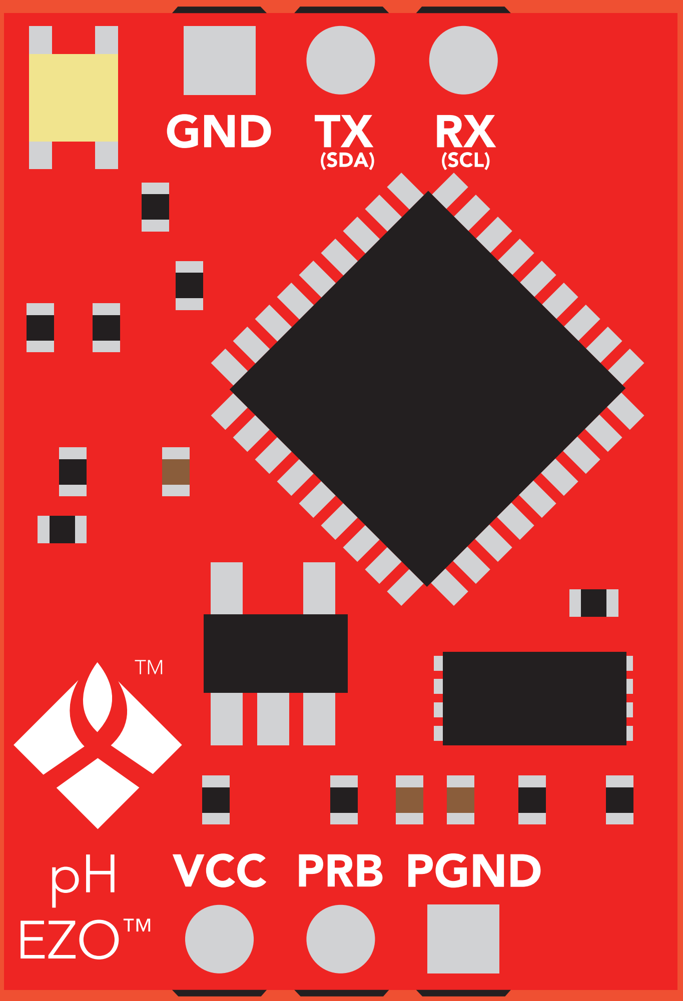
AtlasScientific™
Environmental Robotics
V 5.9
Revised 10/21

EZO-pH™

Embedded pH Circuit

Reads	pH
Range	.001 – 14.000
Resolution	.001
Accuracy	+/– 0.002
Response time	1 reading per sec
Supported probes	Any type & brand
Calibration	1, 2, 3 point
Temp compensation	Yes
Data protocol	UART & I²C
Default I²C address	99 (0x63)
Operating voltage	3.3V – 5V
Data format	ASCII



PATENT PROTECTED

Written by Jordan Press
Designed by Noah Press

This is an evolving document, check back for updates.

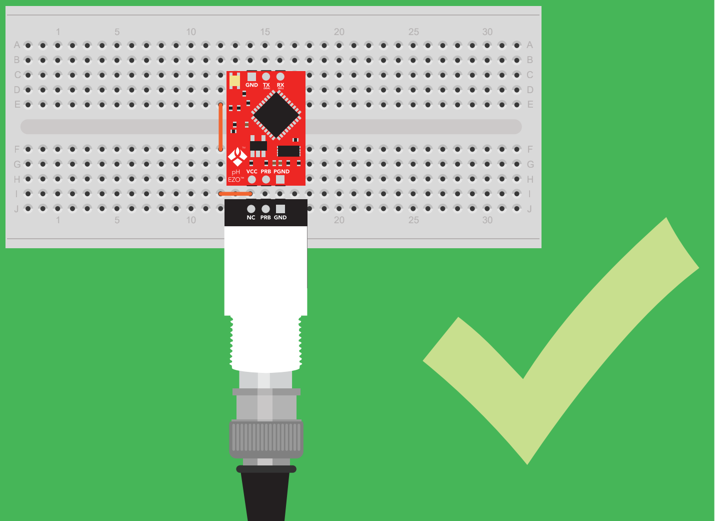
STOP

SOLDERING THIS DEVICE VOIDS YOUR WARRANTY.

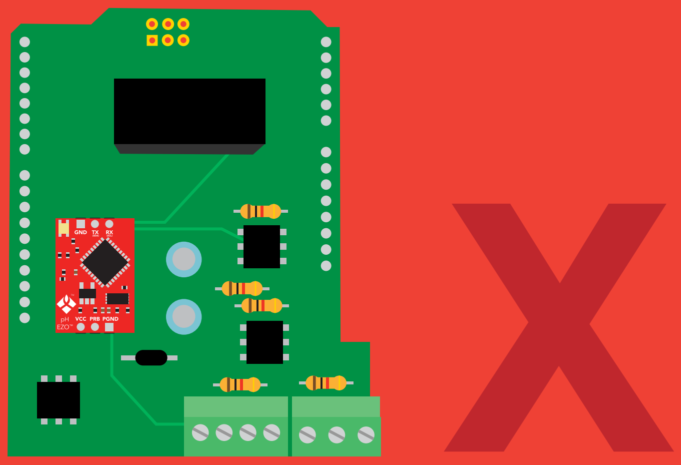
This is sensitive electronic equipment. Get this device working in a solderless breadboard first. Once this device has been soldered it is no longer covered by our warranty.

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!



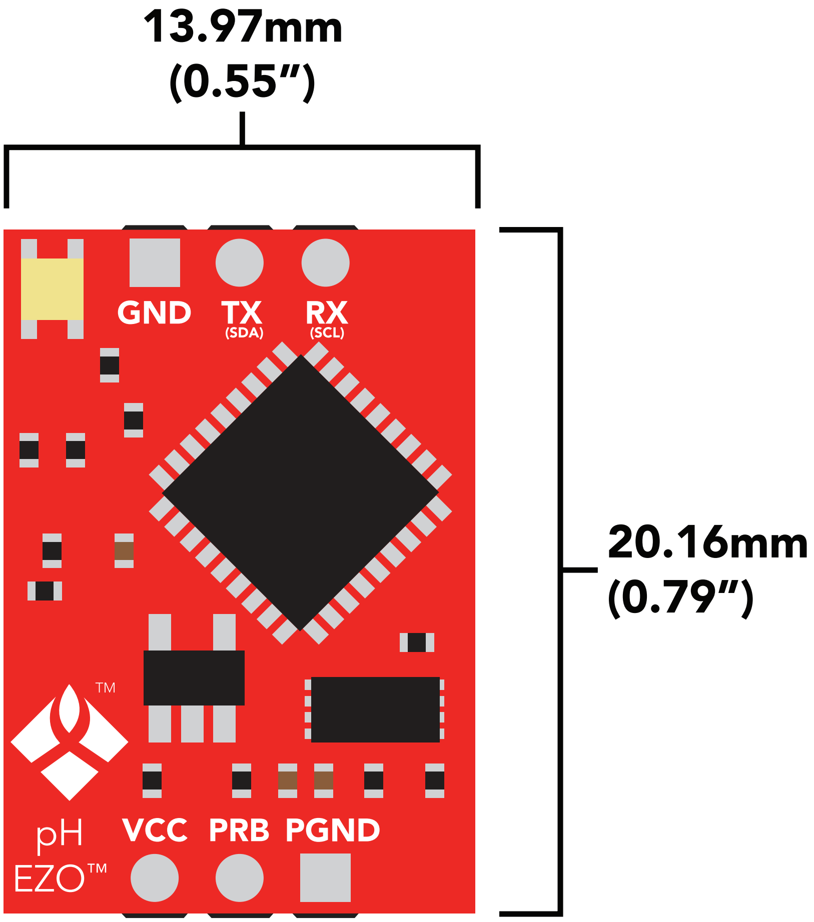
r 0.1

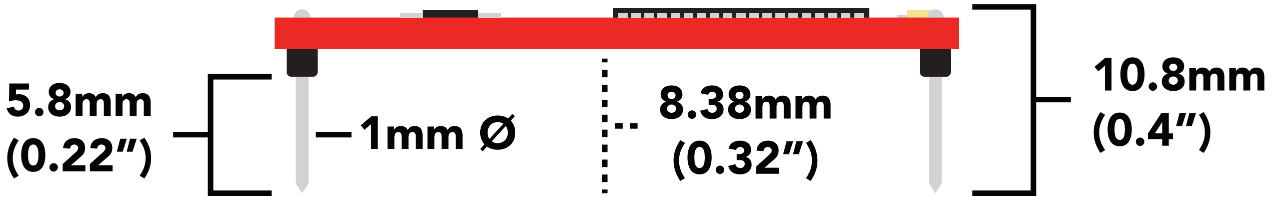
Table of contents

UART

I^2C

EZO™ circuit dimensions





Power consumption

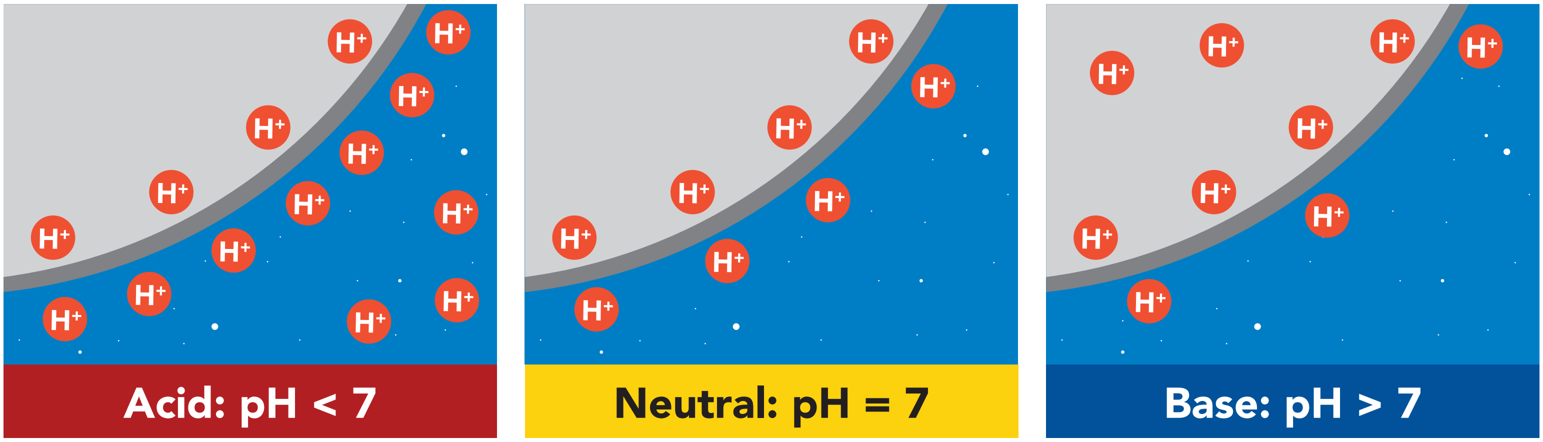
	LED	MAX	STANDBY	SLEEP
5V	ON	18.3 mA	16 mA	1.16 mA
	OFF	13.8 mA	13.8 mA	
3.3V	ON	14.5 mA	13.9 mA	0.995 mA
	OFF	13.3 mA	13.3 mA	

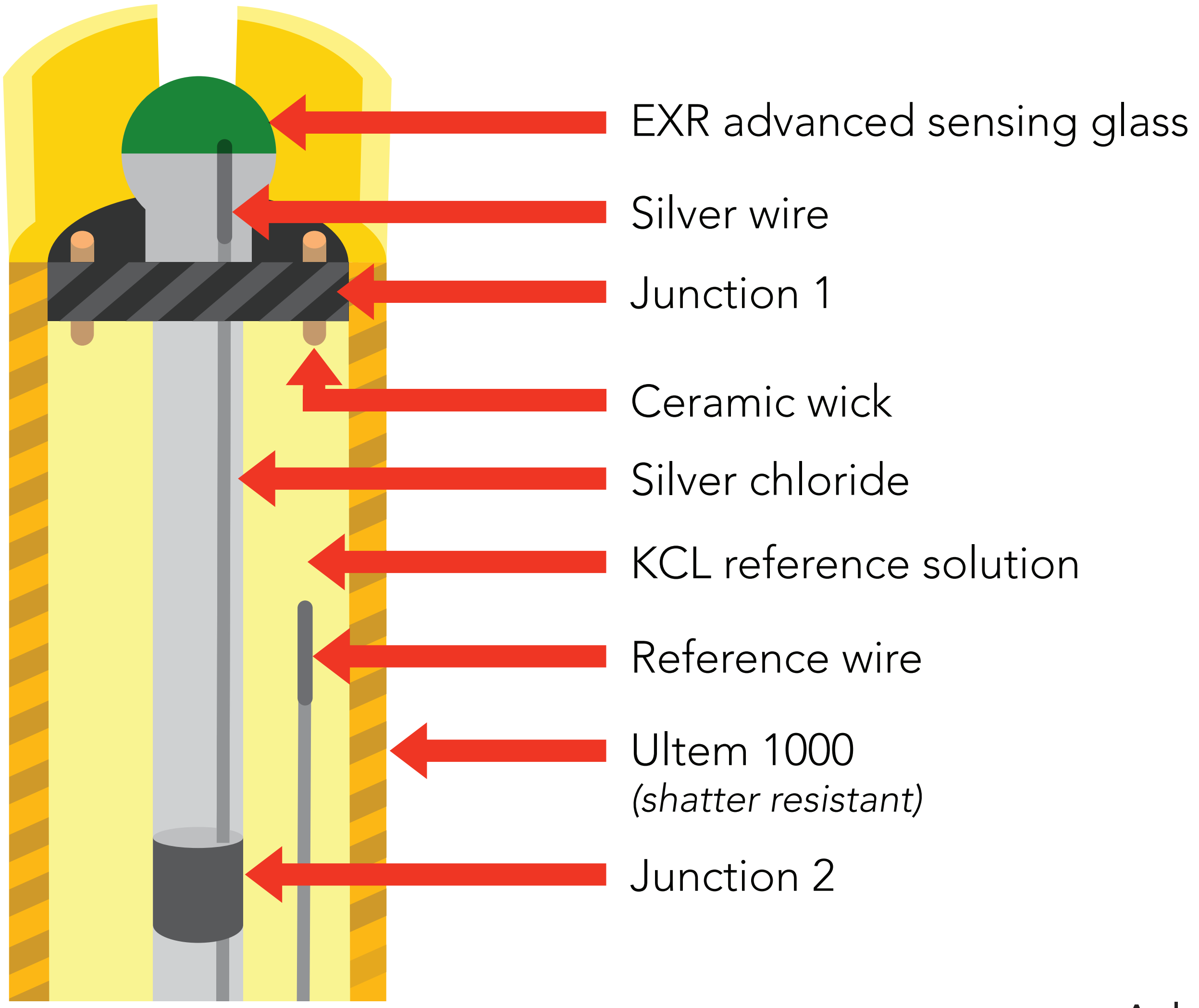
Absolute max ratings

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

Operating principle

A pH ***(potential of Hydrogen)*** probe measures the hydrogen ion activity in a liquid. At the tip of a pH probe is a glass membrane. This glass membrane permits hydrogen ions from the liquid being measured to defuse into the outer layer of the glass, while larger ions remain in the solution. The difference in the concentration of hydrogen ions (outside the probe vs. inside the probe) creates a VERY small current. This current is proportional to the concentration of hydrogen ions in the liquid being measured.

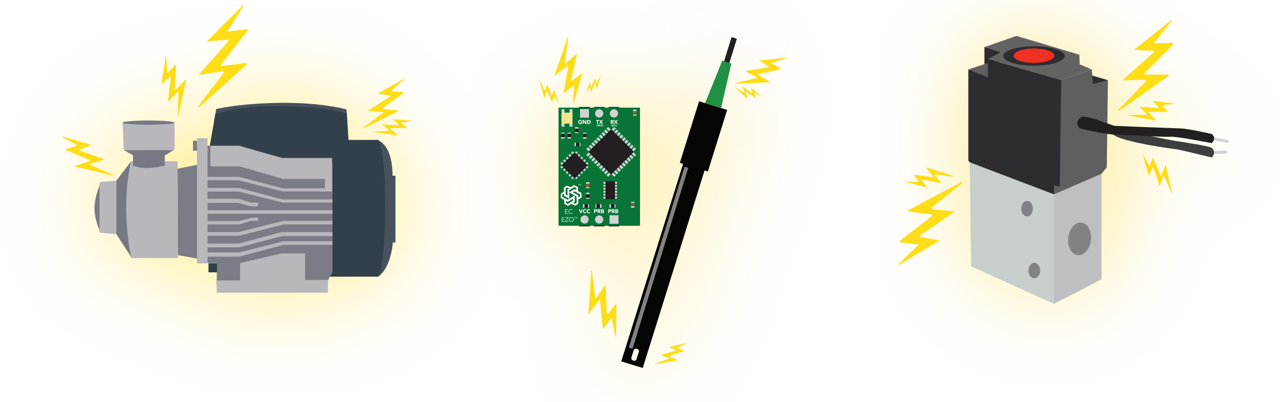




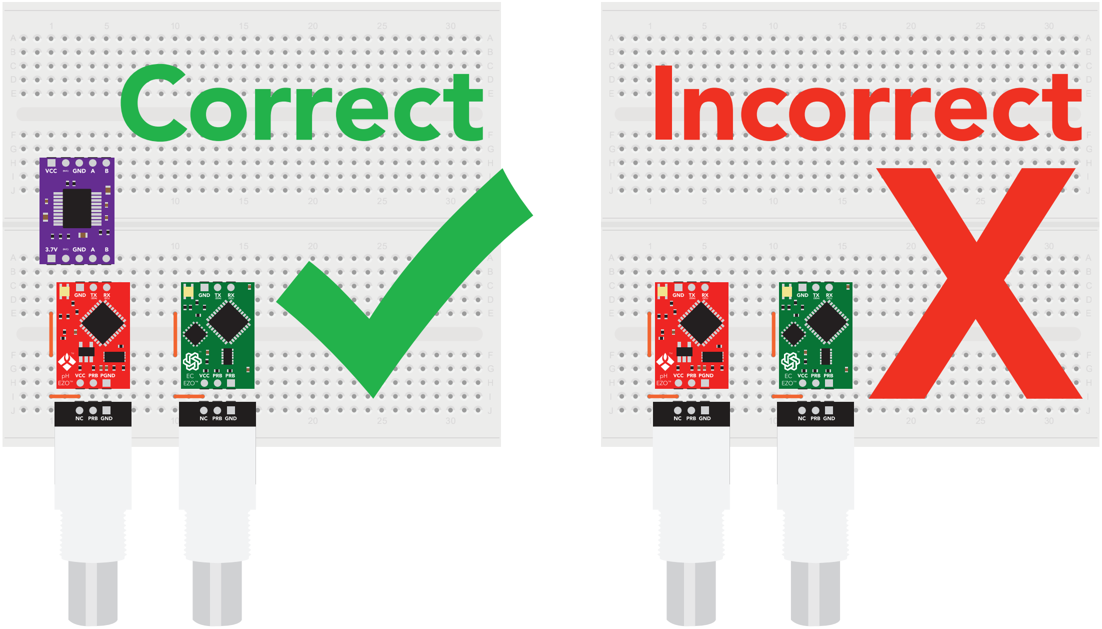
Power and data isolation

The Atlas Scientific EZO™ pH circuit is a very sensitive device. This sensitivity is what gives the pH circuit its accuracy. This also means that the pH 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 pH 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 pH probe in a cup of water by itself. The readings should stabilize quickly, confirming that electrical noise was the issue.



