Atlas Scientific™
Environmental Robotics

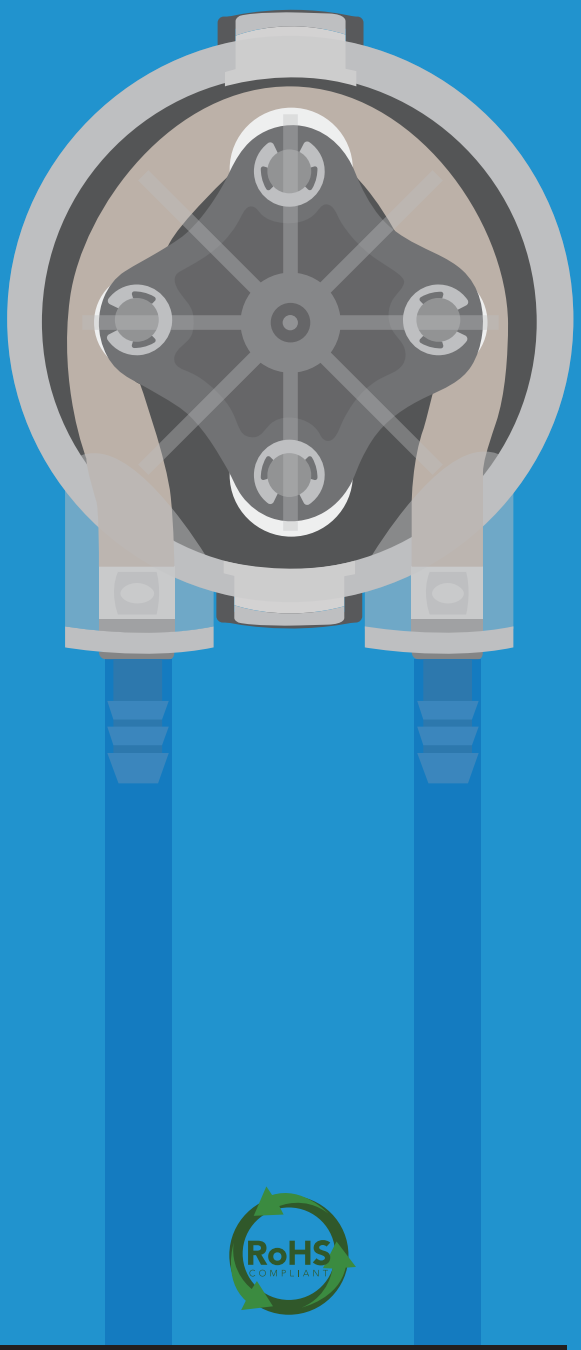
V 1.6

Released 8/24

EZO-PMP-L™

Large Embedded Dosing Pump

Flow rate	**10ml to 750ml/min**
Accuracy	**+/- 2%, +/-2ml**
Viscosity	**0.1 – 20,000 cP**
Modes of operation	**Continuous dispensing** **Volume dispensing** **Dose over time** **Constant flow rate** **Dispense at startup**
Connector	**5 lead data cable**
Calibration	**Single point**
Tubing size	**Any 8mm O.D. tubing**
Data protocol	**UART & I²C**
Default I²C address	**109 (0x6D)**
Operating voltage	**3.3V – 5V (logic)** **24V (motor)**
Pump head	**10.3 meters (34')**
Data format	**ASCII**
Food safe	**Yes**



RoHS COMPLIANT

Written by Jordan Press
Designed by Noah Press

This is an evolving document, check back for updates.

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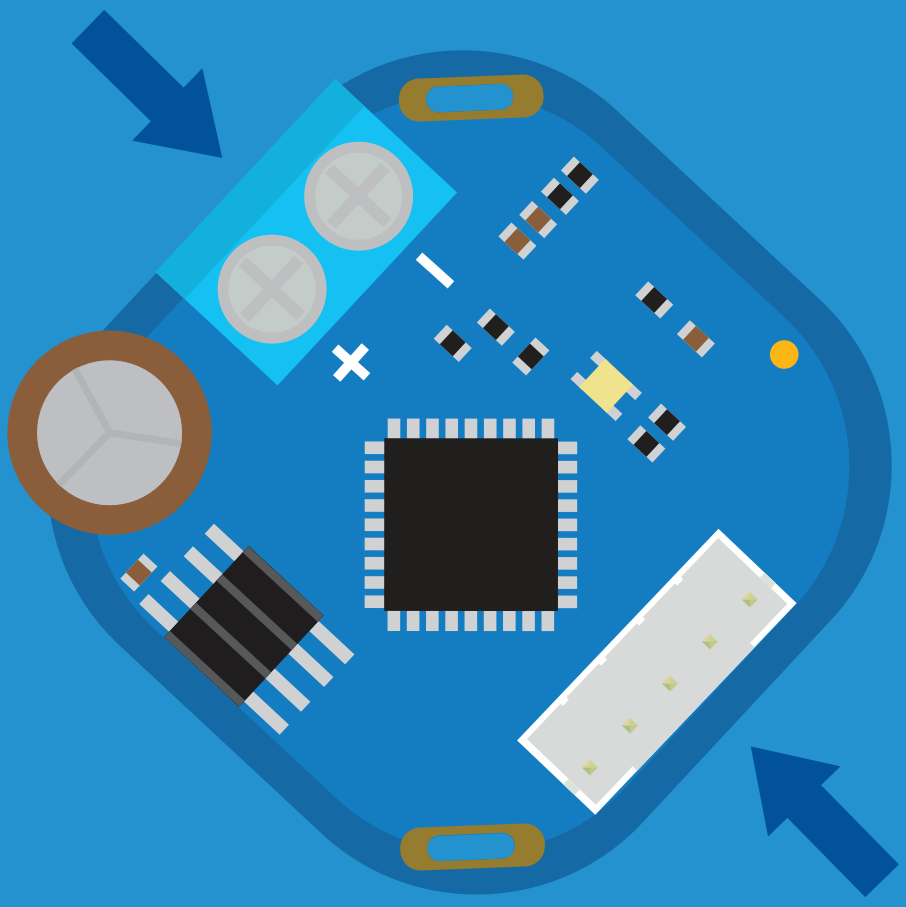
UART

I²C

Attention

The EZO-PMP-L Embedded Dosing Pump requires two power supplies to operate.

24V
to drive the motor



Control system
(Back side of dosing pump)

3.3V – 5.5V
for the control system

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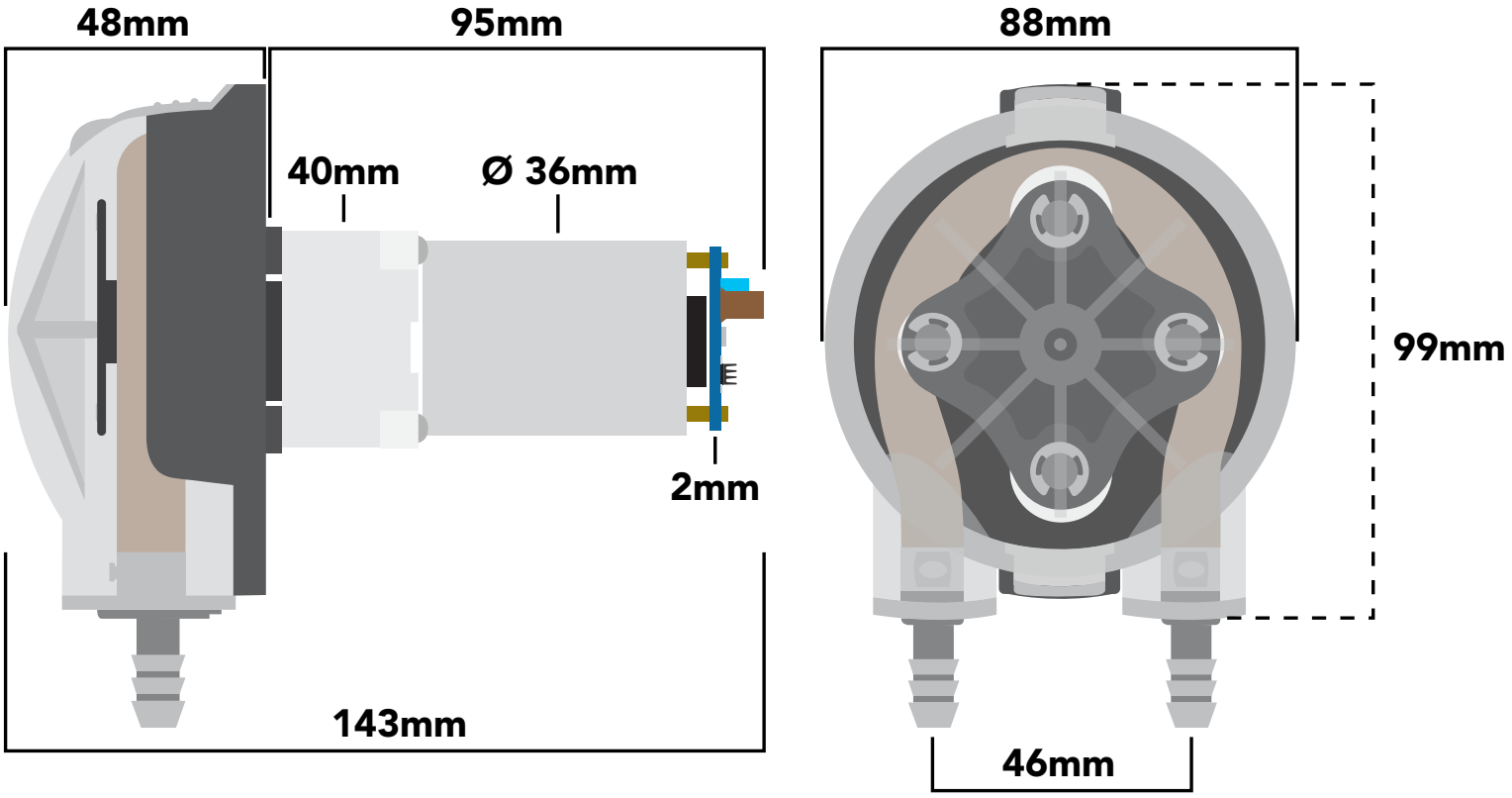
EZO-PMP-L™ dimensions



Weight 405g

Power consumption

	LED	MAX	STANDBY	SLEEP
5V	ON	13.7 mA	13.4 mA	0.415 mA
	OFF	13.1 mA	12.8 mA	
3.3V	ON	12.5 mA	12.4 mA	0.13 mA
	OFF	12.3 mA	12.2 mA	
Motor	24V = ~700mA			

Tubing life span	+1,000 hrs.
Cassette life span	1,500 hrs.
Motor life span	5,000 hrs.

Absolute max ratings

Parameter	MIN	TYP	MAX
Storage temperature (EZO-PMP-L™)	-65 °C		125 °C
Operational temperature (EZO-PMP-L™)	-40 °C	25 °C	85 °C
VCC	3.3V	5V	5.5V
Motor	17V	24V	26V
Max input / output pressure			101.3 kPa

EZO-PMP-L™ tubing

NSF/ANSI 51 Compliant

Tan tubing
Saint-Gobain™ PharMed™ BPT tubing
Length: 15.24cm
Outer diameter: 10mm
Inner diameter: 8mm

This tubing is highly chemically resistant and has 30X more resistant to mechanical wear than silicone tubing.

