AtlasScientific™
Environmental Robotics

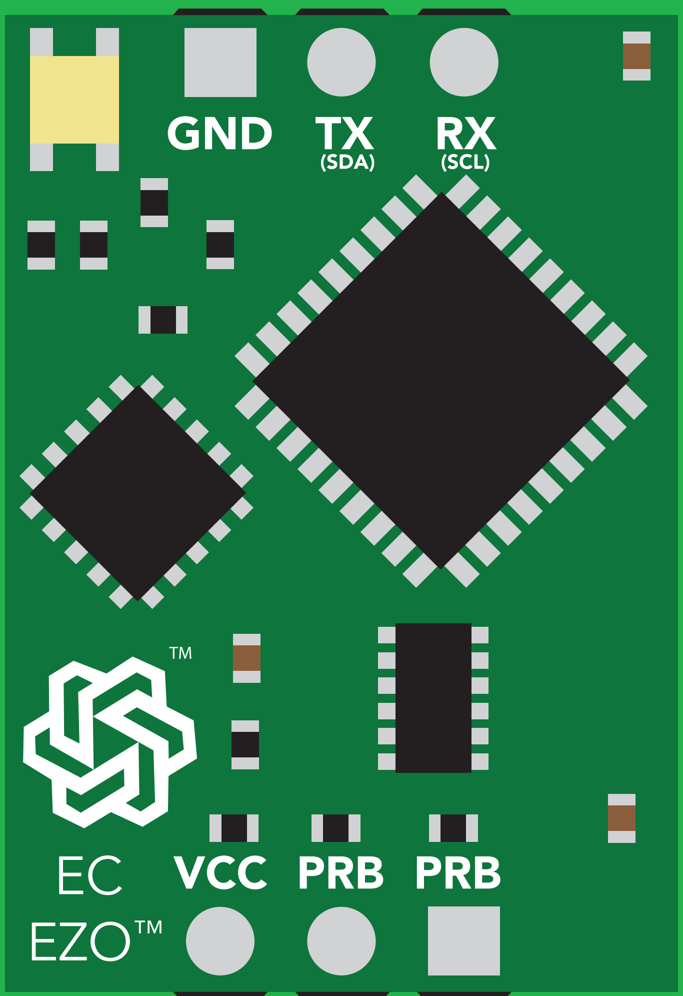
V 5.4

Revised 10/23/18

EZO-EC™

Embedded Conductivity Circuit

Reads	**Conductivity = μS/cm** **Total dissolved solids = ppm** **Salinity = PSU** **Specific gravity** ***(sea water only)* = 1.00 – 1.300**
Range	**0.07 – 500,000+ μS/cm**
Accuracy	**+/– 2%**
Response time	**1 reading per sec**
Supported probes	**K 0.1 – K 10 any brand**
Calibration	**2 or 3 point**
Temp compensation	**Yes**
Data protocol	**UART & I²C**
Default I²C address	**100 (0x64)**
Operating voltage	**3.3V – 5V**
Data format	**ASCII**



Written by Jordan Press
Designed by Noah Press

PATENT PROTECTED

This is an evolving document, check back for updates.

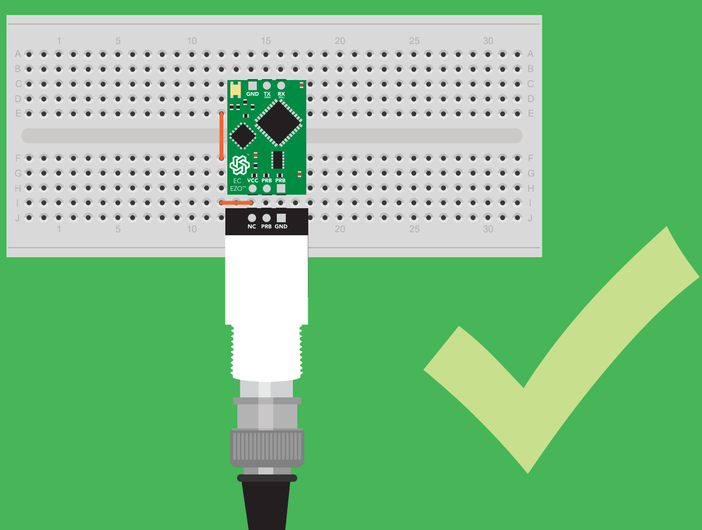
STOP

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!

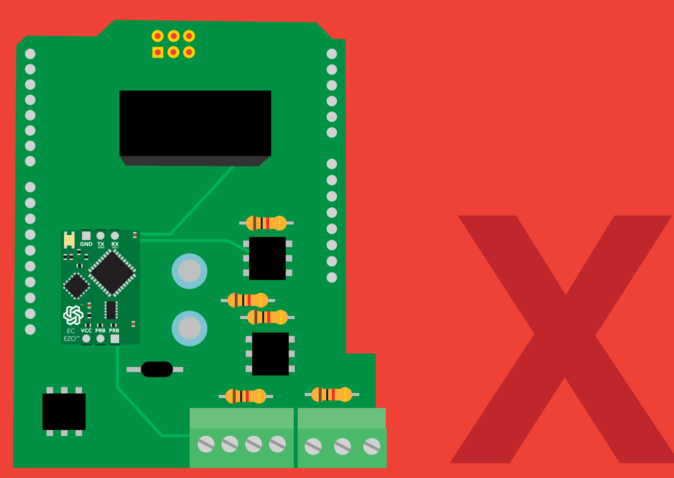


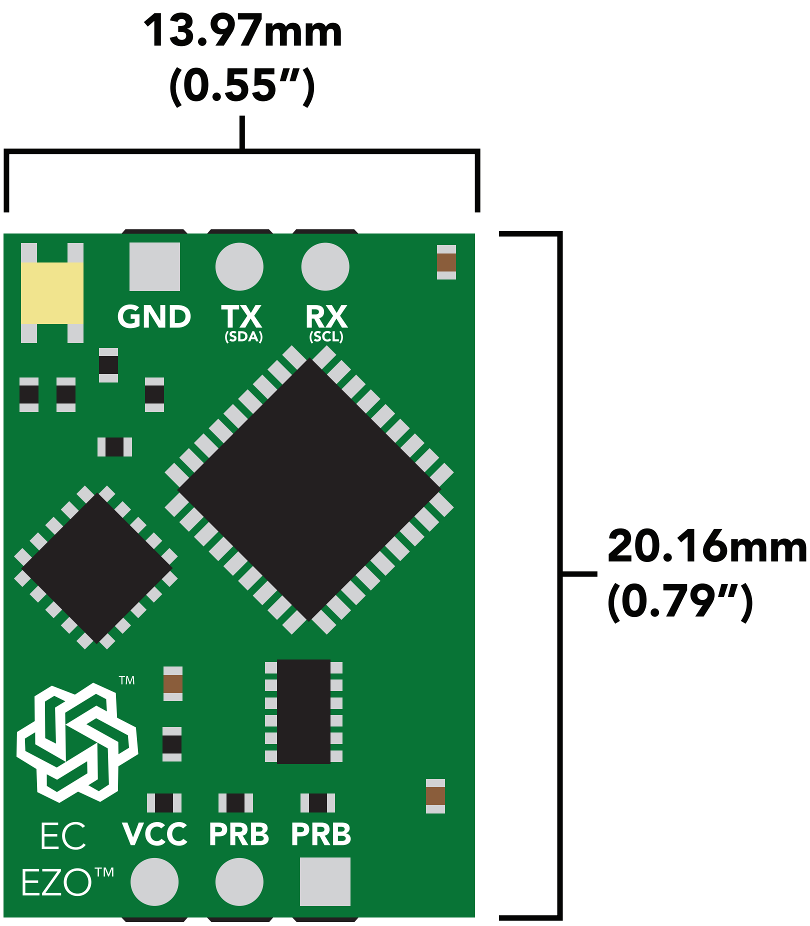
Table of contents

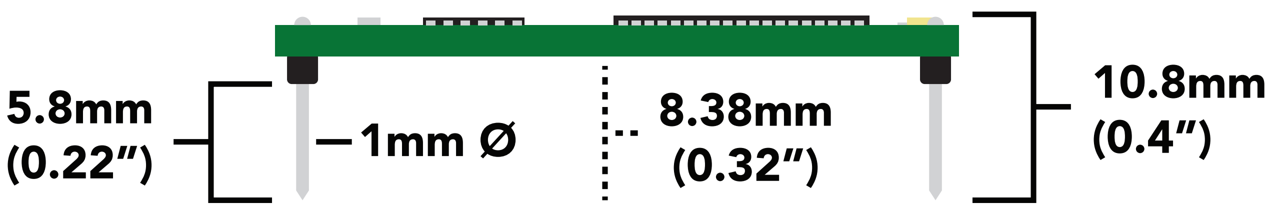
UART

I²C

AtlasScientific™ Environmental Robotics

EZO™ circuit dimensions





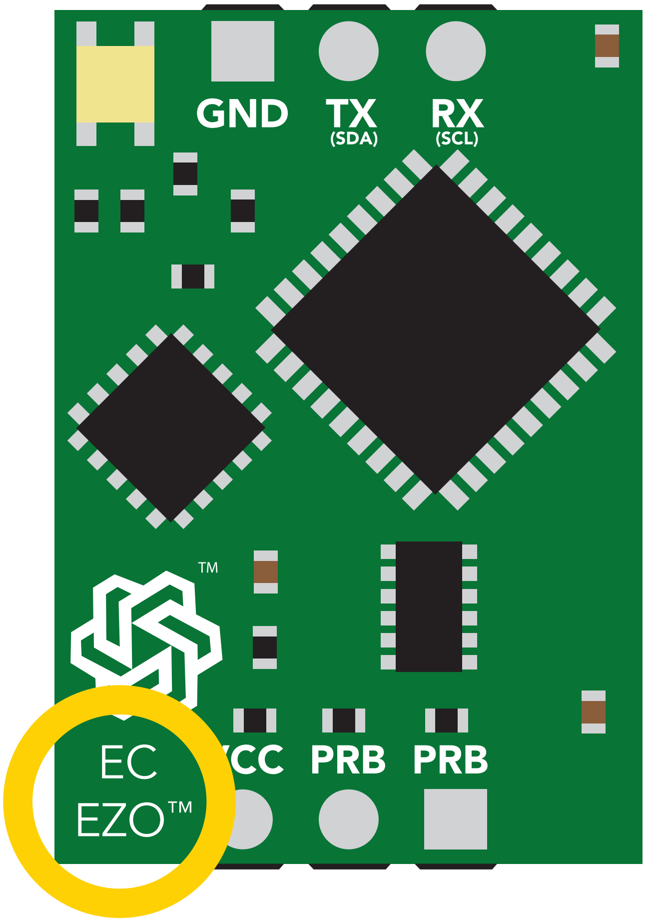
Power consumption

	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	

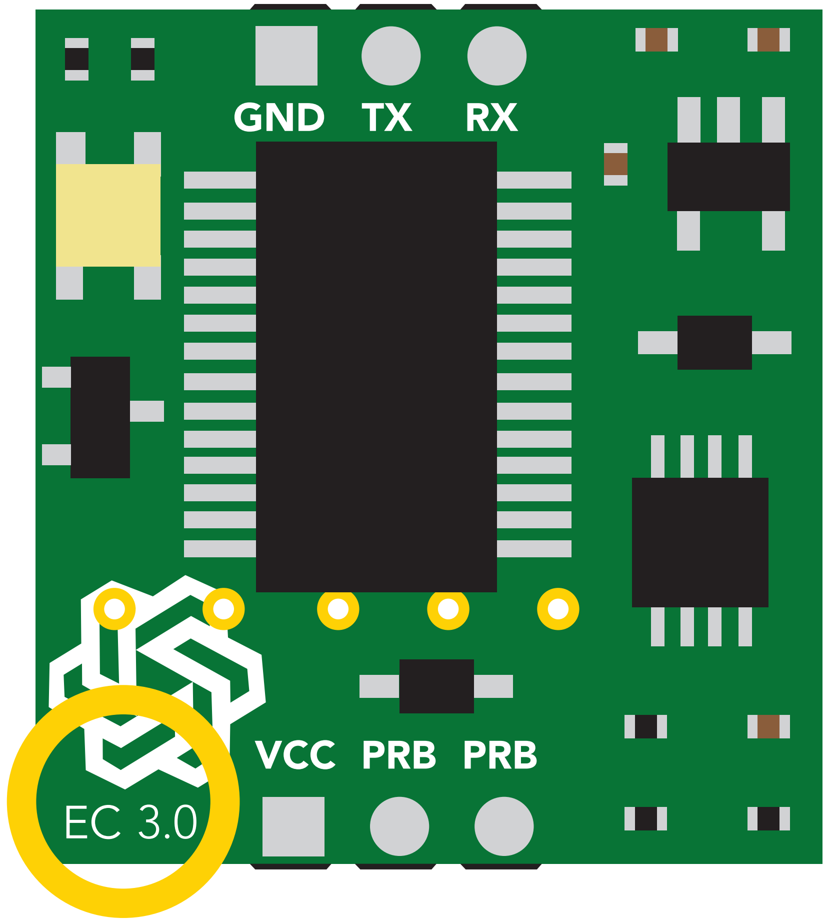
Absolute max ratings

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

EZO™ circuit identification



EZO™ Conductivity circuit



Legacy Conductivity circuit

Viewing correct datasheet

Viewing incorrect datasheet

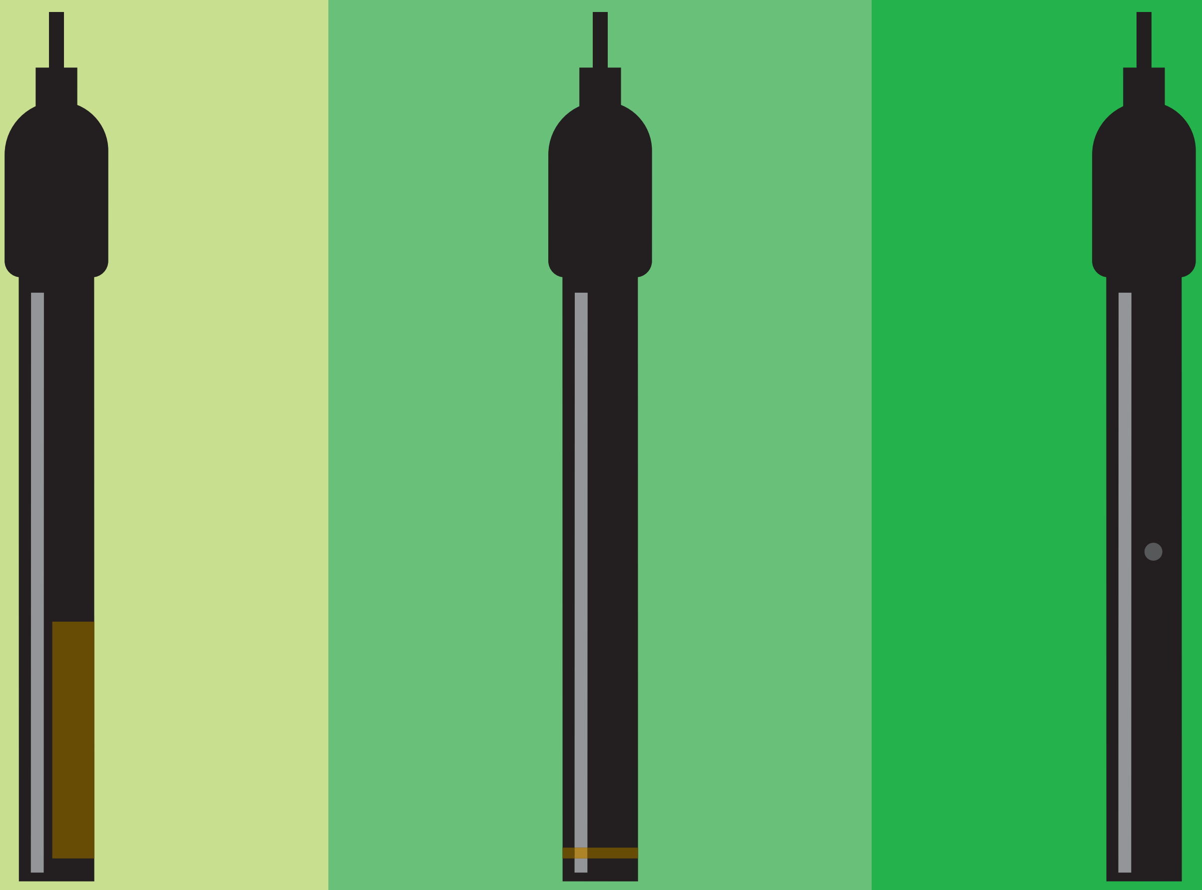
Click here to view legacy datasheet

Conductivity probe range

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

K 0.1 → K 10

Atlas Scientific™ has tested 3 different K value probe types



K 0.1	K 1.0	K 10
accurate reading range	**accurate reading range**	**accurate reading range**
0.07μS – 50,000μS	**5μS – 200,000+μS**	**10μS – 1S**

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.

