AtlasScientific™
Environmental Robotics

V 5.8

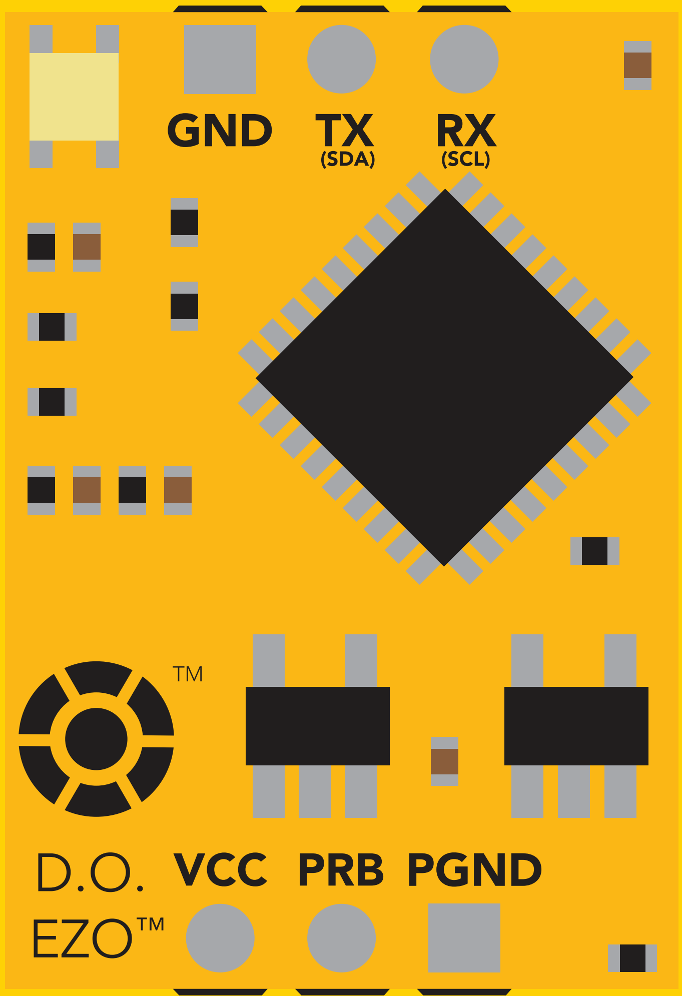
Revised 3/25

EZO-DO™

Embedded Dissolved Oxygen Circuit

ISO 5814 Compliant
(determination of dissolved oxygen)

Reads	**Dissolved Oxygen**
Range	**0.00 – 100 mg/L** **0 – 350% saturation**
Accuracy	**+/– 0.05 mg/L**
D.O. reading time	**600ms**
Supported probes	**Any galvanic probe**
Calibration	**1 or 2 point**
Temperature, salinity and pressure compensation	**Yes**
Data protocol	**UART & I²C**
Default I²C address	**97 (0x61)**
Operating voltage	**3.3V – 5V**
Data format	**ASCII**



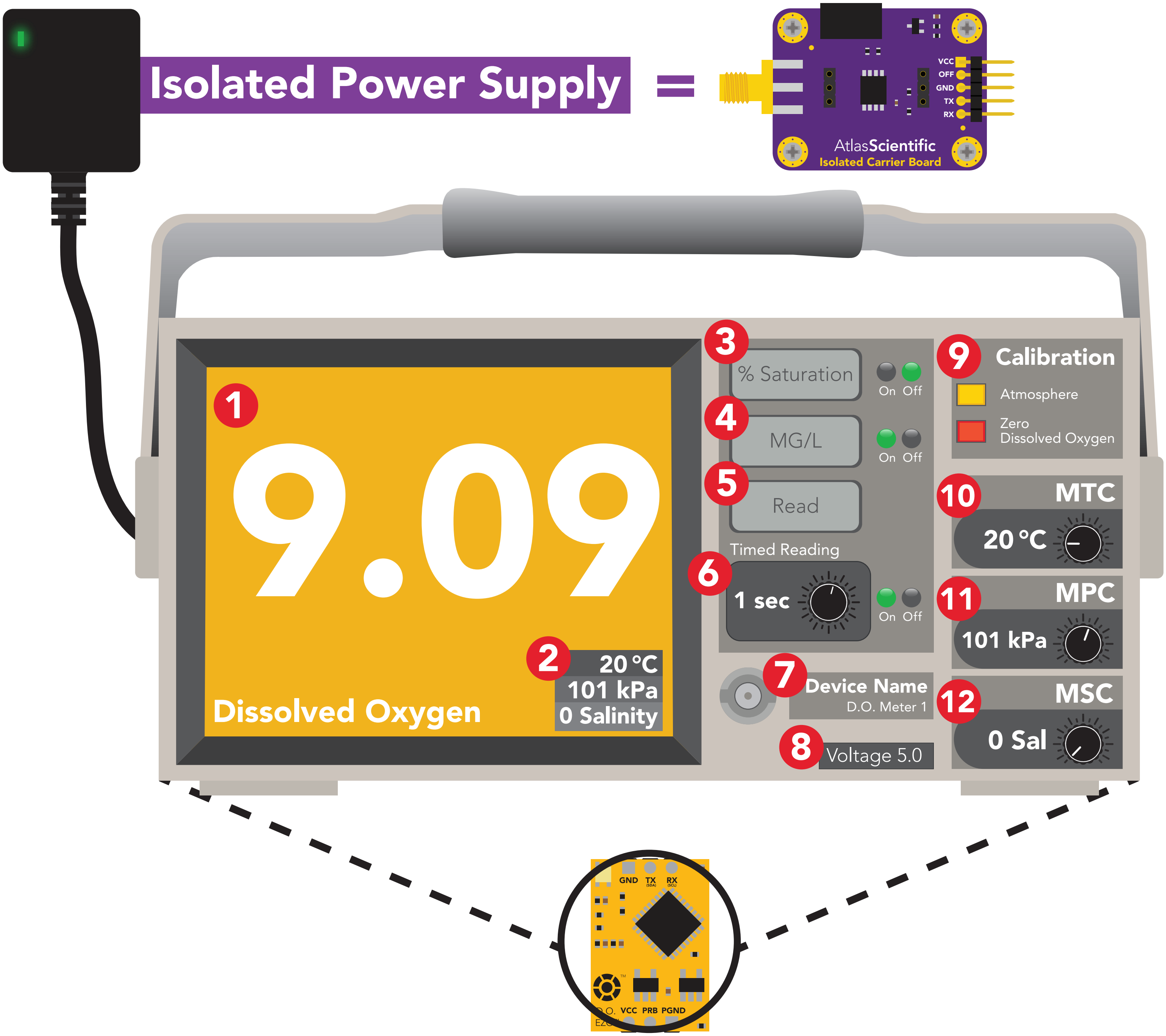
RoHS COMPLIANT

PATENT PROTECTED

Written by Jordan Press
Designed by Noah Press

This is an evolving document, check back for updates.

The EZO™ D.O. Circuit has all the features of this bench top meter.



1 Two decimal D.O. reading

2 Temperature, pressure, and salinity compensation value

3 Percent saturation

4 Milligrams per liter

5 Immediate reading

6 Timed readings

7 Set device name

8 Voltage usage

9 Multi point calibration

10 Manual temperature compensation

11 Manual pressure compensation

12 Manual salinity compensation

The EZO™ D.O. Circuit is compatible with any brand of galvanic D.O. probe.

✓ Available data protocols

UART

Default

I^2C

X Unavailable data protocols

SPI

Analog

RS-485

Mod Bus

4–20mA

AtlasScientific Environmental Robotics

STOP

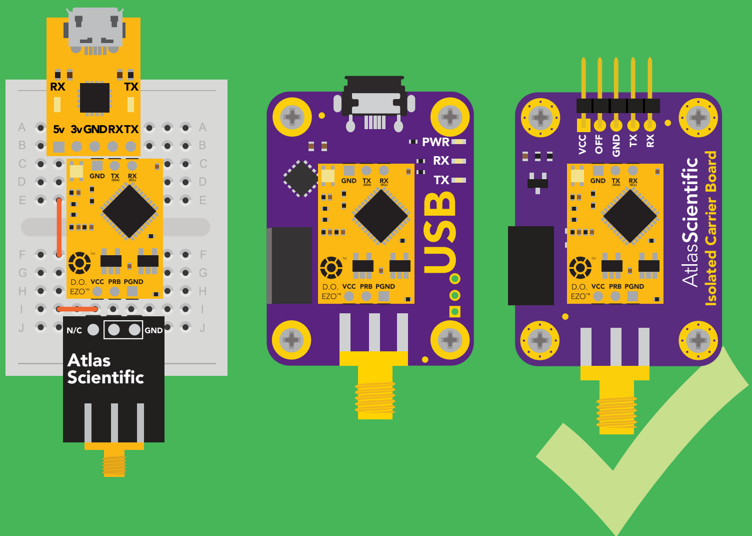
SOLDERING THIS DEVICE VOIDS YOUR WARRANTY.

Are there specific soldering instructions? **Yes, see page 71.**

Can you make a warranty claim after soldering? No.

If you have not used this product before; Observe how a properly working sensor behaves *BEFORE* embedding it into your PCB.

Get this device working using one of these methods first.



Do not embed before you have experience with this sensor.

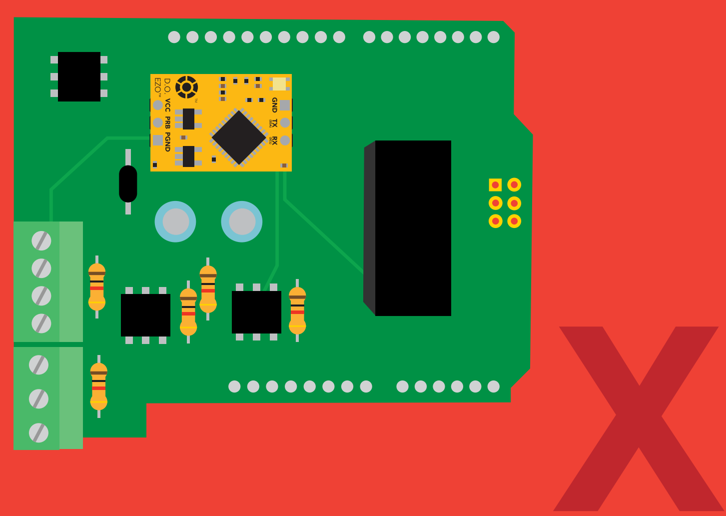
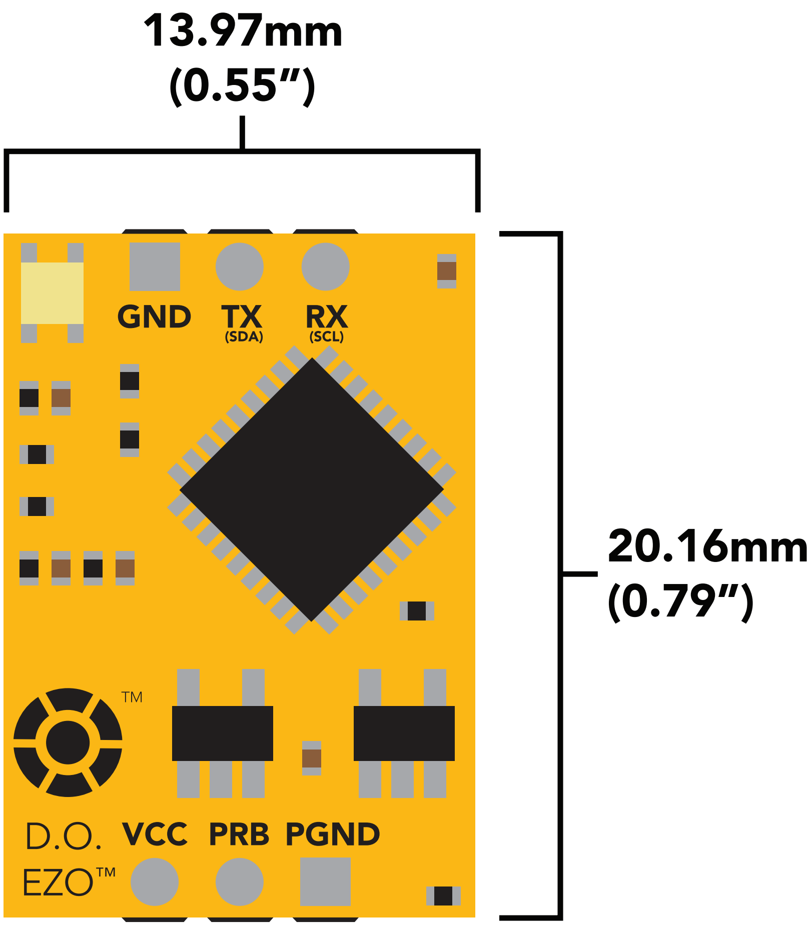


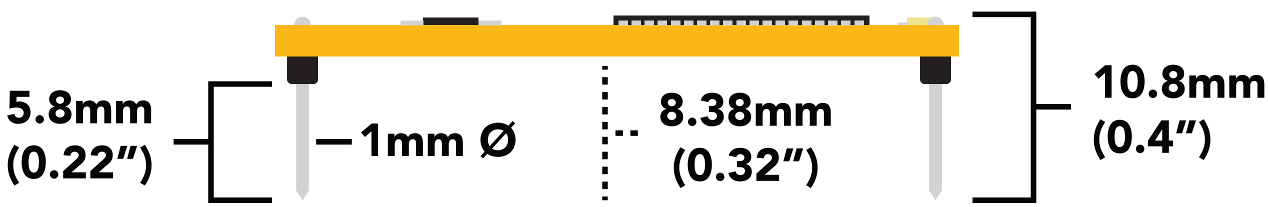
Table of contents

UART

I²C

EZO™ circuit dimensions





Power consumption

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

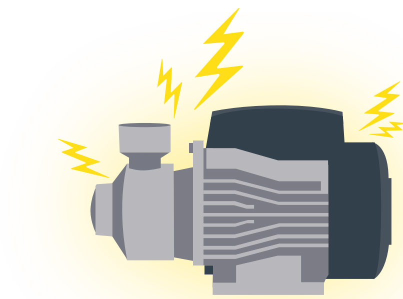
Absolute max ratings

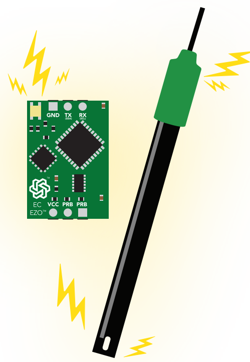
Parameter	MIN	TYP	MAX
Storage temperature (EZO™ D.O.)	-65 °C		125 °C
Operational temperature (EZO™ D.O.)	-40 °C	25 °C	85 °C
VCC	3.3V	5V	5.5V

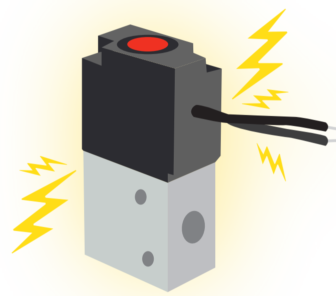
Electrical isolation

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

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



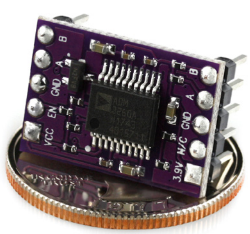




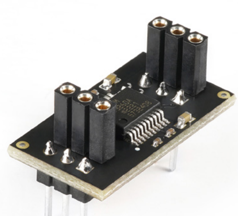
Advice:

When reading D.O. along with other sensors, electrical isolation is strongly recommended.
Never build a commercial product without electrical isolation.

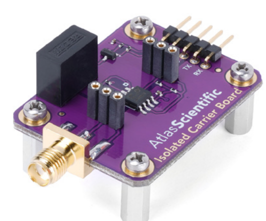
Atlas Scientific offers several different electrical isolation products that can be used in your design. Select the electrical isolation product that works best for your design.



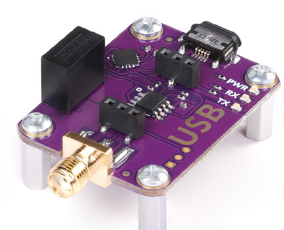
Basic EZO™
Inline Voltage Isolator



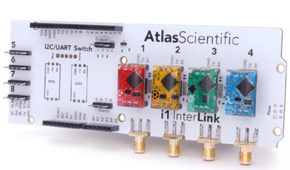
Vertical Isolator



Electrically Isolated
EZO™ Carrier Board



Gen 2 Electrically Isolated
USB EZO™ Carrier Board



i1 InterLink

i2 InterLink

i3 InterLink

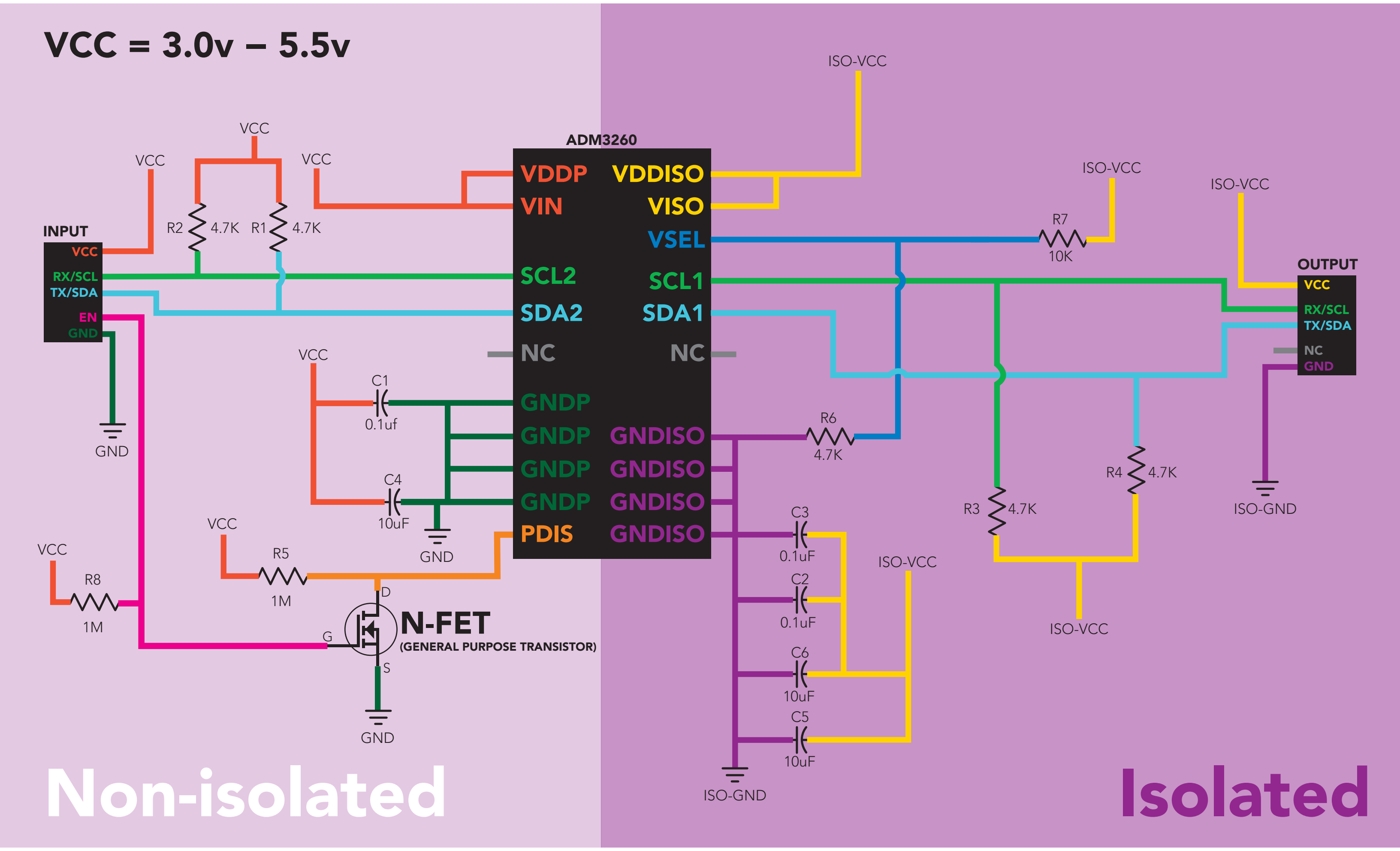
Electrically Isolated EZO™
Carrier Board (old style)

For various reasons, you may need to build your own electrical isolator. Because electrical isolation is so important, we have published our isolation schematic for anyone to use.

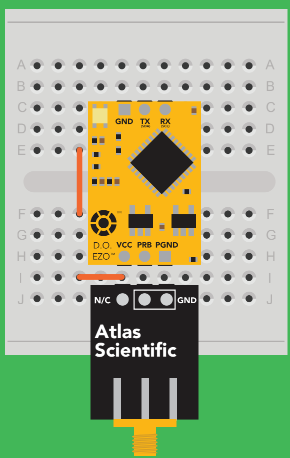
This isolation schematic is based on the ADM3260, which can output up to 150 mW of isolated power. PCB layout requires special attention for EMI/EMC and RF Control. Having good ground planes and keeping the capacitors as close to the chip as possible are crucial for proper performance.