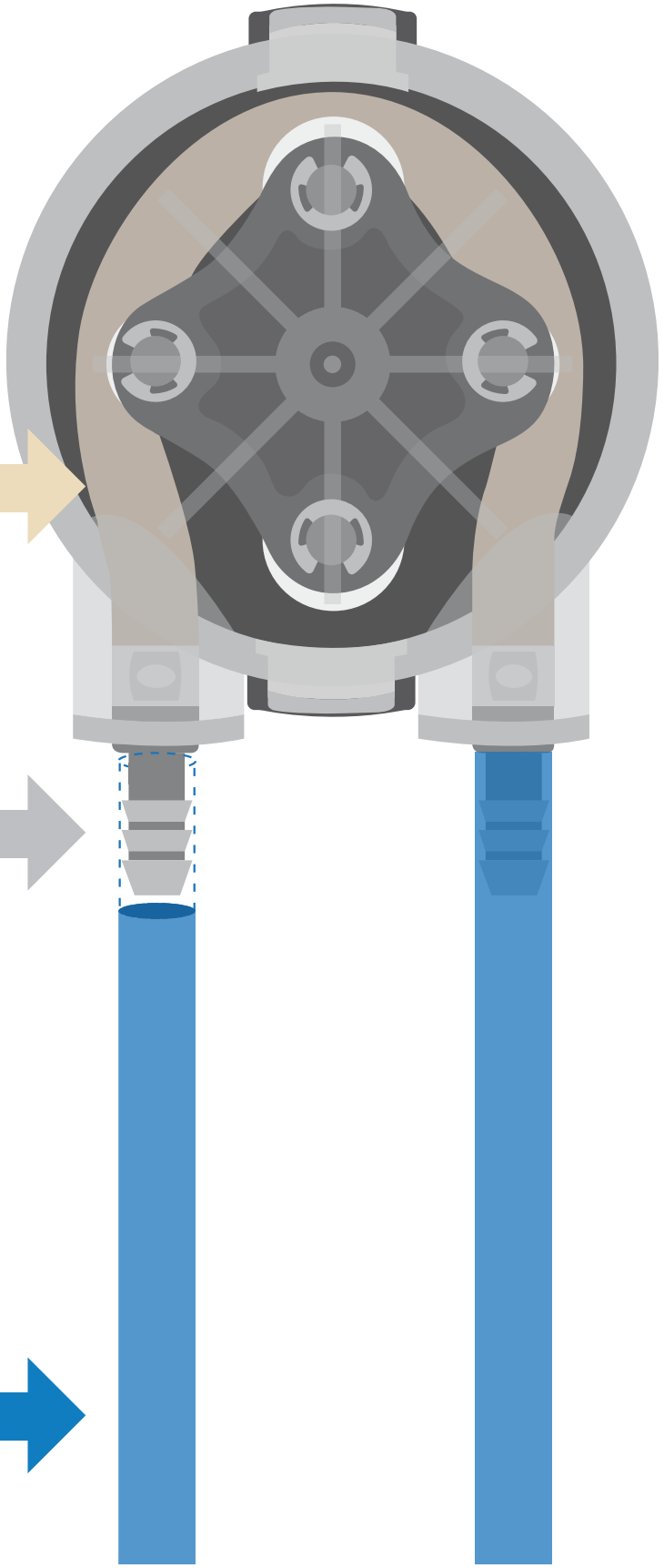
Food safe ✓

Hose barb fitting
ETFE
Length: 2.1cm
Outer diameter: 10mm
Inner diameter: 4.4mm

Food safe ✓

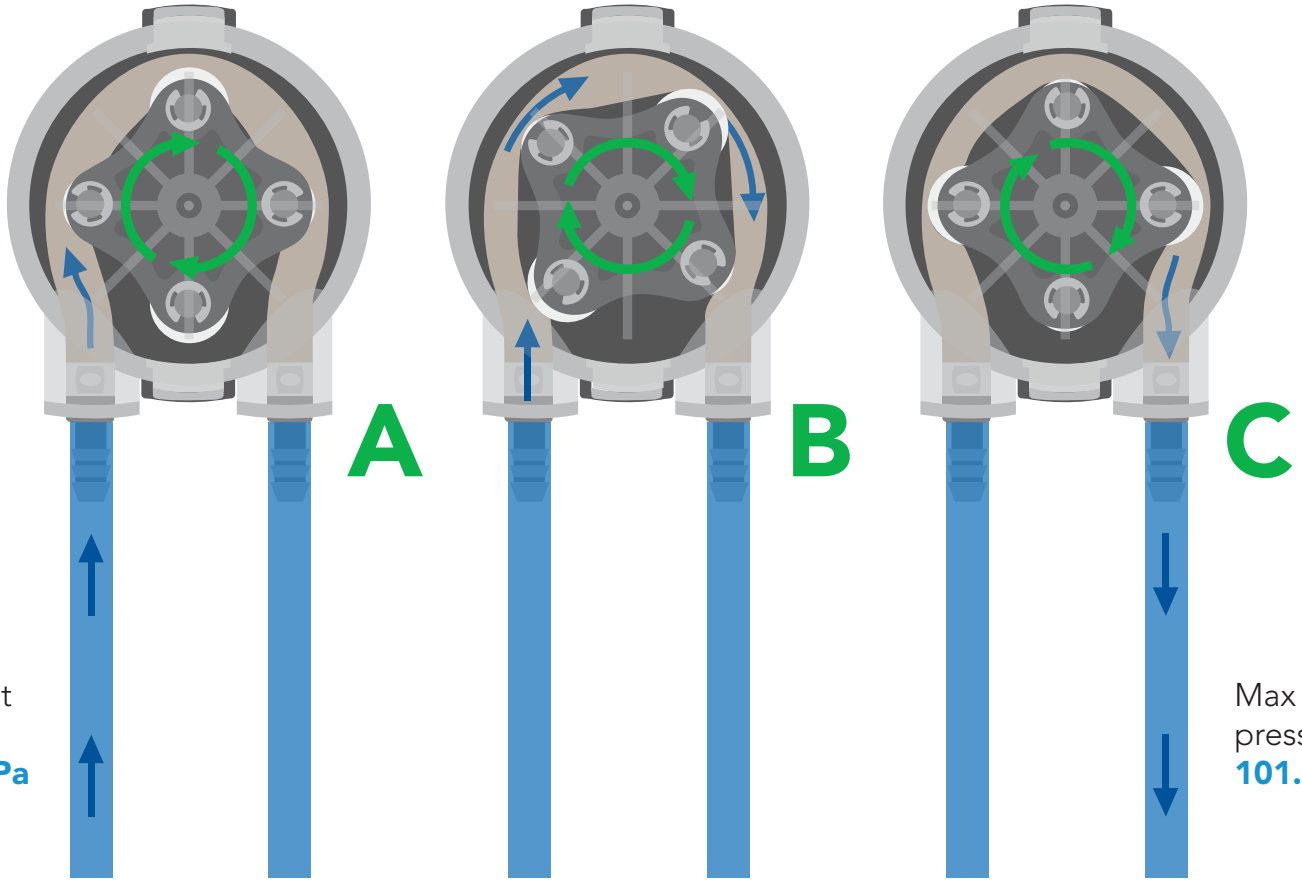
Blue tubing
Silicone
Length: 2x 30.48cm
Outer diameter: 8mm
Inner diameter: 6mm
Bend radius: 24mm
Temperature -67°C to 200°C
Max pressure: 34 kPa (5 PSI)

Food safe ✓



Operating principle

- ✔ Self-priming
- ✔ Run dry



Max input vacuum **-101.3 kPa**

Max output pressure **101.3 kPa**

Operating modes

The EZO-PMP-L™ can operate in four different modes.

Continuous dispensing
Run the pump continuously
750ml/min ∞ *(with supplied tubing)*

Volume dispensing
Pump a specific volume
(Smallest possible volume is 10 ml)

Volume is always in ml.

Dose over time
Pump a specific volume over a set time

Constant flow rate
Pump a specific volume per minute

Dispense at startup
- Dispense a specific volume at startup
- Continuous dispensing at startup
- Dose over time at startup

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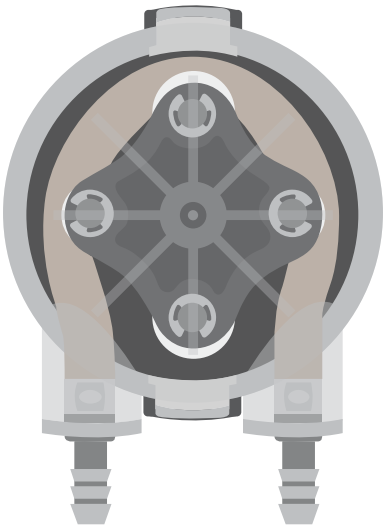
r 0.1

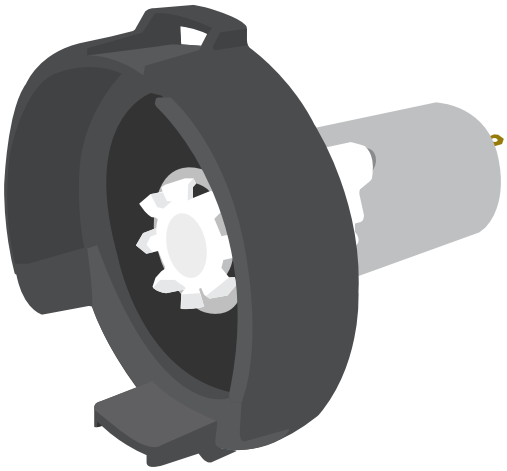
This device requires two power supplies
3.3V–5.5V for the control system
24V to drive the motor

The Atlas Scientific EZO-PMP-L™ consists of three main components.

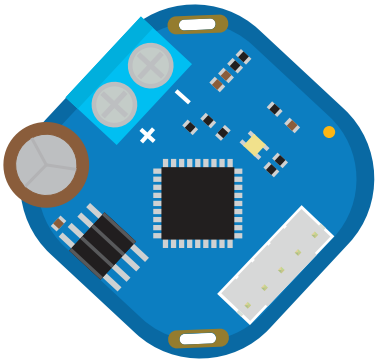


Cassette

Cassettes can be autoclave sterilized



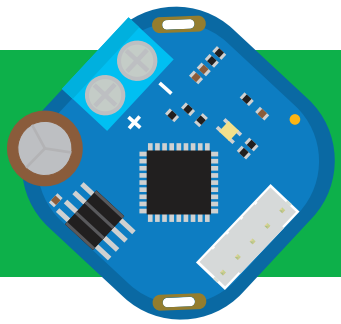
24 volt motor



Control system

The actual peristaltic pumping is done within the cassette. It has been designed to be easily detached from the motor and disassembled.

The 24 volt motor and control system have been soldered together. Both components are designed to operate as one single unit.



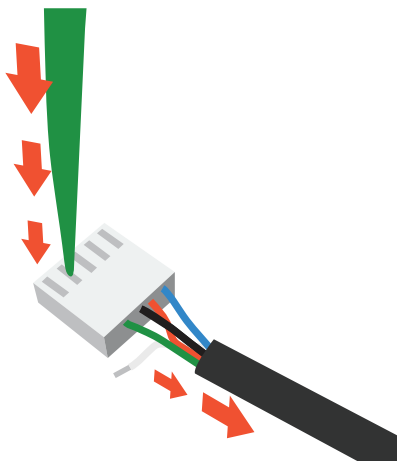
The control system has three main components

Keyed data and power connector
24 volt power input
Status indicator LED

Data and power cable pinout

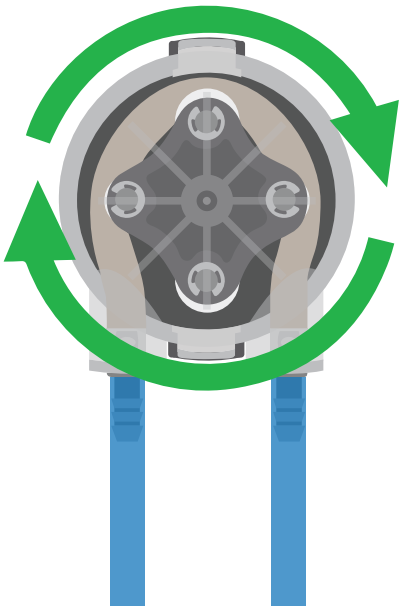
White	–	RX/SCL
Green	–	TX/SDA
Black	–	GND
Red	–	VCC
Blue	–	INT

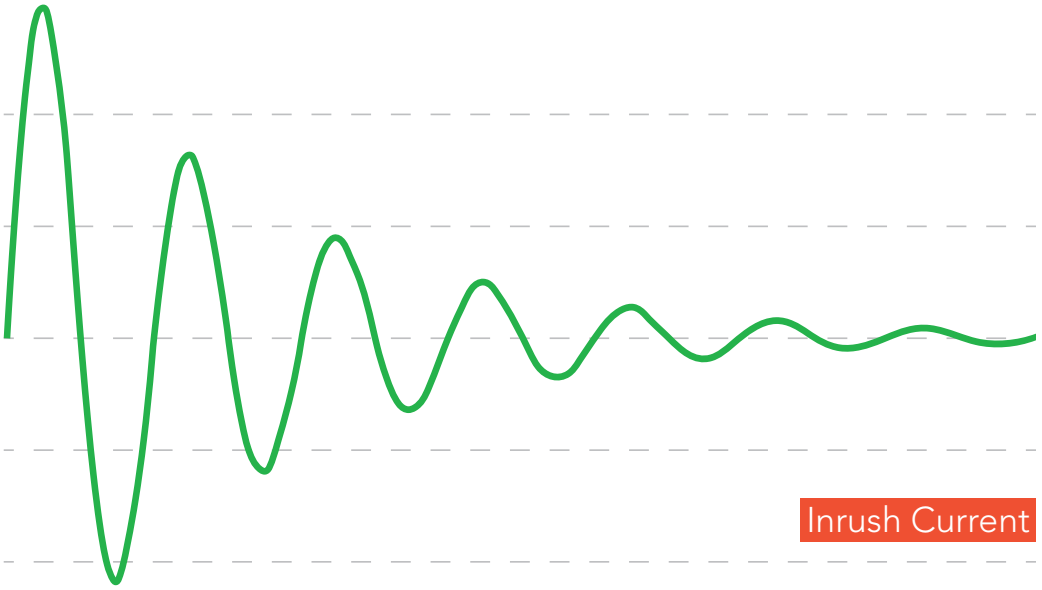
Should you need to remove this connector from the data cable, follow the provided illustration.



Power supplies

The nature of this inductive motor can cause a high inrush current upon its first spin. Threfore, not all power supplies will work with the EZO-PMP-L™.





Most power supplies have a built in protection against inrush currents and will prevent the motor from spinning. It has become very difficult to determine which power supplies will and won't work for the EZO-PMP-L™, as the manufacturers do not list whether it can handle inrush currents in the specs.

Atlas Scientific has tested both of these two power supplies, and can verify that they work with the EZO-PMP-L™.