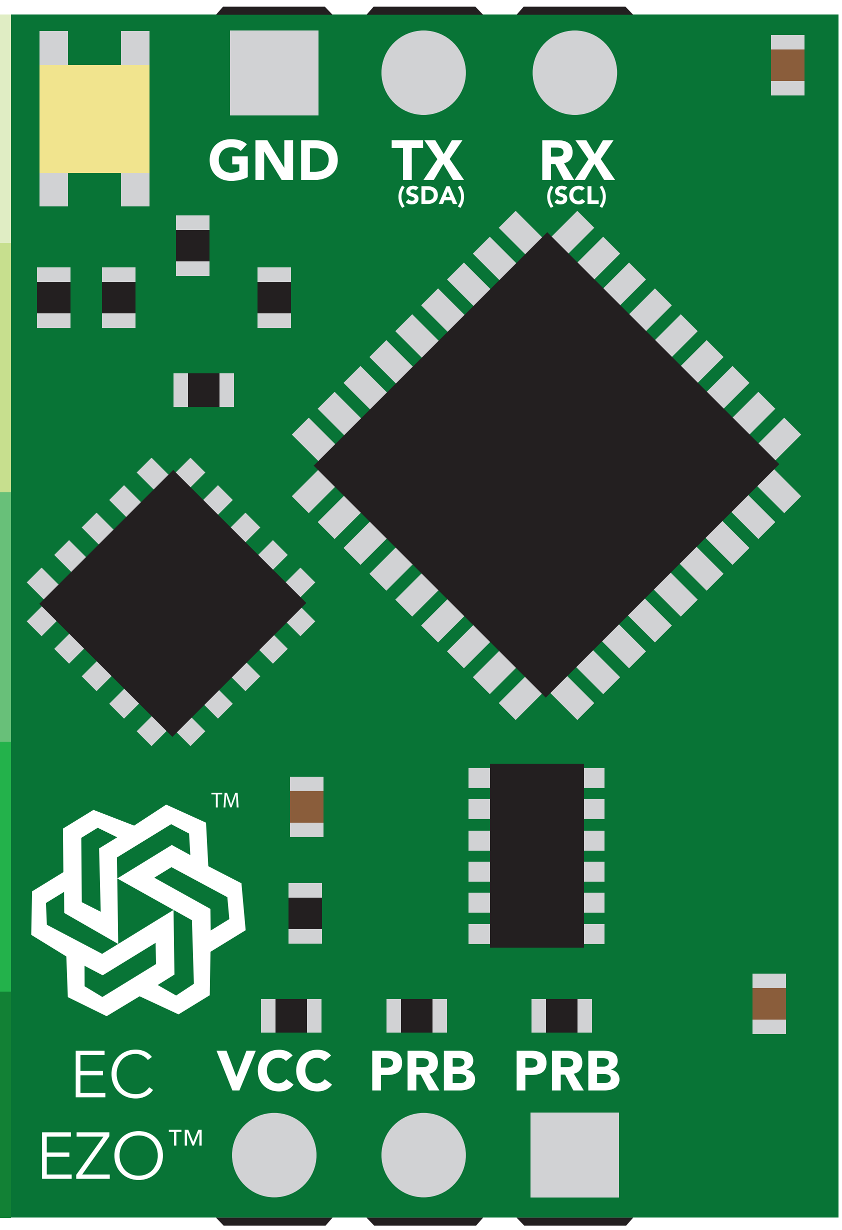
0.07 – 99.99
Resolution = **0.01μS**

100.1 – 999.9
Resolution = **0.1μS**

1,000 – 9,999
Resolution = **1.0μS**

10,000 – 99,990
Resolution = **10μS**

100,000 – 999,900
Resolution = **100μS**

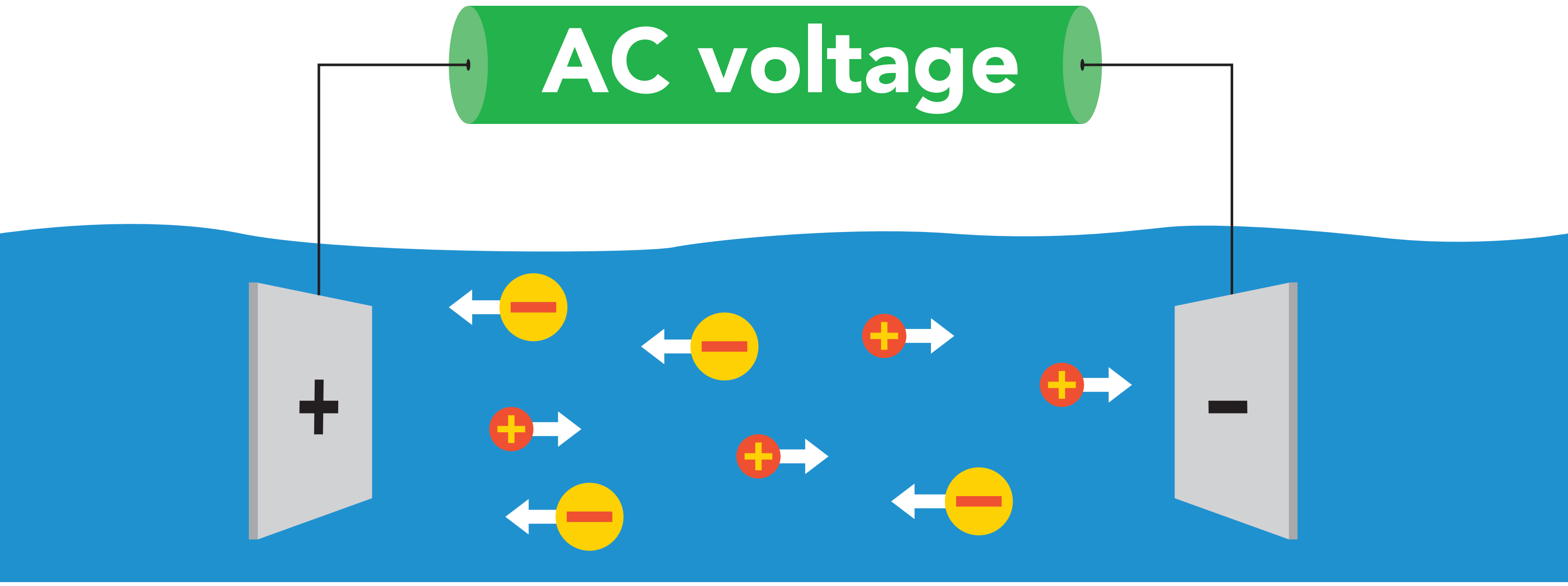


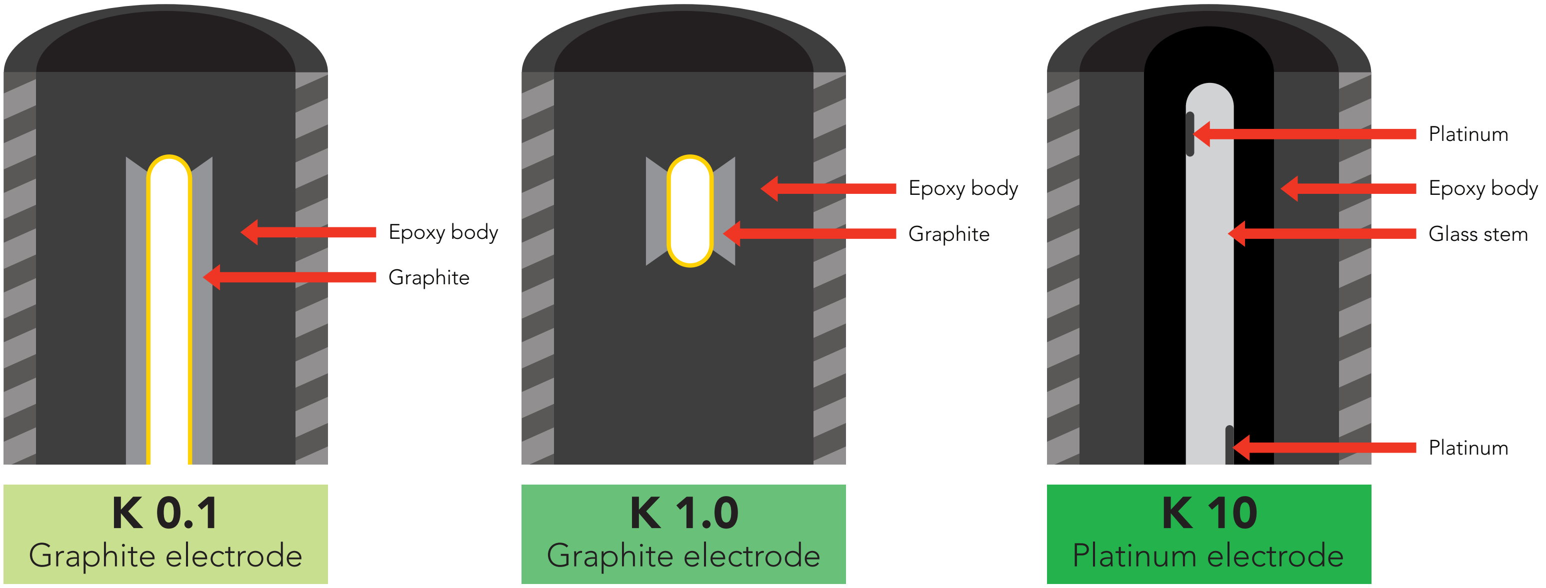
AtlasScientific™ Environmental Robotics

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.





Output units

By default, EZO™ Conductivity circuits with firmware version 2.10 and above will *only* output EC. To enable these parameters see page 31 for UART, and 56 for I²C.

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

Conductivity = μS/cm
Total dissolved solids = ppm
Salinity = PSU
Spacific gravity (sea water only) = 1.00 – 1.300

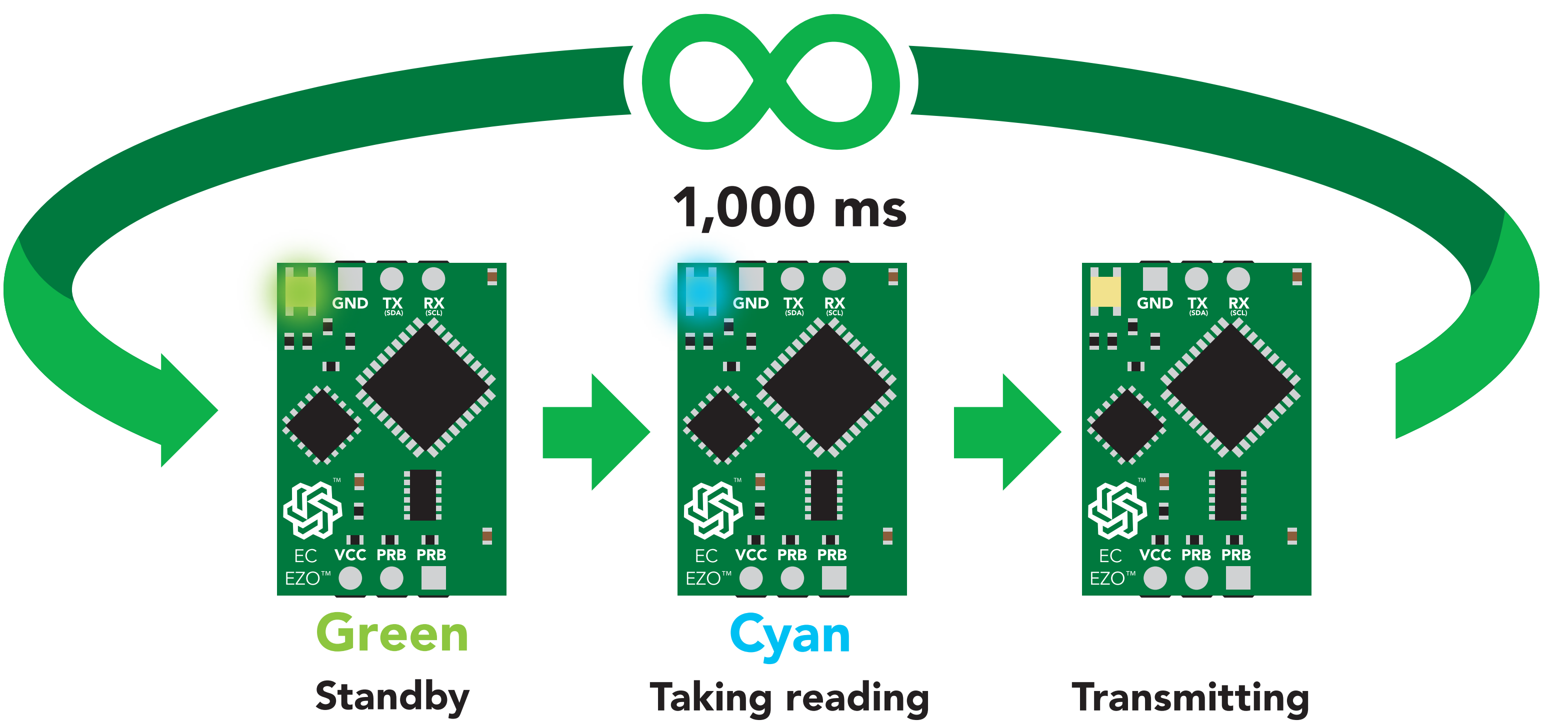
These parameters must be individually enabled within the device. See page **31** to enable each parameter in UART mode, and on page **56** for I²C mode.

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 Continous Mode *(default state)*
This can only happen when the device is in **UART** mode.

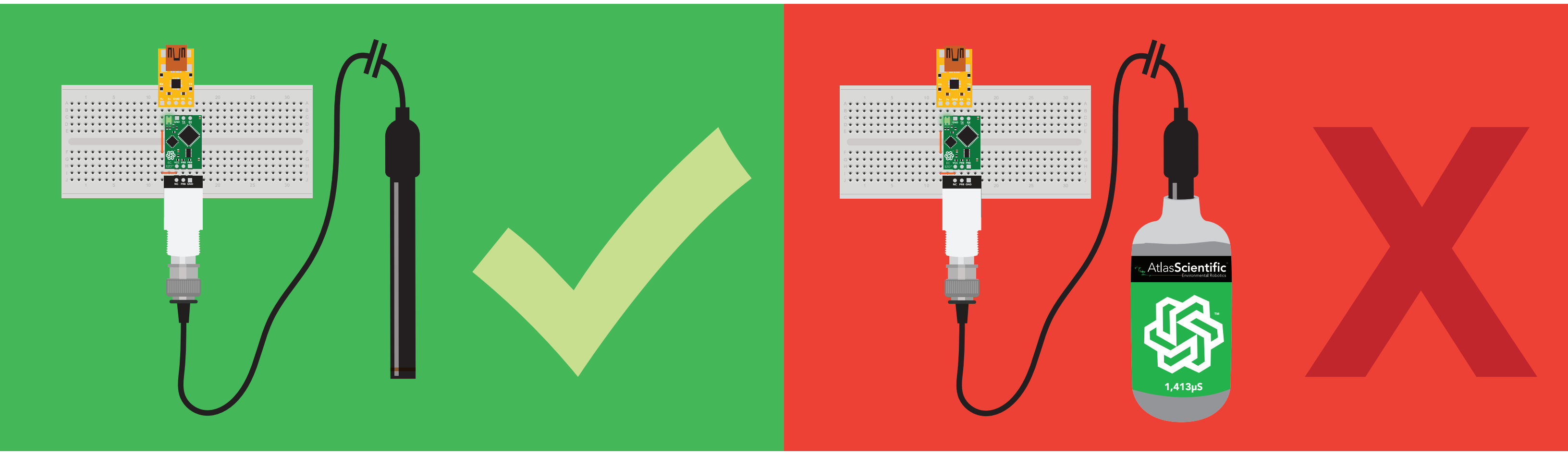


Calibration theory

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, continuous readings). Switching the device to I²C mode after calibration ***will not*** affect the stored calibration. If the device must be calibrated in I²C mode be sure to request readings continuously so you can see the output from the probe.

Pre-calibration setup

First, take readings from dry conductivity probe.



Set probe type

If you are not using a K 1.0 conductivity probe *(default)*, you need to set the probe type by using the **"K,n"** command. *(where n = K value of your probe)*

Dry calibration

Issuing the **"Cal,dry"** command fine tunes the internal electrical properties of the device. This calibration only needs to be done once. Even though you may see reading of 0.00 before issuing the **"Cal,dry"** command, it is still a necessary component of calibration.

17.00 ➡ "Cal,dry" ➡ 0.00 ✓ Correct

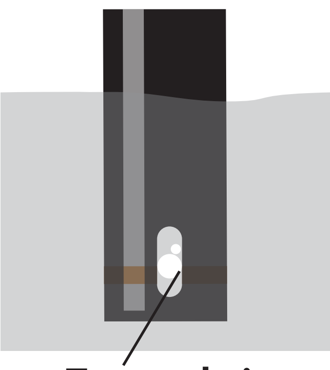
00.00 ➡ "Cal,dry" ➡ 0.00 ✓ Correct

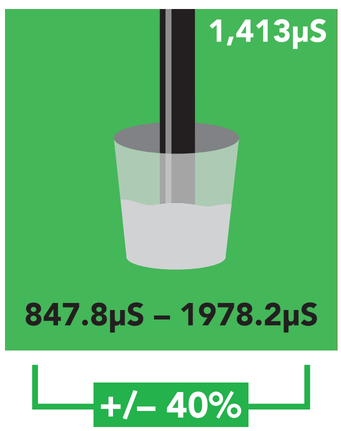
Temperature compensation

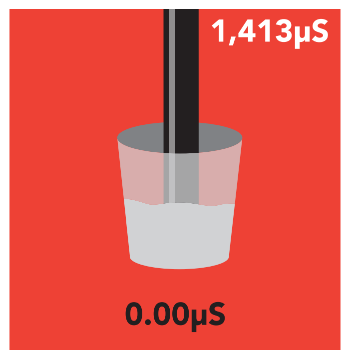
Temperature has a significant effect on conductivity readings. The EZO™ Conductivity circuit has its temperature compensation set to 25° C as the default. If the calibration solution is not within 5° of 25° C, check the temperature chart on the side of the calibration bottle, and calibrate to that value.

Low point/single point calibration

Pour a small amount of the 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).