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



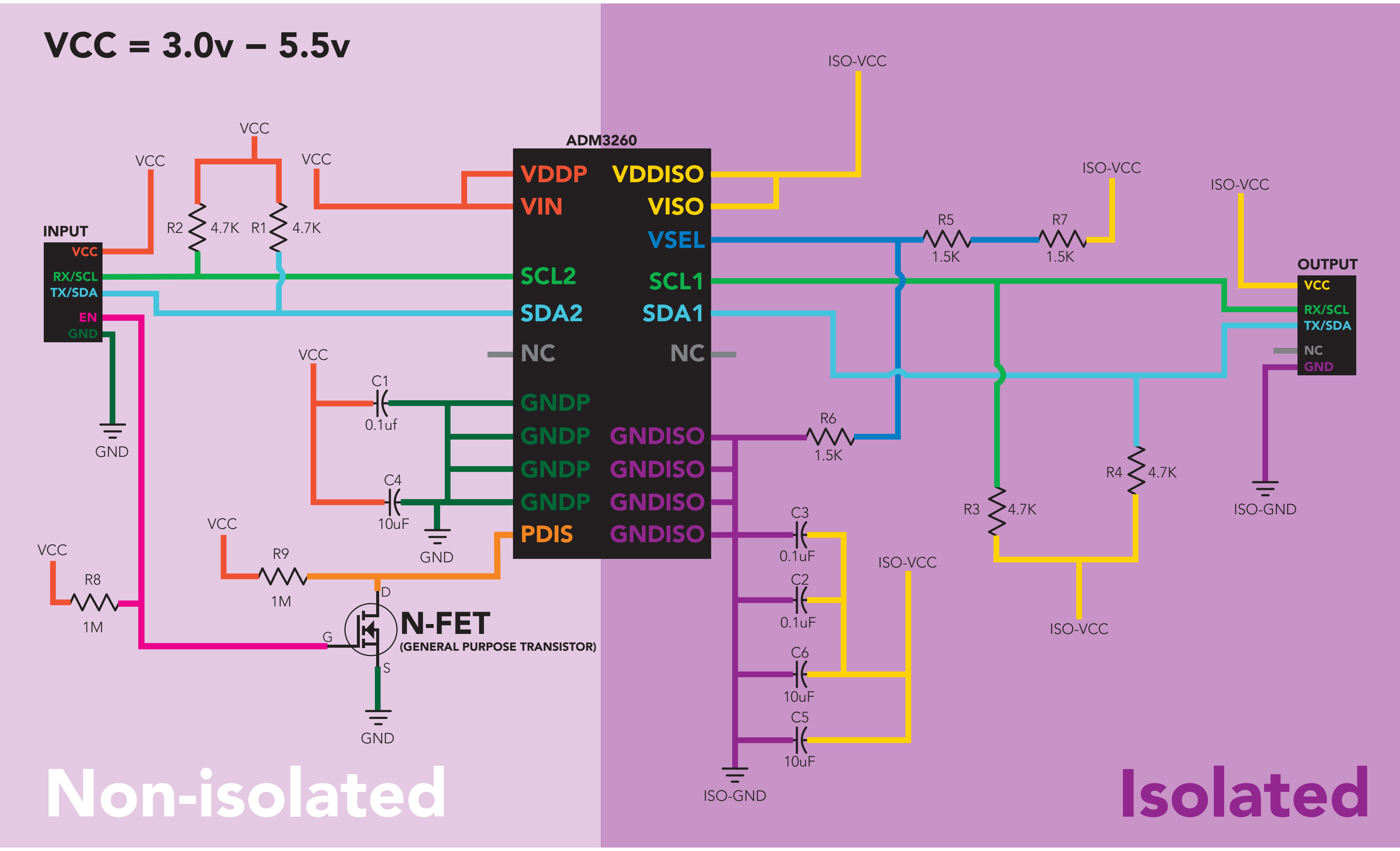
Basic EZO™
Inline Voltage Isolator

Without isolation, Conductivity and Dissolved Oxygen readings will effect pH accuracy.

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

This technology works by using tiny transformers to induce the voltage across an air gap. PCB layout requires special attention for EMI/EMC and RF Control, having proper ground planes and keeping the capacitors as close to the chip as possible are crucial for proper performance. The two data channels have a 4.7kΩ pull up resistor on both the isolated and non-isolated lines (R1, R2, R3, and R4) The output voltage is set using a voltage divider (R5, R6, and R7) this produces a voltage of 3.9V regardless of your input voltage.

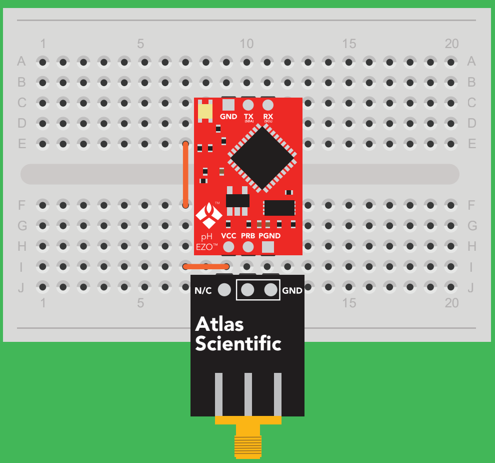
Isolated ground is different from non-isolated ground, these two lines should not be connected together.



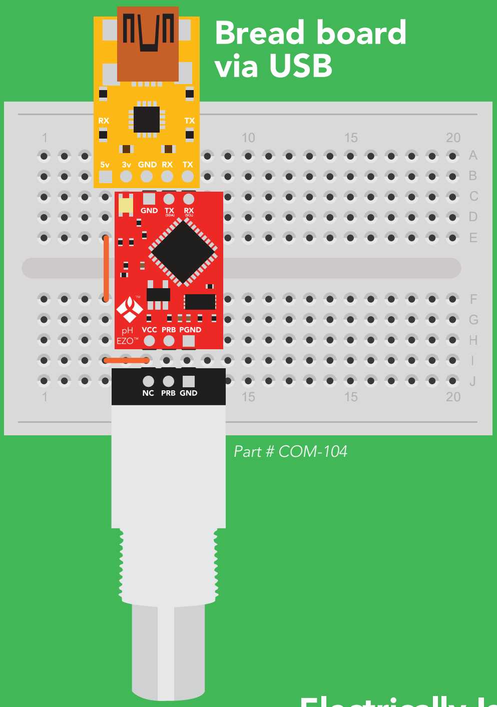
Atlas Scientific™
Environmental Robotics
r 0.2

✓ Correct wiring

Bread board

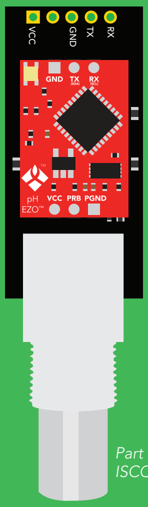


Bread board via USB



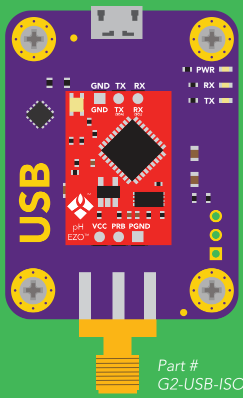
Part # COM-104

Carrier board



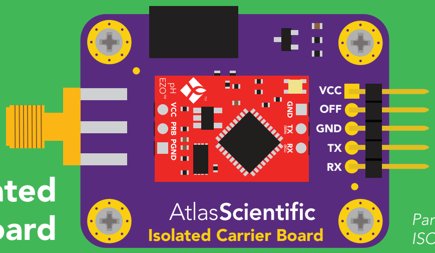
Part # ISCCB

USB carrier board



Part # G2-USB-ISO

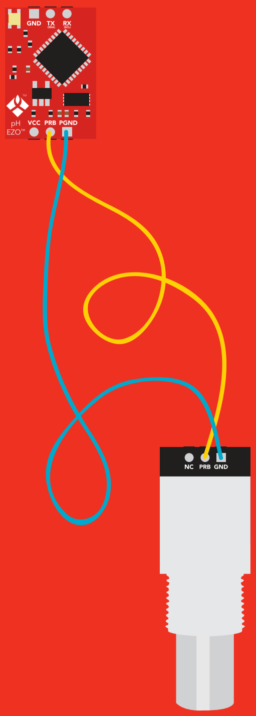
Electrically Isolated EZO™ Carrier Board



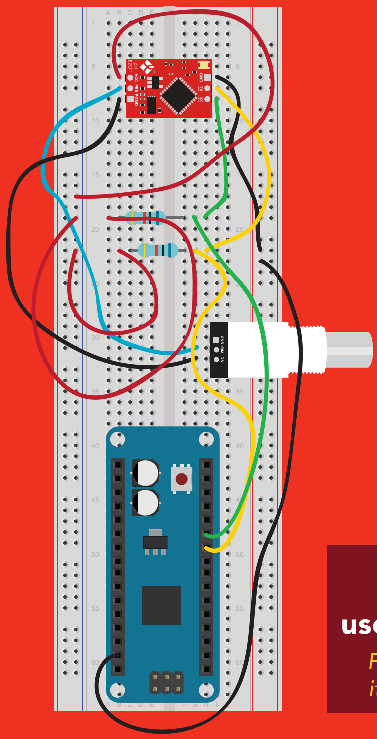
Part # ISCCB-2

X Incorrect wiring

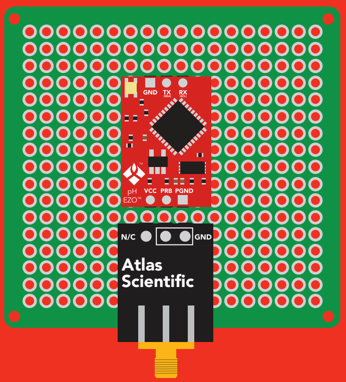
Extended leads



Sloppy setup



Perfboards or Protoboards

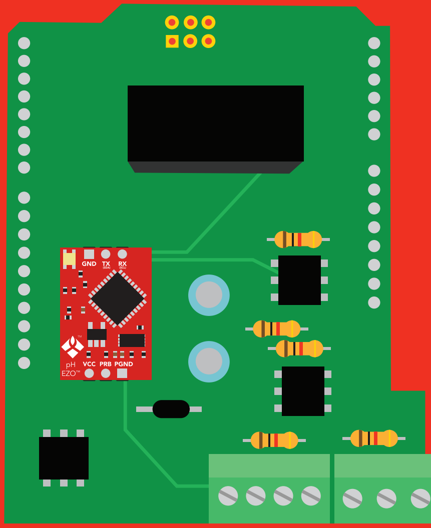


NEVER

use Perfboards or Protoboards

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

*Embedded into your device



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

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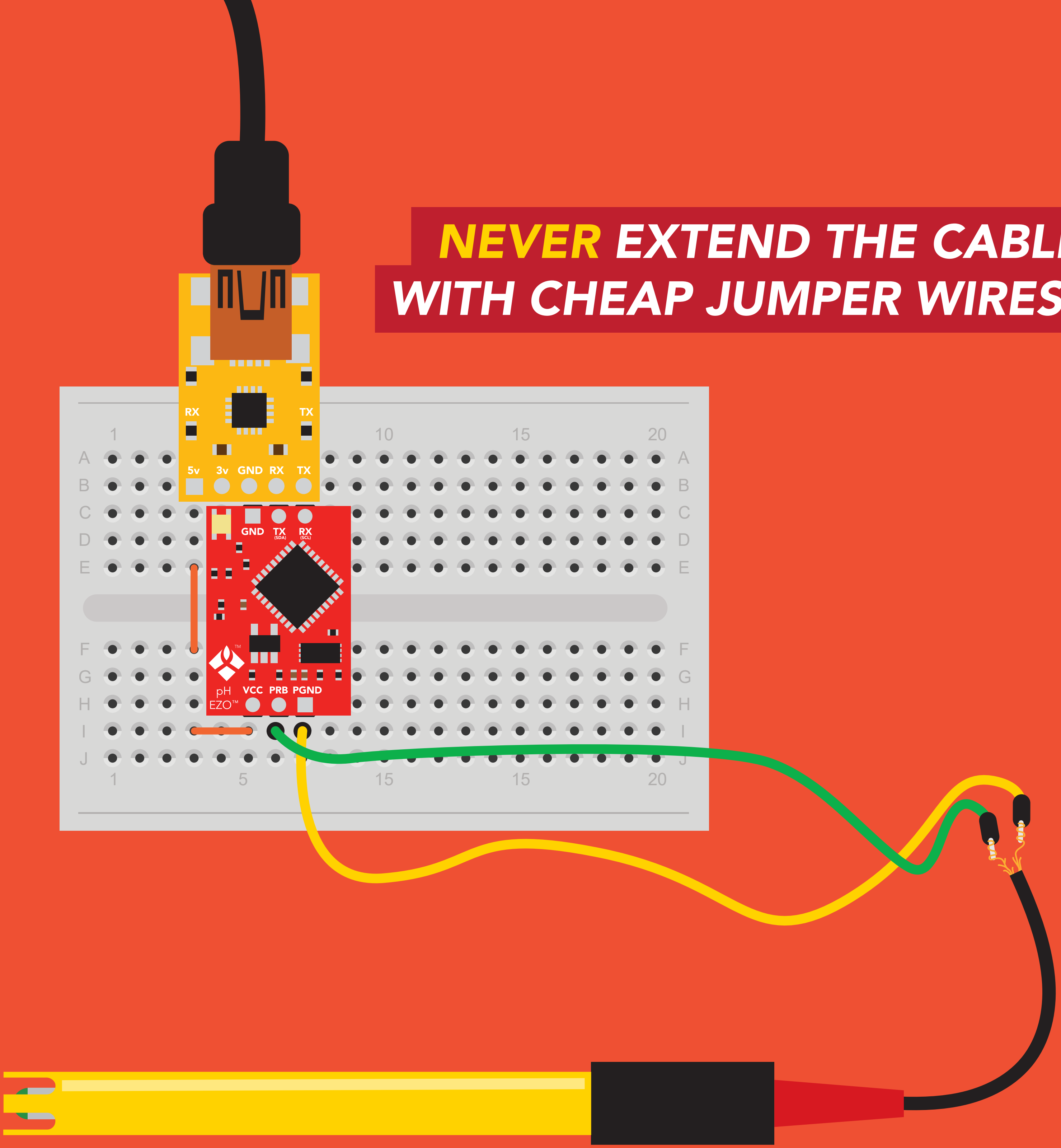
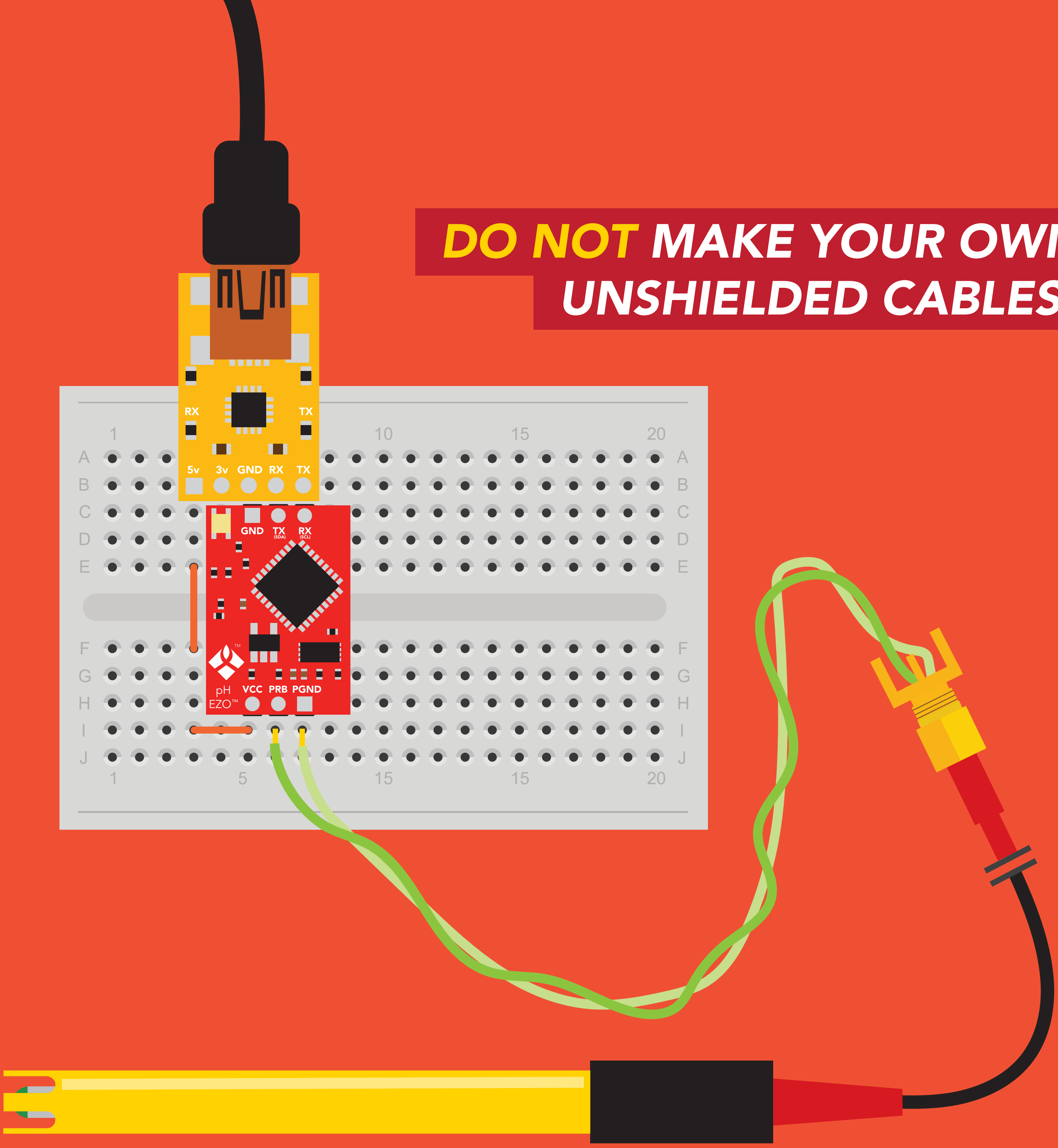
Environmental Robotics



NEVER EXTEND THE CABLE WITH CHEAP JUMPER WIRES!

