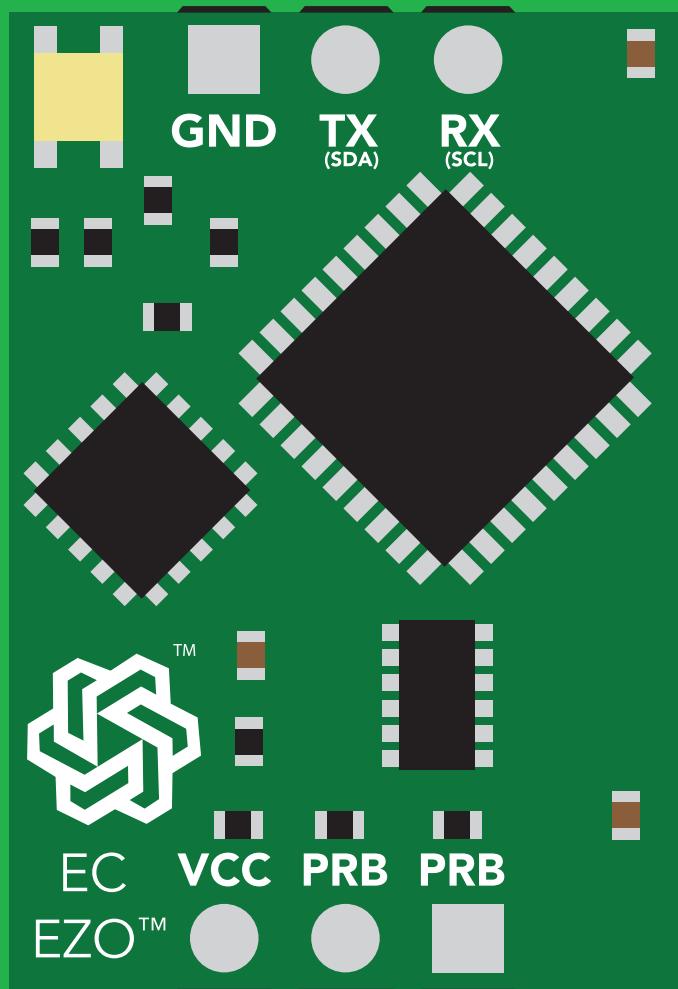


# EZO-EC™

## Embedded Conductivity Circuit

Reads	<b>Conductivity = <math>\mu\text{S}/\text{cm}</math></b> <b>Total dissolved solids = ppm</b> <b>Salinity = PSU (ppt) 0.00 – 42.00</b> <b>Specific gravity (sea water only) = 1.00 – 1.300</b>
Range	<b>0.07 – 500,000+ <math>\mu\text{S}/\text{cm}</math></b>
Accuracy	<b>+/- 2%</b>
Response time	<b>1 reading per sec</b>
Supported probes	<b>K 0.1 – K 10 any brand</b>
Calibration	<b>1 or 2 point</b>
Temp compensation	<b>Yes</b>
Data protocol	<b>UART &amp; I<sup>2</sup>C</b>
Default I <sup>2</sup> C address	<b>100 (0x64)</b>
Operating voltage	<b>3.3V – 5V</b>
Data format	<b>ASCII</b>





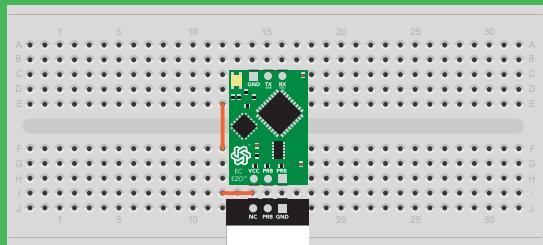
# STOP

**SOLDERING THIS DEVICE VOIDS YOUR WARRANTY.**

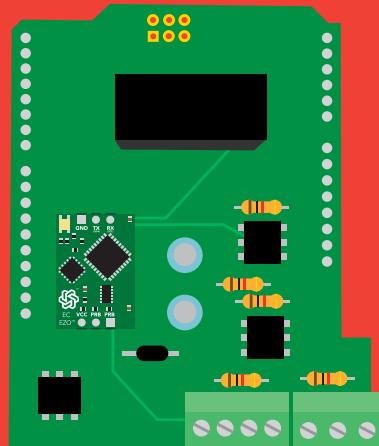
**This is sensitive electronic equipment. Get this device working in a solderless breadboard first. Once this device has been soldered it is no longer covered by our warranty.**

**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

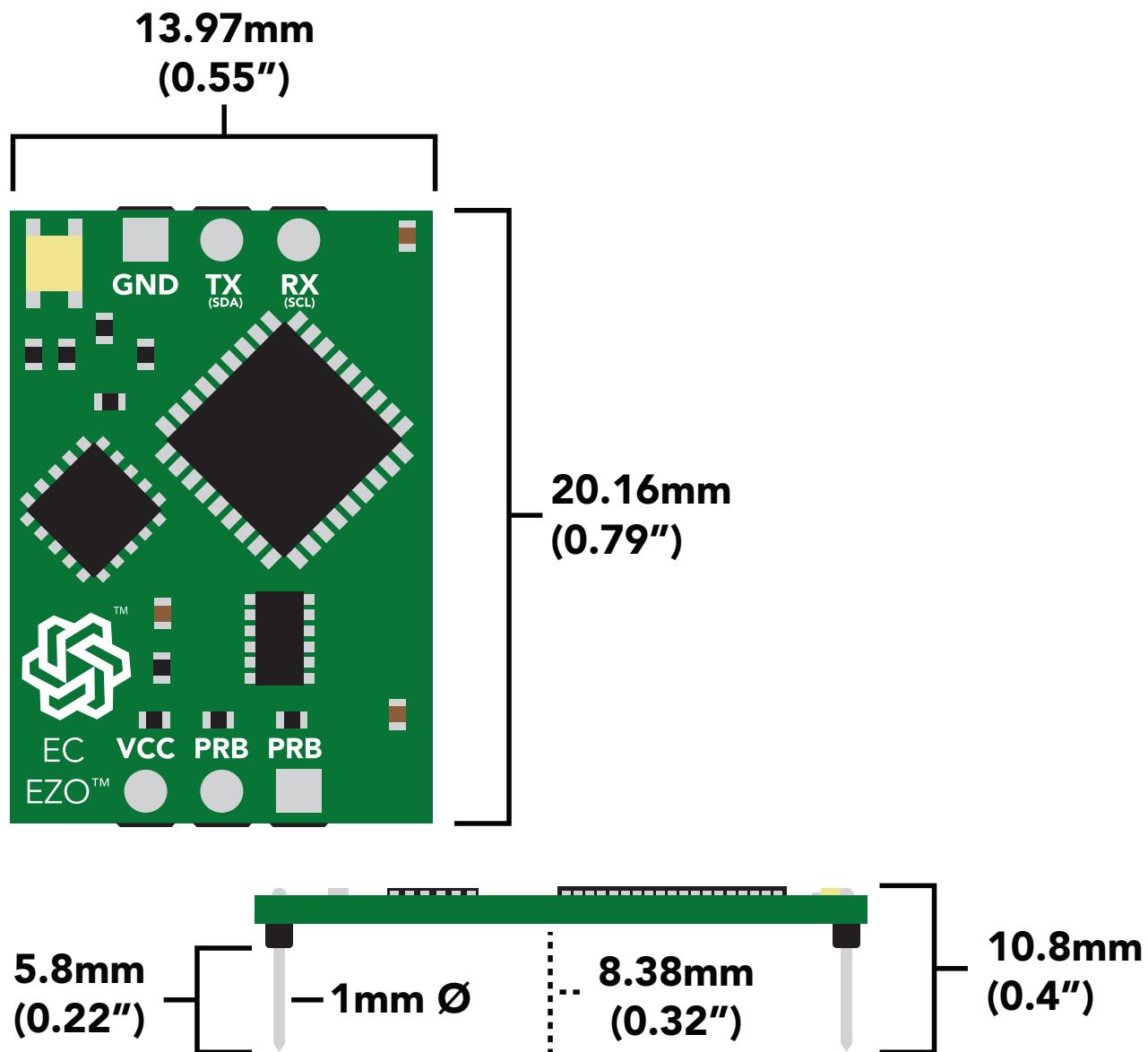
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# EZO™ circuit dimensions



## Power consumption

## Absolute max ratings

	LED	MAX	STANDBY	SLEEP
5V	ON	50 mA	18.14 mA	0.7 mA
	OFF	45 mA	15.64 mA	
3.3V	ON	35 mA	16.85 mA	0.4 mA
	OFF	34 mA	15.85 mA	

Parameter	MIN	TYP	MAX
Storage temperature (EZO™ Conductivity)	-60 °C		150 °C
Operational temperature (EZO™ Conductivity)	-40 °C	25 °C	125 °C
VCC	3.3V	5V	5.5V

# Conductivity probe range

The EZO™ Conductivity circuit is capable of connecting to any two-conductor conductivity probe, ranging from:

**K 0.01**



**K 10**

Atlas Scientific™ has tested three different K value probe types:

**K 0.1**



**K 1.0**



**K 10**



**accurate reading range**

**0.07µS/cm – 50,000µS/cm**

TDS (ppm) 0 – 25,000

Salinity (ppt) 0 – 33

**accurate reading range**

**5µS/cm – 200,000+µS/cm**

TDS (ppm) 2 – 100,000

Salinity (ppt) 0 – 42\*

**\*salinity scale cannot go any higher**

**accurate reading range**

**10µS/cm – 1S/cm**

TDS (ppm) 5 – 500,000

Salinity (ppt) 0 – 42\*

**\*salinity scale cannot go any higher**

Atlas Scientific™ does not know what the accurate reading range would be for conductivity probes, other than the above mentioned values. Determining the accurate reading range of such probes, i.e. **K 2.6**, or **K 0.66**, is the responsibility of the embedded systems engineer.

# Resolution

The EZO™ Conductivity circuit, employs a method of scaling resolution. As the conductivity increases the resolution between readings decreases.

The EZO™ Conductivity circuit will output conductivity readings where the first **4 digits** are valid and the others are set to 0. This excludes conductivity readings that are less than 9.99. In that case, only 3 conductivity digits will be output.

0.07 – 99.99

Resolution = **0.01 $\mu$ S/cm**

100.1 – 999.9

Resolution = **0.1 $\mu$ S/cm**

1,000 – 9,999

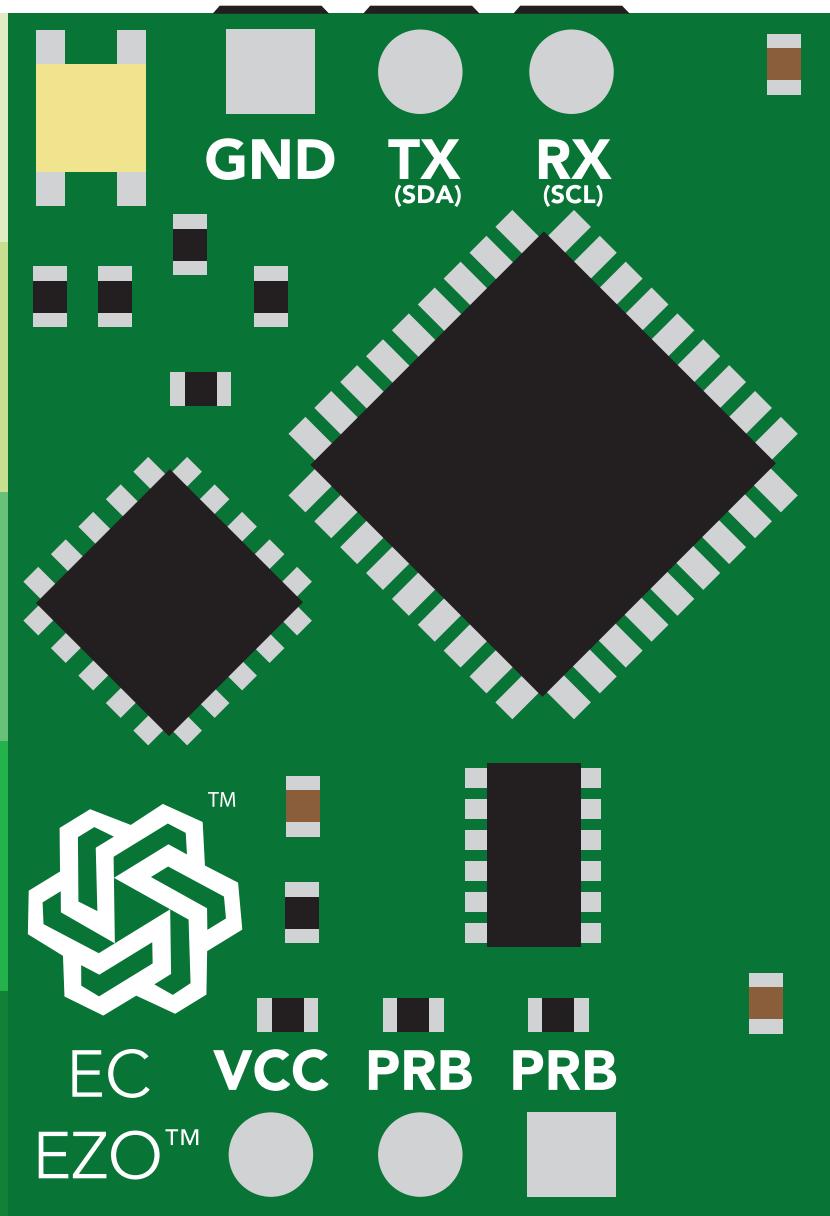
Resolution = **1.0 $\mu$ S/cm**

10,000 – 99,990

Resolution = **10 $\mu$ S/cm**

100,000 – 999,900

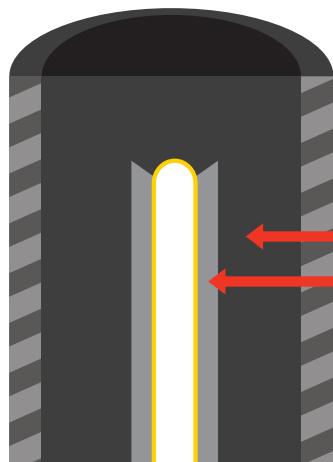
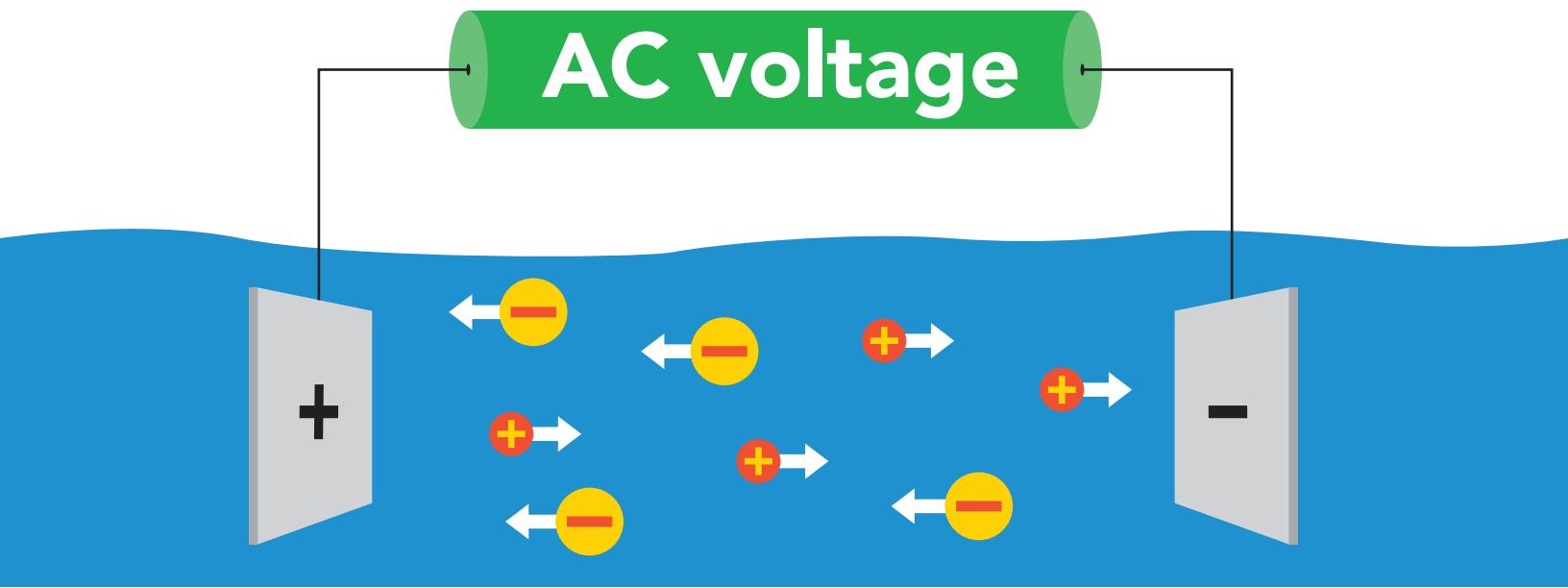
Resolution = **100 $\mu$ S/cm**



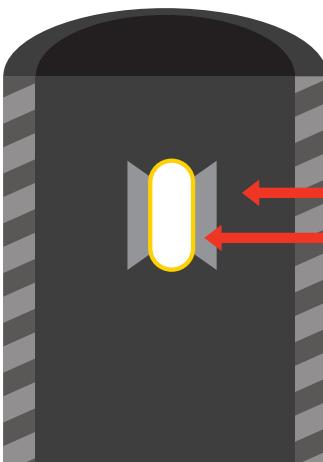
# Operating principle

An E.C. (**electrical conductivity**) probe measures the electrical conductivity in a solution. It is commonly used in hydroponics, aquaculture and freshwater systems to monitor the amount of nutrients, salts or impurities in the water.

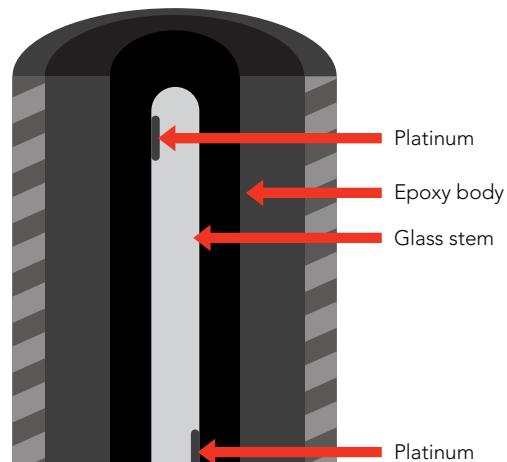
Inside the conductivity probe, two electrodes are positioned opposite from each other, an AC voltage is applied to the electrodes causing cations to move to the negatively charged electrode, while the anions move to the positively electrode. The more free electrolyte the liquid contains, the higher the electrical conductivity.