The two data channels have a 4.7kΩ pull-up resistor on both the isolated and non-isolated lines (R1, R2, R3, and R4). The output voltage is set using a voltage divider (R6 and R7). This produces a voltage of 3.9V regardless of your input voltage.

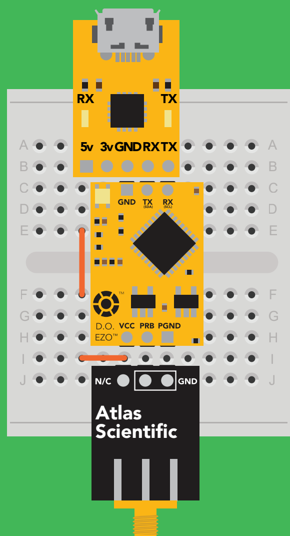
Isolated ground is different from non-isolated ground, these two lines should not be connected together.



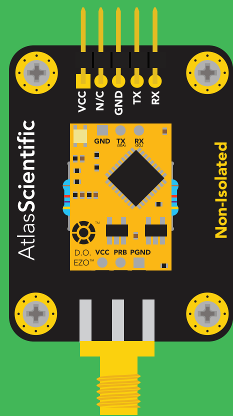
Correct wiring



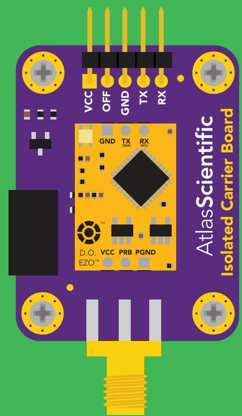
Bread board



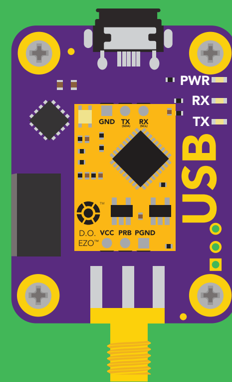
Bread board via USB



Non-Isolated EZO™ Carrier Board



Electrically Isolated EZO™ Carrier Board

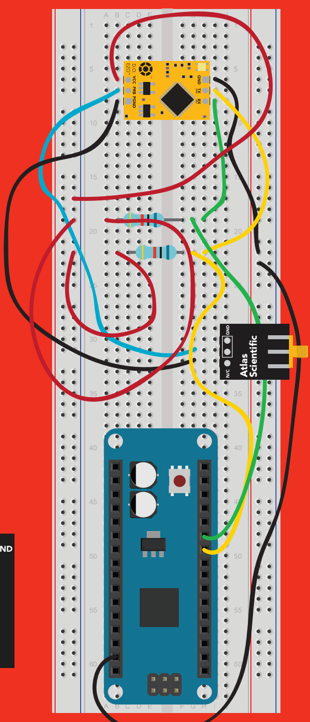


USB carrier board

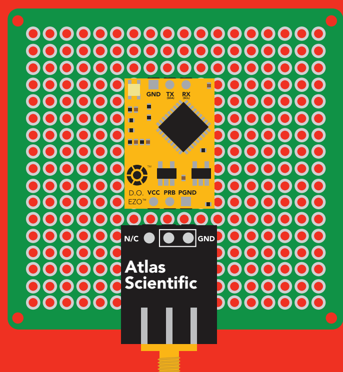
Incorrect wiring

Extended leads

Sloppy setup

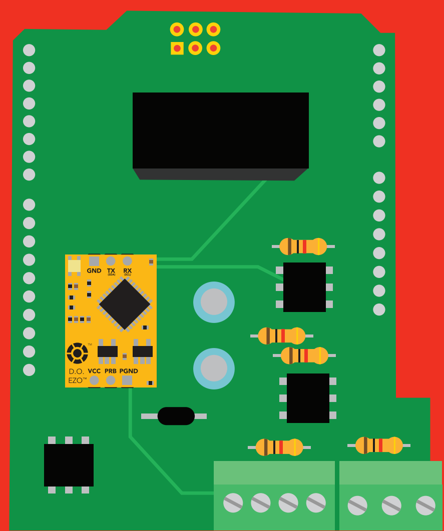


Perfboards or Protoboards



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

*Embedded into your device

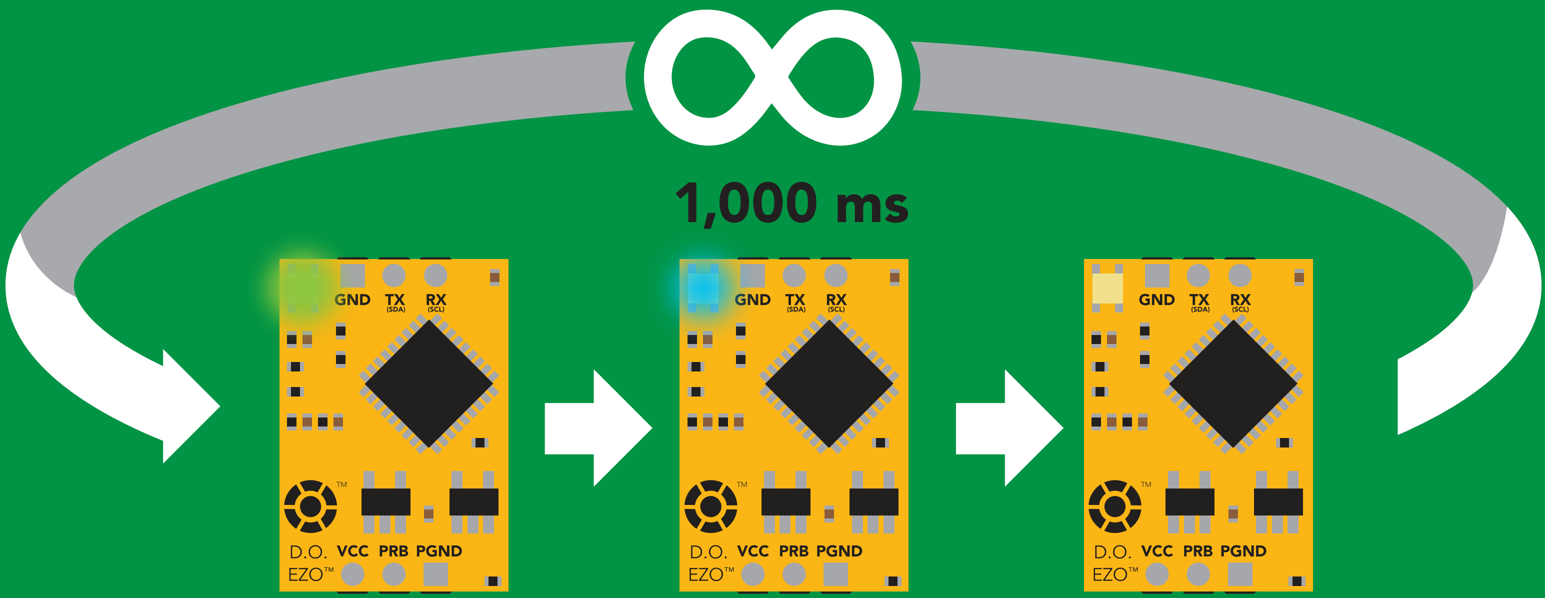


***Only after you are familar with EZO™ circuits operation**

AtlasScientific™
Environmental Robotics

Default state
UART mode

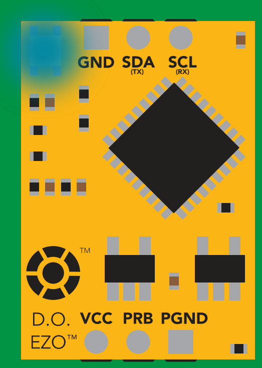
Baud	9,600
Readings	continuous
Units	mg/L
Speed	1 reading per second
LED	on



Green
Standby

Cyan
Taking reading

Transmitting



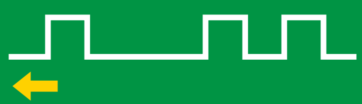
Solid Blue LED
in I²C mode
Not UART ready

UART mode

8 data bits	no parity
1 stop bit	no flow control

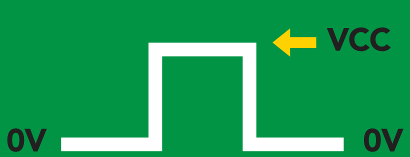
Baud
300
1,200
2,400
9,600 default
19,200
38,400
57,600
115,200

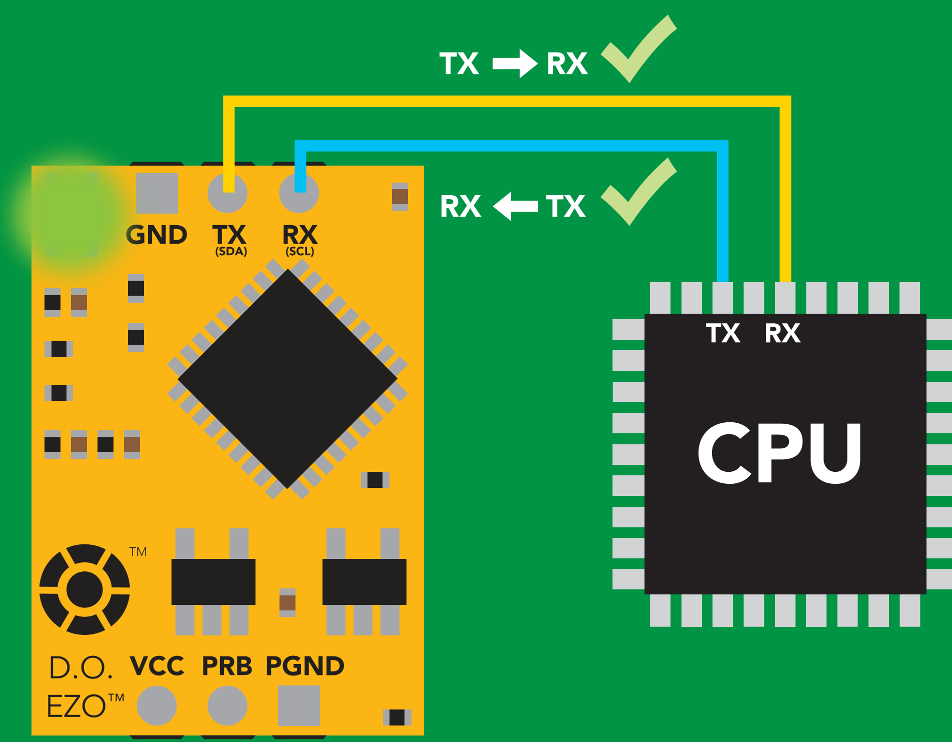
RX
Data in



TX
Data out

Vcc 3.3V – 5.5V



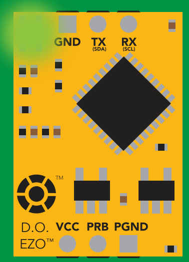


Data format

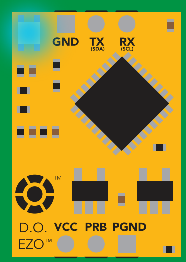
Reading	D.O.	Data type	floating point
Order	mg/L & (% sat) when enabled	Decimal places	mg/L = 2 % sat = 1
Encoding	ASCII	Smallest string	4 characters
Format	string (CSV string when % sat is enabled)	Largest string	40 characters
Terminator	carriage return		

AtlasScientific™
Environmental Robotics

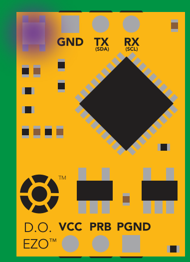
LED color definition



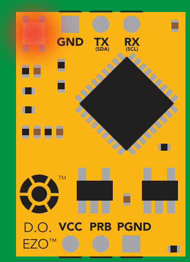
Green
UART standby



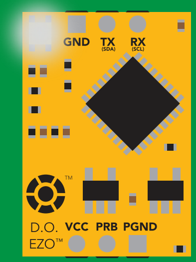
Cyan
Taking reading



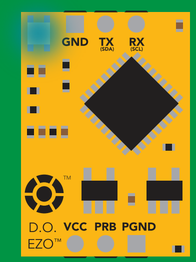
Purple
Changing baud rate



Red
Command not understood



White
Find



Blue
I2C standby

	LED ON
5V	**+0.4 mA**
3.3V	**+0.2 mA**

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
Pressure compensation
Salinity compensation
Sleep mode
Temperature compensation

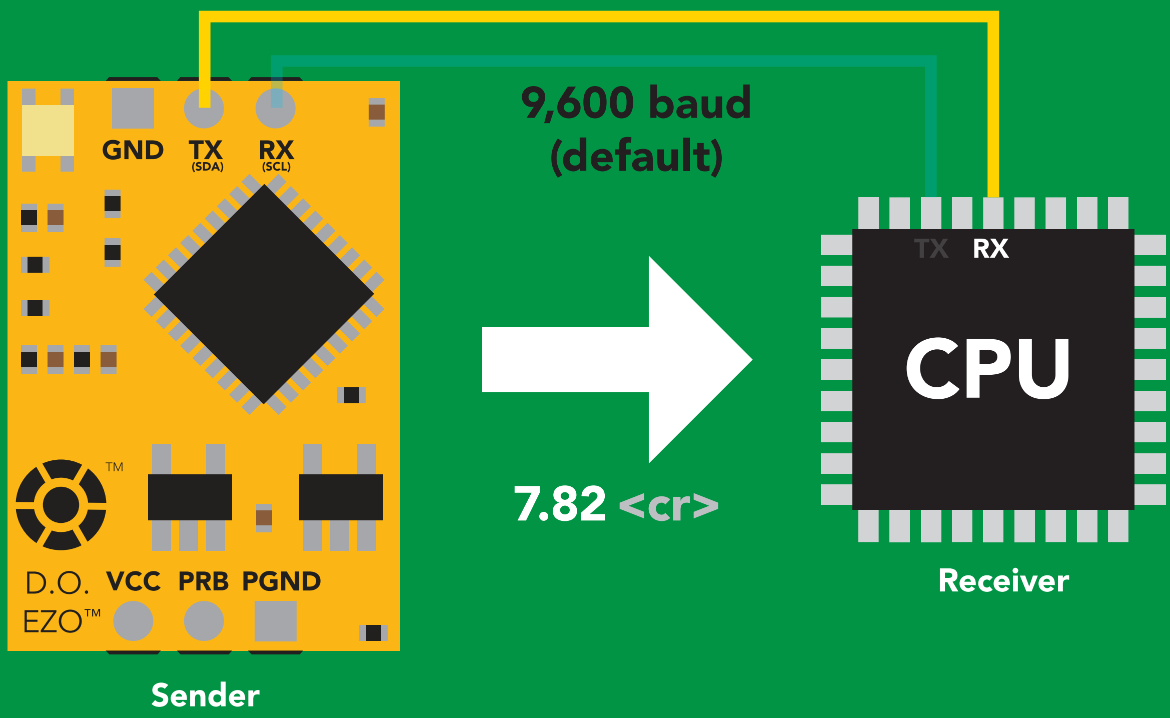
AtlasScientific
Environmental Robotics

Receiving data from device

2 parts

ASCII data string — Command

Carriage return <cr> — Terminator



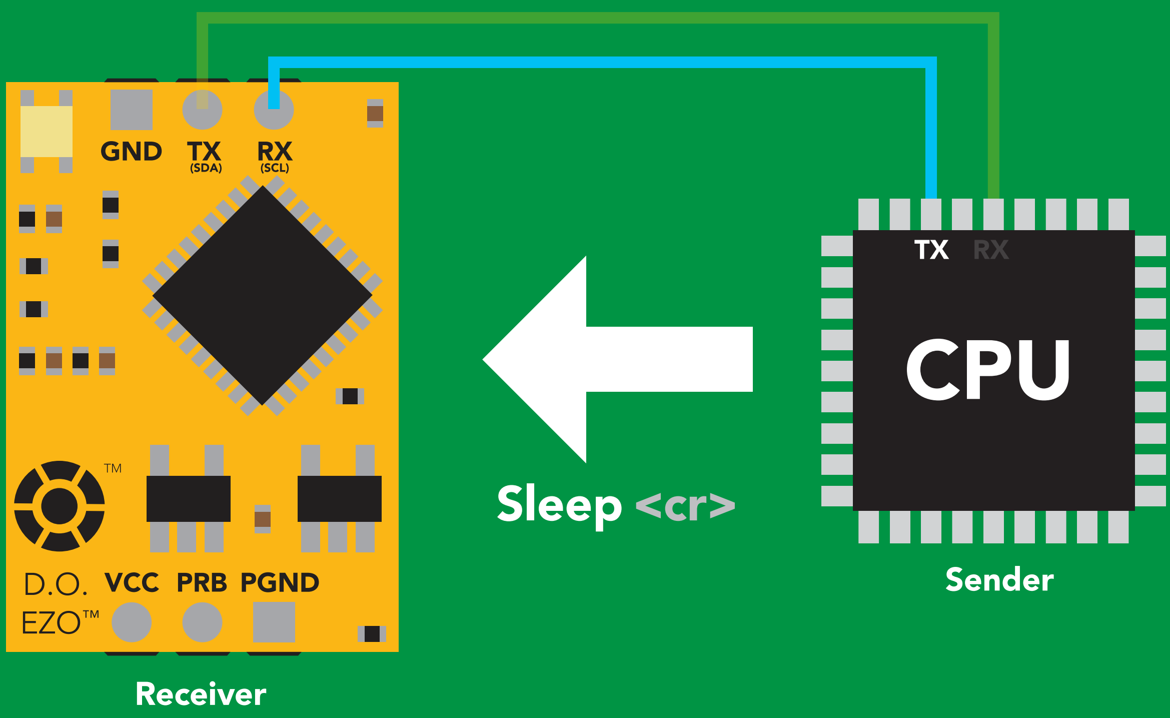
Advanced

ASCII:	7	.	8	2	<cr>
Hex:	37	2E	38	32	0D
Dec:	55	46	56	50	13

Sending commands to device

2 parts

Command (not case sensitive)	Carriage return <cr>
ASCII data string	Terminator



Advanced

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

Atlas Scientific™ Environmental Robotics

UART mode

command quick reference

All commands are ASCII strings or single ASCII characters.