DO NOT CUT THE PROBE CABLE WITHOUT REFERING TO *THIS DOCUMENT!*



DO NOT MAKE YOUR OWN UNSHIELDED CABLES!

ONLY USE SHIELDED CABLES.

Calibration theory

Simple calibration

UART

mode

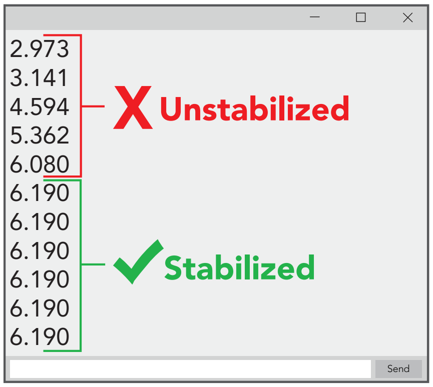
Continuous readings

Advanced calibration

I^2C

mode

Continuously request readings



```
2.973
3.141
4.594
5.362
6.080
6.190
6.190
6.190
6.190
6.190
6.190
```

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

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

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

Calibration order

If this is your first time calibrating the EZO™ pH circuit, we recommend that you follow this calibration order.

1 **Mid point**

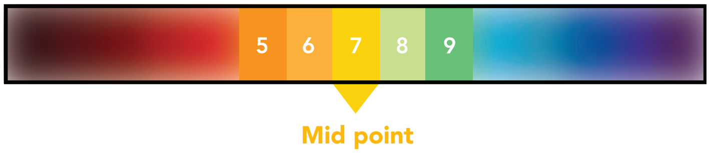
2 **Low point**

3 **High point**

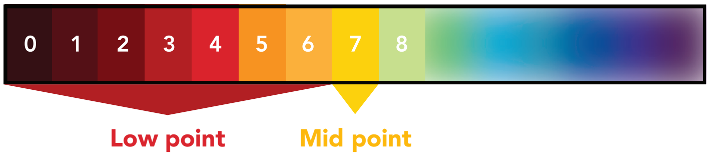
Single, Two point, or Three point calibration

No calibration

Single point calibration

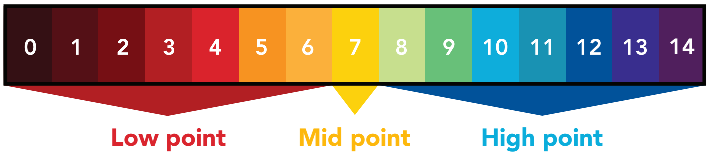


Two point calibration



Two point calibration will provide high accuracy between **7.00** and the second point calibrated against, such as a **4.00**.

Three point calibration

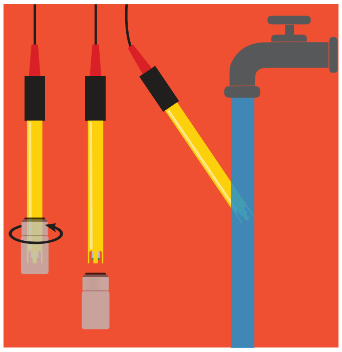


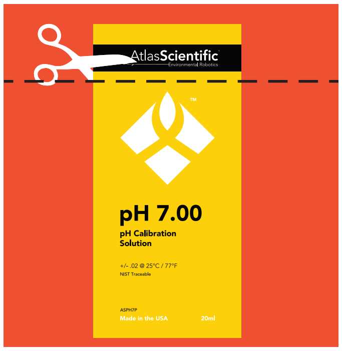
Three point calibration will provide high accuracy over the full pH range. Three point calibration at **4.00**, **7.00** and **10.00** should be considered the standard.

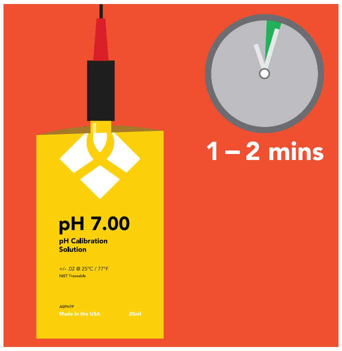
The first calibration point must be the Mid point (pH 7.00)

Mid point calibration

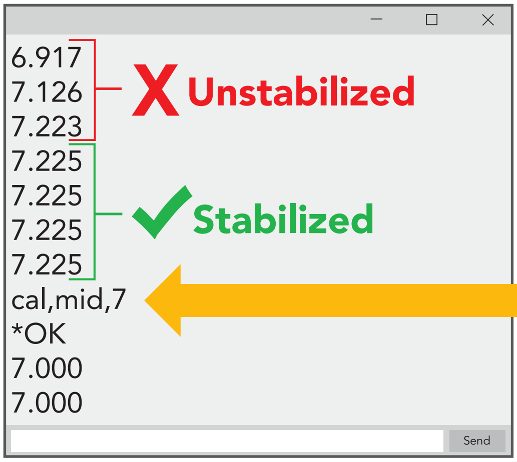
Remove the soaker bottle and rinse off the pH probe. Remove the top of the pH **7.00** calibration solution pouch. Place the pH probe inside the pouch and let the probe sit in the calibration solution until the readings stabilize *(small movement from one reading to the next is normal)*.







pH 7.00
pH Calibration Solution
After Calibration



```
6.917
7.126
7.223
7.225
7.225
7.225
7.225
cal,mid,7
*OK
7.000
7.000
```

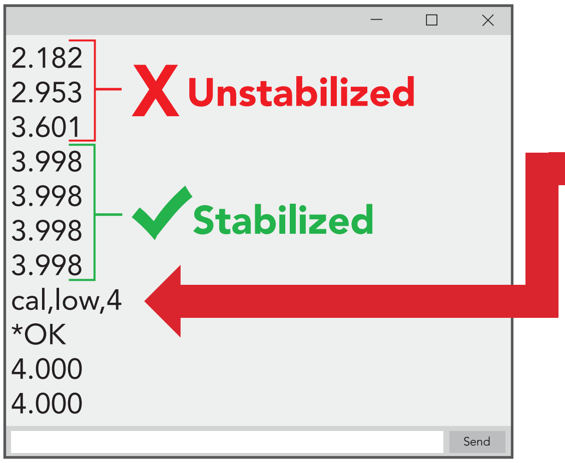
Once the readings have stabilized, issue the Mid point calibration command. **"cal,mid,7"**

After 20 mins, the calibration solution inside an open pouch is no longer considered accurate.

Dispose of the unused solution, after calibration.

Low point calibration

- Rinse off the probe before calibrating to the low point.
- Open the pouch of pH **4.00** calibration solution, and place probe inside the pouch.
- Wait for readings to stabilize *(1 – 2 minutes)*.



```
2.182
2.953
3.601
3.998
3.998
3.998
3.998
cal,low,4
*OK
4.000
4.000
```

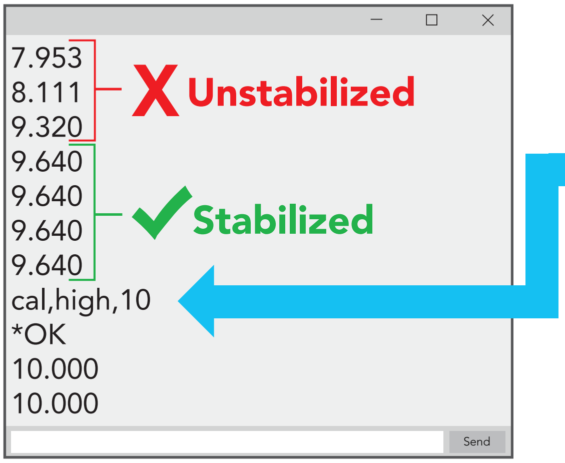
Once the readings have stabilized, issue the Low point calibration command. **"cal,low,4"**

After 20 mins, the calibration solution inside an open pouch is no longer considered accurate.

Dispose of the unused solution, after calibration.

High point calibration

- Rinse off the probe before calibrating to the high point.
- Open the pouch of pH **10.00** calibration solution, and place probe inside the pouch.
- Wait for readings to stabilize *(1 – 2 minutes)*.



```
7.953
8.111
9.320
9.640
9.640
9.640
9.640
cal,high,10
*OK
10.000
10.000
```

Once the readings have stabilized, issue the High point calibration command. **"cal,high,10"**

After 20 mins, the calibration solution inside an open pouch is no longer considered accurate.

Dispose of the unused solution, after calibration.

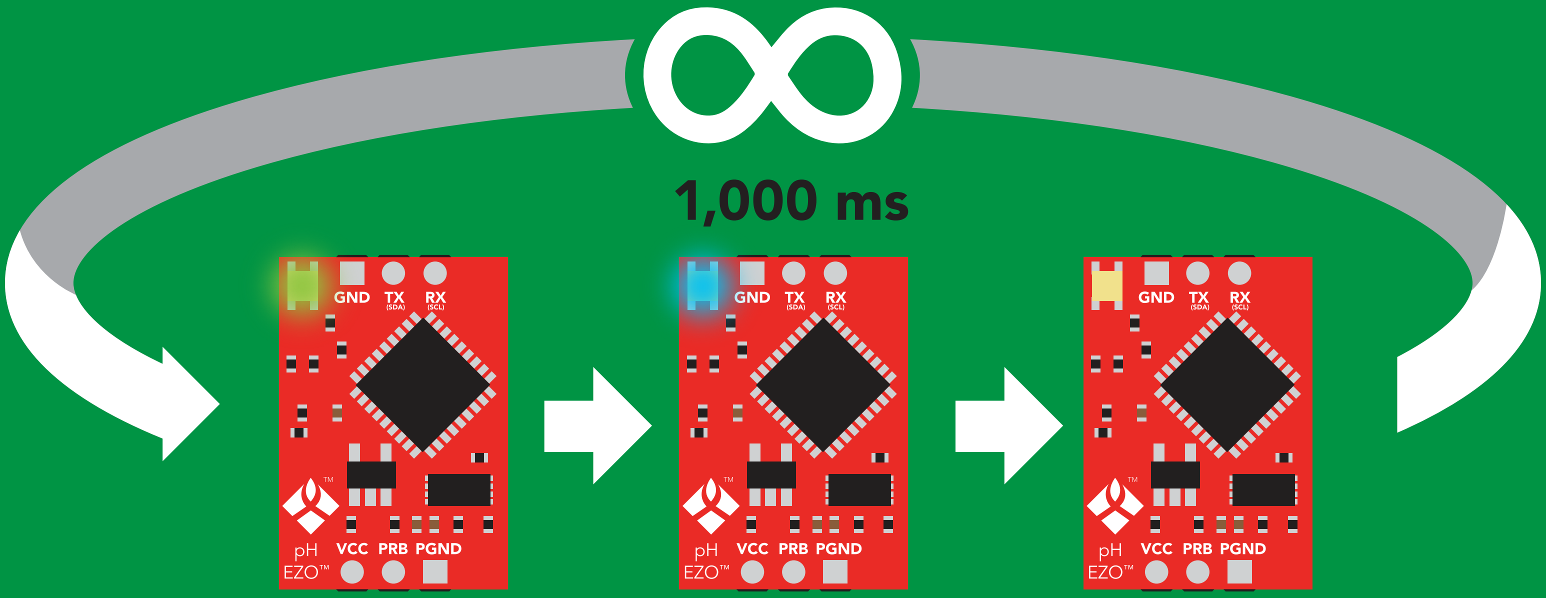
⚠ **Issuing the cal,mid command after the EZO™ pH circuit has been calibrated, will clear the other calibration points. Full calibration will have to be redone.** ⚠

The EZO™ pH circuits default temperature compensation is set to 25° C. If the temperature of the calibration solution is +/- 2° C from 25° C, consider setting the temperature compensation first. ***Temperature changes of < 2° C are insignificant.***

Default state

UART mode

Baud	9,600
Readings	continuous
Speed	1 reading per second
LED	on



1,000 ms

Green
Standby

Cyan
Taking reading

Transmitting

✓ Available data protocols

UART

Default

I^2C

✗ Unavailable data protocols

SPI

Analog

RS-485

Mod Bus

4–20mA

UART mode

Settings that are retained if power is cut

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

Settings that are *NOT* retained if power is cut

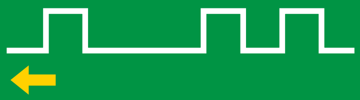
Find
Sleep mode
Temperature compensation

UART mode

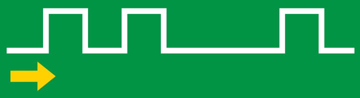
8 data bits	no parity
1 stop bit	no flow control

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

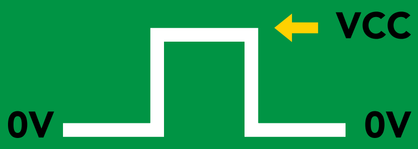
RX
Data in

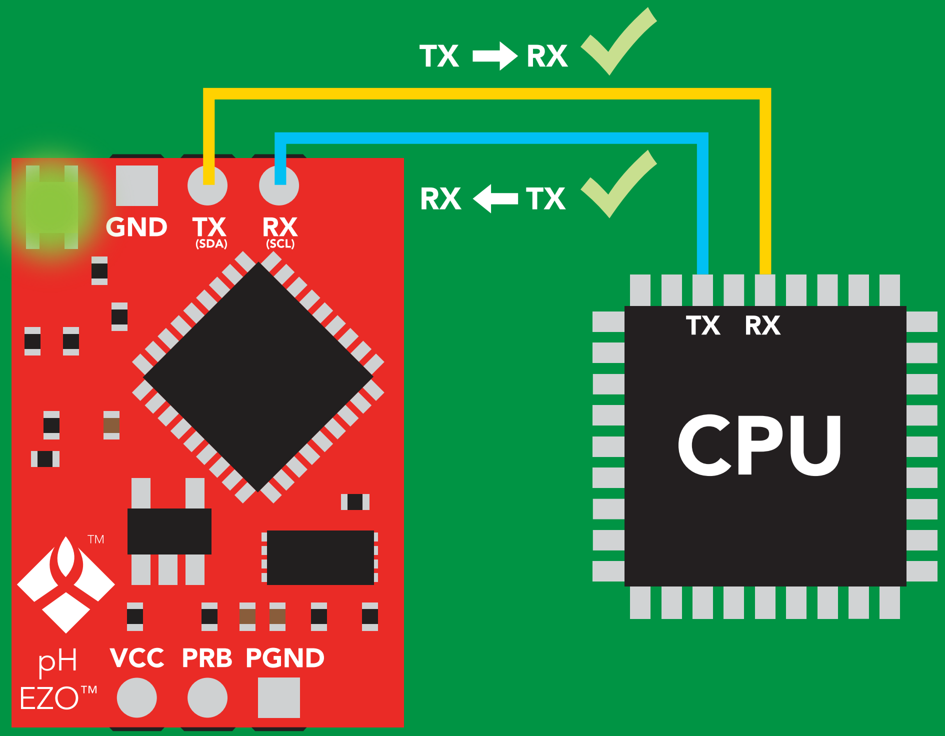


TX
Data out



Vcc 3.3V – 5.5V





Data format

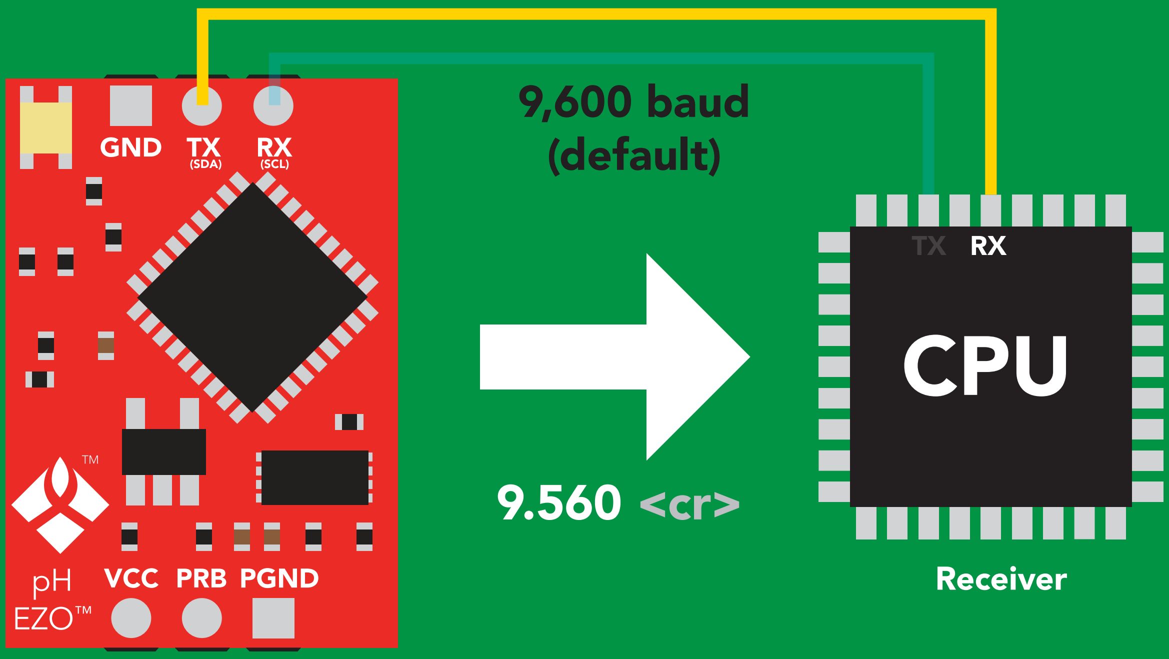
Reading	pH	Data type	floating point
Units	pH	Decimal places	3
Encoding	ASCII	Smallest string	4 characters
Format	string	Largest string	40 characters
Terminator	carriage return		

Receiving data from device

2 parts

ASCII data string
Command

Carriage return <cr>
Terminator



9,600 baud
(default)

