Atlas Scientific™
Environmental Robotics

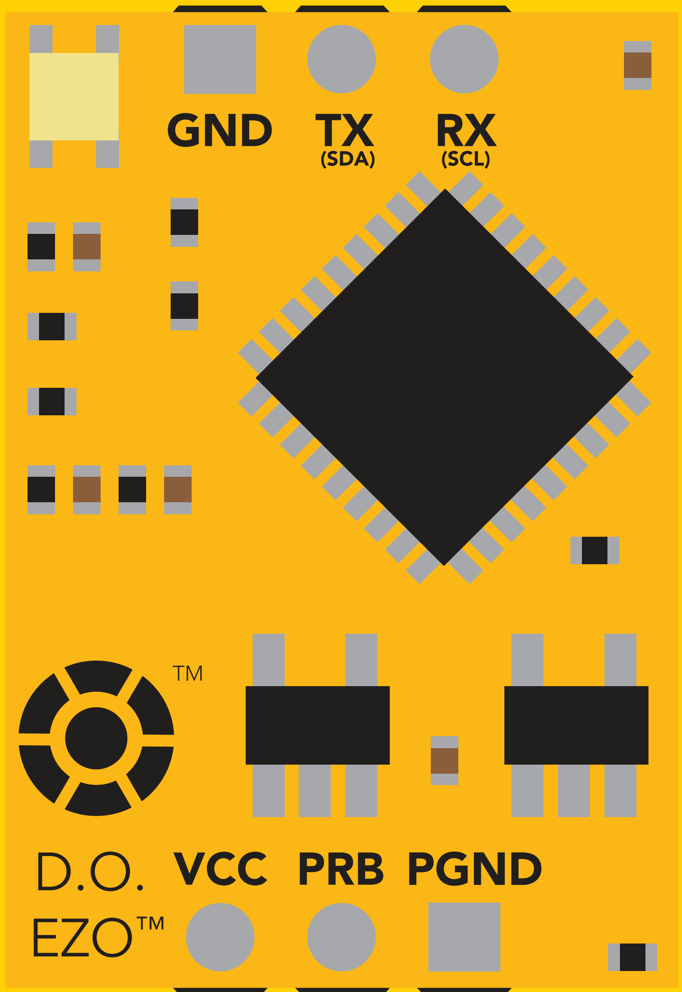
V 5.3

Revised 8/13/19

EZO-DO™

Embedded Dissolved Oxygen Circuit

Reads	**Dissolved Oxygen**
Range	**0.01 – 100+ mg/L** **0.1 – 400+ % saturation**
Accuracy	**+/– 0.05 mg/L**
Response time	**1 reading per sec**
Supported probes	**Any galvanic probe**
Calibration	**1 or 2 point**
Temperature, salinity and pressure compensation	**Yes**
Data protocol	**UART & I^{2}C**
Default I^{2}C 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.

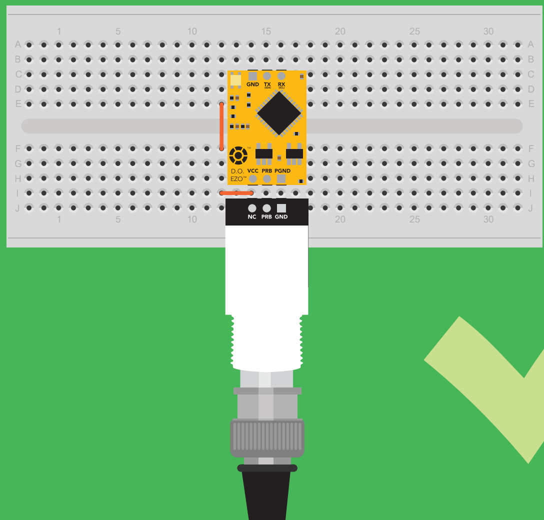
STOP

SOLDERING THIS DEVICE VOIDS YOUR WARRANTY.

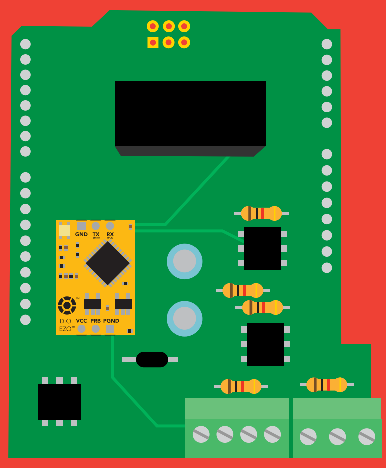
This is sensitive electronic equipment. Get this device working in a solderless breadboard first. Once this device has been soldered it is no longer covered by our warranty.

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

Get this device working in a solderless breadboard first!



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



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UART

I²C

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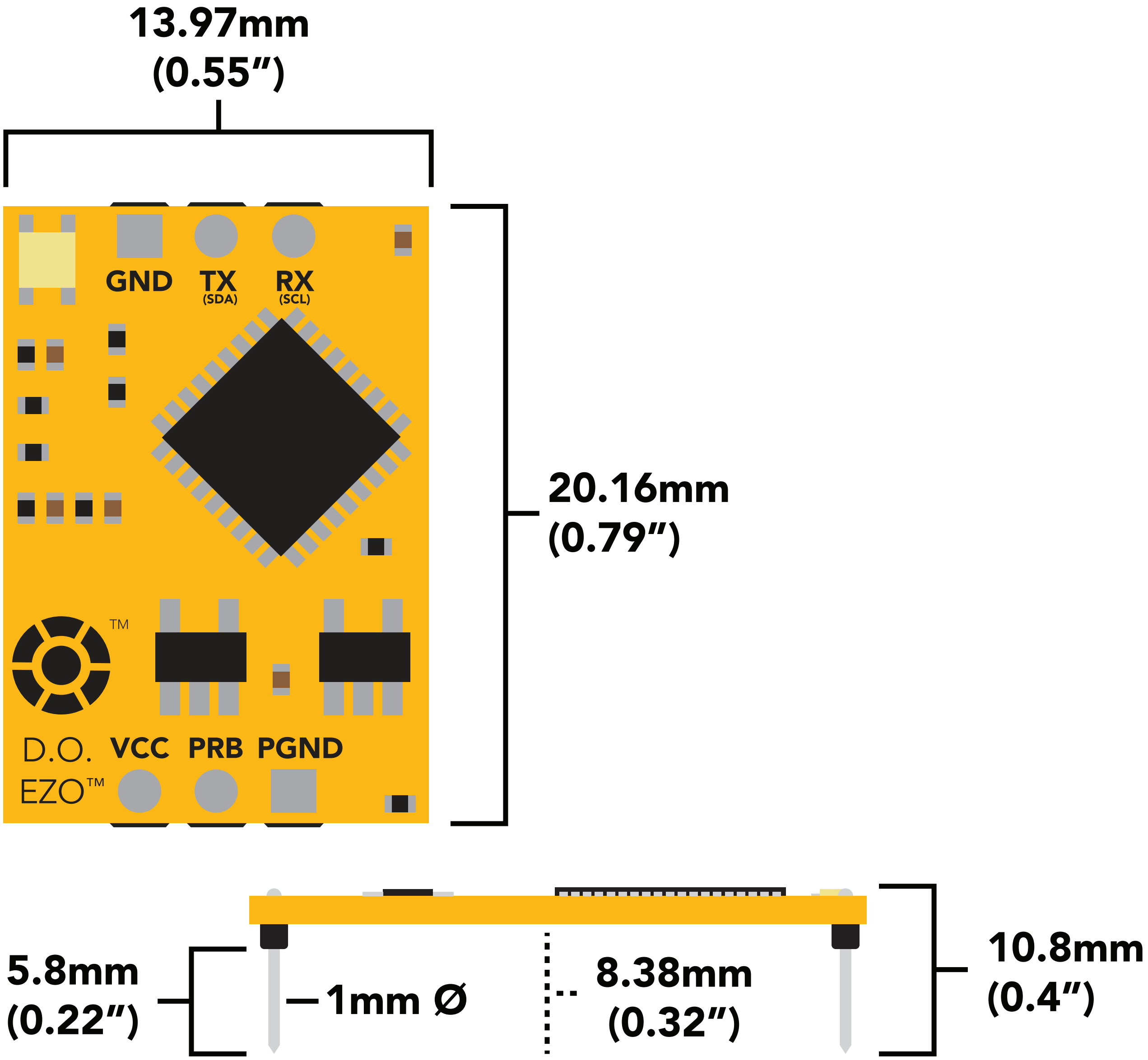
EZO™ circuit dimensions



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

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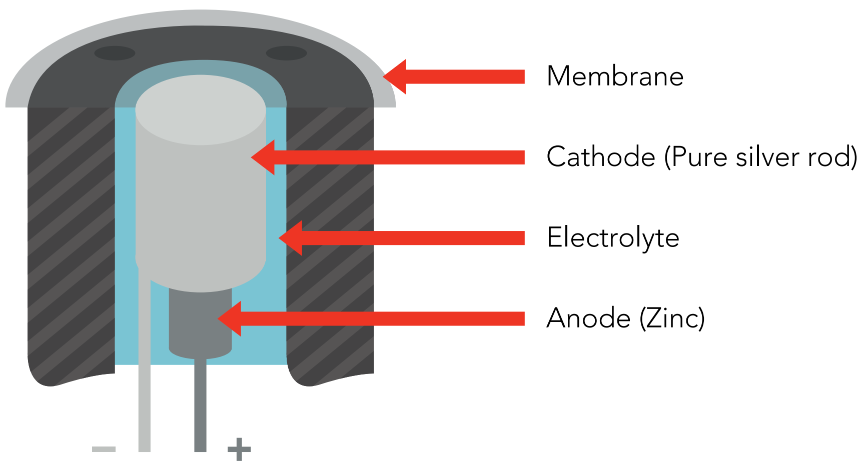
Operating principle

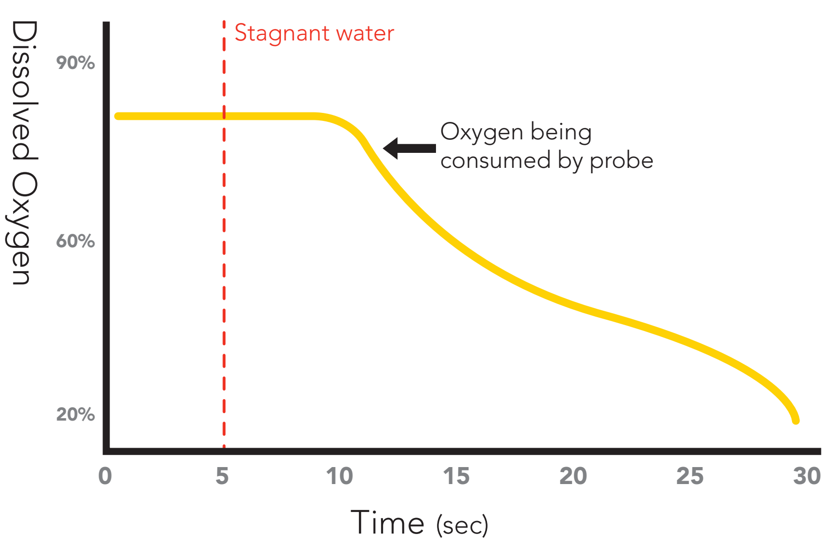
The Atlas Scientific™ EZO™ Dissolved Oxygen circuit works with:

✗ Optical probe	Slow response, requires external power, expensive.
✗ Polar Graphic probe	Requires external power, output in μA.
✓ Galvanic probe	Requires no external power, output in mV.

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



Flow Dependence



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

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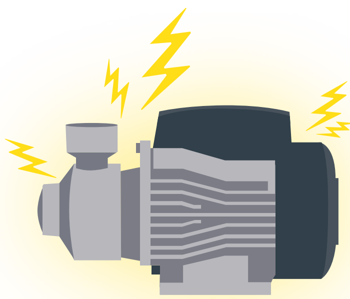
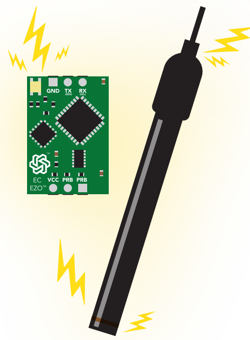
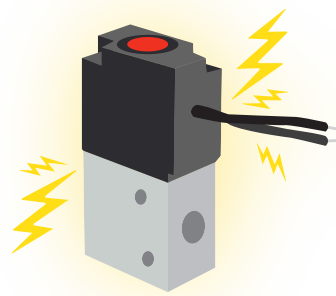
Power and data isolation

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

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

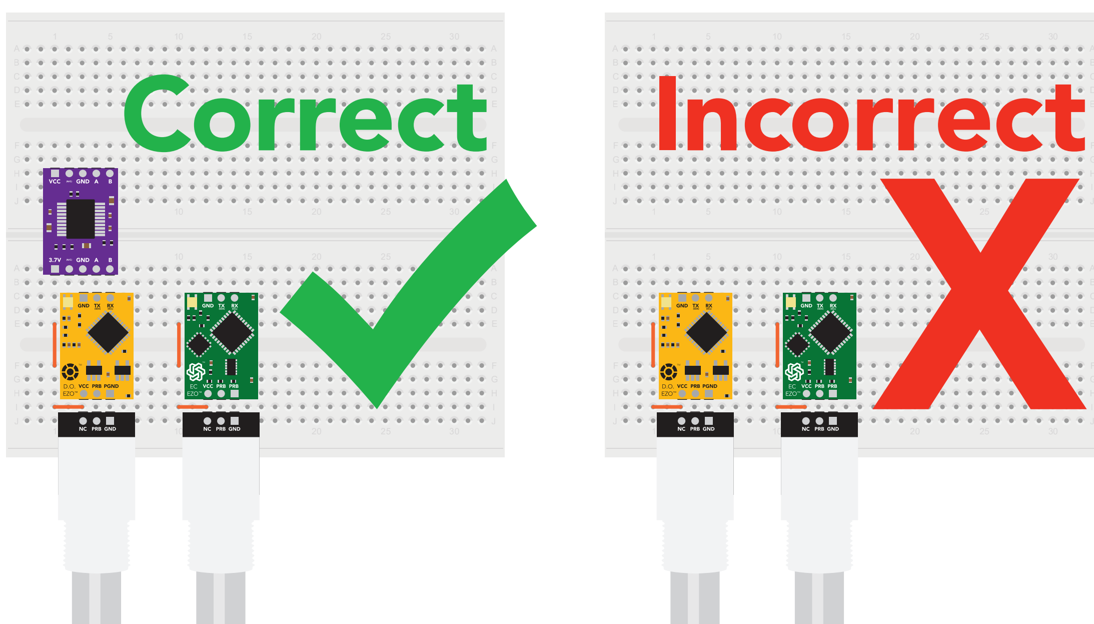






When reading Dissolved Oxygen and Conductivity together, it is ***strongly recommended*** that the EZO™ Dissolved Oxygen circuit is electrically isolated from the EZO™ Conductivity circuit.

Basic EZO™ Inline Voltage Isolator



Without isolation, Conductivity readings will effect Dissolved Oxygen accuracy.