Command	Function		Default state
Baud	change baud rate	pg. 32	9,600
C	enable/disable continuous reading	pg. 18	enabled
Cal	performs calibration	pg. 20	n/a
Export	export calibration	pg. 21	n/a
Factory	enable factory reset	pg. 34	n/a
Find	finds device with blinking white LED	pg. 17	n/a
i	device information	pg. 28	n/a
I2C	change to I^2C mode	pg. 35	not set
Import	import calibration	pg. 22	n/a
L	enable/disable LED	pg. 16	enabled
Name	set/show name of device	pg. 27	not set
O	enable/disable parameters	pg. 26	mg/L
P	atmospheric pressure compensation	pg. 25	101.3 kPa
Plock	enable/disable protocol lock	pg. 33	disabled
R	returns a single reading	pg. 19	n/a
S	salinity compensation	pg. 24	n/a
Sleep	enter sleep mode/low power	pg. 31	n/a
Status	retrieve status information	pg. 30	n/a
T	temperature compensation	pg. 23	20°C
*OK	enable/disable response codes	pg. 29	enable

LED control

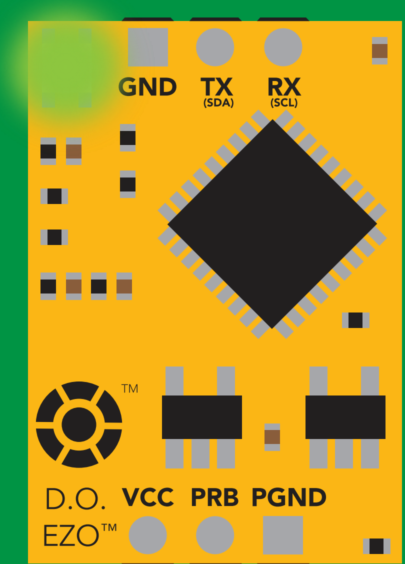
Command syntax

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

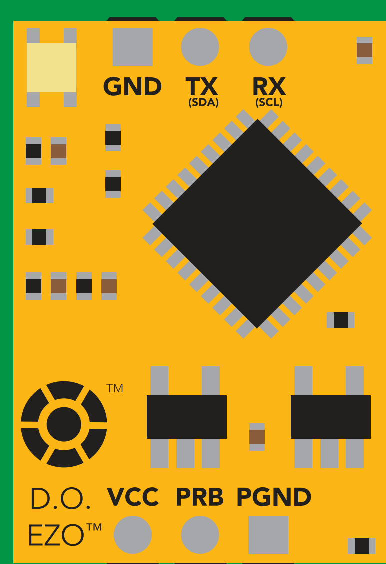
L,0 <cr> LED off

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

AtlasScientific™
Environmental Robotics

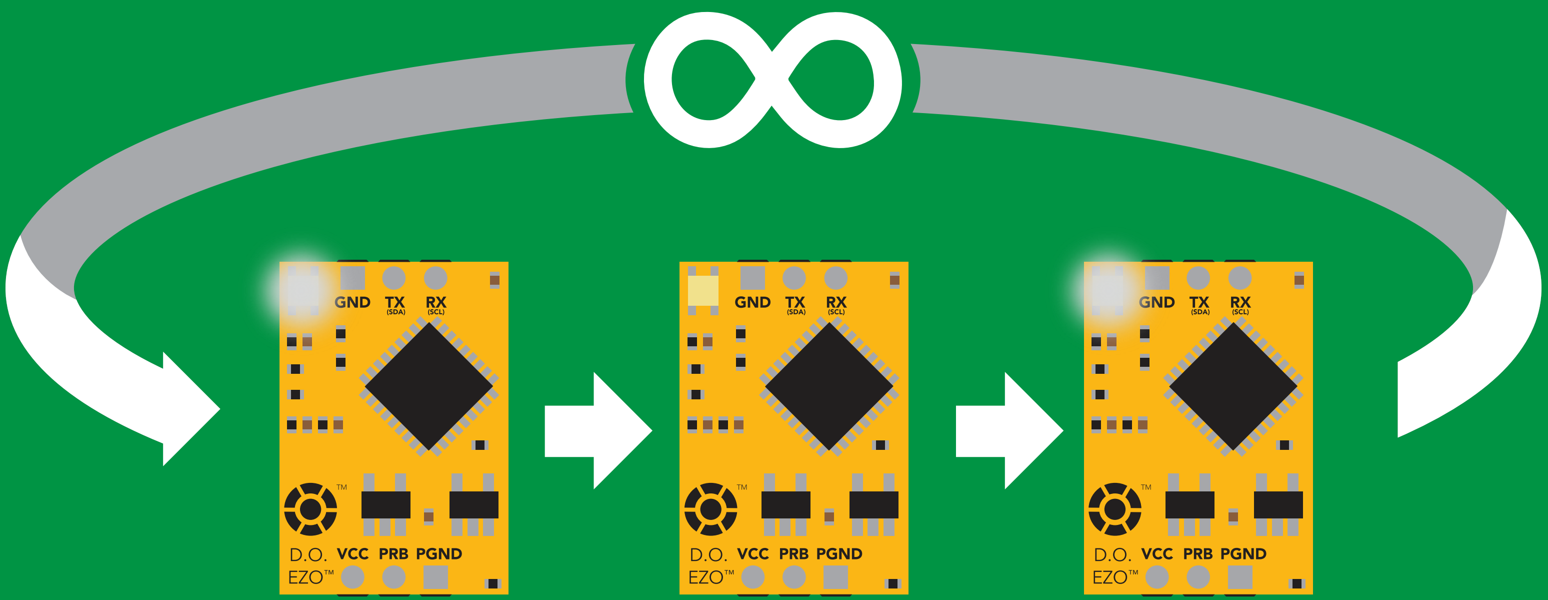
Find

Command syntax

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

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

Example	Response
Find <cr>	***OK** <cr>



Continuous reading mode

Command syntax

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

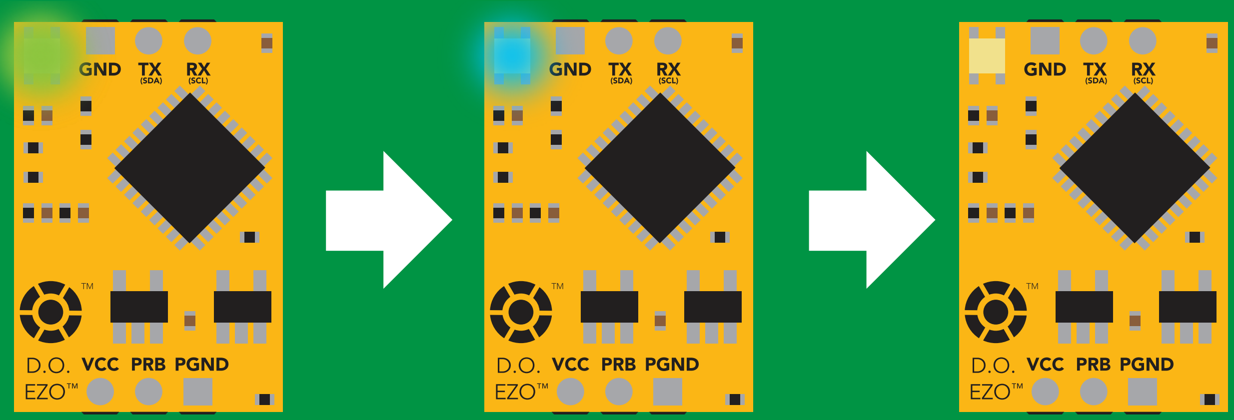
Example	Response
C,1 <cr>	*OK <cr> DO (1 sec) <cr> DO (2 sec) <cr> DO (3 sec) <cr>
C,30 <cr>	*OK <cr> DO (30 sec) <cr> DO (60 sec) <cr> DO (90 sec) <cr>
C,0 <cr>	*OK <cr>
C,? <cr>	?C,1 <cr> or ?C,0 <cr> or ?C,30 <cr> *OK <cr>

Single reading mode

Command syntax

R <cr> **takes single reading**

Example	Response
R <cr>	7.82 <cr> *OK <cr>



Green
Standby

Cyan
Taking reading

Transmitting

600 ms

AtlasScientific™
Environmental Robotics

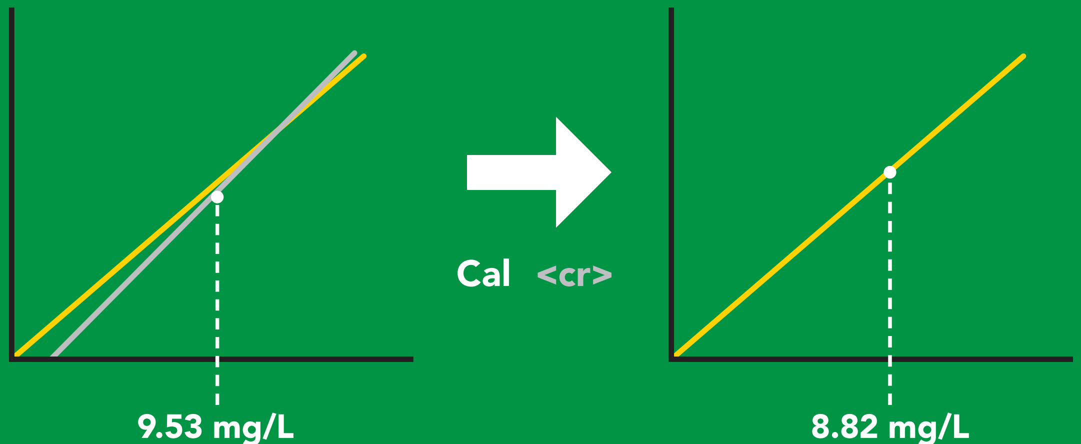
Calibration

Command syntax

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

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

Example	Response
Cal <cr>	*OK <cr>
Cal,0 <cr>	*OK <cr>
Cal,clear <cr>	*OK <cr>
Cal,? <cr>	?Cal,0 <cr> or ?Cal,1 <cr> (single point) or ?Cal,2 <cr> (two point) *OK <cr>



AtlasScientific Environmental Robotics

Export calibration

Command syntax

Export: Use this command to download calibration settings

Export,?	<cr>	calibration string info
Export	<cr>	export calibration string from calibrated device

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

Response breakdown

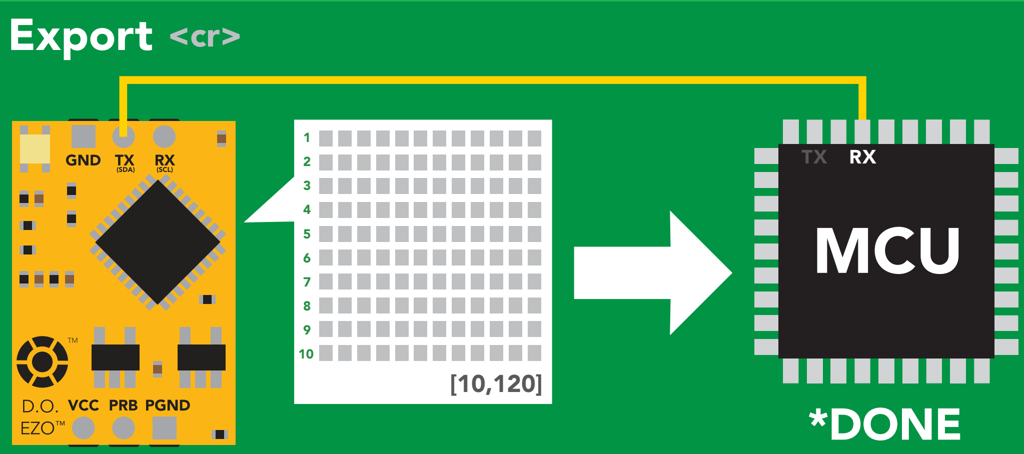
10, 120

# of strings to export — # of bytes to export

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

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)
(7 more)	⋮	
Export <cr>	6F 6C 20 67 75 79 <cr>	(10 of 10)
Export <cr>	*DONE	

Disabling *OK simplifies this process



Import calibration

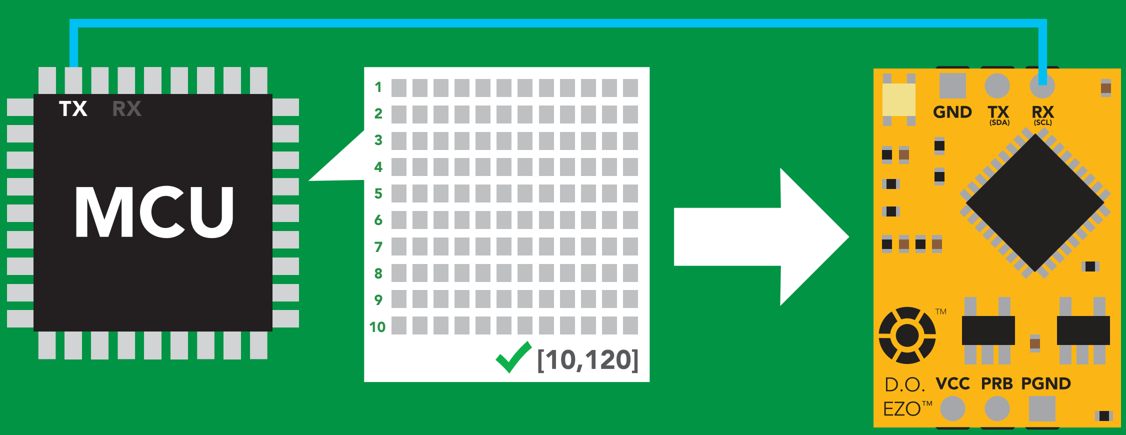
Command syntax

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

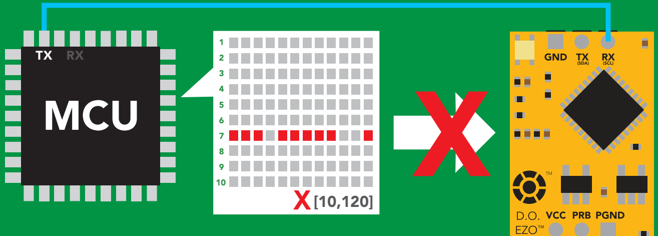
Import,n	<cr>	import calibration string to new device

Example		Response
Import, 59 6F 75 20 61 72 <cr>	(1 of 10)	*OK <cr>
Import, 65 20 61 20 63 6F <cr>	(2 of 10)	*OK <cr>
⋮		⋮
Import, 6F 6C 20 67 75 79 <cr>	(10 of 10)	*OK <cr>

Import,n <cr>



*OK <cr>
system will reboot



*ER <cr>

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

Temperature compensation

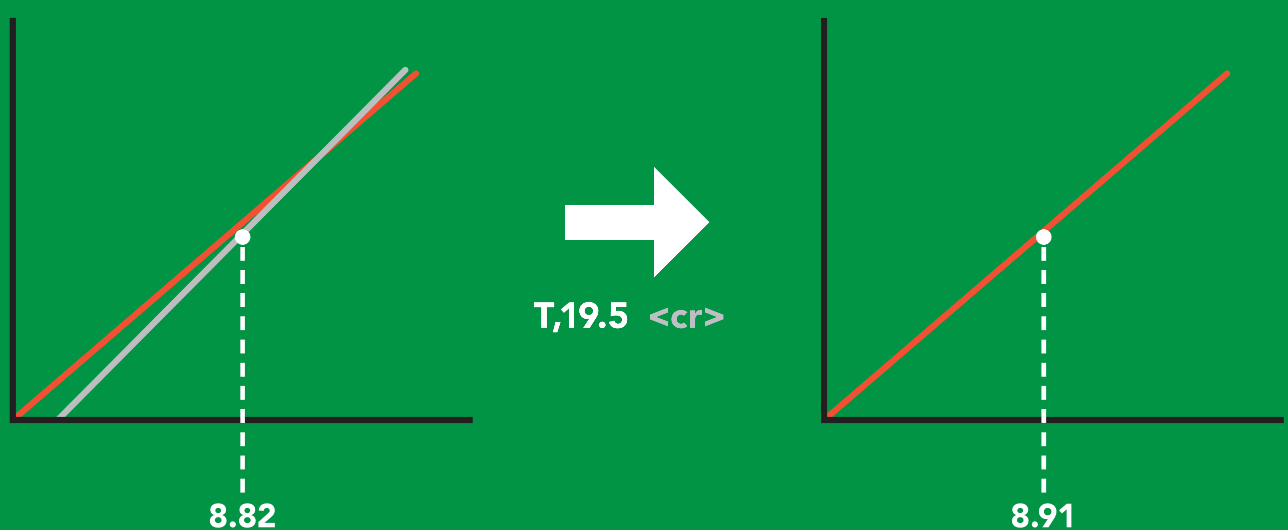
Default temperature = 20°C
Temperature is always in Celsius
Temperature is not retained if power is cut

Command syntax

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>



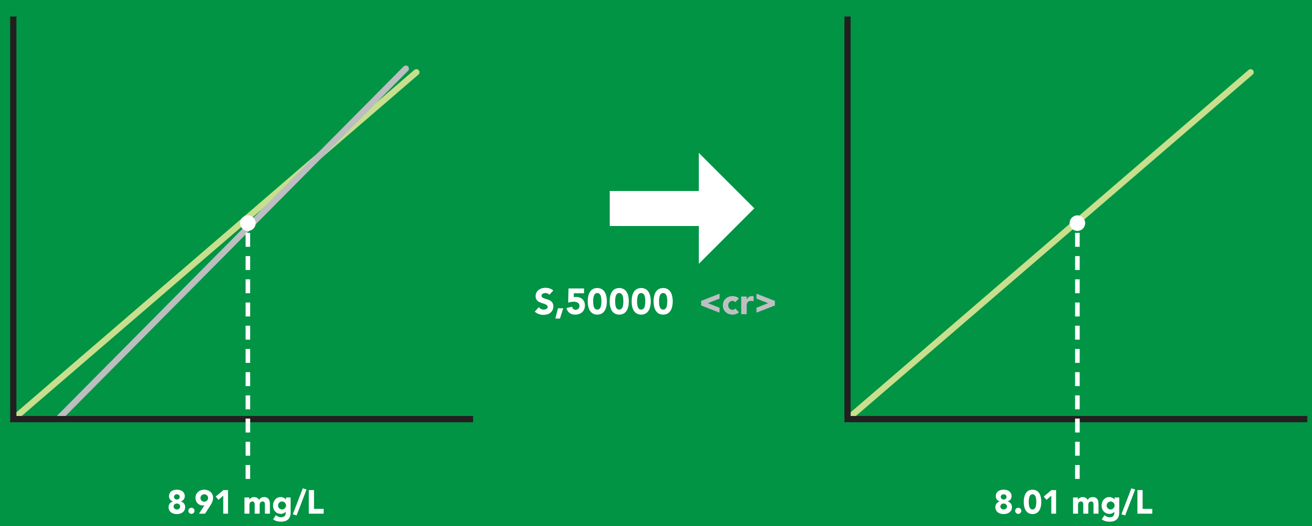
Salinity compensation

Command syntax

Default value = 0 µs
If the conductivity of your water is less than 2,500µS this command is irrelevant

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

Example	Response
S,50000 <cr>	*OK <cr>
S,37.5,ppt <cr>	*OK <cr>
S,? <cr>	?S,50000,µS <cr> or ?S,37.5,ppt <cr> *OK <cr>

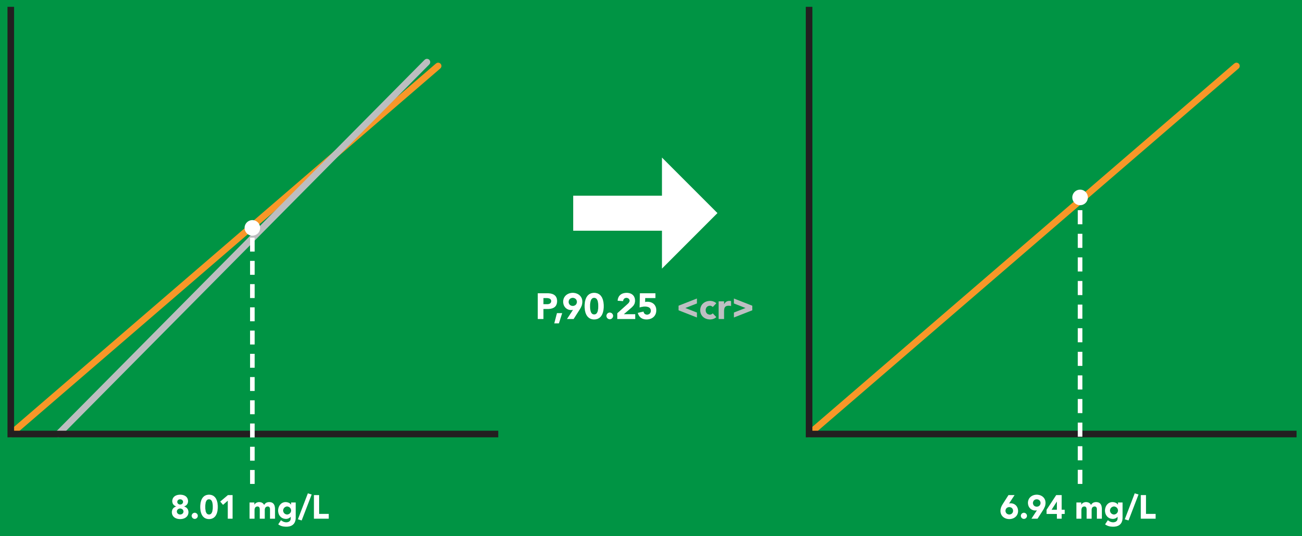


Atmospheric pressure compensation

Command syntax

P,n	<cr>	n = any value in kPa
P,?	<cr>	compensated pressure value?

Example	Response
P,90.25 <cr>	*OK <cr>
P,? <cr>	?,P,90.25 <cr> *OK <cr>



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,mg,1 / O,mg,0 <cr>	*OK <cr> enable / disable mg/L
O,%,1 / O,%,0 <cr>	*OK <cr> enable / disable percent saturation
O,? <cr>	?,O,%,mg <cr> if both are enabled

Parameters

mg	mg/L
%	percent saturation

Followed by 1 or 0

1	enabled
0	disabled

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

Naming device

Command syntax

Do not use spaces in the name

Name,n	<cr>	set name
Name,	<cr>	clears name
Name,?	<cr>	show name

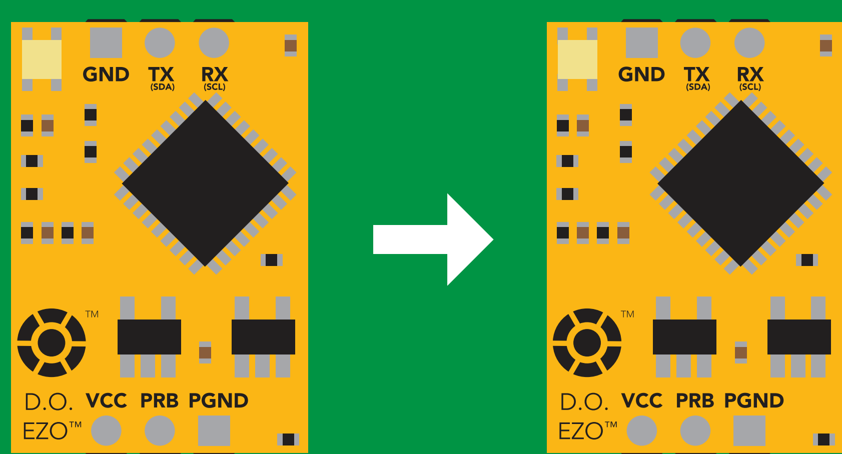
n = _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16

Up to 16 ASCII characters

Example	Response
Name, <cr>	*OK <cr> name has been cleared
Name,zzt <cr>	*OK <cr>
Name,? <cr>	?Name,zzt <cr> *OK <cr>

Name,zzt

Name,?