Once the readings stabilize, issue the low point or single point calibration command.
Low point calibration: **"Cal,low,1413"** *(Readings will **NOT** change)*
Single point calibration: **"Cal,1413"** *(Readings **will** change, calibration complete).*

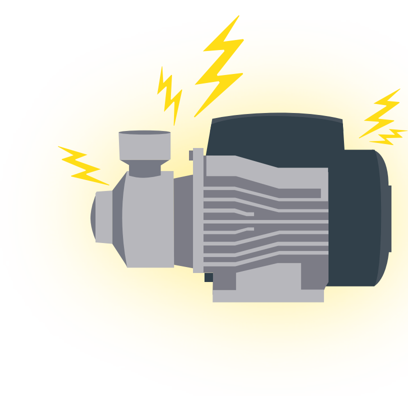
High point calibration

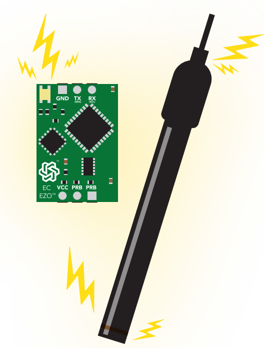
Shake the probe to remove trapped air and adjust the temperature as done in the previous step. Once the readings have stabilized issue the high point calibration command.
High point calibration: **"Cal,high,12880"** *(Readings **will** change, calibration complete).*

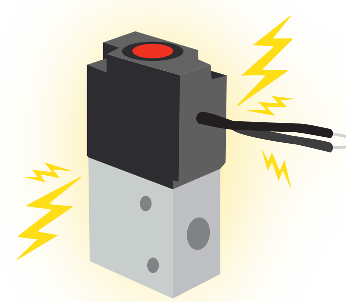
Power and data isolation

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.

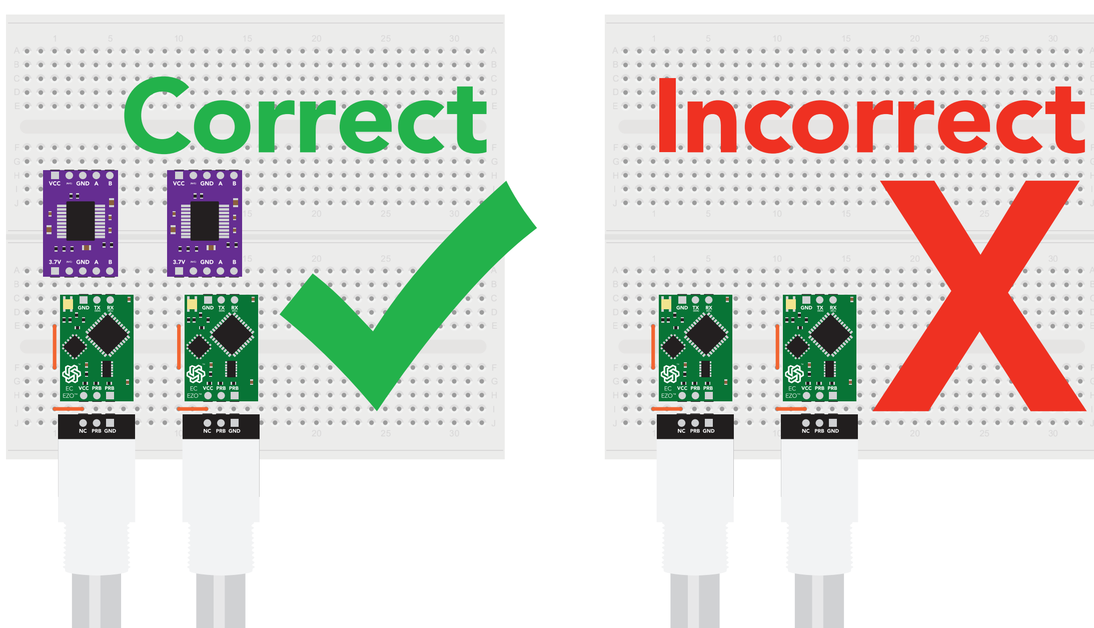






When reading from two EZO™ Conductivity circuits, it is ***strongly recommended*** that they are electrically isolated from each other.

Basic EZO™ Inline Voltage Isolator

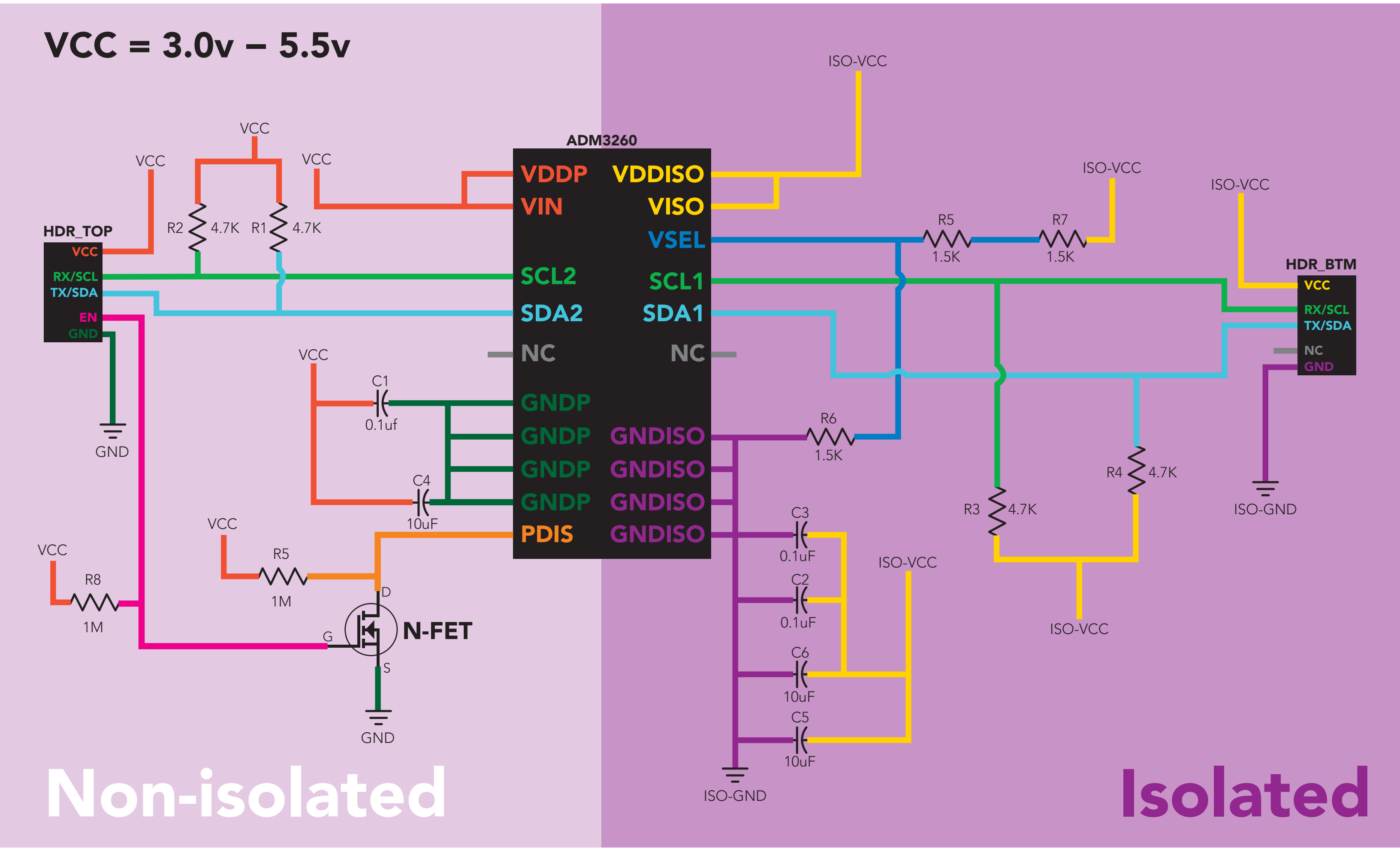


Without isolation, Conductivity readings will effect each other.

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

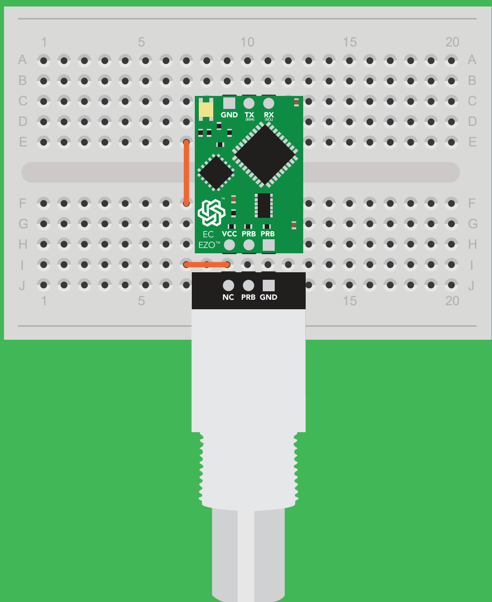
This technology works by using tiny transformers to induce the voltage across an air gap. PCB layout requires special attention for EMI/EMC and RF Control, having proper ground planes and keeping the capacitors as close to the chip as possible are crucial for proper performance. The two data channels 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 R,7) 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.

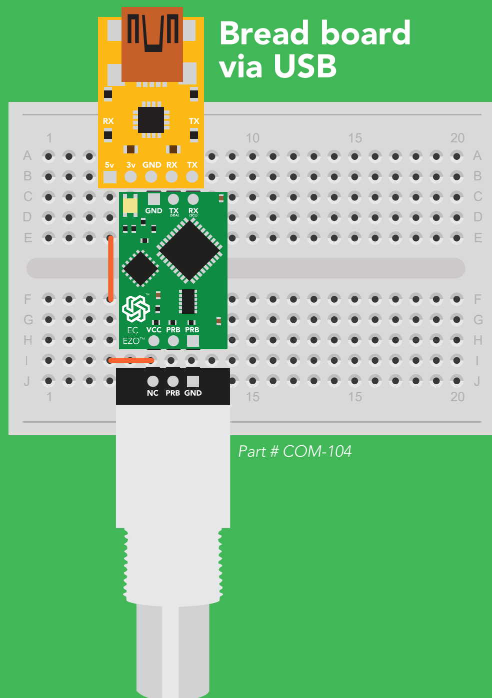


Correct wiring

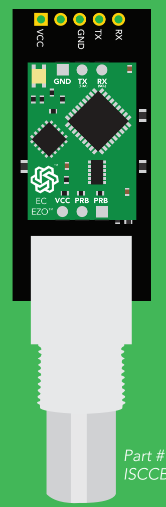
Bread board



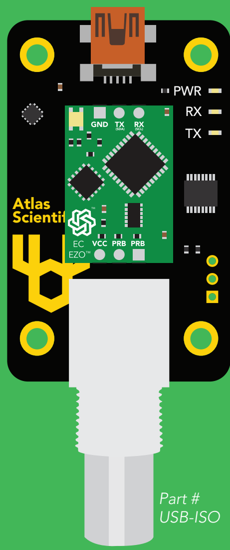
Bread board via USB



Carrier board

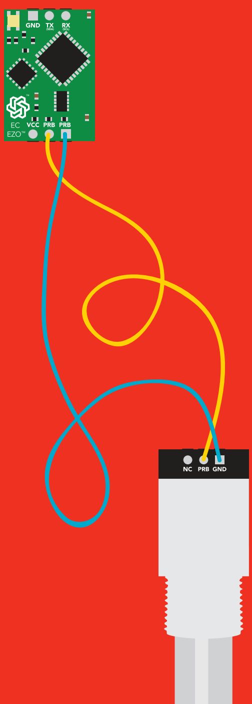


USB carrier board

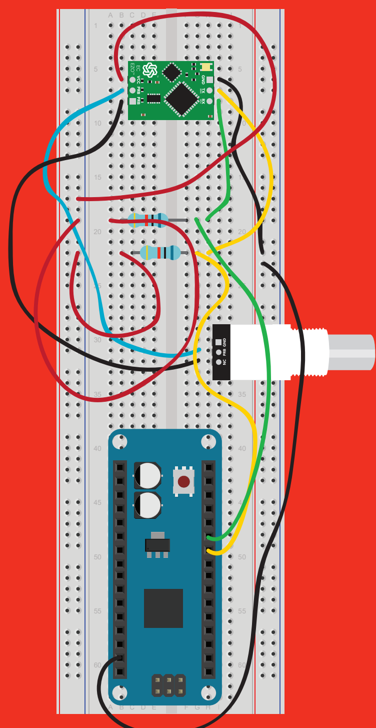


Incorrect wiring

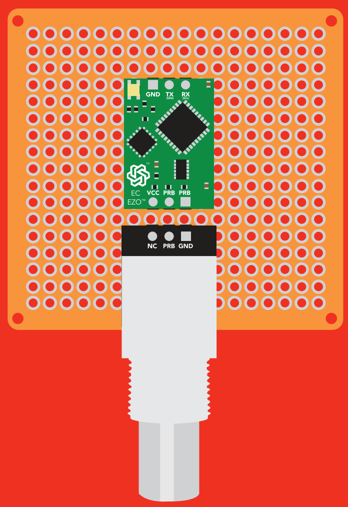
Extended leads



Sloppy setup

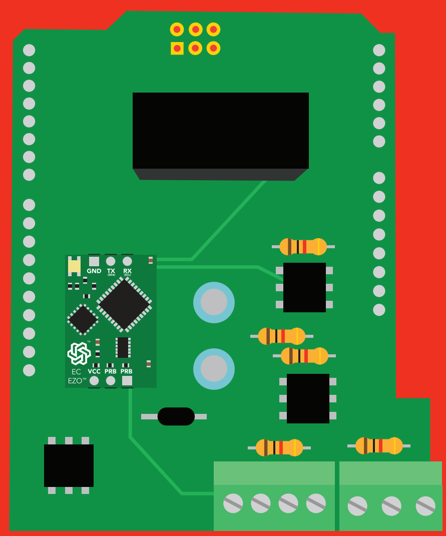


Perfboards or Protoboards



NEVER
use Perfboards or Protoboards

*Embedded into your device



***Only after you are familar with EZO™ circuits operation**

AtlasScientific™ Environmental Robotics

r 0.1

Available data protocols

UART

Default

I²C

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 I²C mode
LED control
Protocol lock
Software switch to I²C mode

Settings that are *NOT* retained if power is cut

Find
Sleep mode
Temperature compensation

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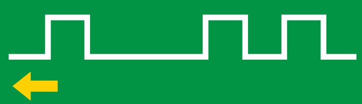
r 0.2

UART mode

8 data bits   no parity
1 stop bit   no flow control

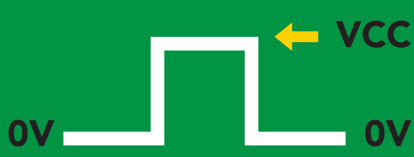
Baud 300
1,200
2,400
9,600 default
19,200
38,400
57,600
115,200

