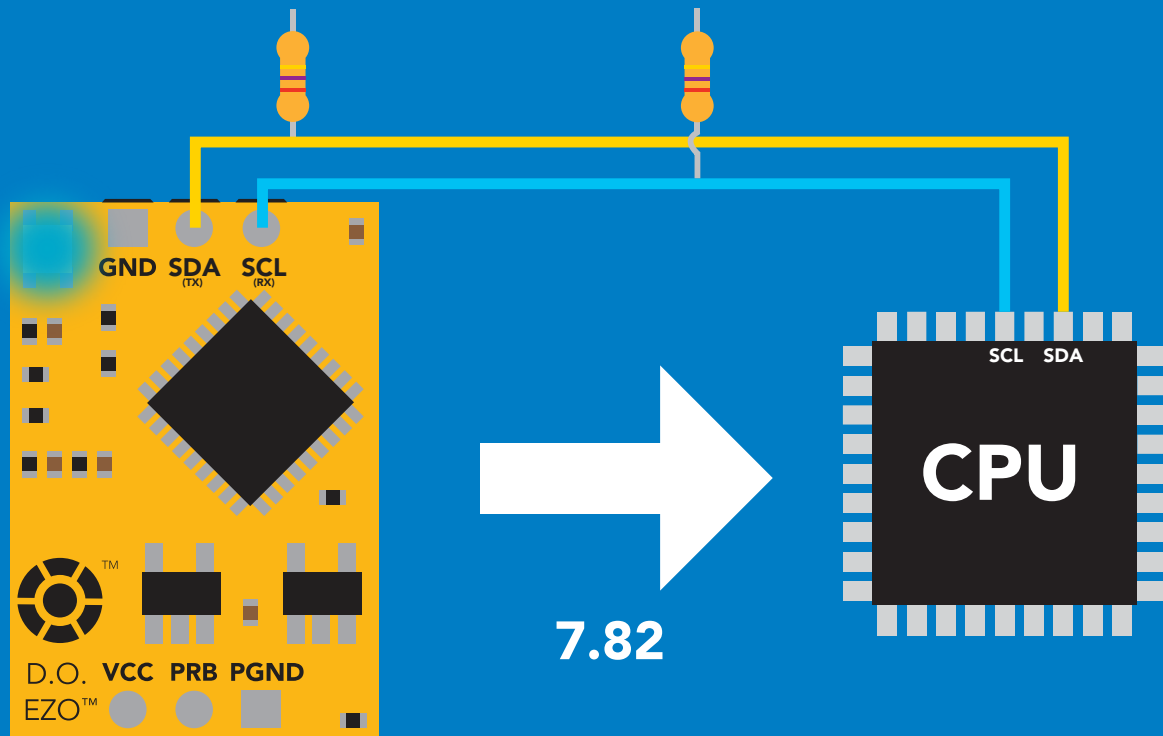
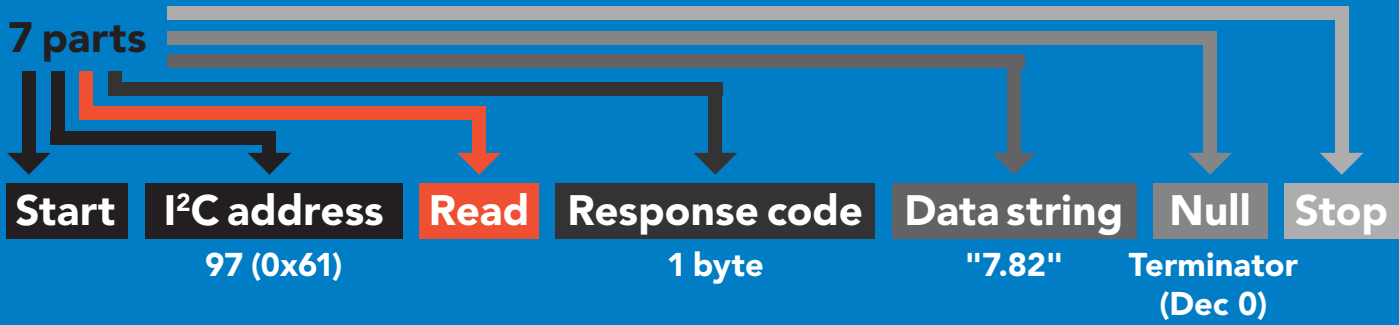