Mean Well #GE30I24-P1J

Included with the EZO-PMP-L™ Kit

Mean Well #EDR-120-24

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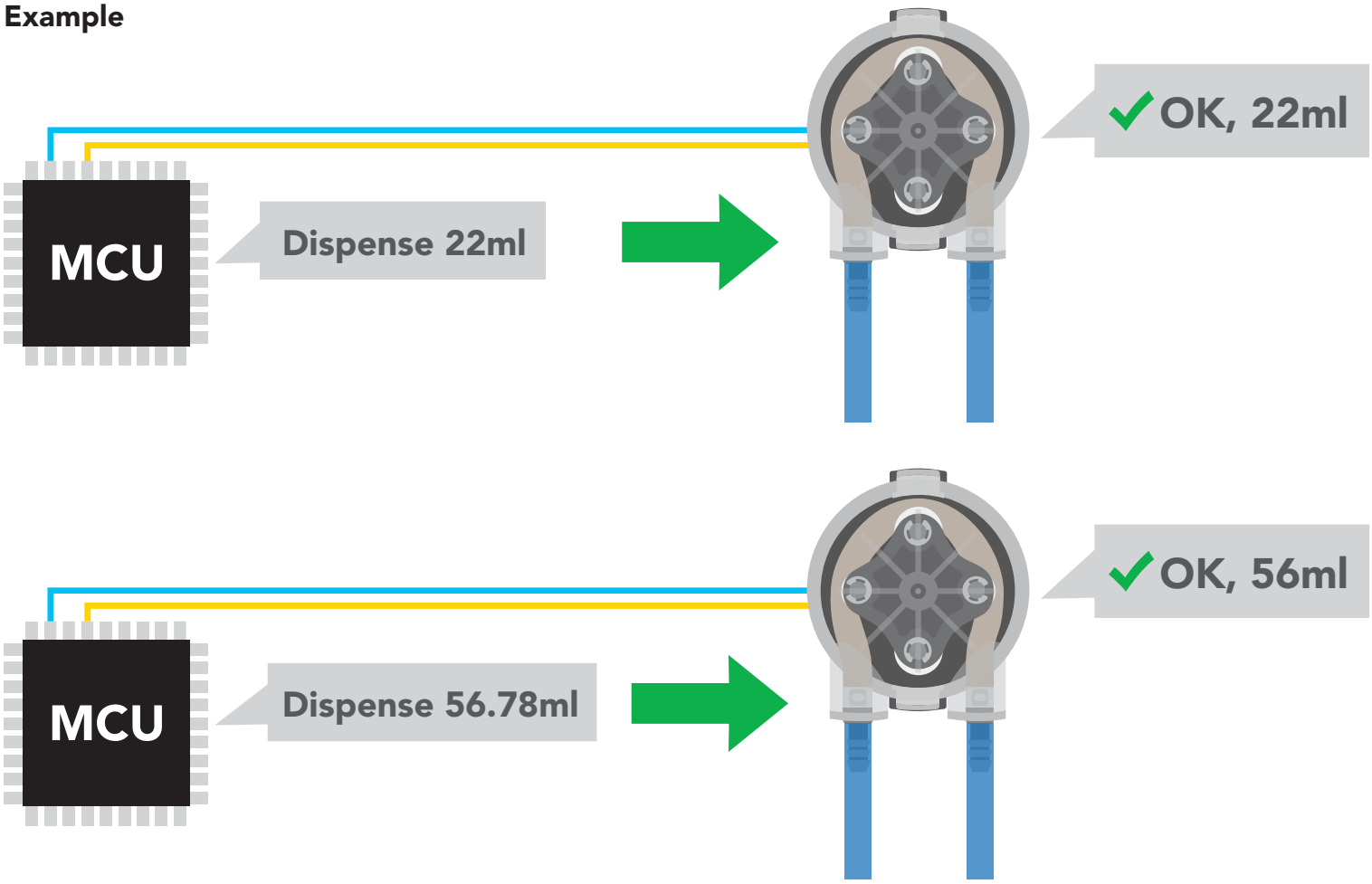
Dispensing volumes

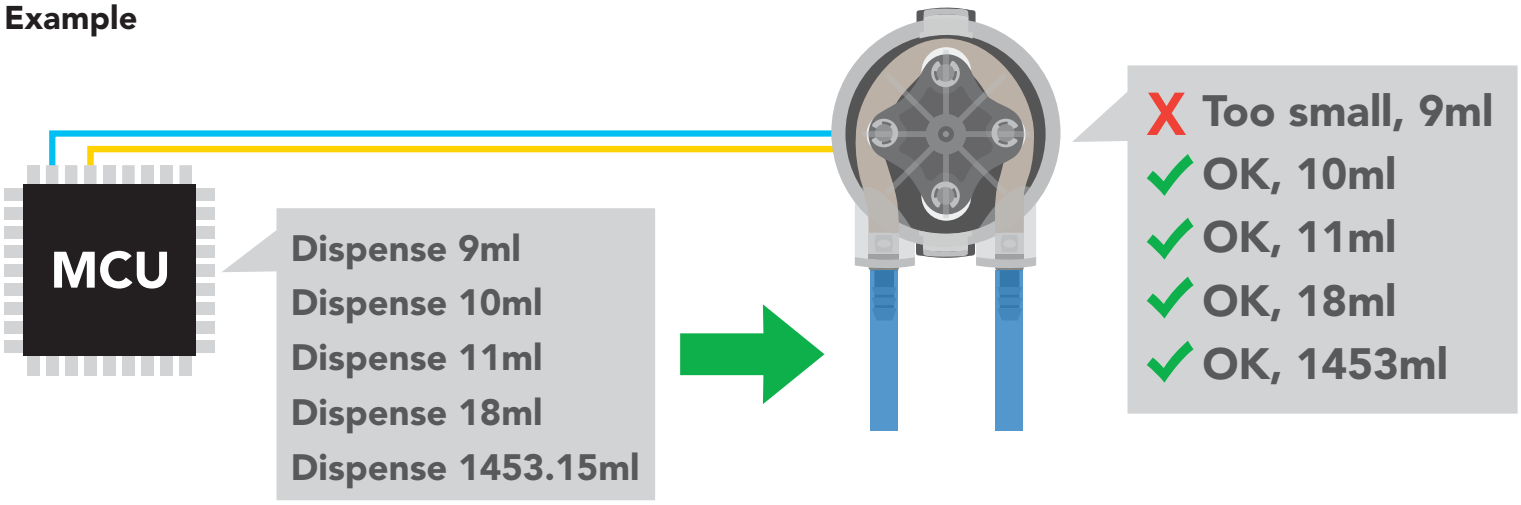
The EZO-PMP-L™ can only dispense volumes in whole numbers. The pump will not reject a request to dispense a volume with a decimal place, it will just ignore the decimal.

Example



The minimum volume the EZO-PMP-L™ can dispense is 10 ml.

Example



✓ Available data protocols

UART

Default

I²C

X Unavailable data protocols

SPI

Analog

RS-485

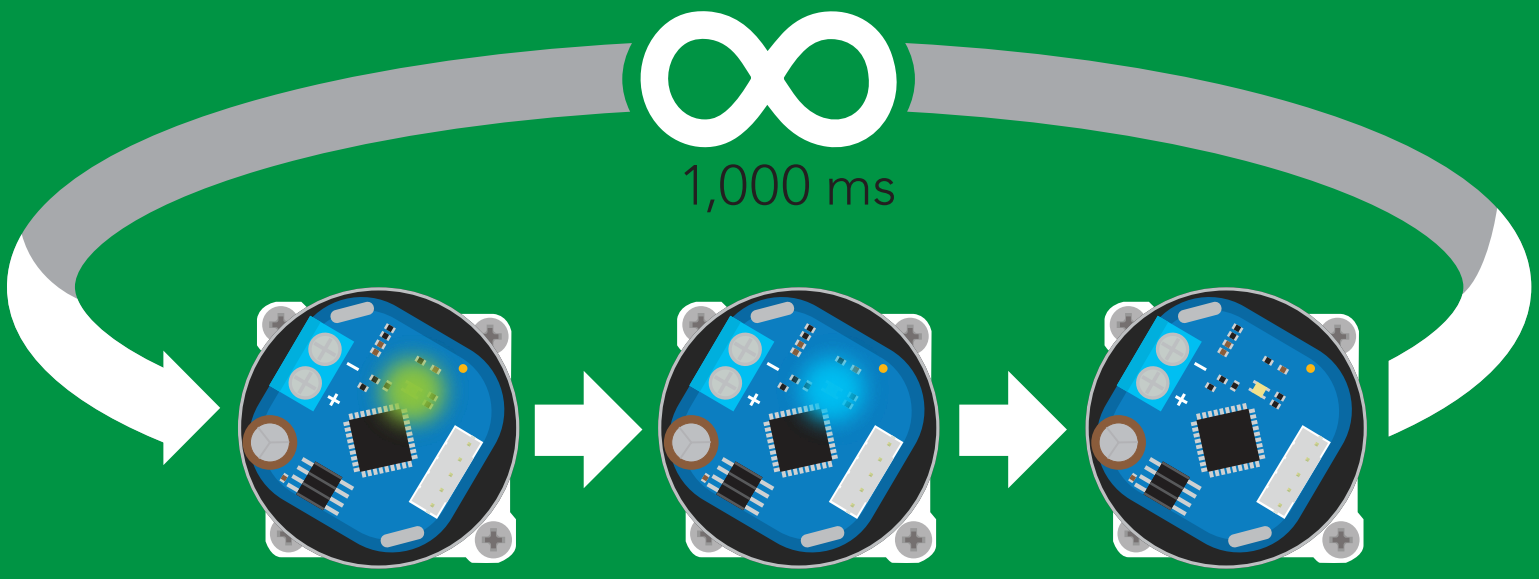
Mod Bus

4–20mA

Default state

UART mode

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



Green
Standby

Cyan
Taking reading

Transmitting

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
Invert
LED control
Protocol lock
Software switch to I^2C mode