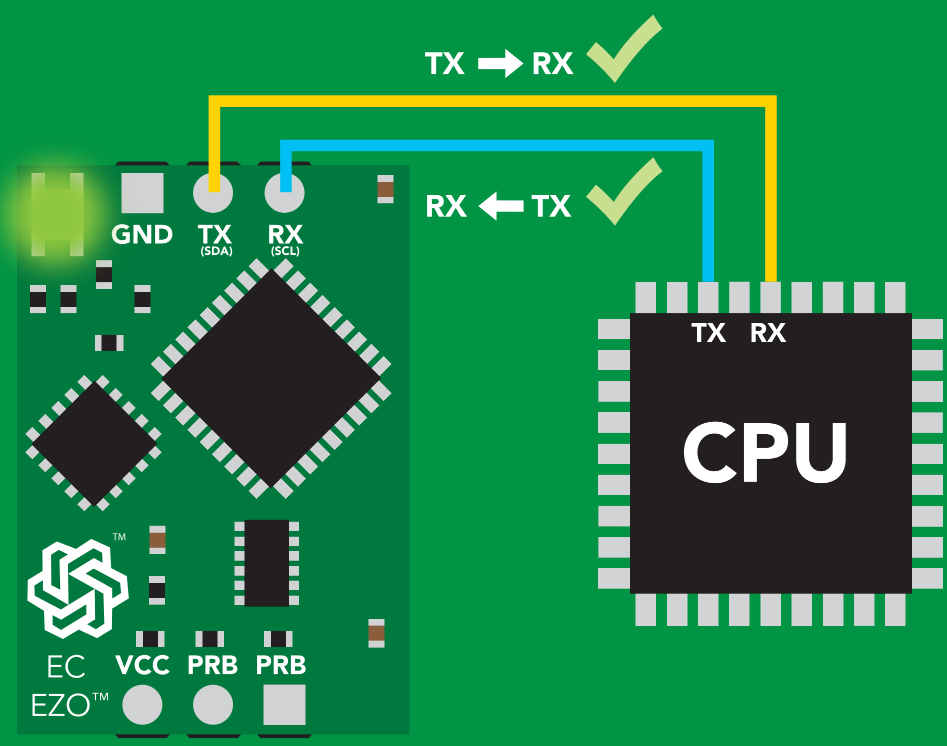
RX
Data in



TX
Data out

Vcc 3.3V – 5.5V





Data format

Reading

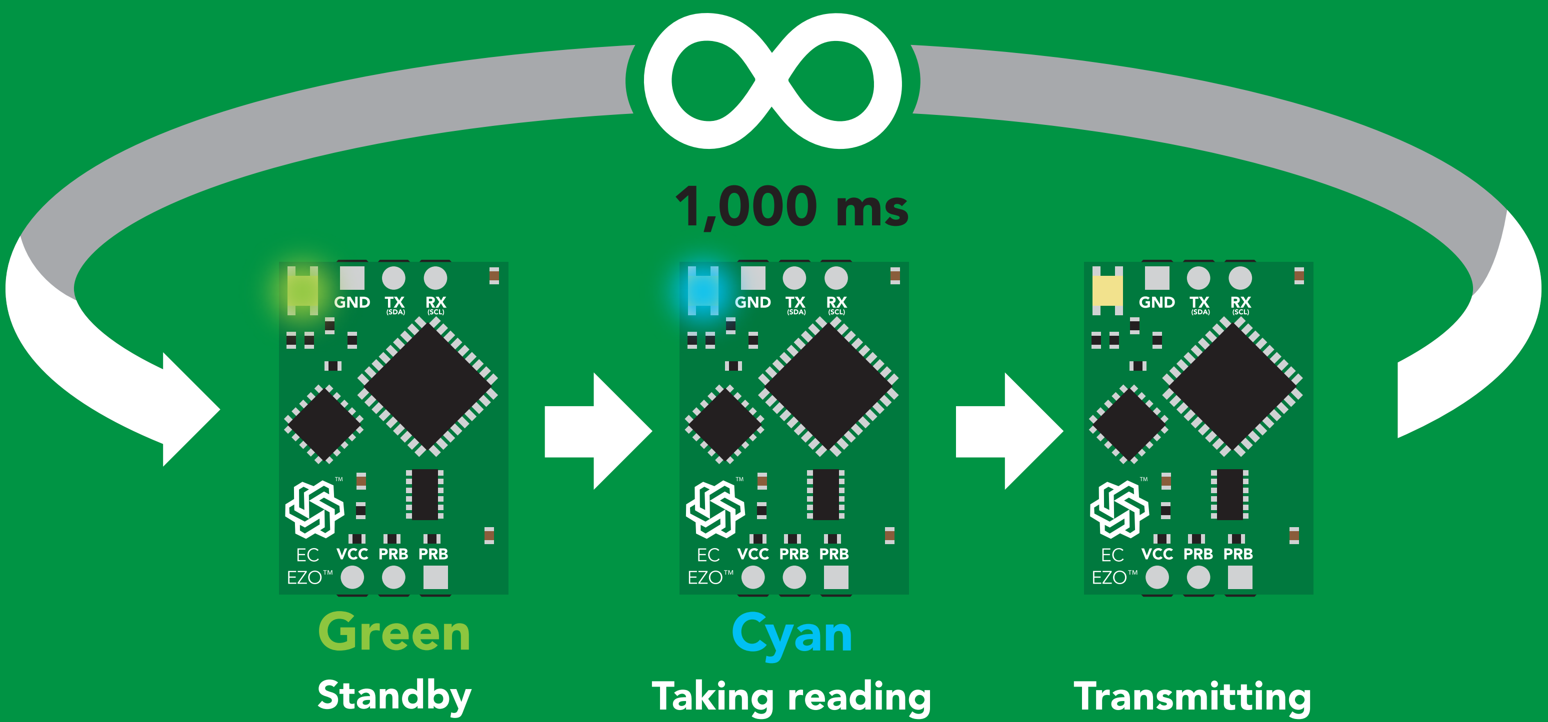
Conductivity = μS/cm
Total dissolved solids = ppm
Salinity = PSU
Specific gravity (sea water only) = 1.00 – 1.300

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

Default state

Mode	**UART**
Baud	**9,600**
Readings	**continuous**
Units	**μS/cm**
Speed	**1 reading per second**
LED	**on**

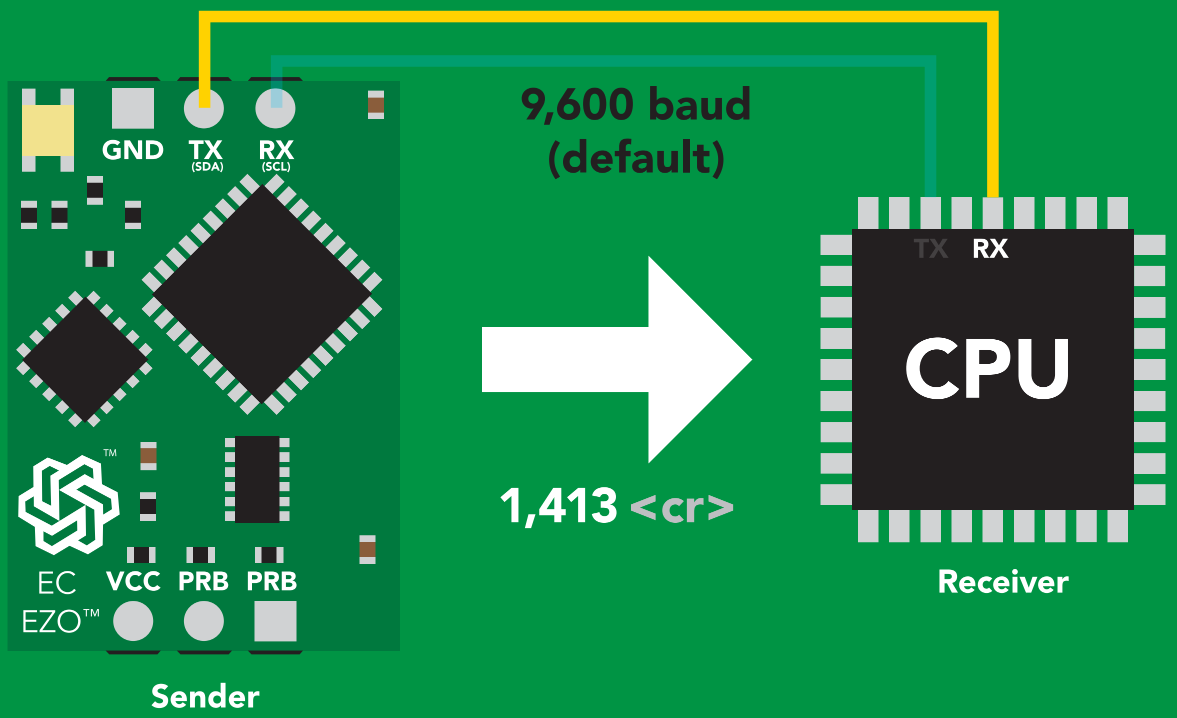


Receiving data from device

2 parts

ASCII data string — Command

Carriage return <cr> — Terminator



Advanced

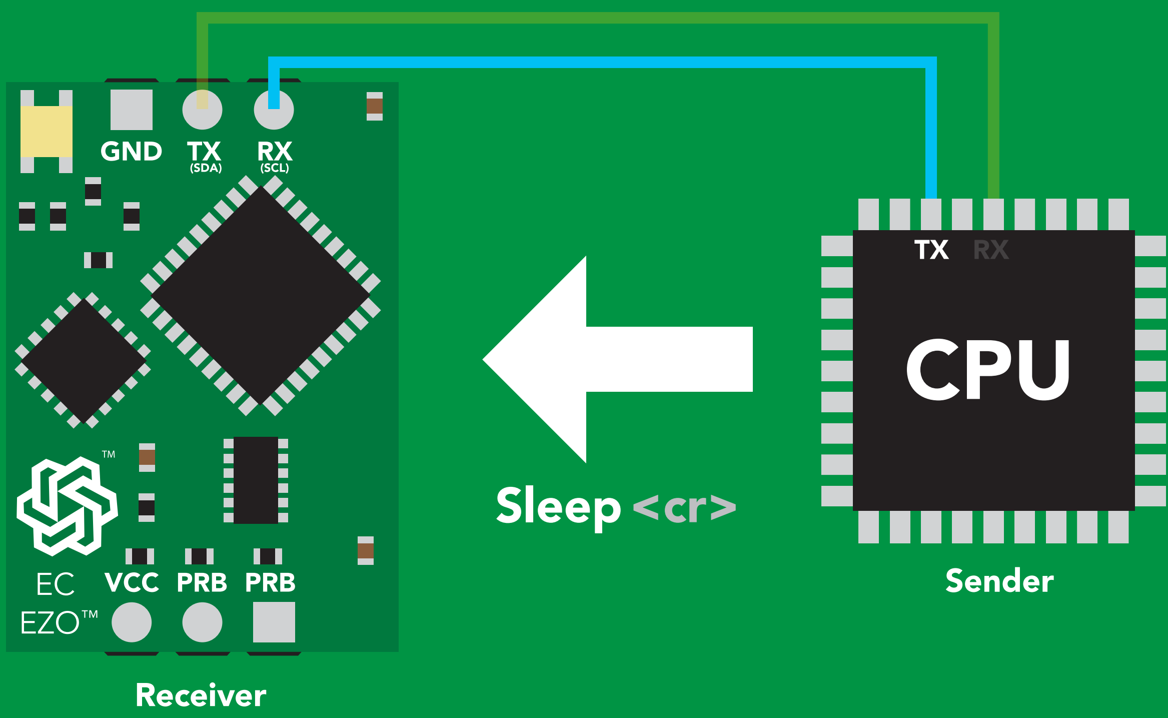
ASCII:	1	,	4	1	3	<cr>
Hex:	31	2C	34	31	33	0D
Dec:	49	44	52	49	51	13

Sending commands to device

2 parts

Command (not case sensitive) — ASCII data string

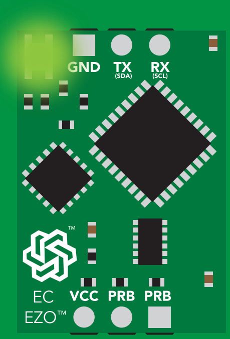
Carriage return <cr> — Terminator



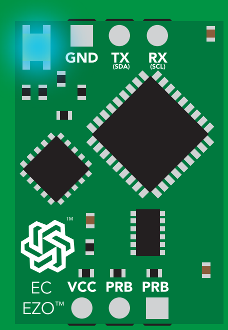
Advanced

ASCII:	S	l	e	e	p	<cr>
Hex:	53	6C	65	65	70	0D
Dec:	83	108	101	101	112	13

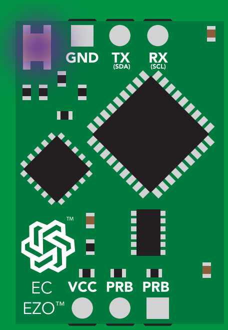
LED color definition



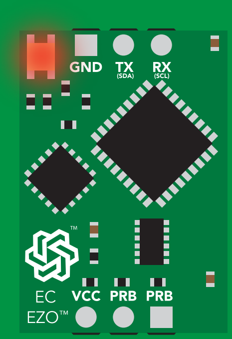
Green
UART standby



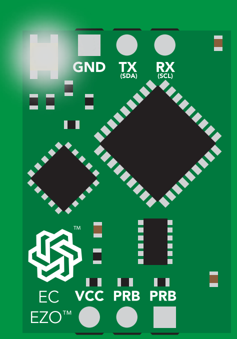
Cyan
Taking reading



Purple
Changing baud rate



Red
Command not understood



White
Find

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

Atlas Scientific™ Environmental Robotics
r 0.1

UART mode

command quick reference

All commands are ASCII strings or single ASCII characters.

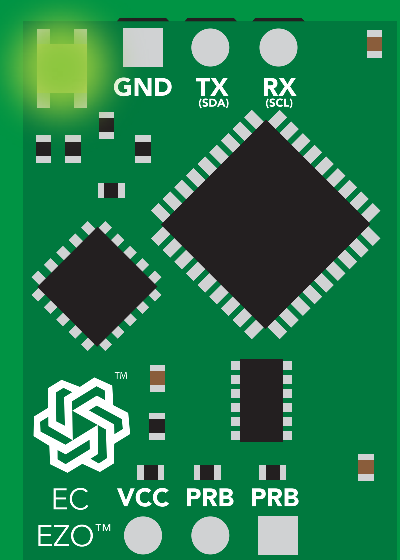
Command	Function		Default state
Baud	change baud rate	pg. 37	9,600
C	enable/disable continuous reading	pg. 25	enabled
Cal	performs calibration	pg. 27	n/a
Export/import	export/import calibration	pg. 28	n/a
Factory	enable factory reset	pg. 39	n/a
Find	finds device with blinking white LED	pg. 24	n/a
i	device information	pg. 33	n/a
I2C	change to I^2C mode	pg. 40	not set
K	Set probe type	pg. 29	K 1.0
L	enable/disable LED	pg. 23	enabled
Name	set/show name of device	pg. 32	not set
O	enable/disable parameters	pg. 31	all enabled
Plock	enable/disable protocol lock	pg. 38	disabled
R	returns a single reading	pg. 26	n/a
Sleep	enter sleep mode/low power	pg. 36	n/a
Status	retrieve status information	pg. 35	enable
T	temperature compensation	pg. 30	25°C
*OK	enable/disable response codes	pg. 34	enable

LED control

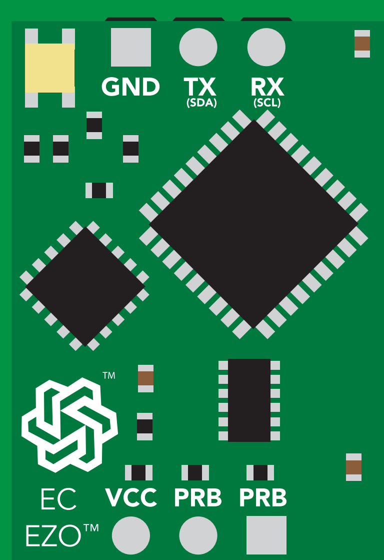
Command syntax

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

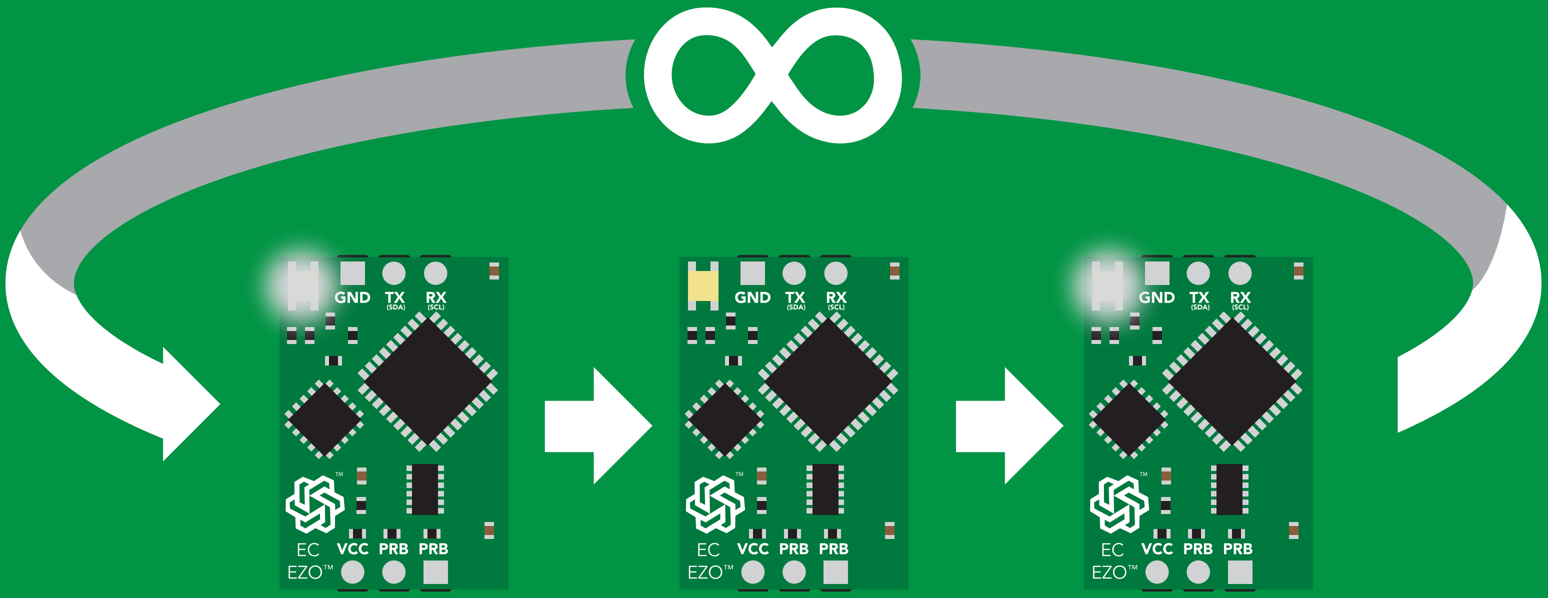
Find

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?

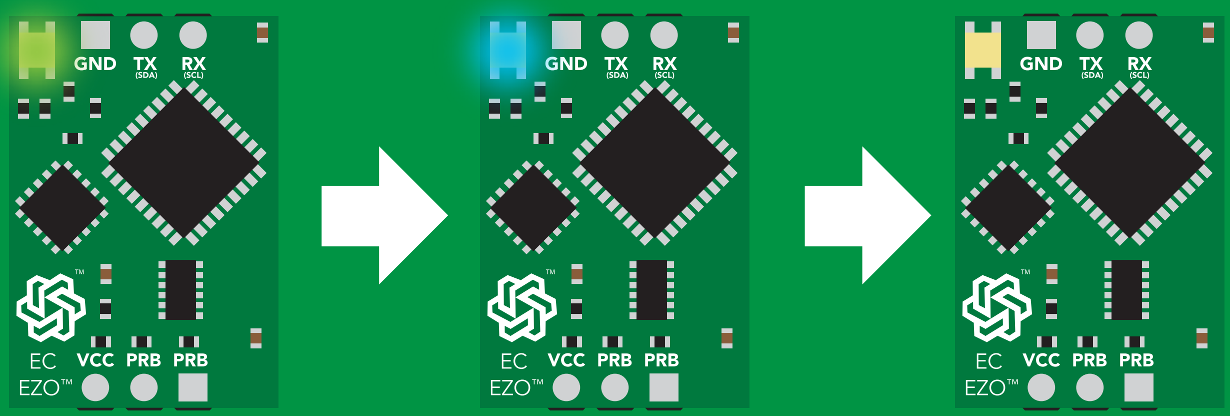
Example	Response
C,1 <cr>	*OK <cr> EC,TDS,SAL,SG (1 sec) <cr> EC,TDS,SAL,SG (2 sec) <cr> EC,TDS,SAL,SG (3 sec) <cr>
C,30 <cr>	*OK <cr> EC,TDS,SAL,SG (30 sec) <cr> EC,TDS,SAL,SG (60 sec) <cr> EC,TDS,SAL,SG (90 sec) <cr>
C,0 <cr>	*OK <cr>
C,? <cr>	?C,1 <cr> or ?C,0 <cr> or ?C,30 <cr> *OK <cr>

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

600 ms

Calibration

Command syntax

Dry calibration must always be done first!