*OK <cr>

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

AtlasScientific Environmental Robotics

Device information

Command syntax

i <cr> **device information**

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

Response breakdown

?i, D.O., 1.98

D.O. = Device
1.98 = Firmware

Response codes

Command syntax

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

Example	Response
R <cr>	7.82 <cr> *OK <cr>
*OK,0 <cr>	no response, *OK disabled
R <cr>	7.82 <cr> *OK disabled
*OK,? <cr>	?*OK,1 <cr> or ?*OK,0 <cr>

Other response codes

*ER	unknown command
*OV	over volt (VCC>=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

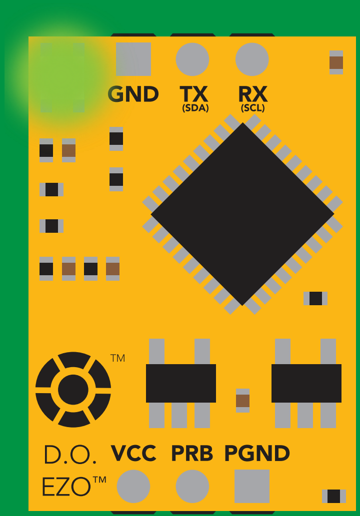
Command syntax

Send any character or command to awaken device.

Sleep <cr> enter sleep mode/low power

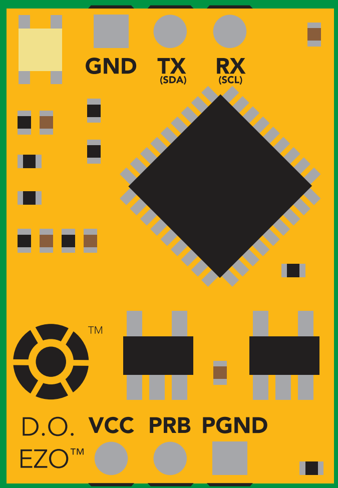
Example	Response
Sleep <cr>	*OK <cr> *SL <cr>
Any command	*WA <cr> wakes up device

	STANDBY	SLEEP
5V	13.1 mA	0.66 mA
3.3V	12 mA	0.3 mA



Standby
13.1 mA

Sleep <cr>



Sleep
0.66 mA

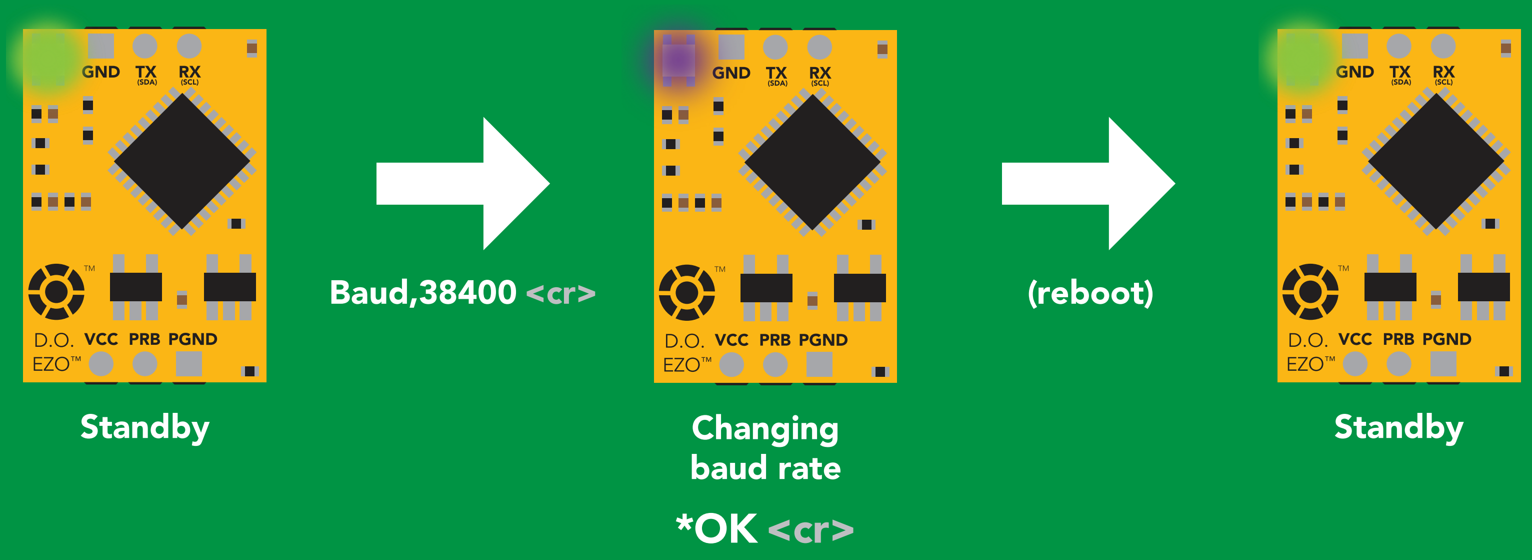
Change baud rate

Command syntax

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

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

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



AtlasScientific Environmental Robotics

Protocol lock

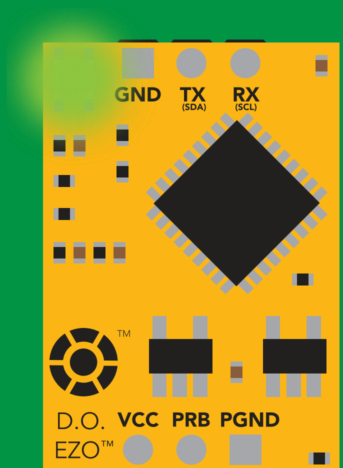
Command syntax

Locks device to UART mode.

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

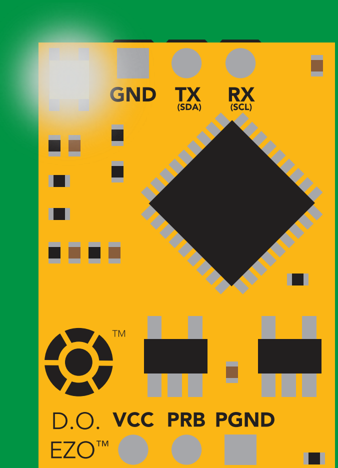
Example	Response
Plock,1 <cr>	*OK <cr>
Plock,0 <cr>	*OK <cr>
Plock,? <cr>	?Plock,1 <cr> or ?Plock,0 <cr>

Plock,1



*OK <cr>

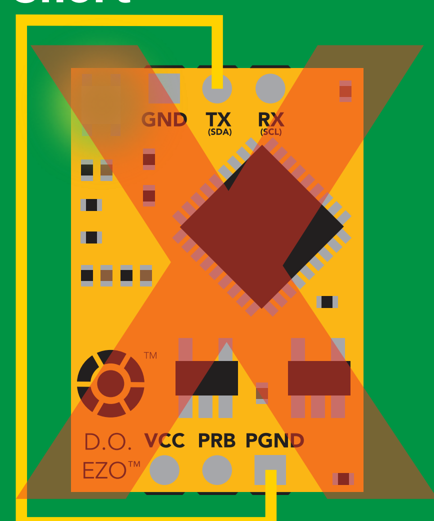
I2C,100



cannot change to I²C

*ER <cr>

Short



cannot change to I²C

AtlasScientific Environmental Robotics

Factory reset

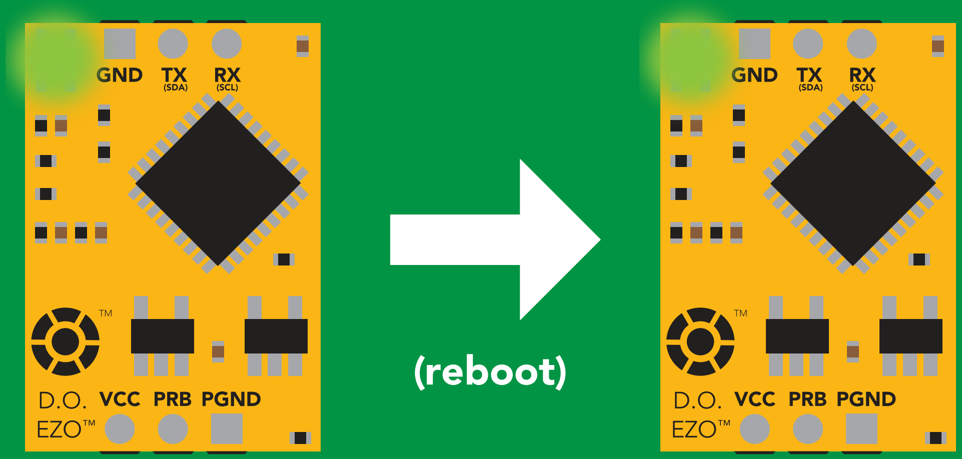
Command syntax

Clears calibration
LED on
"*OK" enabled

Factory <cr> **enable factory reset**

Example	Response
Factory <cr>	*OK <cr>

Factory <cr>



*OK <cr>

*RS <cr>
*RE <cr>

Baud rate will not change

AtlasScientific™ Environmental Robotics

Change to I²C mode

Command syntax

Default I²C address 97 (0x61)

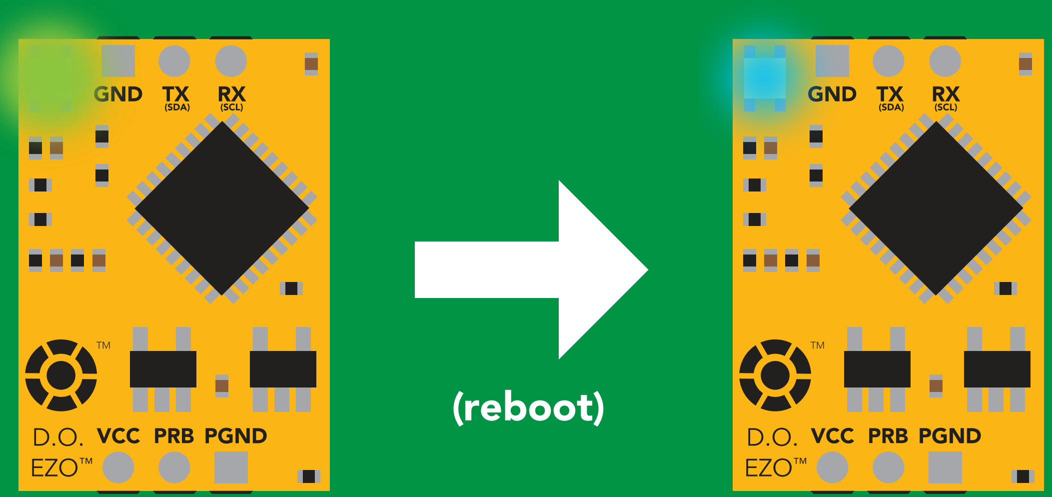
I2C,n <cr> sets I²C address and reboots into I²C mode

n = any number 1 – 127

Example	Response
I2C,100 <cr>	*OK (reboot in I²C mode)

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

I2C,100



Green
*OK <cr>

Blue
now in I²C mode

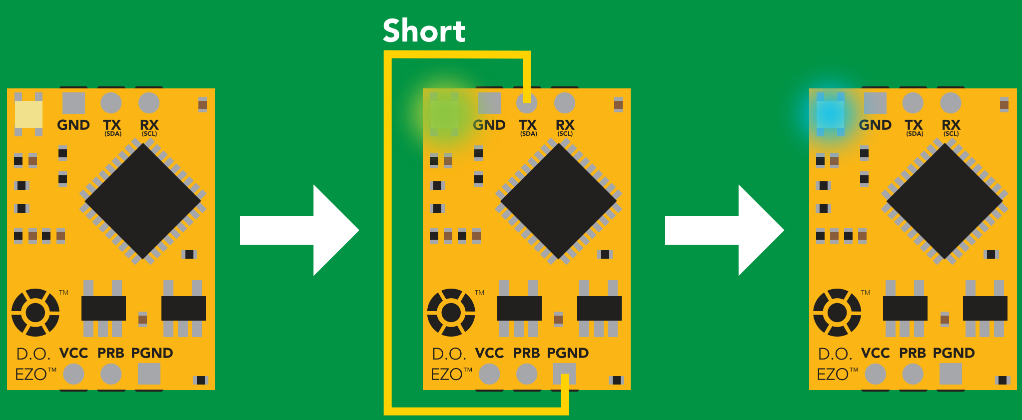
AtlasScientific™
Environmental Robotics

Manual switching to I^{2}C

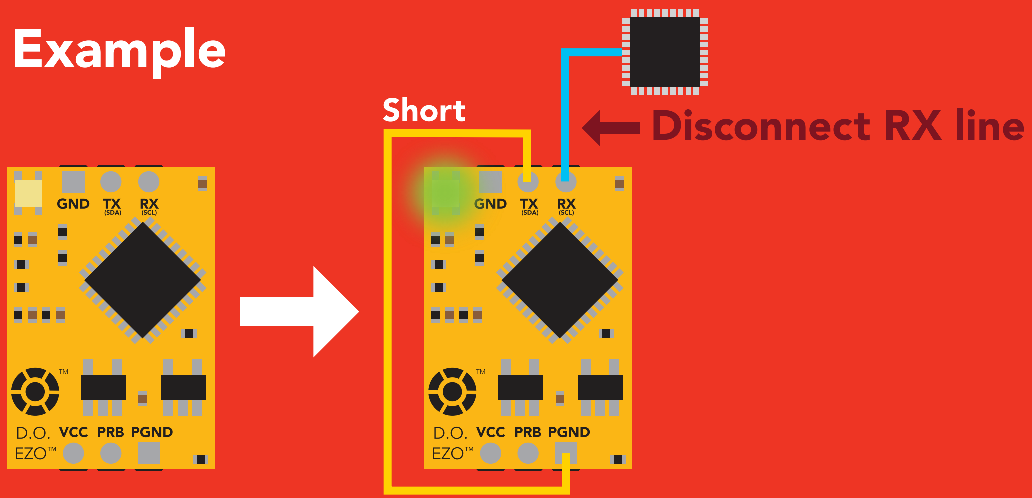
- Disconnect ground (power off)
- Disconnect TX and RX
- Connect TX to PGND
- Confirm RX is disconnected
- Connect ground (power on)
- Wait for LED to change from Green to Blue
- Disconnect ground (power off)
- Reconnect all data and power

Manually switching to I^{2}C will set the I^{2}C address to 97 (0x61)

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
Pressure compensation
Salinity compensation
Sleep mode
Temperature compensation

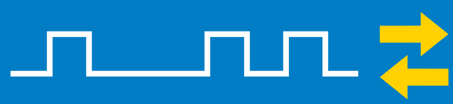
I²C mode

I²C address (0x01 – 0x7F)
97 (0x61) default

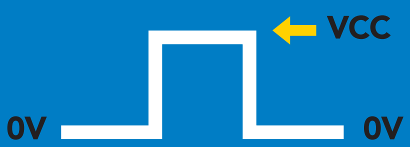
Vcc 3.3V – 5.5V

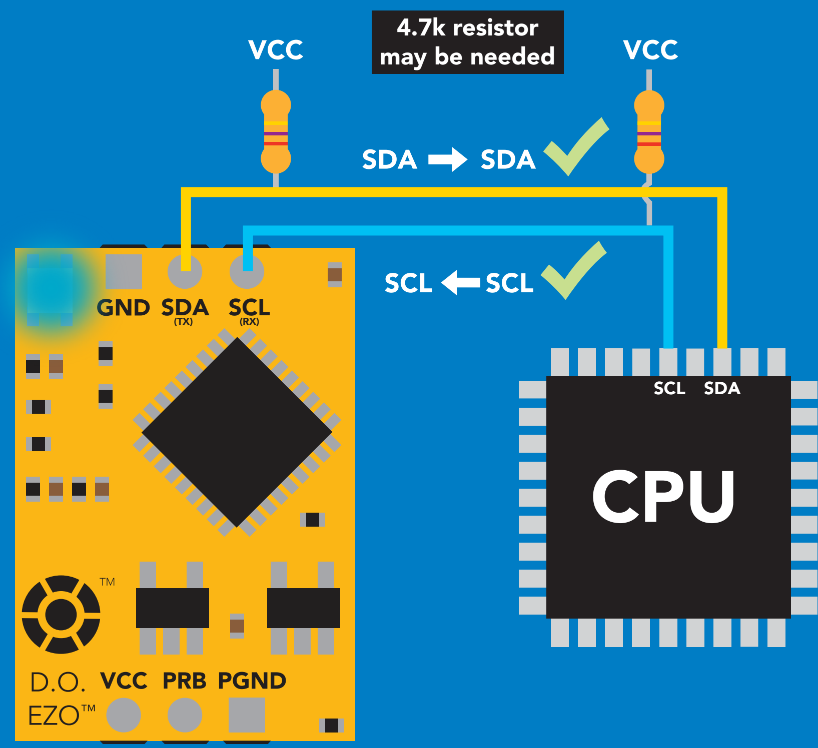
Clock speed 100 – 400 kHz

SDA



SCL





Data format

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

AtlasScientific™
Environmental Robotics

Sending commands to device

5 parts

Start | I^2C address | Write | Command (not case sensitive) | Stop

I^2C address: 97 (0x61)

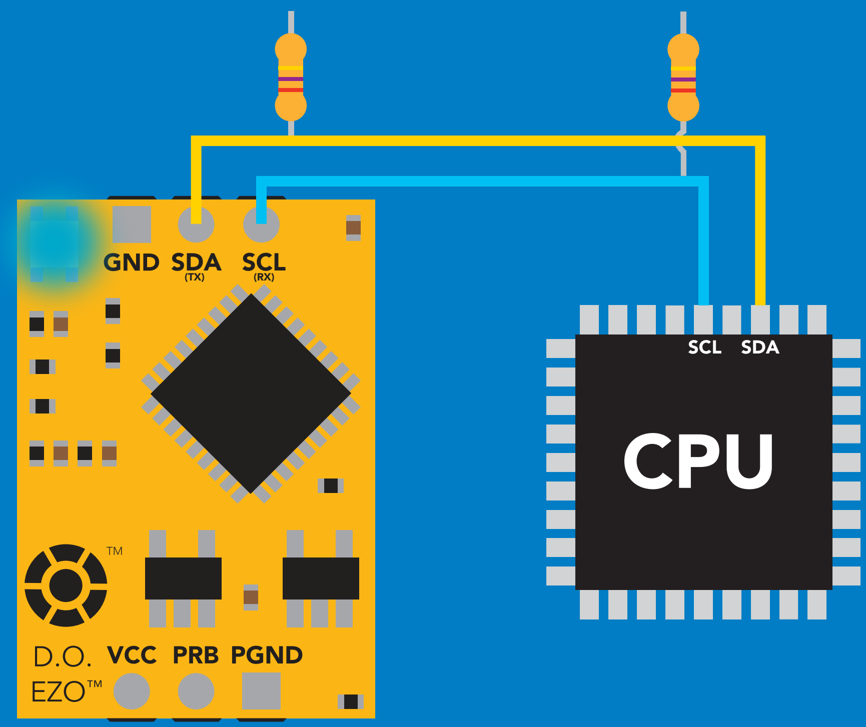
Command: ASCII command string

Example

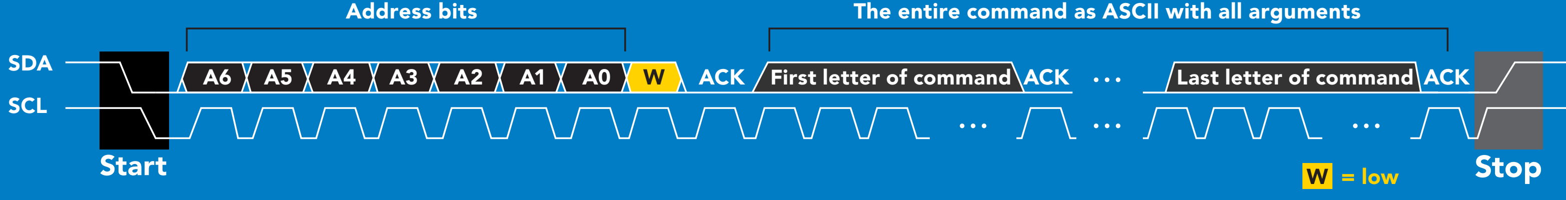
Start | 97 (0x61) | Write | Sleep | Stop