9.560 <cr>

Sender

Receiver

Advanced

ASCII:	9	.	5	6	0	<cr>
Hex:	39	2E	35	36	30	0D
Dec:	57	46	53	54	48	13

Sending commands to device

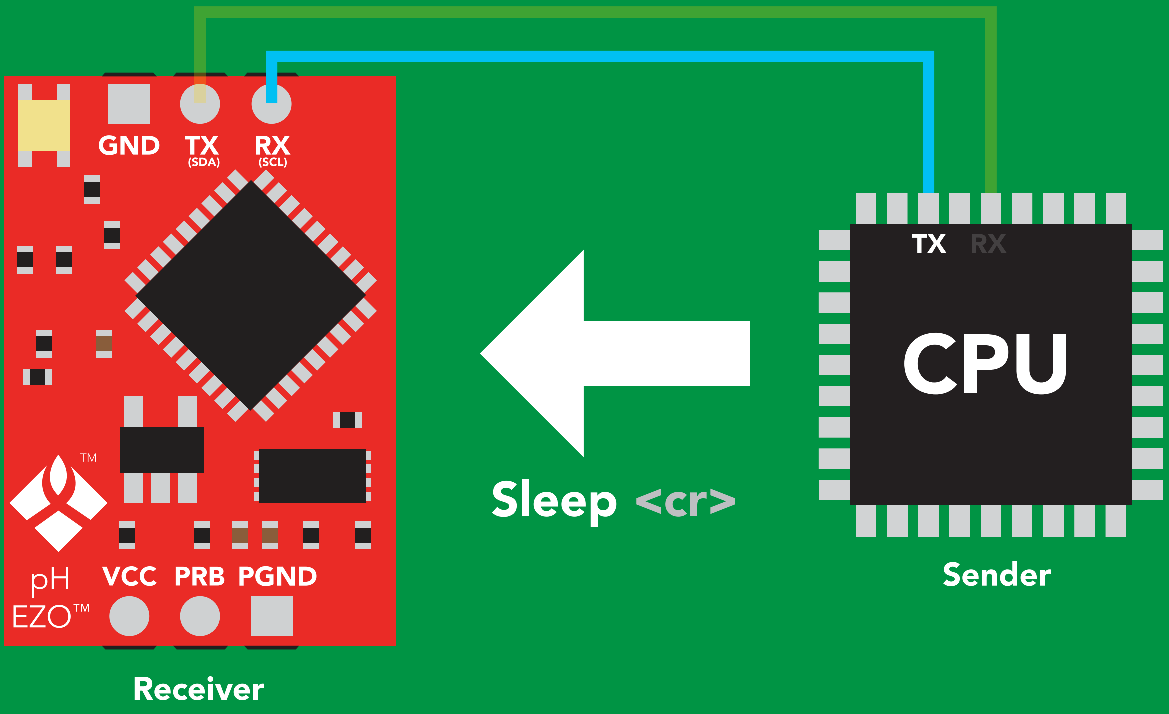
2 parts

Command (not case sensitive)

ASCII data string

Carriage return <cr>

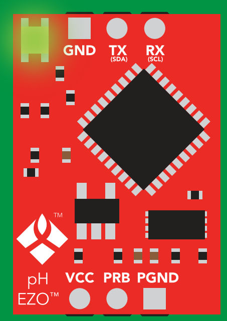
Terminator



Advanced

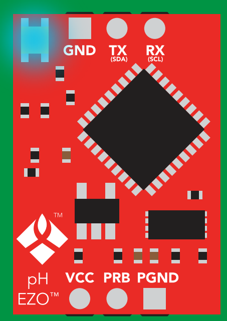
ASCII:	S	l	e	e	p	<cr>
Hex:	53	6C	65	65	70	0D
Dec:	83	108	101	101	112	13

LED color definition



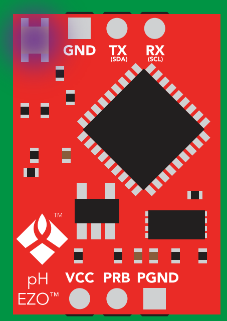
Green

UART standby



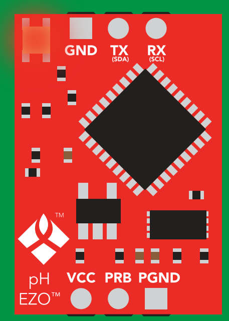
Cyan

Taking reading



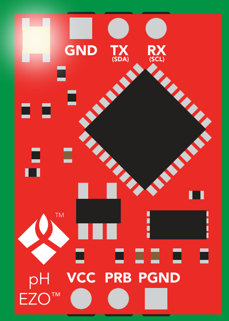
Purple

Changing
baud rate



Red

Command
not understood



White

Find

	LED ON
5V	+2.2 mA
3.3V	+0.6 mA

UART mode

command quick reference

All commands are ASCII strings or single ASCII characters.

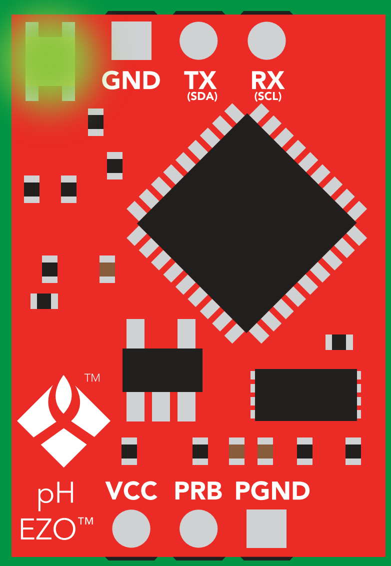
Command	Function		Default state
Baud	change baud rate	pg. 37	9,600
C	enable/disable continuous reading	pg. 24	enabled
Cal	performs calibration	pg. 26	n/a
Export	export calibration	pg. 27	n/a
Factory	enable factory reset	pg. 39	n/a
Find	finds device with blinking white LED	pg. 23	n/a
i	device information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

LED control

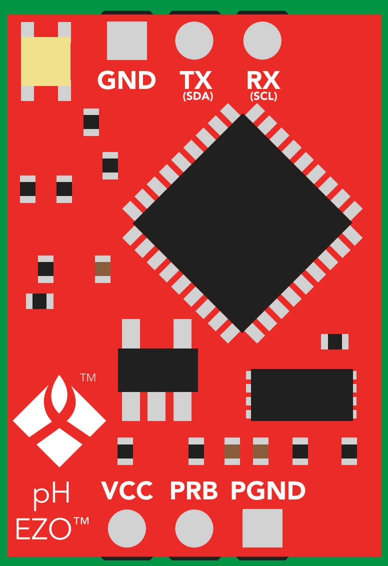
Command syntax

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

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



L,1



L,0

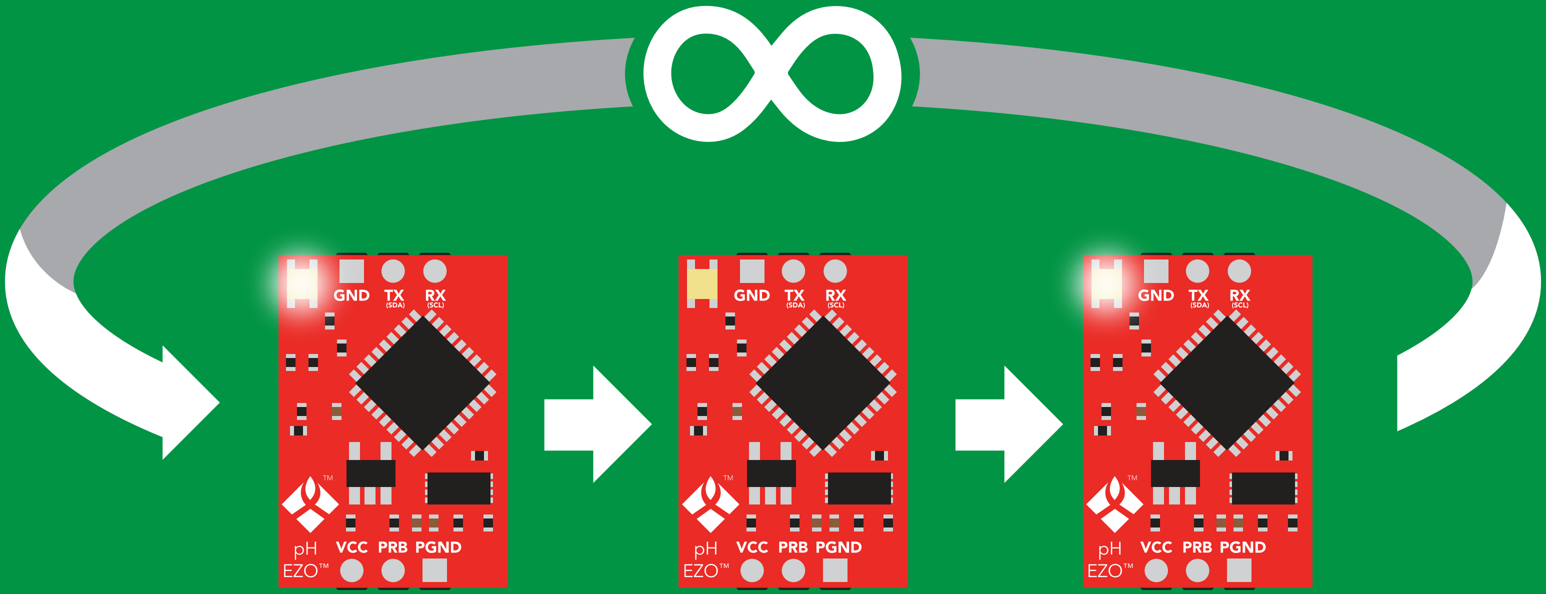
Find

Command syntax

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

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

Example	Response
Find <cr>	*OK <cr>



Continuous reading mode

Command syntax

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

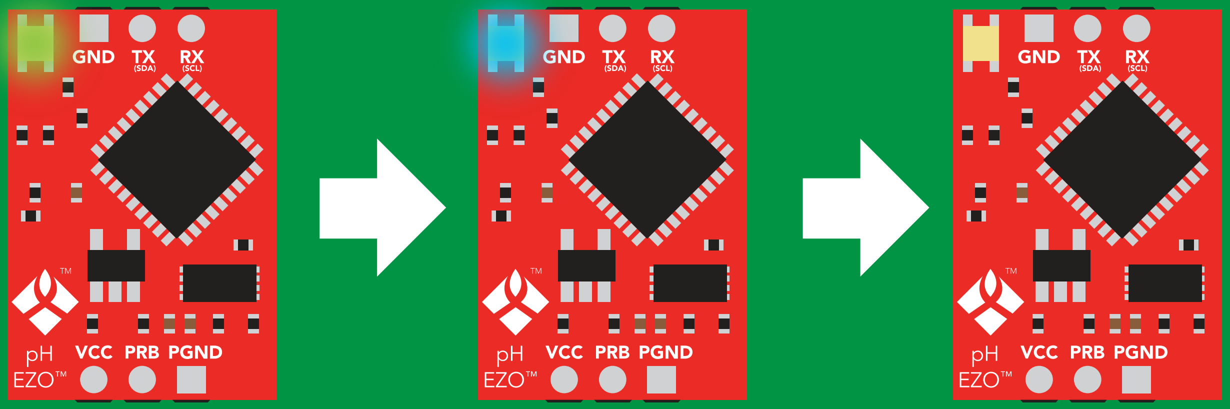
Example	Response
C,1 <cr>	*OK <cr> pH (1 sec) <cr> pH (2 sec) <cr> pH (n sec) <cr>
C,30 <cr>	*OK <cr> pH (30 sec) <cr> pH (60 sec) <cr> pH (90 sec) <cr>
C,0 <cr>	*OK <cr>
C,? <cr>	?C,1 <cr> or ?C,0 <cr> or ?C,30 <cr> *OK <cr>

Single reading mode

Command syntax

R <cr> takes single reading

Example	Response
R <cr>	9.560 <cr> *OK <cr>



Green
Standby

Cyan
Taking reading

Transmitting

800 ms

Calibration

Command syntax

Issuing the cal,mid command after the EZO™ pH circuit has been calibrated, will clear the other calibration points. Full calibration will have to be redone.

Cal,mid,n	<cr>	single point calibration at midpoint
Cal,low,n	<cr>	two point calibration at lowpoint
Cal,high,n	<cr>	three point calibration at highpoint
Cal,clear	<cr>	delete calibration data
Cal,?	<cr>	device calibrated?

Example	Response
Cal,mid,7.00 <cr>	*OK <cr>
Cal,low,4.00 <cr>	*OK <cr>
Cal,high,10.00 <cr>	*OK <cr>
Cal,clear <cr>	*OK <cr>
Cal,? <cr>	?Cal,0 <cr> or ?Cal,1 <cr> or one point ?Cal,2 <cr> or ?Cal,3 <cr> two point three point *OK <cr>

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>
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

Response breakdown

10, 120

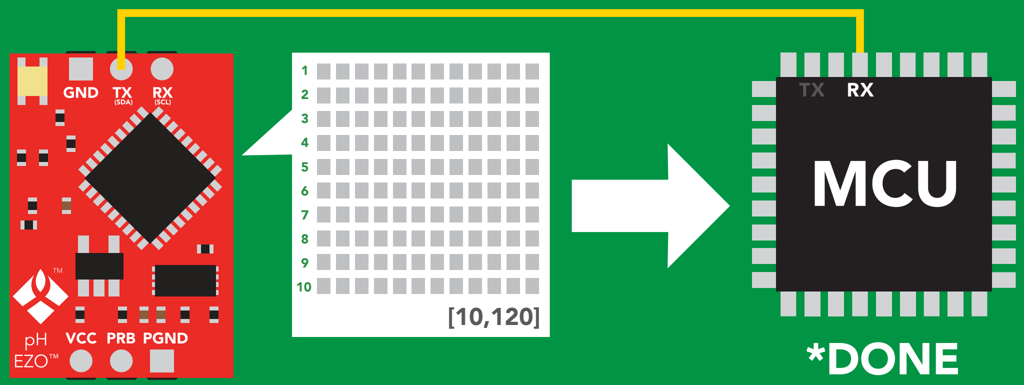
↑ # of strings to export

↑ # of bytes to export

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

Disabling *OK simplifies this process

Export <cr>



***DONE**

Import calibration

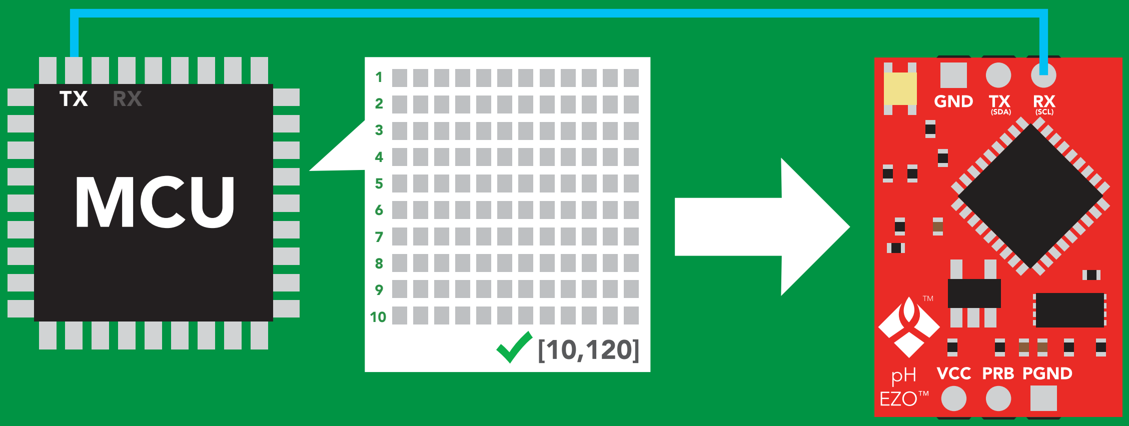
Command syntax

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

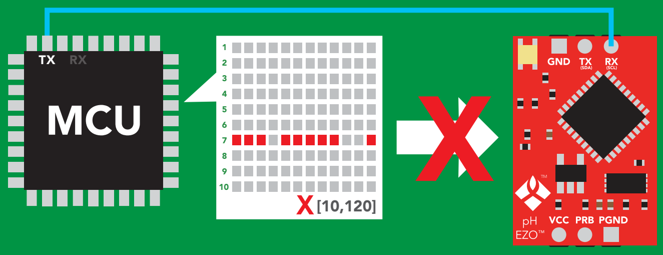
Import,n <cr> **import calibration string to new device**

Example		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.**

Slope

After calibrating a pH probe issuing the slope command will show how closely (in percentage) the calibrated pH probe is working compared to the "ideal" pH probe.

Command syntax

Slope,? <cr> returns the slope of the pH probe

Example	Response
Slope,? <cr>	?Slope,99.7,100.3, -0.89 <cr> *OK <cr>

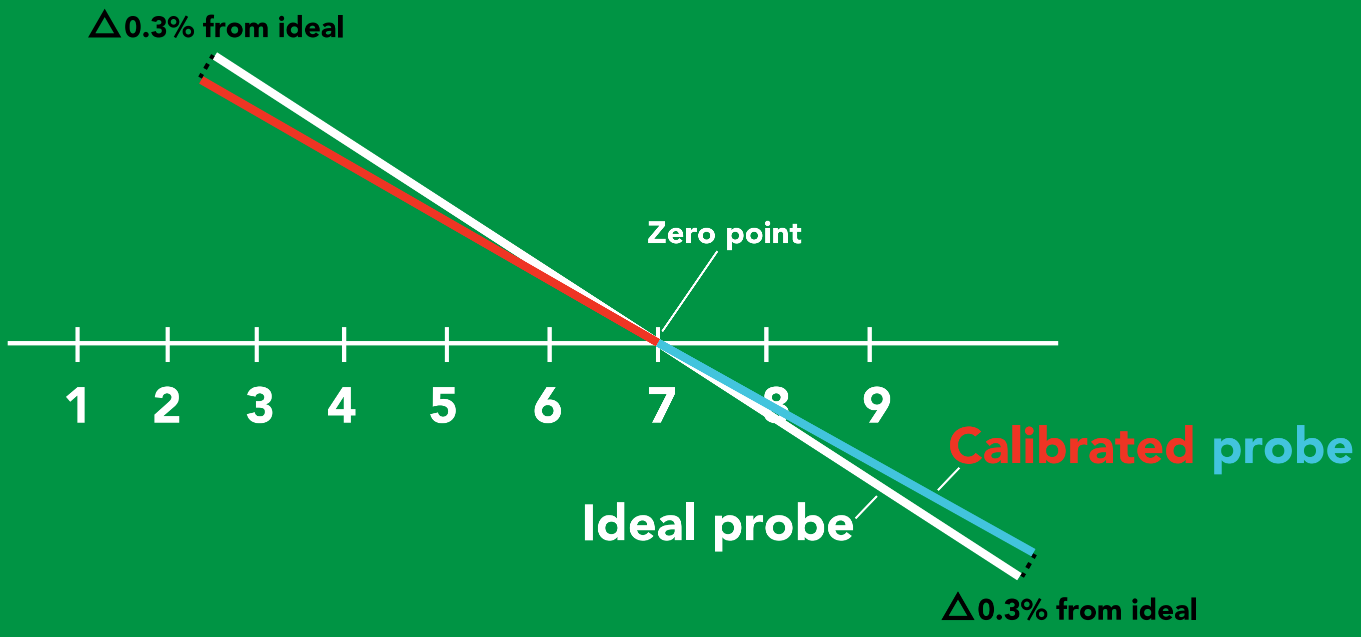
Response breakdown

?Slope, 99.7 100.3 -0.89

99.7 ↑ 99.7% is how closely the slope of the **acid** calibration line matched the "ideal" pH probe.

100.3 ↑ 100.3% is how closely the slope of the **base** calibration matches the "ideal" pH probe.

-0.89 ↑ This is how many millivolts the zero point is off from true 0.



Extended pH scale

Very strong acids and basses can exceed the traditional pH scale. This command extends the pH scale to show below 0 and above 14.