**K 0.1**  
Graphite electrode



**K 1.0**  
Graphite electrode



**K 10**  
Platinum electrode

# Output units

By default, EZO™ Conductivity circuits with firmware version 2.10 and above will **only output EC**. To enable these parameters see page 35 for UART, and 62 for I<sup>2</sup>C.

The EZO™ Conductivity circuit also has the capability to read:

**Conductivity =  $\mu\text{S}/\text{cm}$**

**Total dissolved solids = ppm**

**Salinity = PSU (ppt) 0.00 – 42.00**

**Specific gravity (sea water only) = 1.00 – 1.300**

These parameters must be individually enabled within the device. See page 35 to enable each parameter in UART mode, and on page 62 for I<sup>2</sup>C mode.

Once these parameters have been enabled, output will be a CSV string.

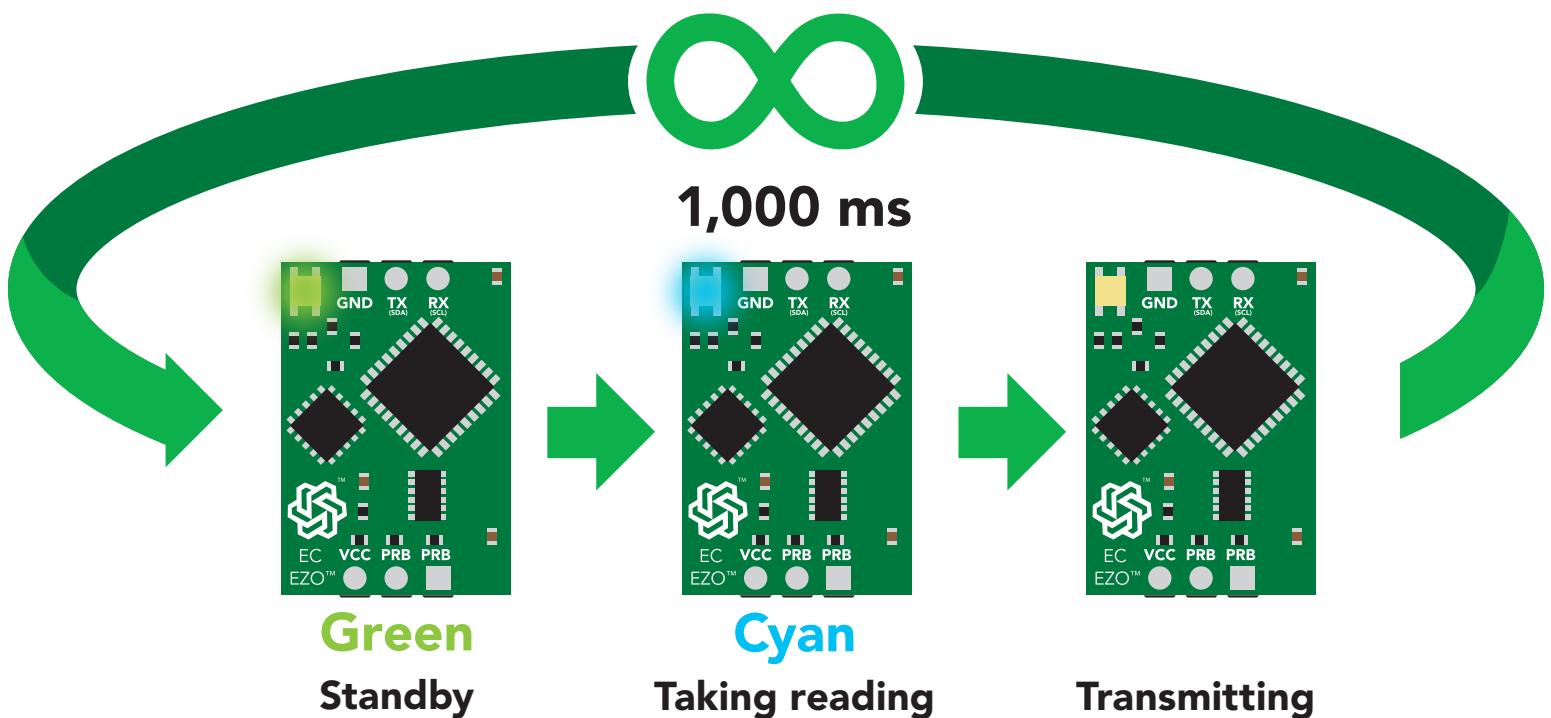
## Example

EC,TDS,SAL,SG

## Default LED blink pattern

This is the LED pattern for Continuous Mode (default state)

This can only happen when the device is in **UART** mode.



# Power and data isolation

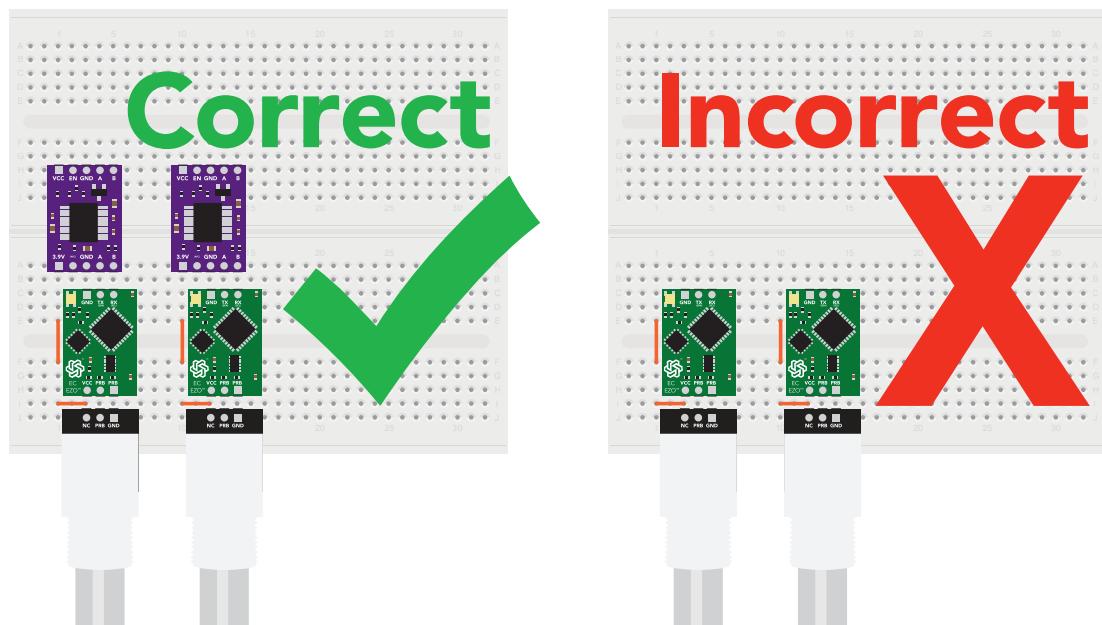
The Atlas Scientific EZO™ Conductivity circuit is a very sensitive device. This sensitivity is what gives the Conductivity circuit its accuracy. This also means that the Conductivity circuit is capable of reading micro-voltages that are bleeding into the water from unnatural sources such as pumps, solenoid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

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



When reading from two EZO™ Conductivity circuits, it is **strongly recommended** that they are electrically isolated from each other.

Basic EZO™  
Inline Voltage Isolator



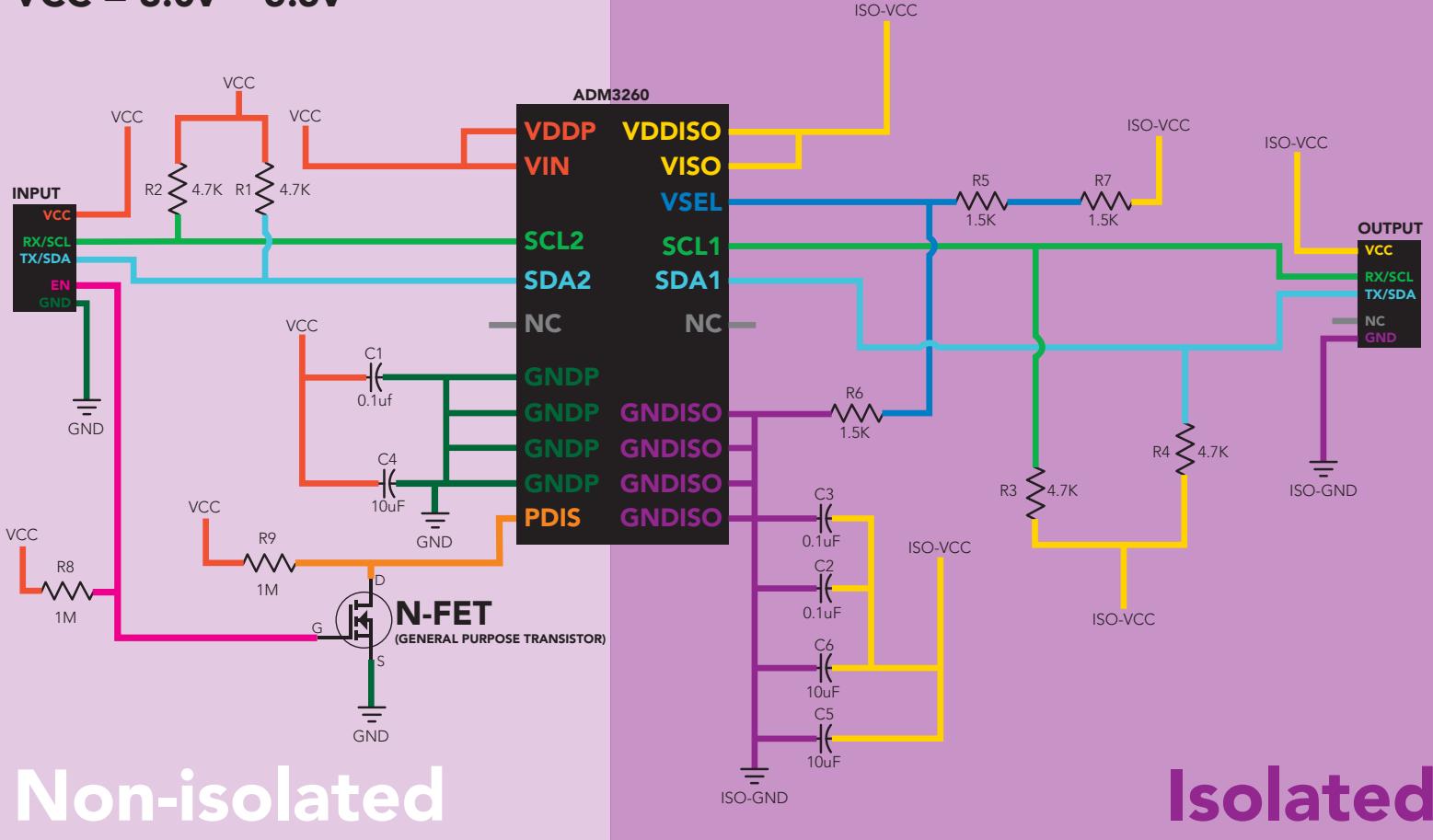
**Without isolation, Conductivity readings will effect each other.**

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  $4.7\text{k}\Omega$  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.

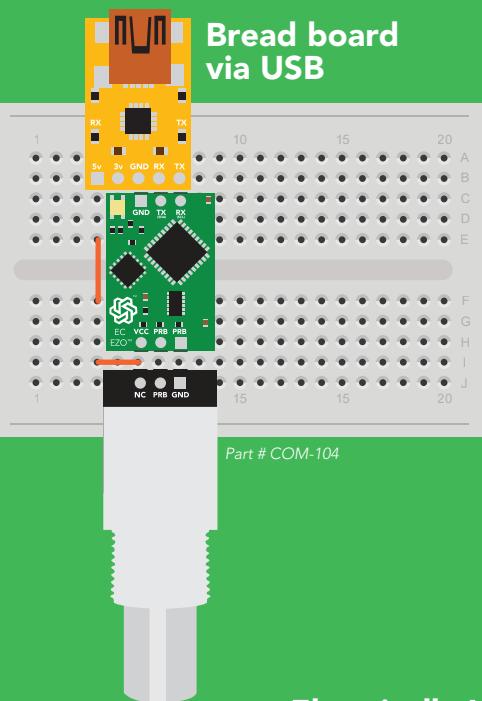
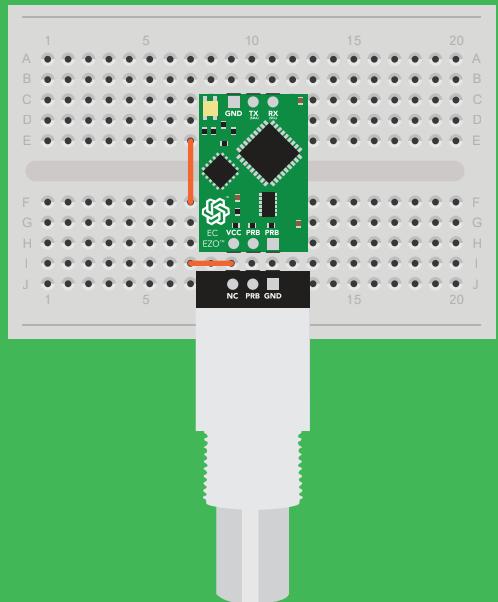
**Isolated ground is different from non-isolated ground, these two lines should not be connected together.**

**VCC = 3.0v – 5.5v**

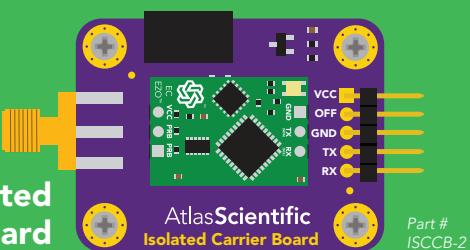
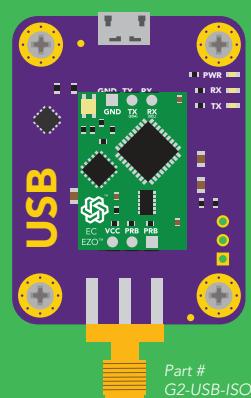
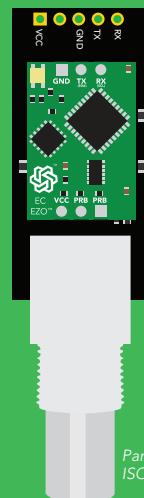


# ✓ Correct wiring

## Bread board



Carrier board      USB carrier board

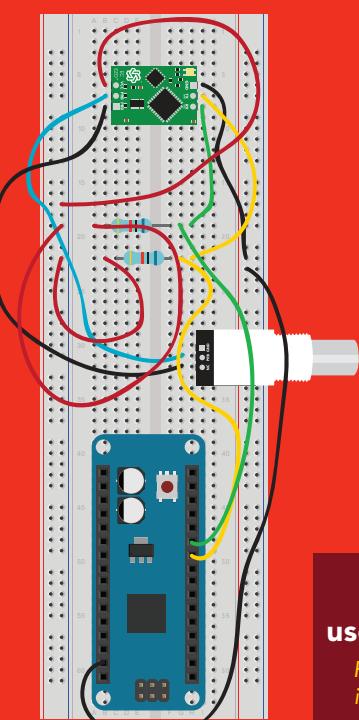


# ✗ Incorrect wiring

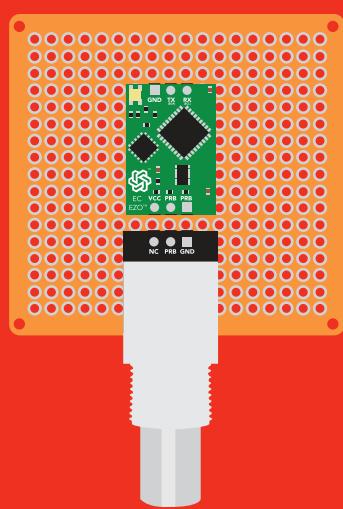
## Extended leads



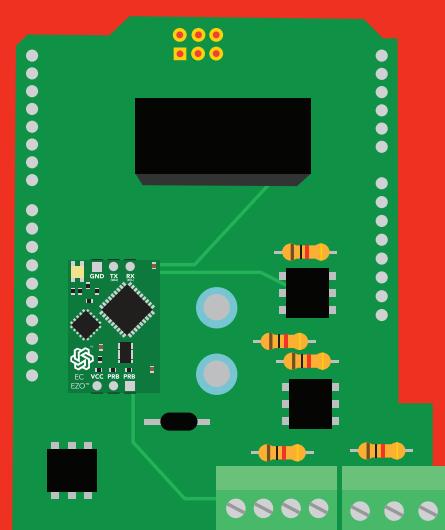
## Sloppy setup



## Perfboards or Protoboards



## \*Embedded into your device



**NEVER**  
use Perfboards or Protoboards  
*Flux residue and shorting wires make it very hard to get accurate readings.*

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

# Calibration theory

## Simple calibration

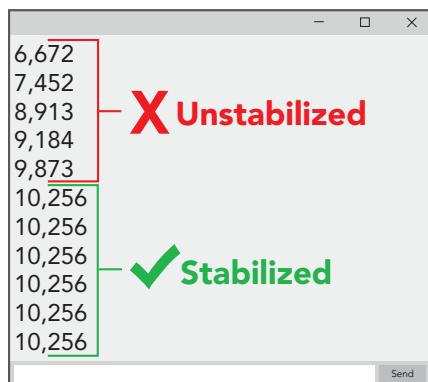
# UART mode

## Continuous readings

# Advanced calibration

I<sup>2</sup>C mode

Continuously request readings



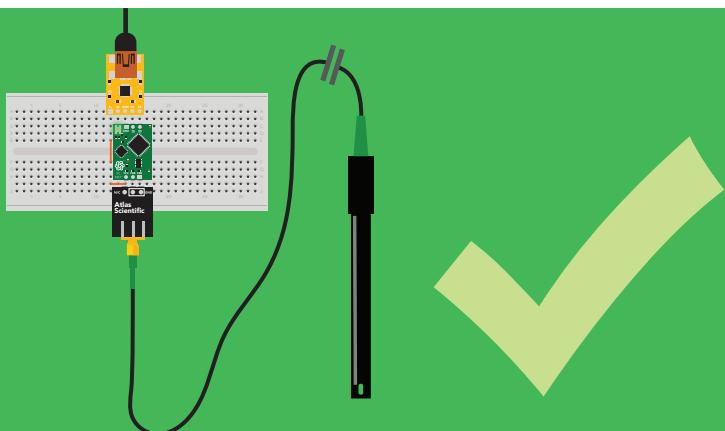
The most important part of calibration is watching the readings during the calibration process.