97 (0x61): I^2C address

Sleep: Command

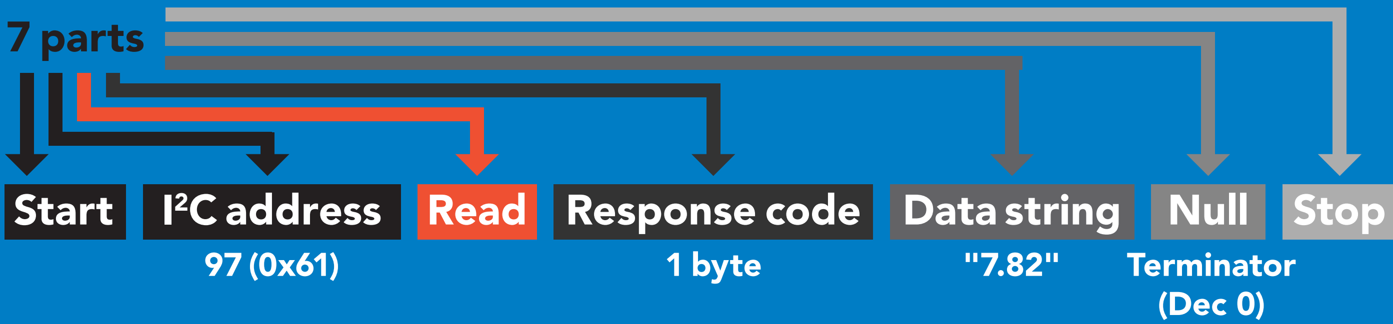


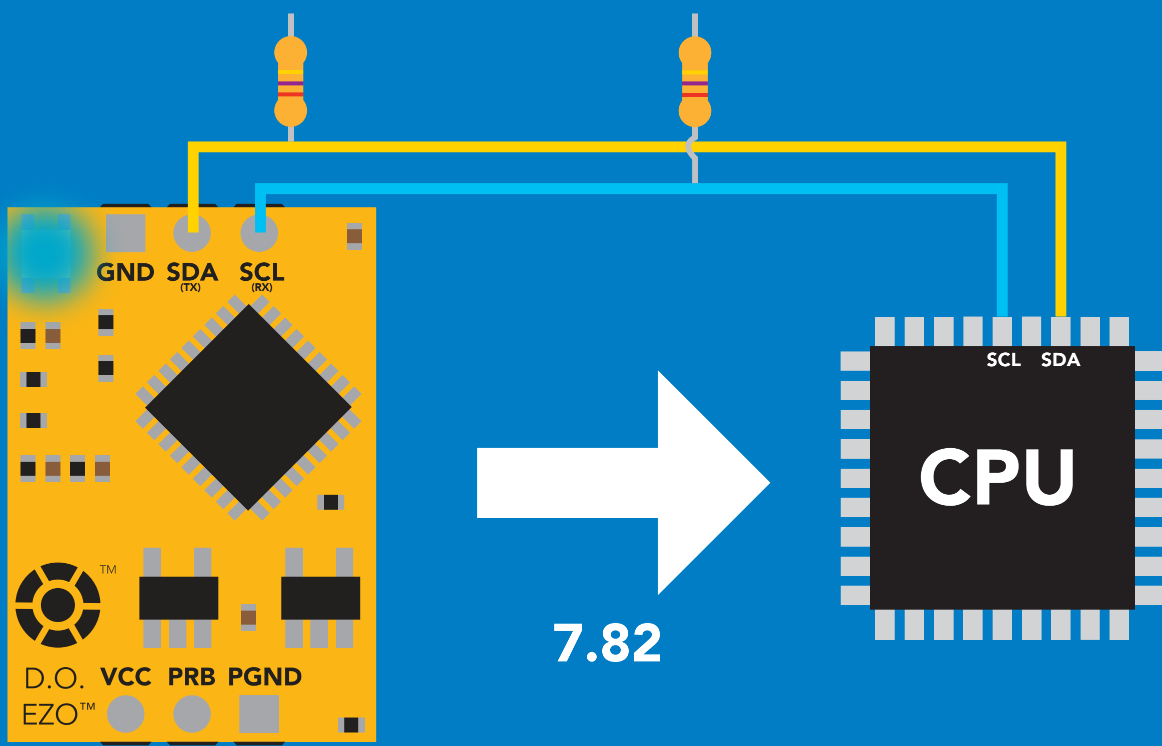
Advanced



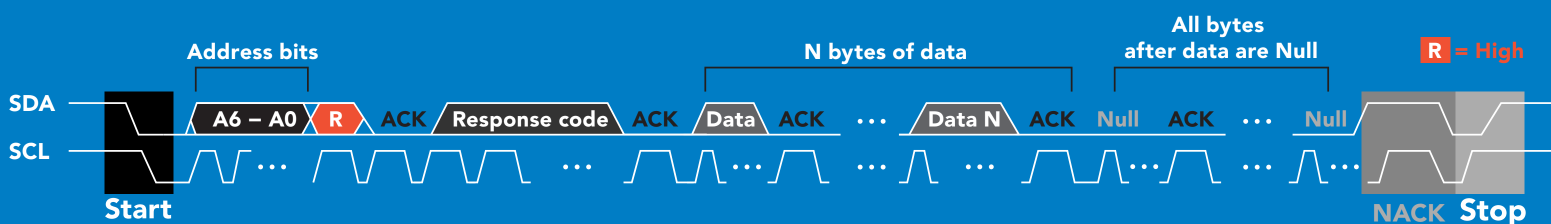
AtlasScientific™
Environmental Robotics

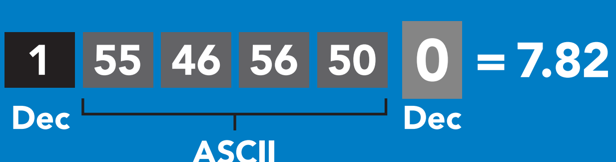
Requesting data from device





Advanced

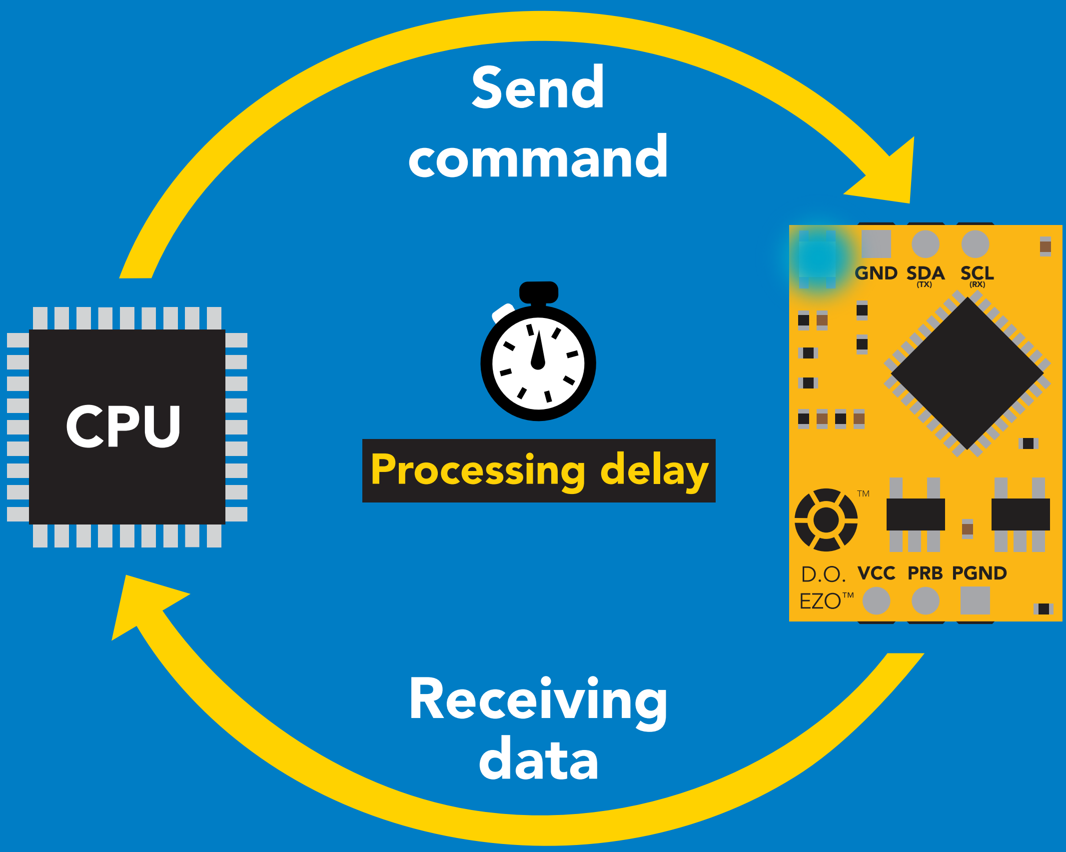




Response codes

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.

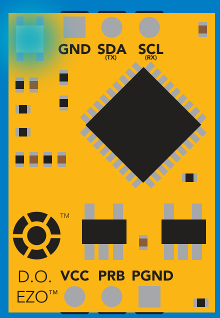
Response codes

Single byte, not string

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

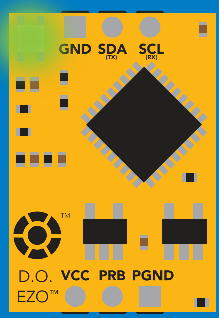
AtlasScientific™ Environmental Robotics

LED color definition



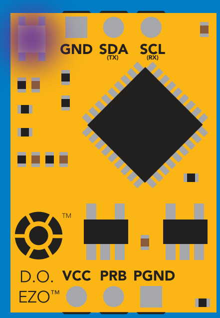
Blue

I²C standby



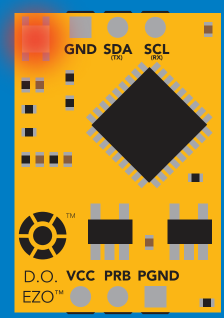
Green

Taking reading



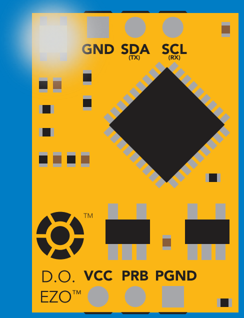
Purple

Changing I²C address



Red

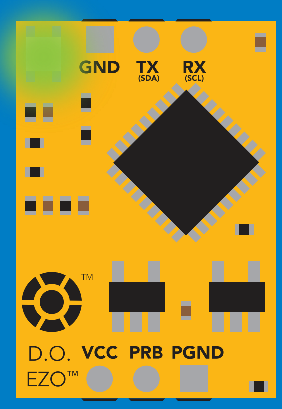
Command not understood



White

Find

	LED ON
5V	**+0.4 mA**
3.3V	**+0.2 mA**



Solid Green LED

in UART mode
Not I²C ready

I²C mode

command quick reference

All commands are ASCII strings or single ASCII characters.

Command	Function	
Baud	change back to UART mode	pg. 61
Cal	performs calibration	pg. 47
Export	export calibration	pg. 48
Factory	enable factory reset	pg. 60
Find	finds device with blinking white LED	pg. 45
i	device information	pg. 55
I2C	change I²C address	pg. 59
Import	import calibration	pg. 49
L	enable/disable LED	pg. 44
Name	set/show name of device	pg. 54
O	removing parameters	pg. 53
P	atmospheric pressure compensation	pg. 52
Plock	enable/disable protocol lock	pg. 58
R	returns a single reading	pg. 46
S	salinity compensation	pg. 51
Sleep	enter sleep mode/low power	pg. 57
Status	retrieve status information	pg. 56
T	temperature compensation	pg. 50

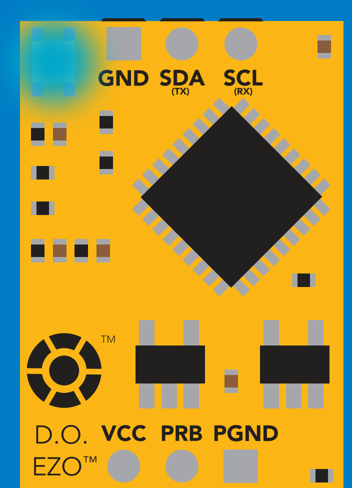
LED control

Command syntax

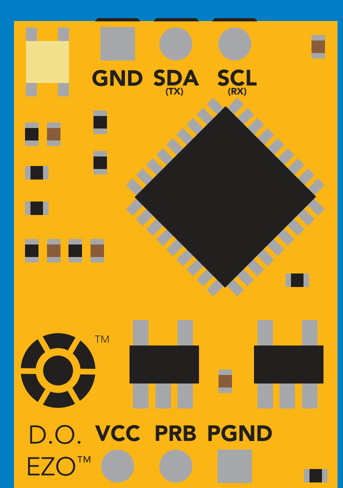
300ms processing delay

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

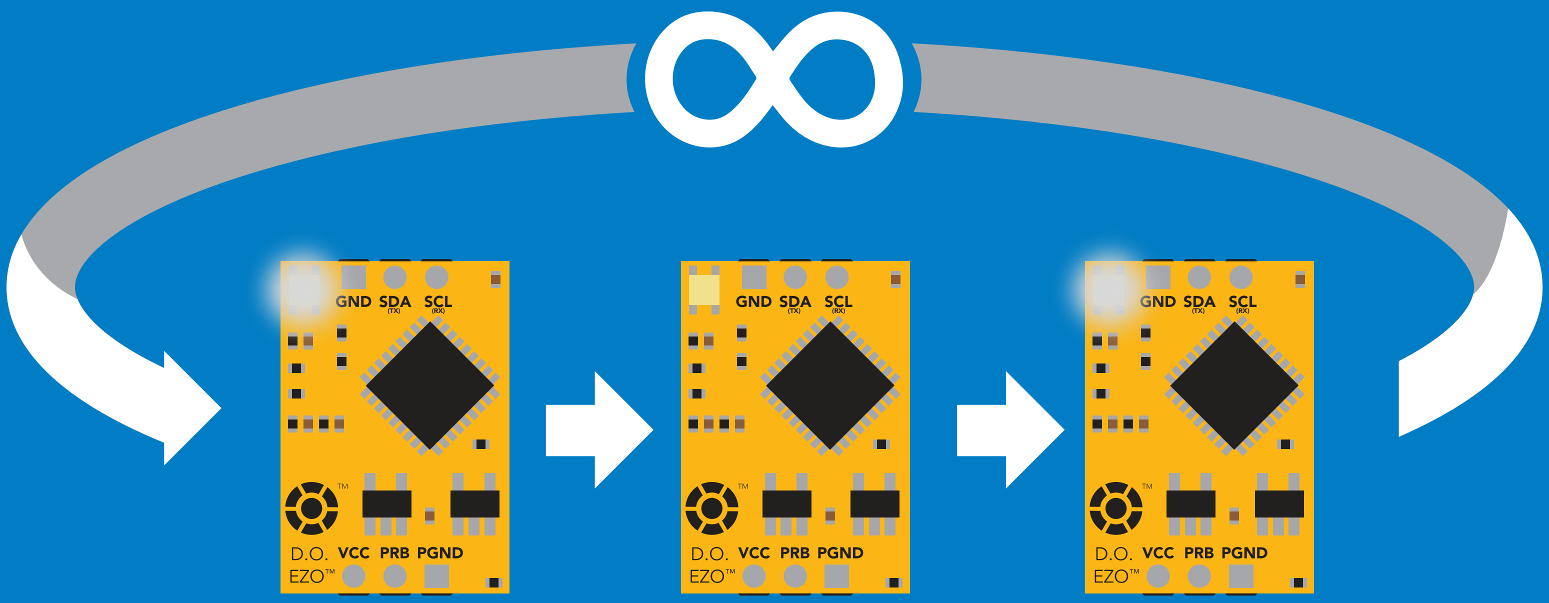
300ms processing delay

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



AtlasScientific™ Environmental Robotics

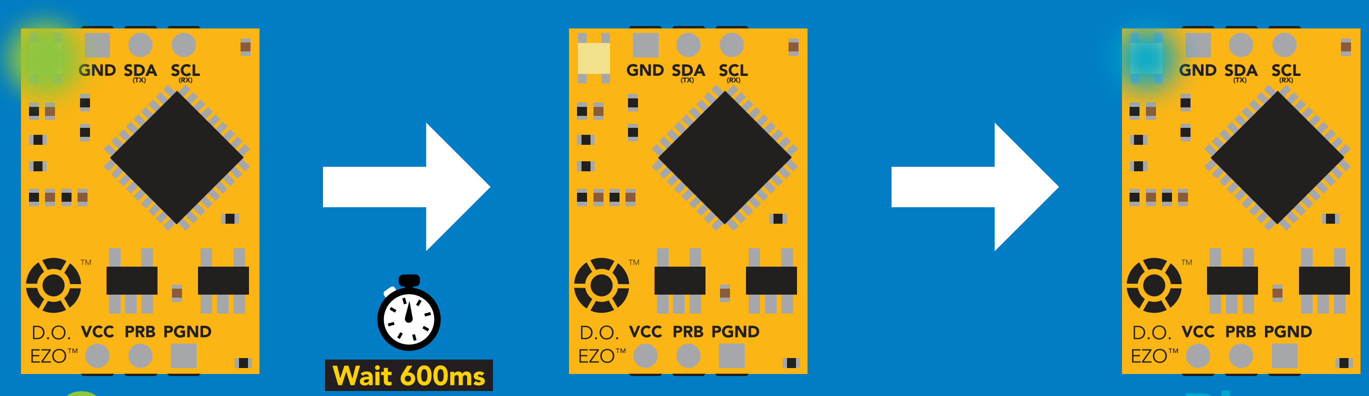
Taking reading

Command syntax

600ms processing delay

R	**return 1 reading**

Example	Response			
R	Wait 600ms	1	7.82	0
		Dec	ASCII	Null



Green
Taking reading

Transmitting

Blue
Standby

Calibration

Command syntax

1300ms processing delay

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

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

Example	Response
Cal	Wait 1300ms — 1 (Dec) 0 (Null)
Cal,0	Wait 1300ms — 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) 0 (Null) or 1 (Dec) ?Cal,2 (ASCII) 0 (Null)

Export calibration

300ms processing delay

Command syntax

Export: Use this command to download calibration settings

Export,?	calibration string info
Export	export calibration string from calibrated device

Example	Response
Export,?	Wait 300ms — 1 (Dec) 10,120 (ASCII) 0 (Null)
Export	Wait 300ms — 1 (Dec) 59 6F 75 20 61 72 (ASCII) 0 (Null) (1 of 10)
Export	Wait 300ms — 1 (Dec) 65 20 61 20 63 6F (ASCII) 0 (Null) (2 of 10)
(7 more)	⋮
Export	Wait 300ms — 1 (Dec) 6F 6C 20 67 75 79 (ASCII) 0 (Null) (10 of 10)
Export	Wait 300ms — 1 (Dec) *DONE (ASCII) 0 (Null)

Response breakdown

10, 120

10: # of strings to export

120: # of bytes to export

Export strings can be up to 12 characters long

Atlas Scientific™ Environmental Robotics

Import calibration

300ms processing delay

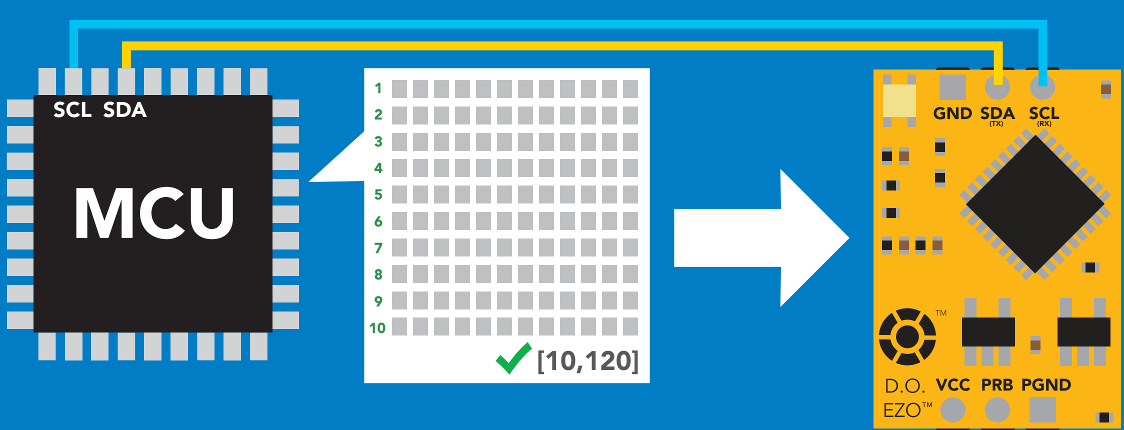
Command syntax

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

Import,n	**import calibration string to new device**

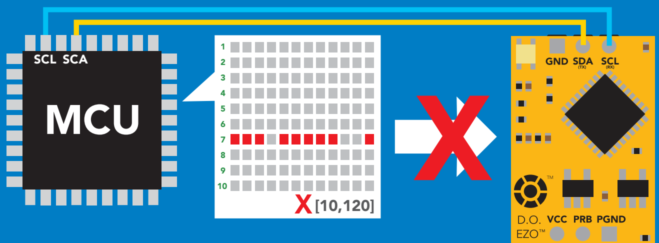
Example		Response
Import, 59 6F 75 20 61 72	(1 of 10)	Wait 300ms 1 Dec 0 Null
Import, 65 20 61 20 63 6F	(2 of 10)	Wait 300ms 1 Dec 0 Null
⋮		⋮
Import, 6F 6C 20 67 75 79	(10 of 10)	Wait 300ms 1 Dec 0 Null