Settings that are *NOT* retained if power is cut

Absolute total volume
Find
Sleep mode
Total volume

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UART mode

8 data bits	no parity
1 stop bit	no flow control

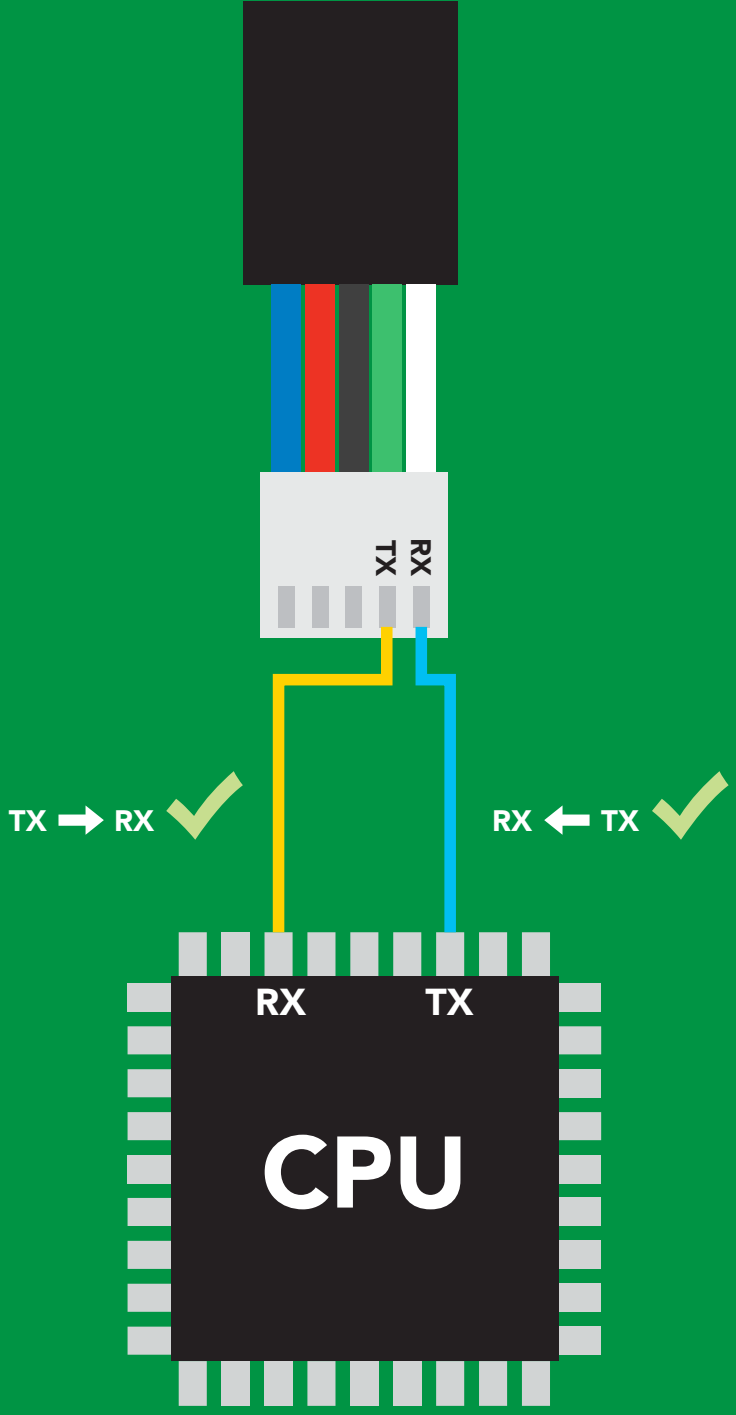
Baud

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

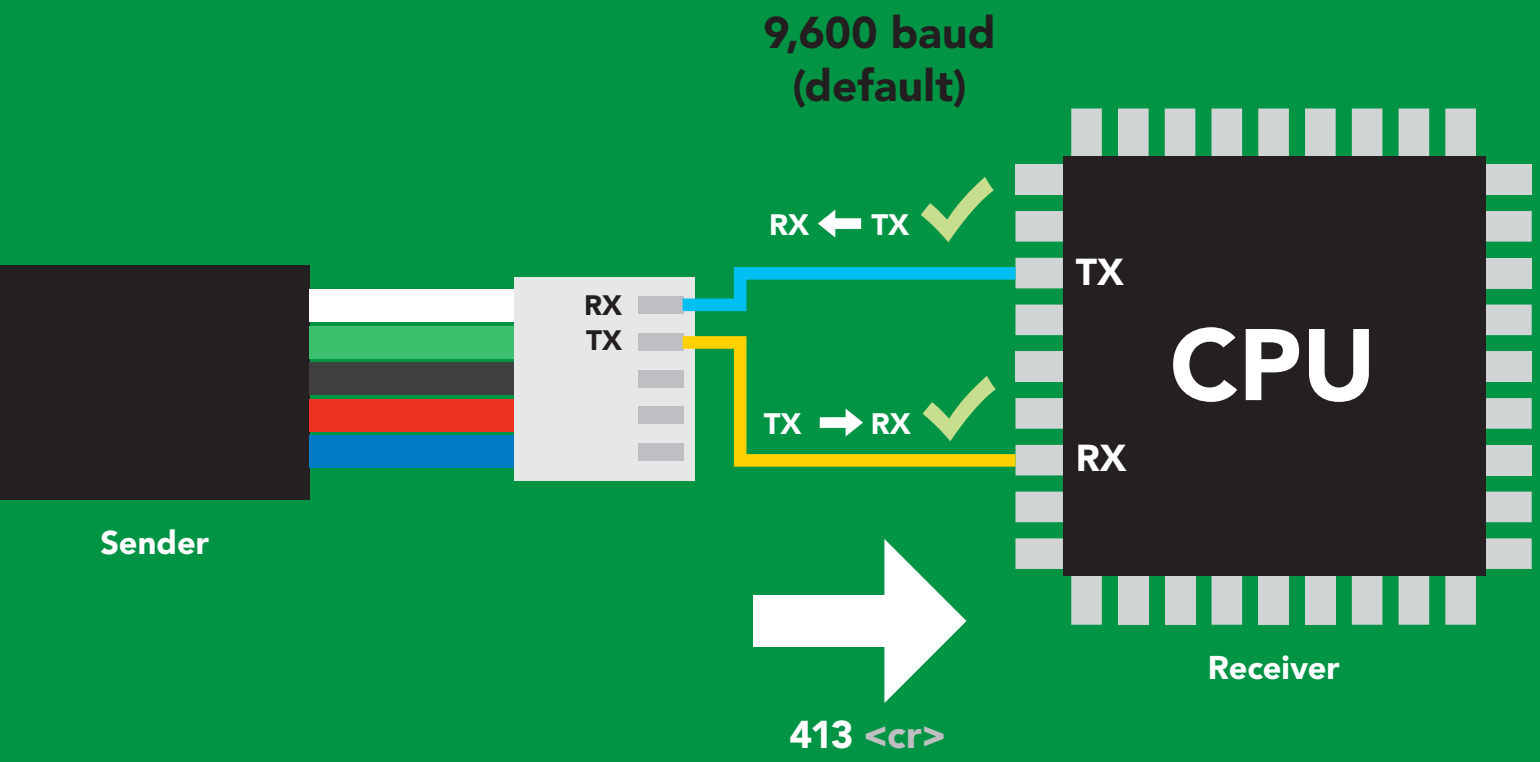
Output	volume
Units	ml
Encoding	ASCII
Format	string
Terminator	carriage return
Data type	long int
Decimal places	none
Smallest string	3 characters
Largest string	39 characters

Receiving data from device

2 parts

ASCII data string
Command

Carriage return <cr>
Terminator



Advanced

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

Sending commands to device

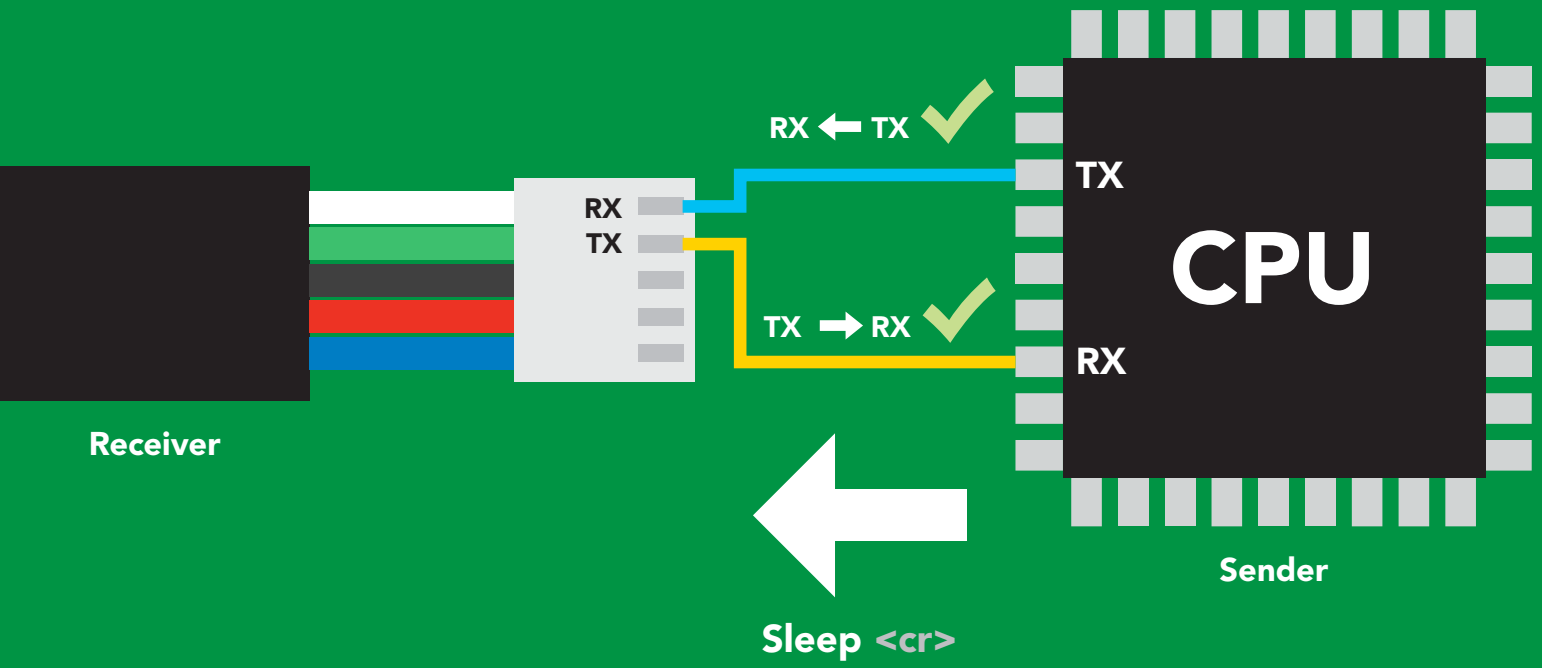
2 parts

Command (not case sensitive)

ASCII data string

Carriage return <cr>

Terminator



Advanced

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

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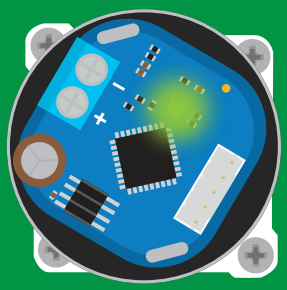
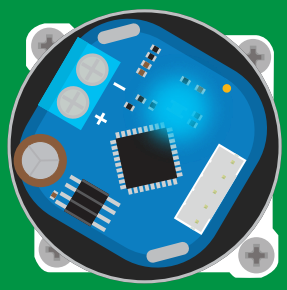
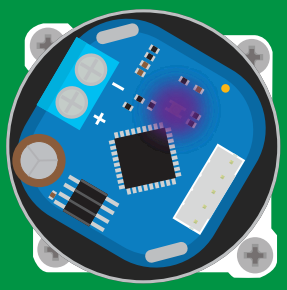
LED color definition



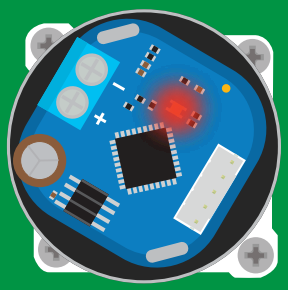
Green
UART standby



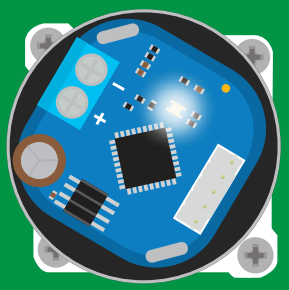
Cyan
Taking reading



Purple
Changing baud rate



Red
Command not understood



White
Find

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

UART mode
command quick reference

All commands are ASCII strings or single ASCII characters.

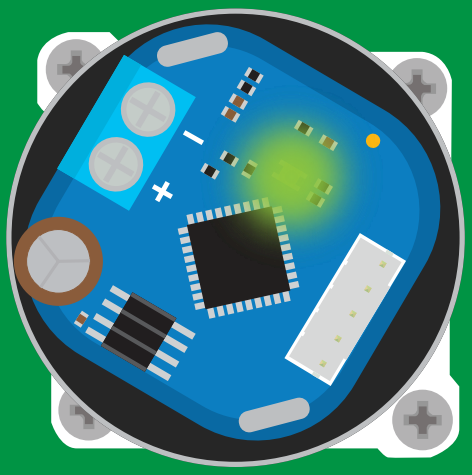
Command	Function		Default state
Baud	change baud rate	pg. 41	9,600
C	enable/disable continuous mode	pg. 20	enabled
Cal	performs calibration	pg. 33	n/a
D	dispense modes	pg. 22 – 28	n/a
Factory	enable factory reset	pg. 43	n/a
Find	finds device with blinking white LED	pg. 19	n/a
i	device information	pg. 37	n/a
Invert	invert dispensing direction	pg. 31	n/a
I2C	change to I²C mode	pg. 44	not set
L	enable/disable LED	pg. 18	enabled
Name	set/show name of device	pg. 36	not set
O	enable/disable parameters	pg. 34	all enabled
P	pause dispensing	pg. 29	n/a
Plock	enable/disable protocol lock	pg. 42	disabled
Pv	check pump voltage	pg. 35	n/a
R	returns a single reading	pg. 21	n/a
Sleep	enter sleep mode/low power	pg. 40	n/a
Status	retrieve status information	pg. 39	enable
Tv	total volume dispensed	pg. 32	n/a
X	stop dispensing	pg. 30	n/a
*OK	enable/disable response codes	pg. 38	enable

LED control

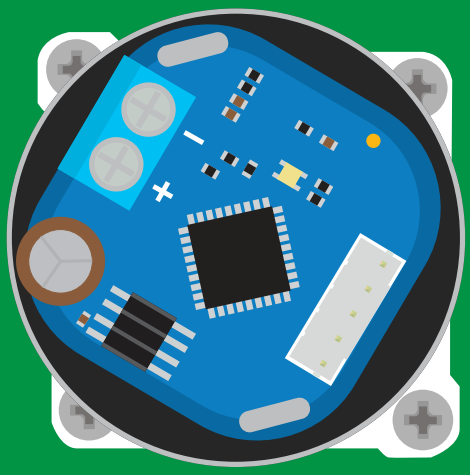
Command syntax

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

Example	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

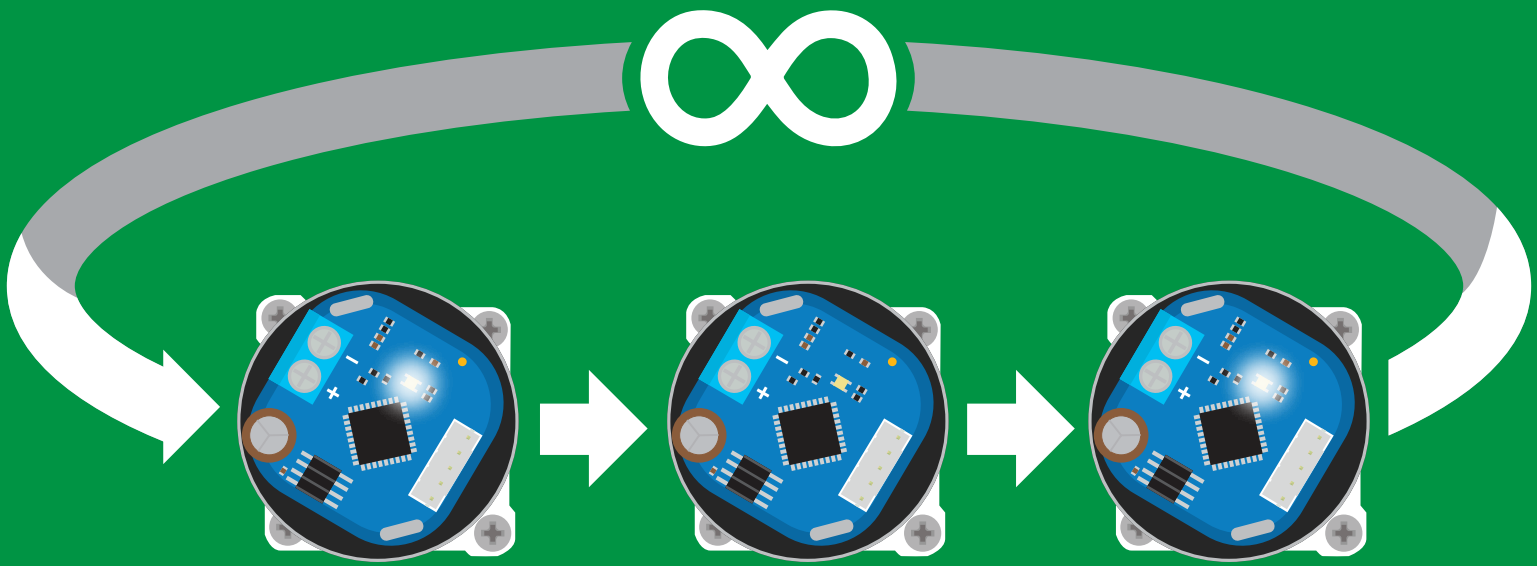
Find

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 mode

Command syntax

C,* <cr> continuously reports volume once per second **default**
C,1 <cr> continuously reports volume only when pumping
C,0 <cr> disable continuous reporting
C,? <cr> continuous reporting mode on/off?