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

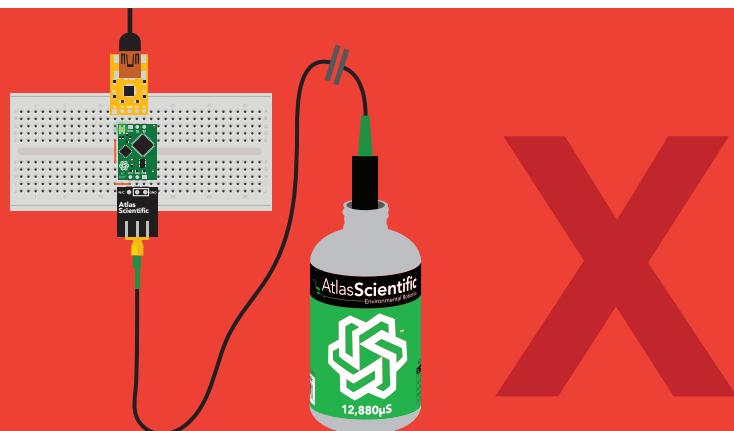
Switching the device to I<sup>2</sup>C mode after calibration **will not** affect the stored calibration. If the device must be calibrated in I<sup>2</sup>C mode be sure to **continuously request readings** so you can see the output from the probe.

## 1. Pre-calibration setup

Connect the dry conductivity probe and take continuous readings.



A simple hardware configuration with dry probe.



**Not yet! Do not put the probe into calibration solution.**

## 2. Set probe type

If your probe  $\neq$  K 1.0 (default), then set the probe type by using the "**K,n**" command. (where n = K value of your probe) for more information, see page [33](#) or [60](#).

### 3. Dry calibration

Perform a dry calibration using the command "**Cal,dry**" Even though you may see reading of 0.00 before issuing the "**Cal,dry**" command, it is still a necessary part of calibration.

00.00 → "Cal,dry" → 0.00 ✓ Correct

17.00 → "Cal,dry" → 0.00 ✓ Also correct

### 4. Single point or Two point calibration

No calibration



Single point calibration



Two point calibration



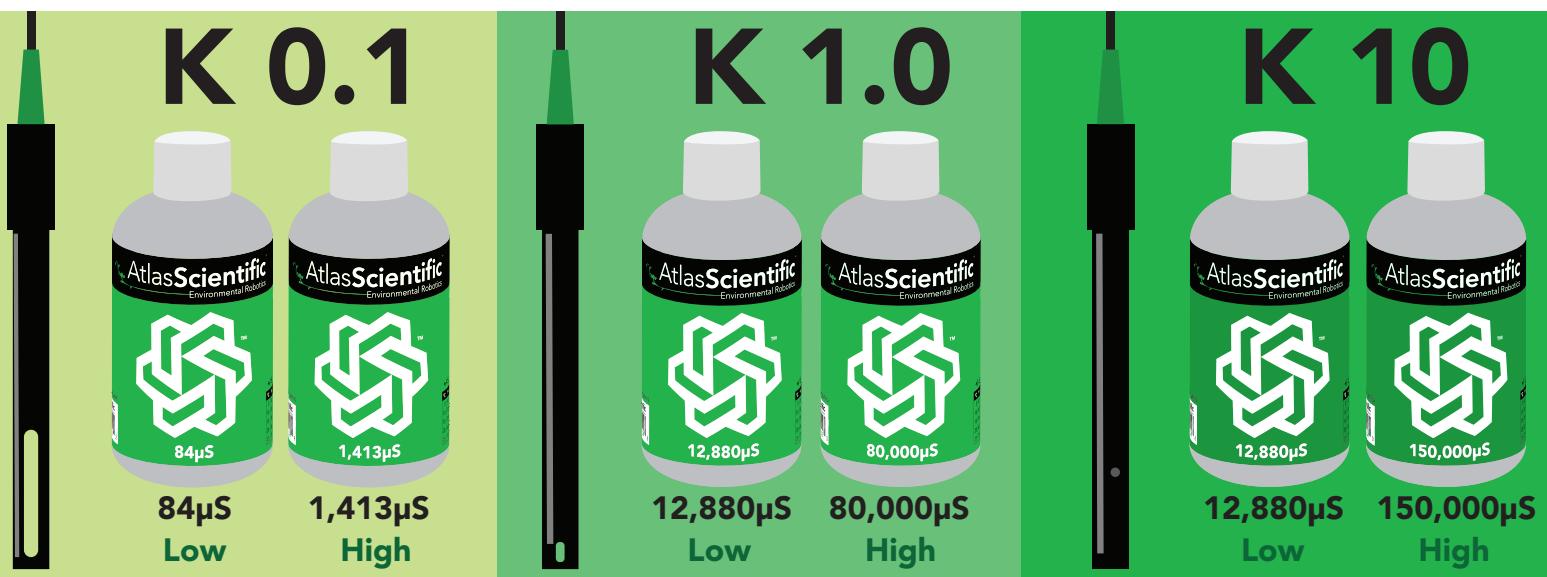
Low point

High point

Narrow range of accuracy

Wide range of accuracy

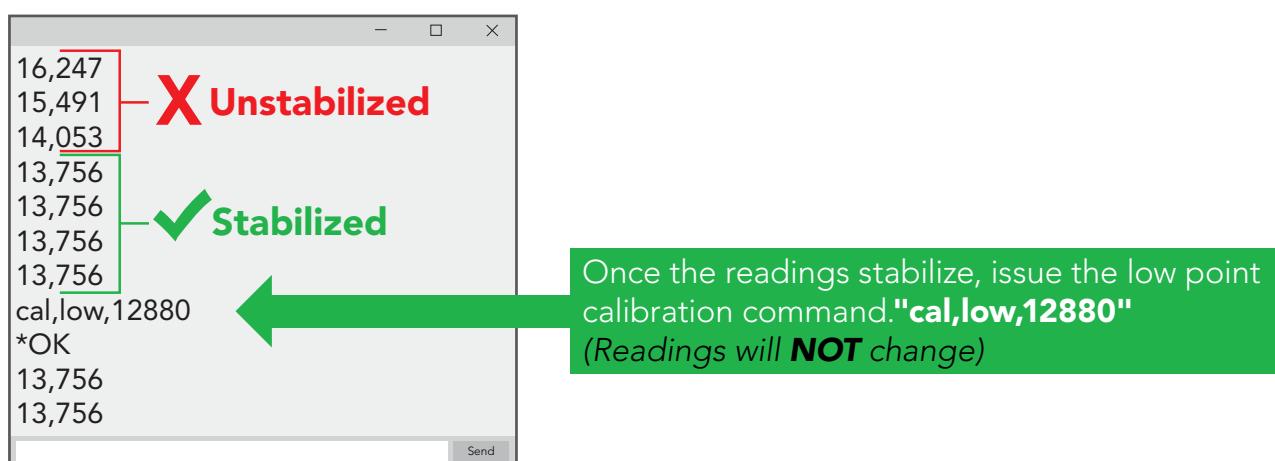
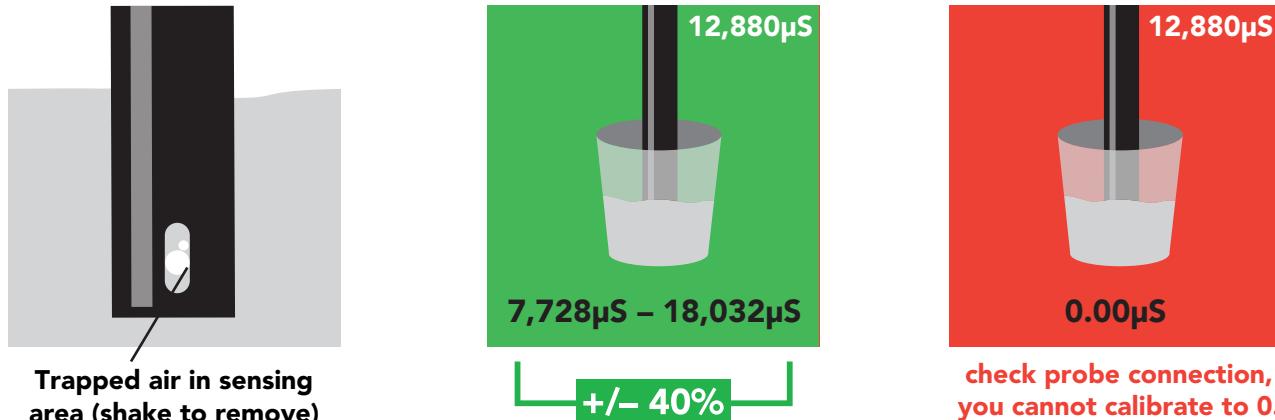
### Recommended calibration points



When calibrating, Atlas Scientific recommends using the above µS values. However, you can use any µS values you want.

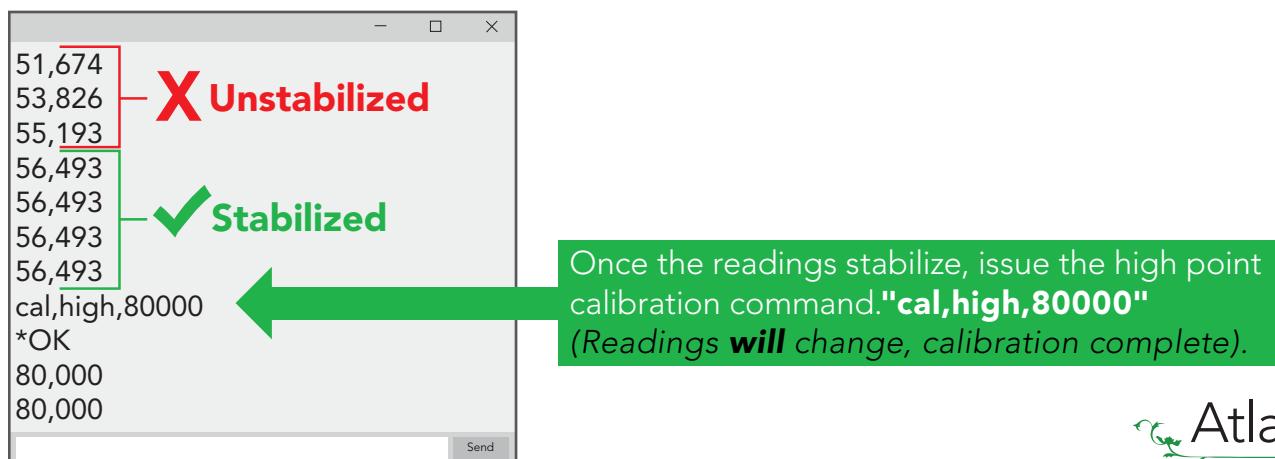
## Two point calibration - low point

Pour a small amount of the low point calibration solution into a cup. Shake the probe to make sure you do not have trapped air bubbles in the sensing area. You should see readings that are off by **1 – 40%** from the stated value of the calibration solution. Wait for readings to stabilize (small movement from one reading to the next is normal).



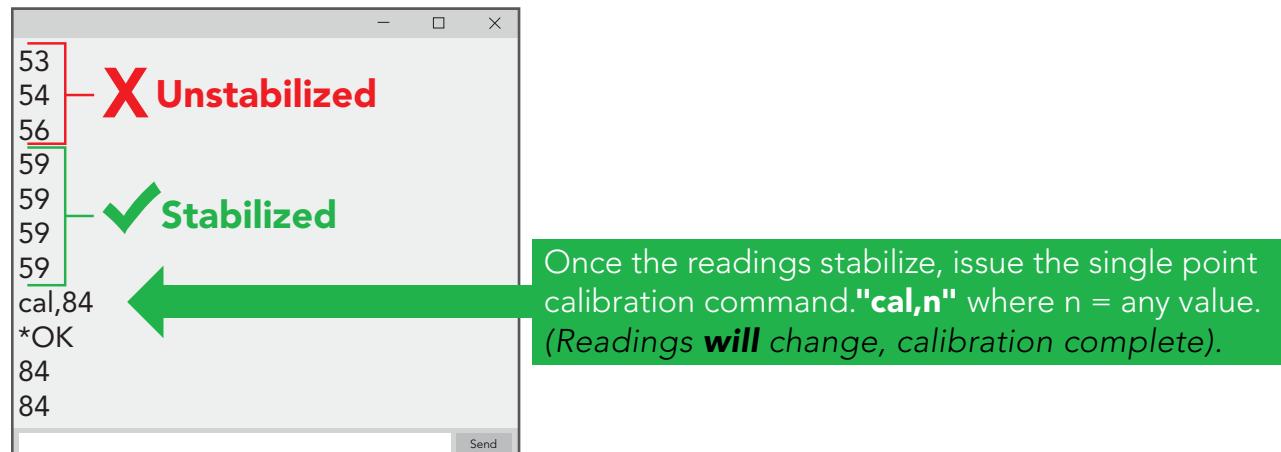
## Two point calibration - high point

- Rinse off the probe before calibrating to the high point.
- Pour a small amount of the high point calibration solution into a cup.
- Shake the probe to remove trapped air.
- Readings may be off by +/- 40%
- Wait for readings to stabilize.



# Single point calibration

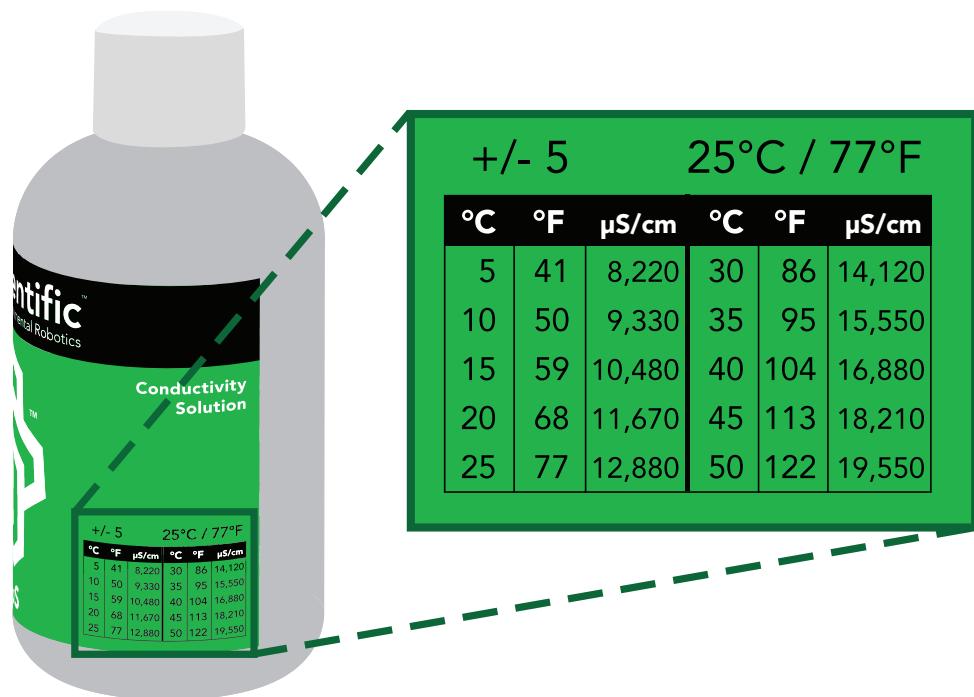
- Pour a small amount of calibration solution into a cup ( $\mu\text{S}$  value of your choice).
- Shake the probe to remove trapped air.
- Readings may be off by +/- 40%
- Wait for readings to stabilize.



## Temperature compensation during calibration

Temperature has a significant effect on conductivity readings. The EZO™ Conductivity circuit has its temperature compensation set to 25° C as the default. **At no point should you change the default temperature compensation during calibration.**

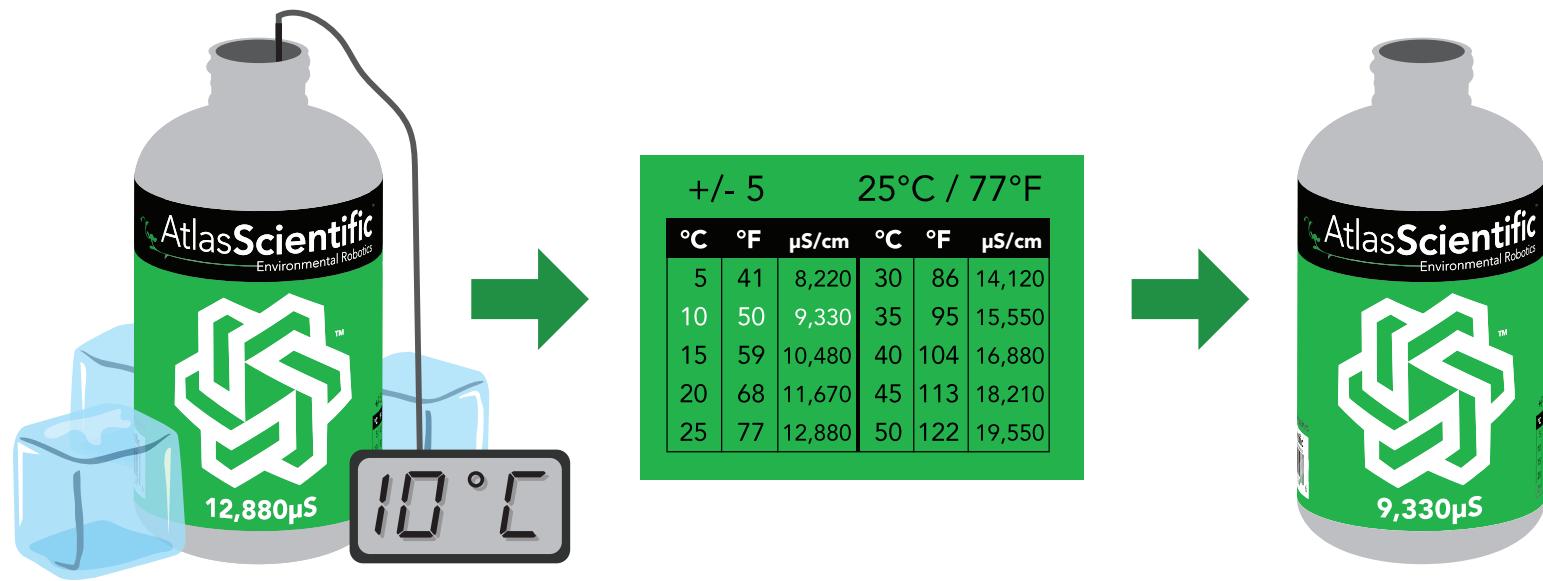
If the solution is +/- 5° C (or more), refer to the chart on the bottle, and calibrate to that value.