Lowest possible reading: **-1.6**
Highest possible reading: **15.6**

Command syntax

pHext,0 <cr>	**extended pH scale off (0 – 14)**	**default**
pHext,1 <cr>	**extended pH scale on (-1.6 – 15.6)**	
pHext,? <cr>	**extended pH scale on/off?**	

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

pHext,0

pH = 0.000

pHext,1

pH = -1.220

Temperature compensation

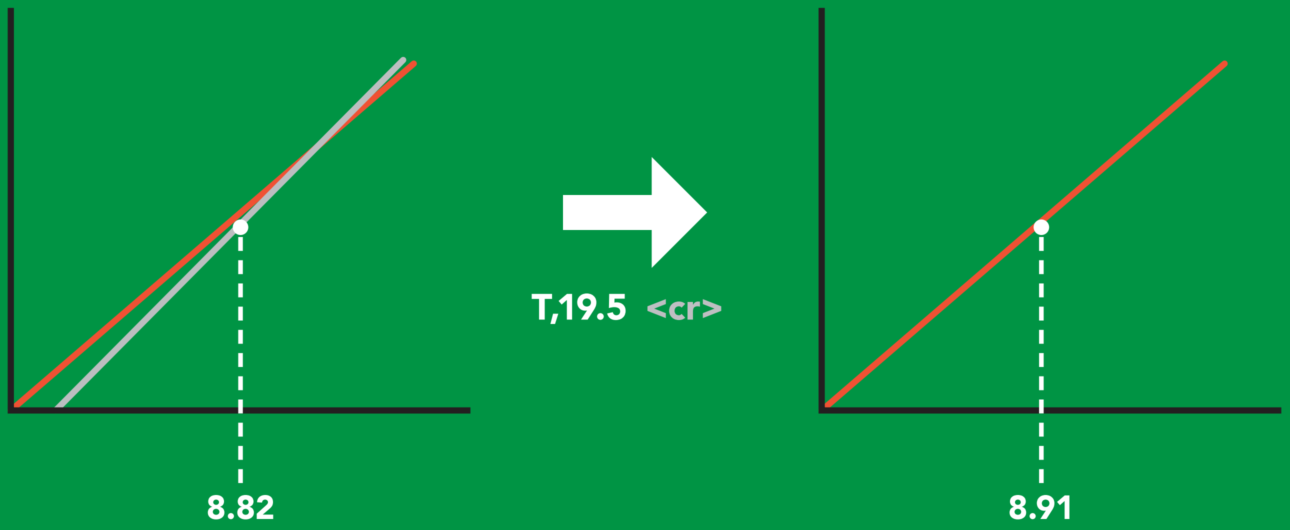
Command syntax

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

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

*This is a new command for firmware V2.12

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>



Naming device

Command syntax

Do not use spaces in the name

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

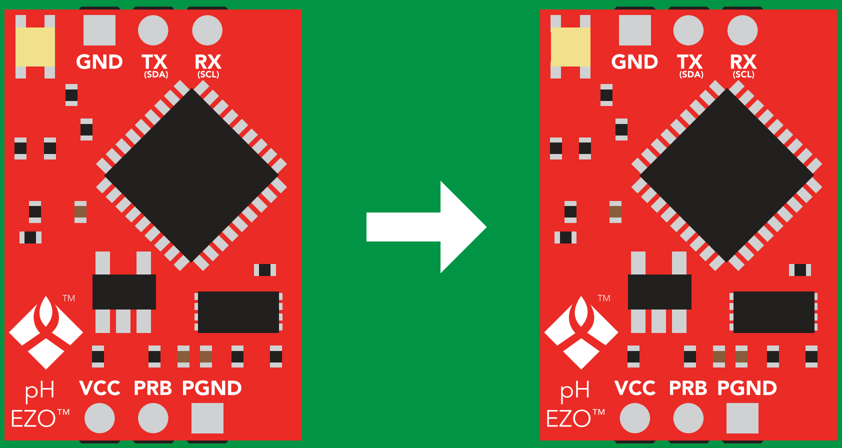
n = _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16

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>

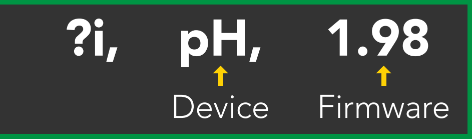
Device information

Command syntax

i <cr> **device information**

Example	Response
i <cr>	?i,pH,1.98 <cr> *OK <cr>

Response breakdown



```
?i,   pH,      1.98
      ↑        ↑
      Device   Firmware
```

Response codes

Command syntax

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

Example	Response
R <cr>	9.560 <cr> *OK <cr>
*OK,0 <cr>	no response, *OK disabled
R <cr>	9.560 <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

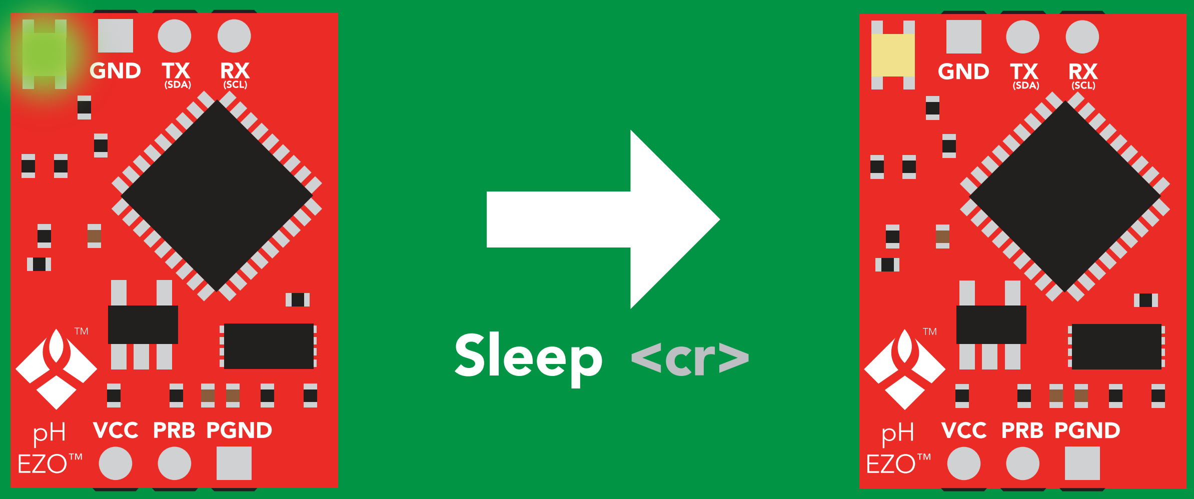
Command syntax

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	16 mA	1.16 mA
3.3V	13.9 mA	0.995 mA



Standby
16 mA

Sleep
1.16 mA

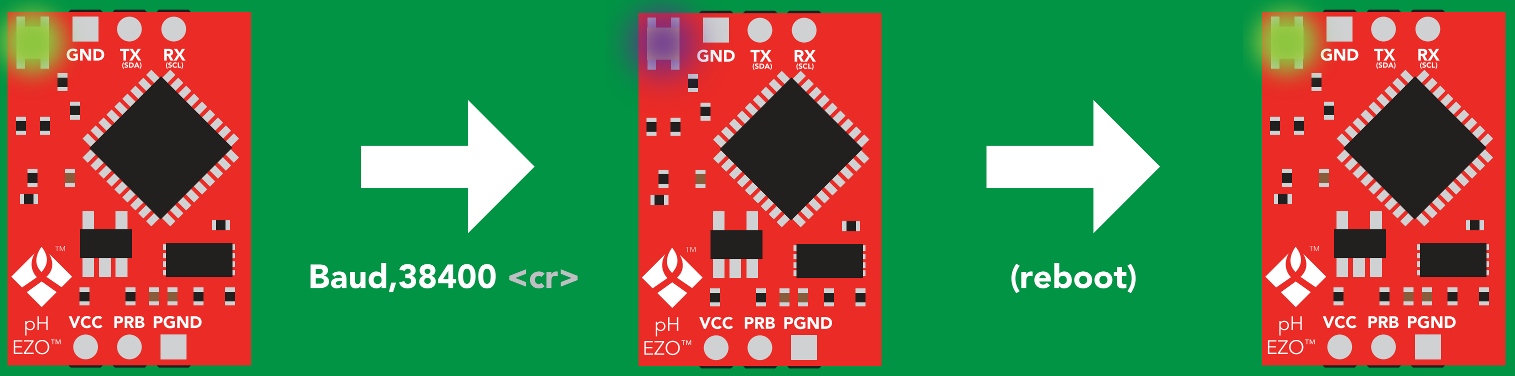
Change baud rate

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



Baud,38400 <cr>

(reboot)

Standby

Changing baud rate

*OK <cr>

Standby

Protocol lock

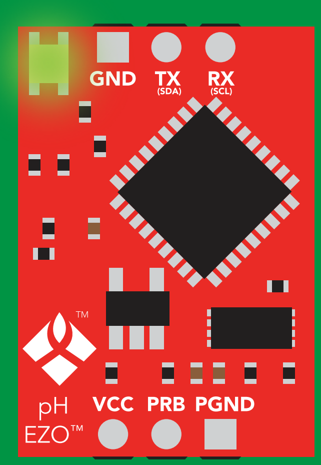
Command syntax

Locks device to UART mode.

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

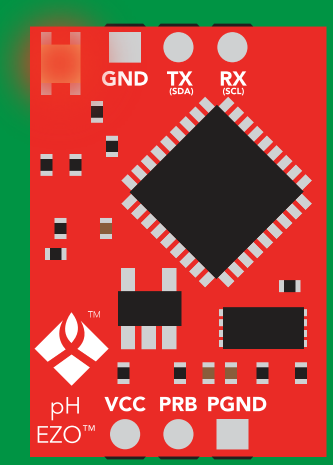
Example	Response
Plock,1 <cr>	*OK <cr>
Plock,0 <cr>	*OK <cr>
Plock,? <cr>	?Plock,1 <cr> or ?Plock,0 <cr>

Plock,1



*OK <cr>

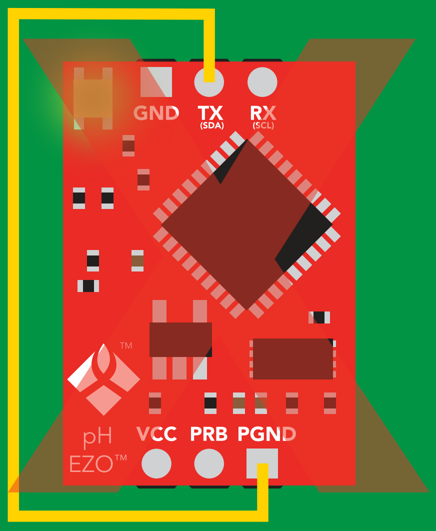
I2C,100



cannot change to I²C

*ER <cr>

Short



cannot change to I²C

Factory reset

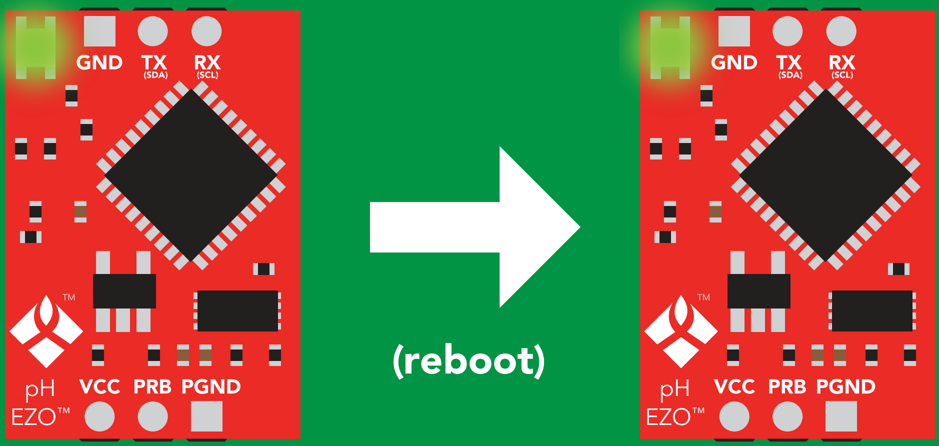
Command syntax

Clears calibration
LED on
"*OK" enabled

Factory <cr> **enable factory reset**

Example	Response
Factory <cr>	*OK <cr>

Factory <cr>



(reboot)

*OK <cr>

*RS <cr>
*RE <cr>

Baud rate will not change

Change to I^{2}C mode

Command syntax

Default I^{2}C address 99 (0x63)

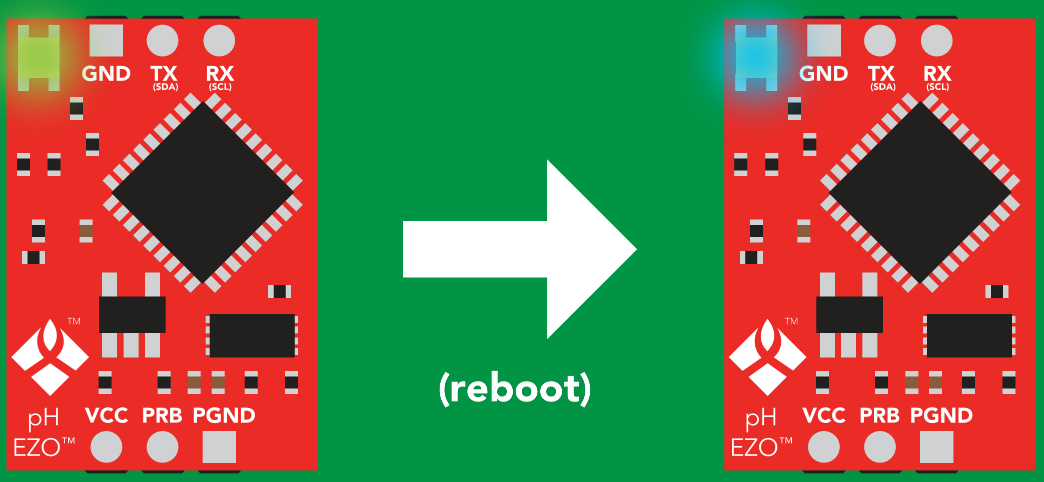
I2C,n <cr> sets I^{2}C address and reboots into I^{2}C mode

n = any number 1 – 127

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

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

I2C,100



Green

*OK <cr>

Blue

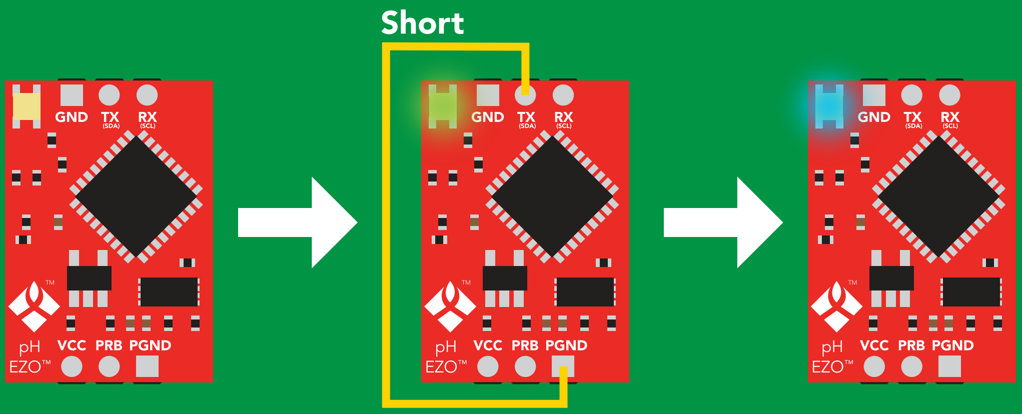
now in I^{2}C mode

Manual switching to I²C

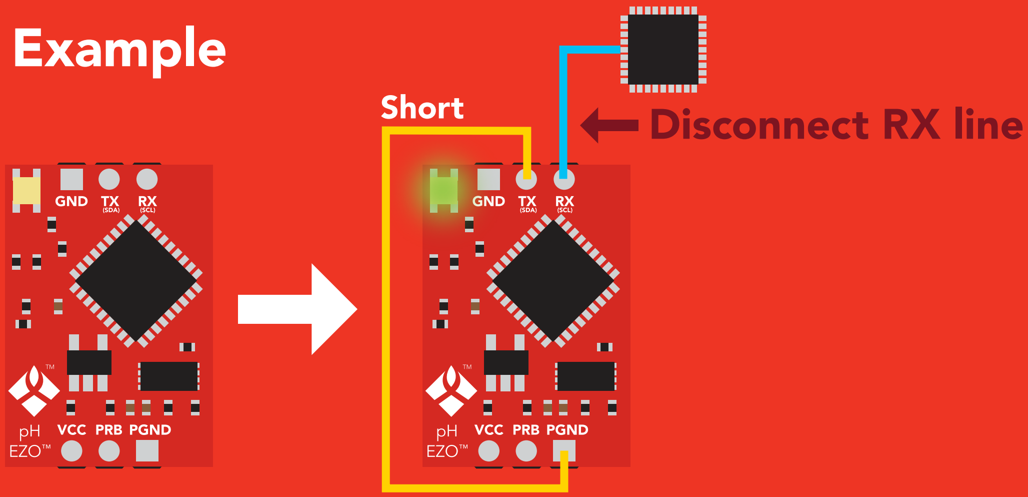
- Disconnect ground (power off)
- Disconnect TX and RX
- Connect TX to PGND
- Confirm RX is disconnected
- Connect ground (power on)
- Wait for LED to change from Green to Blue
- Disconnect ground (power off)
- Reconnect all data and power

Manually switching to I²C will set the I²C address to 99 (0x63)

Example



Wrong Example



I^{2}C mode

The I^{2}C protocol is *considerably more complex* than the UART (RS–232) protocol. Atlas Scientific assumes the embedded systems engineer understands this protocol.