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

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> (two point) or ?CAL,2 (three point) *OK <cr>

Two point calibration:
Step 1. "cal,dry"
Step 2. "cal,n"
Calibration complete!

Three point calibration:
Step 1 "cal,dry"
Step 2 "cal,low,n"
Step 3 "cal,high.n"
Calibration complete!

Export/import calibration

Command syntax

Export: Use this command to save calibration settings
Import: Use this command to load calibration settings to one or more devices.

Export	<cr>	export calibration string from calibrated device
Import	<cr>	import calibration string to new device
Export,?	<cr>	calibration string info

Example	Response
Export,? <cr>	10,120 <cr>

Response breakdown

10, 120

10 = # of strings to export
120 = # of bytes to export

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

Example	Response
Export <cr>	59 6F 75 20 61 72 <cr> (1 of 10)
Export <cr>	65 20 61 20 63 6F <cr> (2 of 10)
(8 more)	⋮
Export <cr>	6F 6C 20 67 75 79 <cr> (10 of 10)
Export <cr>	*DONE

Disabling *OK simplifies this process

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

Setting the probe type

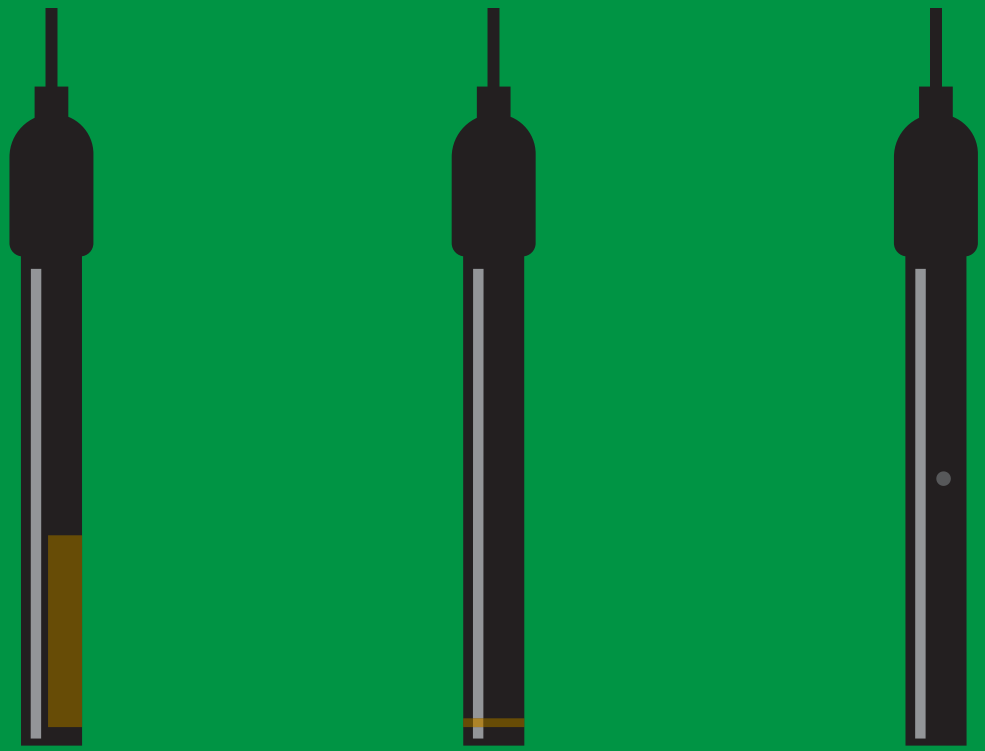
Command syntax

K 1.0 is the default value

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

K,? <cr> probe K value?

Example	Response
K,10 <cr>	*OK <cr>
K,? <cr>	?K,10 <cr> *OK <cr>



K 0.1 K 1.0 K 10

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Temperature compensation

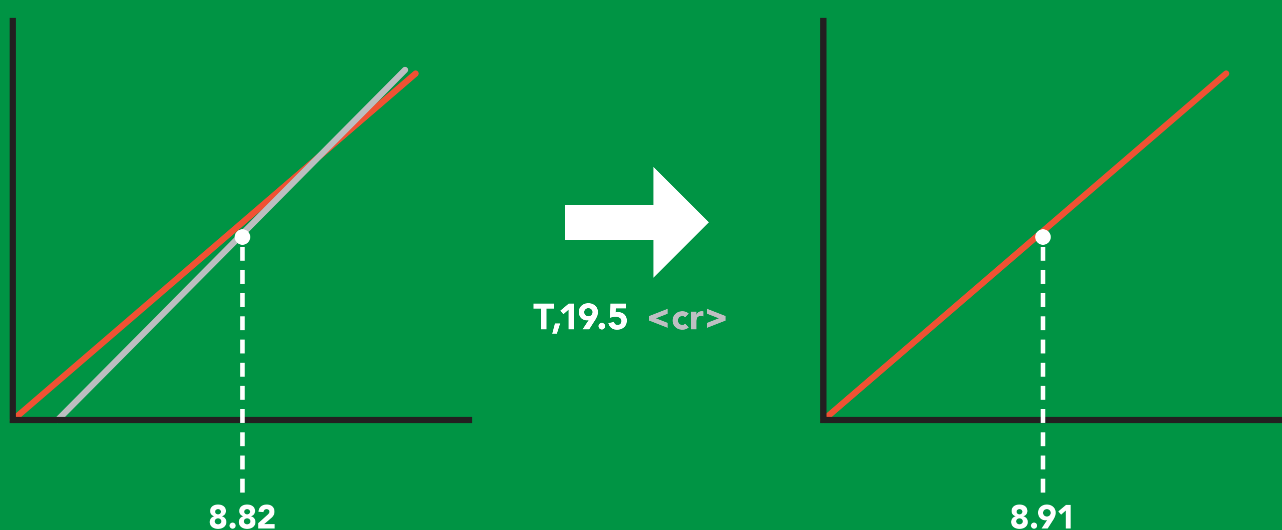
Command syntax

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	Response
T,19.5 <cr>	*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	Response
O,EC,1 / O,EC,0 <cr>	*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**

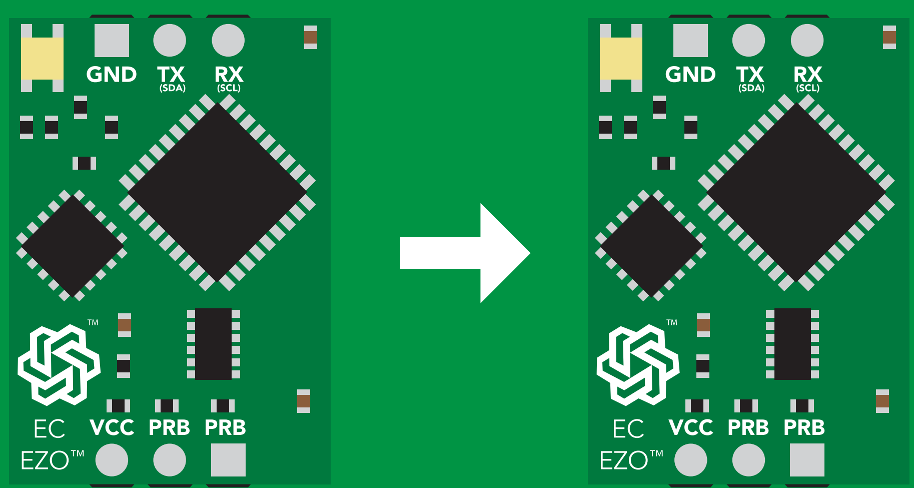
Name,? <cr> **show name**

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

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

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Environmental Robotics
r 0.1

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	Response
Sleep <cr>	*SL
Any command	*WA <cr> wakes up device

	STANDBY	SLEEP
5V	18.14 mA	0.7 mA
3.3V	16.85 mA	0.4 mA

Standby
18.14 mA

Sleep
0.7 mA

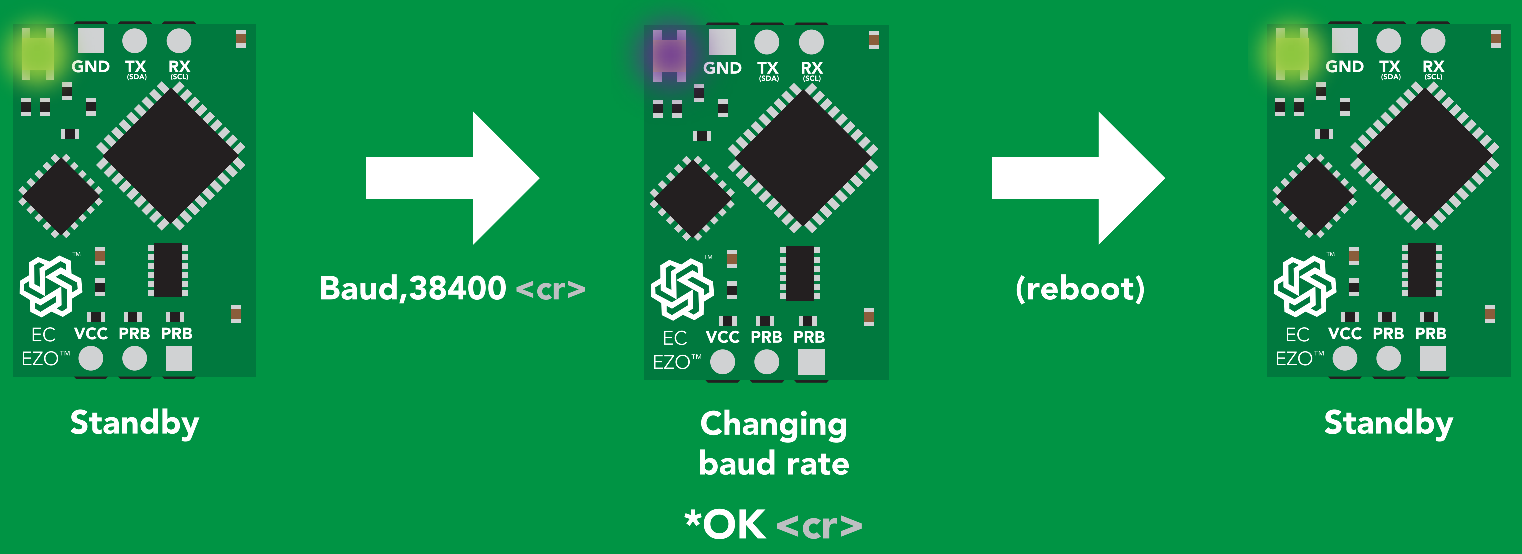
Change baud rate

Command syntax

Baud,n <cr> **change baud rate**

Example	Response
Baud,38400 <cr>	*OK <cr>
Baud,? <cr>	?Baud,38400 <cr> *OK <cr>

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



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Protocol lock

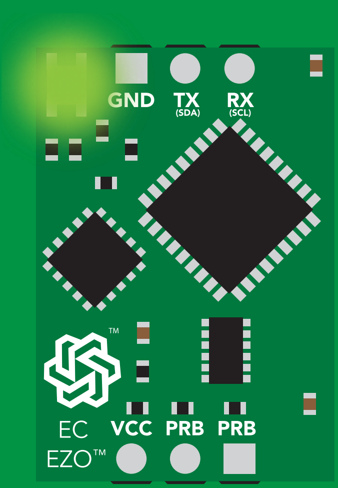
Command syntax

Locks device to UART mode.

Plock,1	<cr>	enable Plock	
Plock,0	<cr>	disable Plock	default
Plock,?	<cr>	Plock on/off?	

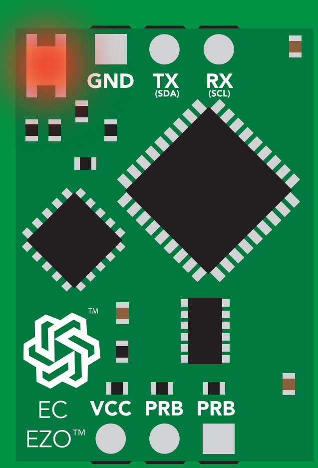
Example	Response
Plock,1 <cr>	*OK <cr>
Plock,0 <cr>	*OK <cr>
Plock,? <cr>	?Plock,1 <cr> or ?Plock,0 <cr>

Plock,1



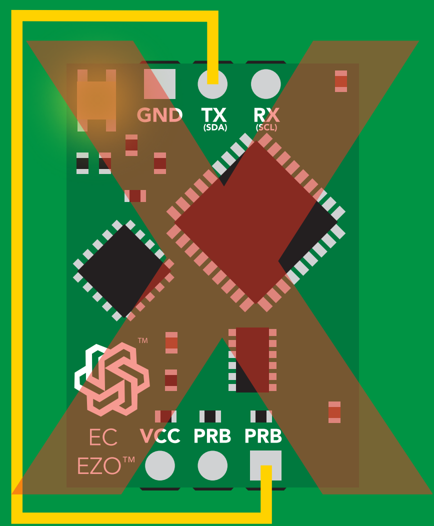
*OK <cr>

I2C,100



cannot change to I²C
*ER <cr>

Short



cannot change to I²C

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r 0.1

Factory reset

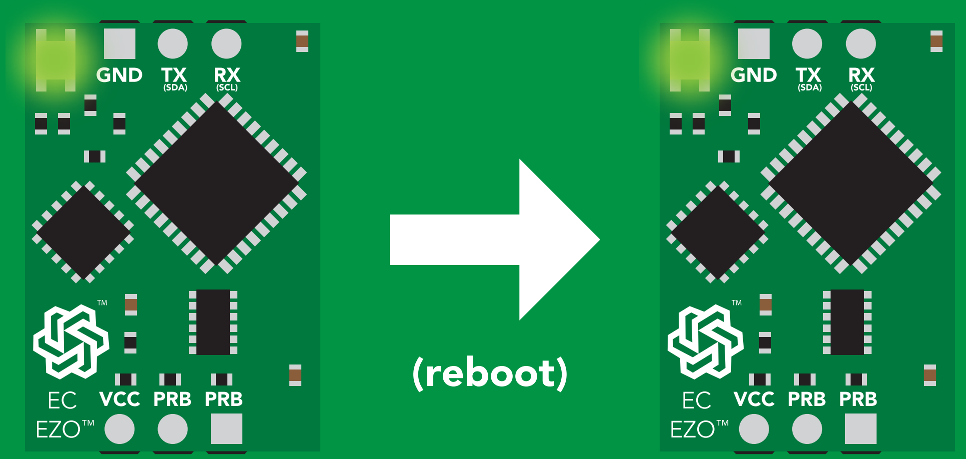
Clears calibration
LED on
"*OK" enabled

Command syntax

Factory	<cr>	**enable factory reset**

Example	Response
Factory <cr>	*OK <cr>

Factory <cr>



*OK <cr>

*RS <cr>
*RE <cr>

Baud rate will not change

Change to I^{2}C mode

Command syntax

Default I^{2}C address 100 (0x64)

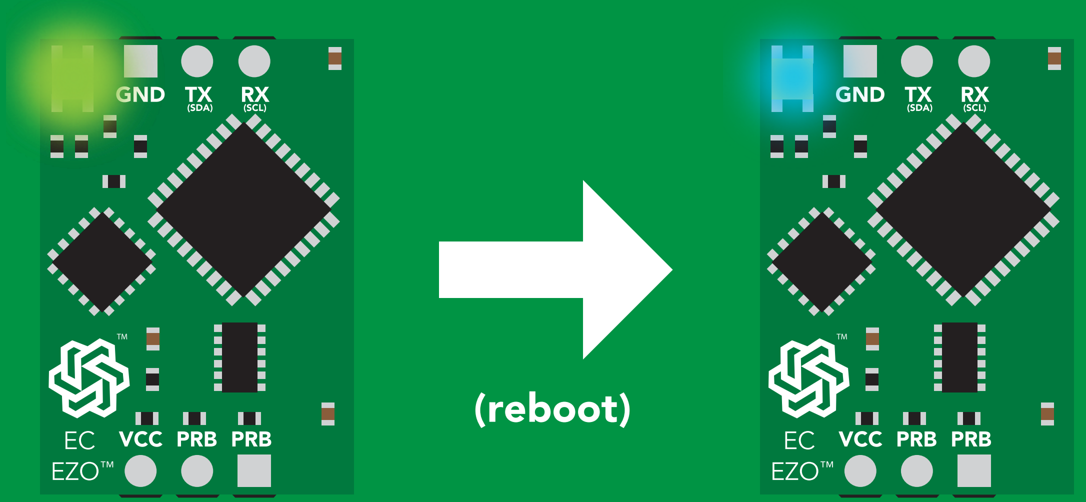
I2C,n <cr> sets I^{2}C address and reboots into I^{2}C mode

n = any number 1 – 127

Example	Response
I2C,100 <cr>	*OK (reboot in I^{2}C mode)