# Temperature compensation example

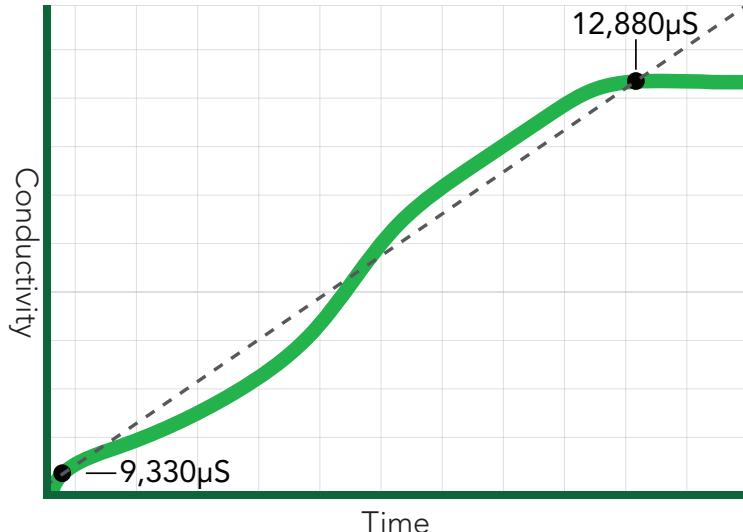
For this example, we brought the temperature of the solution down to 10° C.

Referring to chart on the bottle, you can see the value you should calibrate to is **9,330µS**.



Over time, the readings will normalize as the solution warms to 25° C.

See pages **34** or **61** for more information.



# Default state

# UART mode

Baud

9,600

Readings

continuous

Units

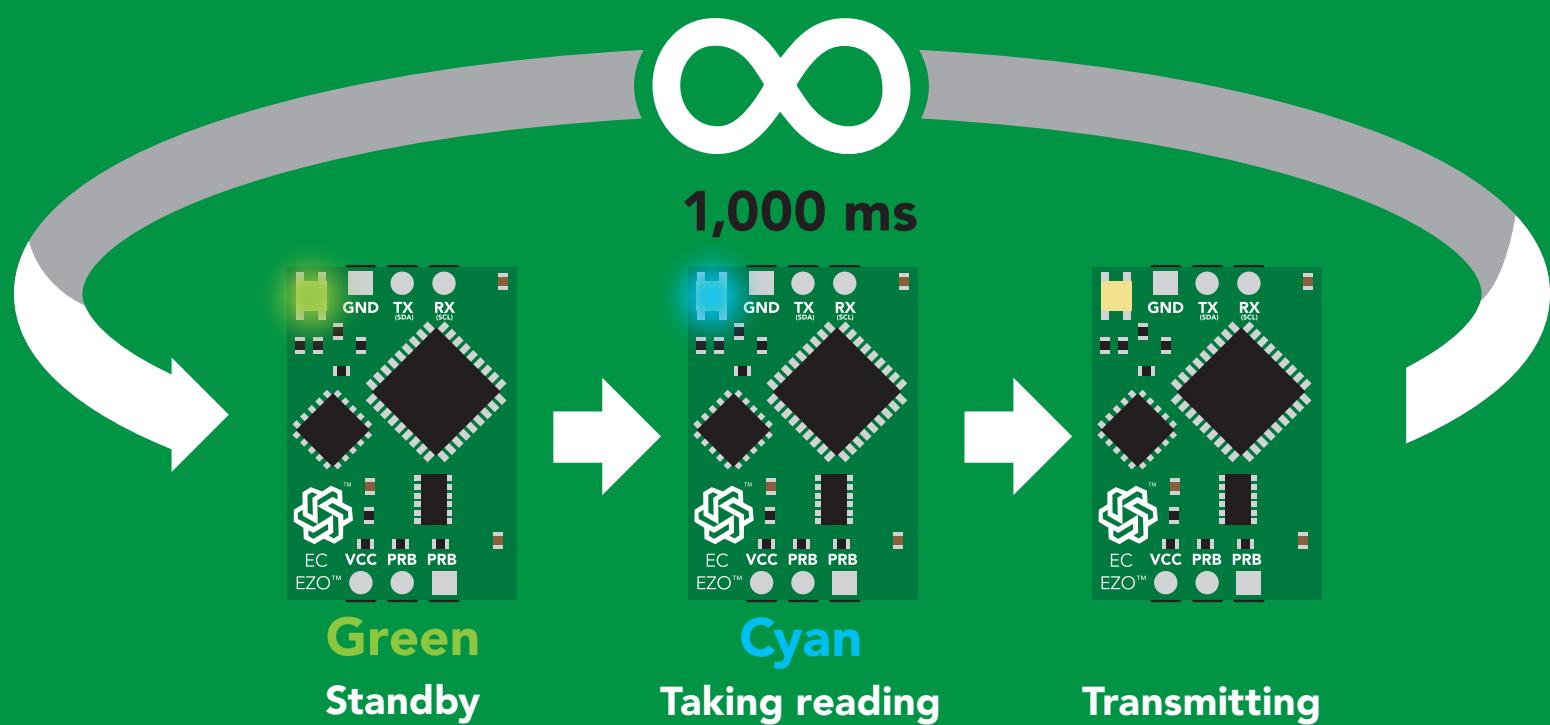
µS/cm

Speed

1 reading per second

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  
Sleep mode  
Temperature compensation

# UART mode

8 data bits      no parity  
1 stop bit      no flow control

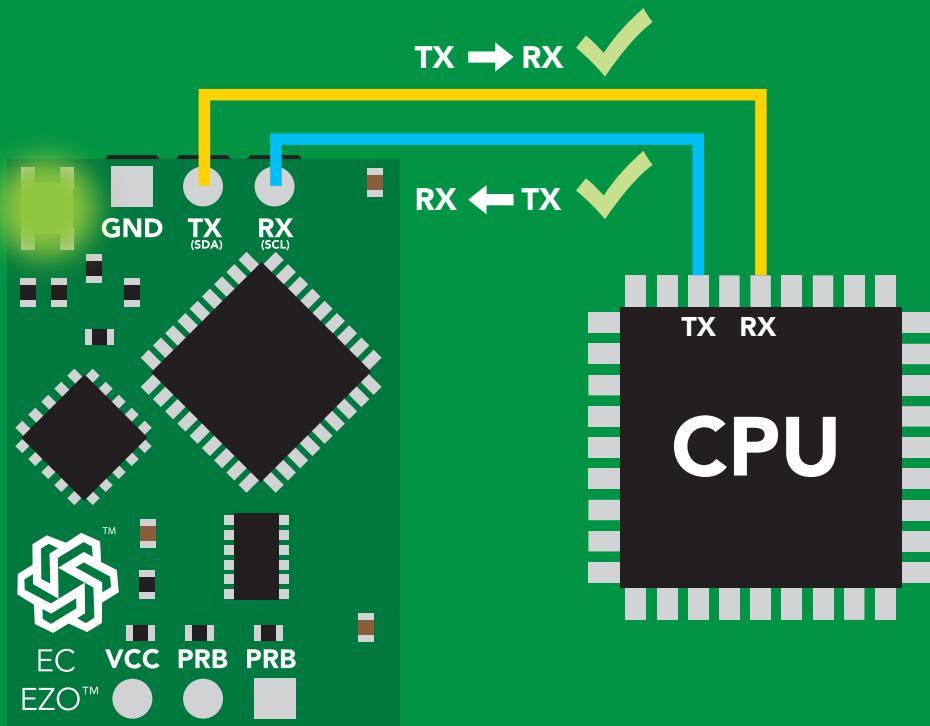
Baud 300  
1,200  
2,400  
**9,600 default**  
19,200  
38,400  
57,600  
115,200

**RX** Data in

**TX** Data out

**Vcc** 3.3V – 5.5V

0V  0V



## Data format

### Reading

Conductivity =  $\mu\text{S}/\text{cm}$

Total dissolved solids = ppm

Salinity = PSU (ppt) 0.00 – 42.00

Specific gravity (sea water only) = 1.00 – 1.300

Units EC,TDS,SAL,SG

Encoding ASCII

Format string

### Terminator

carriage return

### Data type

floating point

### Decimal places

3

### Smallest string

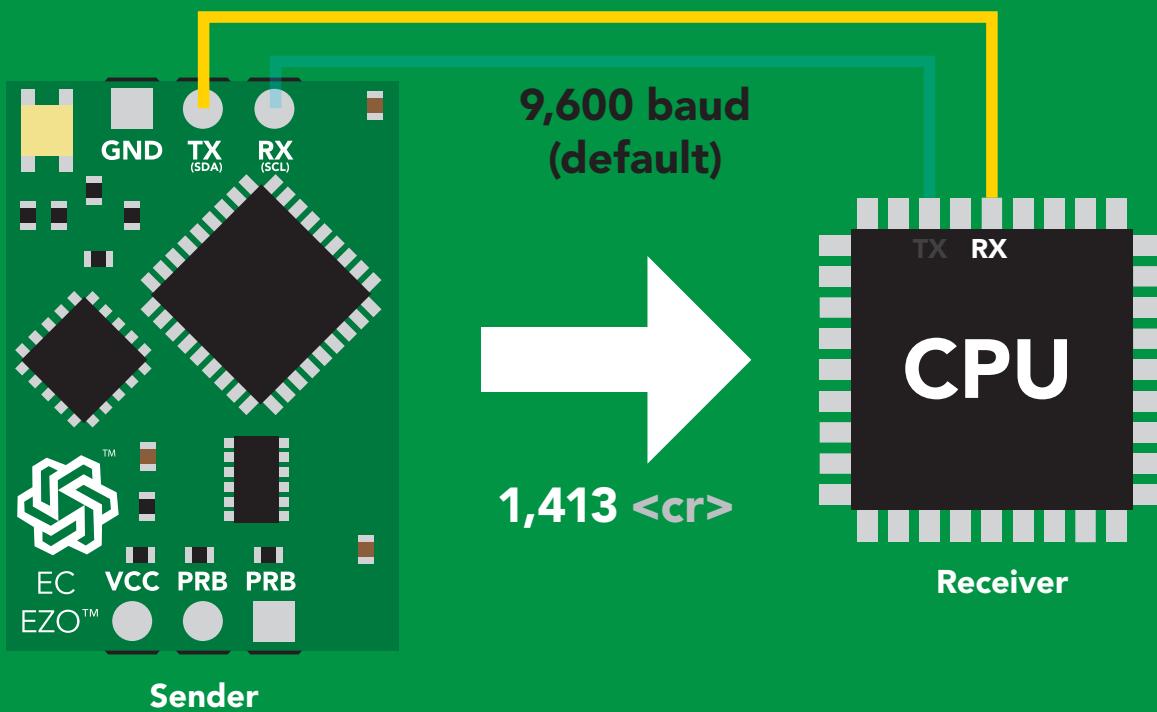
3 characters

### Largest string

40 characters

# Receiving data from device

2 parts



## Advanced

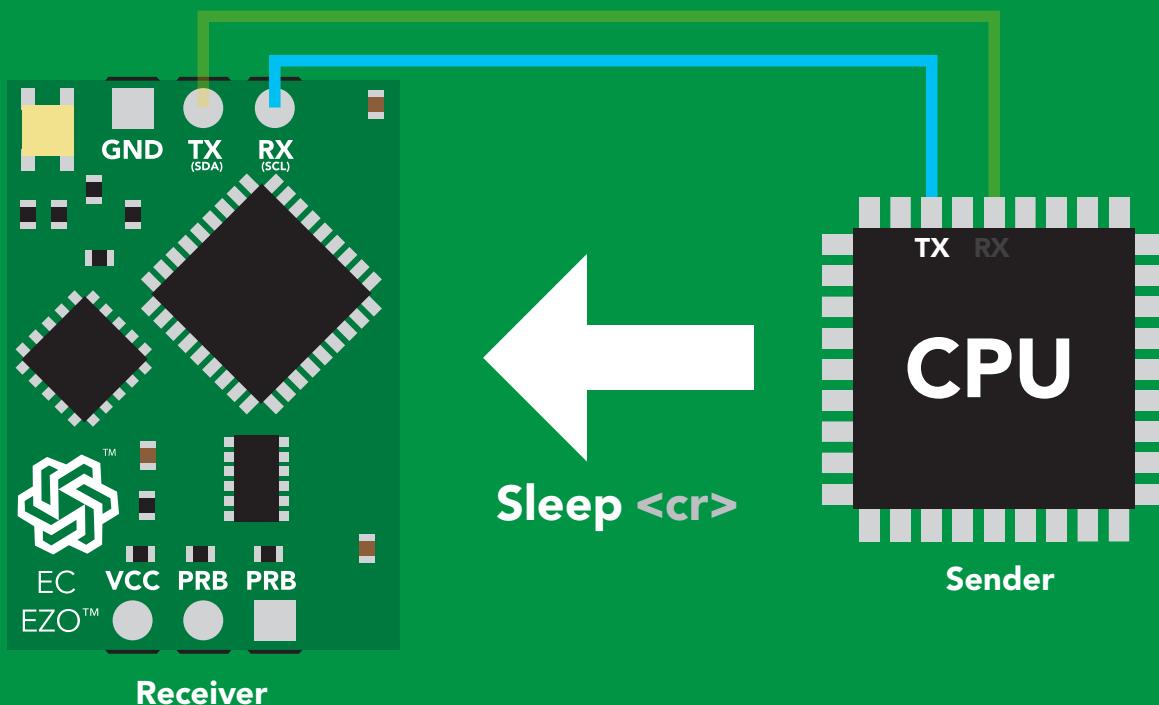
ASCII: 1 , 4 1 3 <cr>

Hex: 31 2C 34 31 33 0D

Dec: 49 44 52 49 51 13

# Sending commands to device

2 parts



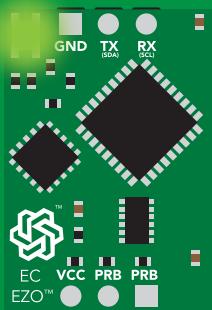
## Advanced

ASCII: S I e e p <cr>

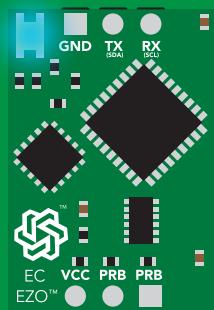
Hex: 53 6C 65 65 70 0D

Dec: 83 108 101 101 112 13

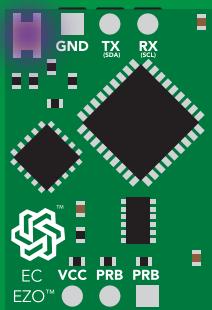
# LED color definition



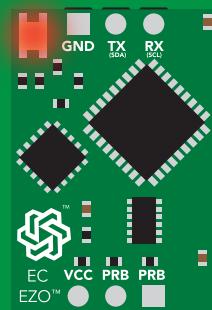
**Green**  
UART standby



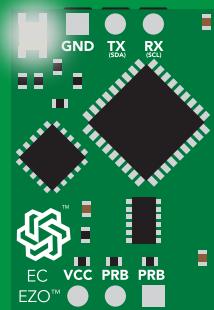
**Cyan**  
Taking reading



**Purple**  
Changing baud rate



**Red**  
Command not understood



**White**  
Find

<b>5V</b>	LED ON <b>+2.5 mA</b>
<b>3.3V</b>	<b>+1 mA</b>

# UART mode

## command quick reference

All commands are ASCII strings or single ASCII characters.

Command	Function	Default state
Baud	change baud rate	pg. 41 9,600
C	enable/disable continuous reading	pg. 27 enabled
Cal	performs calibration	pg. 29 n/a
Export	export calibration	pg. 31 n/a
Factory	enable factory reset	pg. 43 n/a
Find	finds device with blinking white LED	pg. 26 n/a
i	device information	pg. 37 n/a
I2C	change to I <sup>2</sup> C mode	pg. 44 not set
Import	import calibration	pg. 32 n/a
K	Set probe type	pg. 33 K 1.0
L	enable/disable LED	pg. 25 enabled
Name	set/show name of device	pg. 36 not set
O	enable/disable parameters	pg. 35 all enabled
Plock	enable/disable protocol lock	pg. 42 disabled
R	returns a single reading	pg. 28 n/a
Sleep	enter sleep mode/low power	pg. 40 n/a
Status	retrieve status information	pg. 39 enable
T	temperature compensation	pg. 34 25°C
TDS	change the TDS conversion factor	pg. 30 n/a
*OK	enable/disable response codes	pg. 38 enable

# LED control

## Command syntax

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

L,0 <cr> LED off

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

## Example

L,1 <cr>

\*OK <cr>

L,0 <cr>

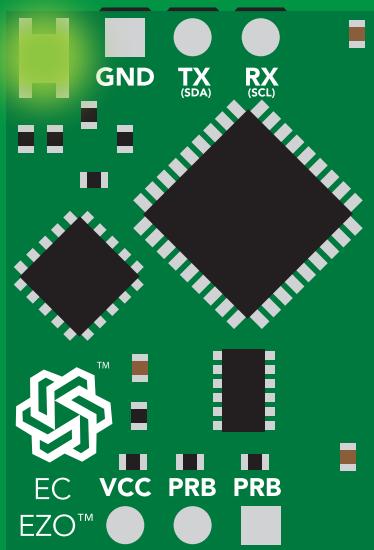
\*OK <cr>

L,? <cr>

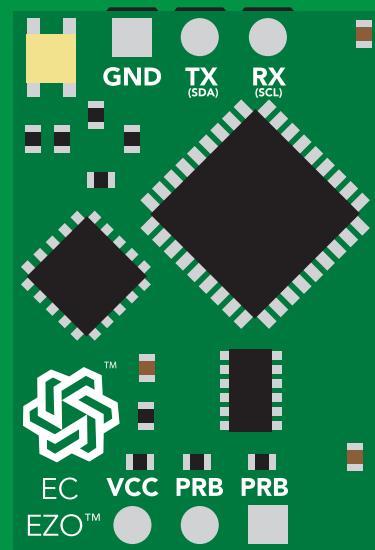
?L,1 <cr> or ?L,0 <cr>

\*OK <cr>

## Response



L,1



L,0

# Find

## Command syntax

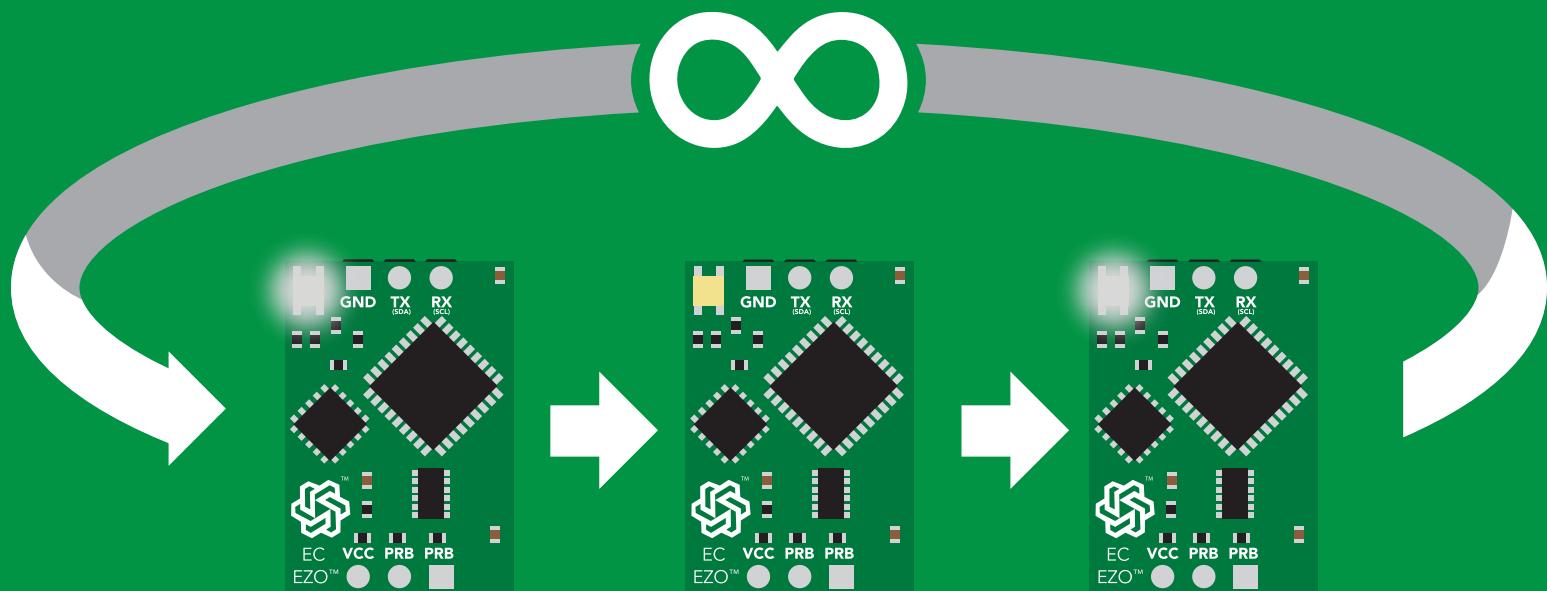
This command will disable continuous mode  
Send any character or command to terminate find.