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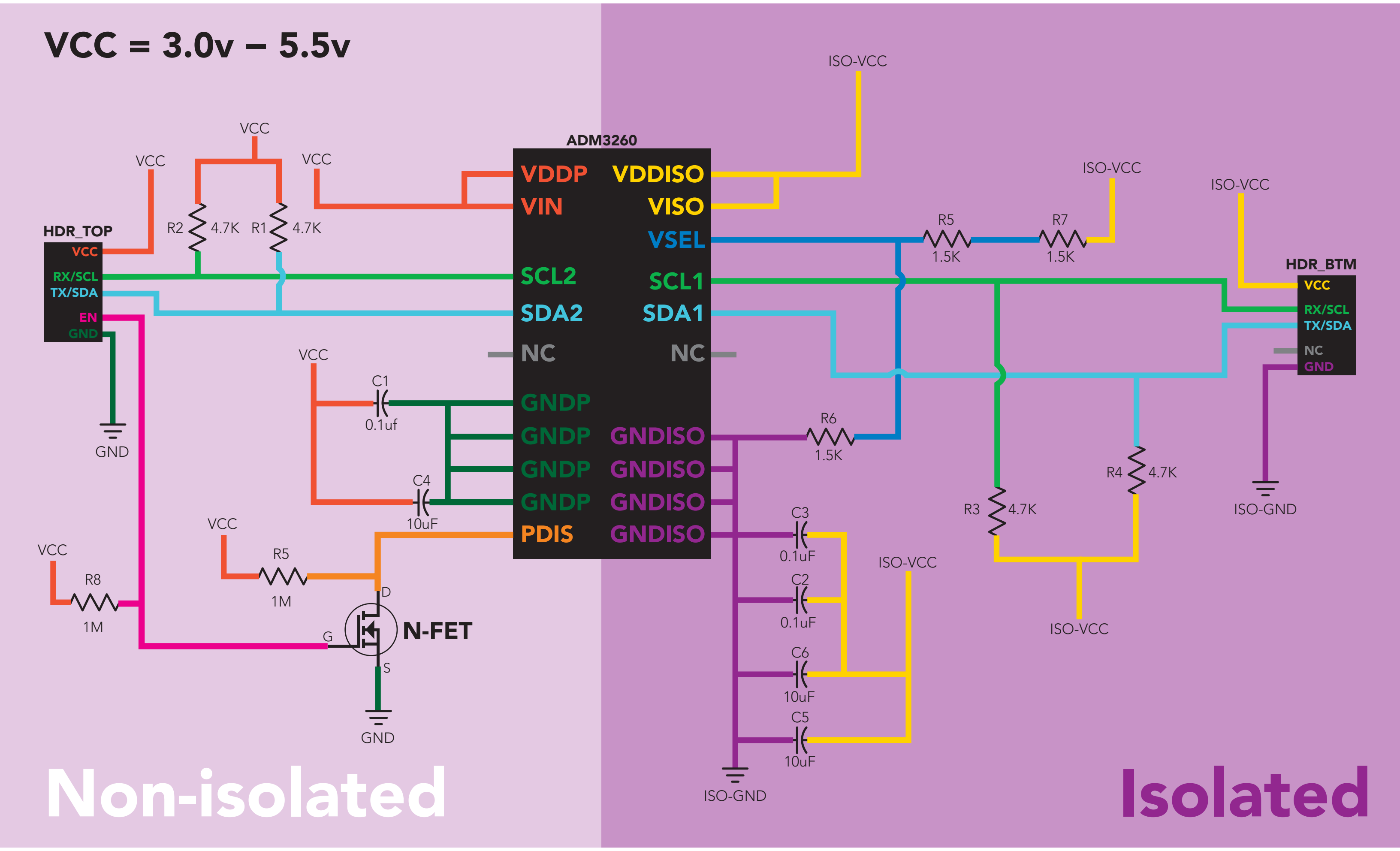
This schematic shows exactly how we isolate data and power using the *ADM3260* and a few passive components. The ADM3260 can output isolated power up to 150 mW and incorporates two bidirectional data channels.

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.



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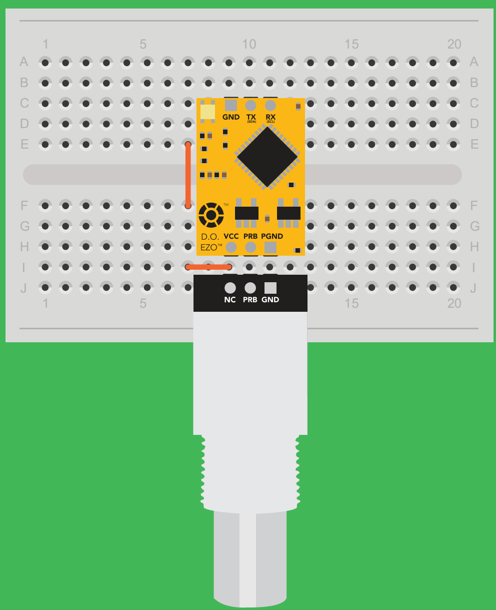
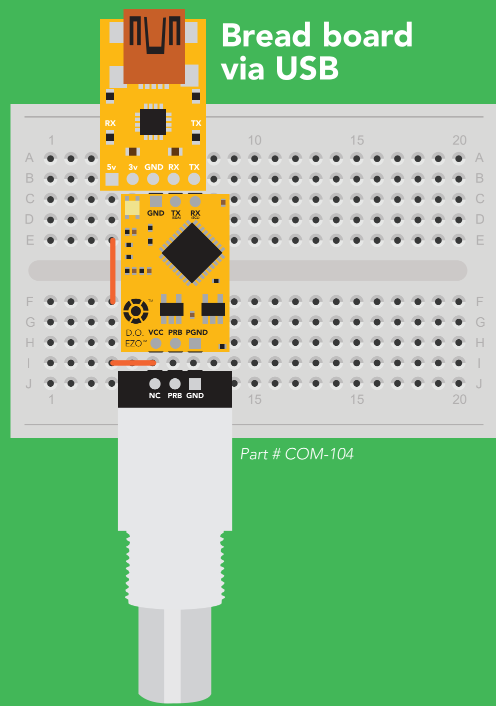
Correct wiring

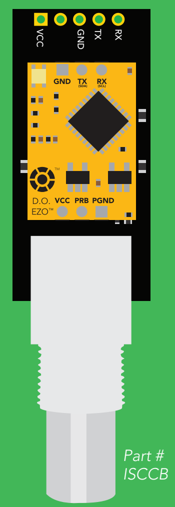
Bread board



Bread board via USB



Carrier board

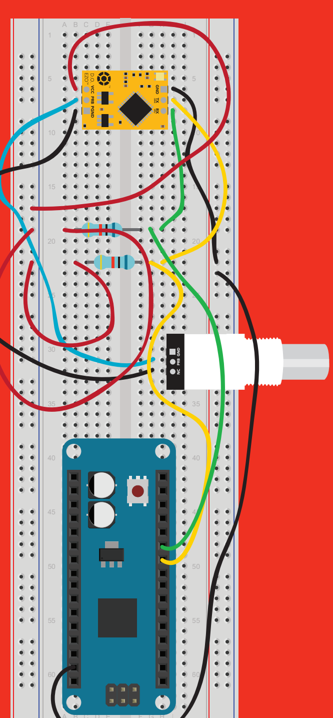


USB carrier board

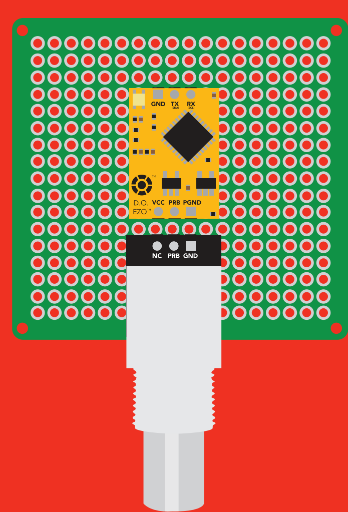
Incorrect wiring

Extended leads

Sloppy setup

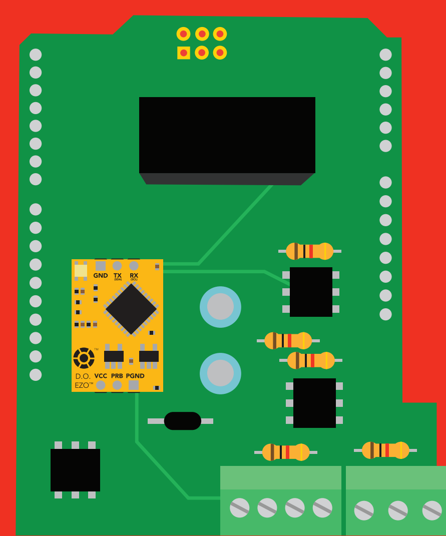


Perfboards or Protoboards



NEVER use Perfboards or Protoboards

*Embedded into your device



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

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Calibration theory

Simple calibration

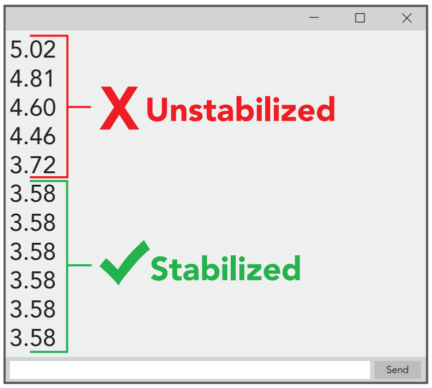
UART mode

Continuous readings

Advanced calibration

I²C mode

Continuously request readings



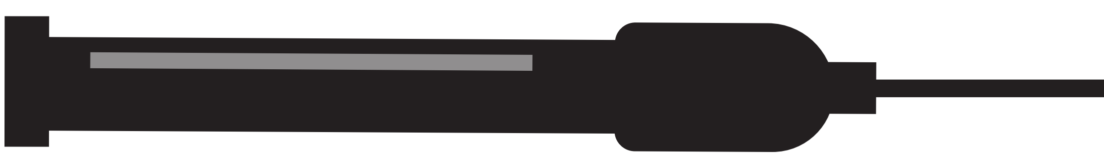
The most important part of calibration is watching the readings during the calibration process.

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

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

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

Calibrate first, compensate later.
Temperature, salinity and pressure compensation values have no effect on calibration.



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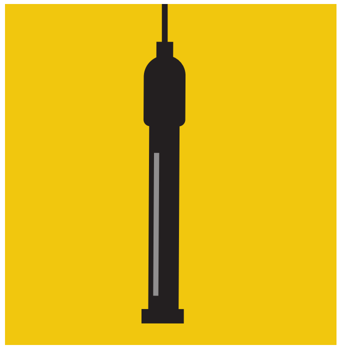
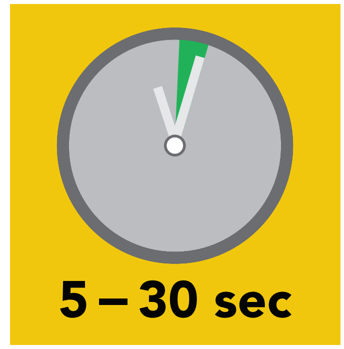
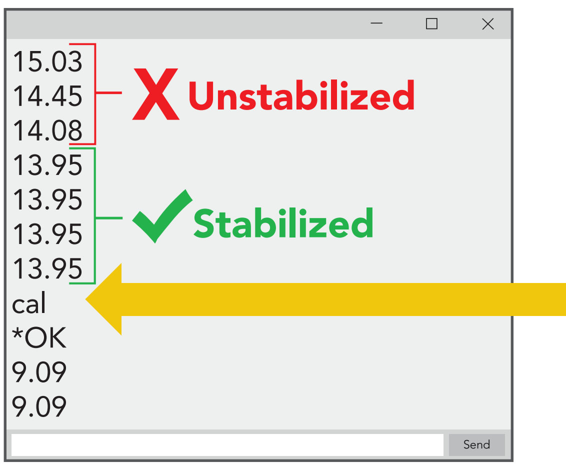
Single point calibration

Carefully pull off and discard the cap from the Dissolved Oxygen probe. Let the Dissolved Oxygen probe sit, exposed to air untill the readings stabalize. *(small movement from one reading to the next is normal).*

Do not unscrew!
Cap is only used to protect the probe during shipping.







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

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

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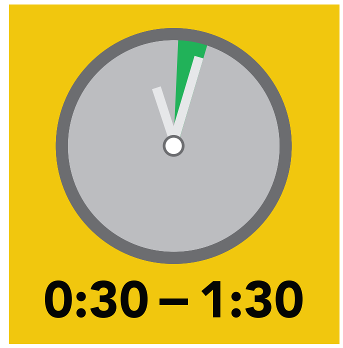
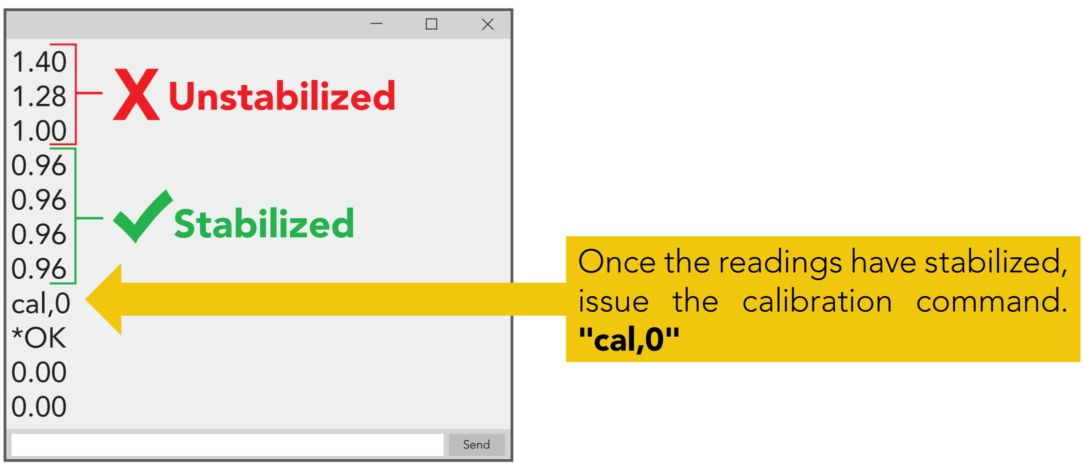
Dual point calibration *(optional)*

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

After you have calibrated the EZO™ Dissolved Oxygen circuit using the "Cal" command; Place the probe into the Zero Dissolved Oxygen calibration solution and stir the probe around to remove trapped air *(which could cause readings to go high)*. Let the probe sit in Zero D.O. calibration solution untill readings stabalize. *(small movement from one reading to the next is normal)*.





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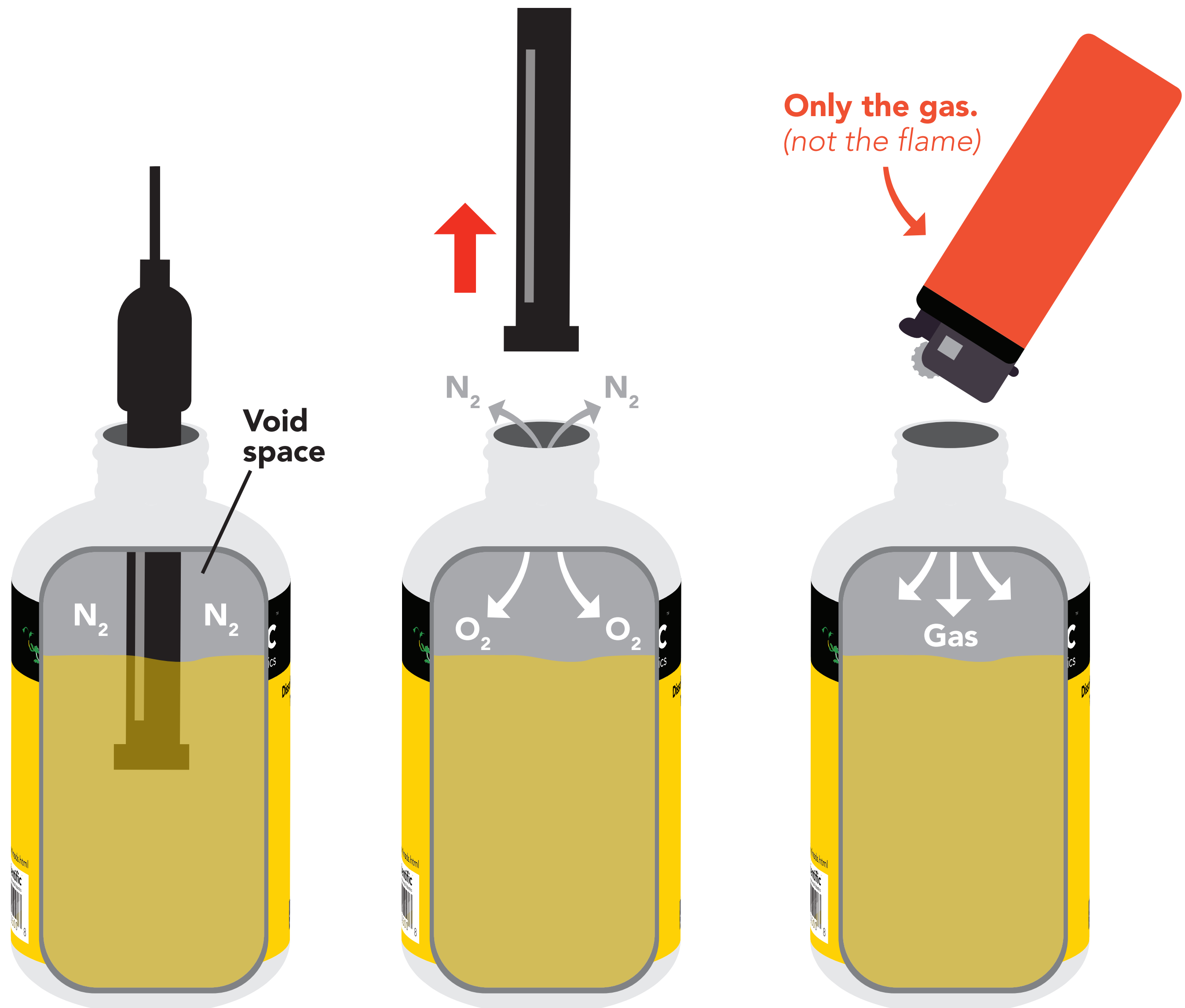
How to preserve the Zero D.O. calibration solution