Wrong example	Response
I2C,139 <cr> n ≯ 127	*ER <cr>

I2C,100



Green
*OK <cr>

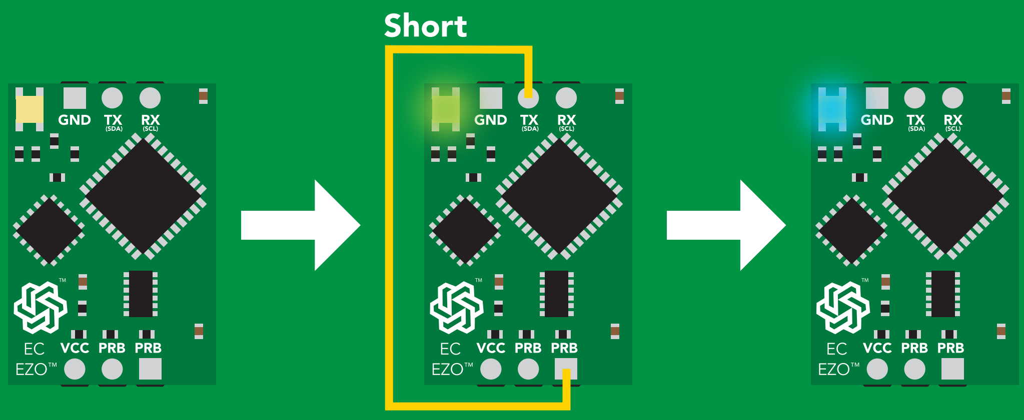
Blue
now in I^{2}C mode

Manual switching to I²C

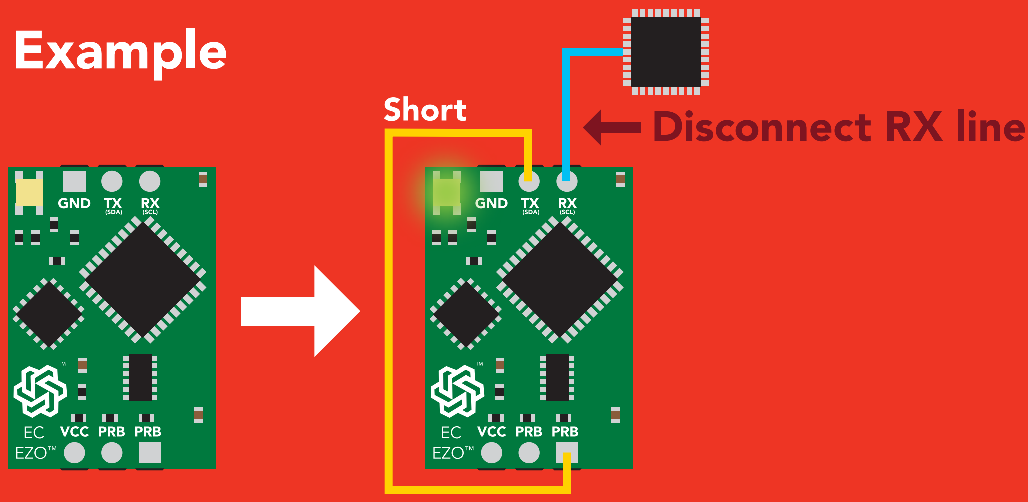
- Make sure Plock is set to 0
- Disconnect ground (power off)
- Disconnect TX and RX
- Connect TX to the right PRB
- Confirm RX is disconnected
- Connect ground (power on)
- Wait for LED to change from Green to Blue
- Disconnect ground (power off)
- Reconnect all data and power

Manually switching to I²C will set the I²C address to 100 (0x64)

Example



Wrong Example



I^2C mode

The I^2C 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^2C mode click here

Settings that are retained if power is cut

Calibration
Change I^2C 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

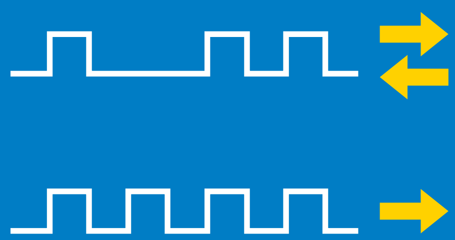
Find
Sleep mode
Temperature compensation

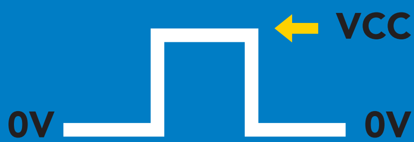
I²C mode

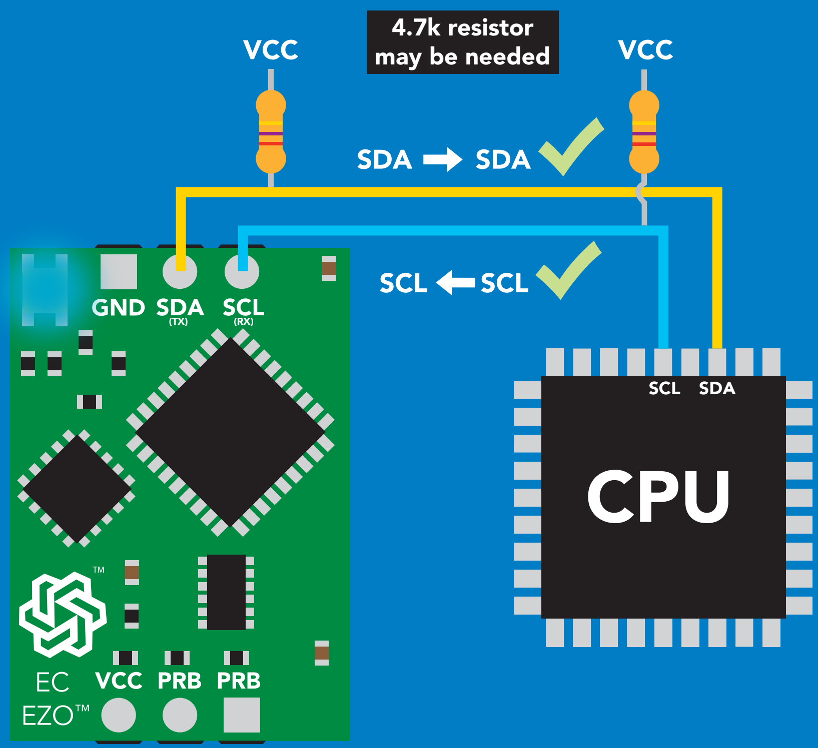
I²C address (0x01 – 0x7F)
100 (0x64) default

Vcc 3.3V – 5.5V

Clock speed 100 – 400 kHz







Data format

Reading	Conductivity = μS/cm Total dissolved solids = ppm Salinity = PSU Specific gravity (sea water only) = 1.00 – 1.300
Units	EC,TDS,SAL,SG
Encoding	ASCII

Format	string
Data type	floating point
Decimal places	3
Smallest string	3 characters
Largest string	399 characters

Sending commands to device

5 parts

Start | I²C address | Write | Command (not case sensitive) | Stop

I²C address: 100 (0x64)

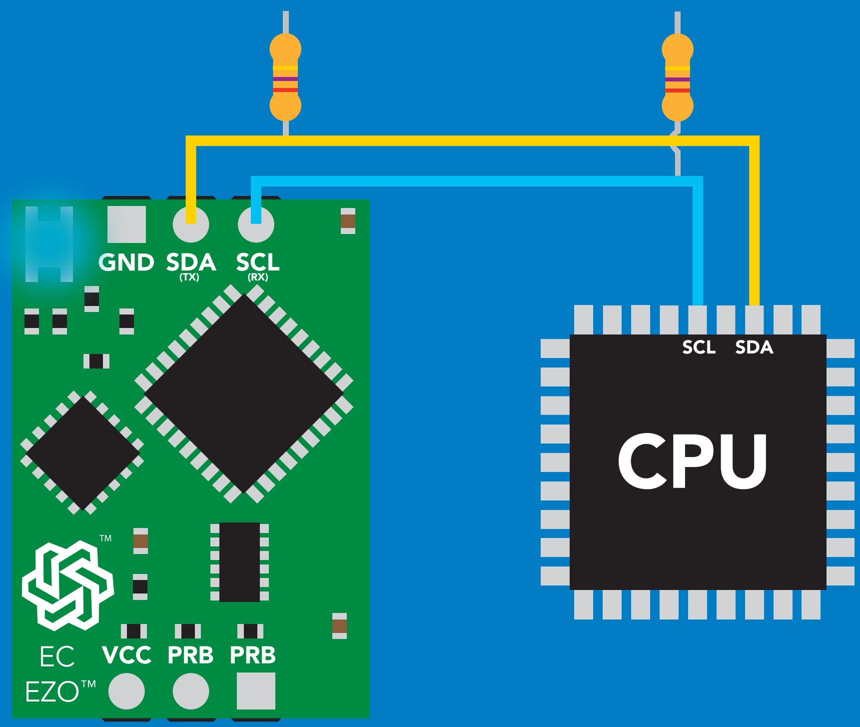
Command: ASCII command string

Example

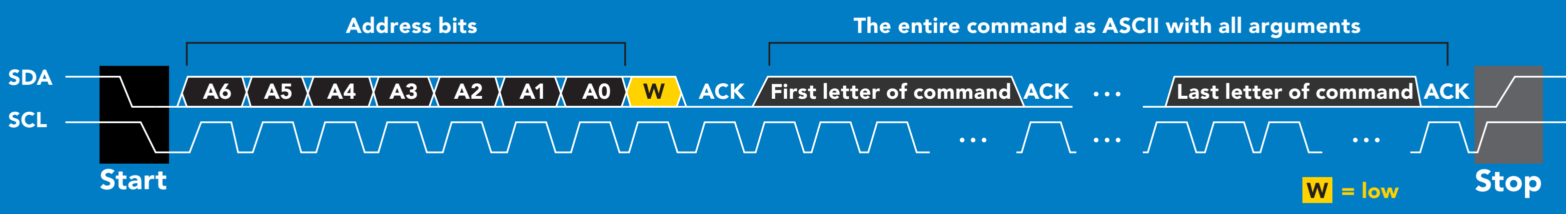
Start | 100 (0x64) | Write | Sleep | Stop

100 (0x64): I²C address

Sleep: Command



Advanced



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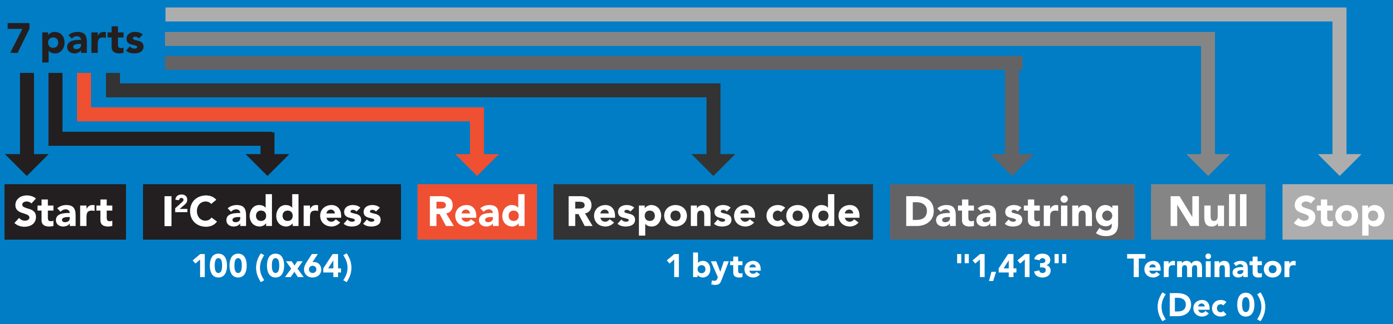
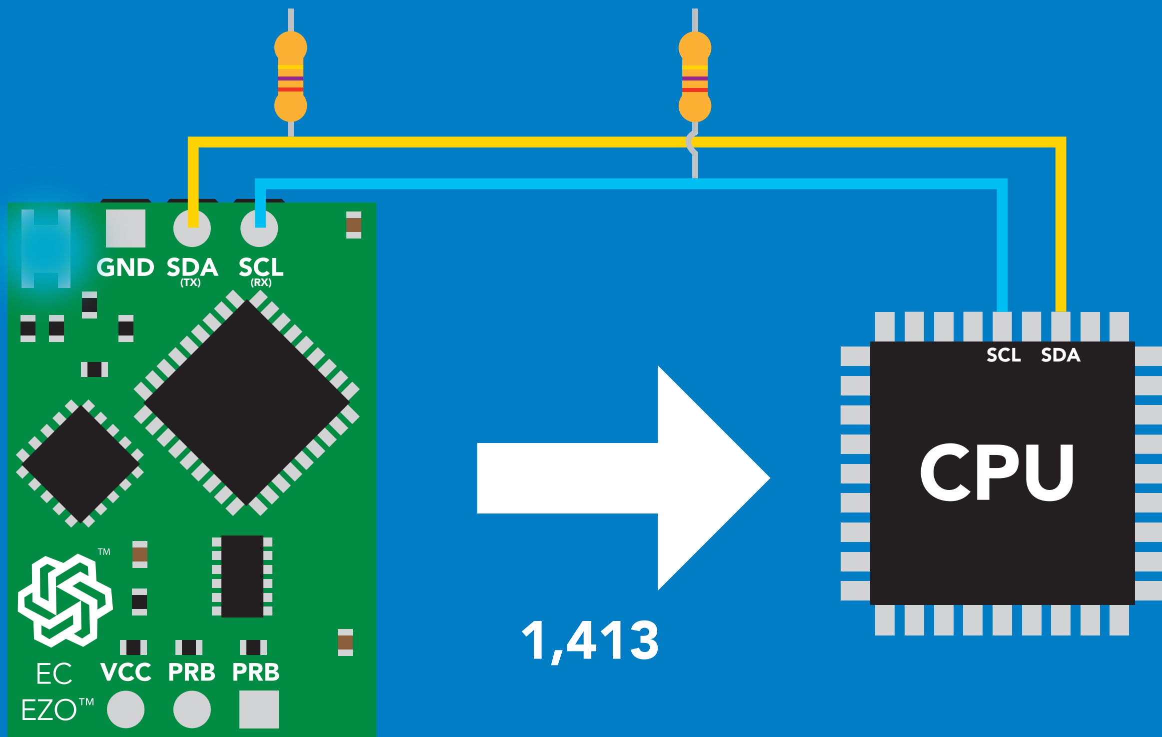
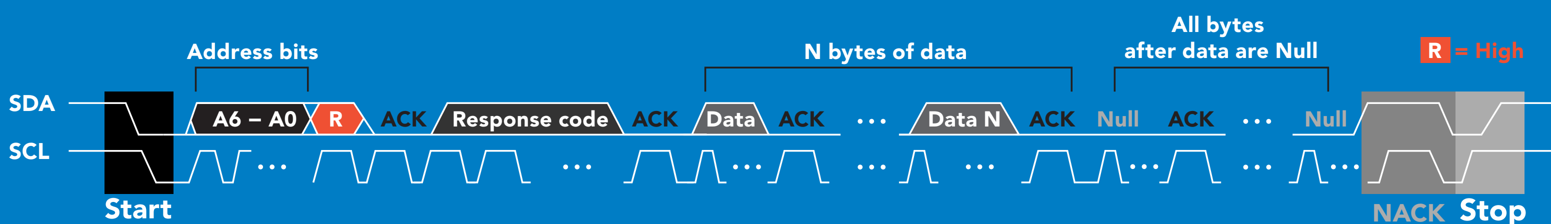
Requesting data from device





Advanced



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

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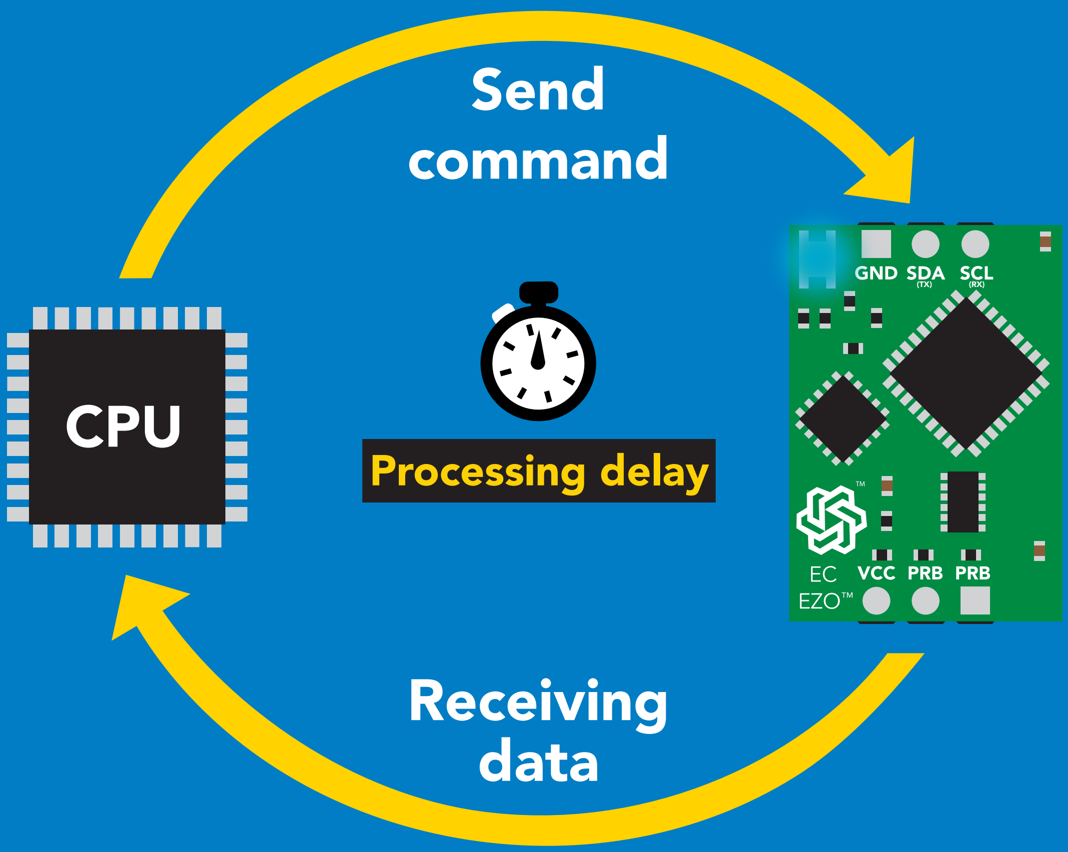
Response codes