Import,n



1 Dec *Pending ASCII 0 Null

system will reboot



reboot

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

AtlasScientific Environmental Robotics

Temperature compensation

Command syntax

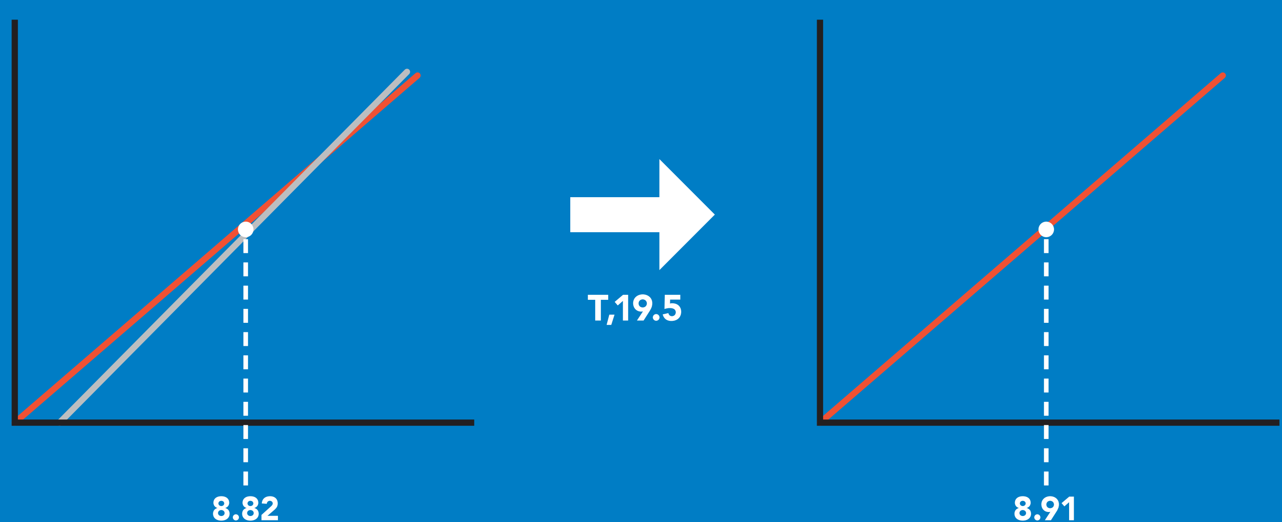
Default temperature = 20°C
Temperature is always in Celsius
Temperature is not retained if power is cut

T,n	n = any value; floating point or int
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)



Atlas Scientific
Environmental Robotics

Salinity compensation

Command syntax

300ms processing delay

S,n	n = any value in microsiemens	default
S,n,ppt	n = any value in ppt	
S,?	compensated salinity value?	

Example	Response
S,50000	Wait 300ms — 1 (Dec) 0 (Null)
S,37.5,ppt	Wait 300ms — 1 (Dec) 0 (Null)
S,?	Wait 300ms — 1 (Dec) ?S,50000,µS (ASCII) 0 (Null) or 1 (Dec) ?S,37.5,ppt (ASCII) 0 (Null)

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

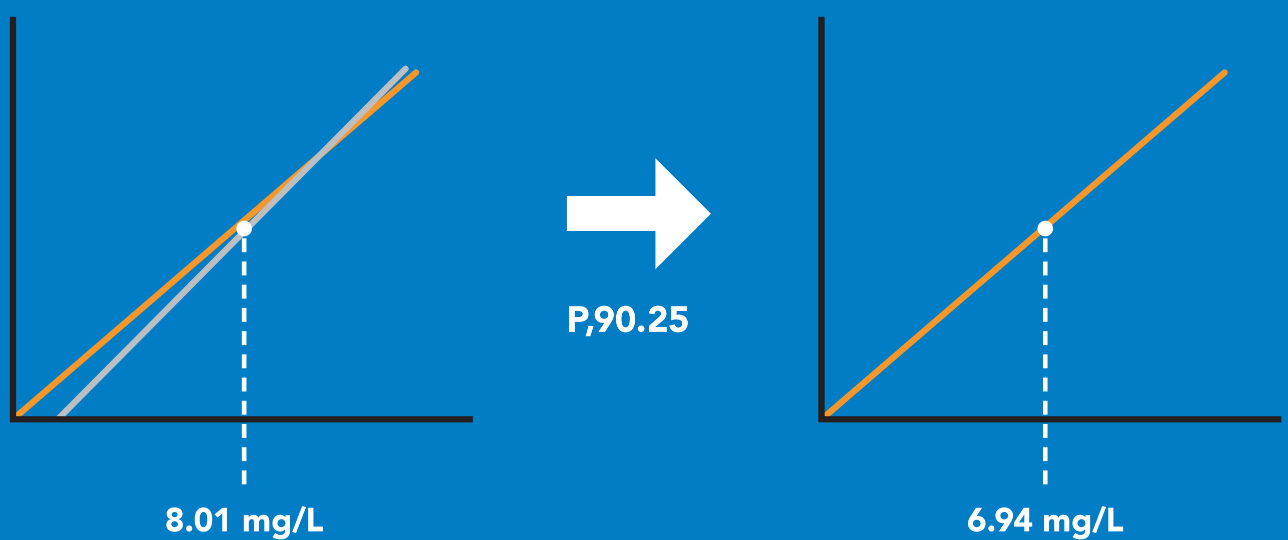
Atmospheric pressure compensation

Command syntax

300ms processing delay

P,n	n = any value in kPa
P,?	compensated pressure value?

Example	Response
P,90.25	Wait 300ms — 1 (Dec) 0 (Null)
P,?	Wait 300ms — 1 (Dec) ?,P,90.25 (ASCII) 0 (Null)



Enable/disable parameters from output string

Command syntax

300ms processing delay

O, [parameter],[1,0]	enable or disable output parameter
O,?	enabled parameter?

Example	Response	
O,mg,1 / O,mg,0	Wait 300ms — 1 Dec, 0 Null	enable / disable mg/L
O,%,1 / O,%,0	Wait 300ms — 1 Dec, 0 Null	enable / disable percent saturation
O,?	Wait 300ms — 1 Dec, ?,O,%,mg ASCII, 0 Null	if both are enabled

Parameters

mg	mg/L
%	percent saturation

Followed by 1 or 0

1	enabled
0	disabled

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

Naming device

300ms processing delay

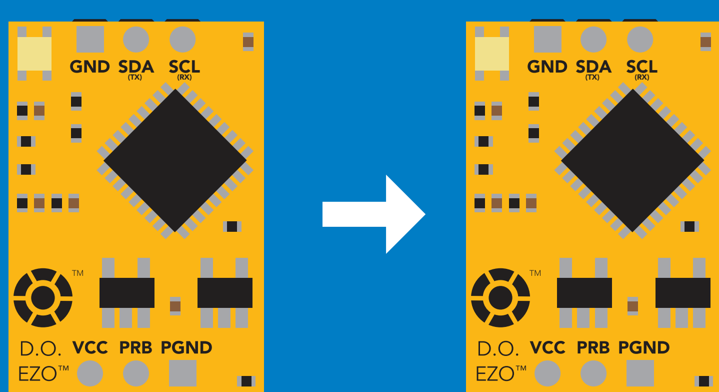
Command syntax

Do not use spaces in the name

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

Example	Response
Name,	Wait 300ms · 1 Dec · 0 Null · name has been cleared
Name,zzt	Wait 300ms · 1 Dec · 0 Null
Name,?	Wait 300ms · 1 Dec · ?Name,zzt ASCII · 0 Null

Name,zzt   Name,?



1 0   1 ?Name,zzt 0

Atlas Scientific™ Environmental Robotics

Device information

Command syntax

300ms processing delay

i	**device information**

Example

Example	Response
i	Wait 300ms · 1 (Dec) · ?i,D.O.,1.98 (ASCII) · 0 (Null)

Response breakdown

?i, D.O., 1.98

D.O. → Device

1.98 → 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	**13.1 mA**	**0.66 mA**
3.3V	**12 mA**	**0.3 mA**

Standby **Sleep**

Protocol lock

Command syntax

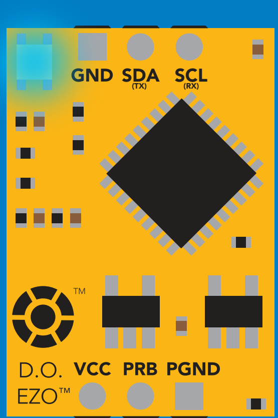
300ms processing delay

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

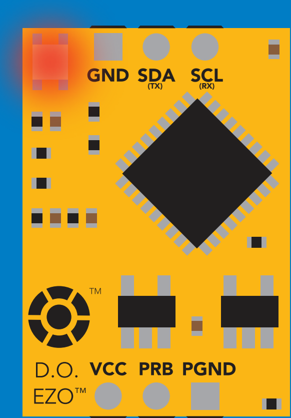
Locks device to I²C mode.

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

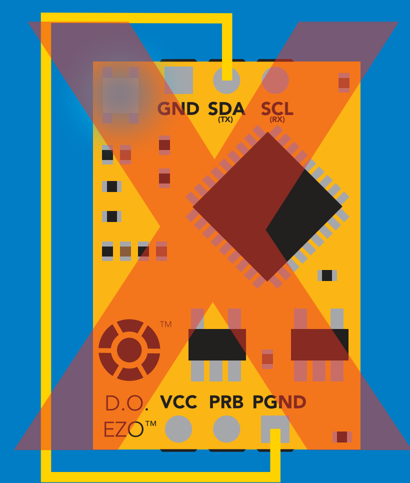
Plock,1



Baud, 9600



cannot change to UART



cannot change to UART

AtlasScientific™ Environmental Robotics

I²C address change

Command syntax

300ms processing delay

I2C,n	sets I²C address and reboots into I²C mode

Example	Response
I2C,100	device reboot (no response given)

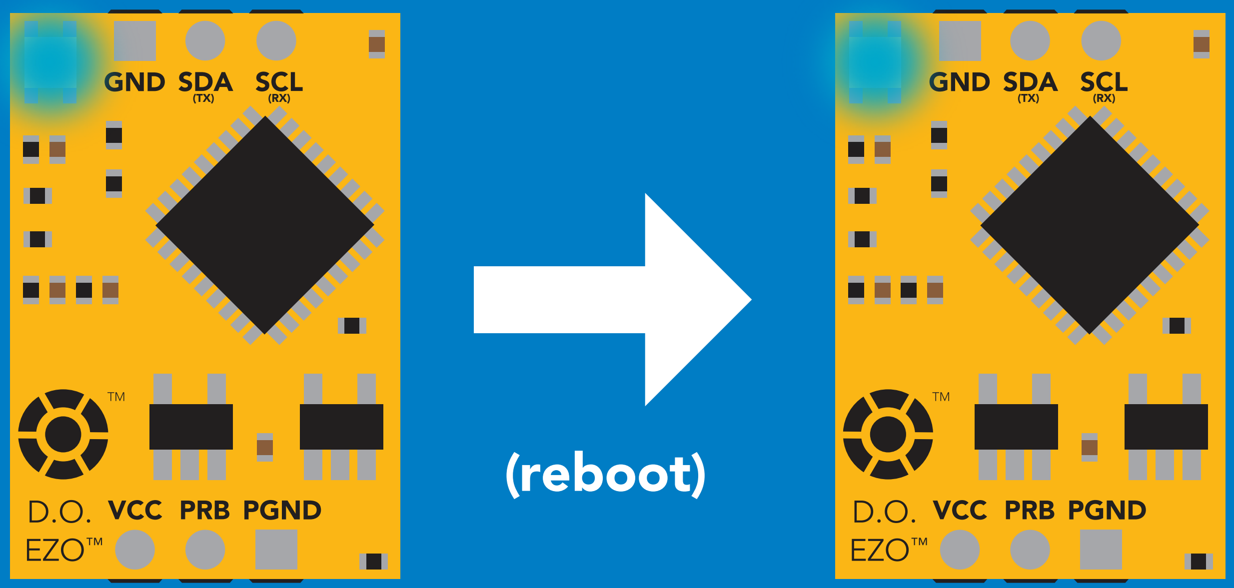
Warning!

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 97 (0x61).

n = any number 1 – 127

I2C,100



Atlas Scientific Environmental Robotics

Factory reset

Command syntax

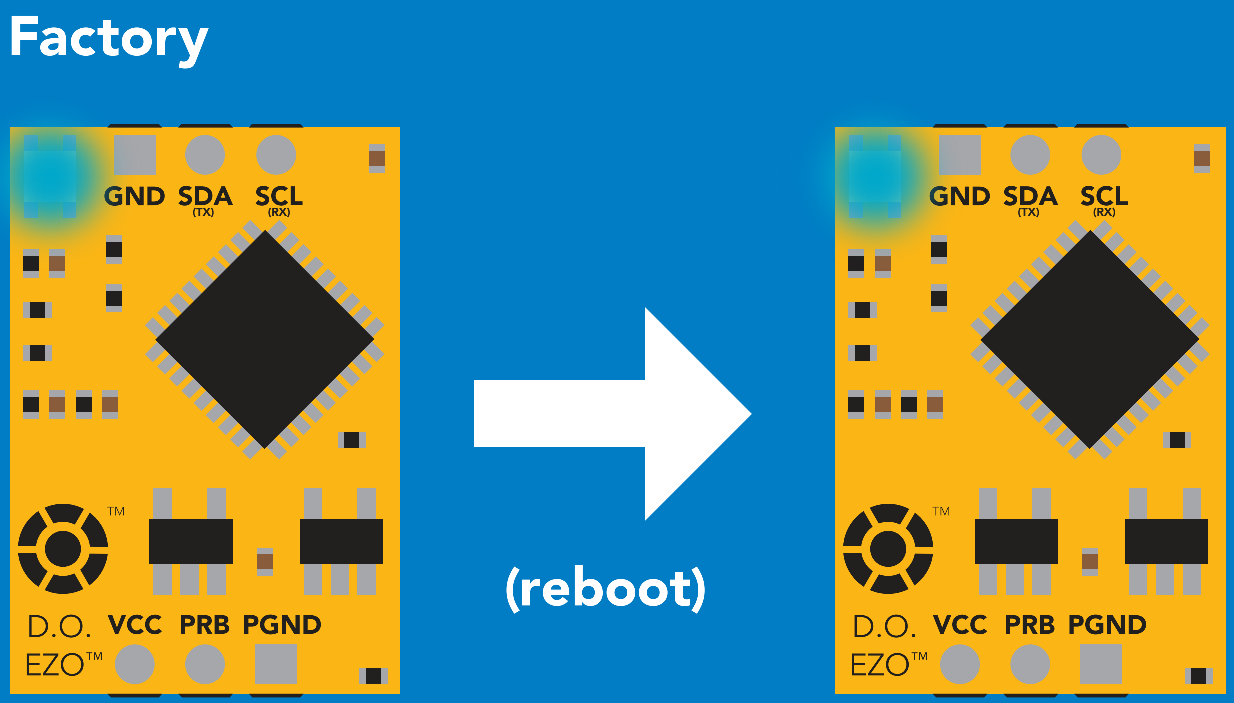
Factory reset will not take the device out of I²C mode.

Factory	enable factory reset

I²C address will not change

Example	Response
Factory	device reboot (no response given)

Clears calibration
LED on
Response codes enabled



AtlasScientific
Environmental Robotics

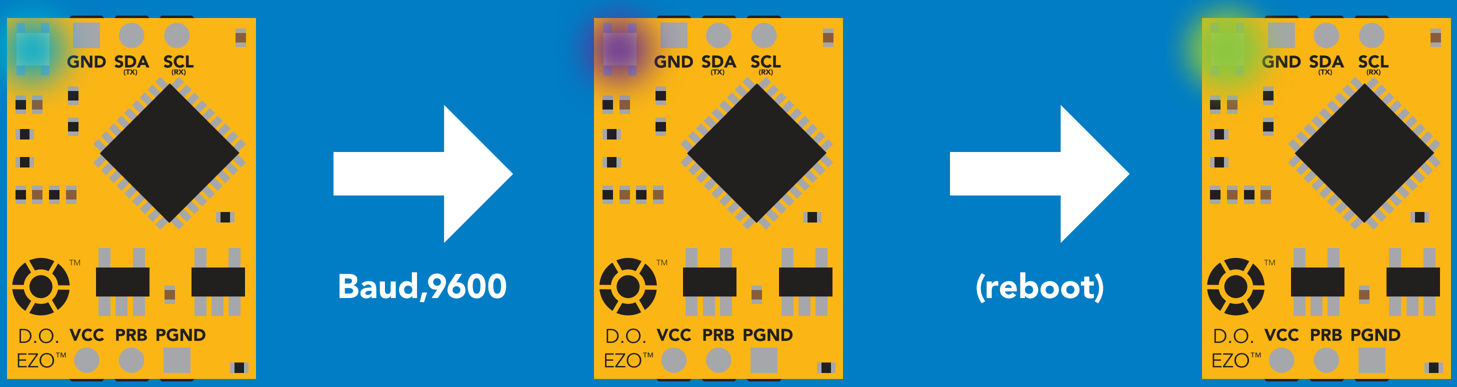
Change to UART mode

Command syntax

Baud,n switch from I²C to UART

Example	Response
Baud,9600	reboot in UART mode (no response given)

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

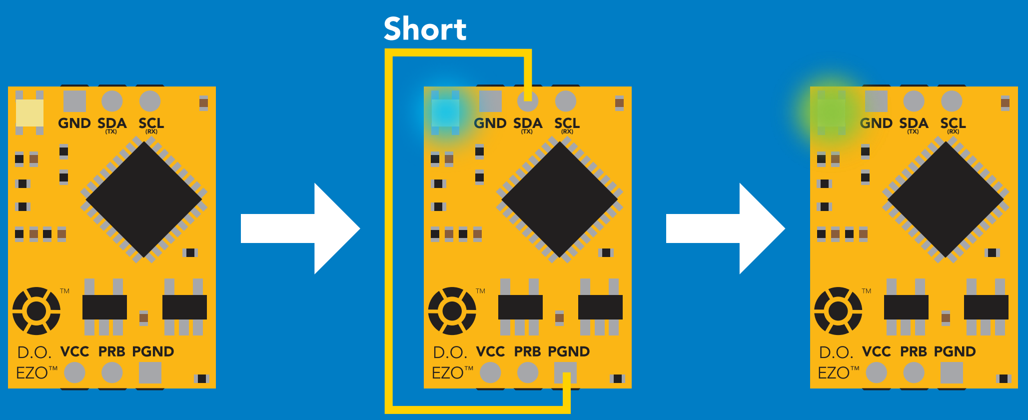


Changing to UART mode

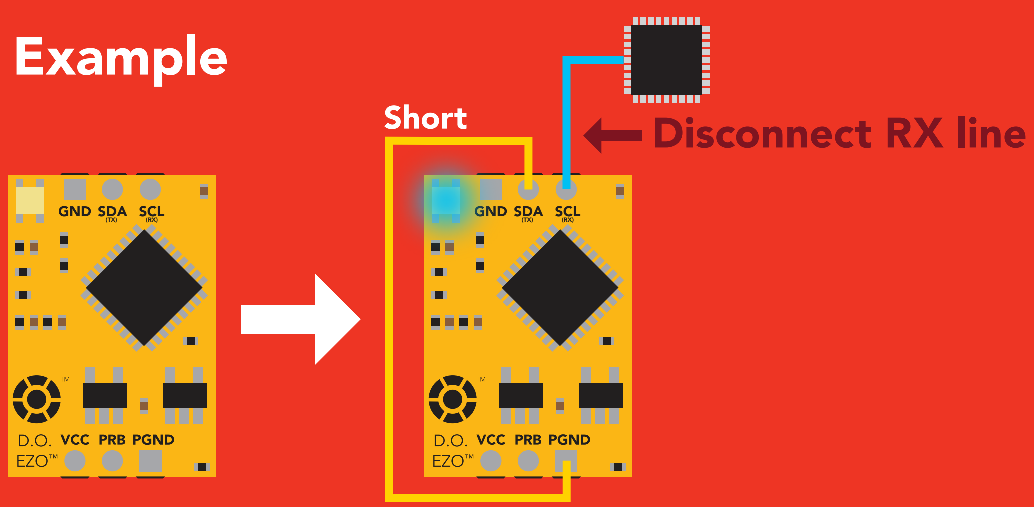
Manual switching to UART

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

Example



Wrong Example

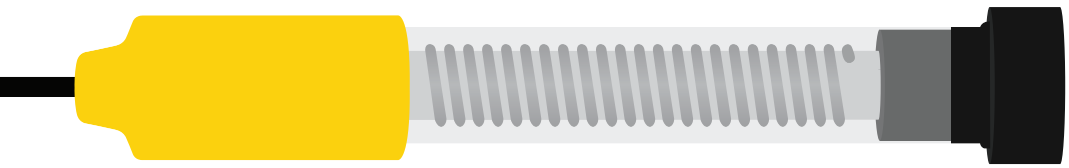


Calibration theory

The accuracy of your readings is directly related to the quality of your calibration.
(Calibration is not difficult, and a little bit of care goes a long way).