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



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

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

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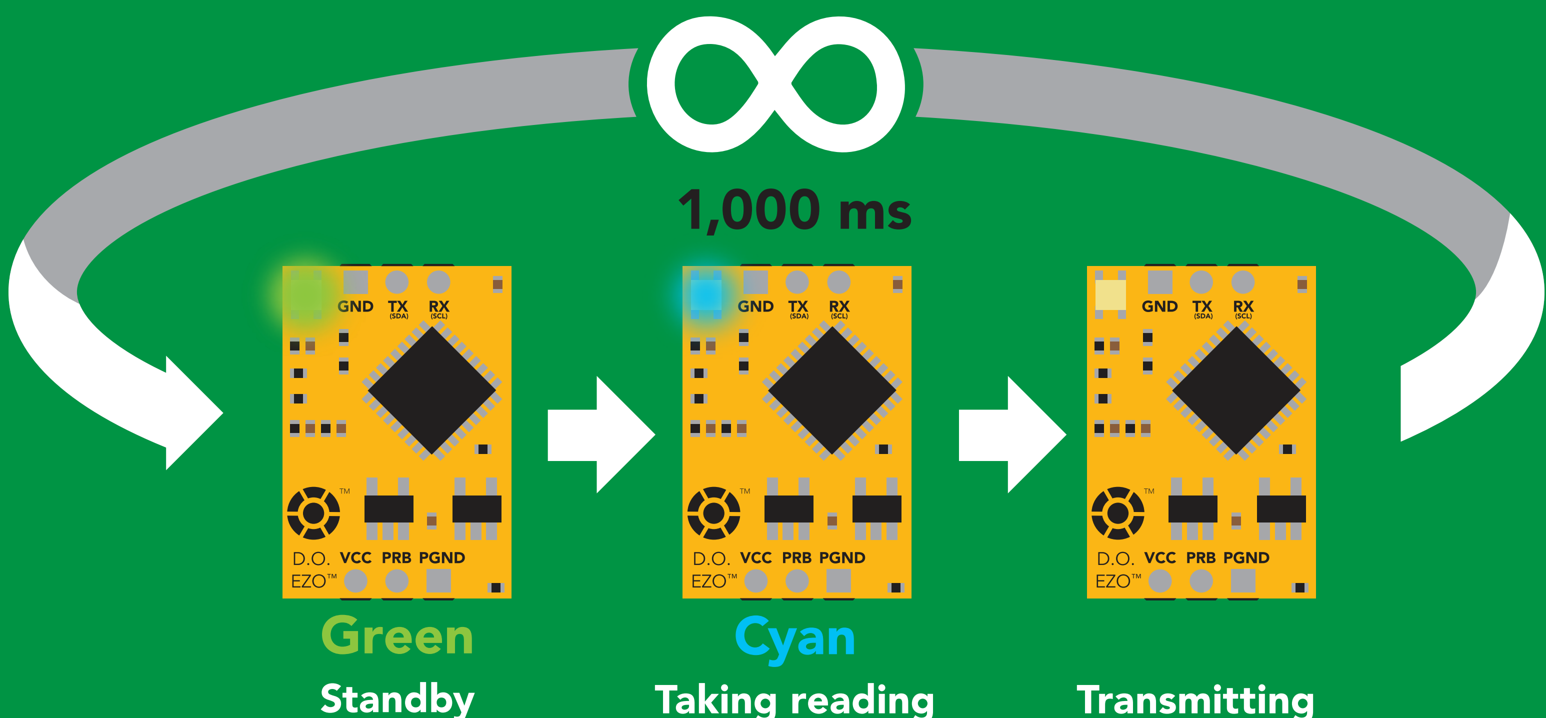
Default state

UART mode

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



Available data protocols

UART

Default

I²C

Unavailable data protocols

SPI

Analog

RS-485

Mod Bus

4–20mA

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UART mode

Settings that are retained if power is cut

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

Settings that are *NOT* retained if power is cut

Find
Pressure compensation
Salinity compensation
Sleep mode
Temperature compensation

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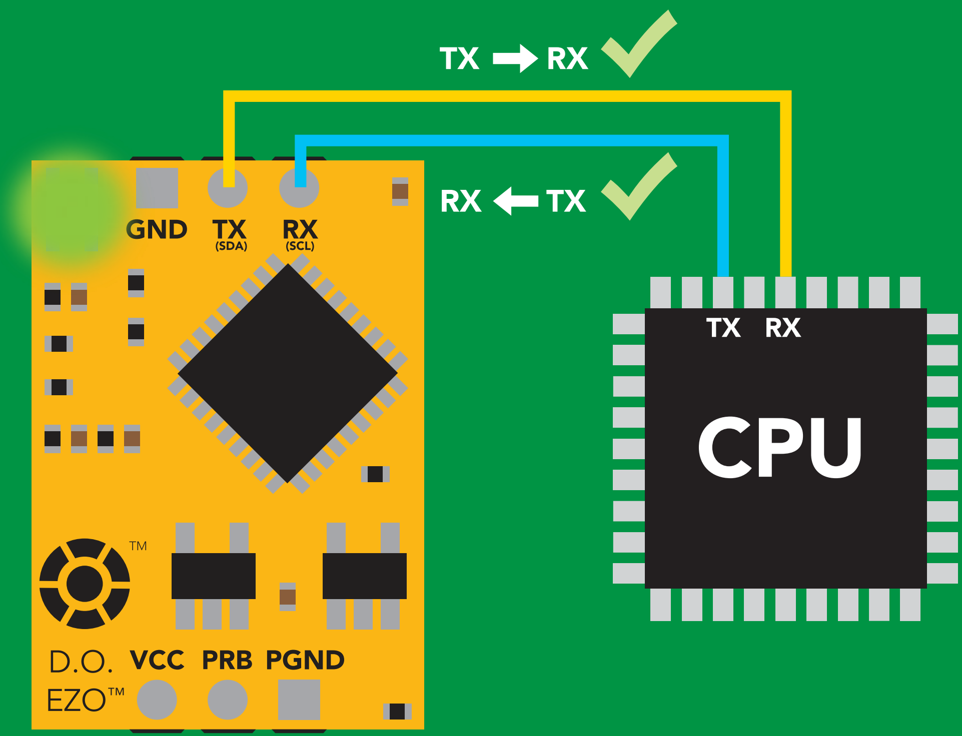
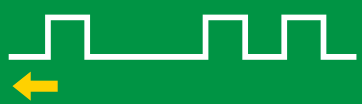
UART mode

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

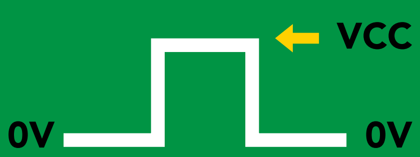


RX
Data in



TX
Data out

Vcc 3.3V – 5.5V



Data format

Reading	D.O.	**Data type**	floating point
Units	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
Terminator	carriage return		

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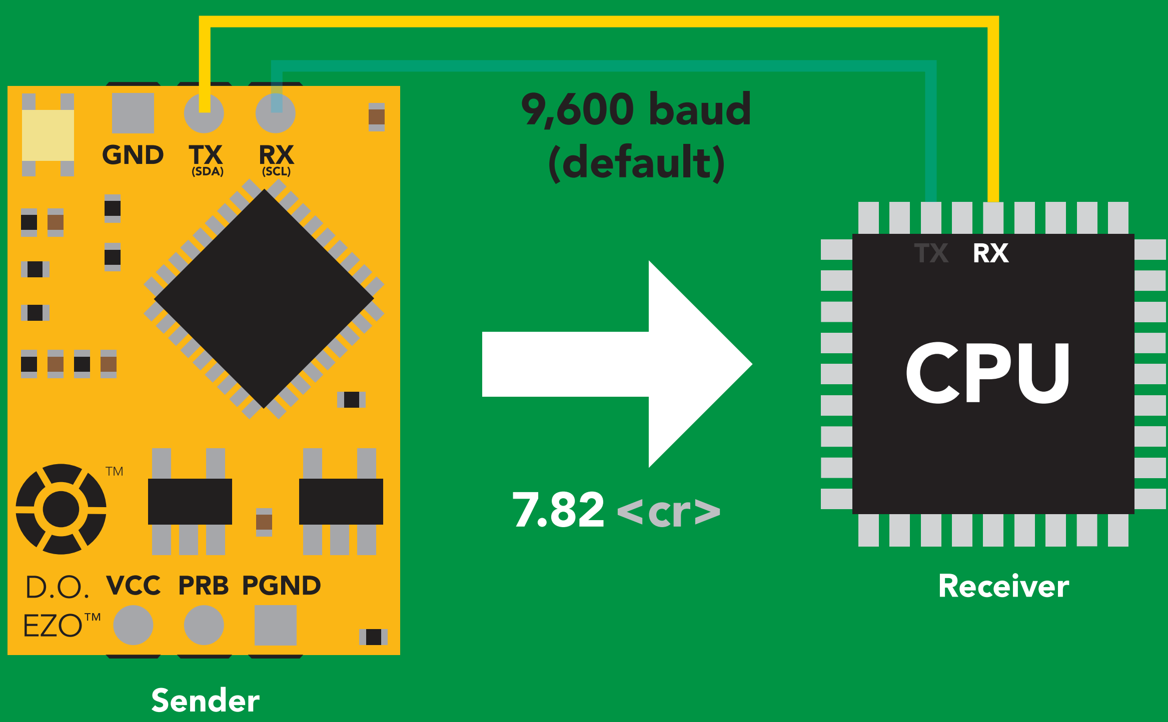
Receiving data from device

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

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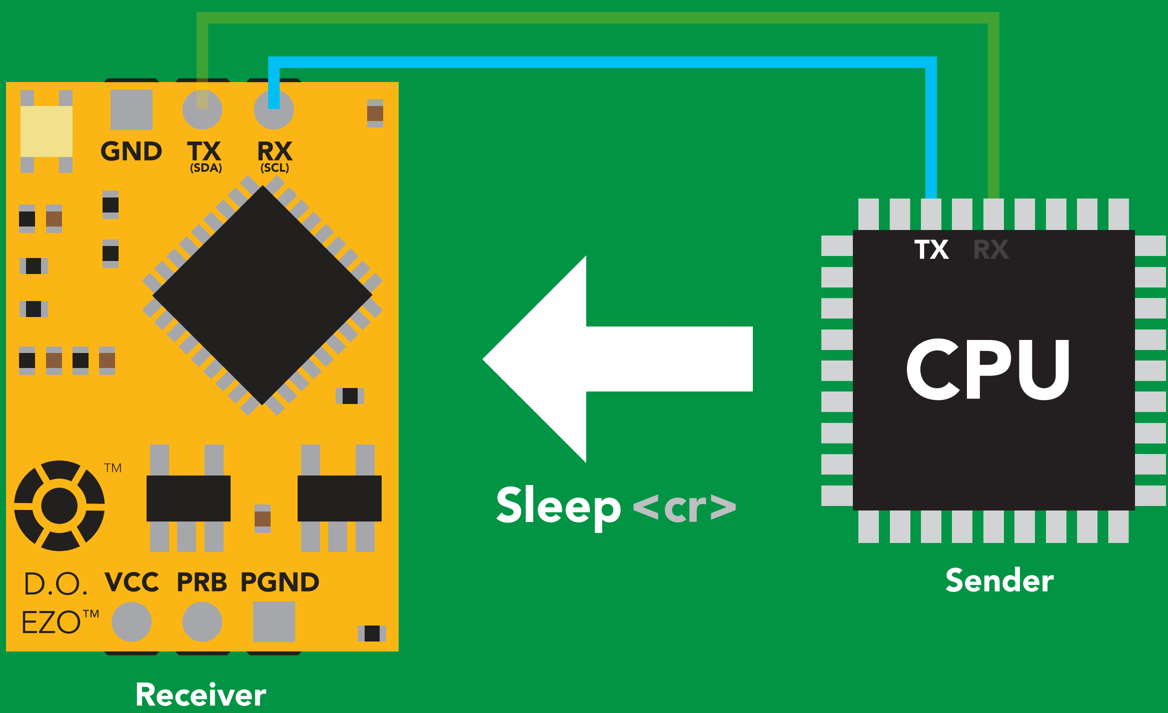
Sending commands to device

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

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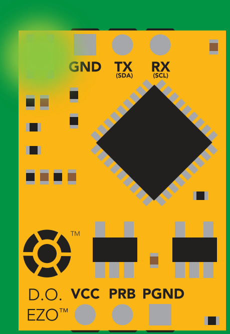
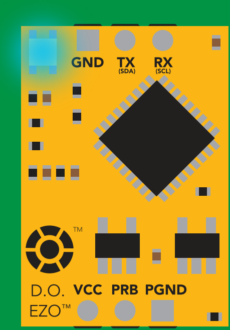
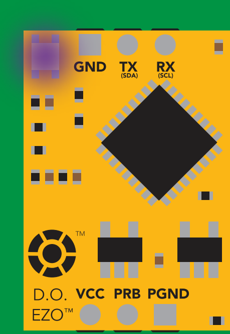
LED color definition



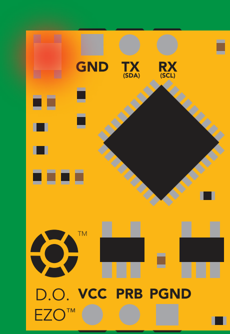
Green
UART standby



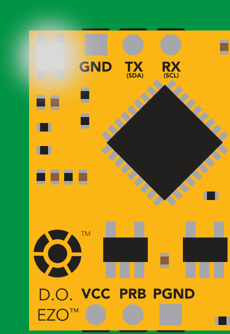
Cyan
Taking reading



Purple
Changing baud rate



Red
Command not understood



White
Find

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

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UART mode

command quick reference

All commands are ASCII strings or single ASCII characters.