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;
```

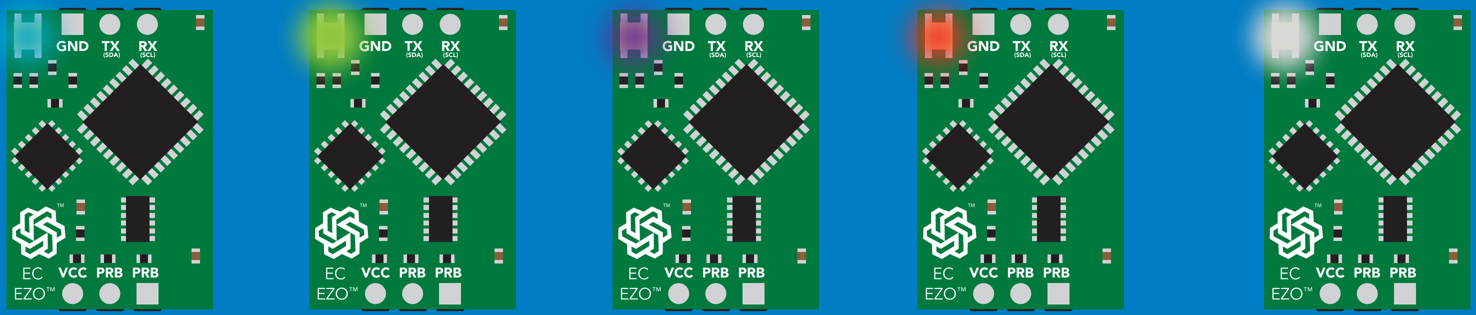
The response code will always be 254, if you do not wait for the processing delay.

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	Green	Purple	Red	White
I²C standby	Taking reading	Changing I²C ID#	Command not understood	Find

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

I²C mode
command quick reference

All commands are ASCII strings or single ASCII characters.

Command	Function	
Baud	switch back to UART mode	pg. 63
Cal	performs calibration	pg. 52
Export/import	export/import calibration	pg. 53
Factory	enable factory reset	pg. 62
Find	finds device with blinking white LED	pg. 50
i	device information	pg. 57
I2C	change I²C address	pg. 61
K	Set probe type	pg. 54
L	enable/disable LED	pg. 49
O	enable/disable parameters	pg. 56
Plock	enable/disable protocol lock	pg. 60
R	returns a single reading	pg. 51
Sleep	enter sleep mode/low power	pg. 59
Status	retrieve status information	pg. 58
T	temperature compensation	pg. 55

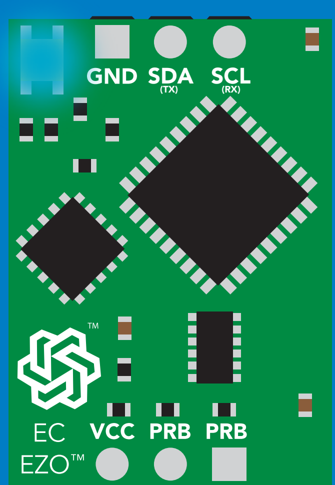
LED control

Command syntax

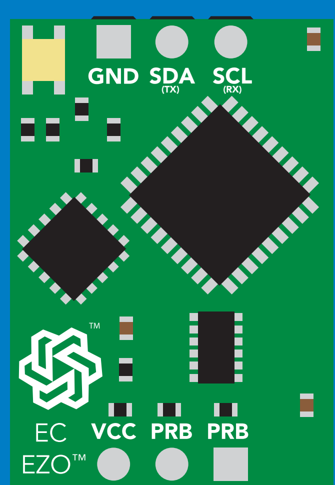
300ms processing delay

L,1	LED on	default
L,0	LED off	
L,?	LED state on/off?	

Example	Response
L,1	Wait 300ms — 1 (Dec) 0 (Null)
L,0	Wait 300ms — 1 (Dec) 0 (Null)
L,?	Wait 300ms — 1 (Dec) ?L,1 (ASCII) 0 (Null) or 1 (Dec) ?L,0 (ASCII) 0 (Null)



L,1



L,0

Find

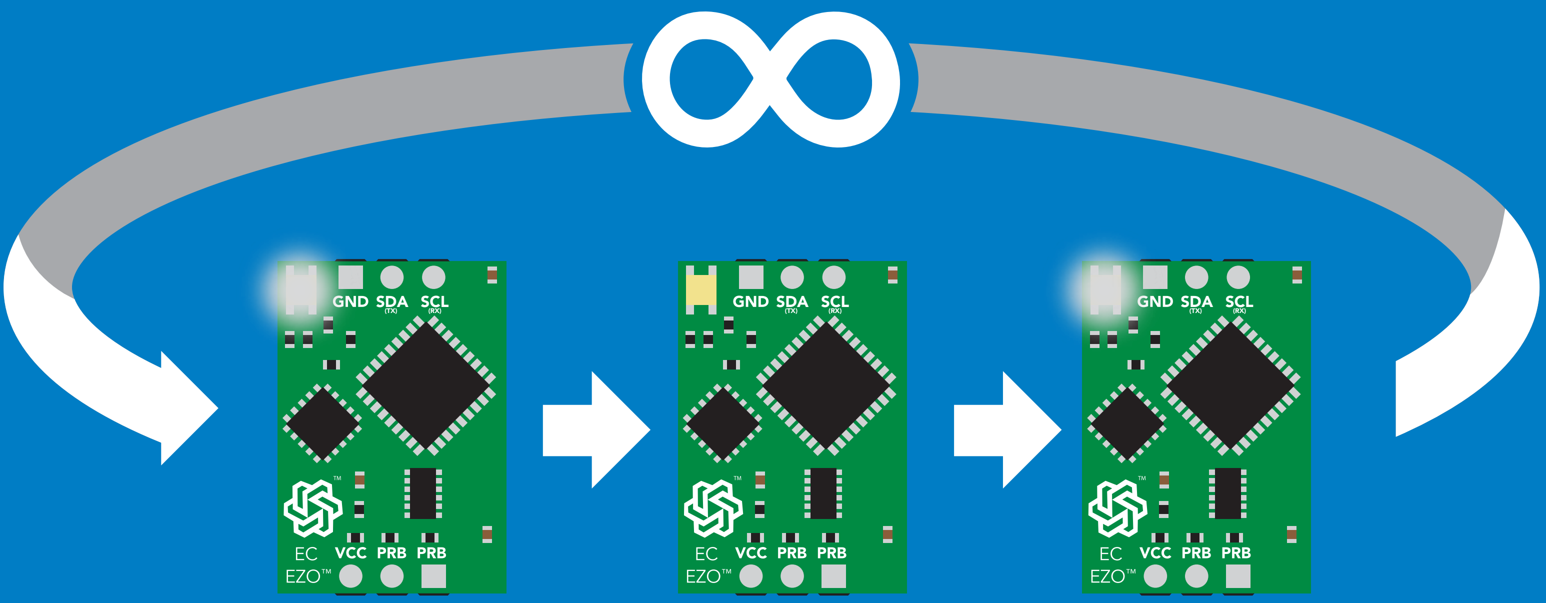
300ms processing delay

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



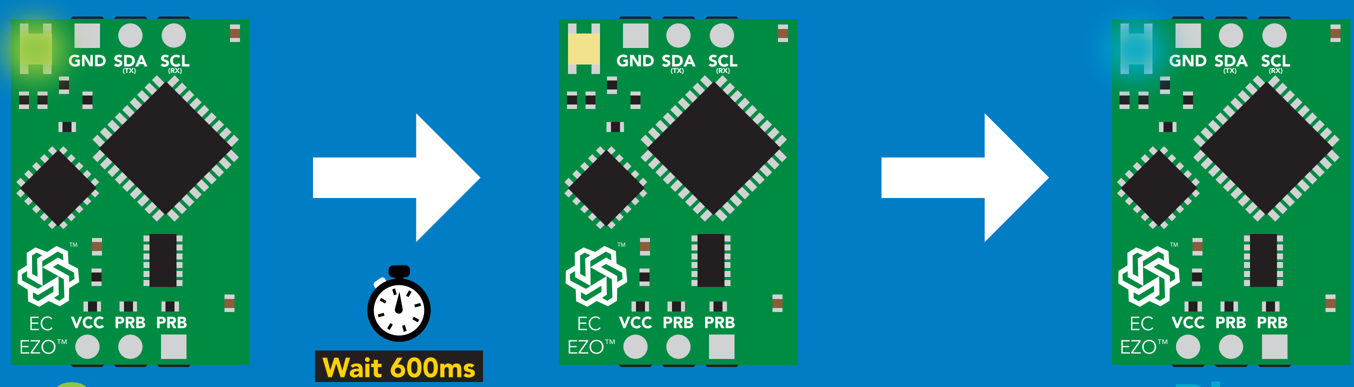
Taking reading

Command syntax

600ms processing delay

R return 1 reading

Example	Response
R	Wait 600ms · 1 (Dec) · 1,413 (ASCII) · 0 (Null)



Green
Taking reading

Transmitting

Blue
Standby

Calibration

600ms processing delay

Dry calibration must always be done first!

Command syntax

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

Example	Response
Cal,dry	Wait 600ms; 1 Dec, 0 Null
Cal,84	Wait 600ms; 1 Dec, 0 Null
Cal,low,12880	Wait 600ms; 1 Dec, 0 Null
Cal,high,80000	Wait 600ms; 1 Dec, 0 Null
Cal,clear	Wait 300ms; 1 Dec, 0 Null
Cal,?	Wait 300ms; 1 Dec, ?CAL,0 ASCII, 0 Null or 1 Dec, ?CAL,1 ASCII (two point), 0 Null or 1 Dec, ?CAL,2 ASCII (three point), 0 Null

Two point calibration:
Step 1. "cal,dry"
Step 2. "cal,n"
Calibration complete!

Three point calibration:
Step 1 "cal,dry"
Step 2 "cal,low,n"
Step 3 "cal,high,n"
Calibration complete!

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Export/import calibration

Command syntax

Export: Use this command to save calibration settings
Import: Use this command to load calibration settings to one or more devices.

Export	export calibration string from calibrated device
Import	import calibration string to new device
Export,?	calibration string info

300ms processing delay

Example	Response
Export,?	Wait 300ms — 1 (Dec) 10,120 (ASCII) 0 (Null)
Export	Wait 300ms — 1 (Dec) 59 6F 75 20 61 72 (ASCII) 0 (Null) (1 of 10)
(8 more)	⋮
Export	Wait 300ms — 1 (Dec) 65 20 61 20 63 6F (ASCII) 0 (Null) (10 of 10)
Export	Wait 300ms — 1 (Dec) *DONE (ASCII) 0 (Null)
Import, n (FIFO)	Import, 59 6F 75 20 61 72 (ASCII) (1 of 10)

Response breakdown

10, 120

10 = # of strings to export; 120 = # of bytes to export

Export strings can be up to 12 characters long

Setting the probe type

Command syntax

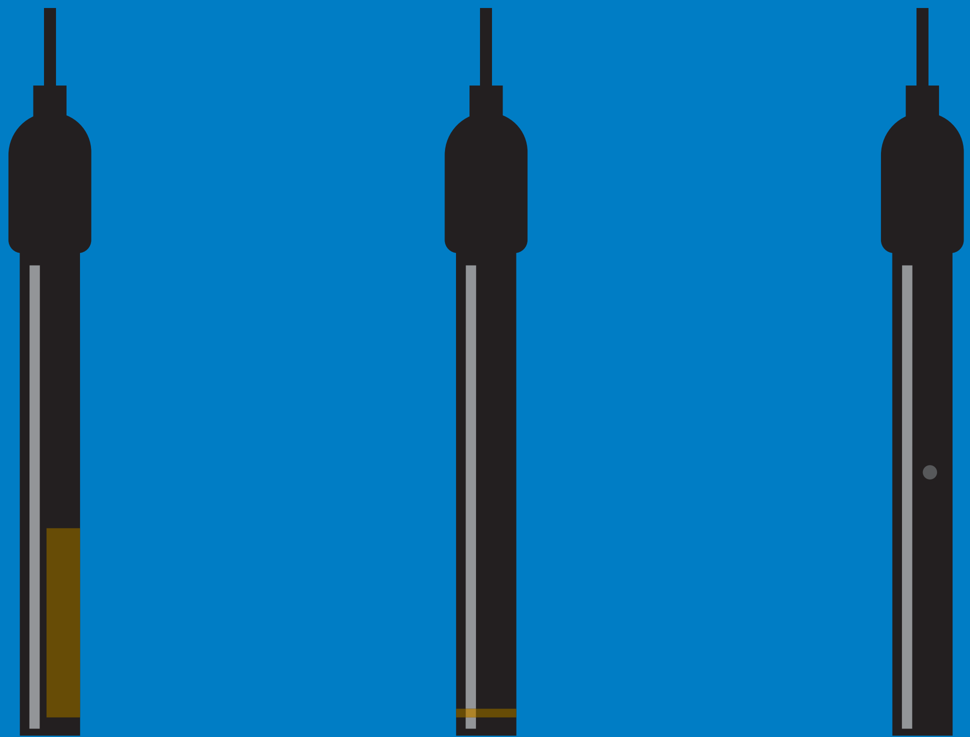
300ms processing delay

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

K,?   probe K value?

K 1.0 is the default 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

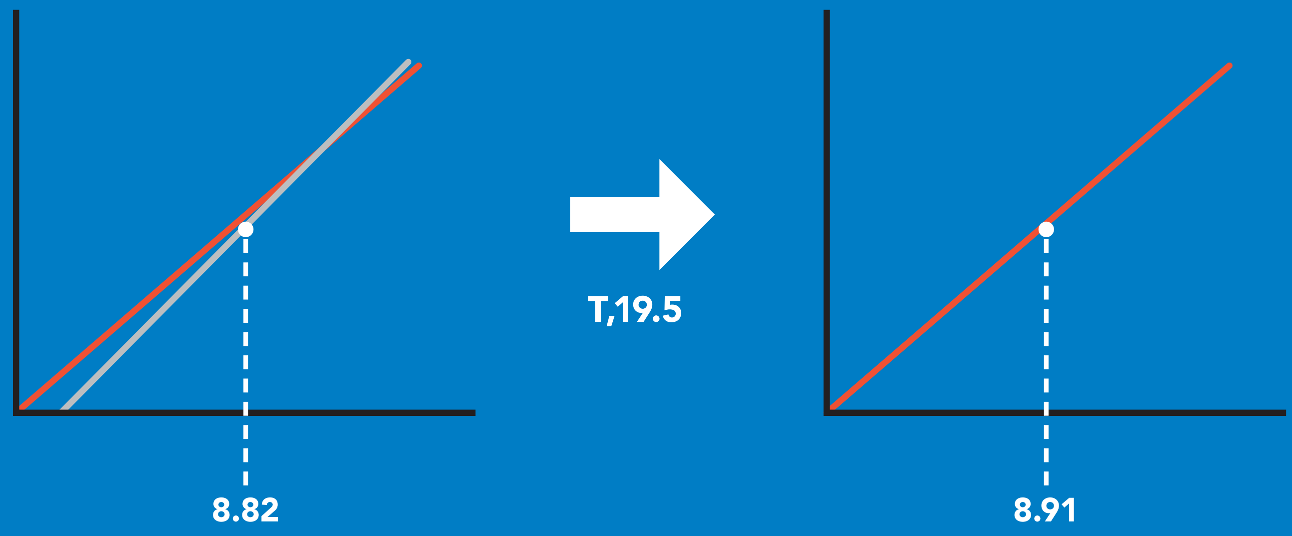
Default temperature = 25°C
Temperature is always in Celsius
Temperature is not retained if power is cut

T,n	n = any value; floating point or int
T,?	compensated temperature value?
RT,n	set temperature compensation and take a reading*

300ms processing delay

This is a new command for firmware V2.13

Example	Response
T,19.5	Wait 300ms — 1 (Dec) 0 (Null)
RT,19.5	Wait 900ms — 1 (Dec) 8.91 (ASCII) 0 (Null)
T,?	Wait 300ms — 1 (Dec) ?T,19.5 (ASCII) 0 (Null)