## Advanced

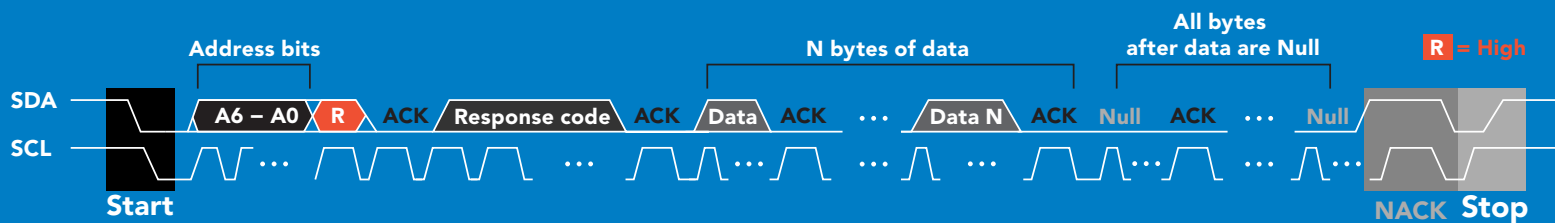




# Requesting data from device



## Advanced

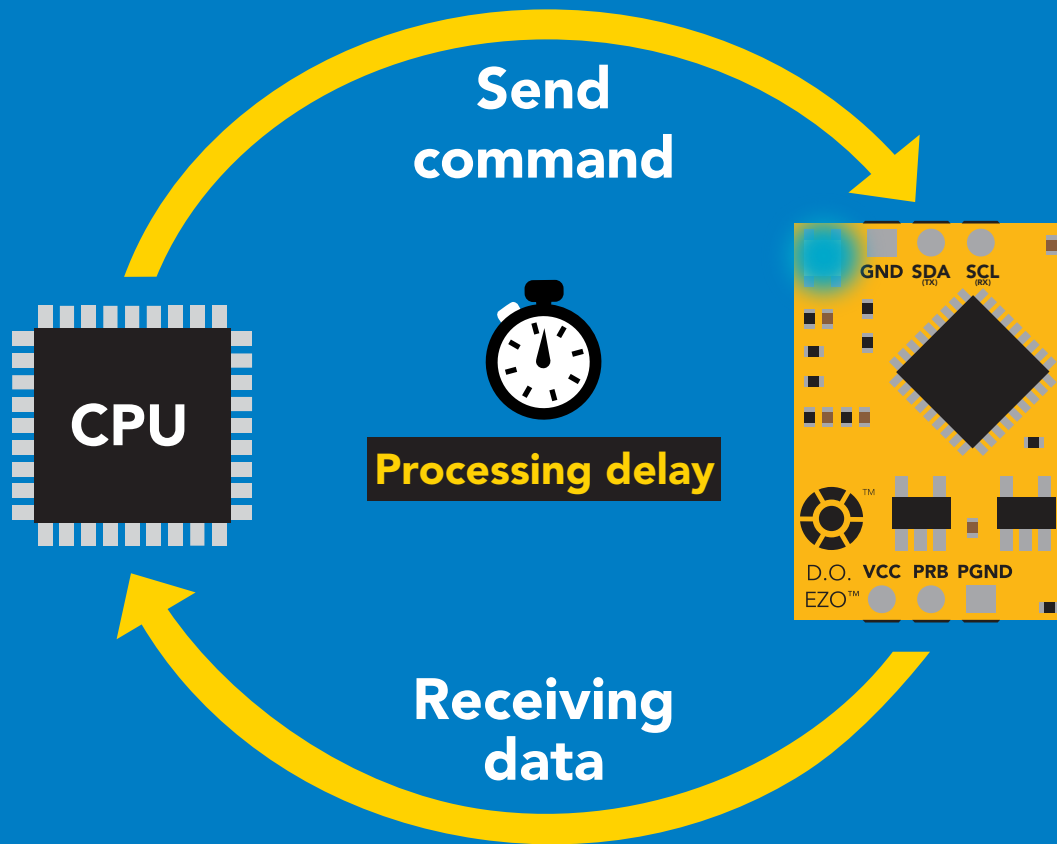


1	55	46	56	50	0	= 7.82
Dec	ASCII				Dec	

# Response codes

After a command has been issued, a 1 byte response code can be read in order to confirm that the command was processed successfully.

*Reading back the response code is completely optional, and is not required for normal operation.*



## Example

```
I2C_start;  
I2C_address;  
I2C_write(EZO_command);  
I2C_stop;
```

`delay(300);`



Processing delay

```
I2C_start;  
I2C_address;  
Char[ ] = I2C_read;  
I2C_stop;
```

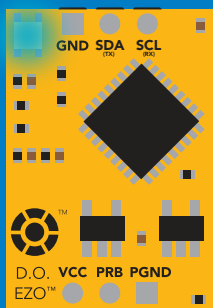
The response code will always be 254, if you do not wait for the processing delay.

### Response codes

Single byte, not string

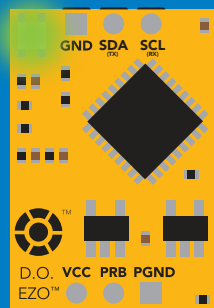
255	no data to send
254	still processing, not ready
2	syntax error
1	successful request

# LED color definition



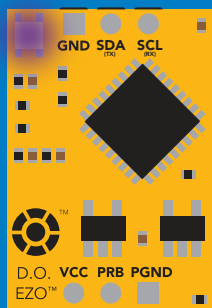
**Blue**

I<sup>2</sup>C standby



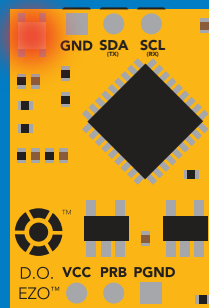
**Green**

Taking reading



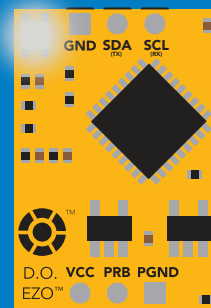
**Purple**

Changing  
I<sup>2</sup>C address



**Red**

Command  
not understood



**White**

Find

**5V**

LED ON

**+0.4 mA**

**3.3V**

**+0.2 mA**

# I<sup>2</sup>C mode

## command quick reference

All commands are ASCII strings or single ASCII characters.

<b>Command</b>	<b>Function</b>	
<b>Baud</b>	change back to UART mode	<b>pg. 66</b>
<b>Cal</b>	performs calibration	<b>pg. 52</b>
<b>Export</b>	export calibration	<b>pg. 53</b>
<b>Factory</b>	enable factory reset	<b>pg. 65</b>
<b>Find</b>	finds device with blinking white LED	<b>pg. 50</b>
<b>i</b>	device information	<b>pg. 60</b>
<b>I2C</b>	change I <sup>2</sup> C address	<b>pg. 64</b>
<b>Import</b>	import calibration	<b>pg. 54</b>
<b>L</b>	enable/disable LED	<b>pg. 49</b>
<b>Name</b>	set/show name of device	<b>pg. 59</b>
<b>O</b>	removing parameters	<b>pg. 58</b>
<b>P</b>	pressure compensation	<b>pg. 57</b>
<b>Plock</b>	enable/disable protocol lock	<b>pg. 63</b>
<b>R</b>	returns a single reading	<b>pg. 51</b>
<b>S</b>	salinity compensation	<b>pg. 56</b>
<b>Sleep</b>	enter sleep mode/low power	<b>pg. 62</b>
<b>Status</b>	retrieve status information	<b>pg. 61</b>
<b>T</b>	temperature compensation	<b>pg. 55</b>

# LED control

## Command syntax

300ms  processing delay

L,1 LED on **default**

L,0 LED off

L,? LED state on/off?

## Example

## Response

L,1

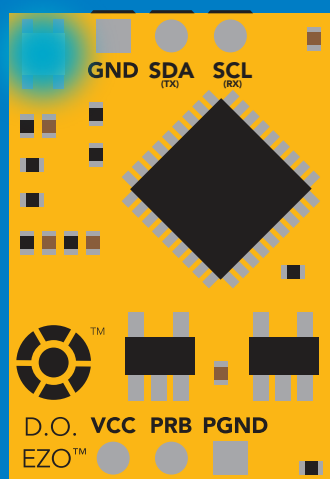
  
Wait 300ms    **1**    **0**  
Dec    Null

L,0

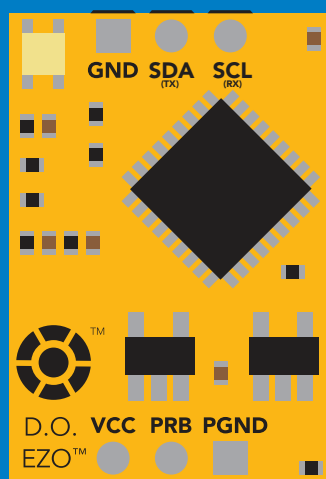
  
Wait 300ms    **1**    **0**  
Dec    Null

L,?