Example	Response
dispense 23ml C,* <cr>	18 <cr> 23 <cr> *Done,23 <cr> 23 <cr> 23 <cr>
C,1 <cr>	18 <cr> 23 <cr> *Done,23 <cr>
C,0 <cr>	*Done,23 <cr>
C,? <cr>	?C,1 <cr> or ?C,0 <cr> or ?C,* <cr> *OK <cr>

Single reading mode

Command syntax

R <cr> returns a single value showing dispensed volume

Example	Response	
R <cr>	25 <cr> *OK <cr>	(If issued half way through dispensing 50ml)
	50 <cr> *OK <cr>	(If issued once dispensing has stopped)

Continuous dispensing

Pump on/pump off

Command syntax

After running in continuous mode for 20 days the EZO-PMP-L™ will reset.

D,* <cr> dispense until the stop command is given

D,-* <cr> dispense in reverse until the stop command is given

D,? <cr> dispense status

Example	Response	
D,* <cr>	*OK <cr>	pump will continuously run at ~750ml/min (with supplied tubing)
D,-* <cr>	*OK <cr>	pump will continuously run in reverse at ~750ml/min (with supplied tubing)
D,? <cr>	?D,*,1 <cr> *OK <cr>	

Response breakdown

?D,*,1

- last volume requested
- pump on

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Volume dispensing

Pump a specific volume

Command syntax

where [ml] is any volume in millimeters >= 0.5

D,[ml]	<cr>	dispense [this specific volume]
D,[-ml]	<cr>	dispense [*in reverse* this specific volume]
D,?	<cr>	dispense status

Example	Response
D,15 <cr>	*OK <cr> 15 ml will be dispensed
D,-40 <cr>	*OK <cr> 40 ml will be dispensed *in reverse*
D,? <cr>	?D,-40,0 <cr> *OK <cr>

Response breakdown

?D,-40,0

- ↑ last volume dispensed
- ↑ pump off

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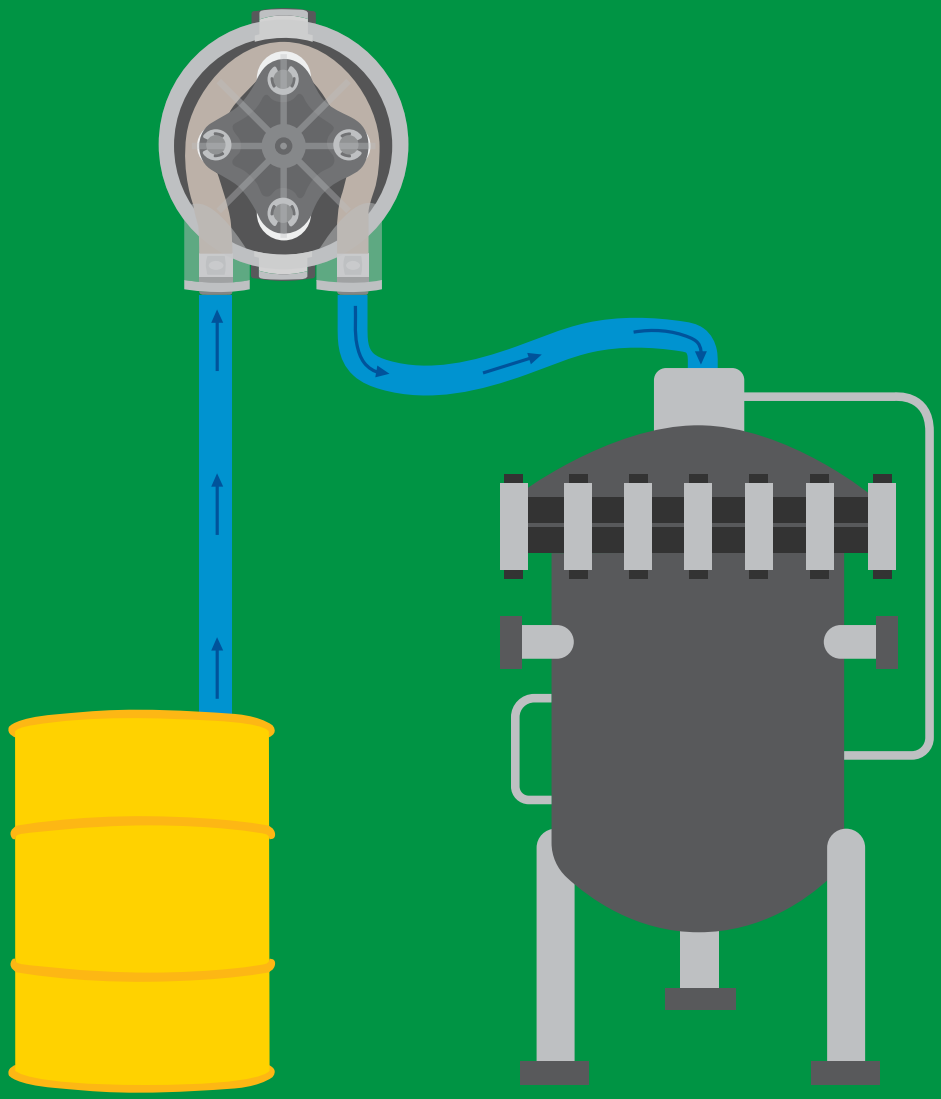
Dose over time

Pump a fixed volume over a fixed time

Command syntax

D,[ml],[min]	<cr>	Dispense [this volume], [over this many minutes]

Example	Response
D,7000,20 <cr>	*OK <cr> Dispense 7000ml over 20 minutes



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Constant flow rate

Maintain a constant flow rate

Command syntax

After running in continuous mode for 20 days the EZO-PMP-L™ will reset.

DC,[ml/min],[min or *] <cr> [maintain this rate],[for this much time]

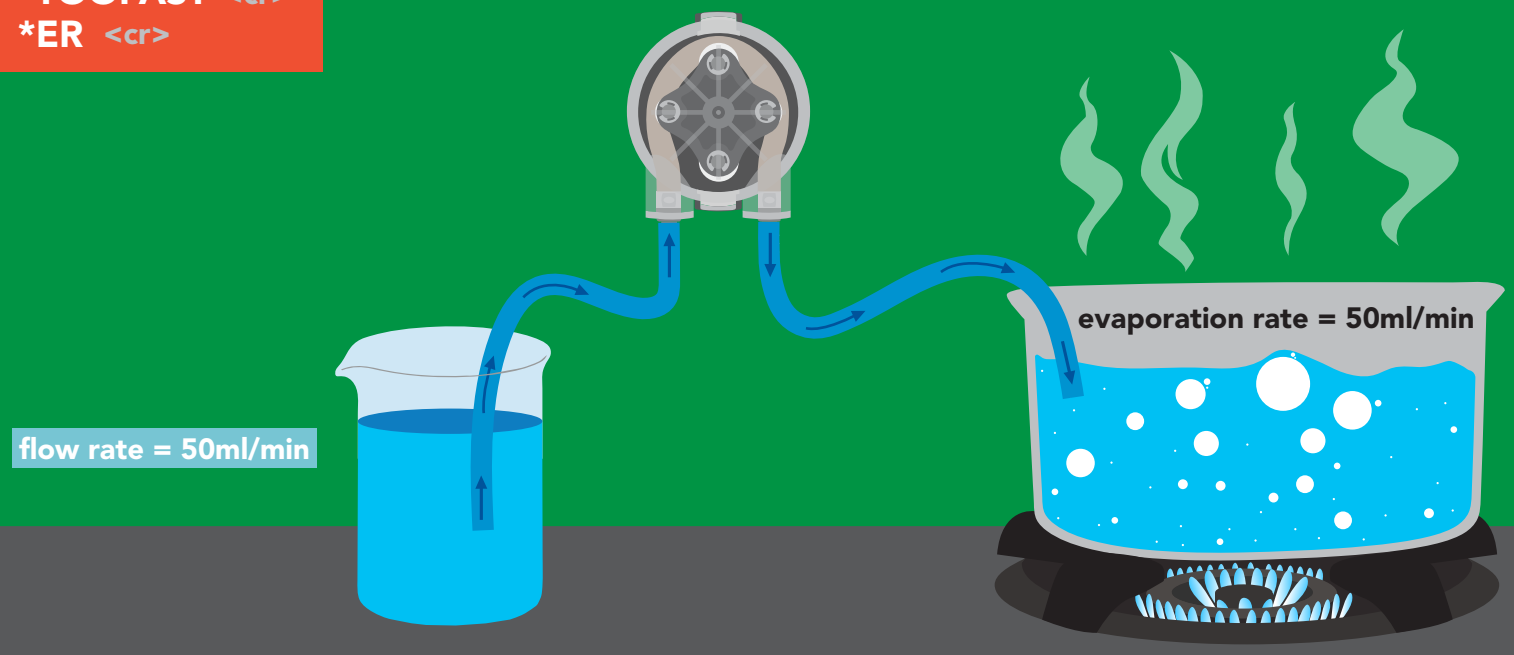
DC,? <cr> reports maximum possible flow rate

[ml/min] = a single number (int or float) representing the desired flow rate
[min or *] = the number of minutes to run or (*) indefinitely
A negative value for ml/min = reverse

Example	Response
DC,50,40 <cr>	*OK <cr> Dispense 50ml per minute for 40 minutes
DC,? <cr>	?MAXRATE,385 <cr> *OK <cr>

The maximum flow rate is determined after calibration.
If the flowrate entered is too fast the EZO-PMP-L™ will send an error.

*TOOFAST <cr>
*ER <cr>



Dispense at startup

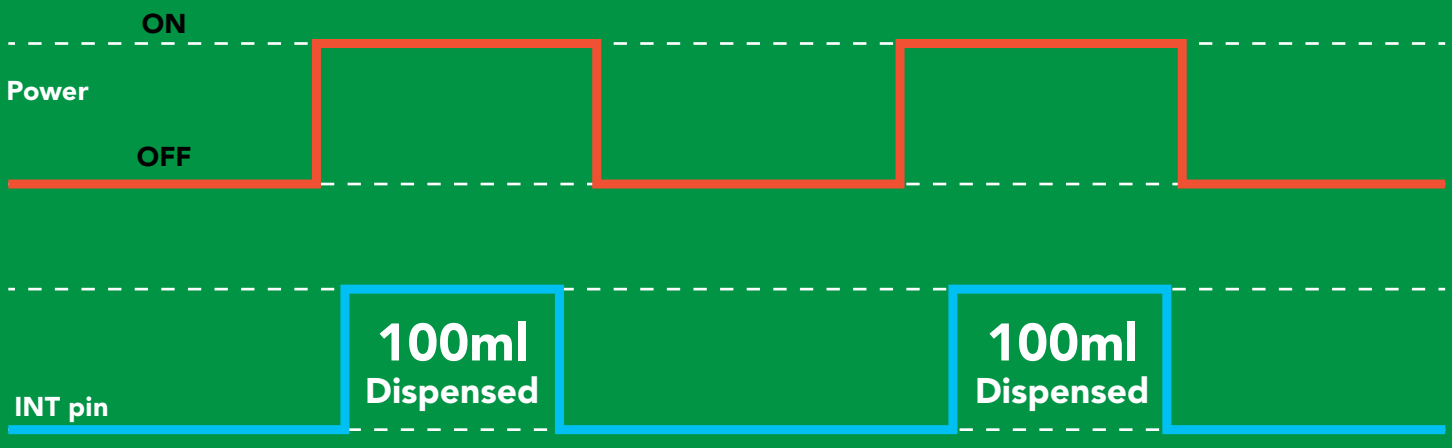
Pump a specific volume at startup and then stop

Use this command to make a simple fixed-volume pump

Command syntax

Dstart,[ml]	<cr>	dispense [this specific volume] at startup
Dstart,off	<cr>	disables dispense at startup mode
Dstart,?	<cr>	startup dispense status

Example	Response
Dstart,100 <cr>	*OK <cr>
Dstart,off <cr>	*OK <cr>
Dstart,? <cr>	?Dstart,100 <cr> or ?Dstart,0 <cr> *OK <cr>



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Continuous dispensing at startup

Pump on & continuously dispense

Command syntax

After running in continuous mode for 20 days the EZO-PMP-L™ will reset.