Confirm the D.O. probe is working correctly

Take readings in air first.



Readings > 10	Readings < 5 or > 25
✓	*Refer to probes datasheet for instructions.*

Calibrate first, compensate later

Compensating for temperature, pressure, and salinity will change your calibrated readings to a value that cannot easily be predicted. This makes it difficult to know if the probe has been calibrated correctly.

Default compensation values	Known calibration value
Temp = 20 °C **Pressure = 101 kPa** **Salinity = 0**	**9.09 Mg/L**
Temp = 29 °C **Pressure = 93 kPa** **Salinity = 5** *(too many variables)*	**???** **(6.84 Mg/L)**

Best practices for calibration

Always watch the readings throughout the calibration process.
Issue calibration commands once the readings have stabilized.

⚠ Never do a blind calibration! ⚠

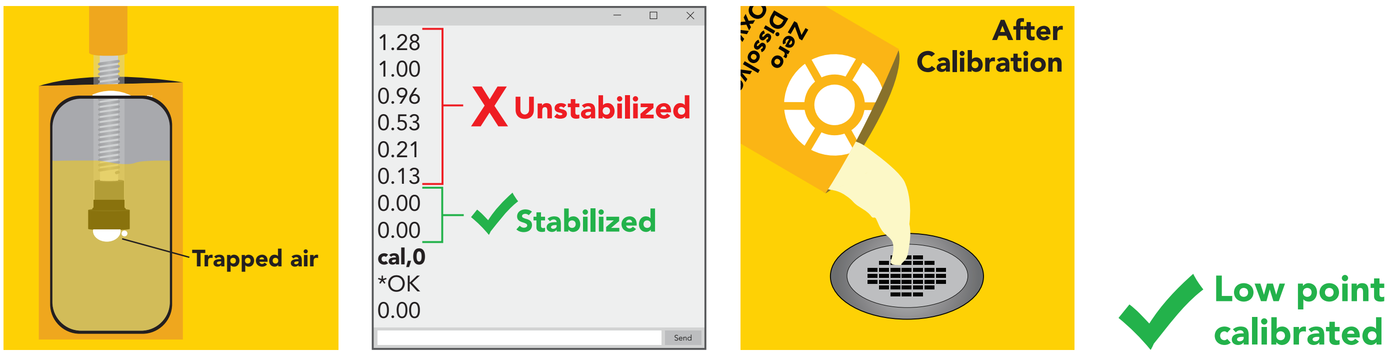
Issuing a calibration command before the readings stabilize will result in drifting readings.

Calibration order

Your dissolved oxygen probe is filled with an electrolyte solution made of water. This water can store its own dissolved oxygen. Before we can get accurate readings, we must remove any dissolved oxygen that is hiding in the electrolyte solution.

1. Low point calibration

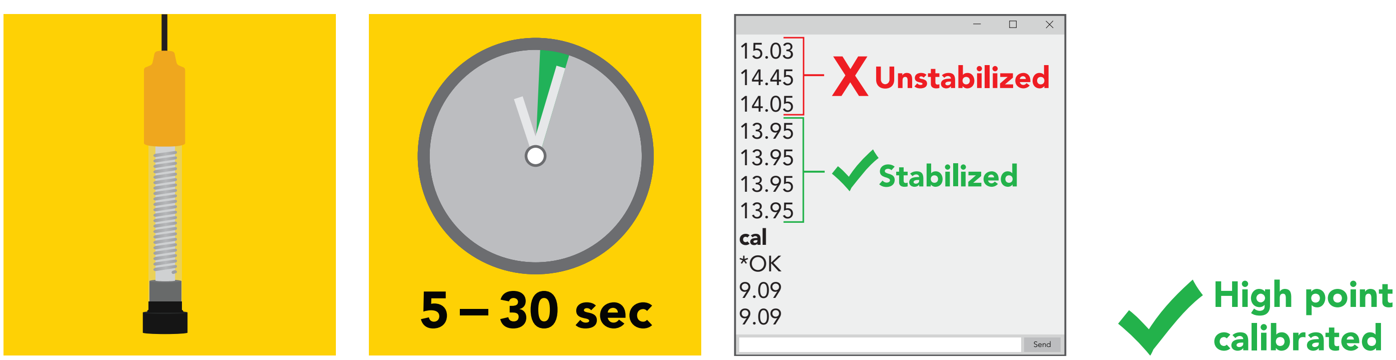
Insert the probe into the Zero Dissolved Oxygen calibration solution, and stir it around to remove any trapped air *(which could cause readings to go high)*. Take continuous readings until they reach zero.



A new probe will have a small amount of internal dissolved oxygen and getting the readings to zero will only take a few minutes. However, If you just added new electrolyte to your probe, it will have a ***VERY*** high amount of dissolved oxygen and getting the readings to zero <u>*may take several hours*</u>.

2. High point calibration

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



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

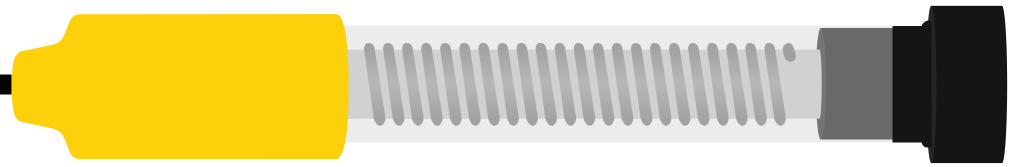
Advanced calibration

Probe temperature calibration

Probe temperature calibration ≠ Temperature compensation.

When a Dissolved Oxygen probe is calibrated, it is calibrated to the oxygen level and ambient temperature. As a D.O. probe is heated or cooled, its response curve will change. A small temperature change (≤ 5 °C) will not affect the probe. However, a large temperature change will be noticeable.

Calibrated probe

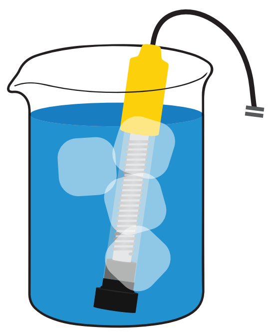


Air temperature

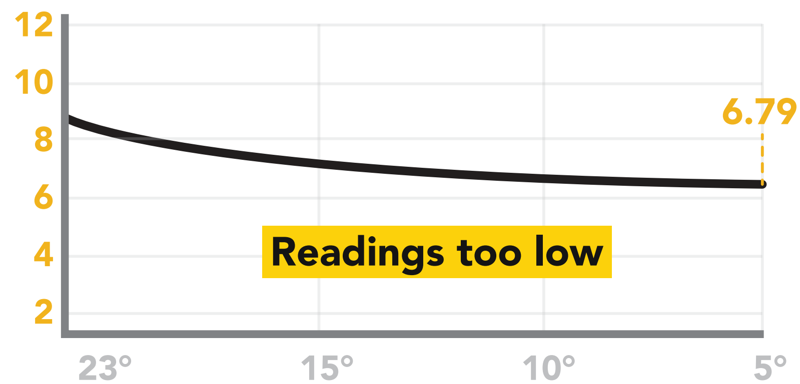
23°C

Air Reading

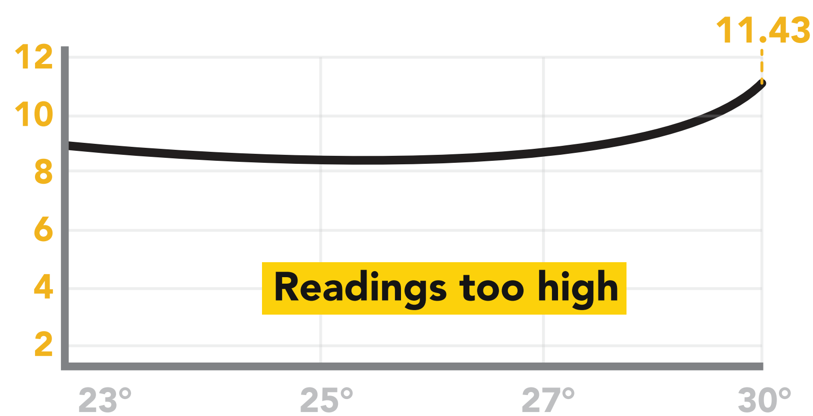
9.10 mg/L



5°C



30°C

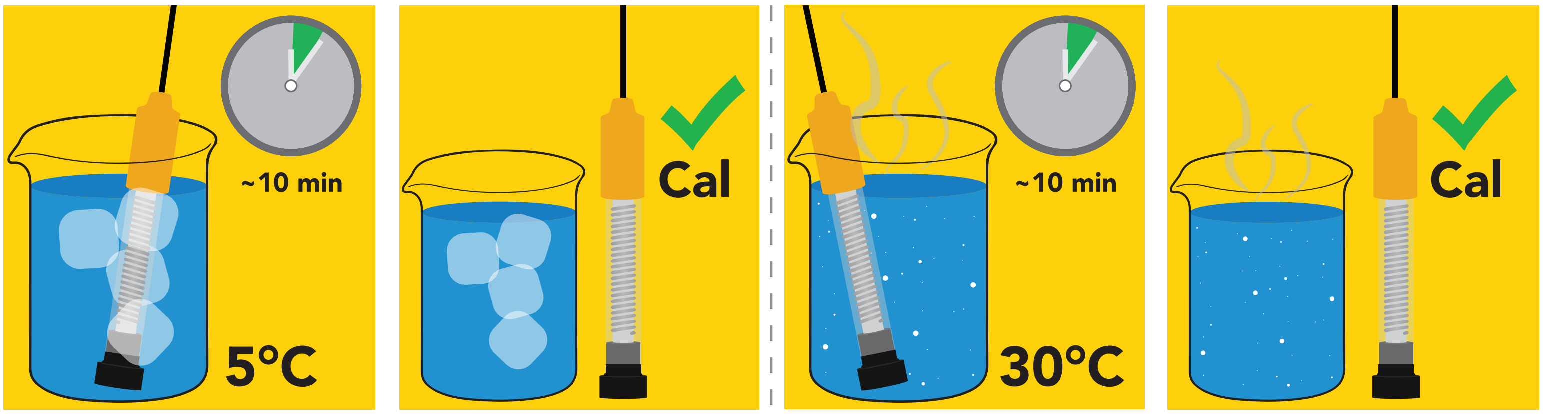


AtlasScientific
Environmental Robotics

Advanced calibration

What to do:

After the Dissolved Oxygen probe has been properly calibrated, another calibration can be done to account for the probe temperature.

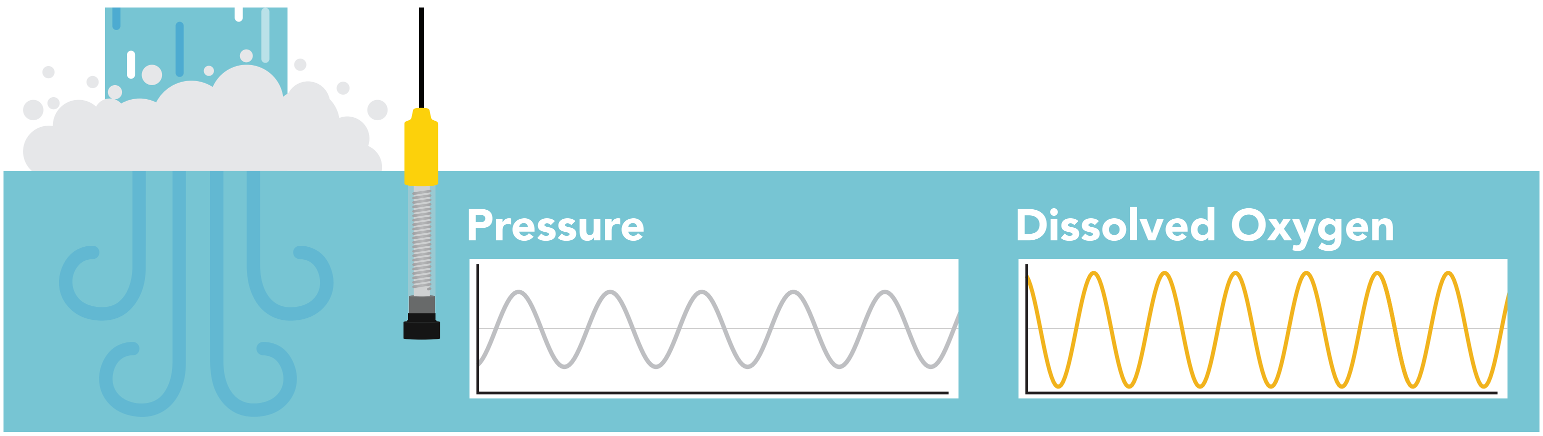


Let the probe acclimate to its operating temperature and then recalibrate. Once the probe has been calibrated at its intended operating temperature, using temperature compensation will give accurate readings.

Understanding D.O. measurements

Most chemical sensors do not directly measure the parameter they are designed for. Dissolved oxygen is no exception. A galvanic D.O. probe is actually an oxygen pressure sensor. It only measures the partial pressure of oxygen.

Keep this in mind when choosing a spot to place the probe.



It just so happens that partial pressure of oxygen is the same in water as it is in air.

(While the pressure is the same, the amount is not. Pure water at sea level can only hold ~9 mg/L of oxygen, while the atmosphere holds ~300mg/L)

By comparing oxygens pressure to its solubility in water, the mg/L are derived.

There are three factors that affect waters ability to hold oxygen.

Temperature
Salinity
Atmospheric Pressure

Temperature

Water temperature has the largest effect; the colder the water, the more oxygen it holds. As water heats up, its ability to hold oxygen goes down.

Pure water at 1°C can hold 14.2 mg/L

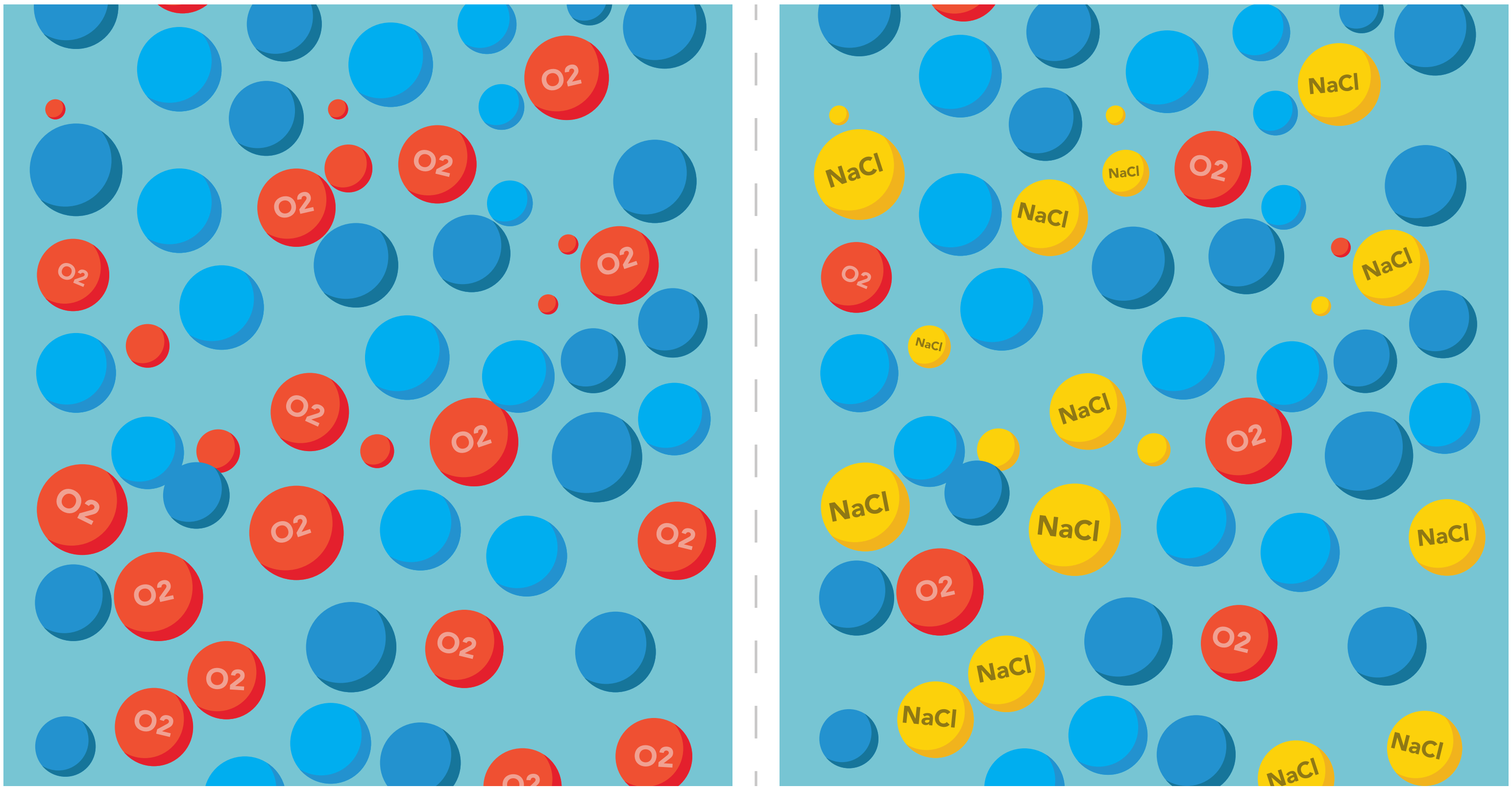
And at 40°C it can only hold 6.4 mg/L

Understanding D.O. measurements

Salinity

When salt is added to water, it drives out oxygen by competing for the same space.

Sea water at 1°C can only hold 10.7 mg/L
Pure water at 1°C can hold 14.2 mg/L



Atmospheric Pressure

A D.O. probe is an oxygen pressure sensor.

Dissolved oxygen pressure cannot be higher than atmospheric oxygen pressure. This is why the probe is calibrated to the atmosphere; it defines the probe's response to the maximum oxygen pressure available. However, oxygen pressure does not tell us how much oxygen is available to dissolve in the water. That information is derived from atmospheric pressure (where atmospheric pressure = altitude).

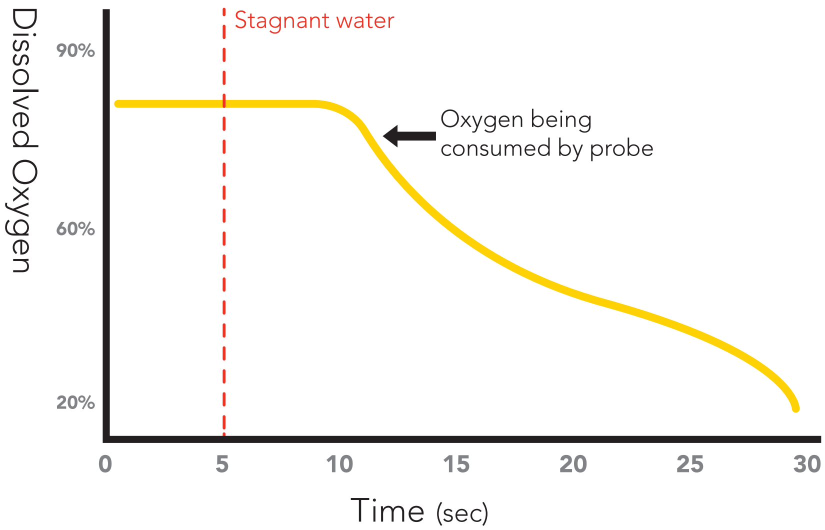
As altitude increases, oxygen concentration decreases, and because D.O. readings are expressed in Mg/L, the oxygen concentration must be known.