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> EC,TDS,SAL,SG (1 sec) <cr> EC,TDS,SAL,SG (2 sec) <cr> EC,TDS,SAL,SG (3 sec) <cr>
C,30 <cr>	*OK <cr> EC,TDS,SAL,SG (30 sec) <cr> EC,TDS,SAL,SG (60 sec) <cr> EC,TDS,SAL,SG (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

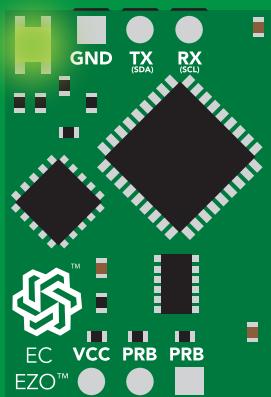
R <cr> takes single reading

### Example Response

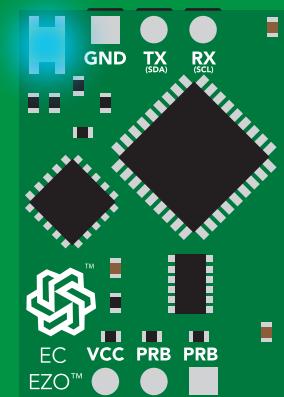
R <cr>

1,413 <cr>

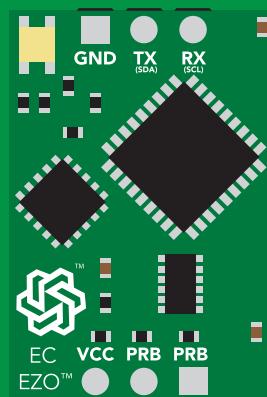
\*OK <cr>



Green  
Standby



Cyan  
Taking reading



Transmitting



# Calibration

## Command syntax

Dry calibration must always be done first!

Cal,dry	<cr>	<b>dry calibration</b>
Cal,n	<cr>	<b>single point calibration, where n = any value</b>
Cal,low,n	<cr>	<b>low end calibration, where n = any value</b>
Cal,high,n	<cr>	<b>high end calibration, where n = any value</b>
Cal,clear	<cr>	<b>delete calibration data</b>
Cal,?	<cr>	<b>device calibrated?</b>

## Example

## Response

Cal,dry <cr>	*OK <cr>
Cal,84 <cr>	*OK <cr>
Cal,low,12880 <cr>	*OK <cr>
Cal,high,80000 <cr>	*OK <cr>
Cal,clear <cr>	*OK <cr>
Cal,? <cr>	?CAL,0 <cr> or ?CAL,1 <cr> or ?CAL,2 one point two point *OK <cr>

### One point calibration:

Step 1. "cal,dry"

Step 2. "cal,n"

**Calibration complete!**

### Two point calibration:

Step 1 "cal,dry"

Step 2 "cal,low,n"

Step 3 "cal,high.n"

**Calibration complete!**

# Changing the TDS (ppm) conversion factor

## Command syntax

There are several different conversion factors used to read TDS(ppm). For some applications, it may be necessary to use a conversion factor other than the default value of 0.54

**TDS,n <cr>** set custom conversion factor, n = any value between 0.01 – 1.00  
**TDS,? <cr>** conversion factor being used

## Example

**TDS,? <cr>**

## Response

?TDS,0.54 <cr>  
\*OK <cr>

**R <cr>**

EC      TDS  
↓      ↓  
100,54 <cr>  
\*OK <cr>

**TDS,0.46 <cr>**

\*OK <cr>

**R <cr>**

EC      TDS  
↓      ↓  
100,460 <cr>  
\*OK <cr>

## Common conversion factors

NaCl    0.47 – 0.50  
KCL     0.50 - 0.57  
"442"   0.65 – 0.85

## Formula

EC x conversion factor = TDS

# 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

Export,? <cr>

## Response

10,120 <cr>

### Response breakdown

10, 120

# of strings to export

# of bytes to export

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>

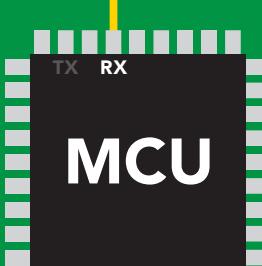
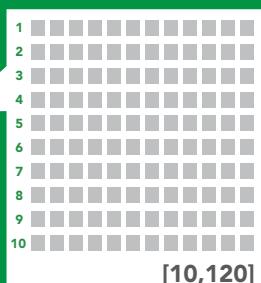
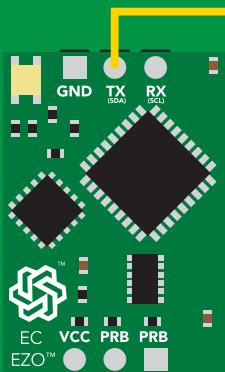
6F 6C 20 67 75 79 <cr> (10 of 10)

Export <cr>

\*DONE

Disabling \*OK simplifies this process

Export <cr>



\*DONE

# 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

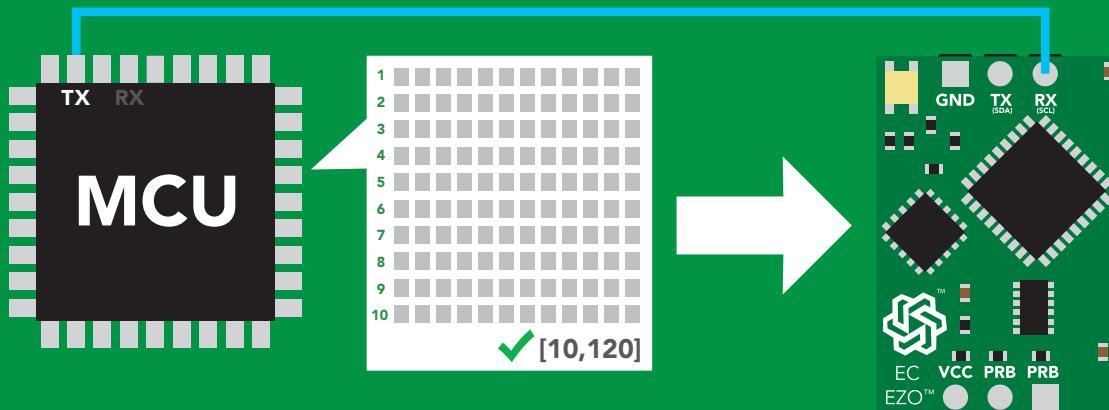
\*OK <cr>

\*OK <cr>

⋮

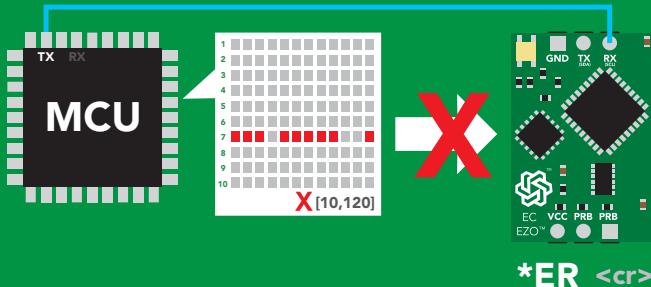
\*OK <cr>

**Import,n <cr>**



\*OK <cr>

system will reboot



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

\*ER <cr>

# Setting the probe type

## Command syntax

K 1.0 is the default value

**K,n <cr>** n = any value; floating point in ASCII

**K,? <cr>** probe K value?

### Example

**K,10 <cr>**

### Response

**\*OK <cr>**

**K,? <cr>**

**?K,10 <cr>**

**\*OK <cr>**



**K 0.1**



**K 1.0**



**K 10**

# Temperature compensation

## Command syntax

Default temperature = 25°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

T,19.5 <cr>

## Response

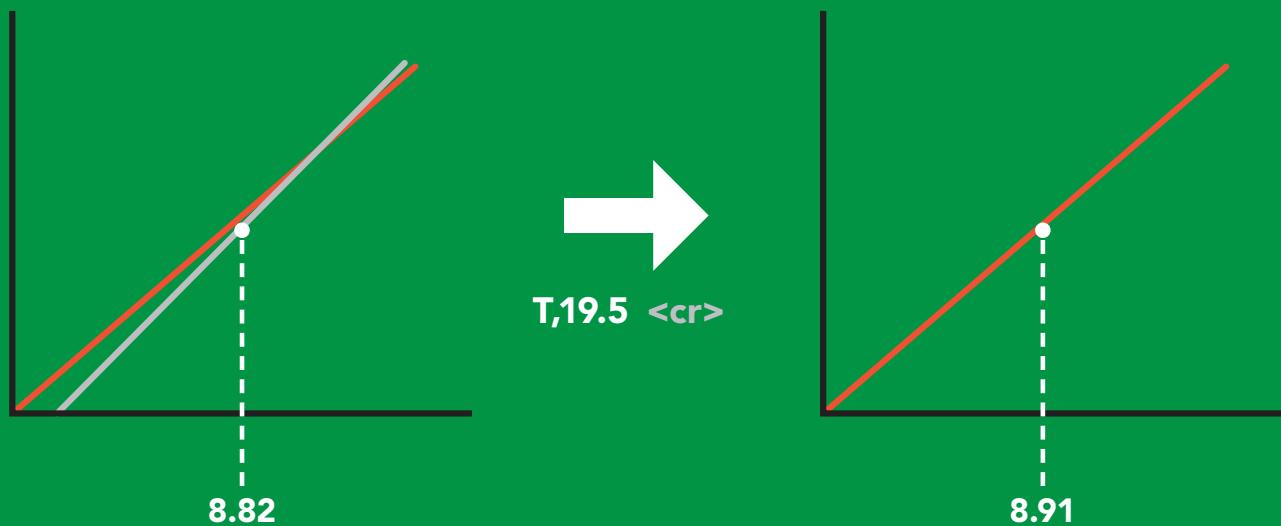
\*OK <cr>

RT,19.5 <cr>

\*OK <cr>  
8.91 <cr>

T,? <cr>

?T,19.5 <cr>  
\*OK <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,EC,1 / O,EC,0 <cr>

### Response

\*OK <cr> enable / disable conductivity

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

\*OK <cr> enable / disable total dissolved solids

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

\*OK <cr> enable / disable salinity

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

\*OK <cr> enable / disable specific gravity

O,? <cr>

? ,O,EC,TDS,S,SG <cr> if all are enabled

### Parameters

EC conductivity

TDS total dissolved solids

S salinity

SG specific gravity

### 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

Name,n <cr> set name

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

Name,? <cr> show name

Do not use spaces in the name

Up to 16 ASCII characters

## Example

Name,zzt <cr>

\*OK <cr>

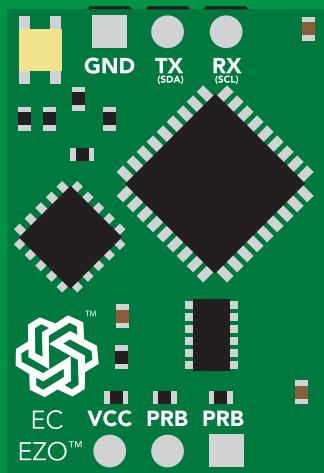
Name,? <cr>

?Name,zzt <cr>

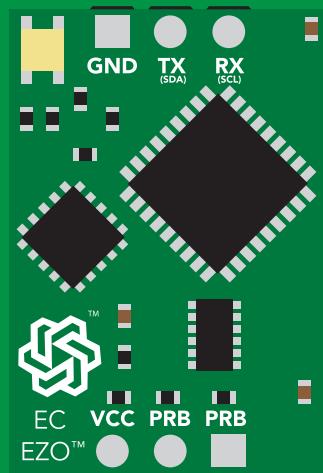
\*OK <cr>

## Response

Name,zzt



Name,?



\*OK <cr>

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

# Device information

## Command syntax

**i <cr> device information**

### Example      Response

**i <cr>**

**?i,EC,2.10 <cr>  
\*OK <cr>**

### Response breakdown

**?i, EC, 2.10**

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>

1,413 <cr>  
\*OK <cr>

\*OK,0 <cr>

**no response, \*OK disabled**

R <cr>

1,413 <cr> \*OK disabled

\*OK,? <cr>

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

## Other response codes

\*ER unknown command  
\*OV over volt (VCC>=5.5V)  
\*UV under volt (VCC<=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      Response

Status <cr>

?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

**Sleep <cr>**

### Response

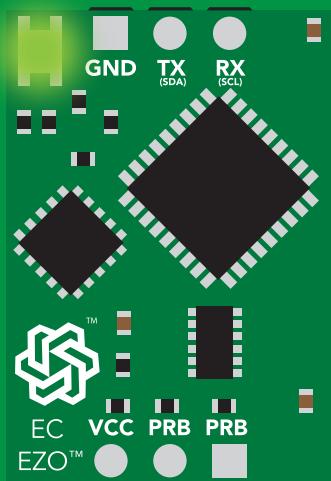
**\*OK <cr>**  
**\*SL <cr>**

### Any command

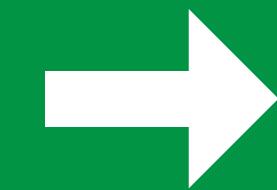
**\*WA <cr> wakes up device**

	STANDBY	SLEEP
<b>5V</b>	<b>18.14 mA</b>	<b>0.7 mA</b>

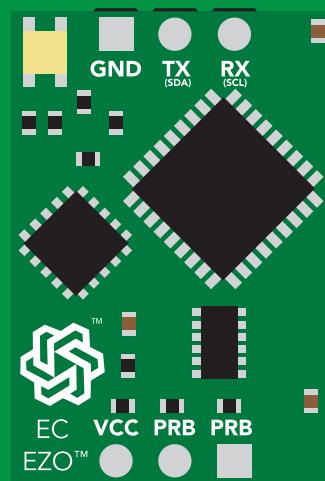
<b>3.3V</b>	<b>16.85 mA</b>	<b>0.4 mA</b>
-------------	-----------------	---------------



**Standby**  
**18.14 mA**



**Sleep <cr>**



**Sleep**  
**0.7 mA**

# Change baud rate

## Command syntax

Baud,n <cr> change baud rate

### Example

Baud,38400 <cr>

### Response

\*OK <cr>

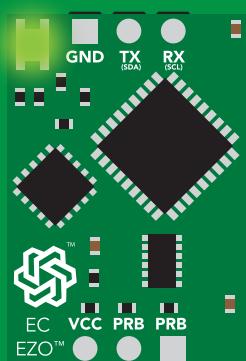
### Example

Baud,? <cr>

?Baud,38400 <cr>

\*OK <cr>

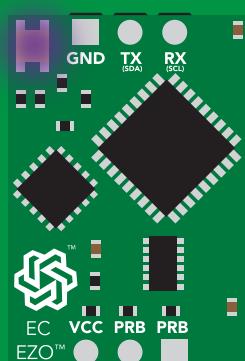
n = [ 300  
1200  
2400  
**9600 default**  
19200  
38400  
57600  
115200 ]



Standby



Baud,38400 <cr>

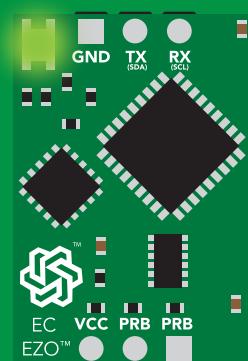


Changing  
baud rate

\*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

Plock,1 <cr>

\*OK <cr>

Plock,0 <cr>

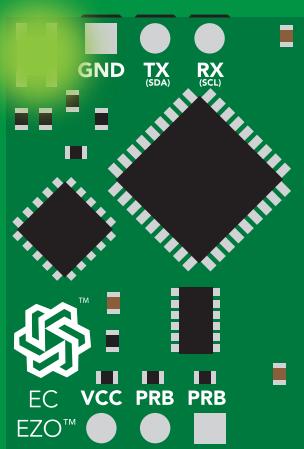
\*OK <cr>

Plock,? <cr>

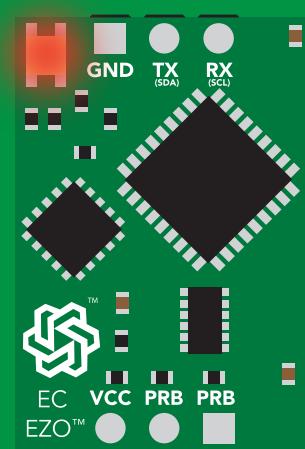
?Plock,1 <cr> or ?Plock,0 <cr>

## Response

Plock,1



I²C,100

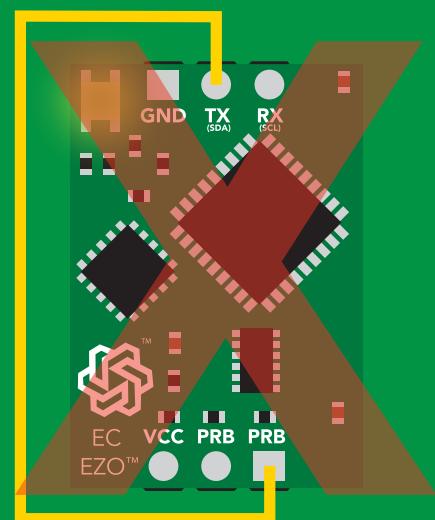


\*OK <cr>

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

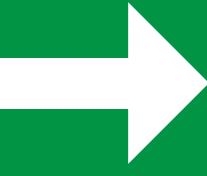
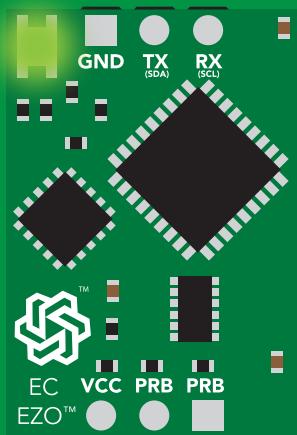
Factory <cr> enable factory reset