Dstart,*	<cr>	dispense at startup until the stop command is given
Dstart,-*	<cr>	dispense in reverse at startup until the stop command is given
Dstart,?	<cr>	startup dispense status

Example		Response	
Dstart,*	<cr>	*OK <cr>	Pump will startup and continuously run at ~750ml/min (with supplied tubing)
Dstart,-*	<cr>	*OK <cr>	Pump will startup and continuously run in reverse at ~750ml/min (with supplied tubing)
Dstart,?	<cr>	?Dstart,* <cr>	

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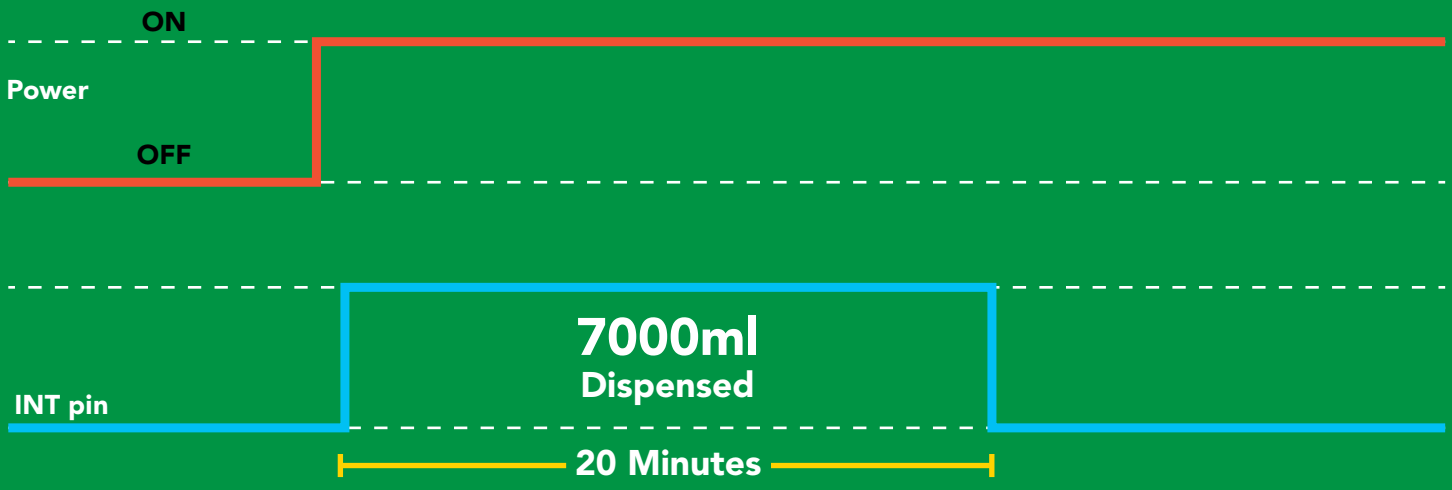
Dose Over time at startup

Pump a fixed volume over a fixed time at startup

Command syntax

Dstart[ml],[min]	<cr>	Dispense [volume], [over this many minutes] at startup

Example		Response	
Dstart,7000,20	<cr>	*OK <cr>	Pump will startup and dispense 7000ml over 20 minutes
Dstart,?	<cr>	?Dstart,7000,20.00	<cr>



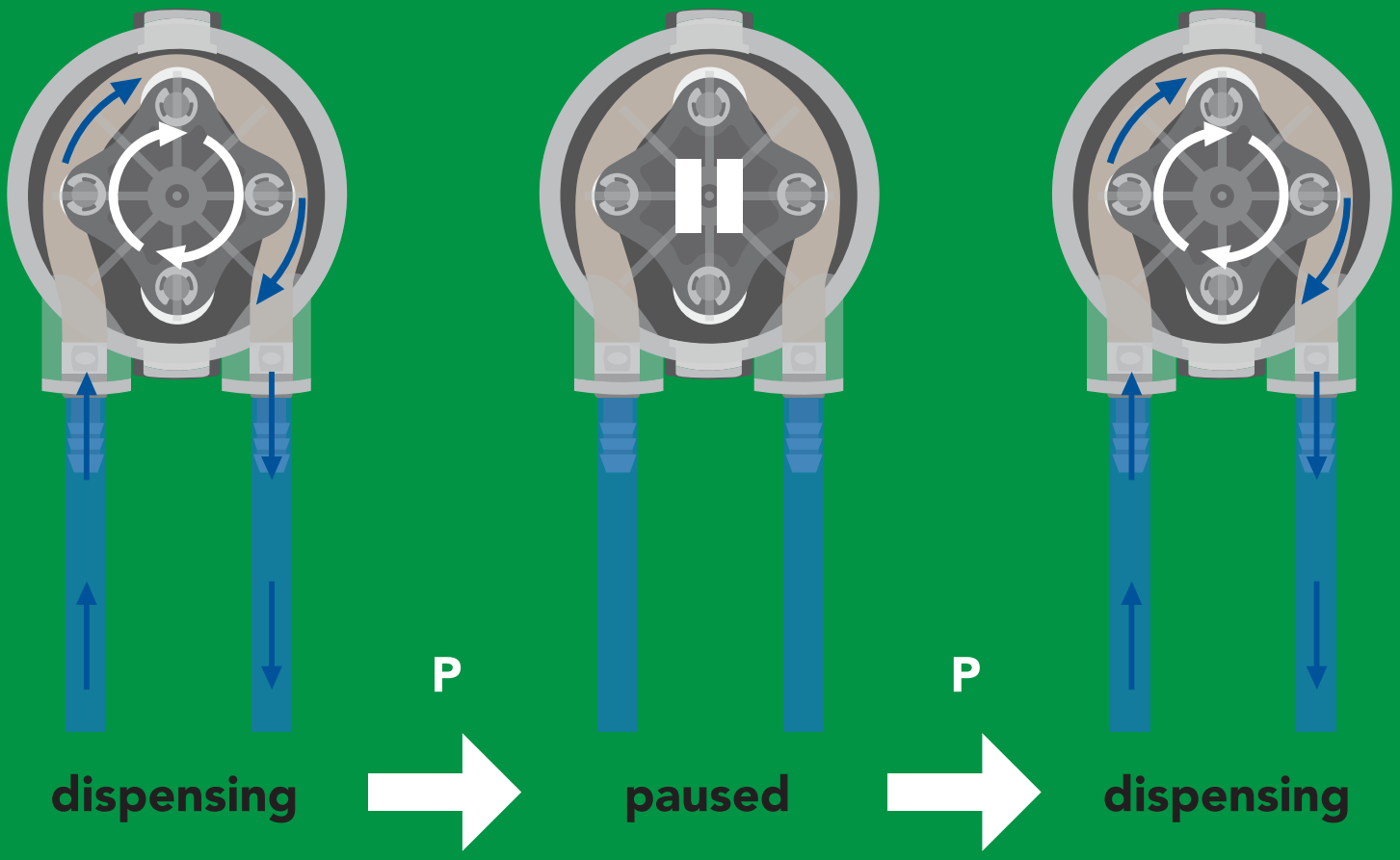
Pause dispensing

Command syntax

Issue the command again to resume dispensing

P <cr>	pauses the pump during dispensing
P,? <cr>	pause status

Example	Response
P <cr>	*OK <cr>
P,? <cr>	?P,1 <cr> (paused) or ?P,0 <cr> (unpaused) *OK <cr>



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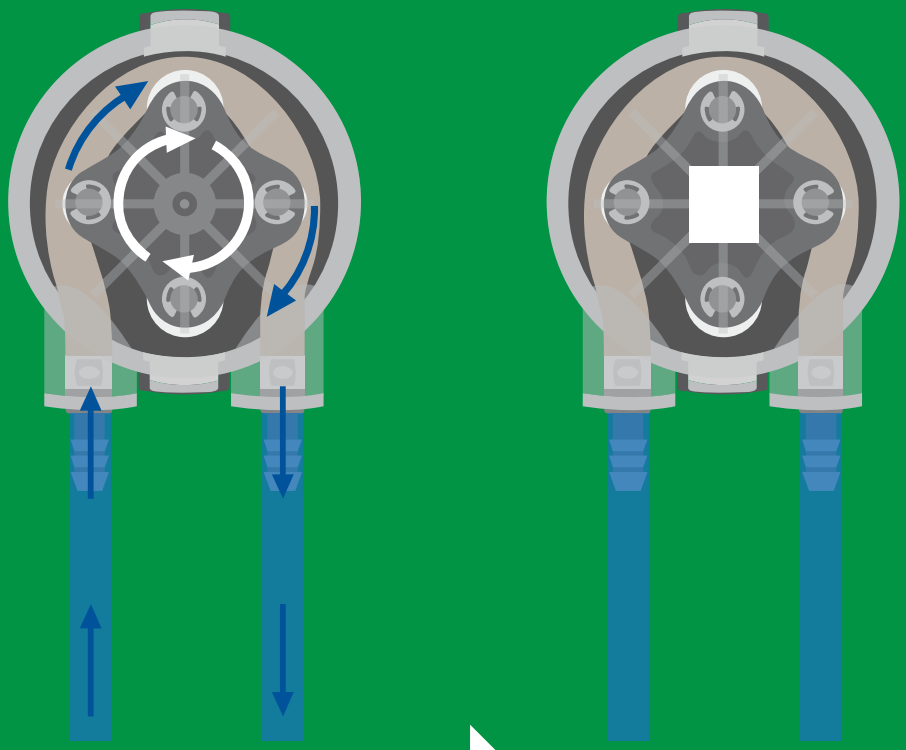
Stop dispensing

Command syntax

X <cr> stop dispensing

Example	Response	
X <cr>	*DONE,v <cr>	v = volume dispensed



X
dispensing

*DONE,645.8
Stopped

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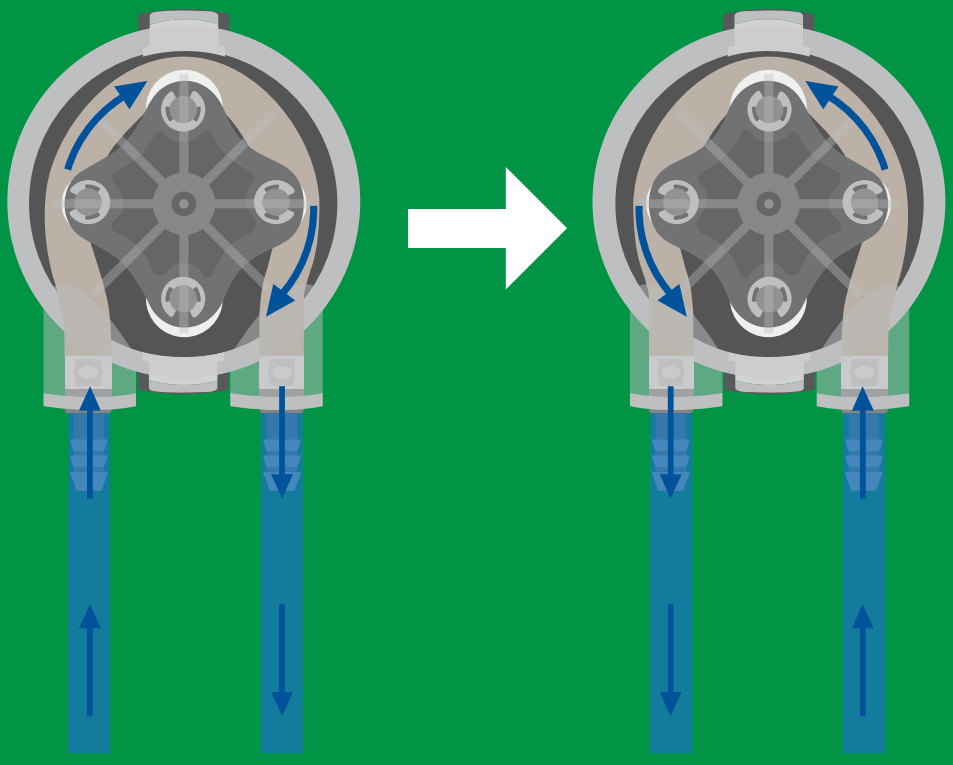
Invert dispensing direction

Command syntax

Invert direction will be retained if power is cut

Invert <cr> changes dispensing direction of pump

Example	Response
Invert <cr>	***OK** <cr>
Invert,? <cr>	**?Invert,1** <cr> **or** **?Invert,0** <cr> inverted uninverted ***OK** <cr>



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Total volume dispensed

Command syntax

TV,? <cr> shows total volume dispensed

ATV,? <cr> absolute value of the total volume dispensed

Clear <cr> clears the total dispensed volume

Example	Response
TV,? <cr>	?TV,434.50 <cr>
ATV,? <cr>	?ATV,623.00 <cr>
Clear <cr>	*OK <cr> total now 0.00

This data will be lost if the power is cut.

Calibration

Command syntax

Calibrate to the actual volume dispensed.

Cal,v	<cr>	v = corrected volume
Cal,clear	<cr>	delete all calibration data
Cal,?	<cr>	device calibrated?

This command is used for both, single dose and dose over time calibrations.

Example	Response
Cal,146.2 <cr>	*OK <cr>
Cal,clear <cr>	*OK <cr>
Cal,? <cr>	?Cal,1 <cr> (fixed volume) or ?Cal,2 <cr> (volume/time) or ?Cal,3 <cr> (both) or ?Cal,0 <cr> (uncalibrated) *OK <cr>

Click here for more information on the calibration procedure.

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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,V,1 <cr>	*OK <cr> enable volume being pumped
O,TV,0 <cr>	*OK <cr> disable total volume pumped
O,ATV,1 <cr>	*OK <cr> enable absolute volume pumped
O,? <cr>	?,O,V,TV,ATV <cr> if all three are enabled

Pump voltage

Command syntax

PV,? <cr> **check pump voltage**

Example	Response
PV,? <cr>	?PV,24.67 <cr> *OK <cr>

Response breakdown

?PV, 24.67

Pump input voltage

Naming device

Command syntax

Do not use spaces in the name

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

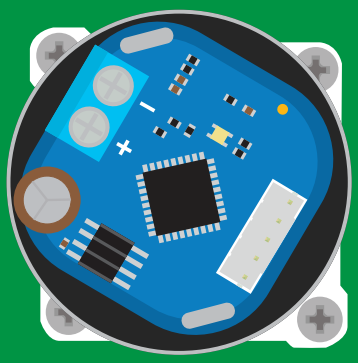
n = _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _

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

Up to 16 ASCII characters

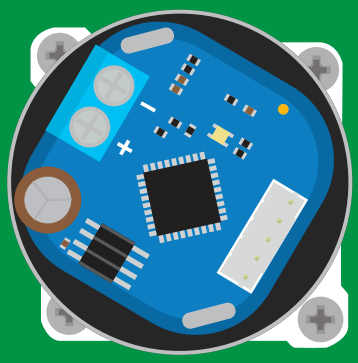
Example	Response
Name, <cr>	*OK <cr> name has been cleared
Name,zzt <cr>	*OK <cr>
Name,? <cr>	?Name,zzt <cr> *OK <cr>

Name,zzt



*OK <cr>

Name,?