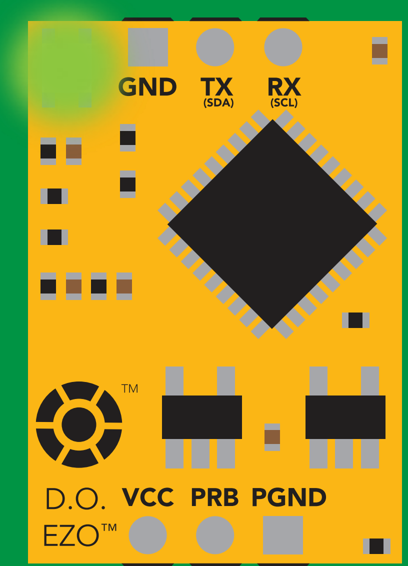
Command	Function		Default state
Baud	change baud rate	pg. 37	9,600
C	enable/disable continuous reading	pg. 23	enabled
Cal	performs calibration	pg. 25	n/a
Export	export calibration	pg. 26	n/a
Factory	enable factory reset	pg. 39	n/a
Find	finds device with blinking white LED	pg. 22	n/a
i	device information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

LED control

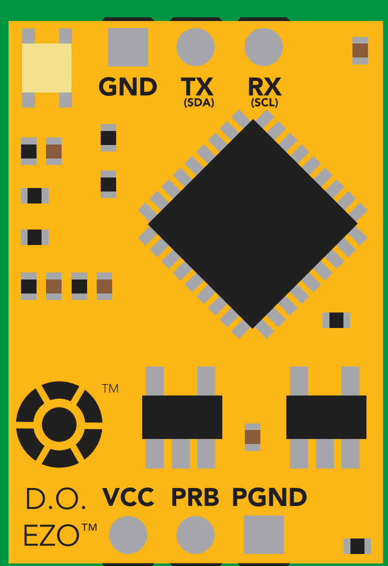
Command syntax

L,1 <cr> **LED on** **default**
L,0 <cr> **LED off**
L,? <cr> **LED state on/off?**

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



L,1



L,0

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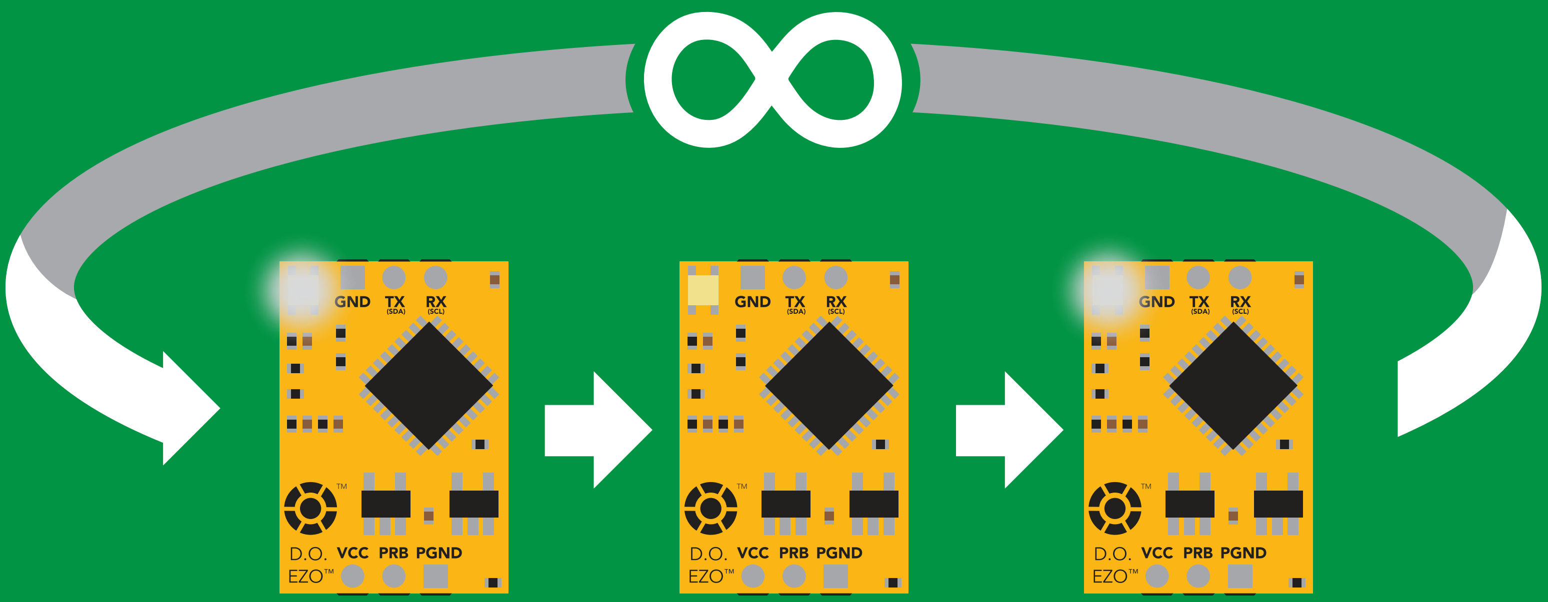
Find

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>



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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>

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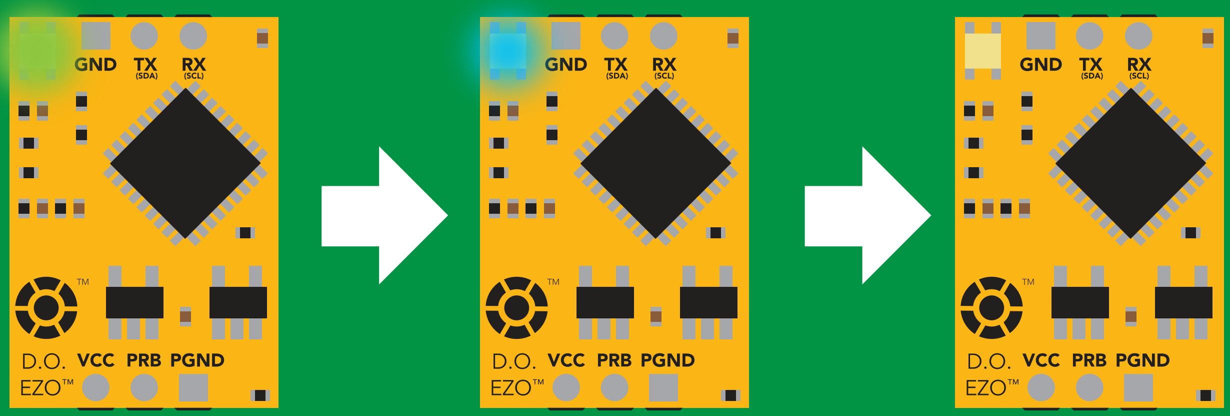
Single reading mode

Command syntax

R <cr> **takes single reading**

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



Green Standby

Cyan Taking reading

Transmitting

600 ms

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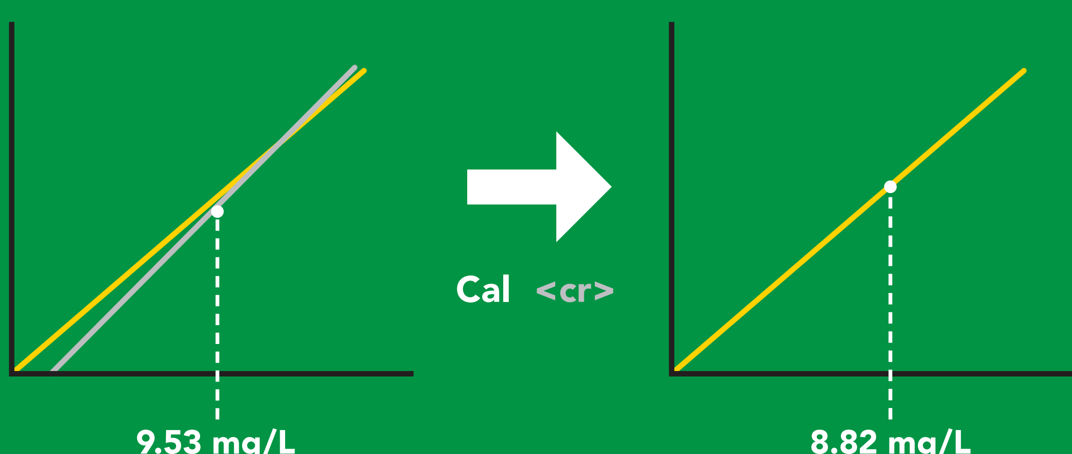
Calibration

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>



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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

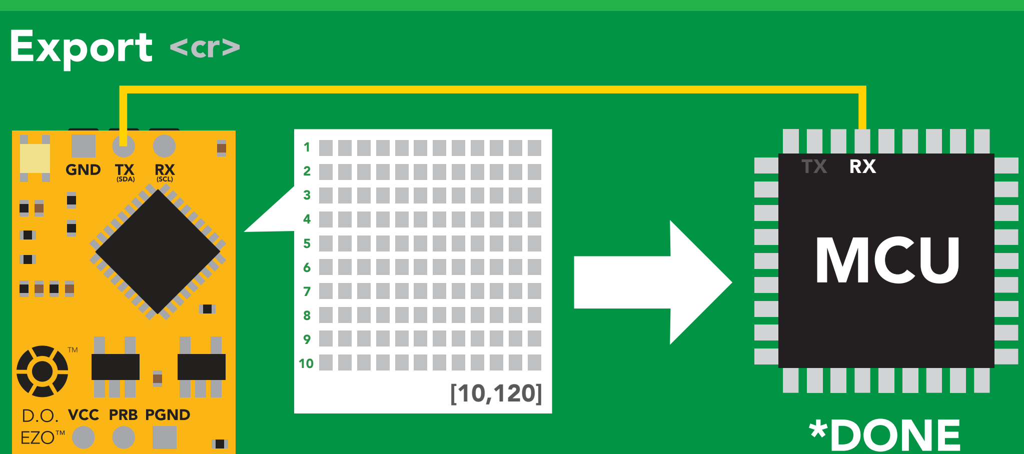
10, 120

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

Disabling *OK simplifies this process



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r 0.2

Import calibration

Command syntax

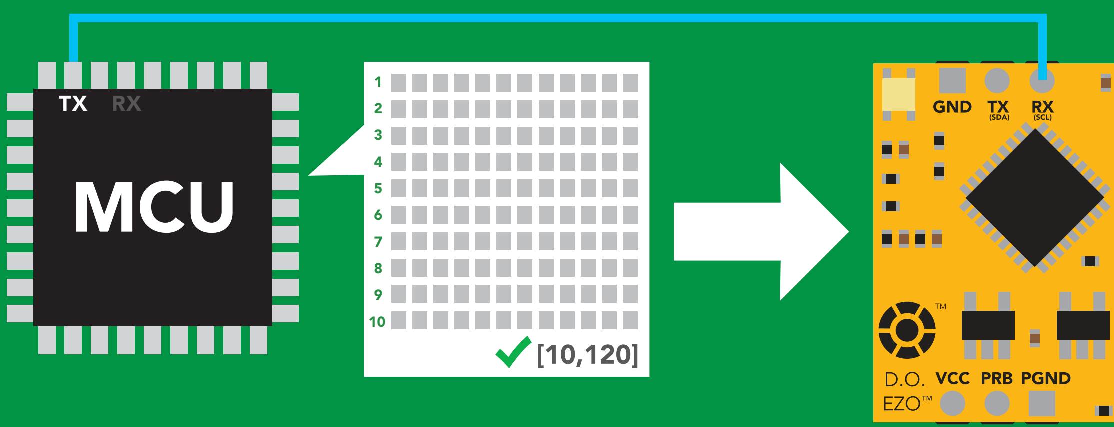
Import: Use this command to upload calibration settings to one or more devices.

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

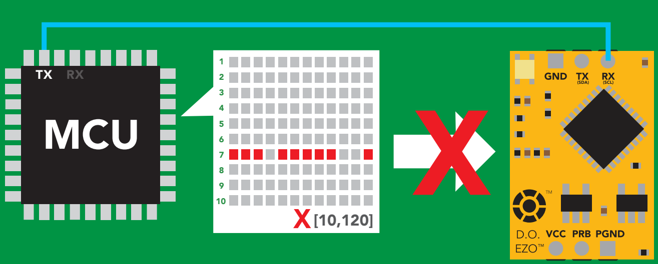
Example / Response

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.**

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Temperature compensation

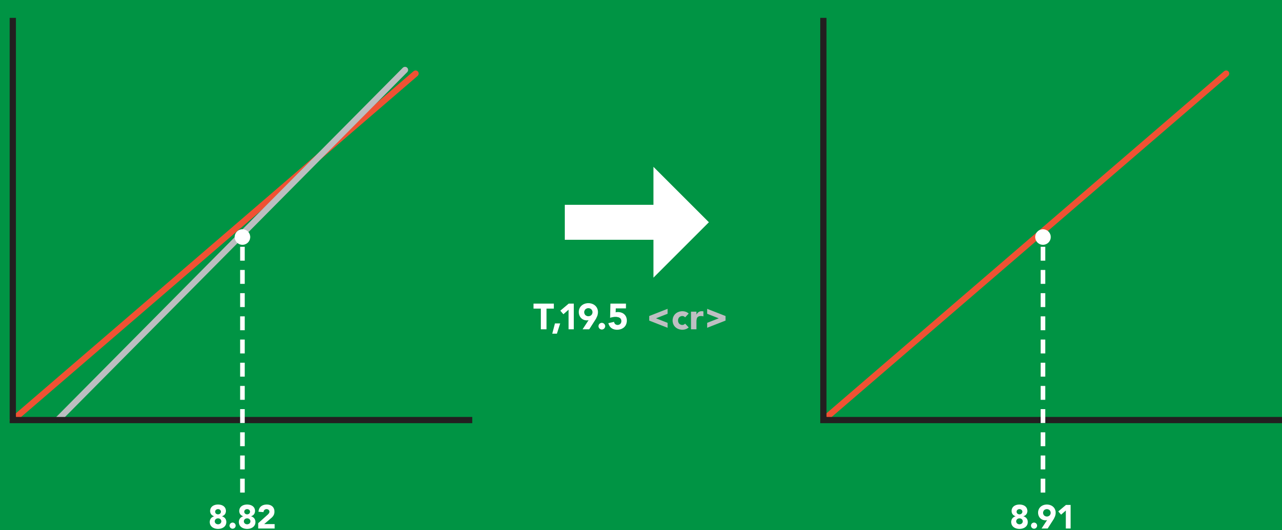
Command syntax

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

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

*This is a new command for firmware V2.13

Example	Response
T,19.5 <cr>	*OK <cr>
RT,19.5 <cr>	*OK <cr> 8.91 <cr>
T,? <cr>	?T,19.5 <cr> *OK <cr>



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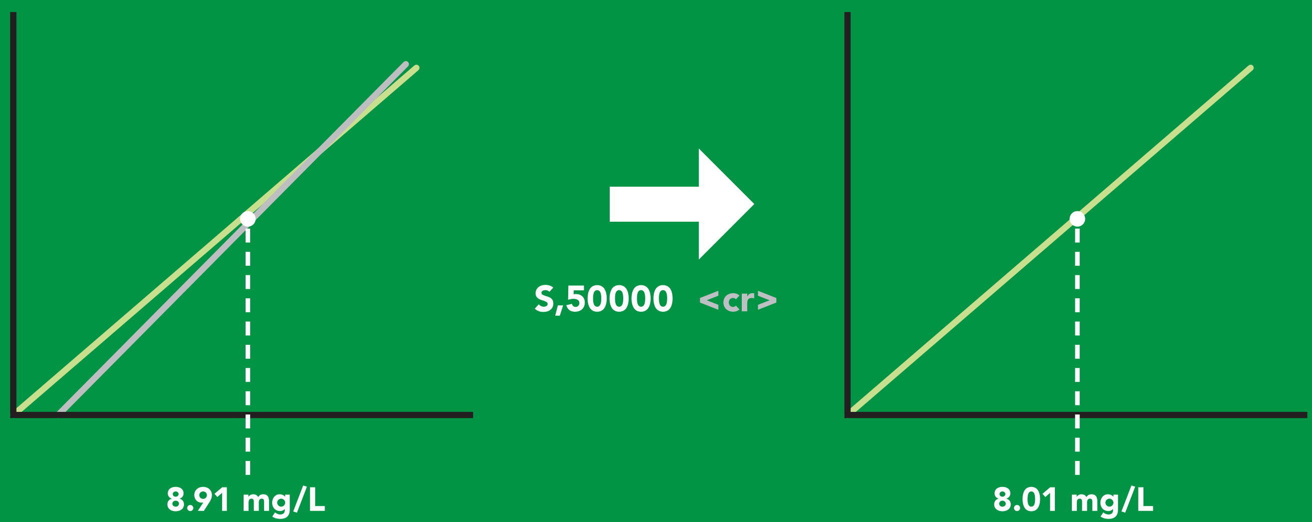
Salinity compensation

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>



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Pressure compensation

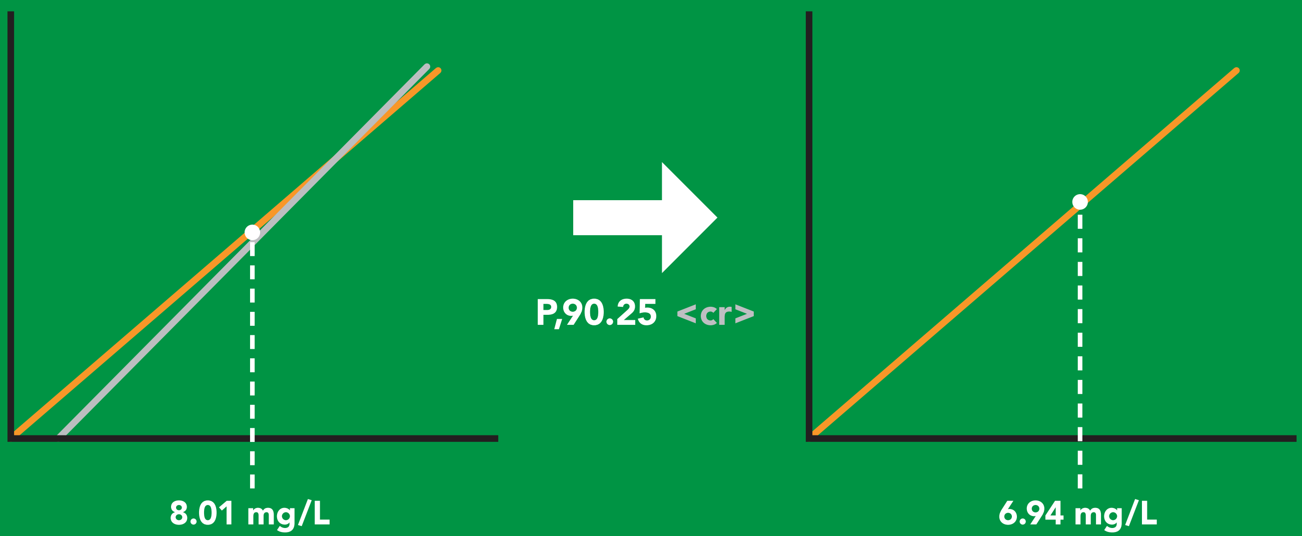
Command syntax

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

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

P,? <cr> compensated pressure value?