## Example Response

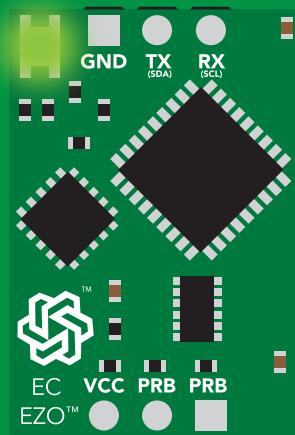
Factory <cr>

\*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 100 (0x64)

I<sup>2</sup>C,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

I<sup>2</sup>C,100 <cr>

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

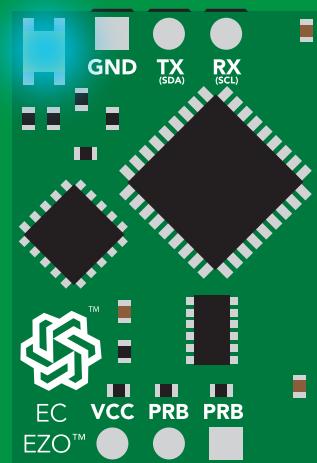
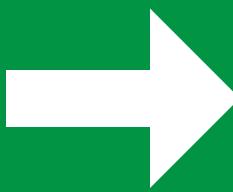
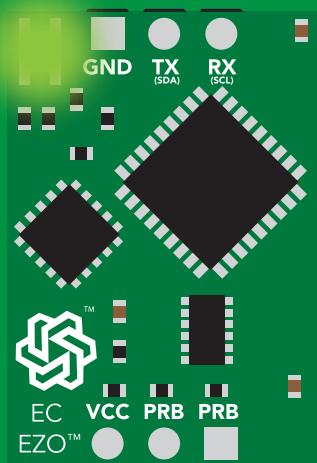
## Wrong example

I<sup>2</sup>C,139 <cr> n ≠ 127

## Response

\*ER <cr>

I<sup>2</sup>C,100



Green  
\*OK <cr>

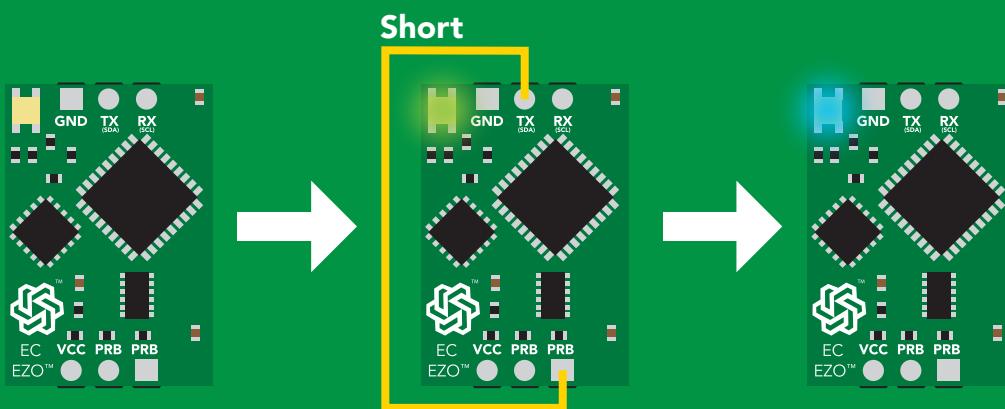
Blue  
now in I<sup>2</sup>C mode

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

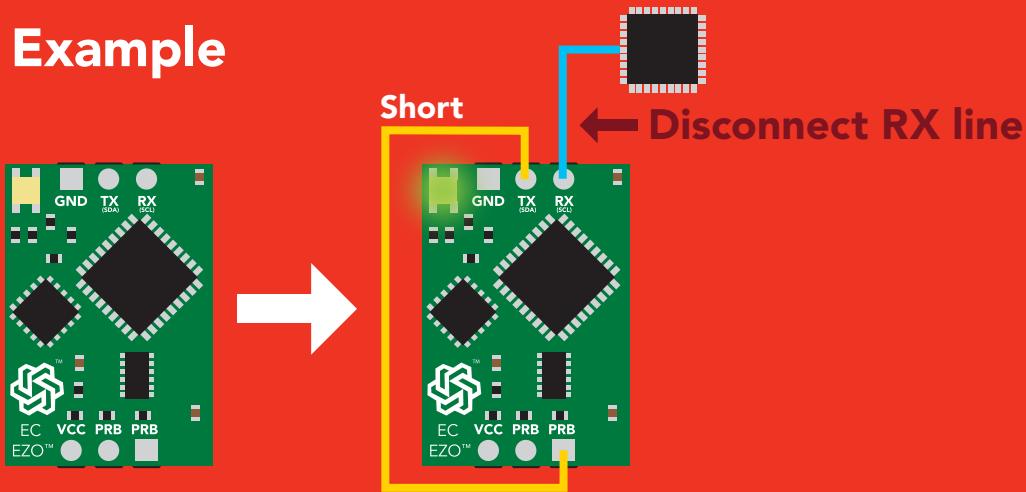
- Disconnect ground (power off)
- Disconnect TX and RX
- Connect TX to the right PRB
- Confirm RX is disconnected
- Connect ground (power on)
- Wait for LED to change from Green to Blue
- Disconnect ground (power off)
- Reconnect all data and power

Manually switching to I<sup>2</sup>C will set the I<sup>2</sup>C address to 100 (0x64)

## 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

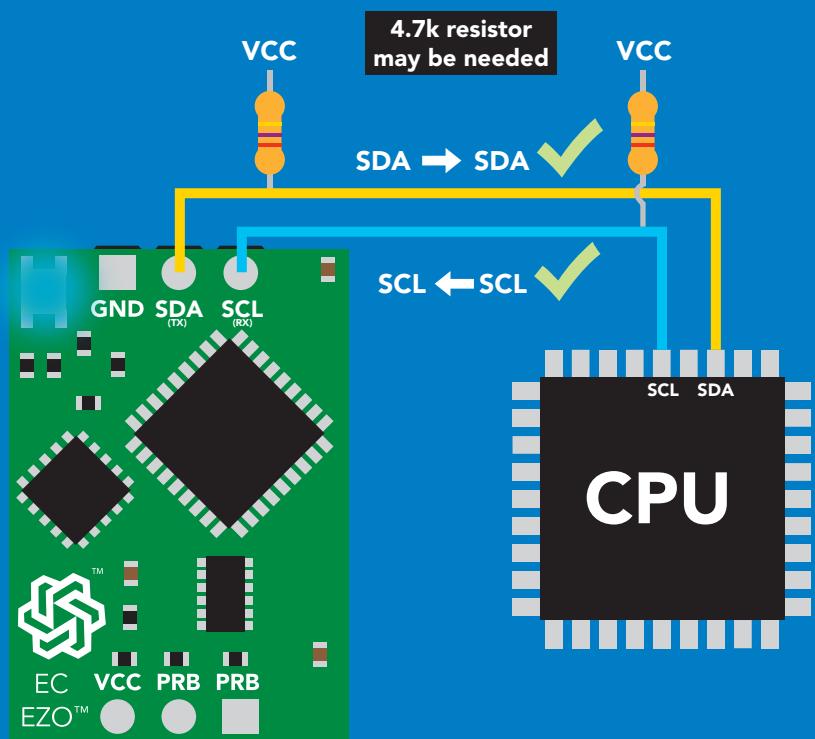
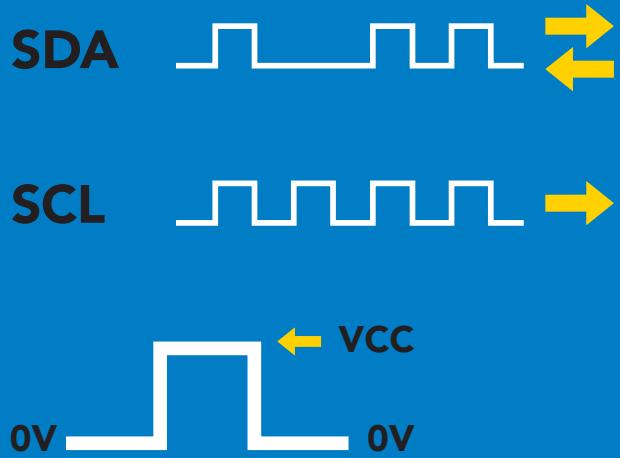
- Find
- Sleep mode
- Temperature compensation

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

I<sup>2</sup>C address (0x01 – 0x7F)  
100 (0x64) default

V<sub>cc</sub> 3.3V – 5.5V

Clock speed 100 – 400 kHz



## Data format

**Reading** Conductivity =  $\mu\text{S}/\text{cm}$   
Total dissolved solids = ppm  
Salinity = PSU (ppt) 0.00 – 42.00  
Specific gravity  
(sea water only) = 1.00 – 1.300

**Units** EC, TDS, SAL, SG

**Encoding** ASCII

<b>Format</b>	<b>string</b>
<b>Data type</b>	<b>floating point</b>
<b>Decimal places</b>	<b>3</b>
<b>Smallest string</b>	<b>3 characters</b>
<b>Largest string</b>	<b>40 characters</b>

# Sending commands to device

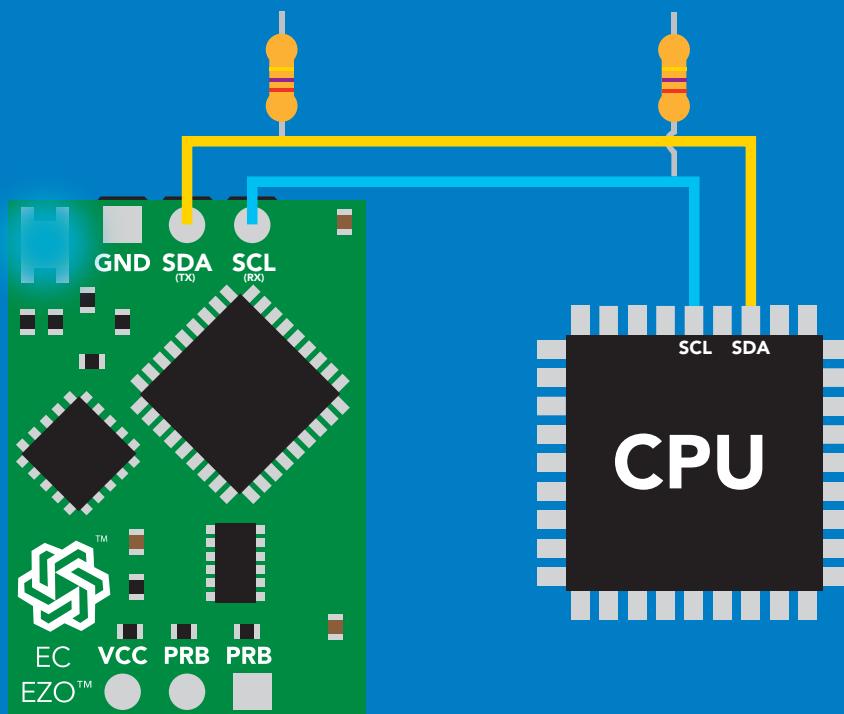
5 parts



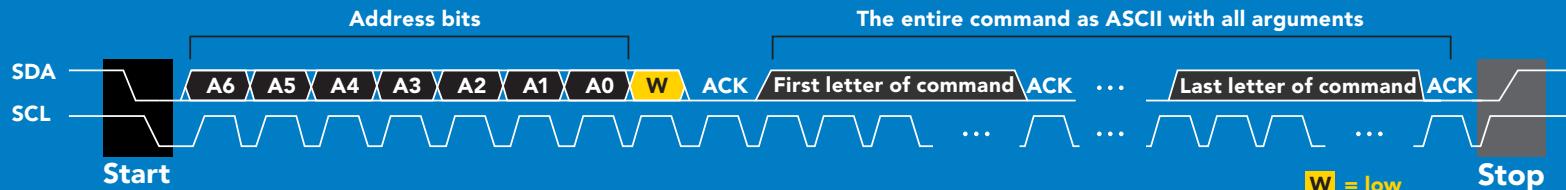
## Example

Start    100 (0x64)    Write    Sleep    Stop

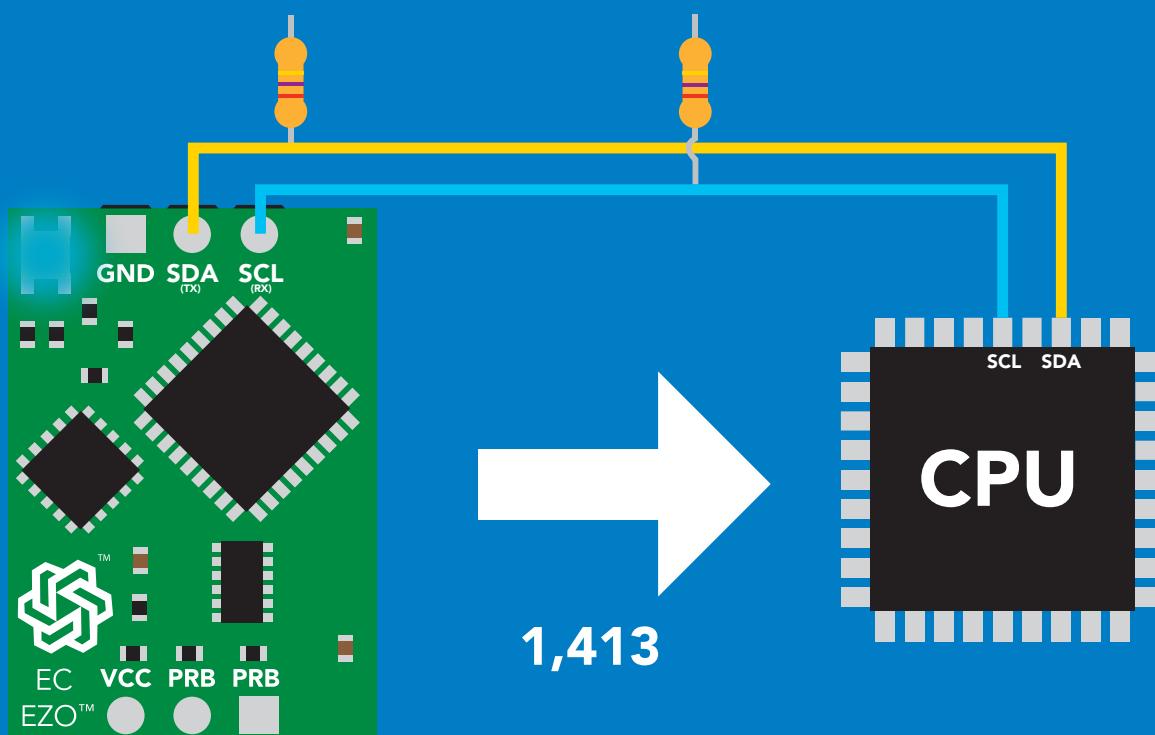
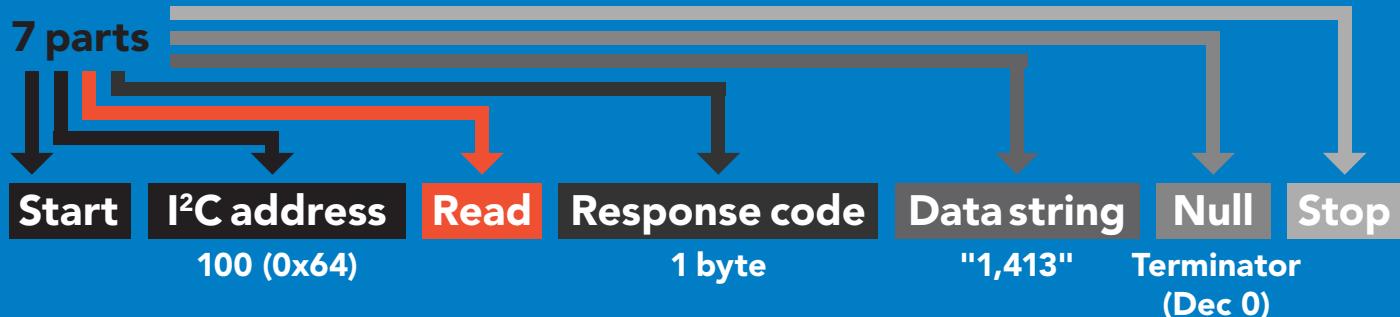
I<sup>2</sup>C address              Command