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

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Device information

Command syntax

i <cr> **device information**

Example	Response
i <cr>	**?i,PMPL,1.1** <cr> ***OK** <cr>

Response breakdown

?i, PMPL, 1.1

PMPL: Device

1.1: 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>	413 <cr> *OK <cr>
*OK,0 <cr>	no response, *OK disabled
R <cr>	413 <cr> *OK disabled
*OK,? <cr>	?*OK,1 <cr> or ?*OK,0 <cr>

Other response codes

*ER	unknown command
*OV	over volt (VCC>=5.5V)
*UV	under volt (VCC<=3.1V)
*RS	reset
*RE	boot up complete, ready
*SL	entering sleep mode
*WA	wake up
*DONE	dispensing complete
*MINVOL	dispense amount too low
*TOOFAST	ml/min set to fast

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

- 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

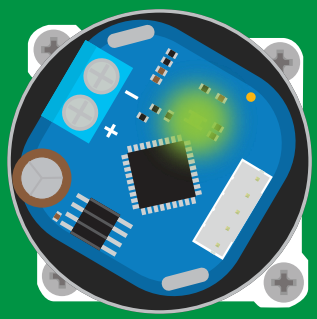
Command syntax

Send any character or command to awaken device.

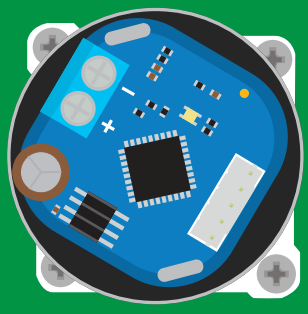
Sleep <cr> enter sleep mode/low power

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

	STANDBY	SLEEP
5V	13.4 mA	0.415 mA
3.3V	12.4 mA	0.13 mA



Sleep <cr>



Standby
13.4 mA

Sleep
0.415 mA

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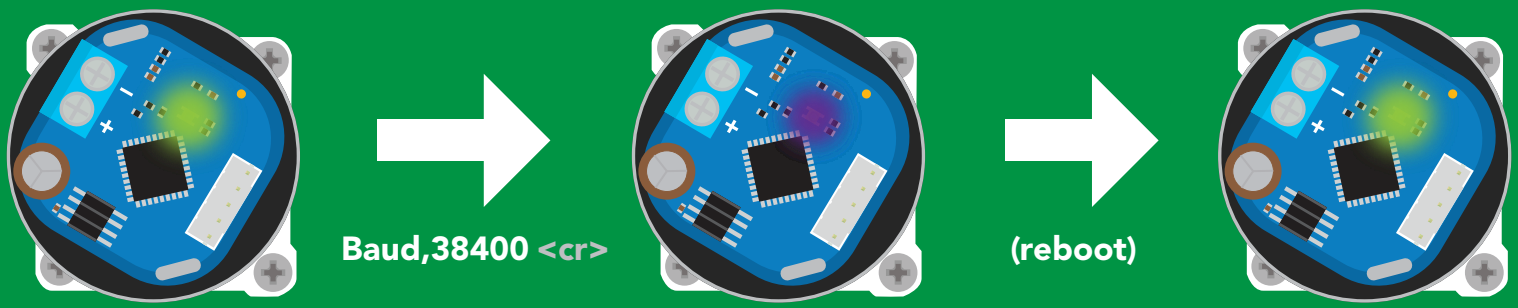
Change baud rate

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



Standby

Changing baud rate

*OK <cr>

Standby

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Protocol lock

Command syntax

Locks device to UART mode.

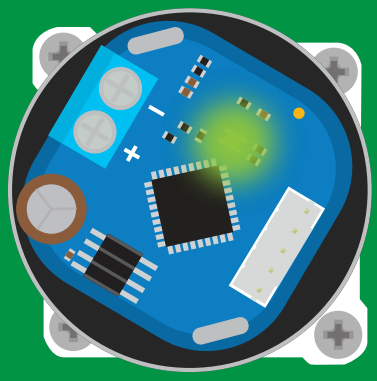
Plock,1 <cr> enable Plock

Plock,0 <cr> disable Plock **default**

Plock,? <cr> Plock on/off?

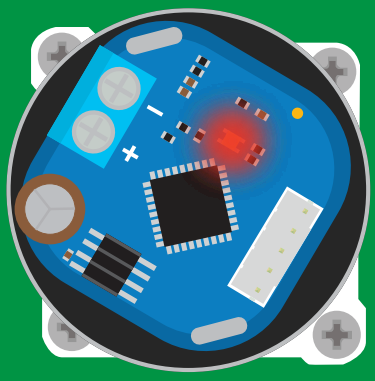
Example	Response
Plock,1 <cr>	*OK <cr>
Plock,0 <cr>	*OK <cr>
Plock,? <cr>	?Plock,1 <cr> or ?Plock,0 <cr>

Plock,1



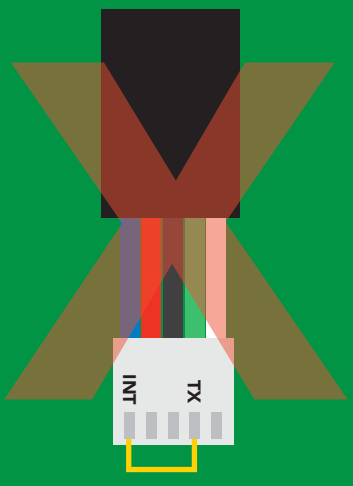
*OK <cr>

I2C,100



cannot change to I²C

*ER <cr>



cannot change to I²C

Factory reset

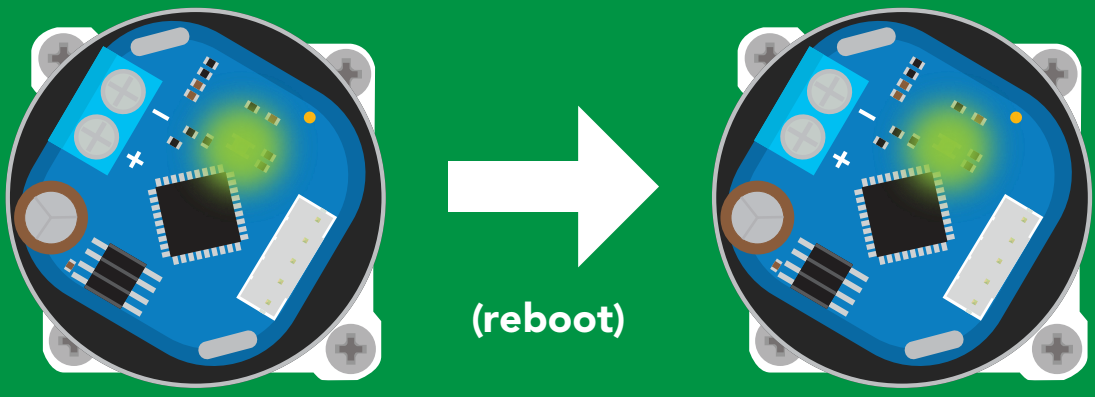
Command syntax

Clears calibration
LED on
"*OK" enabled

Factory <cr> enable factory reset

Example	Response
Factory <cr>	*OK <cr>

Factory <cr>



*OK <cr>

(reboot)

*RS <cr>
*RE <cr>

Baud rate will not change

Change to I²C mode

Command syntax

Default I²C address 109 (0x6D)

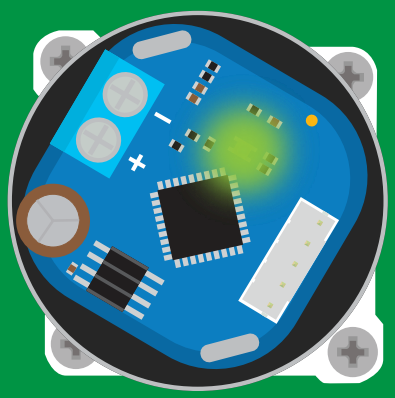
I2C,n <cr> sets I²C address and reboots into I²C mode

n = any number 1 – 127

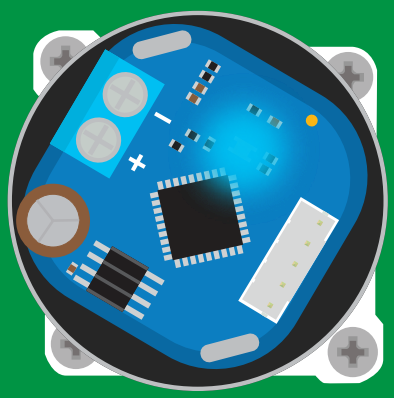
Example	Response
I2C,100 <cr>	*OK (reboot in I²C mode)

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

I2C,100



(reboot)



Green
*OK <cr>

Blue
now in I²C mode

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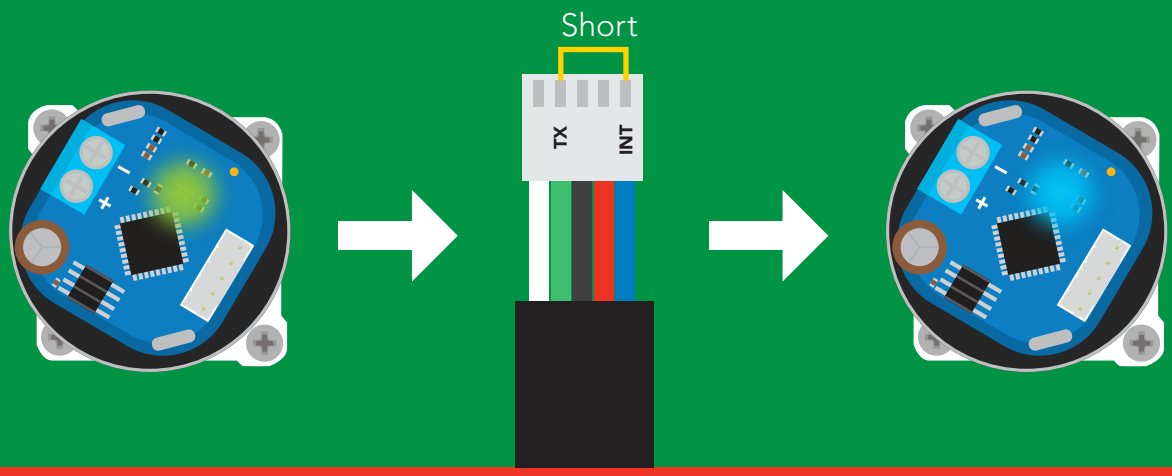
Manual switching to I²C

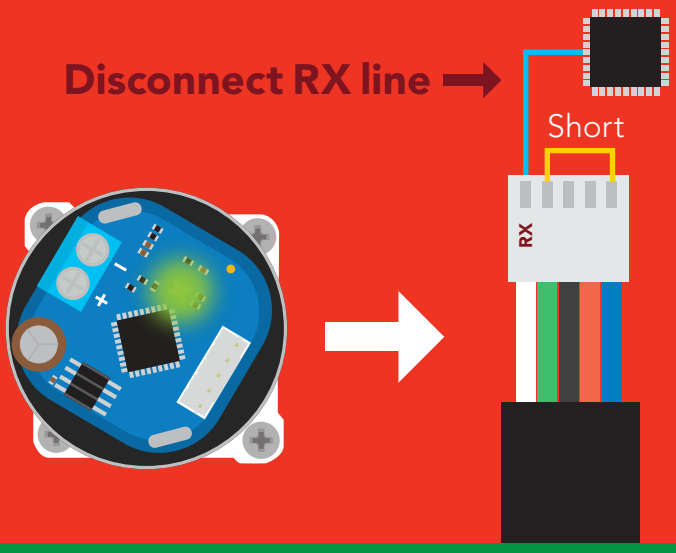
- Disconnect ground (power off)
- Disconnect TX and RX
- Connect TX to INT
- Confirm RX is disconnected
- Connect ground (power on)
- Wait for LED to change from Green to Blue
- Disconnect ground (power off)
- Reconnect all data and power

Manually switching to I²C will set the I²C address to 109 (0x6D)

Example



Wrong Example



I²C 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-PMP-L™ 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
Invert
LED control
Protocol lock
Software switch to UART mode

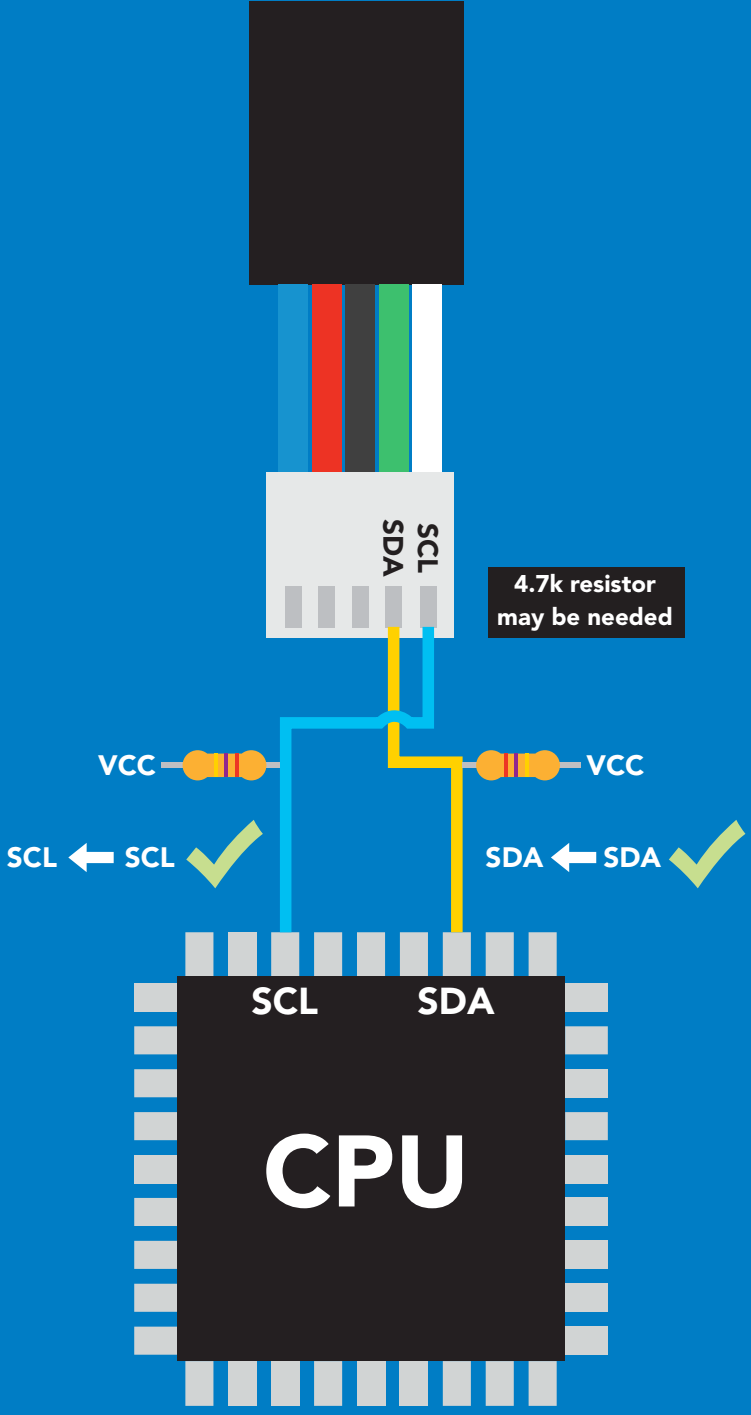
Settings that are ***NOT*** retained if power is cut
Absolute total volume
Find
Sleep mode
Total volume