  
Wait 300ms    **1**    **?L,1**    **0**    or    **1**    **?L,0**    **0**  
Dec    ASCII    Null    Dec    ASCII    Null



L,1



L,0

# Find

300ms  processing delay

## Command syntax

This command will disable continuous mode  
Send any character or command to terminate find.

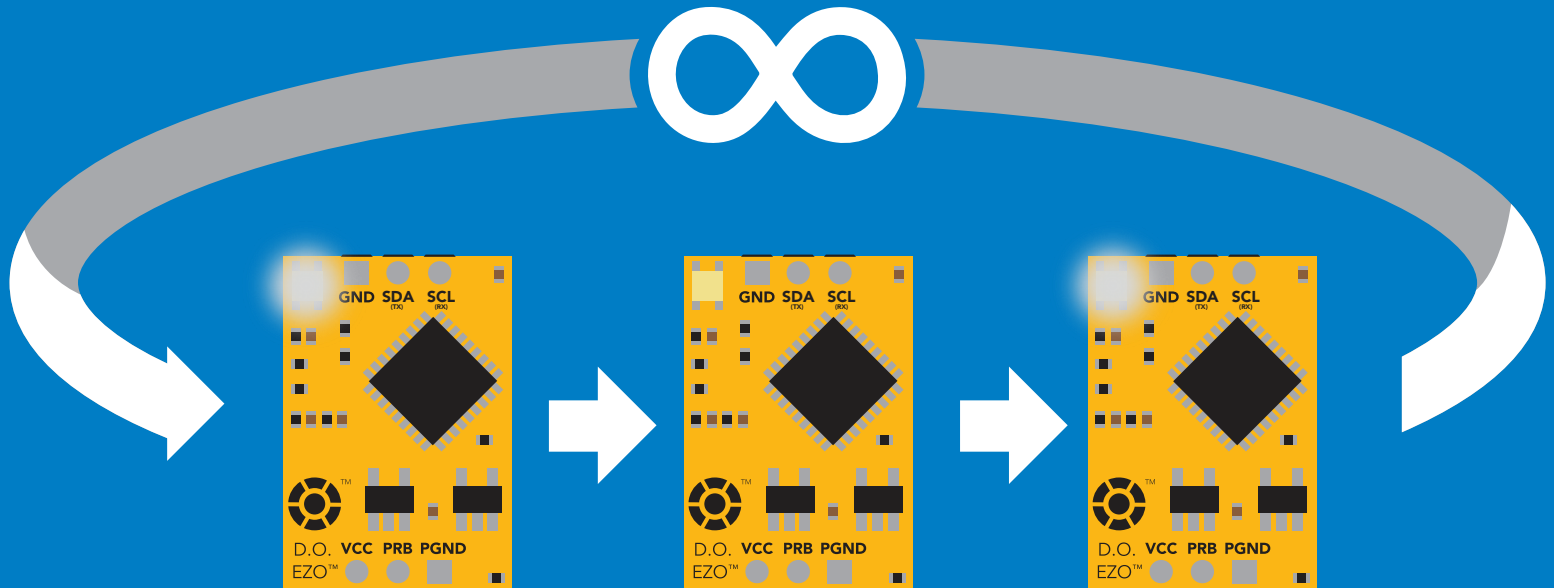
Find LED rapidly blinks white, used to help find device

## Example

## Response

Find

 Wait 300ms  
1 Dec 0 Null



# Taking reading

Command syntax

600ms  processing delay

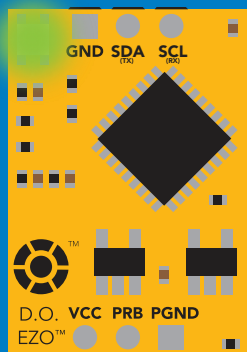
R return 1 reading

Example

Response

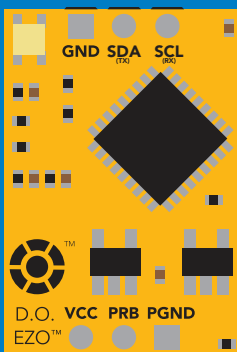
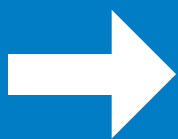
R

 Wait 600ms    1    7.82    0  
Dec    ASCII    Null

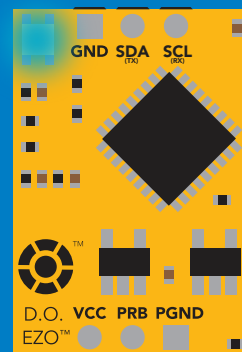


Green

Taking reading



Transmitting



Blue

Standby

# Calibration

## Command syntax

1300ms  processing delay

- Cal calibrate to atmospheric oxygen levels
- Cal,0 calibrate device to 0 dissolved oxygen
- Cal,clear delete calibration data
- Cal,? device calibrated?

The EZO™ Dissolved Oxygen circuit uses single and/or two point calibration

## Example

## Response

Cal

  
Wait 1300ms    1    0  
Dec    Null


Cal,0

  
Wait 1300ms    1    0  
Dec    Null

Cal,clear

  
Wait 300ms    1    0  
Dec    Null

Cal,?

  
Wait 300ms    1    ?Cal,0    0    or    1    ?Cal,1    0  
Dec    ASCII    Null    Dec    ASCII    Null

or    1    ?Cal,2    0  
Dec    ASCII    Null



# Export calibration

300ms  processing delay

## Command syntax

Export: Use this command to download calibration settings

Export,? calibration string info

Export export calibration string from calibrated device

## Example

## Response

Export,?



Wait 300ms

1

Dec

10,120

ASCII

0

Null

## Response breakdown

10, 120

# of strings to export # of bytes to export

Export strings can be up to 12 characters long

Export



Wait 300ms

1

Dec

59 6F 75 20 61 72

ASCII

0

Null

(1 of 10)

Export



Wait 300ms

1

Dec

65 20 61 20 63 6F

ASCII

0

Null

(2 of 10)

(7 more)

⋮

Export



Wait 300ms

1

Dec

6F 6C 20 67 75 79

ASCII

0

Null

(10 of 10)

Export



Wait 300ms

1

Dec

\*DONE

ASCII

0

Null

# Import calibration

300ms  processing delay

## Command syntax

Import: Use this command to upload calibration settings to one or more devices.