To set your EZO™ device into I^{2}C mode click here

Settings that are retained if power is cut

Calibration
Change I^{2}C address
Hardware switch to UART mode
LED control
Protocol lock
Software switch to UART mode

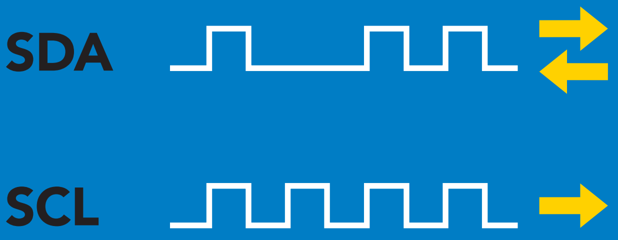
Settings that are *NOT* retained if power is cut

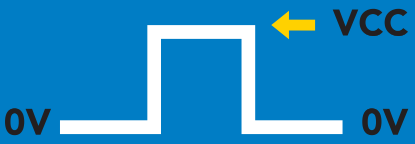
Find
Sleep mode
Temperature compensation

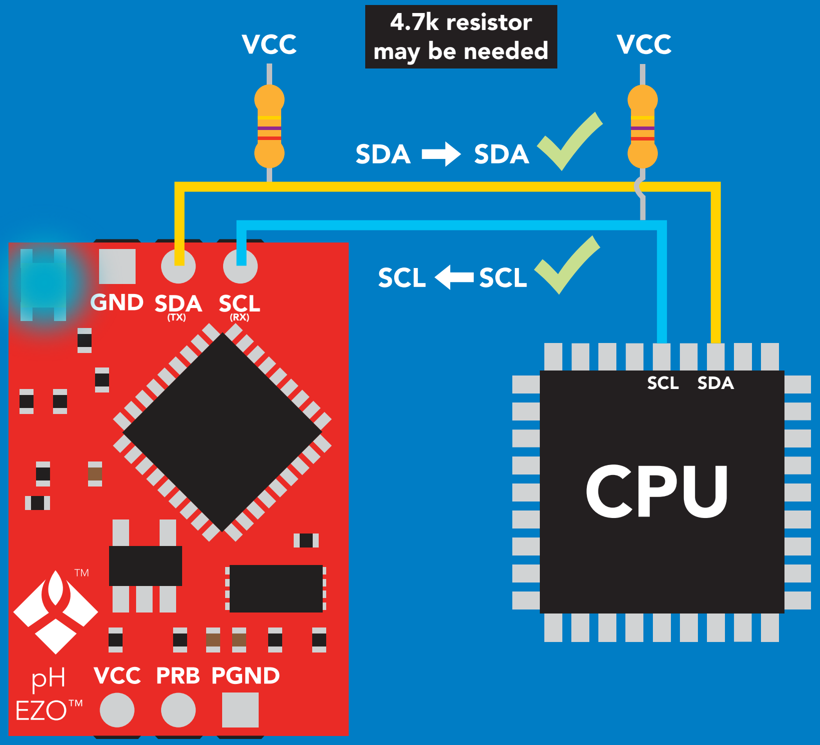
AtlasScientific™
Environmental Robotics

I^{2}C mode

I^{2}C address	(0x01 – 0x7F) 99 (0x63) default
Vcc	3.3V – 5.5V
Clock speed	100 – 400 kHz



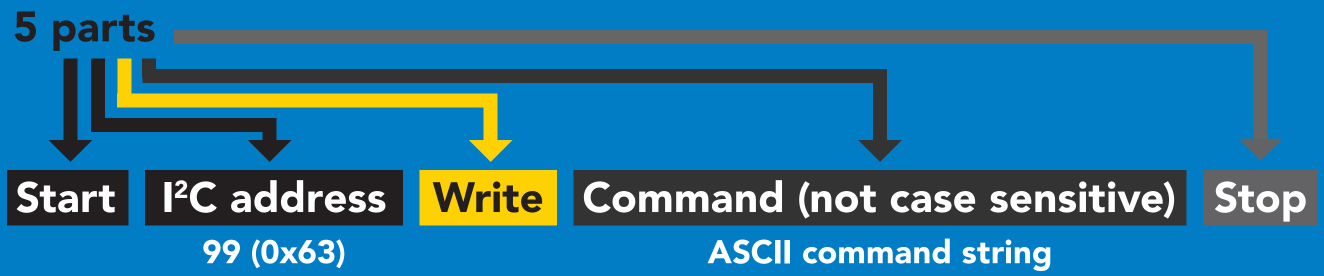




Data format

Reading	pH	Data type	floating point
Units	pH	Decimal places	3
Encoding	ASCII	Smallest string	4 characters
Format	string	Largest string	40 characters

Sending commands to device



5 parts

Start

I²C address
99 (0x63)

Write

Command (not case sensitive)
ASCII command string

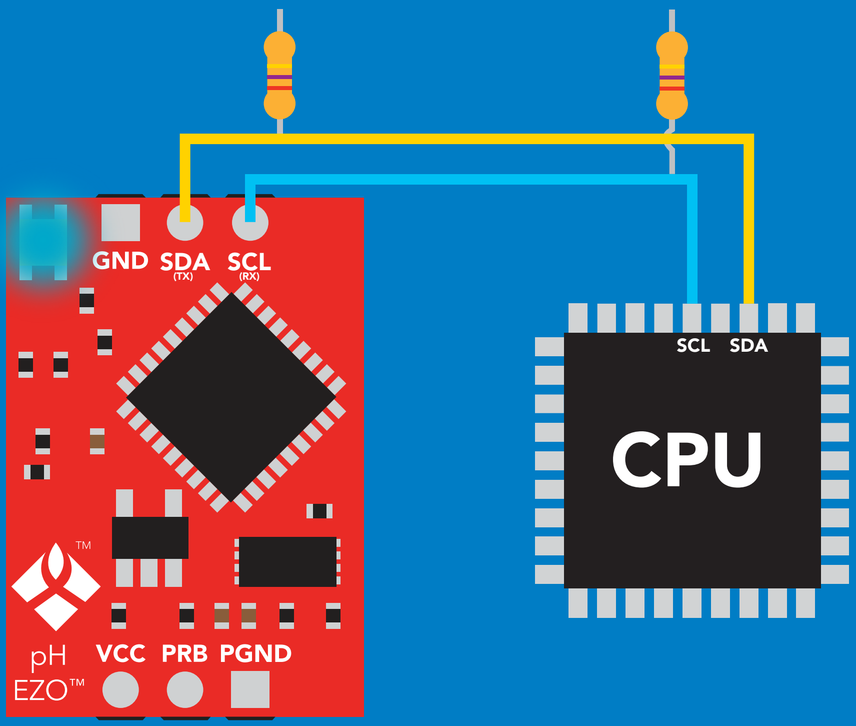
Stop

Example

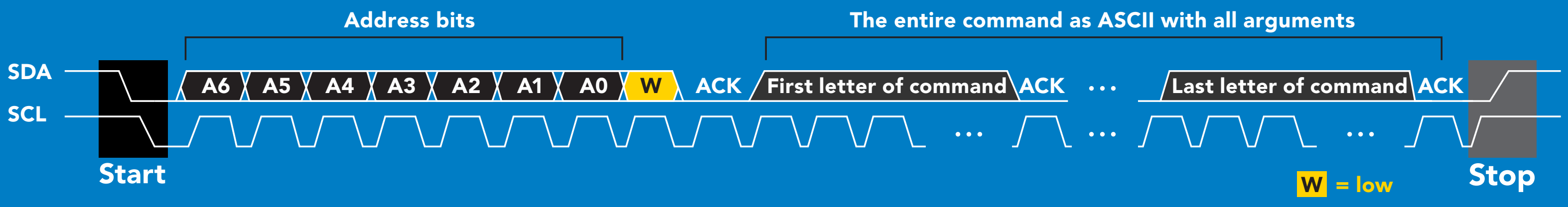
Start | 99 (0x63) | Write | Sleep | Stop

99 (0x63): I²C address

Sleep: Command



Advanced



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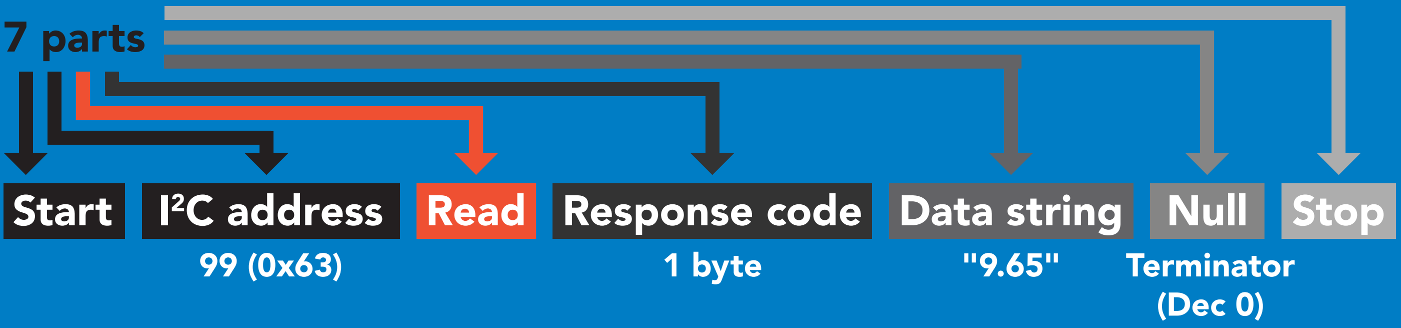
Environmental Robotics

r 0.1

Requesting data from device



7 parts

Start

I^{2}C address
99 (0x63)

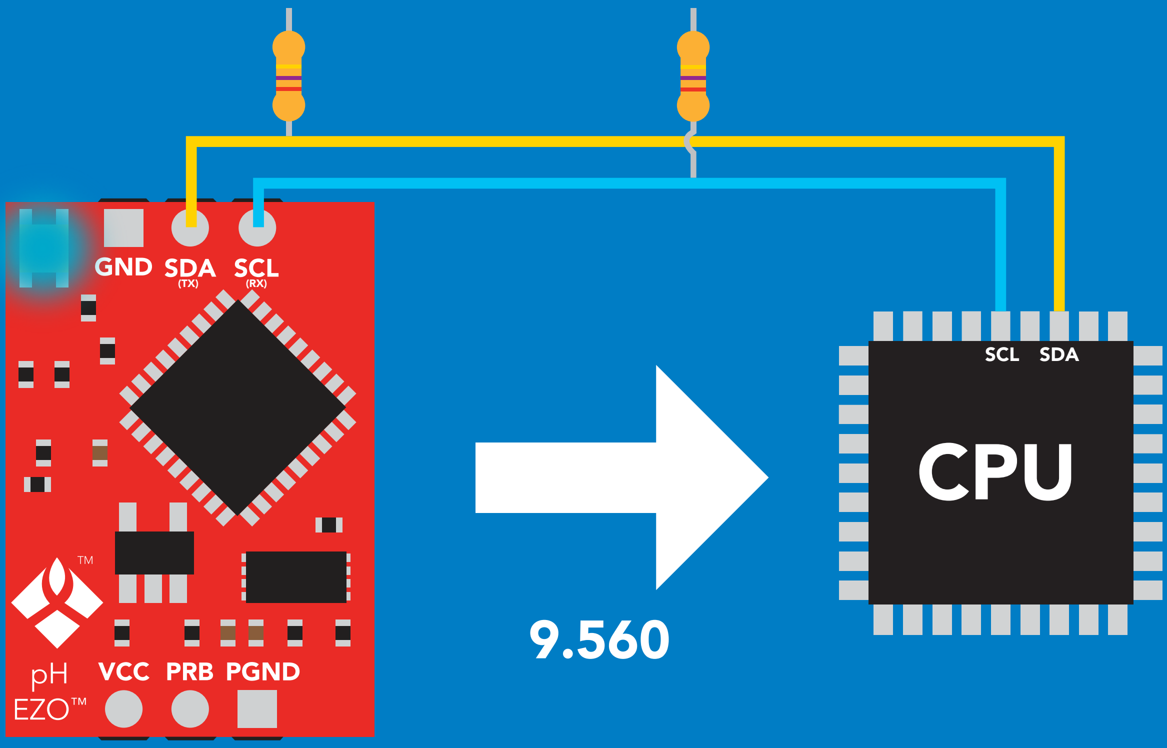
Read

Response code
1 byte

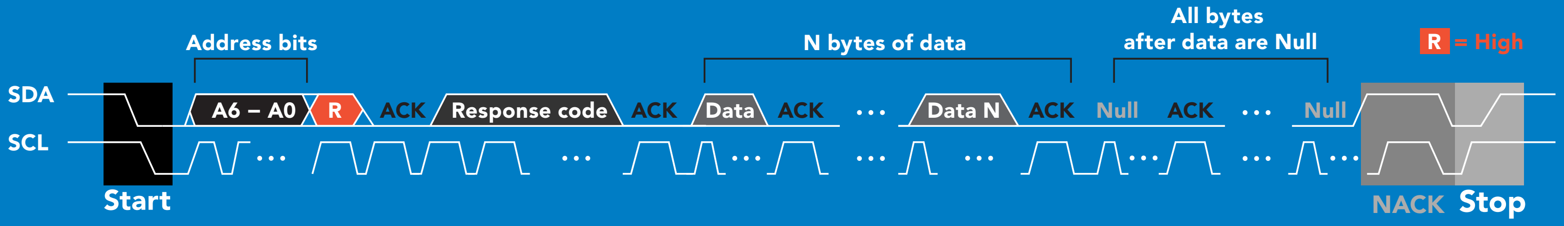
Data string
"9.65"

Null
Terminator
(Dec 0)

Stop



Advanced



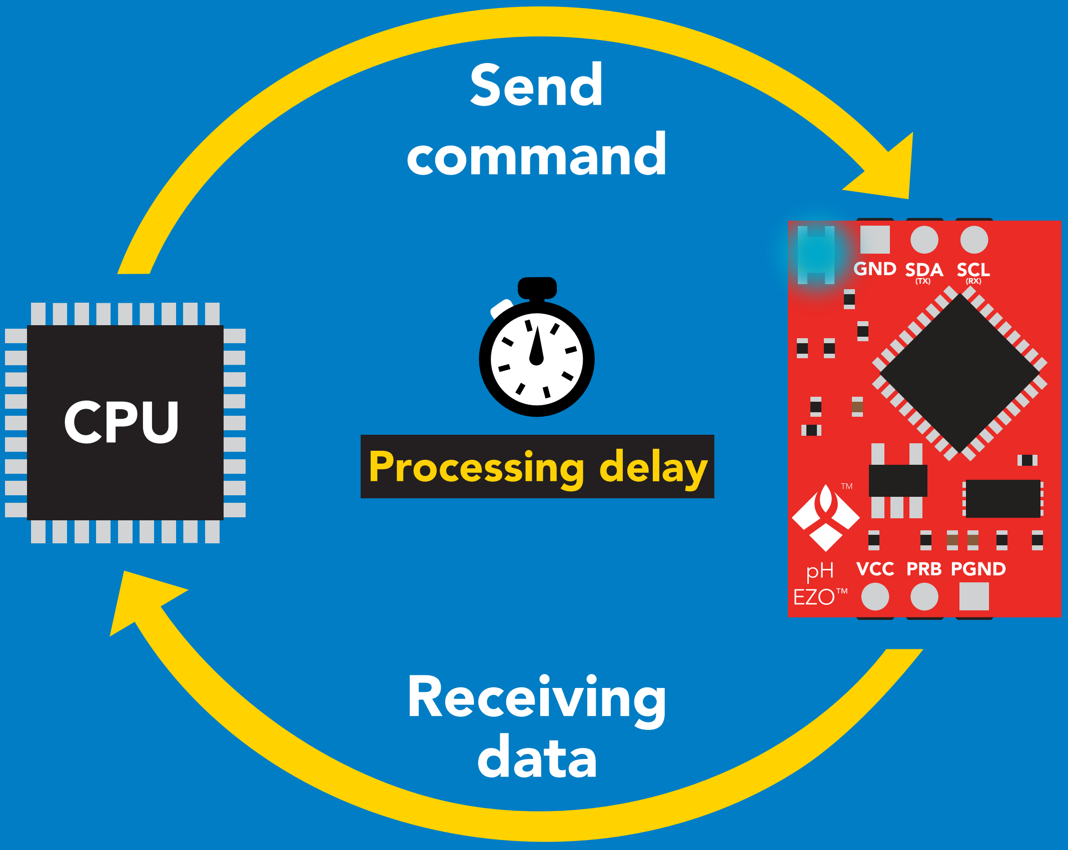
1 57 46 53 54 48 0 = 9.560

Dec ASCII Dec

Response codes

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

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



Send command

Processing delay

Receiving data

Example

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

delay(300);        Processing delay

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

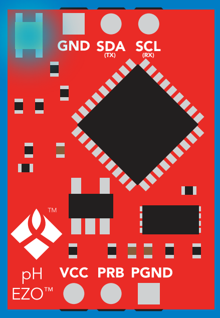
If there is no processing delay or the processing delay is too short, the response code will always be 254.

Response codes

Single byte, not string

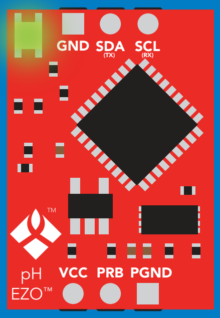
255	no data to send
254	still processing, not ready
2	syntax error
1	successful request

LED color definition



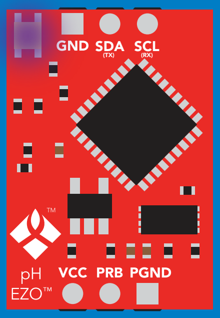
Blue

I²C standby



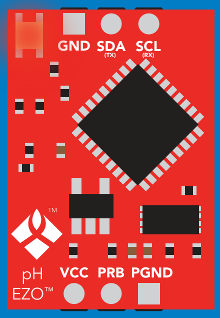
Green

Taking reading



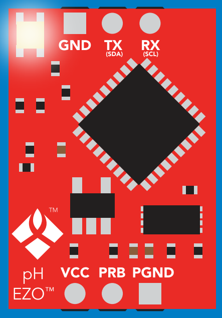
Purple

Changing
I²C address



Red

Command
not understood



White

Find

	LED ON
5V	+2.2 mA
3.3V	+0.6 mA

I^{2}C mode

command quick reference

All commands are ASCII strings or single ASCII characters.