AtlasScientific™ Environmental Robotics
r 0.2

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,EC,1 / O,EC,0	Wait 300ms · 1 Dec · 0 Null	enable / disable conductivity
O,TDS,1 / O,TDS,0	Wait 300ms · 1 Dec · 0 Null	enable / disable total dissolved solids
O,S,1 / O,S,0	Wait 300ms · 1 Dec · 0 Null	enable / disable salinity
O,SG,1 / O,SG,0	Wait 300ms · 1 Dec · 0 Null	enable / disable specific gravity
O,?	Wait 300ms · 1 Dec · ?,O,EC,TDS,S,SG ASCII · 0 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”.

AtlasScientific™ Environmental Robotics

Device information

Command syntax

300ms processing delay

i	**device information**

Example / Response

Example	Response
i	Wait 300ms · 1 (Dec) · ?i,EC, 2.10 (ASCII) · 0 (Null)

Response breakdown

?i, EC, 2.10

EC, ↑ Device

2.10 ↑ 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 (Dec) ?Status,P,5.038 (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
Any command	wakes up device

Do not read status byte after issuing sleep command.

	STANDBY	SLEEP
5V	18.14 mA	0.7 mA
3.3V	16.85 mA	0.4 mA

Standby Sleep

Protocol lock

Command syntax

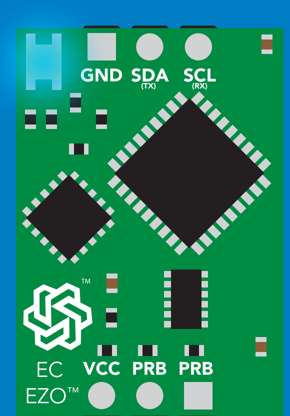
300ms processing delay

Locks device to I²C mode.

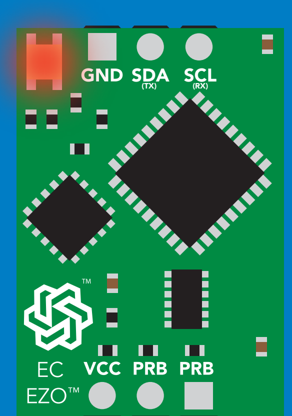
Plock,1	enable Plock	
Plock,0	disable Plock	default
Plock,?	Plock on/off?	

Example	Response
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)

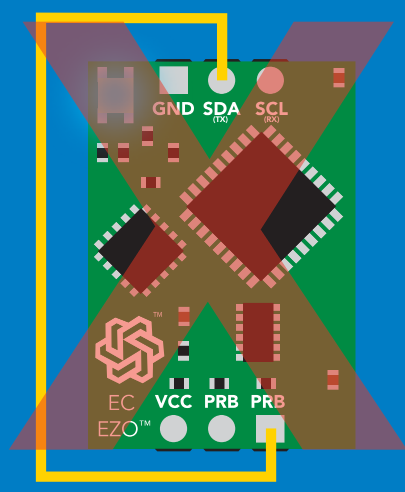
Plock,1



Baud, 9600



cannot change to UART



cannot change to UART

I²C address change

Command syntax

300ms processing delay

I2C,n sets I²C address and reboots into I²C mode

Example	Response
I2C,101	device reboot

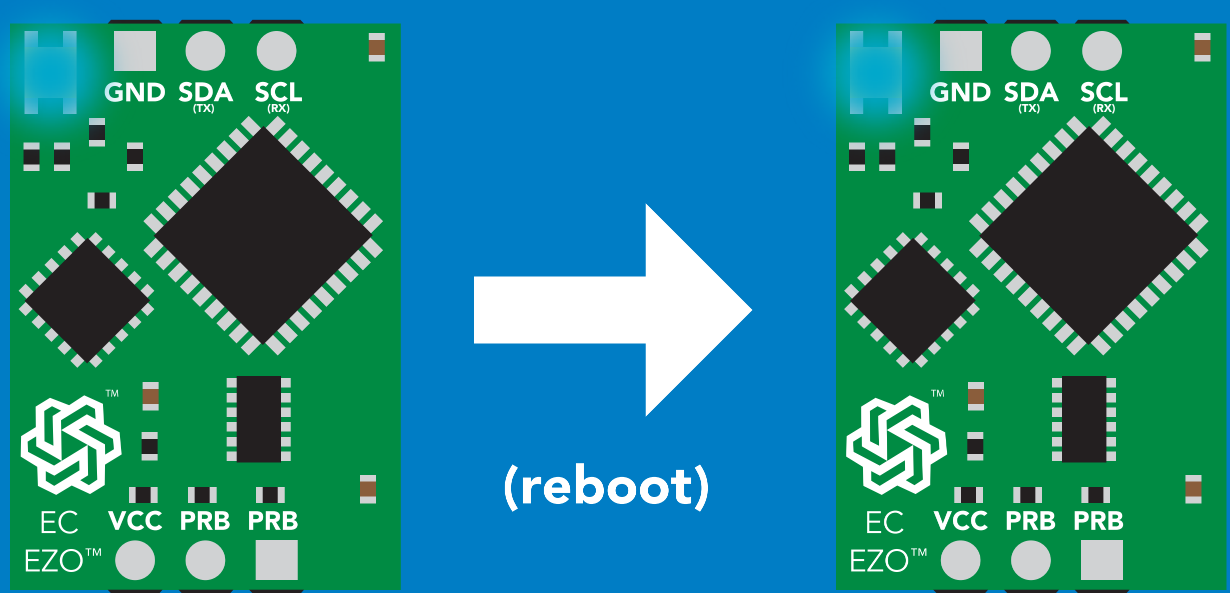
Warning!

Changing the I²C address will prevent communication between the circuit and the CPU until your CPU is updated with the new I²C address.

Default I²C address is 100 (0x64).

n = any number 1 – 127

I2C,101



Factory reset

Command syntax

Factory reset will not take the device out of I²C mode.

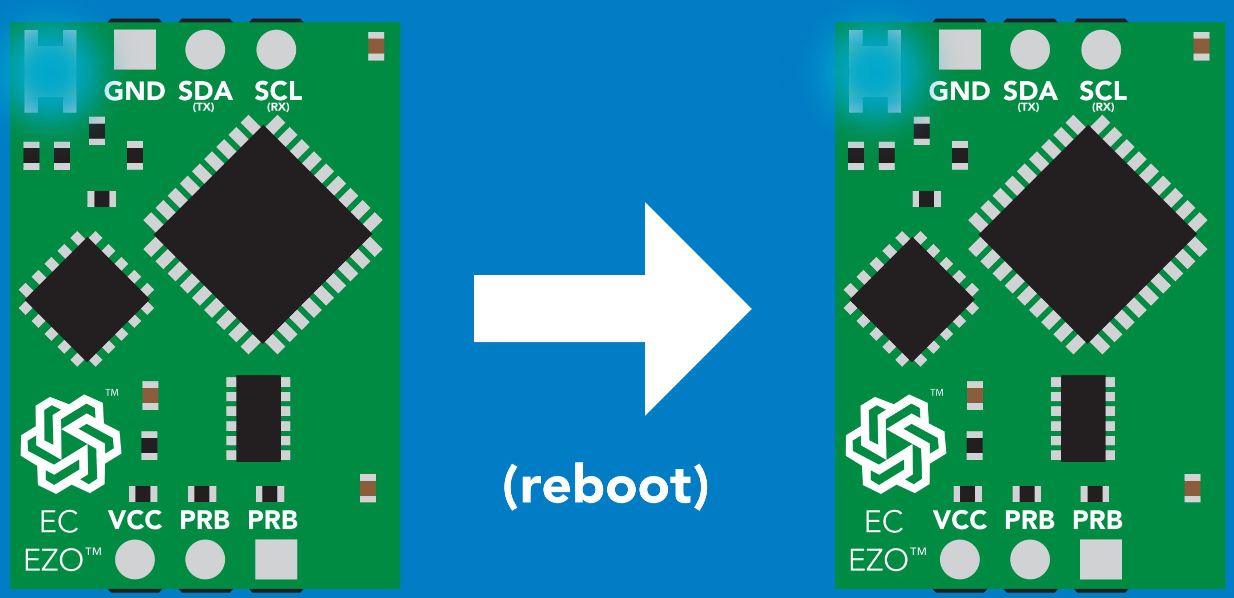
Factory enable factory reset

I²C address will not change

Example	Response
Factory	device reboot

Clears calibration
LED on
Response codes enabled

Factory



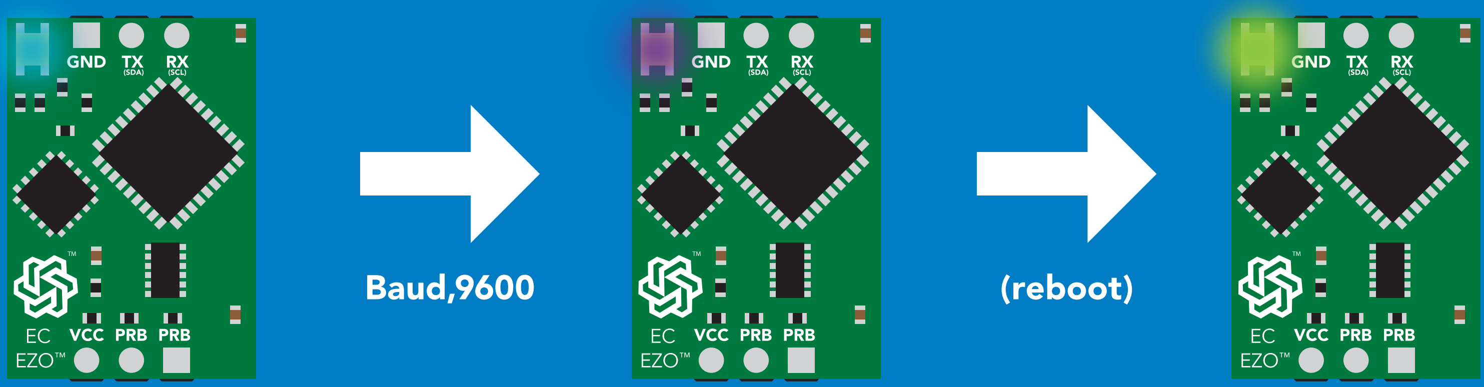
Change to UART mode

Command syntax

Baud,n switch from I²C to UART

Example	Response
Baud,9600	reboot in UART mode

n =
- 300
- 1200
- 2400
- 9600
- 19200
- 38400
- 57600
- 115200

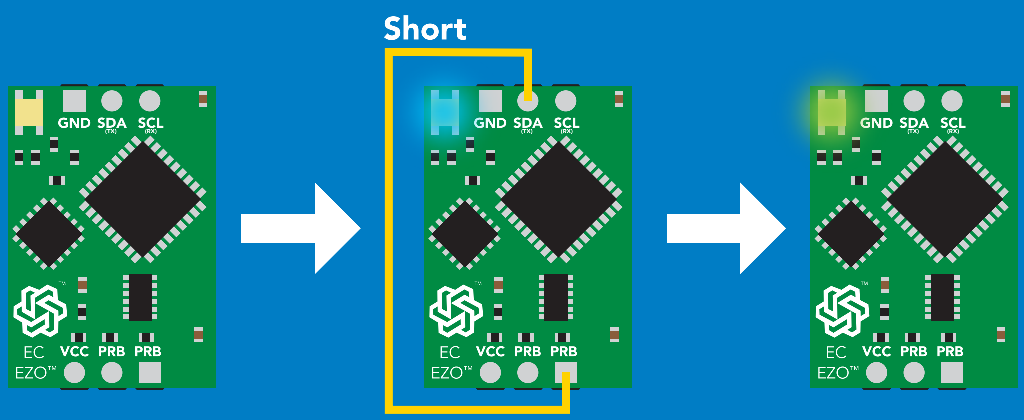


Changing to
UART mode

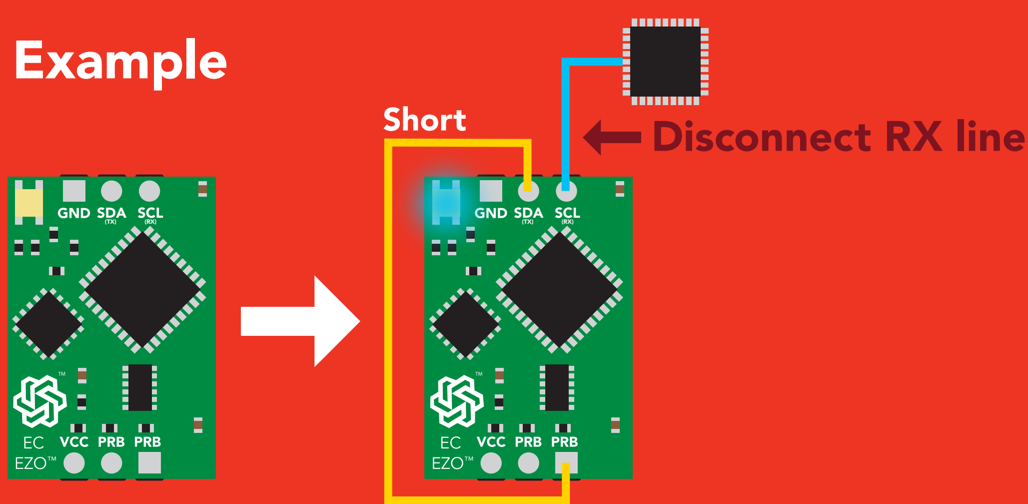
Manual switching to UART

- Make sure Plock is set to 0
- 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

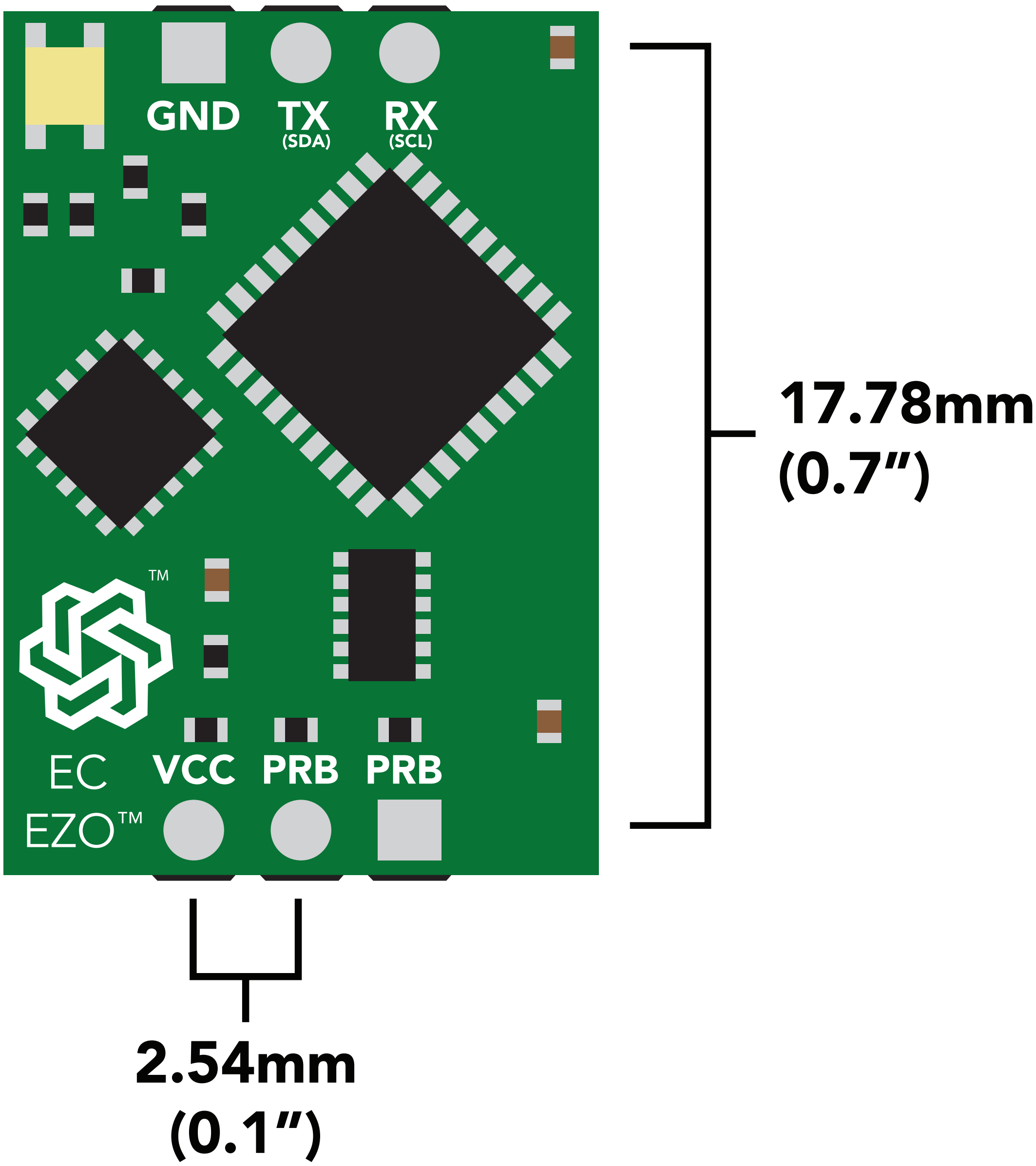


Wrong Example

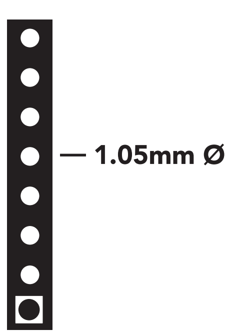


Atlas Scientific
Environmental Robotics

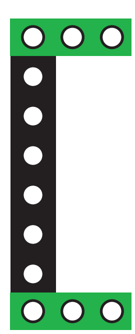
EZO™ circuit footprint



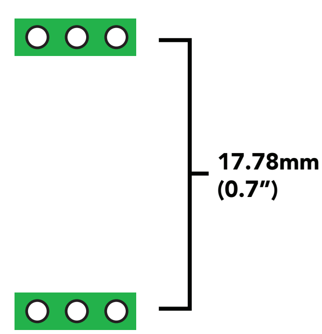
1 In your CAD software, place a 8 position header.



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.



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r 0.1

Datasheet change log

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^2C).
Added firmware information to Firmware update list.

Datasheet V 5.2

Revised calibration information on pages 27 & 52.

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^2C).

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 change log

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^2C).

Datasheet V 4.2

Revised Plock pages to show default value.

Datasheet V 4.1

Corrected I^2C 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 – I2C bug (Dec 1, 2014)
- Fixed I^2C bug where the circuit may inappropriately respond when other I2C 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 glitch where EEPROM would get erased if the circuit lost power 900ms into startup

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 glitch in sleep mode, where circuit would wake up to a different I^2C address.

V2.13 – (July 16, 2018)
- Added "RT" command to Temperature compensation.

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.