Import,n import calibration string to new device

## Example

Import, 59 6F 75 20 61 72 (1 of 10)

Import, 65 20 61 20 63 6F (2 of 10)

⋮

Import, 6F 6C 20 67 75 79 (10 of 10)

## Response

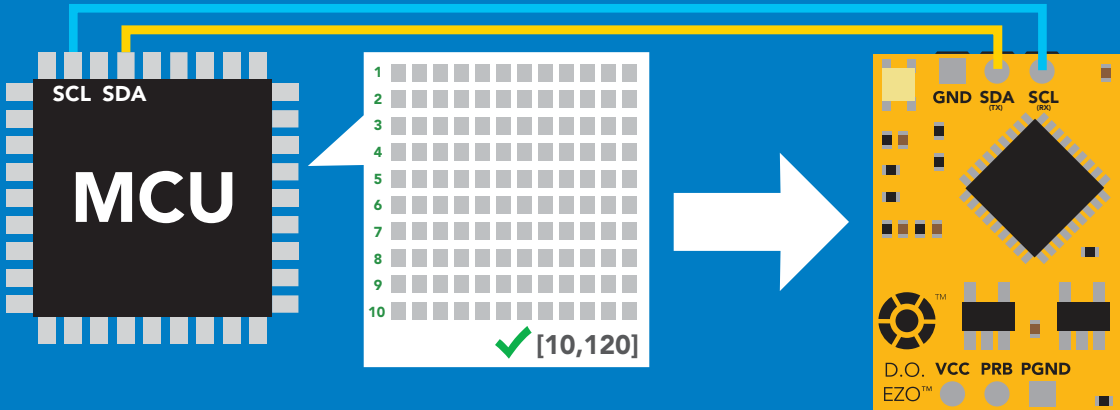
 Wait 300ms **1** **0**  
Dec Null

 Wait 300ms **1** **0**  
Dec Null

⋮

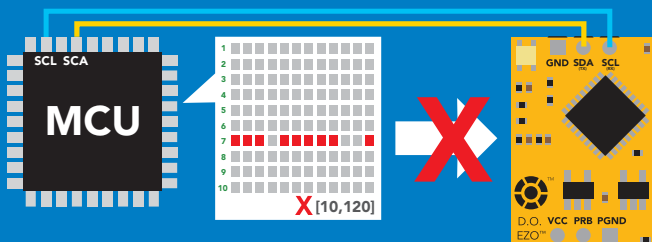
 Wait 300ms **1** **0**  
Dec Null

Import,n



**1** **\*Pending** **0**  
Dec ASCII Null

system will reboot



reboot

\* If one of the imported strings is not correctly entered, the device will not accept the import and reboot.

# Temperature compensation

## Command syntax

Default temperature = 20°C  
Temperature is always in Celsius  
Temperature is not retained if power is cut

T,n n = any value; floating point or int 300ms  processing delay

T,? compensated temperature value?

RT,n set temperature compensation and take a reading\*

This is a new command for firmware V2.13

## Example

## Response

T,19.5

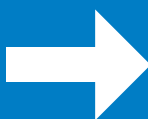
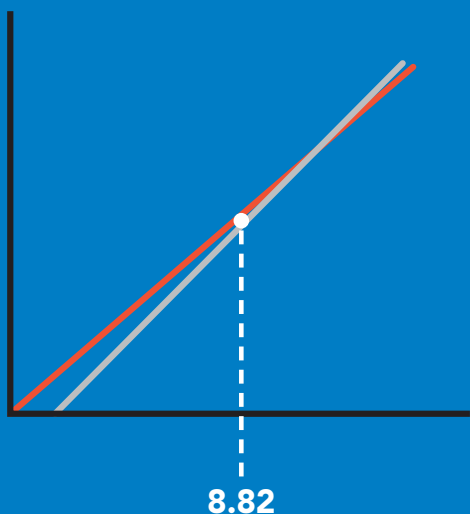
 Wait 300ms **1** **0**  
Dec Null

RT,19.5

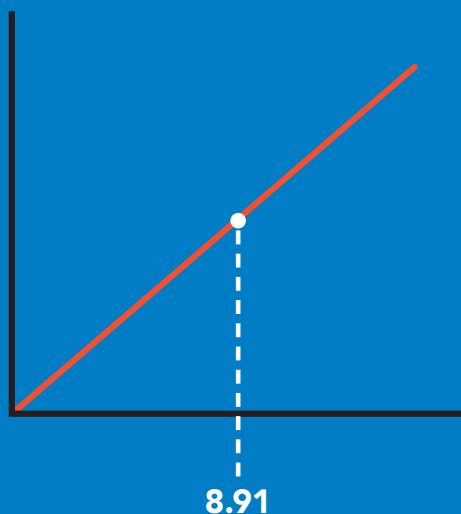
 Wait 900ms **1** **8.91** **0**  
Dec ASCII Null

T,?

 Wait 300ms **1** **?T,19.5** **0**  
Dec ASCII Null



T,19.5



# Salinity compensation

## Command syntax

300ms  processing delay

S,n n = any value in microsiemens

**default**

S,n,ppt n = any value in ppt

S,? compensated salinity value?

## Example

## Response

S,50000



Wait 300ms

1

Dec

0

Null

S,37.5,ppt



Wait 300ms

1

Dec

0

Null

S,?



Wait 300ms

1

Dec

?S,50000,μS

ASCII

0

Null

or

1

Dec

?S,37.5,ppt

ASCII

0

Null

If the conductivity of your water is less than 2,500μS this command is irrelevant

# Pressure compensation

## Command syntax

300ms  processing delay

P,n n = any value in kPa

P,? compensated pressure value?

This parameter can be omitted if the water is less than 10 meters deep

## Example

P,90.25



1  
Dec

0  
Null

P,?