Command	Function	
Baud	switch 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 I^{2}C address	pg. 63
Import	import calibration	pg. 54
L	enable/disable LED	pg. 49
Name	set/show name of device	pg. 58
pHext	enable/disable extended pH scale	pg. 56
Plock	enable/disable protocol lock	pg. 62
R	returns a single reading	pg. 51
Sleep	enter sleep mode/low power	pg. 61
Slope	returns the slope of the pH probe	pg. 55
Status	retrieve status information	pg. 60
T	temperature compensation	pg. 57

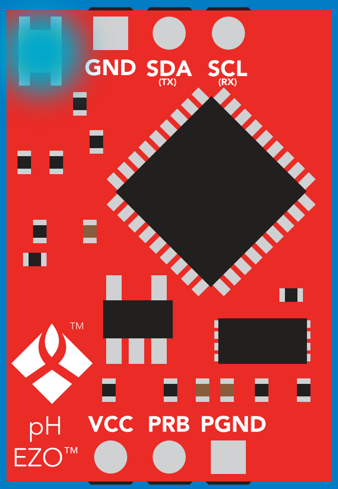
LED control

Command syntax

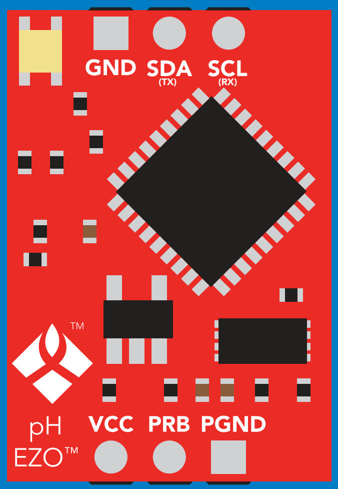
300ms ⏱ processing delay

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

Example	Response
L,1	⏱ Wait 300ms 1 0 Dec Null
L,0	⏱ Wait 300ms 1 0 Dec Null
L,?	⏱ Wait 300ms 1 ?L,1 0 or 1 ?L,0 0 Dec ASCII Null Dec ASCII Null



L,1



L,0

Find

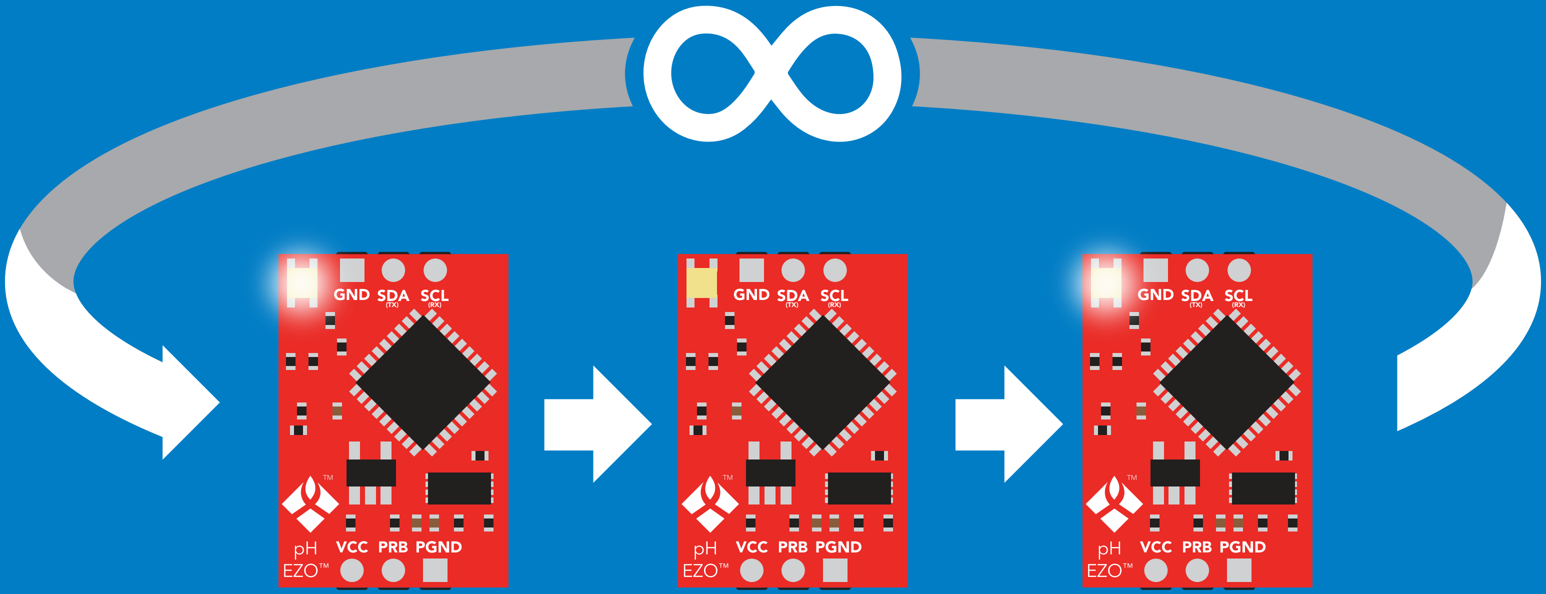
300ms processing delay

Command syntax

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

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

Example	Response
Find	Wait 300ms 1 Dec 0 Null



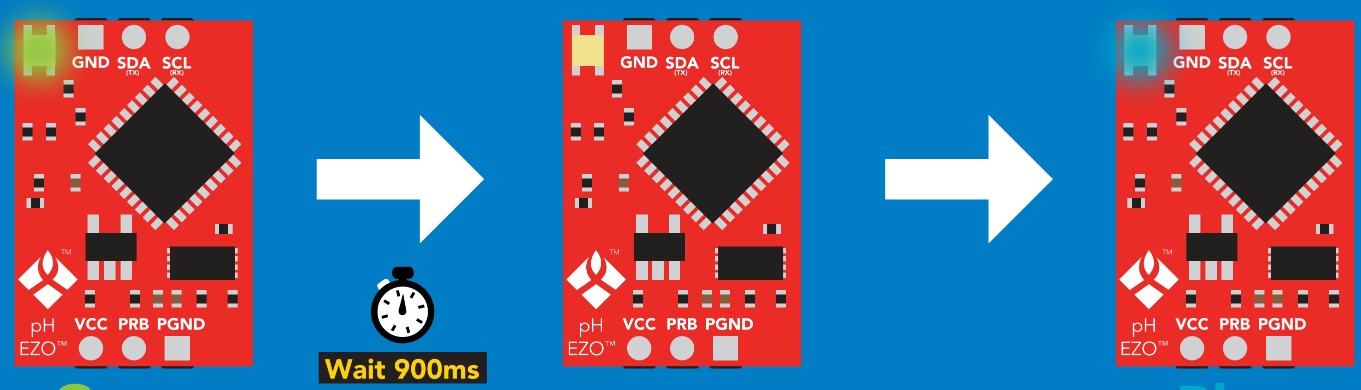
Taking reading

Command syntax

900ms ⏱ processing delay

R	**return 1 reading**

Example	Response			
R	⏱ Wait 900ms	1 Dec	9.560 ASCII	0 Null



Green
Taking reading

Transmitting

Blue
Standby

Calibration

900ms ⏱ processing delay

Issuing the cal,mid command after the EZO™ pH circuit has been calibrated, will clear the other calibration points. Full calibration will have to be redone.

Command syntax

Cal,mid,n	single point calibration at midpoint
Cal,low,n	two point calibration at lowpoint
Cal,high,n	three point calibration at highpoint
Cal,clear	delete calibration data
Cal,?	device calibrated?

Example	Response
Cal,mid,7.00	⏱ Wait 900ms 1 Dec 0 Null
Cal,low,4.00	⏱ Wait 900ms 1 Dec 0 Null
Cal,high,10.00	⏱ Wait 900ms 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 (one point), 0 Null 1 Dec, ?Cal,2 ASCII (two point), 0 Null or 1 Dec, ?Cal,3 ASCII (three point), 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

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

Response breakdown

10, 120

↑ # of strings to export ↑ # of bytes to export

Export strings can be up to 12 characters long

Import calibration

300ms processing delay

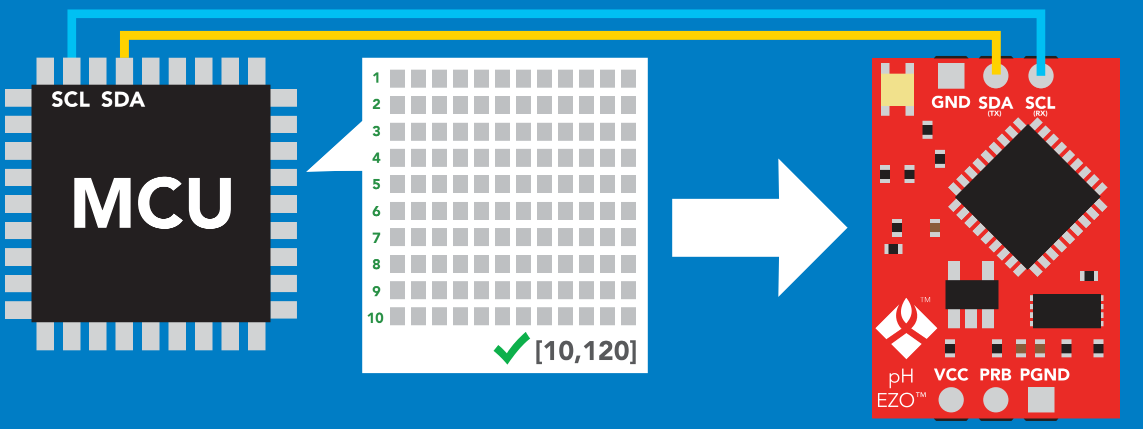
Command syntax

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

Import,n import calibration string to new device

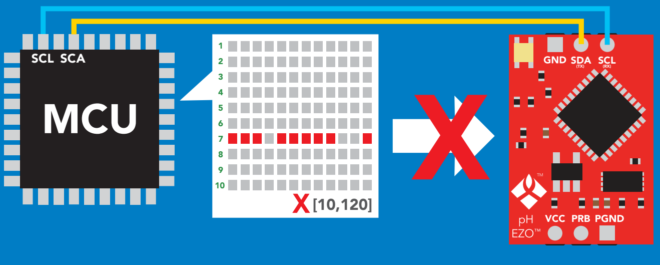
Example		Response
Import, 59 6F 75 20 61 72	(1 of 10)	Wait 300ms 1 Dec 0 Null
Import, 65 20 61 20 63 6F	(2 of 10)	Wait 300ms 1 Dec 0 Null
⋮		⋮
Import, 6F 6C 20 67 75 79	(10 of 10)	Wait 300ms 1 Dec 0 Null

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

r 0.2

Slope

300ms ⏱ processing delay

After calibrating a pH probe issuing the slope command will show how closely (in percentage) the calibrated pH probe is working compared to the "ideal" pH probe.

Command syntax

Slope,? returns the slope of the pH probe

Example

Slope,?

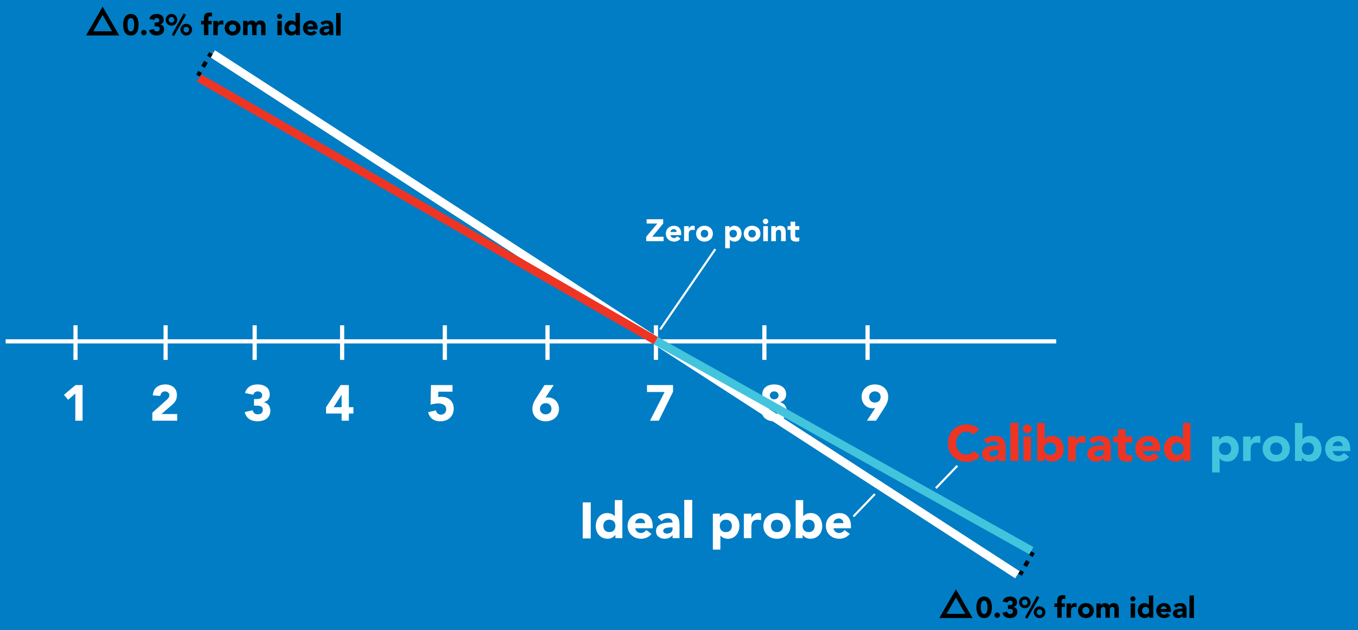
Response

⏱ Wait 300ms

1	?Slope,99.7,100.3, -0.89	0
Dec	ASCII	Null

Response breakdown

?Slope,	99.7	100.3	-0.89
	99.7% is how closely the slope of the acid calibration line matched the "ideal" pH probe.	100.3% is how closely the slope of the base calibration matches the "ideal" pH probe.	This is how many millivolts the zero point is off from true 0.



AtlasScientific™ Environmental Robotics

r 0.1

Extended pH scale

300ms ⏱ processing delay

Very strong acids and basses can exceed the traditional pH scale. This command extends the pH scale to show below 0 and above 14.

Lowest possible reading: **-1.6**
Highest possible reading: **15.6**

Command syntax

pHext,0	**extended pH scale off (0 – 14)**	**default**
pHext,1	**extended pH scale on (-1.6 – 15.6)**	
pHext,?	**extended pH scale on/off?**	

Example	Response
pHext,1	⏱ Wait 300ms · 1 (Dec) · 0 (Null)
pHext,0	⏱ Wait 300ms · 1 (Dec) · 0 (Null)
pHext,?	⏱ Wait 300ms · 1 (Dec) · ?pHext,1 (ASCII) · 0 (Null) **or** 1 (Dec) · ?pHext,0 (ASCII) · 0 (Null)

pHext,0

pH = 0.000

pHext,1

pH = -1.220

Temperature compensation

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

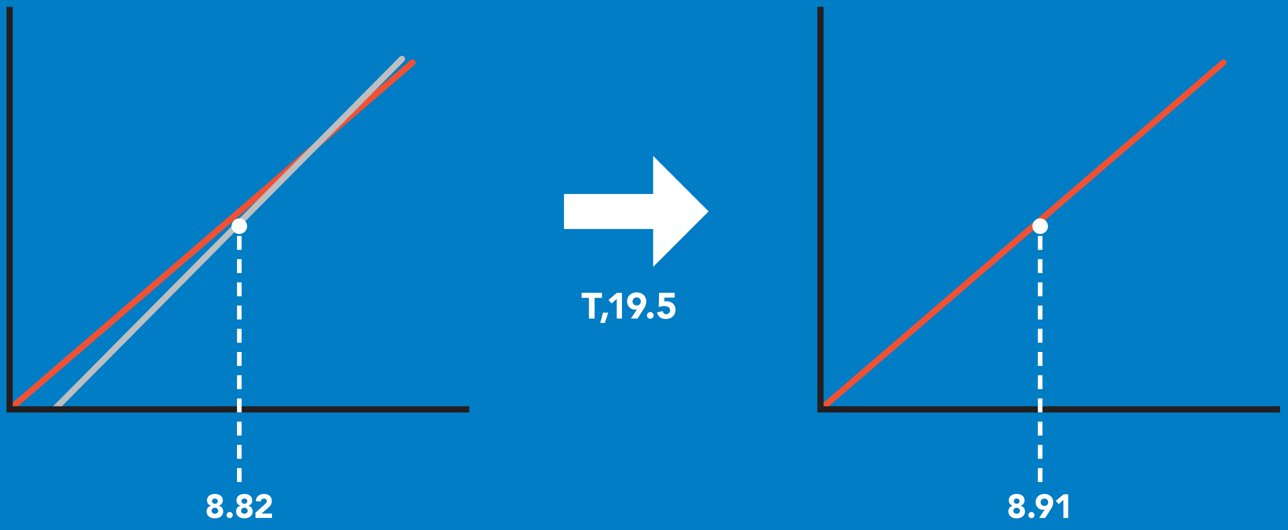
Command syntax

300ms ⏱ processing delay

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

This is a new command for firmware V2.12

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



Naming device

300ms ⏱ processing delay

Command syntax

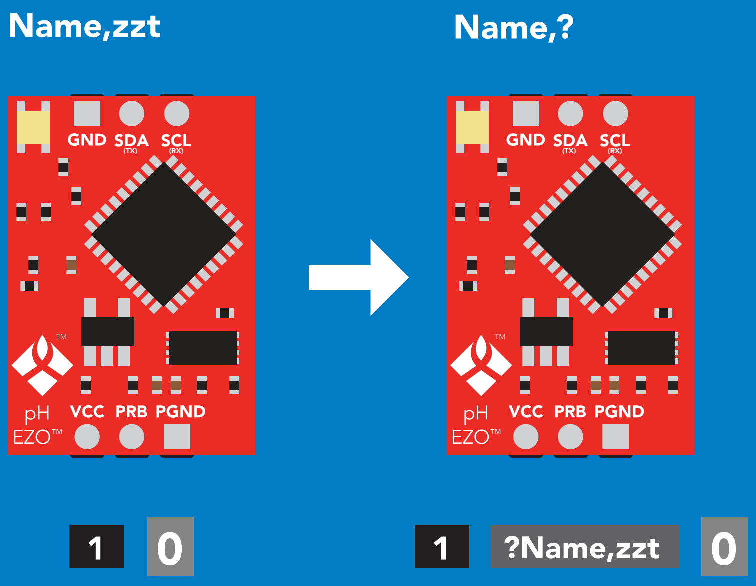
Do not use spaces in the name

Name,n	set name
Name,	clears name
Name,?	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,	⏱ 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



Device information

Command syntax

300ms ⏱ processing delay

i	device information

Example	Response
i	⏱ Wait 300ms 1 Dec ?i,pH,1.98 ASCII 0 Null

Response breakdown

?i,	pH,	1.98
	↑ Device	↑ Firmware

Reading device status

Command syntax

300ms processing delay

Status voltage at Vcc pin and reason for last restart

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

Response breakdown

?Status, P, 5.038

P, ↑ Reason for restart

5.038 ↑ 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	16 mA	1.16 mA
3.3V	13.9 mA	0.995 mA

GND
SDA
(TX)
SCL
(RX)
TM
pH
EZO™
VCC
PRB
PGND
Sleep
GND
SDA
(TX)
SCL
(RX)
TM
pH
EZO™
VCC
PRB
PGND

Standby

Sleep

Protocol lock

Command syntax

300ms ⏱ processing delay

Plock,1 enable Plock

Plock,0 disable Plock **default**

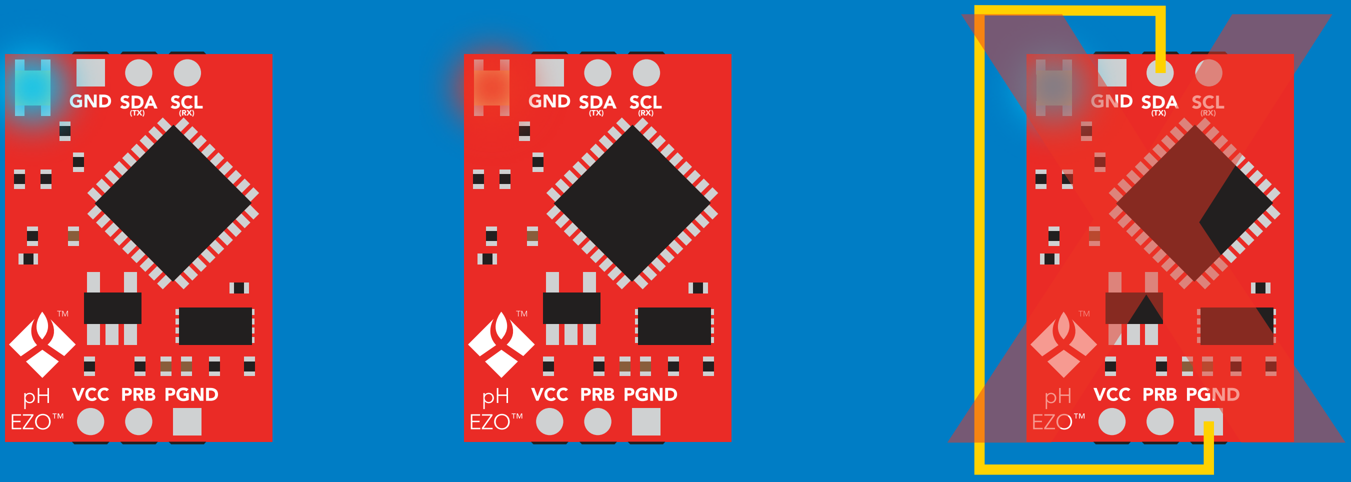
Plock,? Plock on/off?