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



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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".

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Naming device

Command syntax

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

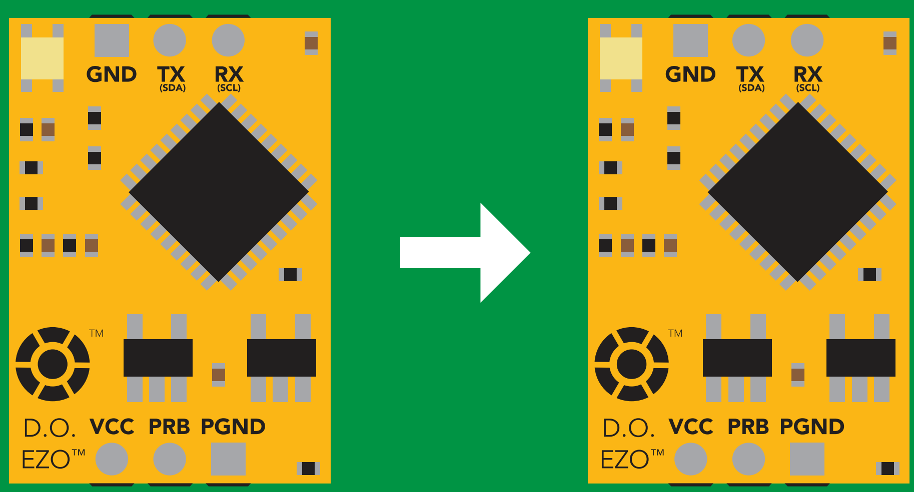
n = _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16

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>

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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
	Device	Firmware

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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

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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

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Sleep mode/low power

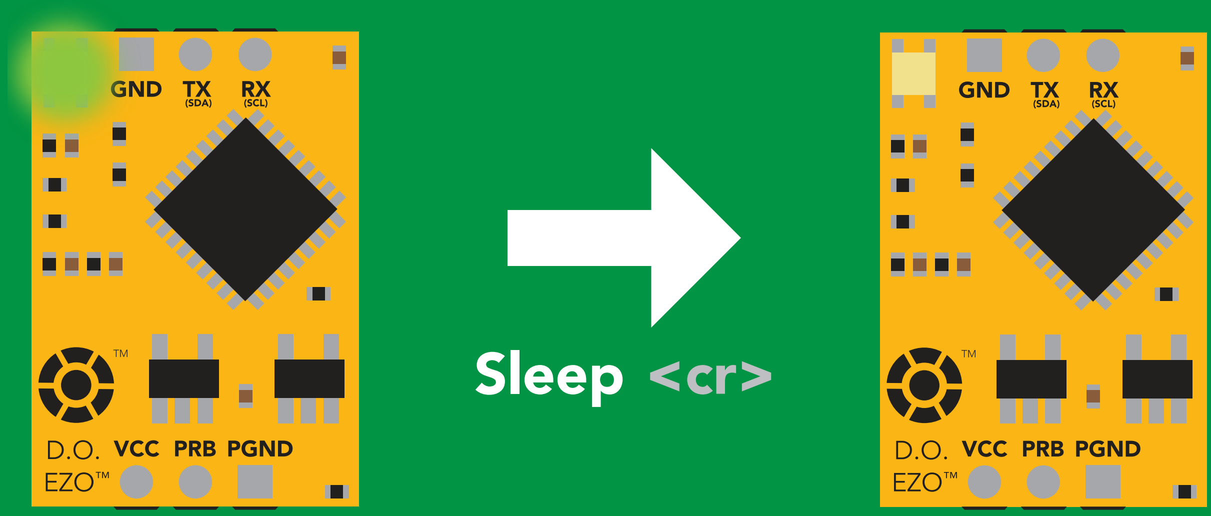
Command syntax

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
0.66 mA

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r 0.2

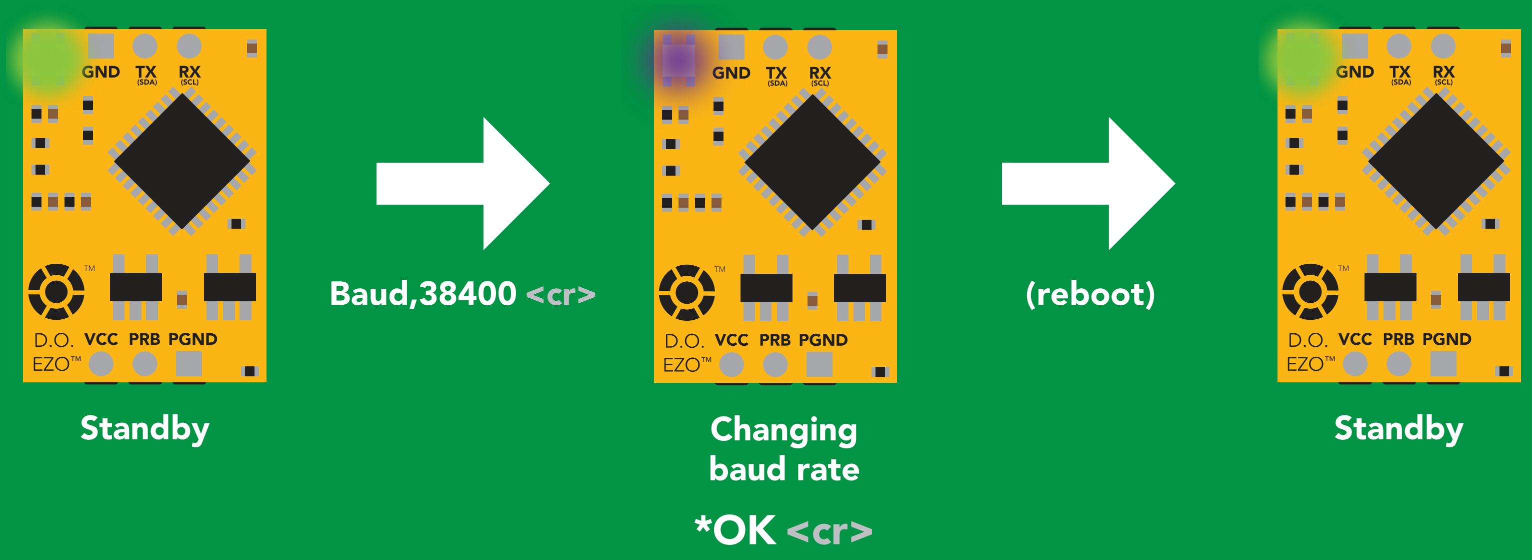
Change baud rate

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

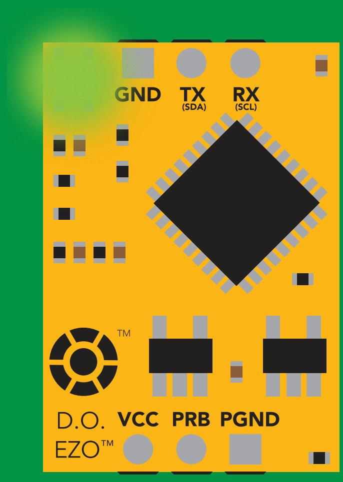
Command syntax

Locks device to UART mode.

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

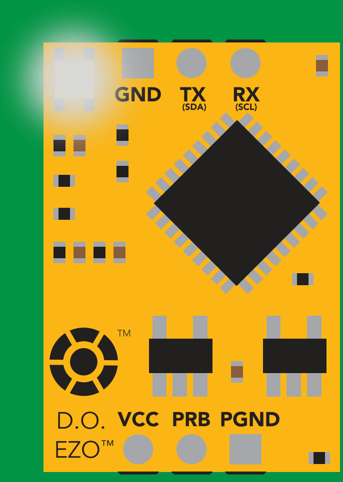
Example	Response
Plock,1 <cr>	*OK <cr>
Plock,0 <cr>	*OK <cr>
Plock,? <cr>	?Plock,1 <cr> or ?Plock,0 <cr>

Plock,1



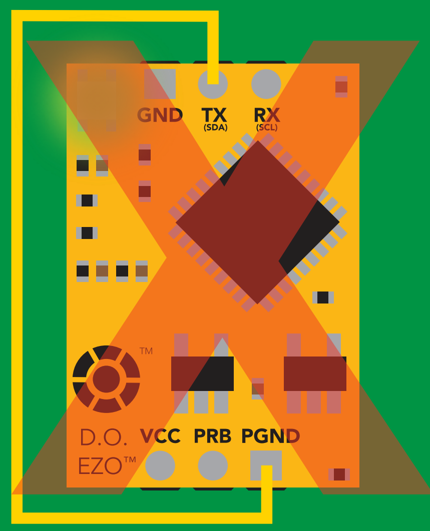
*OK <cr>

I2C,100



cannot change to I²C
*ER <cr>

Short



cannot change to I²C

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Factory reset

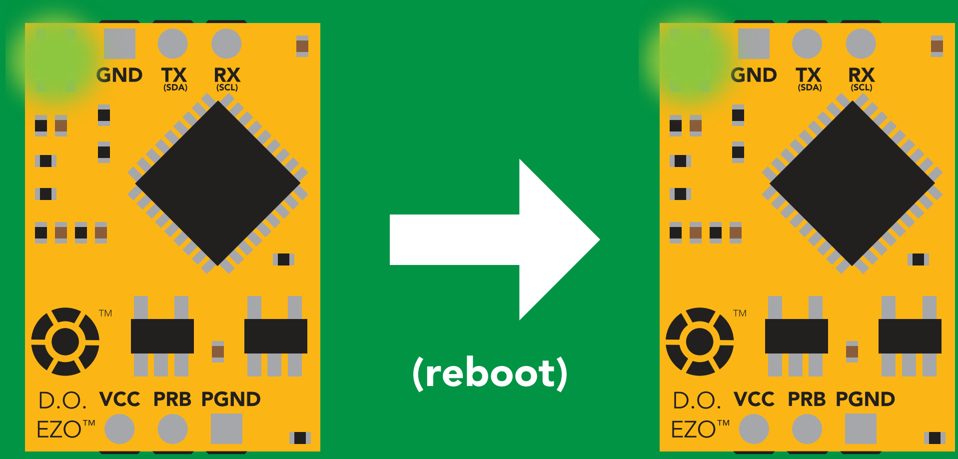
Command syntax

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

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Change to I^2C mode

Command syntax

Default I^2C address 97 (0x61)

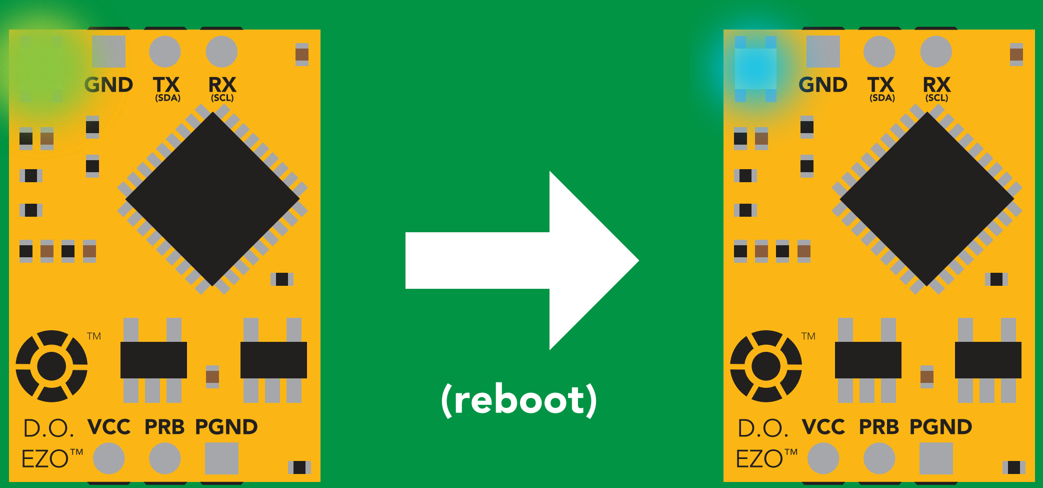
I2C,n <cr> sets I^2C address and reboots into I^2C mode

n = any number 1 – 127

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

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

I2C,100



Green
*OK <cr>

Blue
now in I^2C mode

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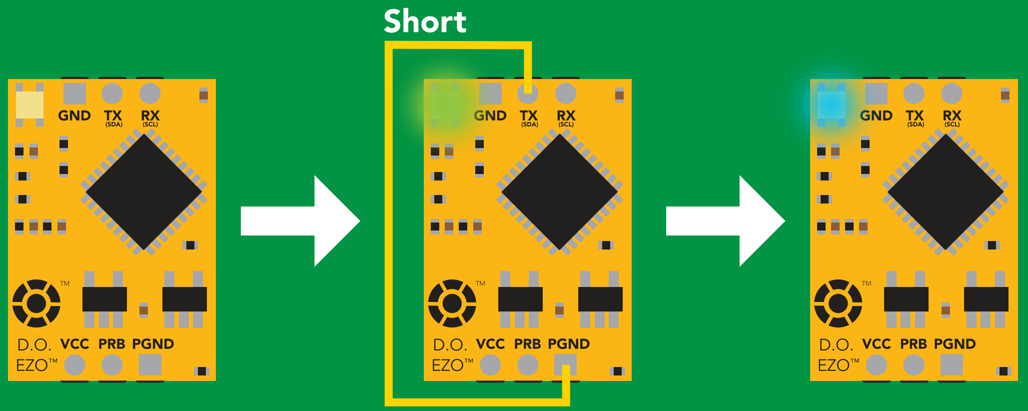
r 0.2

Manual switching to I^{2}C

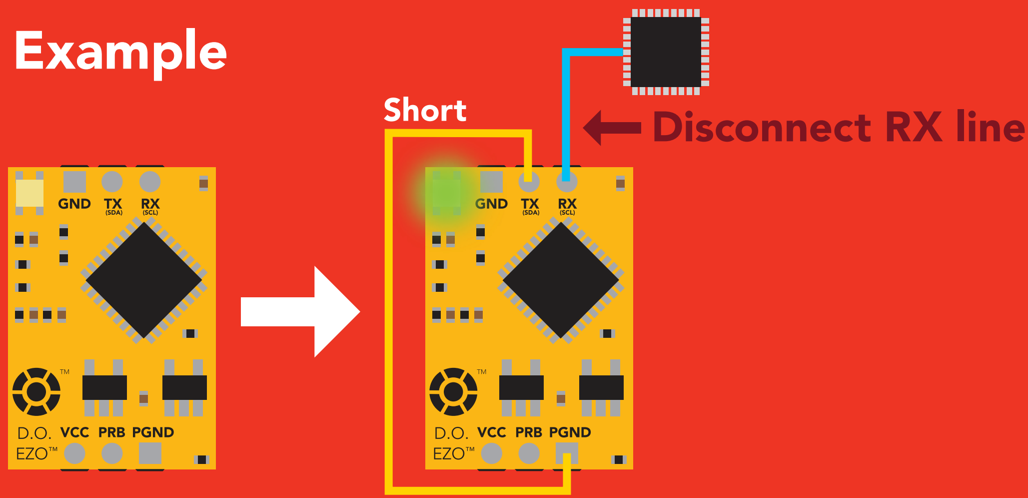
- Make sure Plock is set to 0
- Disconnect ground (power off)
- Disconnect TX and RX
- Connect TX to PGND
- Confirm RX is disconnected
- Connect ground (power on)
- Wait for LED to change from Green to Blue
- Disconnect ground (power off)
- Reconnect all data and power