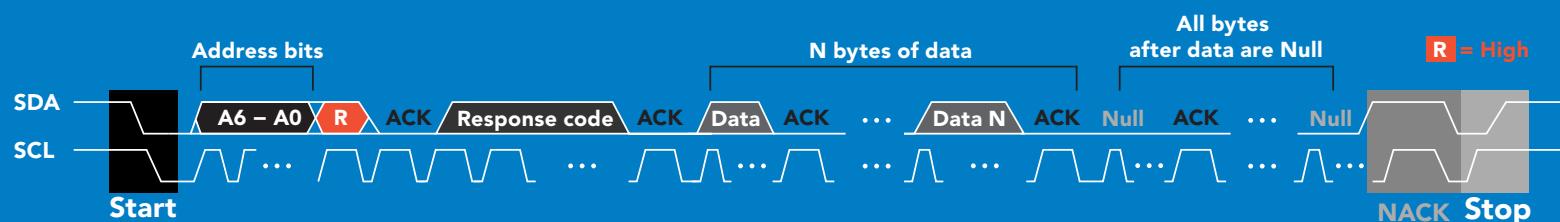
## Advanced



# Requesting data from device



## Advanced

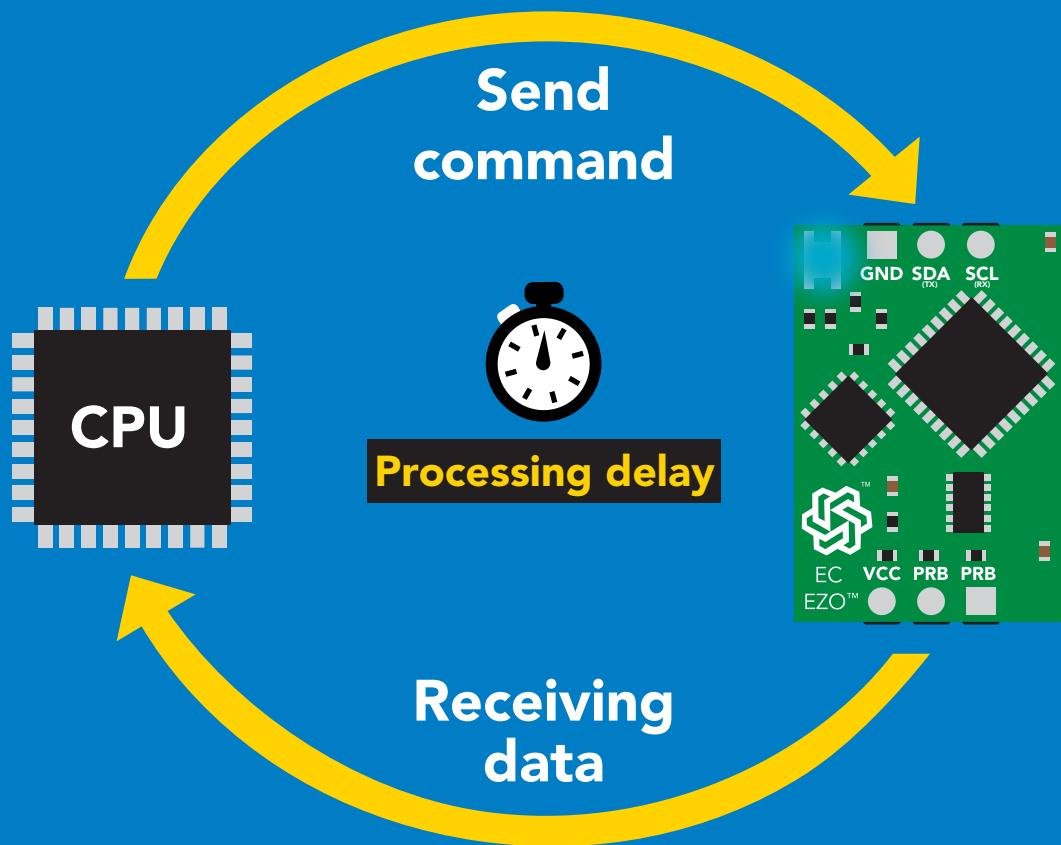


1 49 44 52 49 51 0 = 1,413  
Dec Dec  
ASCII

# 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;
```

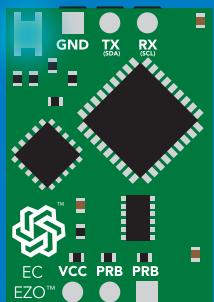
The response code will always be 254, if you do not wait for the processing delay.

### Response codes

Single byte, not string

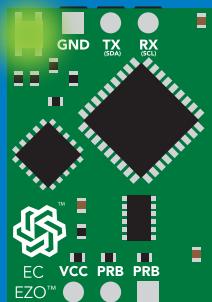
255	no data to send
254	still processing, not ready
2	syntax error
1	successful request

# LED color definition



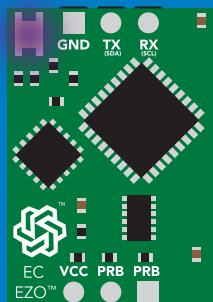
Blue

I<sup>2</sup>C standby



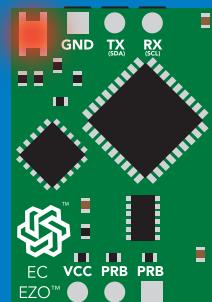
Green

Taking reading



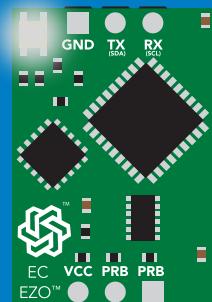
Purple

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



Red

Command not understood



White

Find

5V	LED ON +2.5 mA
3.3V	+1 mA

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

## command quick reference

All commands are ASCII strings or single ASCII characters.

Command	Function	
Baud	switch back to UART mode	pg. 70
Cal	performs calibration	pg. 56
Export	export calibration	pg. 58
Factory	enable factory reset	pg. 69
Find	finds device with blinking white LED	pg. 54
i	device information	pg. 64
I2C	change I <sup>2</sup> C address	pg. 68
Import	import calibration	pg. 59
K	set probe type	pg. 60
L	enable/disable LED	pg. 53
Name	set/show name of device	pg. 63
O	enable/disable parameters	pg. 62
Plock	enable/disable protocol lock	pg. 67
R	returns a single reading	pg. 55
Sleep	enter sleep mode/low power	pg. 66
Status	retrieve status information	pg. 65
T	temperature compensation	pg. 61
TDS	change the TDS conversion factor	pg. 57

# LED control

## Command syntax

300ms  processing delay

L,1 LED on **default**

L,0 LED off

L,? LED state on/off?

## Example

L,1

  
Wait 300ms

**1**  
Dec  
Null

L,0

  
Wait 300ms

**1**  
Dec  
Null

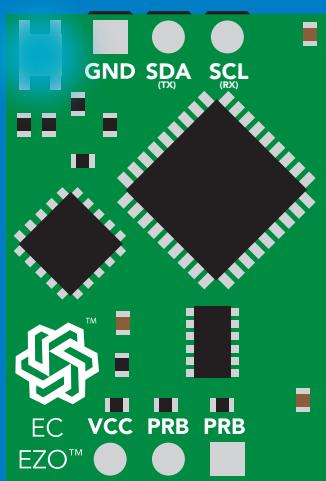
L,?

  
Wait 300ms

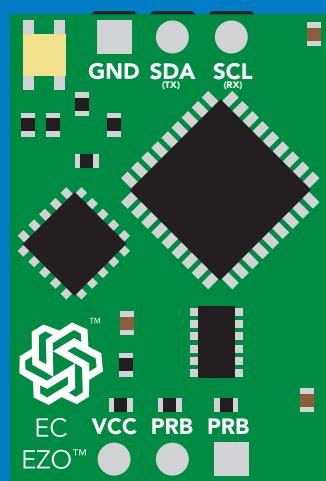
**1** **?L,1** **0**  
Dec ASCII Null

or

**1** **?L,0** **0**  
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

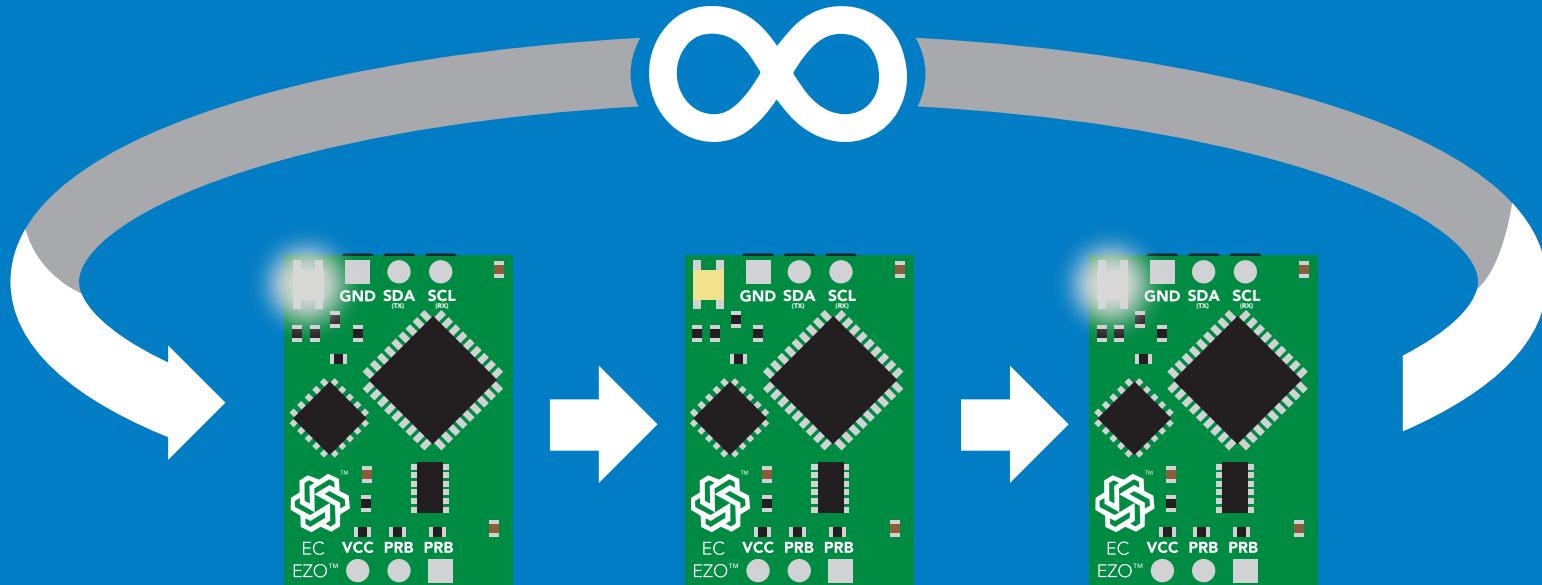
## Example Response

Find

  
Wait 300ms

1  
Dec  
Null

## Response



# Taking reading

## Command syntax

600ms  processing delay

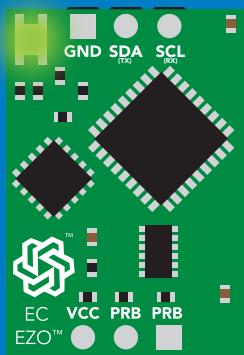
R return 1 reading

## Example Response

R

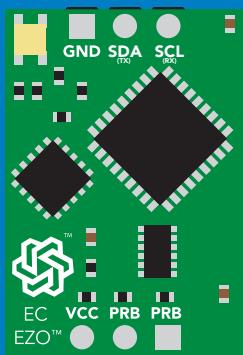
  
Wait 600ms

1	1,413	0
Dec	ASCII	Null

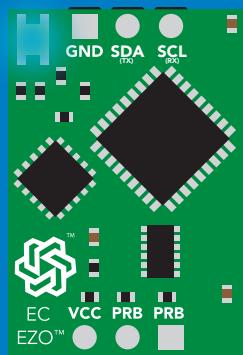


Green

Taking reading



Transmitting



Blue

Standby

# Calibration

## Command syntax

600ms  processing delay

Dry calibration must always be done first!

Cal,dry	<b>dry calibration</b>
Cal,n	<b>single point calibration, where n = any value</b>
Cal,low,n	<b>low end calibration, where n = any value</b>
Cal,high,n	<b>high end calibration, where n = any value</b>
Cal,clear	<b>delete calibration data</b>
Cal,?	<b>device calibrated?</b>

## Example Response

Cal,dry	 Wait 600ms <b>1</b> Dec <b>0</b> Null
Cal,84	 Wait 600ms <b>1</b> Dec <b>0</b> Null
Cal,low,12880	 Wait 600ms <b>1</b> Dec <b>0</b> Null
Cal,high,80000	 Wait 600ms <b>1</b> Dec <b>0</b> Null
Cal,clear	 Wait 300ms <b>1</b> Dec <b>0</b> Null
Cal,?	 Wait 300ms <b>1</b> Dec <b>?CAL,0</b> <b>0</b> or <b>1</b> Dec <b>?CAL,1</b> <b>0</b> or <b>1</b> Dec <b>?CAL,2</b> <b>0</b> ASCII one point Null ASCII two point Null

### One point calibration:

Step 1. "cal,dry"

Step 2. "cal,n"

**Calibration complete!**

### Two point calibration:

Step 1 "cal,dry"

Step 2 "cal,low,n"

Step 3 "cal,high,n"

**Calibration complete!**

# Changing the TDS (ppm) conversion factor

300ms  processing delay

## Command syntax

There are several different conversion factors used to read TDS(ppm). For some applications, it may be necessary to use a conversion factor other than the default value of 0.54

- TDS,n      set custom conversion factor, n = any value between 0.01 – 1.00  
TDS,?      conversion factor being used

## Example

TDS,?

## Response

 Wait 300ms    1 Dec    ?TDS,0.54 ASCII    0 Null

R

 Wait 300ms    1 Dec    EC TDS  
                  ↓    ↓    100,54 ASCII    0 Null

TDS,0.46

 Wait 300ms    1 Dec    0 Null

R

 Wait 300ms    1 Dec    EC TDS  
                  ↓    ↓    100,460 ASCII    0 Null

## Common conversion factors

NaCl	0.47 – 0.50
KCL	0.50 - 0.57
"442"	0.65 – 0.85

## Formula

$$\text{EC} \times \text{conversion factor} = \text{TDS}$$

# 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

**Export,?**



Wait 300ms

1

10,120

0

Dec

ASCII

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

59 6F 75 20 61 72

0

Dec

ASCII

Null

(1 of 10)

**Export**



Wait 300ms

1

65 20 61 20 63 6F

0

Dec

ASCII

Null

(2 of 10)

**(7 more)**



**Export**



Wait 300ms

1

6F 6C 20 67 75 79

0

Dec

ASCII

Null

(10 of 10)

**Export**



Wait 300ms

1

\*DONE

0

Dec

ASCII

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)

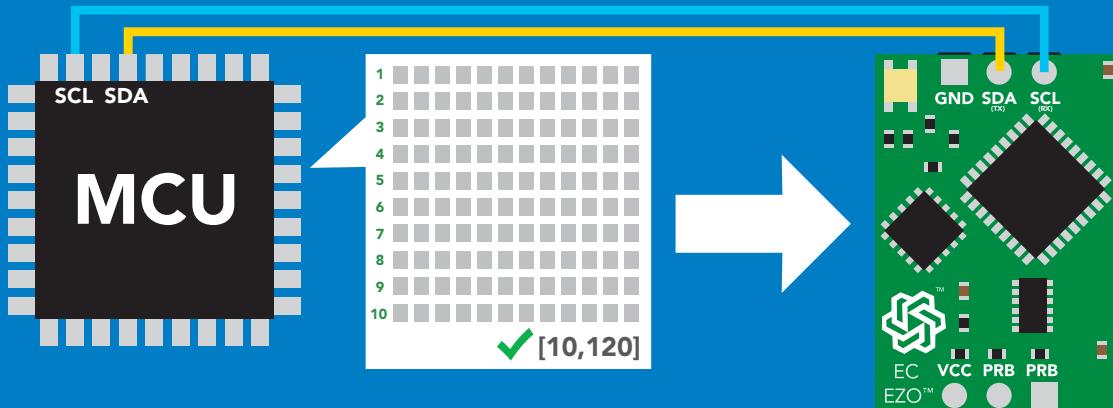
## Response

 1 0 Null  
Wait 300ms

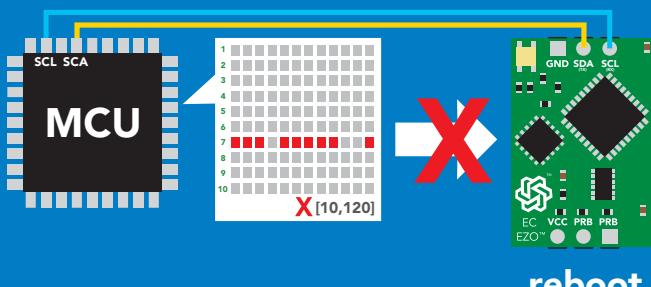
 1 0 Null  
Wait 300ms

⋮  
 1 0 Null  
Wait 300ms

Import,n



system will reboot



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

# Setting the probe type

Command syntax

300ms  processing delay

K,n n = any value; floating point in ASCII

K 1.0 is the default value

K,? probe K value?

Example

Response

K,10

 Wait 300ms  
1 Dec 0 Null

K,?

 Wait 600ms  
1 Dec K,10 ASCII 0 Null



K 0.1



K 1.0



K 10

# Temperature compensation

## Command syntax

Default temperature = 25°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

T,19.5

## Response

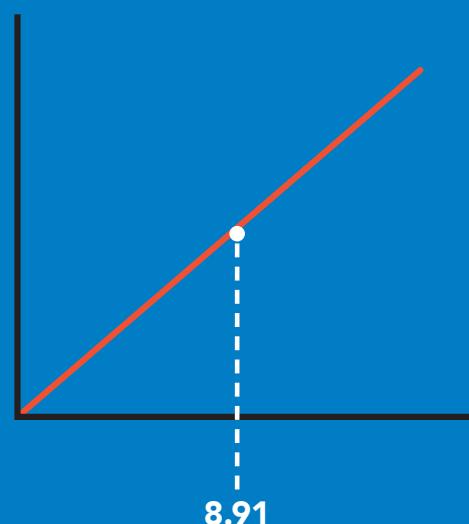
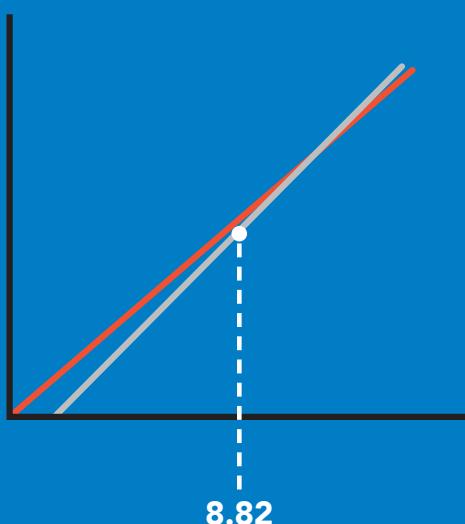
 Wait 300ms    1 Dec 0 Null

RT,19.5

 Wait 900ms    1 Dec 8.91 0 Null

T,?

 Wait 300ms    1 Dec ?T,19.5 0 Null



# Enable/disable parameters from output string

## Command syntax

300ms  processing delay

O, [parameter],[1,0]

enable or disable output parameter  
enabled parameter?

## Example

O,EC,1 / O,EC,0

## Response

 Wait 300ms	1	Dec	0	enable / disable conductivity
 Wait 300ms	1	Dec	0	enable / disable total dissolved solids
 Wait 300ms	1	Dec	0	enable / disable salinity
 Wait 300ms	1	Dec	0	enable / disable specific gravity
O,?	1	Dec	?O,EC,TDS,S,SG	0 ASCII Null if all are enabled

## Parameters

EC conductivity

TDS total dissolved solids

S salinity

SG specific gravity

## 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,?    show name

Up to 16 ASCII characters

## Example

## Response

Name,zzt

 Wait 300ms

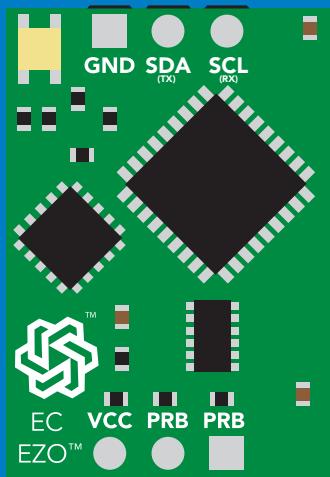
1 Dec 0 Null

Name,?

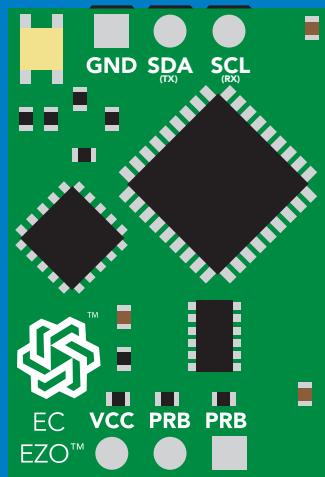
 Wait 300ms