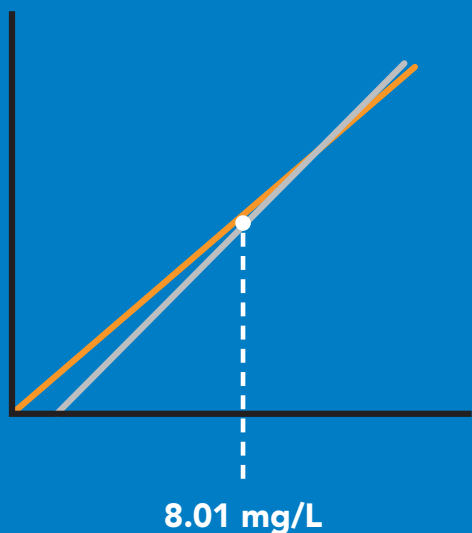


1  
Dec

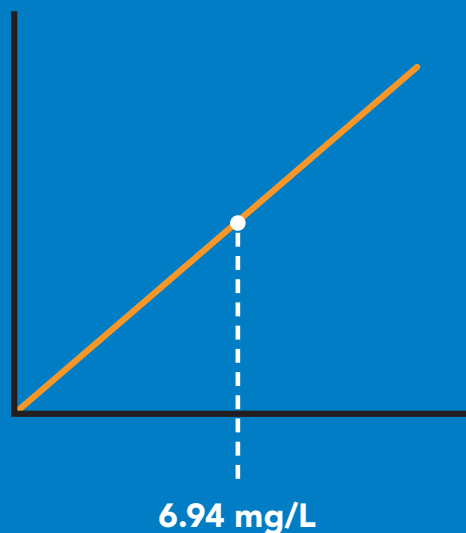
?,P,90.25  
ASCII

0  
Null

## Response



P,90.25



# Enable/disable parameters from output string

## Command syntax

300ms  processing delay

O, [parameter],[1,0]

enable or disable output parameter

O,?

enabled parameter?

## Example

## Response

O,mg,1 / O,mg,0



**1** **0**  
Dec Null

enable / disable mg/L

O,%,1 / O,%,0



**1** **0**  
Dec Null

enable / disable percent saturation

O,?



**1** **? , O , % , mg** **0**  
Dec ASCII Null

if both are enabled

### Parameters

mg mg/L  
% percent saturation

### Followed by 1 or 0

1 enabled  
0 disabled

\* If you disable all possible data types your readings will display "no output".

# Naming device

300ms  processing delay

## Command syntax

Do not use spaces in the name

Name,n	set name	n =	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Name,	clears name		Up to 16 ASCII characters															
Name,?	show name																	

## Example

## Response

Name,

 Wait 300ms

<b>1</b>	<b>0</b>	name has been cleared
Dec	Null	

Name,zzt

 Wait 300ms

<b>1</b>	<b>0</b>
Dec	Null

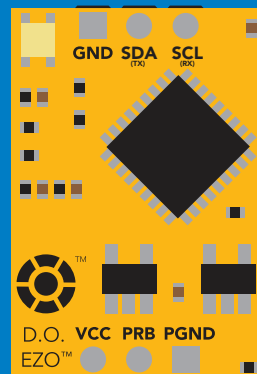
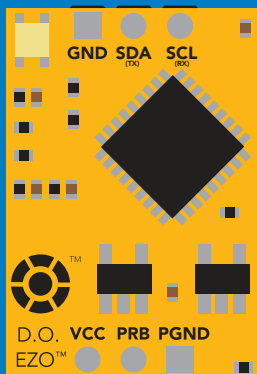
Name,?

 Wait 300ms

<b>1</b>	<b>?Name,zzt</b>	<b>0</b>
Dec	ASCII	Null

Name,zzt

Name,?



**1** **0**

**1** **?Name,zzt** **0**

# Device information

Command syntax

300ms  processing delay

i device information

Example

Response

i



Wait 300ms

1

Dec

?i,D.O.,1.98

ASCII

0

Null

Response breakdown

?i, D.O., 1.98  
↑     ↑  
Device Firmware



# Reading device status

Command syntax

300ms  processing delay

Status voltage at Vcc pin and reason for last restart

## Example

## Response

Status

 **1** **?Status,P,5.038** **0**  
Wait 300ms Dec ASCII Null

## Response breakdown

**?Status,** **P,** **5.038**  
Reason for restart Voltage at Vcc

### Restart codes

P powered off  
S software reset  
B brown out  
W watchdog  
U unknown

# Sleep mode/low power

## Command syntax

Sleep enter sleep mode/low power

Send any character or command to awaken device.

### Example

### Response

Sleep

no response

Do not read status byte after issuing sleep command.

Any command

wakes up device

5V

STANDBY

SLEEP

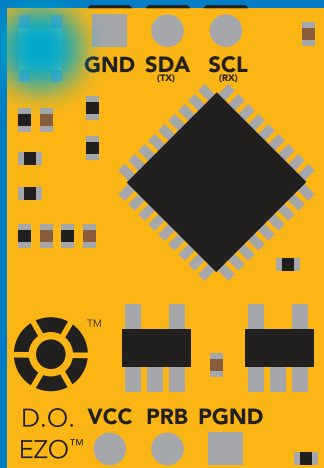
13.1 mA

0.66 mA

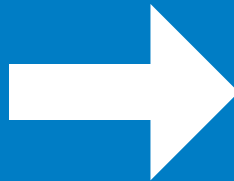
3.3V

12 mA

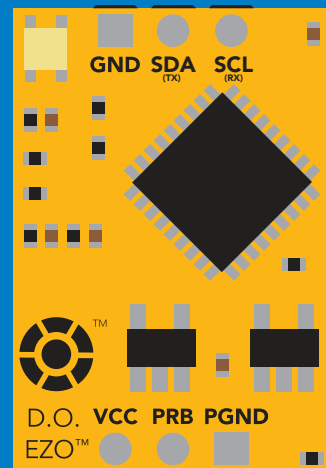
0.3 mA



Standby



Sleep



Sleep

# Protocol lock

## Command syntax

300ms  processing delay

Plock,1 enable Plock

Plock,0 disable Plock

Plock,? Plock on/off?

**default**

Locks device to I<sup>2</sup>C mode.

## Example

## Response

Plock,1

  
Wait 300ms

<b>1</b>	<b>0</b>
Dec	Null

Plock,0

  
Wait 300ms

<b>1</b>	<b>0</b>
Dec	Null

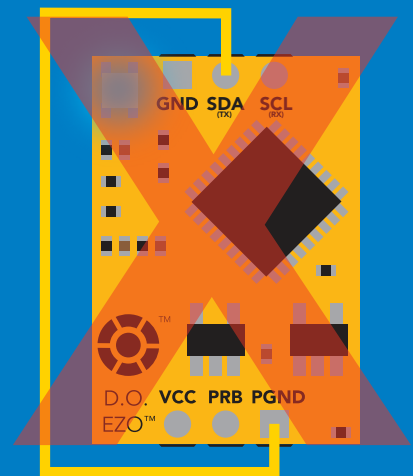
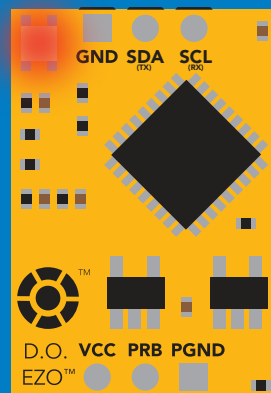
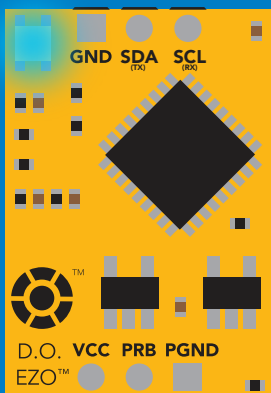
Plock,?