At sea level, 1°C pure water can hold 14.2 mg/L

At 1,500 meters, 1°C pure water can hold 11.7 mg/L

At -1,200 meters, 1°C pure water can hold 16.2 mg/L

Flow Dependence



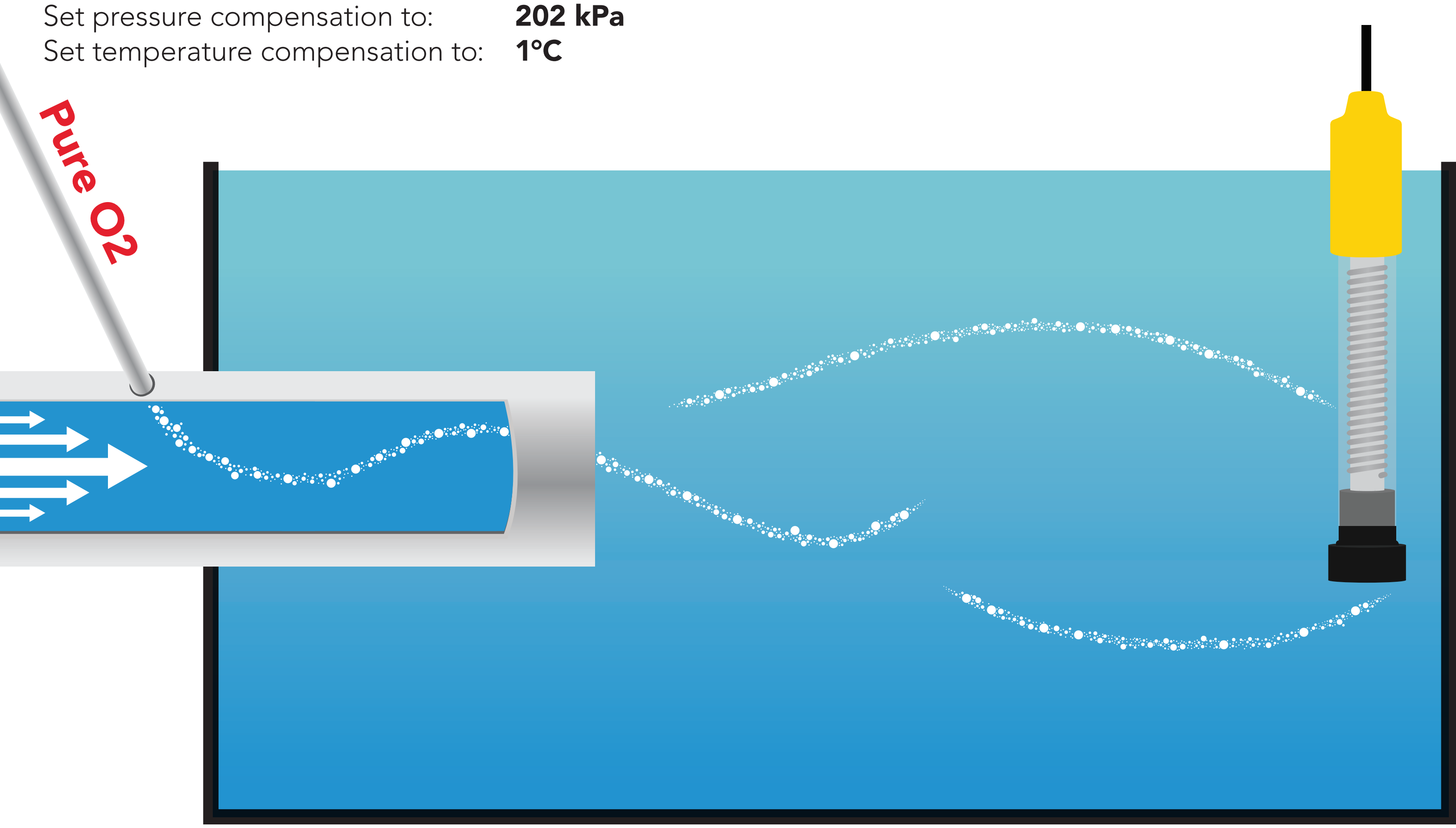
One of the drawbacks from using a galvanic probe is that it consumes a ***VERY*** small amount of the oxygen it reads. Therefore, a small amount of water movement is necessary to take accurate readings. **Approximately 60 ml/min**.

Hyper saturation with pure oxygen

Dissolved oxygen measurements are based on natural occurring oxygen levels. However, some applications may require pure oxygen to achieve extremely high saturation levels. Because injecting pure oxygen into water is not a naturally occurring event, you will need to change some compensation parameters to achieve extremely high readings.

To reach 100mg/L and a saturation of 350%

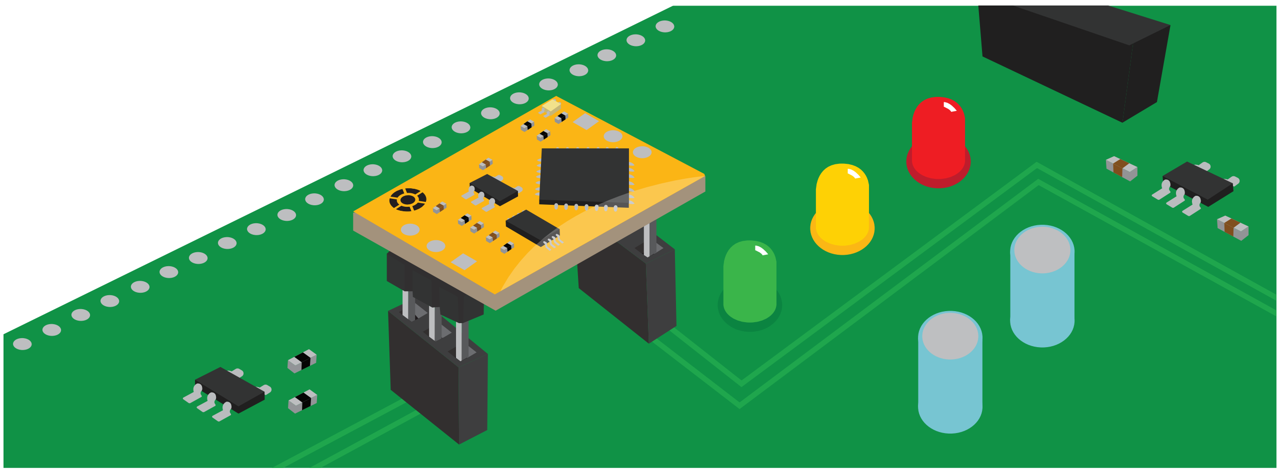
Set pressure compensation to: **202 kPa**
Set temperature compensation to: **1°C**



Soldering

Do not directly solder an EZO circuit to your PCB. If something goes wrong during the soldering process it may become impossible to correct the problem. It is simply not worth the risk.

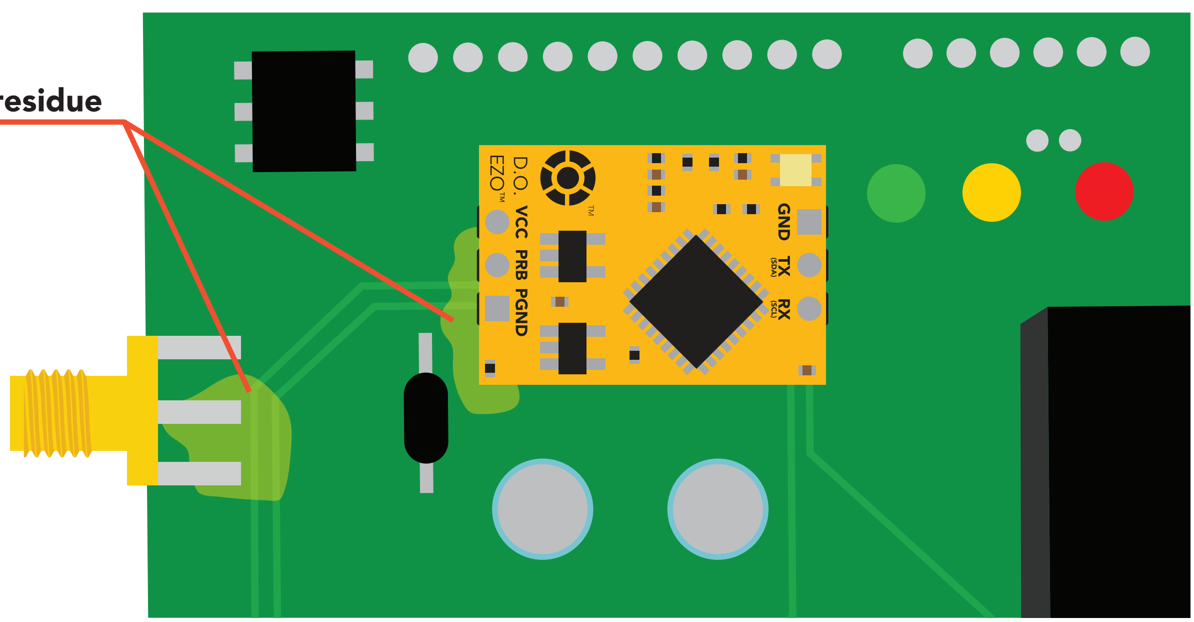
Instead, solder female header pins to your PCB and place the EZO device in the female headers.



Avoid using rosin core solder.
Use as little flux as possible.

Flux residue will severely affect your readings. Any Flux residue that comes in contact with the PRB pins or your probes connector will cause a "flux short".

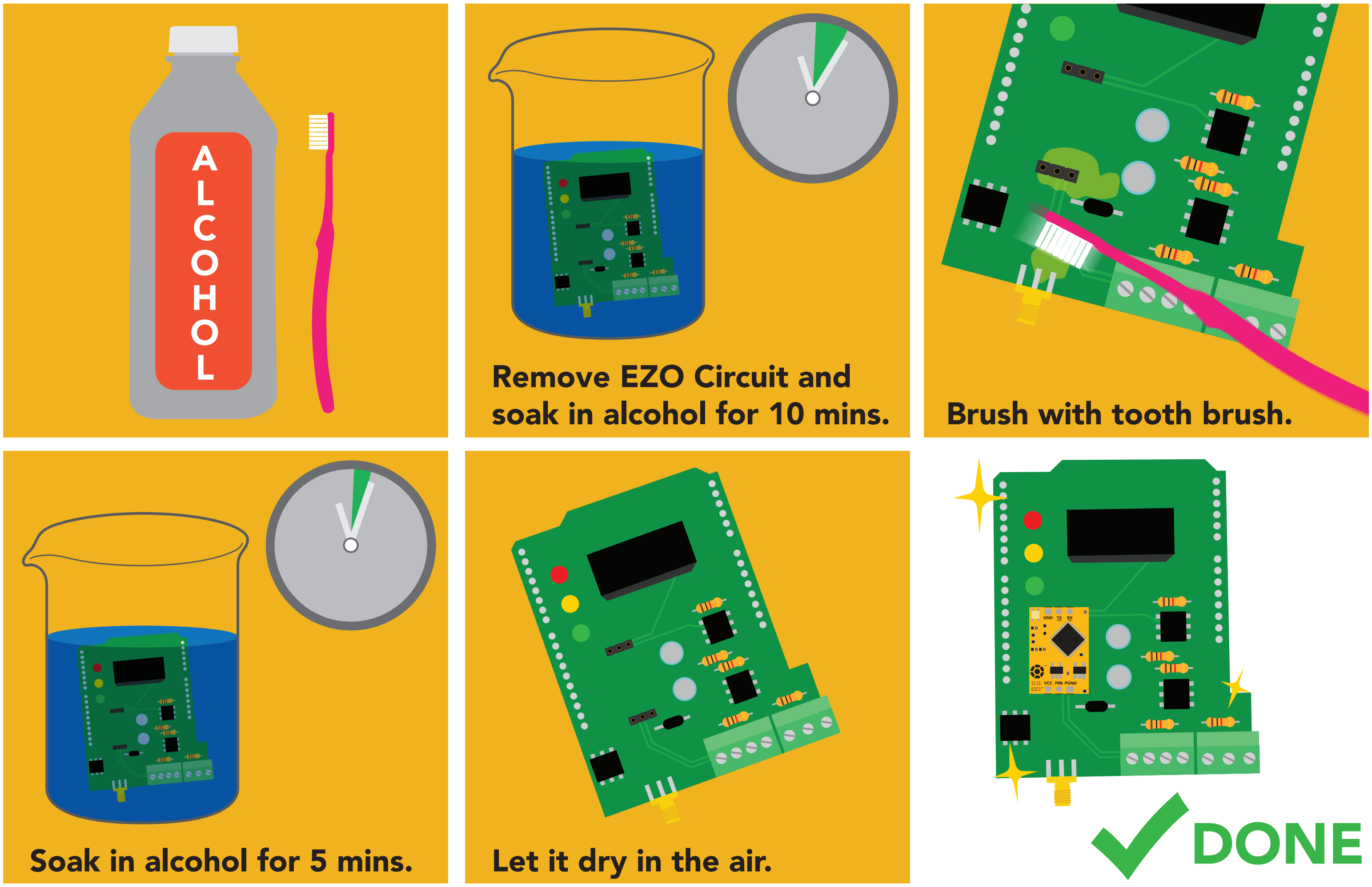
Flux residue



You ***MUST*** remove all the flux residue from your PCB after soldering.

Soldering

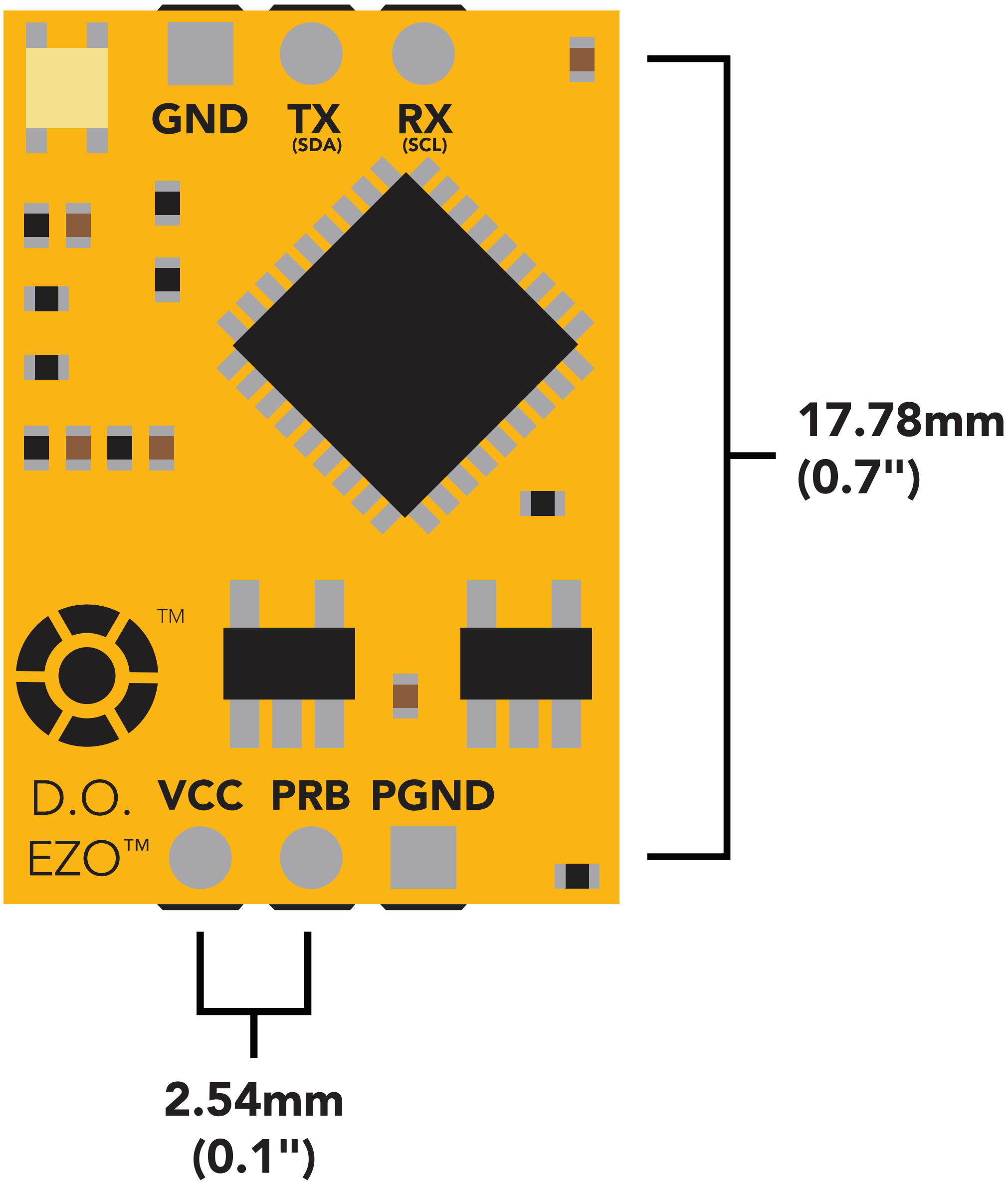
Removing flux residue can be done with commercially available products such as flux off or you can use alcohol and a tooth brush.



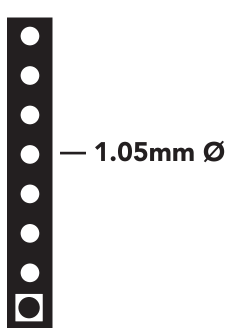
What does a flux short look like?

Readings move slowly and take serval minutes to reach the correct value.

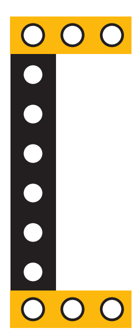
EZO™ circuit footprint



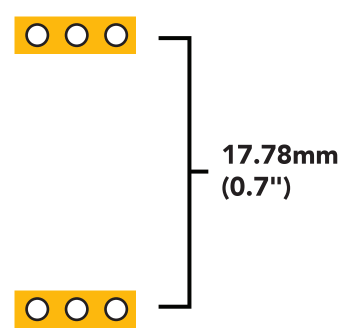
1 In your CAD software place a 8 position header.



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



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



Datasheet change log

Datasheet V 5.8

Revised calibration order on page 65.

Datasheet V 5.7

Revised artwork in document.

Datasheet V 5.6

Revised enitre document.

Datasheet V 5.5

Revised naming device info on pages 32 & 59.

Datasheet V 5.4

Revised artwork within datasheet.

Datasheet V 5.3

Moved Default state to pg 13.

Datasheet V 5.2

Updated firmware changes on page 70.

Datasheet V 5.1

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

Datasheet V 5.0

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

Datasheet V 4.9

Corrected temperature compensation typo on pages 26 & 52.

Datasheet V 4.8

Revised isolation schematic on pg. 10

Datasheet change log

Datasheet V 4.7

Added new command:
"RT,n" for Temperature compensation located on pages 26 (UART) & 52 (I^2C).
Added firmware information to Firmware update list.

Datasheet V 4.6

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

Datasheet V 4.5

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

Datasheet V 4.4

Removed note from certain commands about firmware version.

Datasheet V 4.3

Added information to calibration theory on pg 7.

Datasheet V 4.2

Revised definition of response codes on pg 44.

Datasheet V 4.1

Updated firmware changes on pg. 66.

Datasheet V 4.0

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

Datasheet V 3.9

Revised information on cover page.

Datasheet V 3.8

Update firmware changes on pg. 66.

Datasheet change log

Datasheet V 3.7

Revised Plock pages to show default value.

Datasheet V 3.6

Added new commands:
"Find" pages 21 (UART) & 48 (I^2C).
"Export/Import calibration" pages 25 (UART) & 51 (I^2C).
Added new feature to continous mode "C,n" pg 22.

Datasheet V 3.5

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

Datasheet V 3.4

Added manual switching to UART information on pg. 59.

Datasheet V 3.3

Updated firmware changes to refeclt V1.99 update.

Datasheet V 3.2

Revised entire datasheet.

Firmware updates

V1.1 – Initial release (Oct 30, 2014)
- Change output to mg/L, then percentage (was previously percentage, then mg/L).

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

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

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

V1.95 – Plock (March 31, 2016)
- Added protocol lock feature "Plock"

V1.96 – EEPROM (April 26, 2016)
- Fixed bug where EEPROM would get erased if the circuit lost power 900ms into startup.

V1.97 – EEPROM (Oct 10, 2016)
- Fixed bug in the cal clear command, improves how it calculates the DO, adds calibration saving and loading.

V1.98 – EEPROM (Nov 14, 2016)
- Updated firmware for new circuit design.

V1.99 – (Feb 2, 2017)
- Revised "O" command to accept mg.

V2.10 – (April 12, 2017)
- Added "Find" command.
- Added "Export/import" command.
- Modified continuous mode to be able to send readings every "n" seconds.

V2.11 – (Sept 28, 2017)
- Fixed bug where the temperature would default to 0 on startup.

V2.12 – (Dec 19, 2017)
- Improved accuracy of dissolved oxygen equations.

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

V2.14 – (June 7, 2019)
- Fixed bug where the output buffer overflows when the cal and cal,0 point are too close together.

Firmware updates

V2.15 – (Sept 8, 2022)
• Internal update for new part compatibility.

Warranty

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

The debugging phase

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

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

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

Reasoning behind this warranty

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

Please keep this in mind:

1. **All Atlas Scientific™ devices have been designed to be embedded into a custom made system by you, the embedded systems engineer.**

2. **All Atlas Scientific™ devices have been designed to run indefinitely without failure in the field.**

3. **All Atlas Scientific™ devices can be soldered into place, however you do so at your own risk.**

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