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

Example



Wrong Example



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I^2C mode

The I²C 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 I²C mode click here

Settings that are retained if power is cut

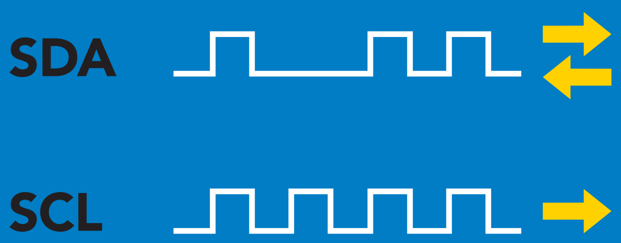
Calibration
Change I²C address
Enable/disable parameters
Hardware switch to UART mode
LED control
Protocol lock
Software switch to UART mode

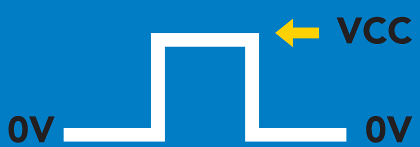
Settings that are *NOT* retained if power is cut

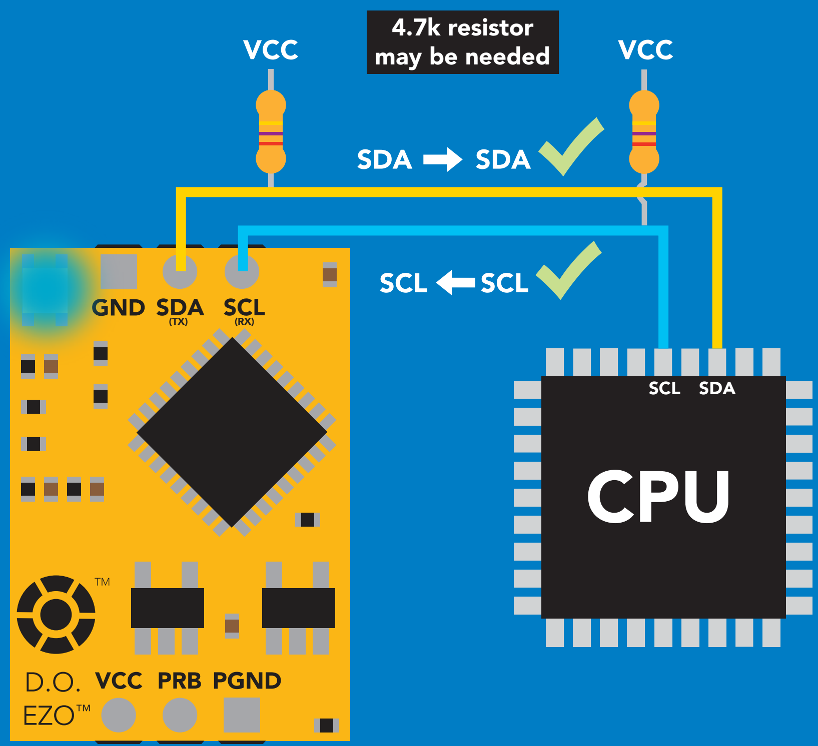
Find
Pressure compensation
Salinity compensation
Sleep mode
Temperature compensation

I²C mode

I²C address	(0x01 – 0x7F) **97 (0x61) default**
Vcc	3.3V – 5.5V
Clock speed	100 – 400 kHz







Data format

Reading	D.O.	**Data type**	floating point
Units	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

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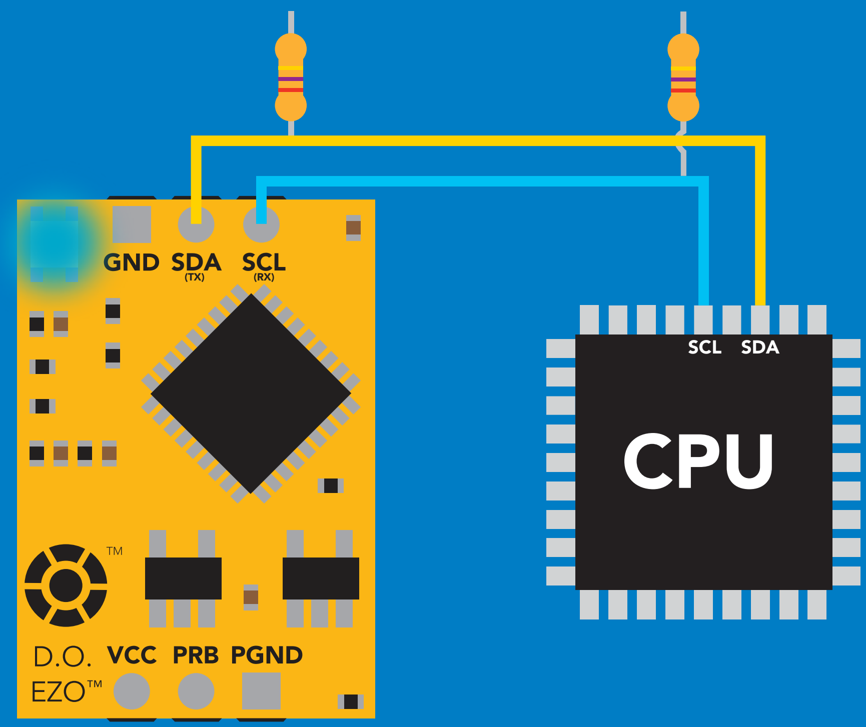
Sending commands to device

5 parts

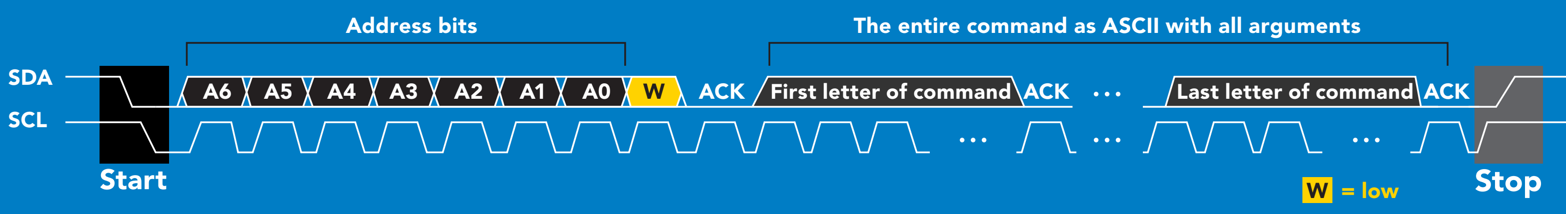
Start	I²C address	Write	Command (not case sensitive)	Stop
	97 (0x61)		ASCII command string	

Example

Start	97 (0x61)	Write	Sleep	Stop
	I²C address		Command	



Advanced



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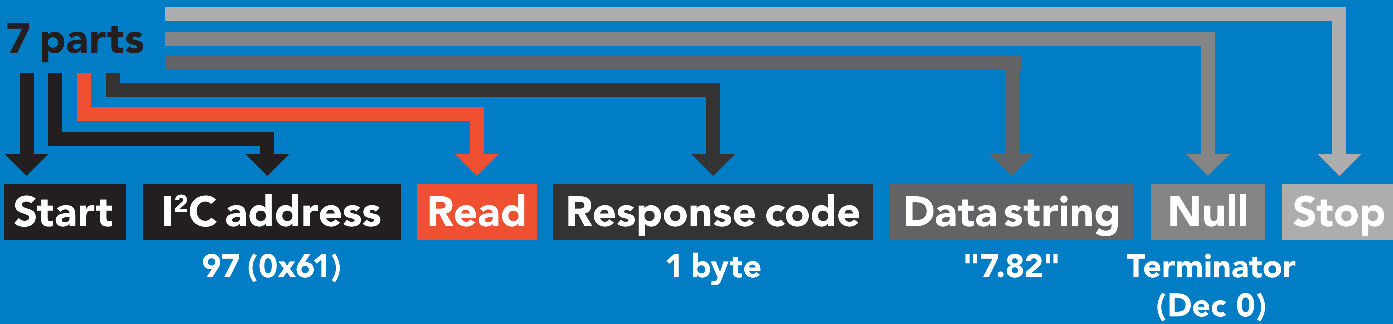
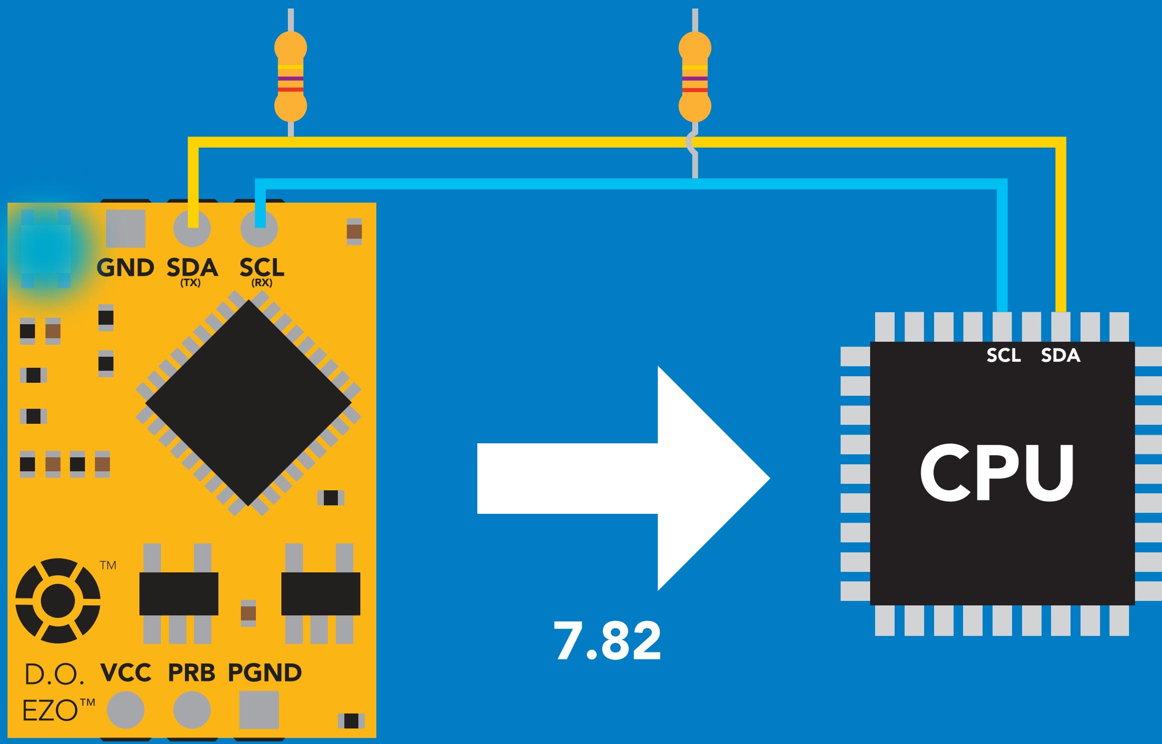
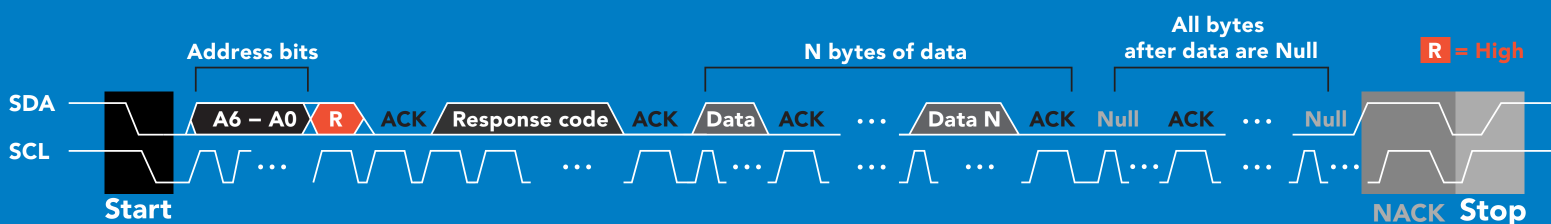
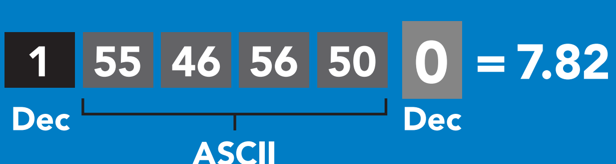
Requesting data from device





Advanced





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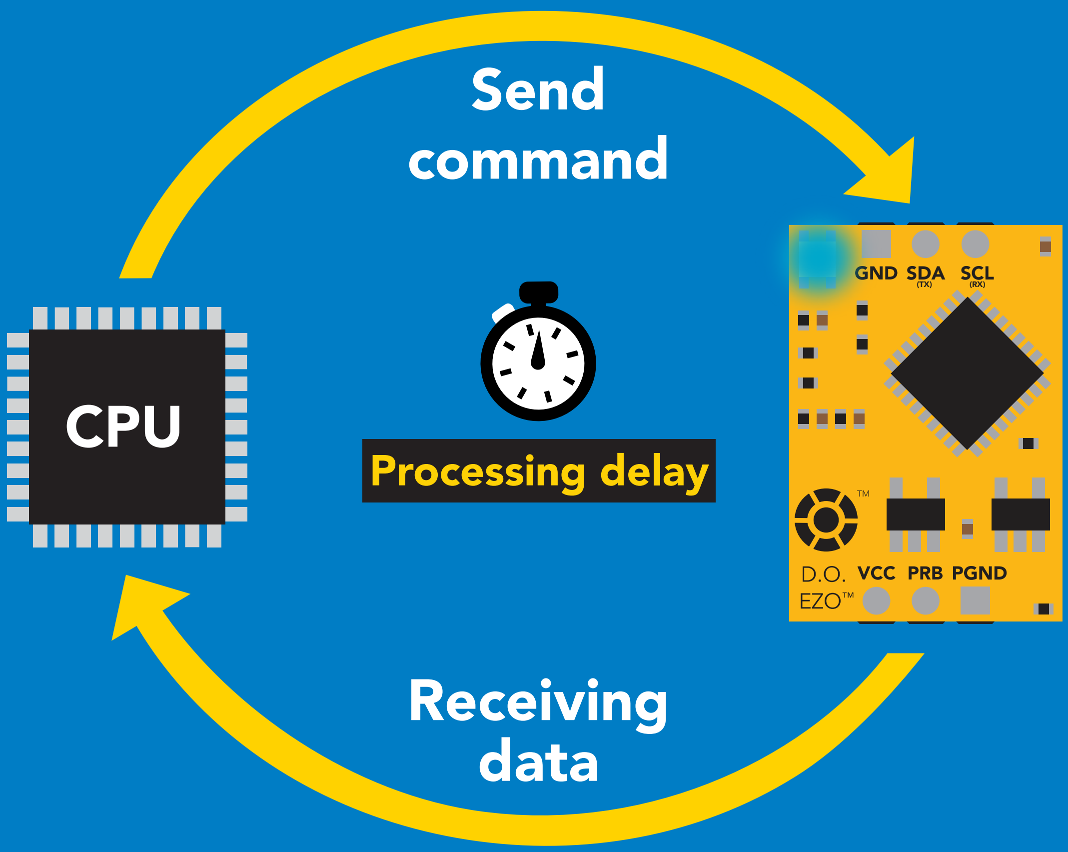
Response codes

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

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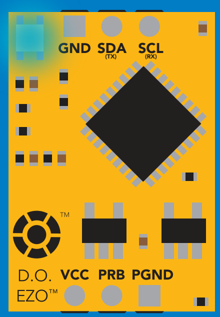
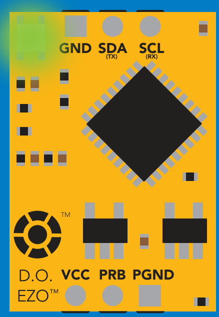
LED color definition



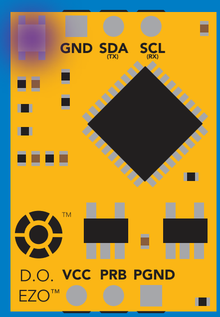
Blue

I²C standby



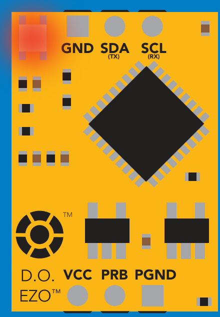
Green

Taking reading



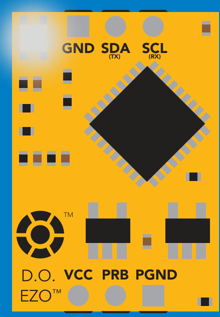
Purple

Changing I²C address



Red

Command not understood



White

Find

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

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I²C mode
command quick reference

All commands are ASCII strings or single ASCII characters.