  
Wait 300ms

<b>1</b>	<b>?Plock,1</b>	<b>0</b>
Dec	ASCII	Null

Plock,1

Baud, 9600



cannot change to UART

cannot change to UART

# I<sup>2</sup>C address change

Command syntax

300ms  processing delay

I2C,n sets I<sup>2</sup>C address and reboots into I<sup>2</sup>C mode

Example

Response

I2C,100

device reboot  
(no response given)

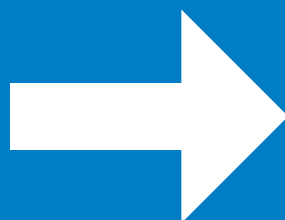
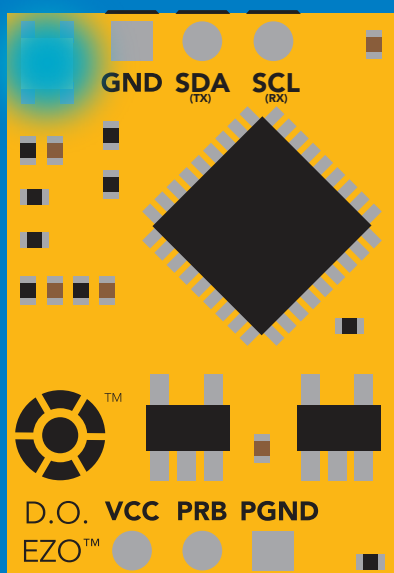
## Warning!

Changing the I<sup>2</sup>C address will prevent communication between the circuit and the CPU until your CPU is updated with the new I<sup>2</sup>C address.

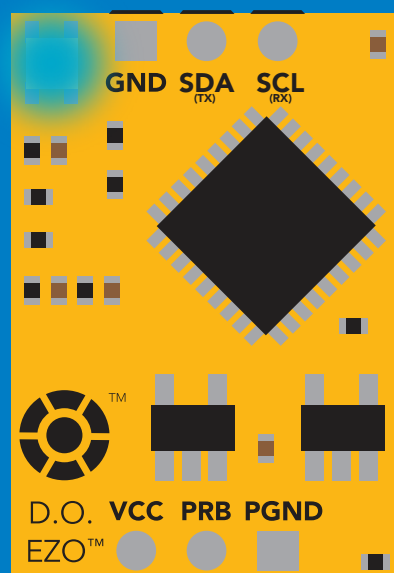
Default I<sup>2</sup>C address is 97 (0x61).

n = any number 1 – 127

## I2C,100



(reboot)



# Factory reset

## Command syntax

Factory reset will not take the device out of I<sup>2</sup>C mode.

Factory enable factory reset

I<sup>2</sup>C address will not change

## Example

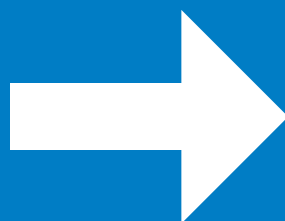
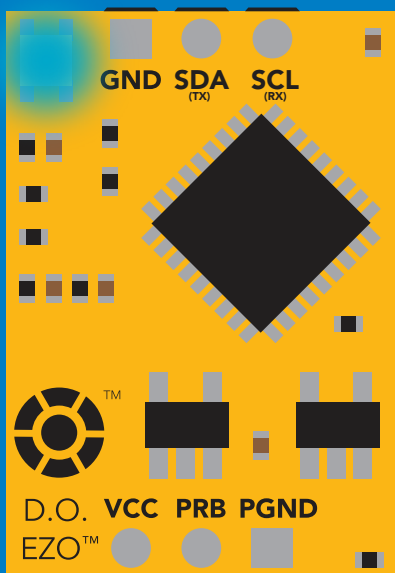
## Response

Factory

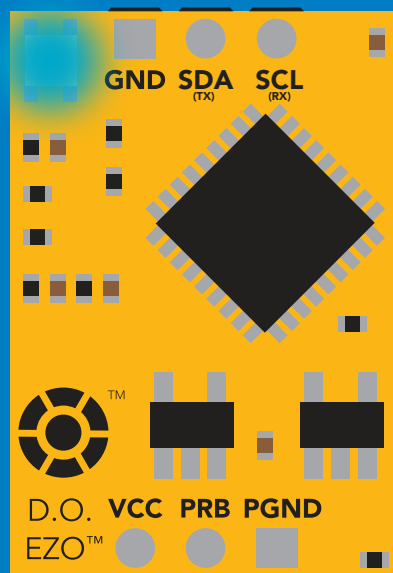
device reboot  
(no response given)

Clears calibration  
LED on  
Response codes enabled

## Factory



(reboot)



# Change to UART mode

## Command syntax

Baud,n switch from I<sup>2</sup>C to UART

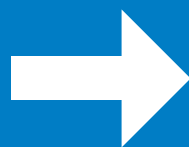
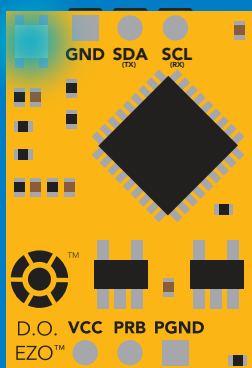
### Example

Baud,9600

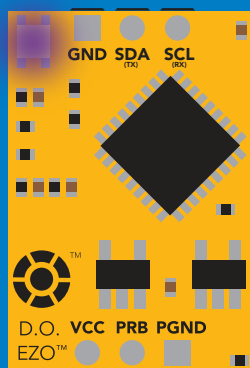
### Response

reboot in UART mode  
(no response given)

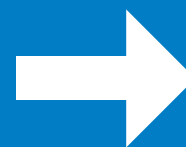
n = [ 300  
1200  
2400  
9600  
19200  
38400  
57600  
115200