1 Dec ?Name,zzt 0 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,EC, 2.10  
ASCII

0  
Null

Response breakdown

?i, EC, 2.10  
↑      ↑  
Device Firmware

# Reading device status

## Command syntax

300ms  processing delay

Status voltage at Vcc pin and reason for last restart

## Example Response

Status



Wait 300ms

1

?Status,P,5.038

Dec

ASCII

0

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**

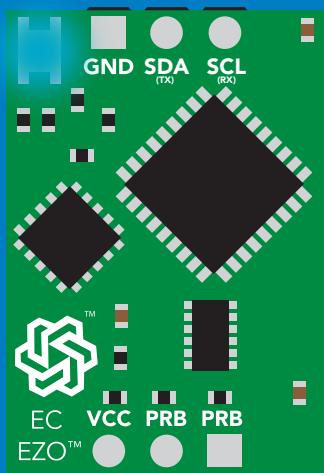
Do not read status byte after issuing sleep command.

**Any command**

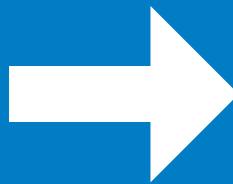
**wakes up device**

	STANDBY	SLEEP
<b>5V</b>	<b>18.14 mA</b>	<b>0.7 mA</b>

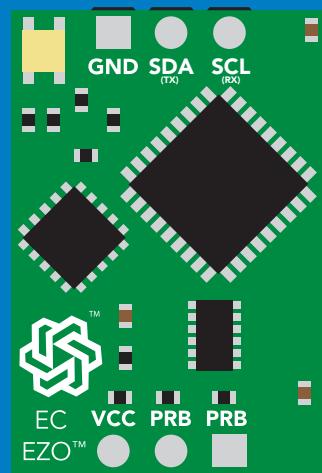
<b>3.3V</b>	<b>16.85 mA</b>	<b>0.4 mA</b>
-------------	-----------------	---------------



Standby



Sleep



Sleep

# Protocol lock

## Command syntax

300ms  processing delay

Plock,1 enable Plock

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

Plock,0 disable Plock

default

Plock,? Plock on/off?

## Example

Plock,1

 Wait 300ms

1  
Dec  
0  
Null

Plock,0

 Wait 300ms

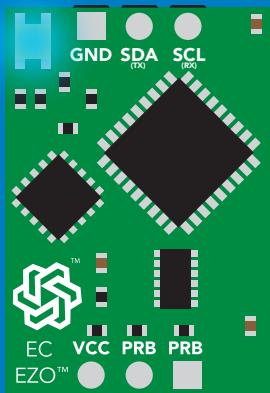
1  
Dec  
0  
Null

Plock,?

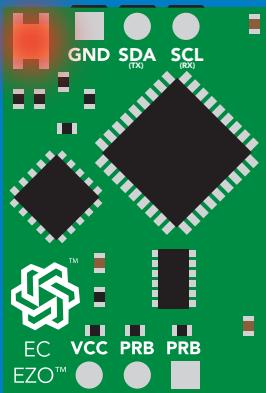
 Wait 300ms

1  
Dec  
?Plock,1  
ASCII  
0  
Null

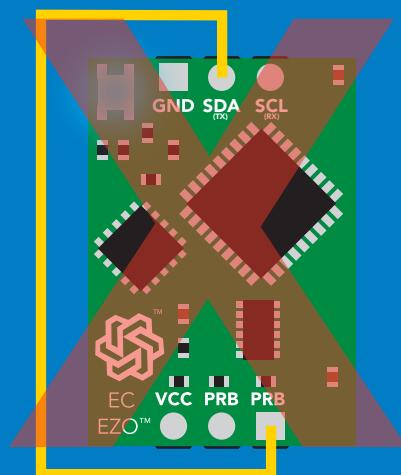
Plock,1



Baud, 9600



cannot change to UART



cannot change to UART

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

## Command syntax

300ms  processing delay

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

## Example Response

I<sup>2</sup>C,101

device reboot

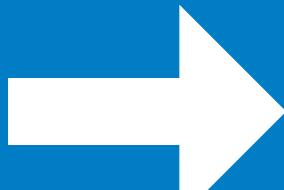
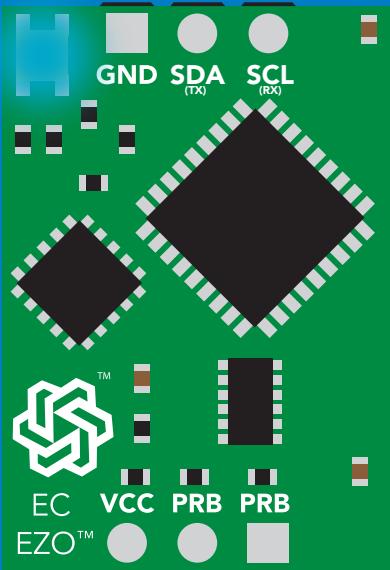
## Warning!

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.

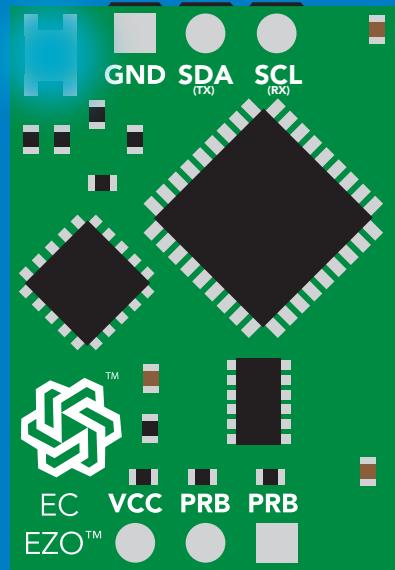
Default I<sup>2</sup>C address is 100 (0x64).

n = any number 1 – 127

I<sup>2</sup>C,101



(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

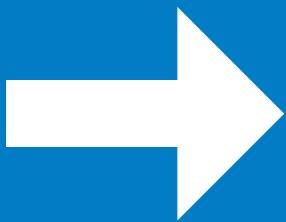
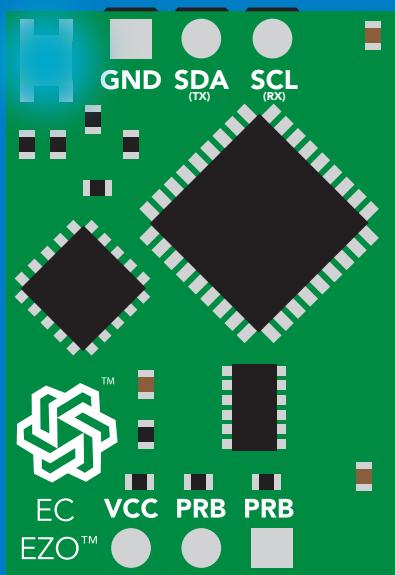
## Example Response

Factory

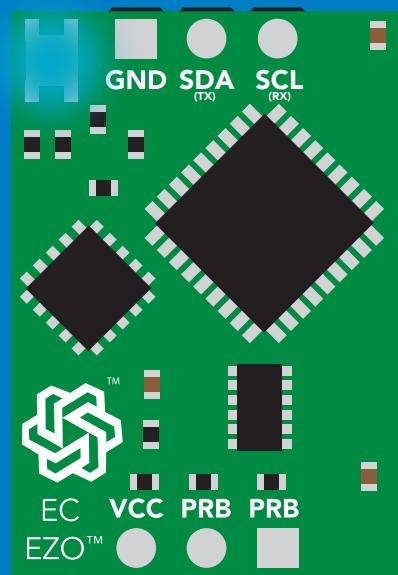
device reboot

Clears calibration  
LED on  
Response codes enabled

Factory



(reboot)



# Change to UART mode

## Command syntax

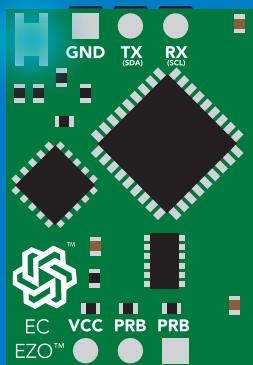
Baud,n switch from I<sup>2</sup>C to UART

### Example Response

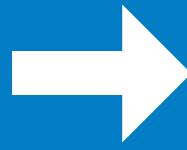
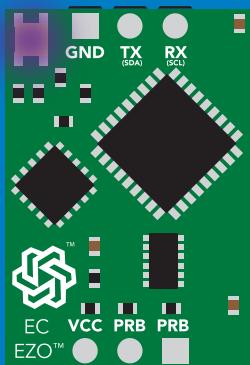
Baud,9600

reboot in UART mode

n = [ 300  
1200  
2400  
9600  
19200  
38400  
57600  
115200 ]

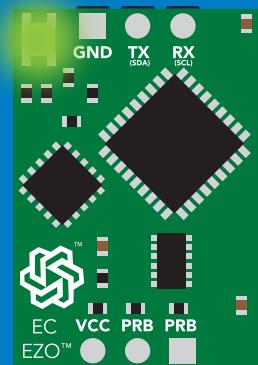


Baud,9600



(reboot)

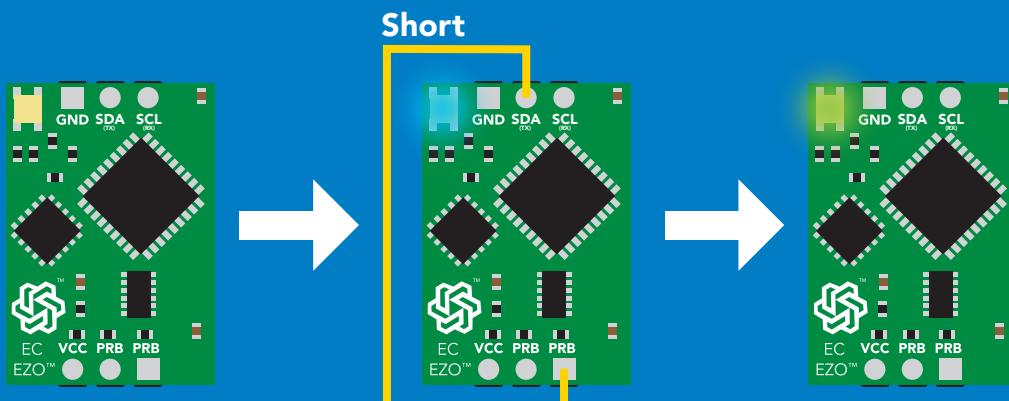
Changing to  
UART mode



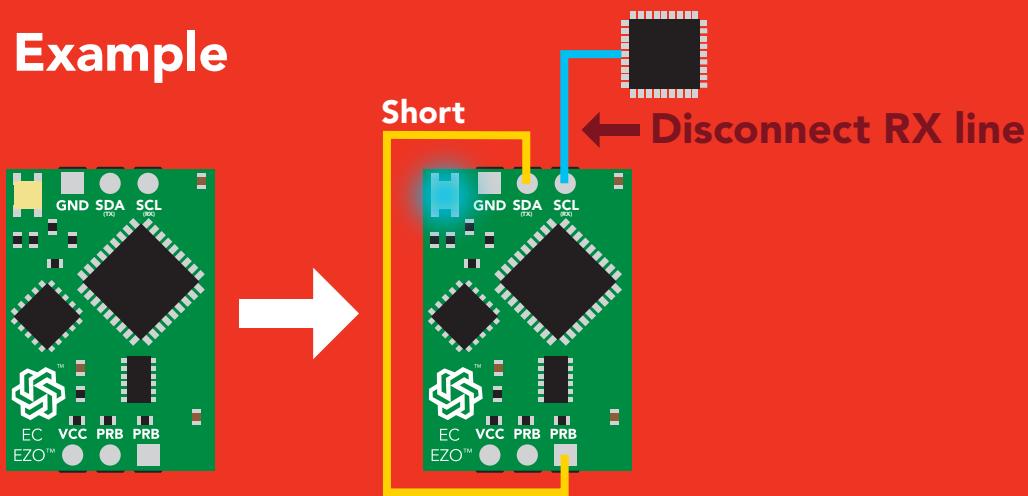
# Manual switching to UART

- Disconnect ground (power off)
- Disconnect TX and RX
- Connect TX to the right PRB
- 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

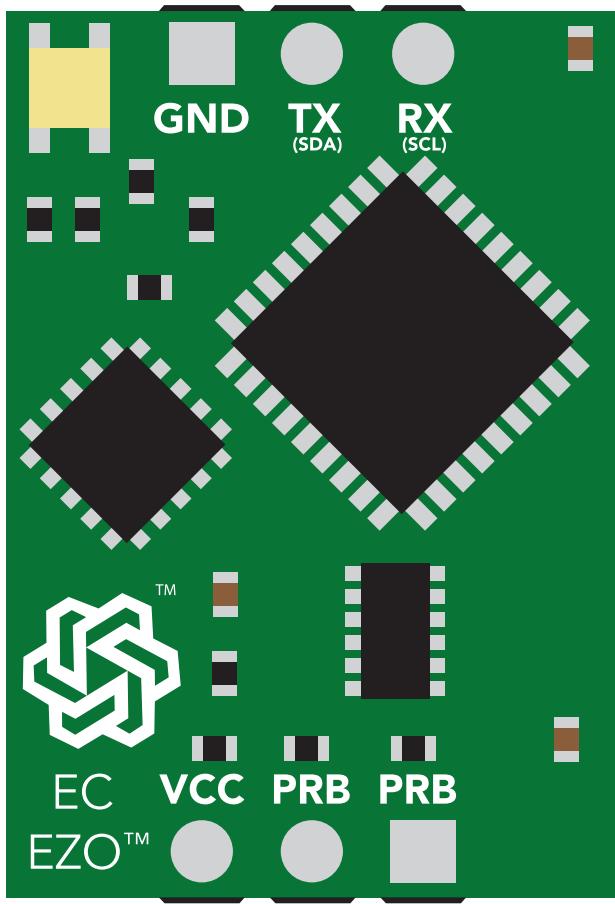
## Example



## Wrong Example



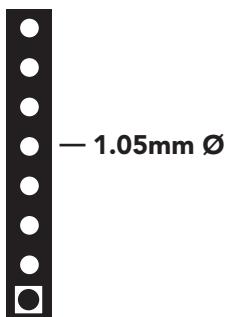
# EZO™ circuit footprint



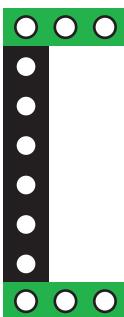
17.78mm  
(0.7")

2.54mm  
(0.1")

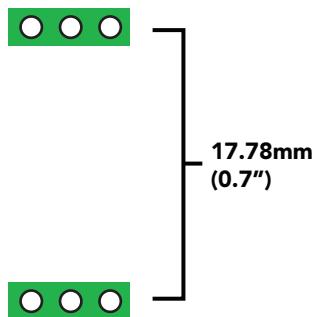
**1** In your CAD software,  
place a 8 position header.



**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 6.2

### **Added new command:**

"TDS,n" Changing the TDS (ppm) conversion factor on pages 30 (UART) & 57 (I<sup>2</sup>C).

## Datasheet V 6.1

Corrected typos within the datasheet.

## Datasheet V 6.0

Changed the K value range from 0.1 to 0.01 on pg 5.

## Datasheet V 5.9

Moved Default state to pg 17.

## Datasheet V 5.8

Revised conductivity probe range information on pg 5.

## Datasheet V 5.7

Revised response for the sleep command in UART mode on pg 39.

## Datasheet V 5.6

Added more information on the Export calibration and Import calibration commands.

## Datasheet V 5.5

Revised calibration theory pages, added information on temperature compensation on pg. 15, moved data isolation to pg 9, and correct wiring to pg 11.

## Datasheet V 5.4

Revised isolation schematic on pg. 13

## Datasheet V 5.3

### **Added new command:**

"RT,n" for Temperature compensation located on pages 30 (UART) & 55 (I<sup>2</sup>C).

Added firmware information to Firmware update list.

## Datasheet V 5.2

Revised calibration information on pages 27 & 52.

# Datasheet change log

## Datasheet V 5.1

Added more information about temperature compensation on pages 30 & 55.

## Datasheet V 5.0

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

## Datasheet V 4.9

Removed note from certain commands about firmware version.  
Added steps to calibration command pages 27 (UART) and 52 (I<sup>2</sup>C).

## Datasheet V 4.8

Revised definition of response codes on pg 46.

## Datasheet V 4.7

Revised cover page art.

## Datasheet V 4.6

Updated calibration processing delay time on pg.52.

## Datasheet V 4.5

Revised Enable/disable parameters information on pages 31 & 56.

## Datasheet V 4.4

Updated High point calibration info on page 11.

## Datasheet V 4.3

Updated calibration info on pages 27 (UART) and 52 (I<sup>2</sup>C).

## Datasheet V 4.2

Revised Plock pages to show default value.

## Datasheet V 4.1

Corrected I<sup>2</sup>C calibration delay on pg. 52.

## Datasheet V 4.0

Revised entire datasheet.

# Firmware updates

V1.0 – Initial release (April 17, 2014)

V1.1 – (June 2, 2014)

- Change specific gravity equation to return 1.0 when the uS reading is < 1000 (previously returned 0.0)
- Change accuracy of specific gravity from 2 decimal places to 3 decimal places
- Don't save temperature changes to EEPROM

V1.2 – (Aug 1, 2014)

- Baud rate change is now a long, purple blink

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

V1.8 – 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  
This would cause the EZO circuit to revert back to UART mode if set to I<sup>2</sup>C

V2.10 – (April 12, 2017)

- Added "Find" command.
- Added "Export/import" command.
- Modified continuous mode to be able to send readings every "n" seconds.
- Default output changed from CSV string of 4 values to just conductivity; Other values must be enabled

V2.11 – (April 28, 2017)

- Fixed "Sleep" bug, where it would draw excessive current.

V2.12 – (May 9, 2017)

- Fixed bug in sleep mode, where circuit would wake up to a different I<sup>2</sup>C address.

V2.13 – (July 16, 2018)

- Added "RT" command to Temperature compensation

V2.14 – (Nov 26, 2019)

- The K value range has been extended to 0.01

V2.15 – (June 29, 2020)

- Fixed bug where output doesn't always round to 0

# Warranty

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

## The debugging phase

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

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