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

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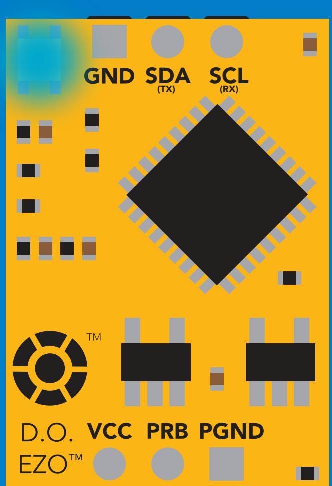
LED control

Command syntax

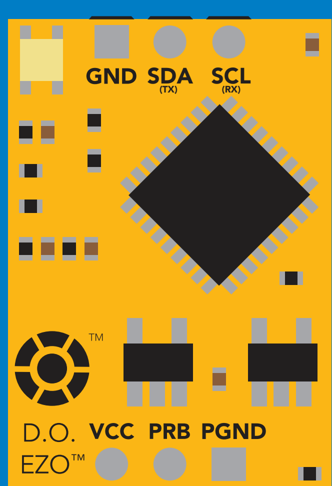
300ms processing delay

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

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Find

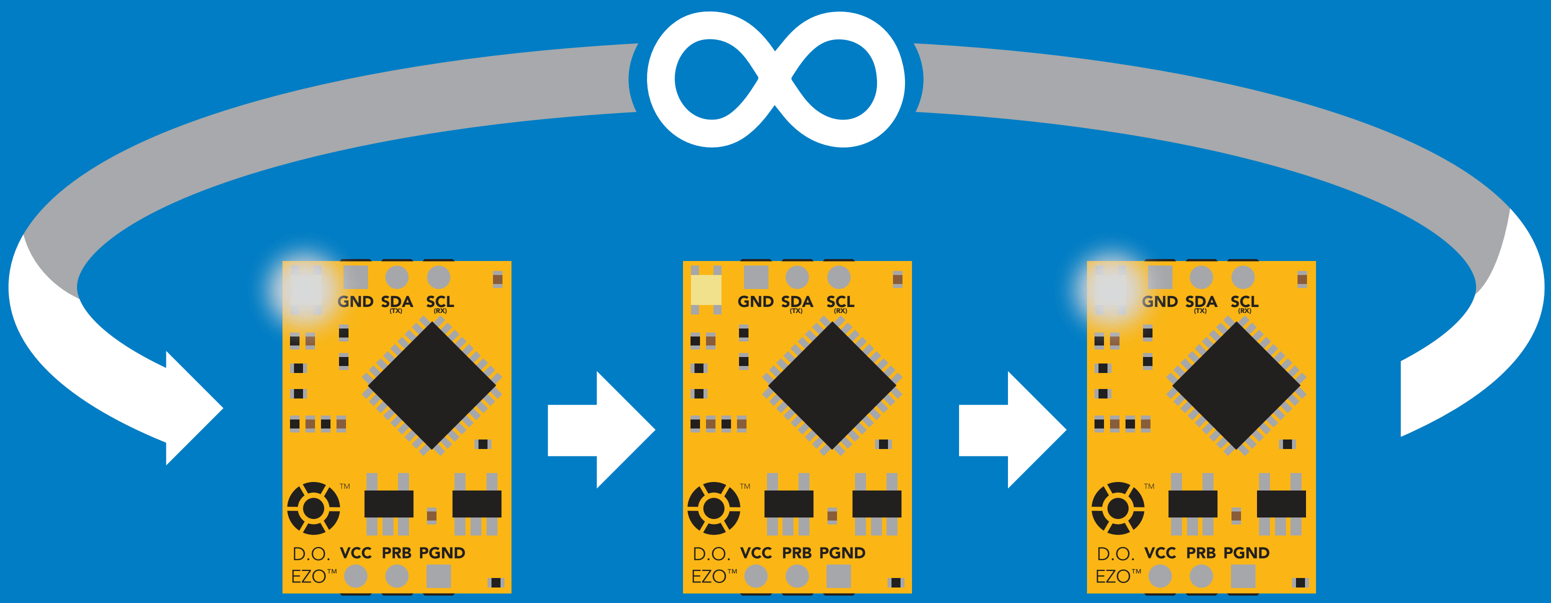
300ms processing delay

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



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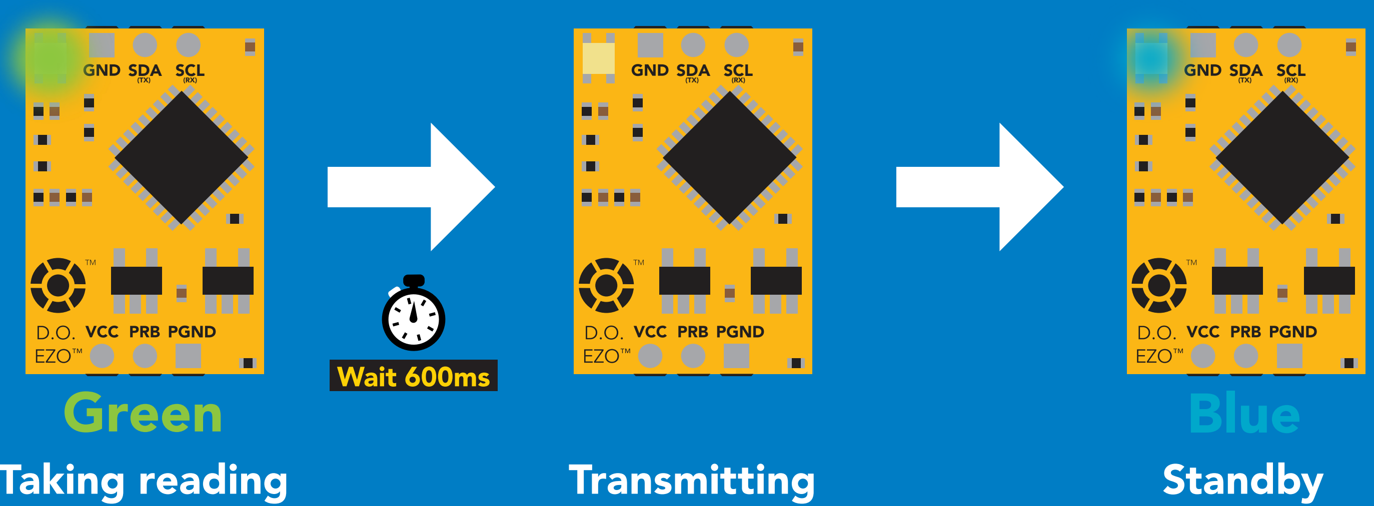
Taking reading

Command syntax

600ms processing delay

R return 1 reading

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



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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)

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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

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Import calibration

300ms processing delay

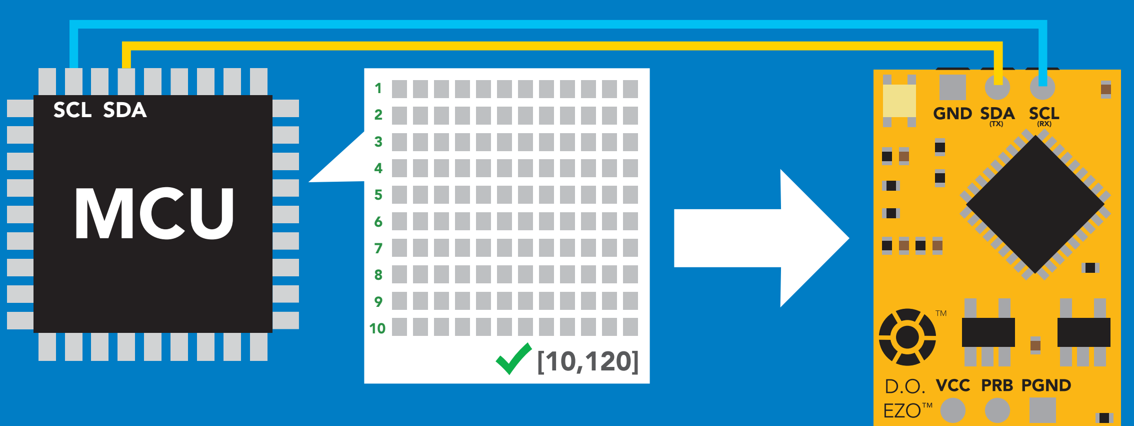
Command syntax

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

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

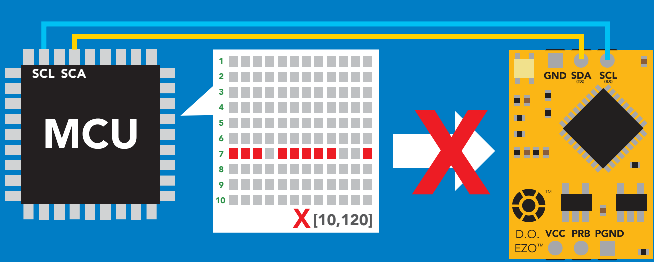
Example		Response
Import, 59 6F 75 20 61 72	(1 of 10)	Wait 300ms · 1 Dec · 0 Null
Import, 65 20 61 20 63 6F	(2 of 10)	Wait 300ms · 1 Dec · 0 Null
⋮		⋮
Import, 6F 6C 20 67 75 79	(10 of 10)	Wait 300ms · 1 Dec · 0 Null

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.**

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Temperature compensation

Command syntax

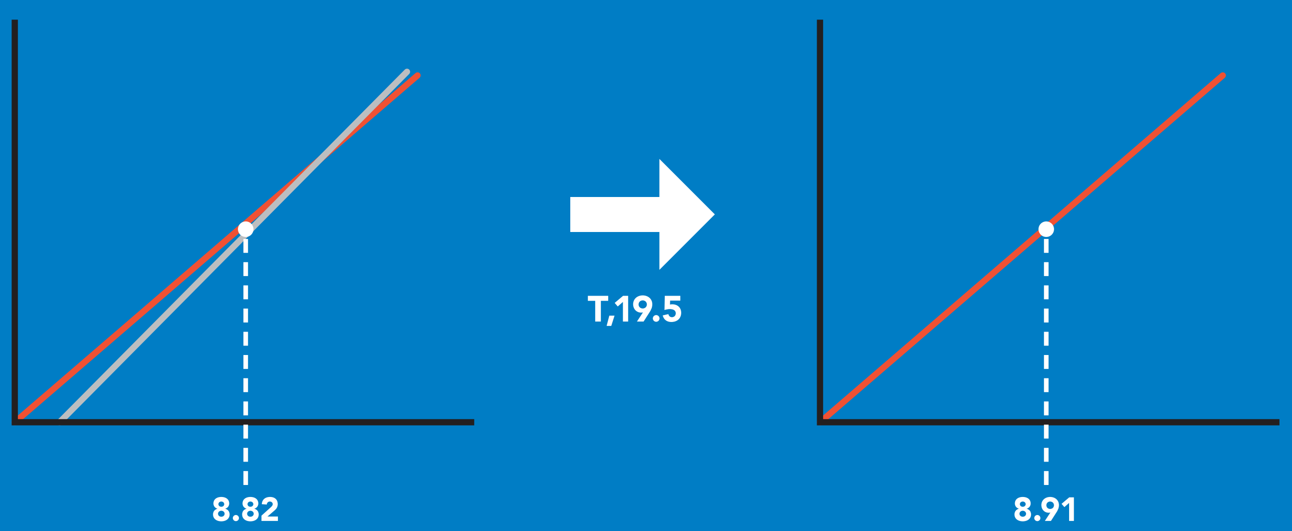
Default temperature = 20°C
Temperature is always in Celsius
Temperature is not retained if power is cut

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)



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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

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Pressure compensation

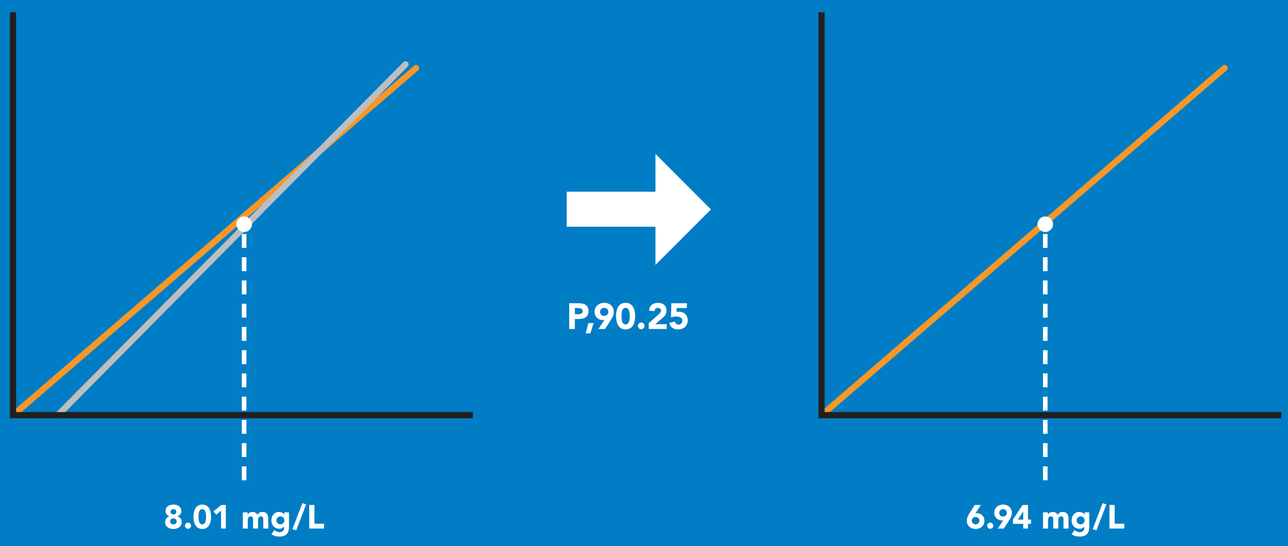
Command syntax

300ms processing delay

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

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

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



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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".

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Device information

Command syntax

300ms processing delay

i	device information

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

Response breakdown

?i, D.O., 1.98

D.O. → Device

1.98 → Firmware

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Reading device status

Command syntax

300ms processing delay

Status	**voltage at Vcc pin and reason for last restart**

Example

Status

Response

Wait 300ms

1	?Status,P,5.038	0
Dec	ASCII	Null

Response breakdown

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

Restart codes

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

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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

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Protocol lock

Command syntax

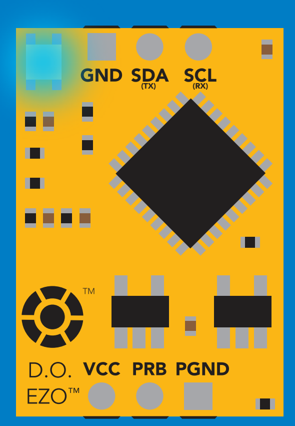
300ms processing delay

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

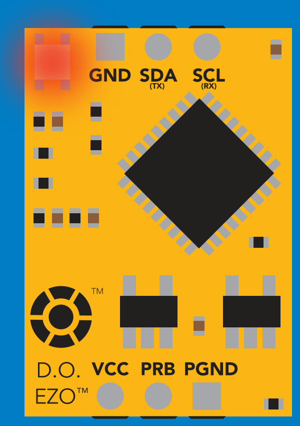
Locks device to I²C mode.