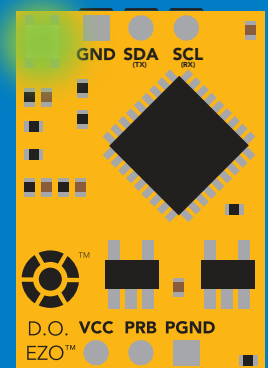
Baud,9600



Changing to  
UART mode



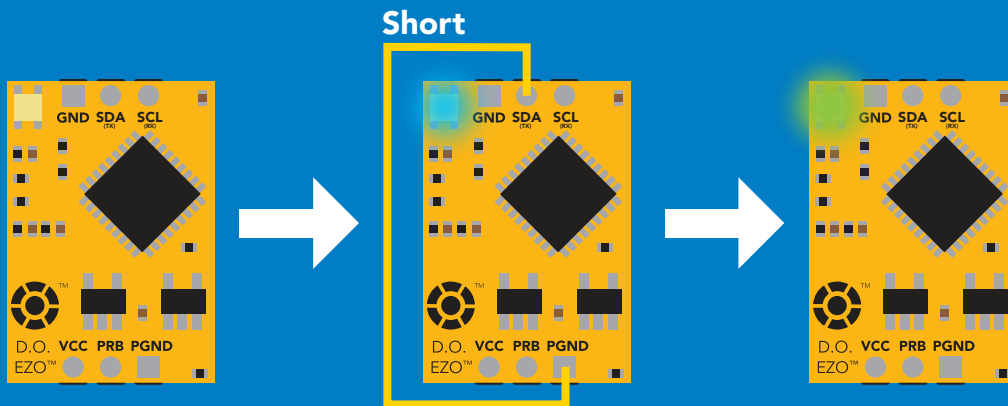
(reboot)



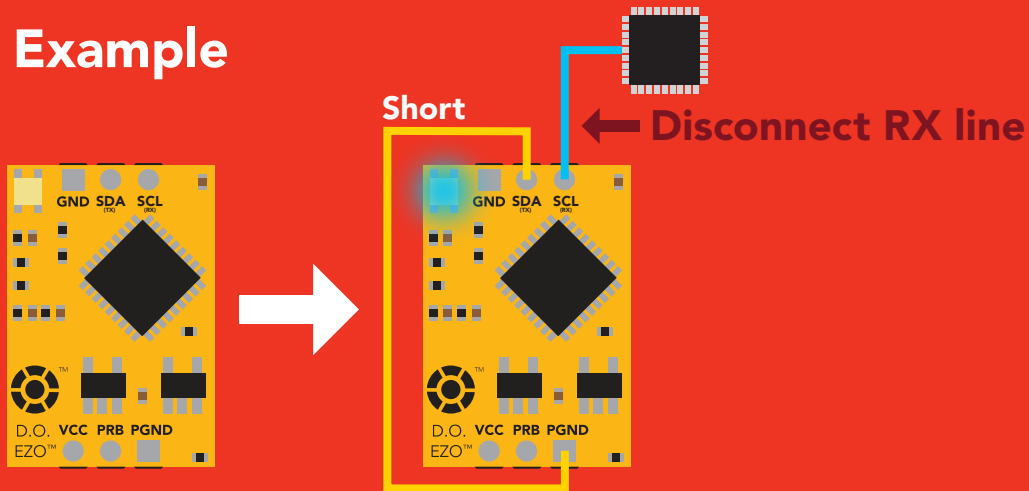
# Manual switching to UART

- Disconnect ground (power off)
- Disconnect TX and RX
- Connect TX to PGND
- Confirm RX is disconnected
- Connect ground (power on)
- Wait for LED to change from Blue to Green
- Disconnect ground (power off)
- Reconnect all data and power