Locks device to I^{2}C 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

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)

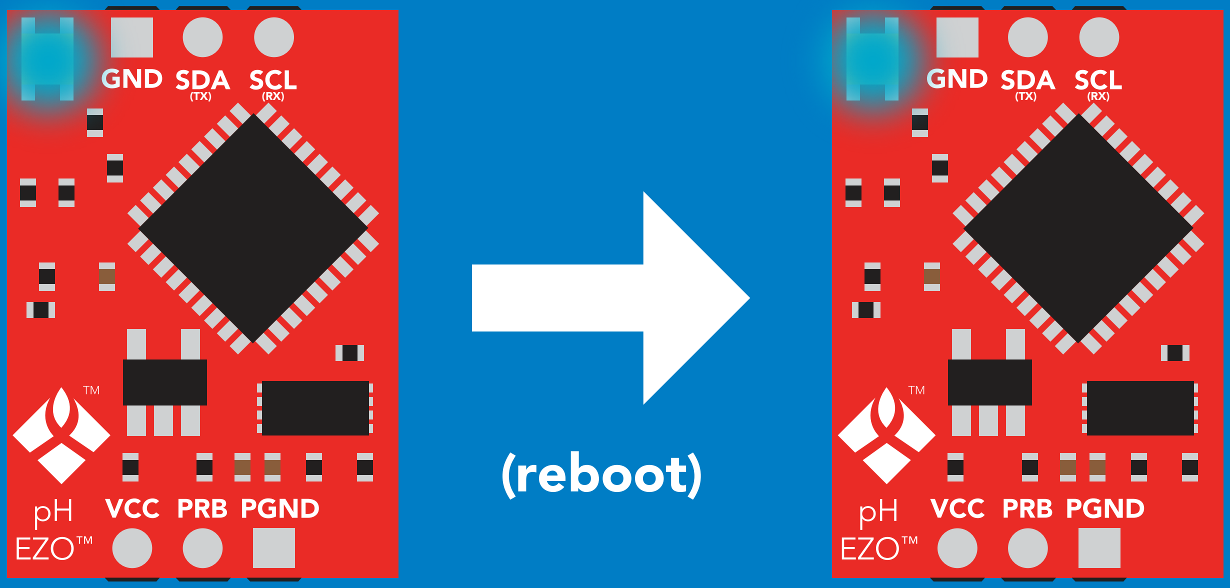
Warning!

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

Default I²C address is 99 (0x63).

n = any number 1 – 127

I2C,100



Factory reset

Command syntax

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

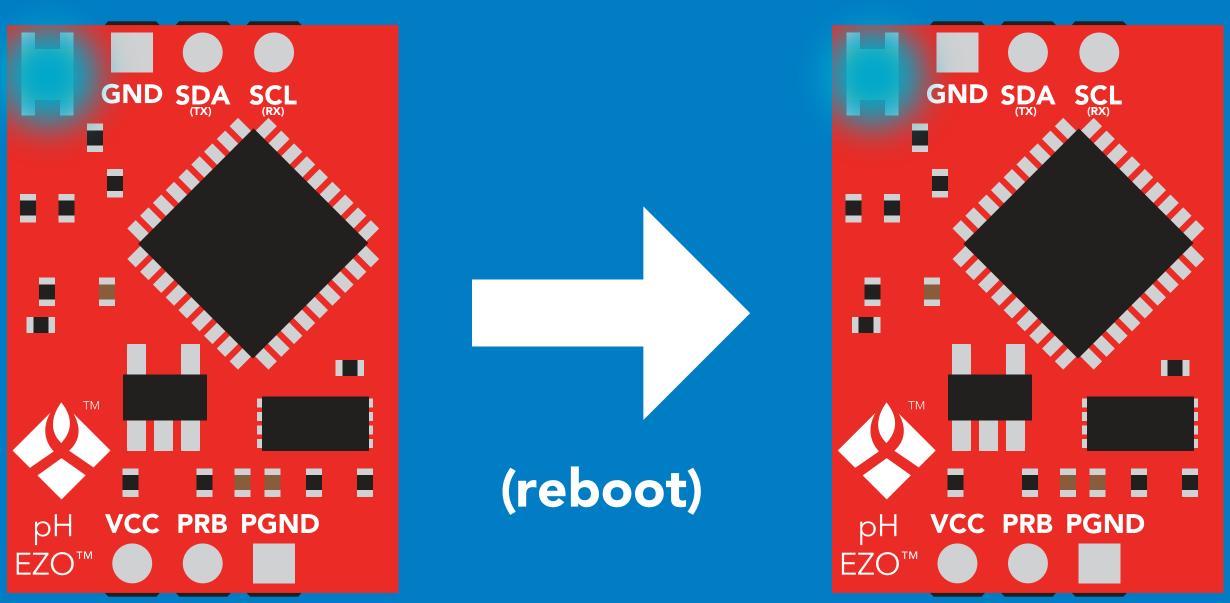
Factory	**enable factory reset**

I²C address will not change

Example	Response
Factory	**device reboot** (no response given)

Clears calibration
LED on
Response codes enabled

Factory



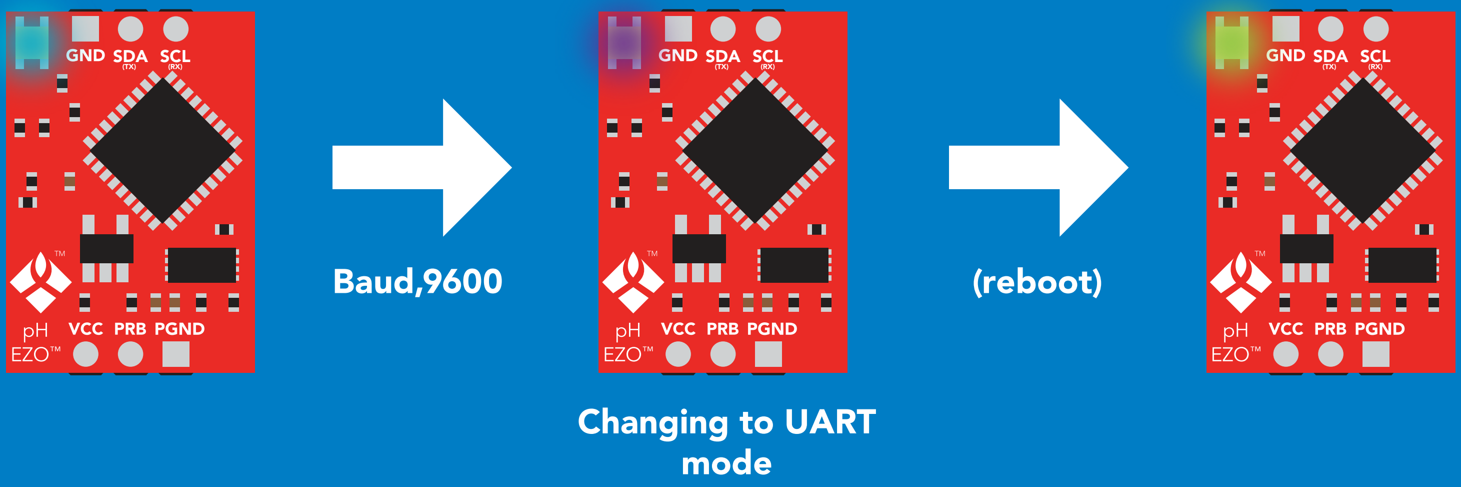
Change to UART mode

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



Baud,9600

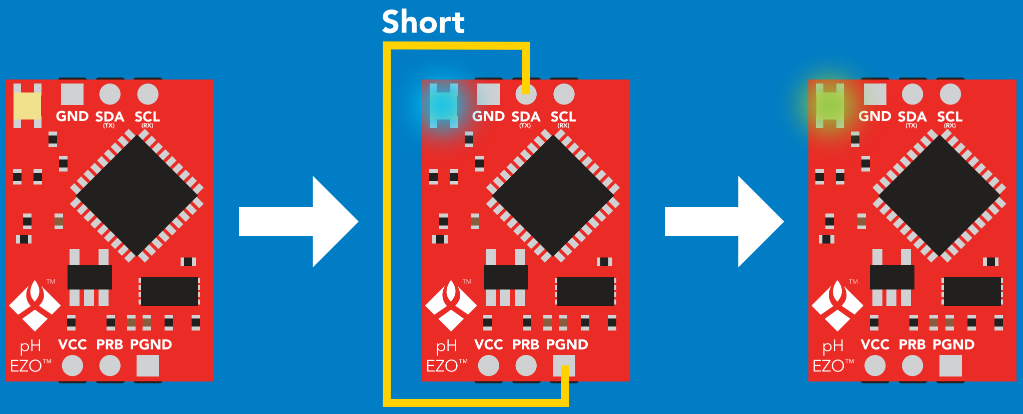
(reboot)

Changing to UART mode

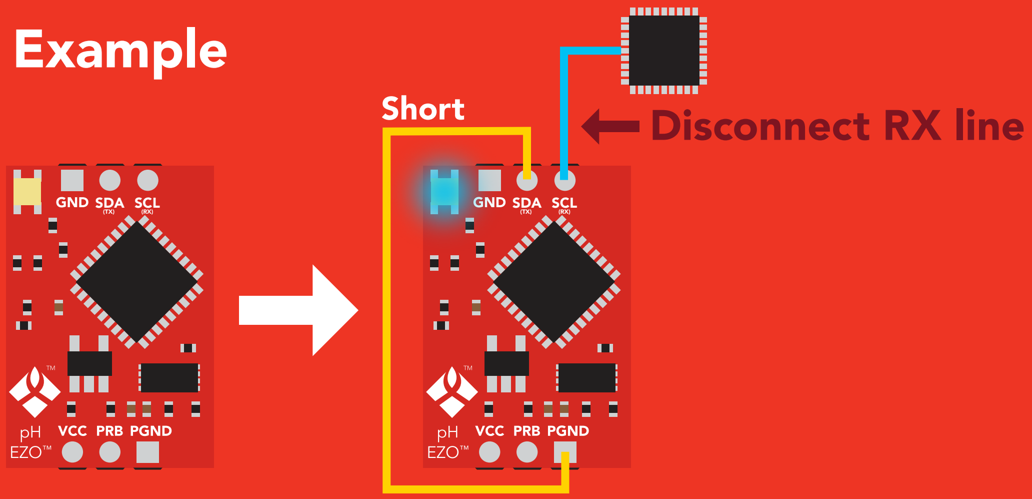
Manual switching to UART

- 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

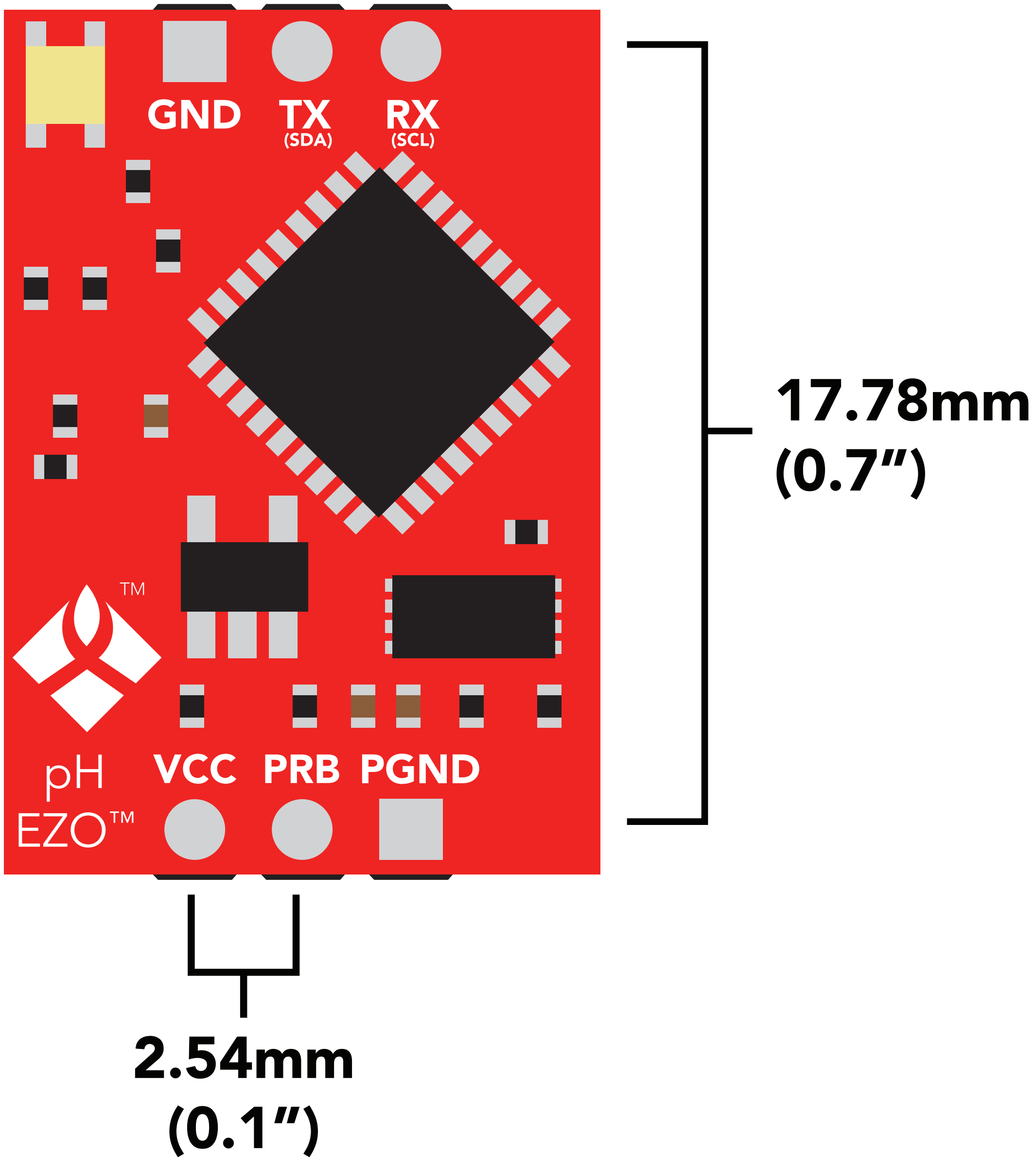
Example



Wrong Example



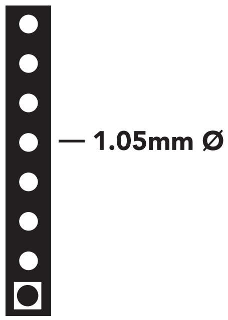
EZO™ circuit footprint

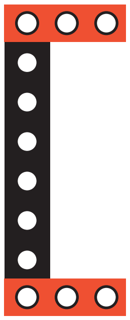


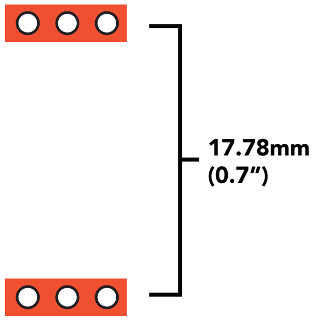
1 In your CAD software place a 8 position header.

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 5.9

Revised naming device info on pages 32 & 58.

Datasheet V 5.8

Revised calibration info and art on pages 11 & 12.

Datasheet V 5.7

Added new command:
"Extended pH Scale" pages 30 (UART) & 56 (I^2C).

Datasheet V 5.6

Revised information on the slope command found on pages 29 & 54.

Datasheet V 5.5

Revised artwork within datasheet.

Datasheet V 5.4

Moved the Default state to pg 14.

Datasheet V 5.3

Revised response for the sleep command in UART mode on pg 35.

Datasheet V 5.2

Revised calibration theory on page 11, and added more information on the Export calibration and Import calibration commands.

Datasheet V 5.1

Revised isolation schematic on pg 10.

Datasheet V 5.0

Added more information about temperature compensation on pages 29 & 53.

Datasheet V 4.9

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

Datasheet V 4.8

Added new command:
"RT,n" for Temperature compensation located on pages 29 (UART) & 53 (I^2C).
Added firmware information to Firmware update list.

Datasheet V 4.7

Removed note from certain commands about firmware version.

Datasheet V 4.6

Added information to calibration theory on pg 7.

Datasheet V 4.5

Revised definition of response codes on pg 44.

Datasheet V 4.4

Added resolution range to cover page.

Datasheet V 4.3

Revised isolation information on pg 9.

Datasheet V 4.2

Revised Plock pages to show default value.

Datasheet V 4.1

Added new commands:
"Find" pages 23 (UART) & 46 (I^2C).
"Export/Import calibration" pages 27 (UART) & 49 (I^2C).
Added new feature to continous mode "C,n" pg 24.

Datasheet V 4.0

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

Datasheet V 3.9

Revised calibration theory on pg. 7.

Datasheet V 3.8

Revised entire datasheet.

Firmware updates

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

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

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

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

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

V1.97 – EEPROM (Oct 10, 2016)
- Added the option to save and load calibration.

V1.98 – EEPROM (Nov 14, 2016)
- Fixed bug during calibration process.

V2.10 – (May 9, 2017)
- Added "Find" command.
- Added "Export/import" command.
- Modified continuous mode to be able to send readings every "n" seconds.

V2.11 – (June 12, 2017)
- Fixed "I" command to return "pH" instead of "PH".

V2.12 – (April 16, 2018)
- Fixed "cal,clear" was not clearing stored calibration in EEPROM.
- Added "RT" command to Temperature compensation.

V2.13 – (June 25, 2019)
- Added calibration offset to slope.
- Added calibration with temperature compensation.

V2.14 – (June 10, 2020)
- Added extended pH scale.

v2.15 – (Nov 3, 2021)
- Internal update for new part compatibility.

v2.16 – (Nov 19, 2021)
- Fixed bug in I2C mode with timing and sleep mode.

Warranty

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

The debugging phase

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

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