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)

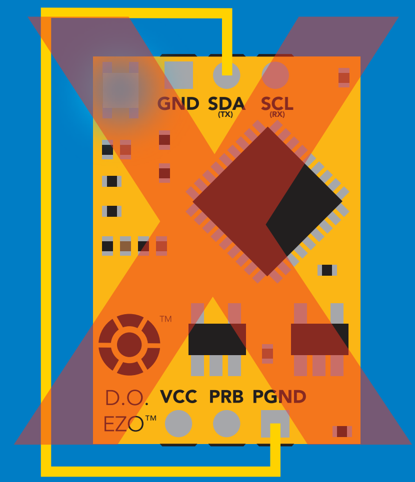
Plock,1



Baud, 9600



cannot change to UART



cannot change to UART

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I²C address change

Command syntax

300ms processing delay

I2C,n	sets I²C address and reboots into I²C mode

Example	Response
I2C,100	device reboot

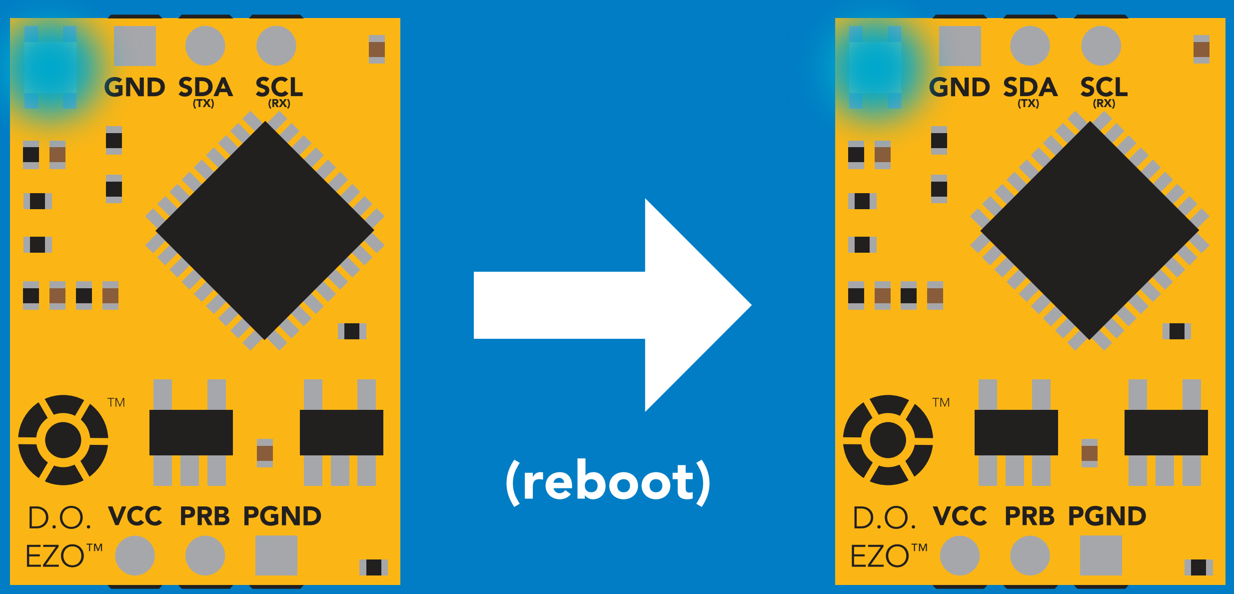
Warning!

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 97 (0x61).

n = any number 1 – 127

I2C,100



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Factory reset

Command syntax

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

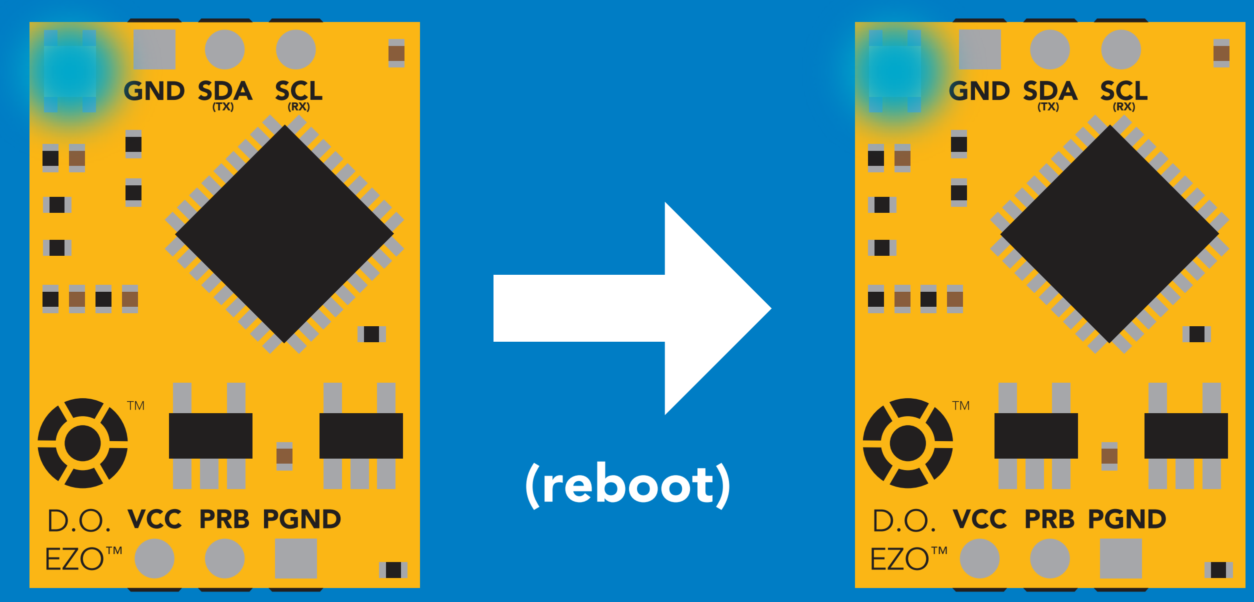
Factory	enable factory reset

I²C address will not change

Example	Response
Factory	device reboot

Clears calibration
LED on
Response codes enabled

Factory



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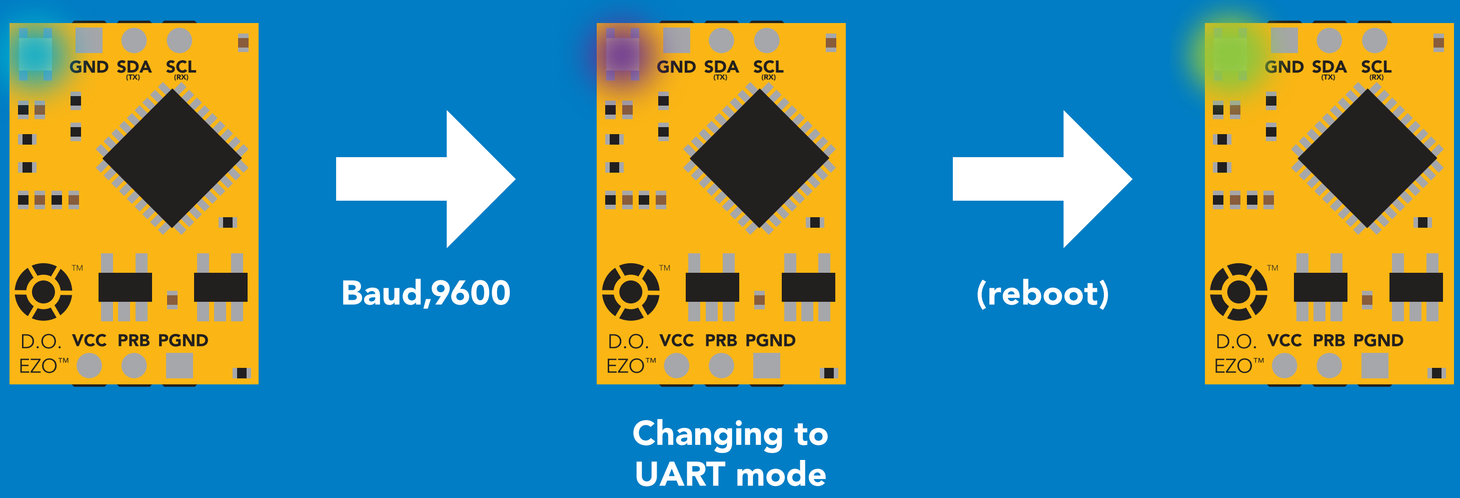
Change to UART mode

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



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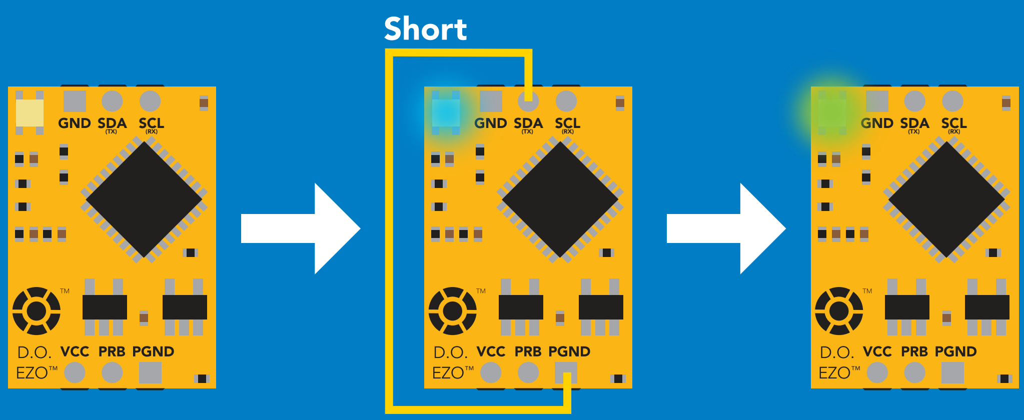
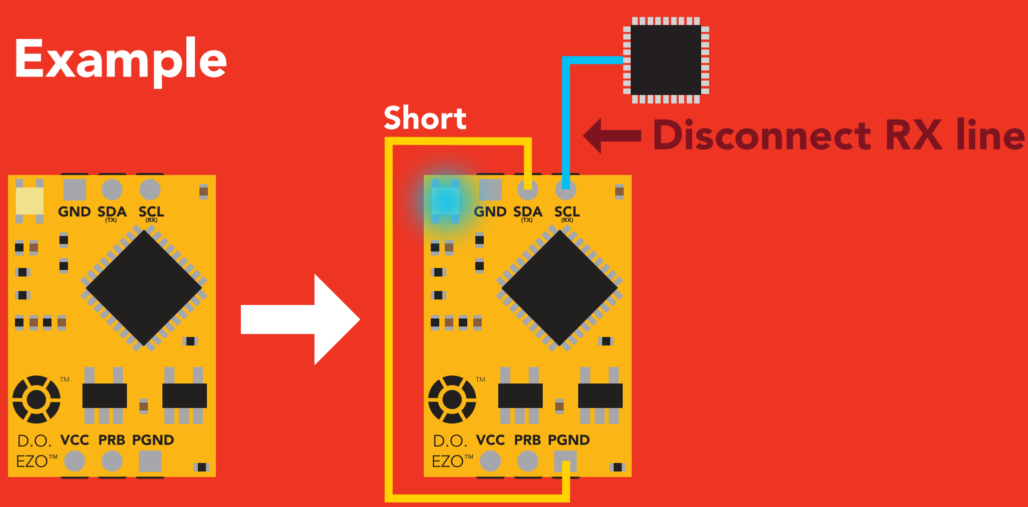
Manual switching to UART

- Make sure Plock is set to 0
- 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



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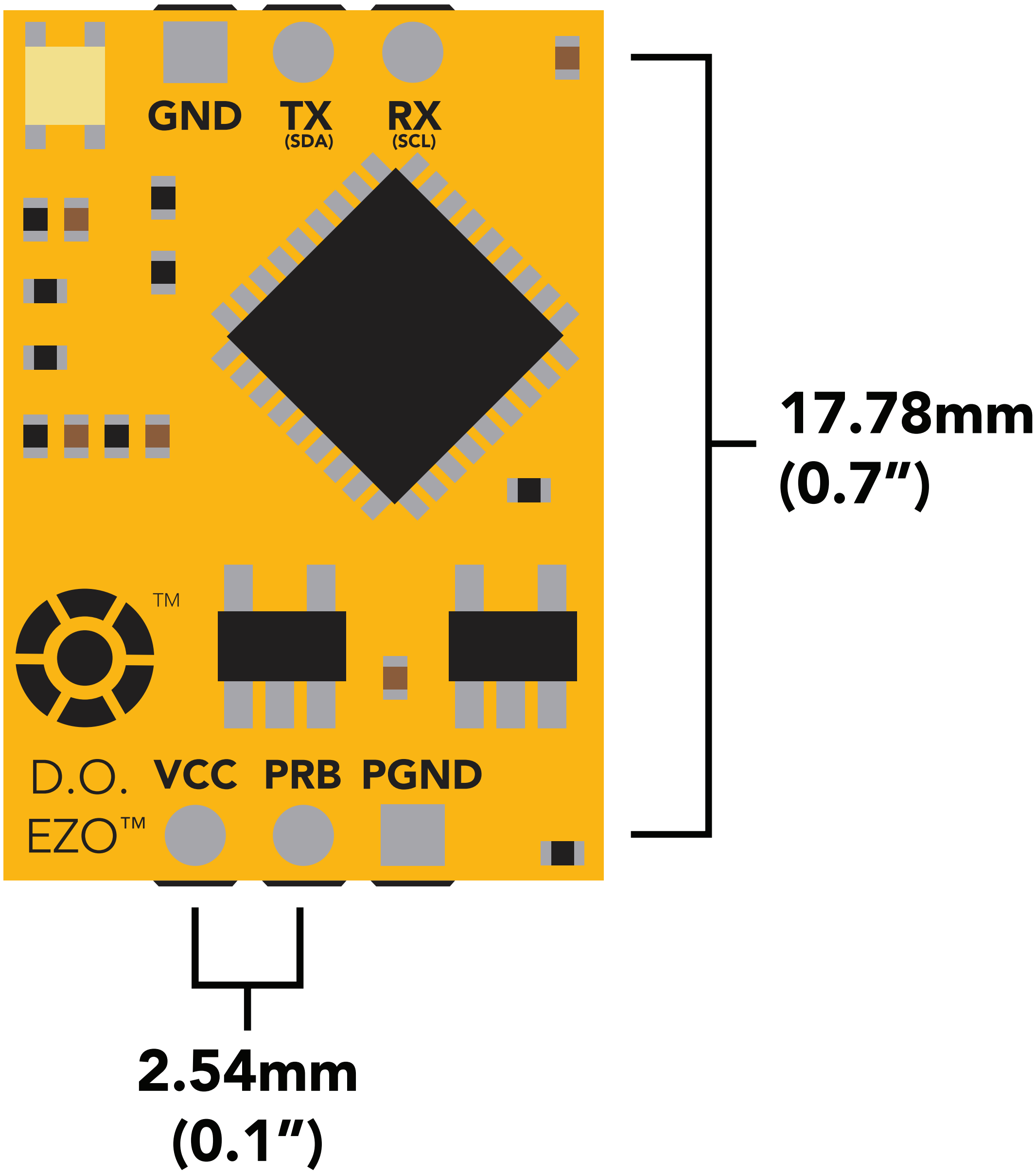
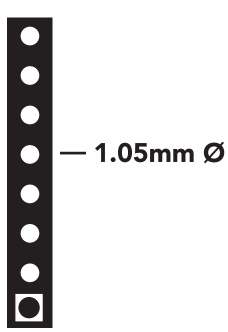
EZO™ circuit footprint

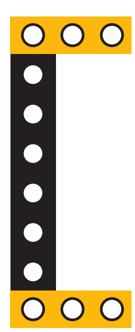


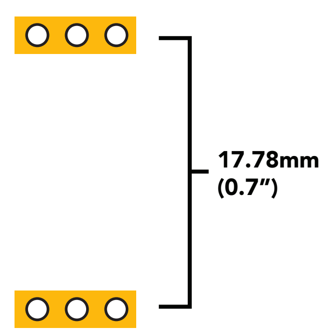
1 In your CAD software place a 8 position header.

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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Datasheet change log

Datasheet V 5.3

Moved Default state to pg 13.

Datasheet V 5.2

Updated firmware changes on page 70.

Datasheet V 5.1

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

Datasheet V 5.0

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

Datasheet V 4.9

Corrected temperature compensation typo on pages 26 & 52.

Datasheet V 4.8

Revised isolation schematic on pg. 10

Datasheet V 4.7

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

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Datasheet change log

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 V 3.7

Revised Plock pages to show default value.

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Datasheet change log

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.

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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.

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.**

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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.

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