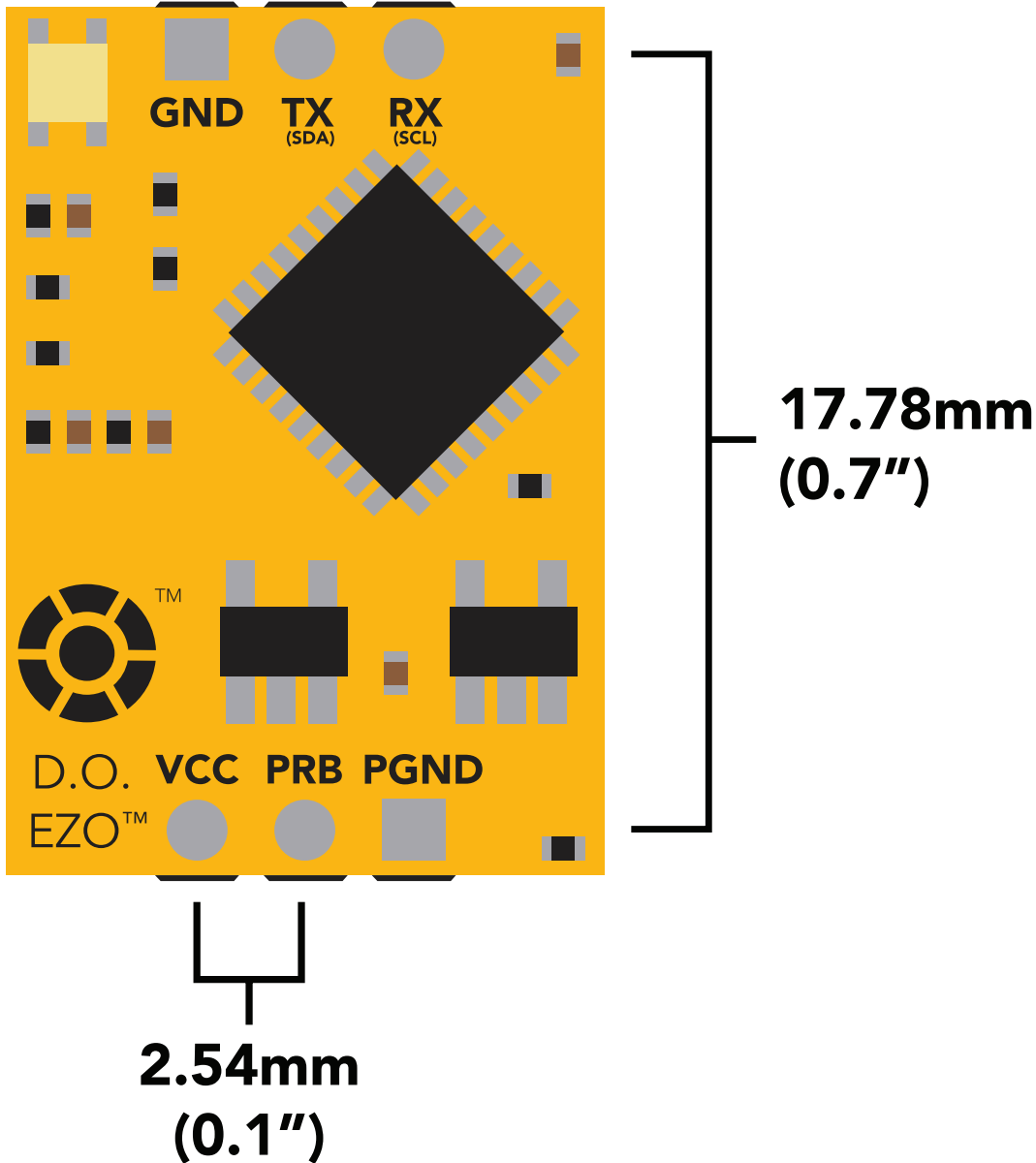
## Example



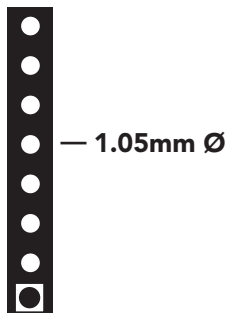
## Wrong Example



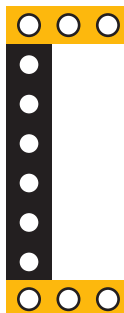
# EZO™ circuit footprint



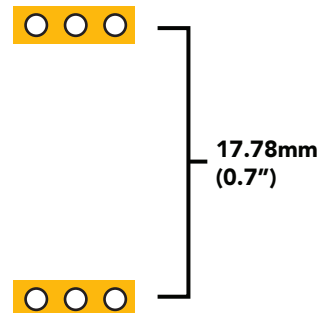
**1** In your CAD software place a 8 position header.



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



**3** Delete the 8 position header. The two 3 position headers are now 17.78mm (0.7") apart from each other.





# Datasheet change log

## Datasheet V 5.5

Revised naming device info on pages 32 & 59.

## Datasheet V 5.4

Revised artwork within datasheet.

## Datasheet V 5.3

Moved Default state to pg 13.

## Datasheet V 5.2

Updated firmware changes on page 70.

## Datasheet V 5.1

Revised response for the sleep command in UART mode on pg 36.

## Datasheet V 5.0

Revised calibration theory on page 9, and added more information on the Export calibration and Import calibration commands.

## Datasheet V 4.9

Corrected temperature compensation typo on pages 26 & 52.

## Datasheet V 4.8

Revised isolation schematic on pg. 10

## Datasheet V 4.7

### **Added new command:**

"RT,n" for Temperature compensation located on pages 26 (UART) & 52 (I<sup>2</sup>C).  
Added firmware information to Firmware update list.

## **Datasheet V 4.6**

Added more information about temperature compensation on pages 26 & 52.

## **Datasheet V 4.5**

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

## **Datasheet V 4.4**

Removed note from certain commands about firmware version.

## **Datasheet V 4.3**

Added information to calibration theory on pg 7.

## **Datasheet V 4.2**

Revised definition of response codes on pg 44.

## **Datasheet V 4.1**

Updated firmware changes on pg. 66.

## **Datasheet V 4.0**

Revised Enable/disable parameters information on pages 29 (UART) & 55 (I<sup>2</sup>C).

## **Datasheet V 3.9**

Revised information on cover page.

## **Datasheet V 3.8**

Update firmware changes on pg. 66.

## **Datasheet V 3.7**

Revised Plock pages to show default value.

# Datasheet change log

## Datasheet V 3.6

### Added new commands:

"Find" pages 21 (UART) & 48 (I<sup>2</sup>C).

"Export/Import calibration" pages 25 (UART) & 51 (I<sup>2</sup>C).

Added new feature to continuous mode "C,n" pg 22.

## Datasheet V 3.5

Added accuracy range on cover page, and revised isolation info on pg. 10.

## Datasheet V 3.4

Added manual switching to UART information on pg. 59.

## Datasheet V 3.3

Updated firmware changes to reflect V1.99 update.

## Datasheet V 3.2

Revised entire datasheet.

# Firmware updates

V1.1 – Initial release (Oct 30, 2014)

- Change output to mg/L, then percentage (was previously percentage, then mg/L).

V1.5 – Baud rate change (Nov 6, 2014)

- Change default baud rate to 9600

V1.6 – I<sup>2</sup>C bug (Dec 1, 2014)

- Fixed I<sup>2</sup>C bug where the circuit may inappropriately respond when other I<sup>2</sup>C devices are connected.

V1.7 – Factory (April 14, 2015)

- Changed "X" command to "Factory"

V1.95 – Plock (March 31, 2016)

- Added protocol lock feature "Plock"

V1.96 – EEPROM (April 26, 2016)

- Fixed bug where EEPROM would get erased if the circuit lost power 900ms into startup.

V1.97 – EEPROM (Oct 10, 2016)

- Fixed bug in the cal clear command, improves how it calculates the DO, adds calibration saving and loading.

V1.98 – EEPROM (Nov 14, 2016)

- Updated firmware for new circuit design.

V1.99 – (Feb 2, 2017)

- Revised "O" command to accept mg.

V2.10 – (April 12, 2017)

- Added "Find" command.
- Added "Export/import" command.
- Modified continuous mode to be able to send readings every "n" seconds.

V2.11 – (Sept 28, 2017)

- Fixed bug where the temperature would default to 0 on startup.

V2.12 – (Dec 19, 2017)

- Improved accuracy of dissolved oxygen equations.

V2.13 – (July 16, 2018)

- Added "RT" command to Temperature compensation.

V2.14 – (June 7, 2019)

- Fixed bug where the output buffer overflows when the cal and cal,0 point are too close together.

# Warranty

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

## The debugging phase

The debugging phase as defined by Atlas Scientific™ is the time period when the EZO™ class Dissolved Oxygen circuit is inserted into a bread board, or shield. If the EZO™ class Dissolved Oxygen circuit is being debugged in a bread board, the bread board must be devoid of other components. If the EZO™ class Dissolved Oxygen circuit is being connected to a microcontroller, the microcontroller must be running code that has been designed to drive the EZO™ class Dissolved Oxygen circuit exclusively and output the EZO™ class Dissolved Oxygen 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 Dissolved Oxygen circuit warranty:**

- **Soldering any part of the EZO™ class Dissolved Oxygen circuit.**
- **Running any code, that does not exclusively drive the EZO™ class Dissolved Oxygen circuit and output its data in a serial string.**
- **Embedding the EZO™ class Dissolved Oxygen 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 Dissolved Oxygen circuit, against the thousands of possible variables that may cause the EZO™ class Dissolved Oxygen 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 Dissolved Oxygen circuits continued operation. This is because that would be equivalent to Atlas Scientific™ taking responsibility over the correct operation of your entire device.