I²C mode

I²C address	(0x01 – 0x7F) 109 (0x6D) default
Vcc	3.3V – 5.5V
Clock speed	100 – 400 kHz

SDA

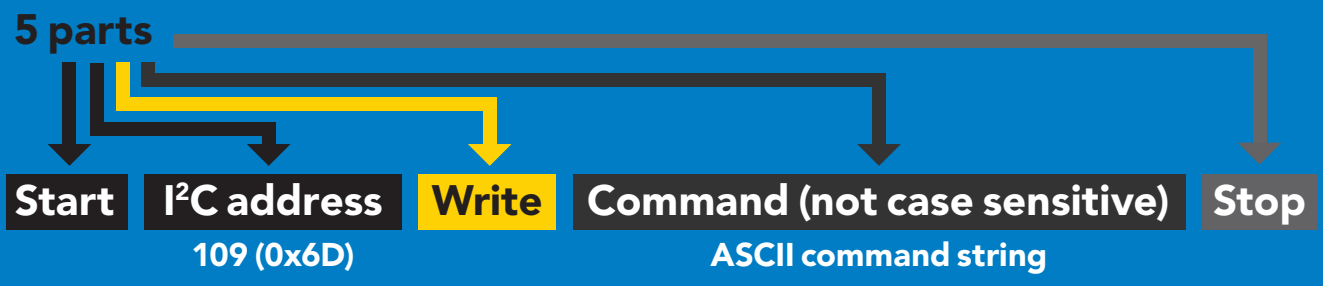
SCL



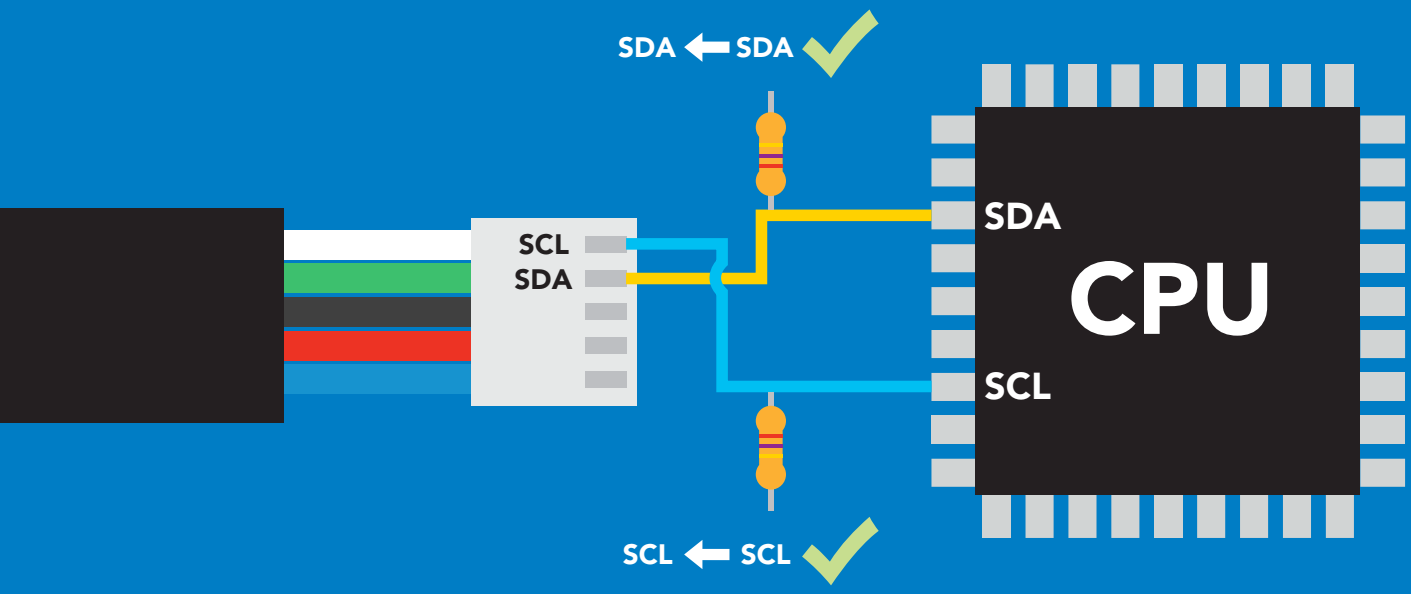
Data format

Reading	volume	Data type	long int
Units	ml	Decimal places	none
Encoding	ASCII	Smallest string	3 characters
Format	string	Largest string	39 characters

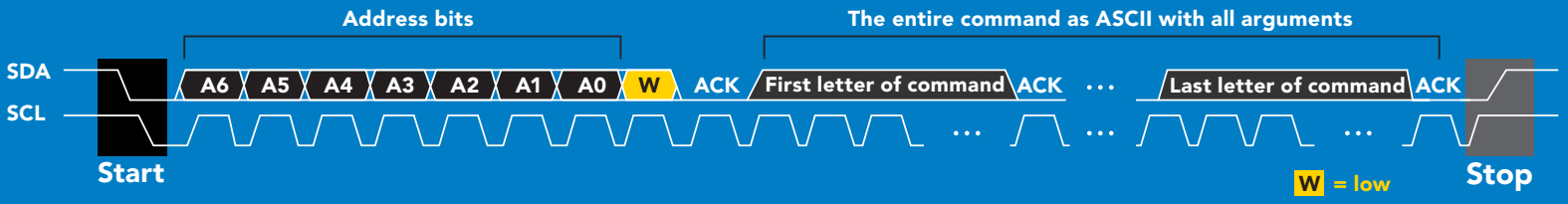
Sending commands to device



Example



Advanced



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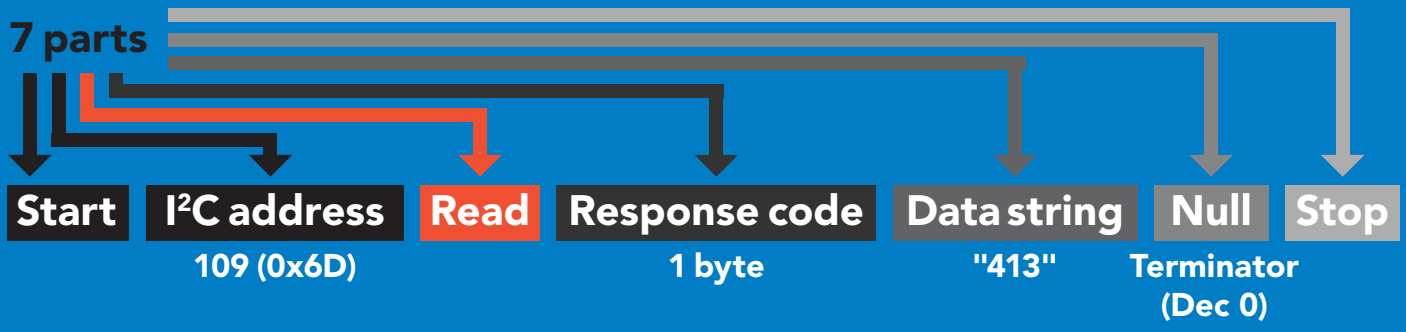
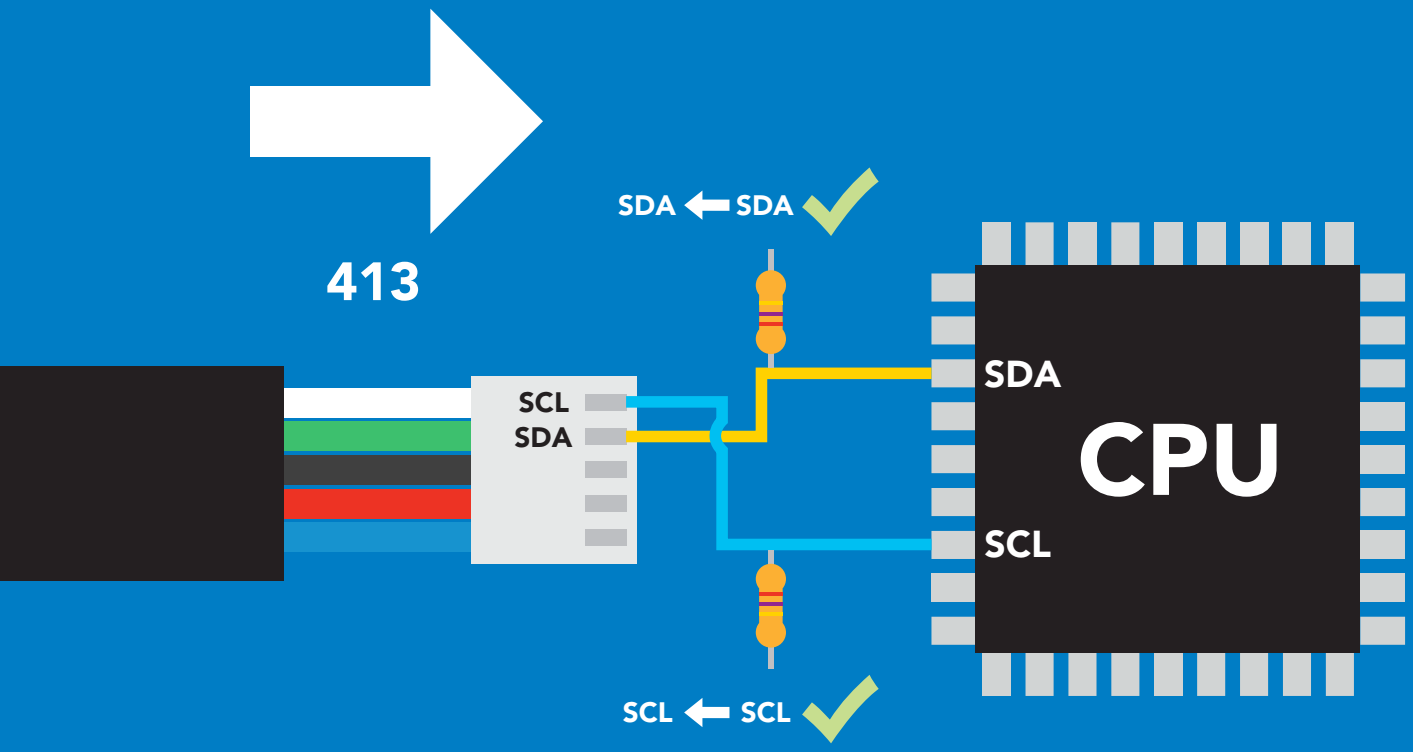
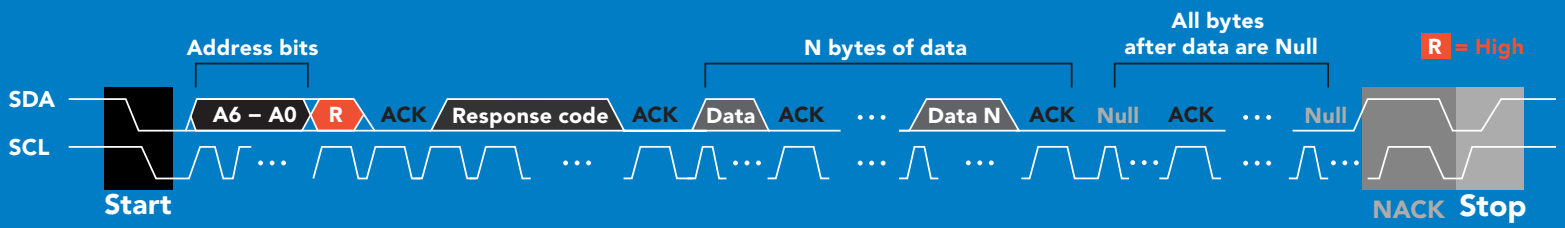
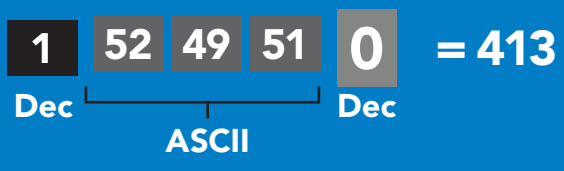
Requesting data from device





Advanced





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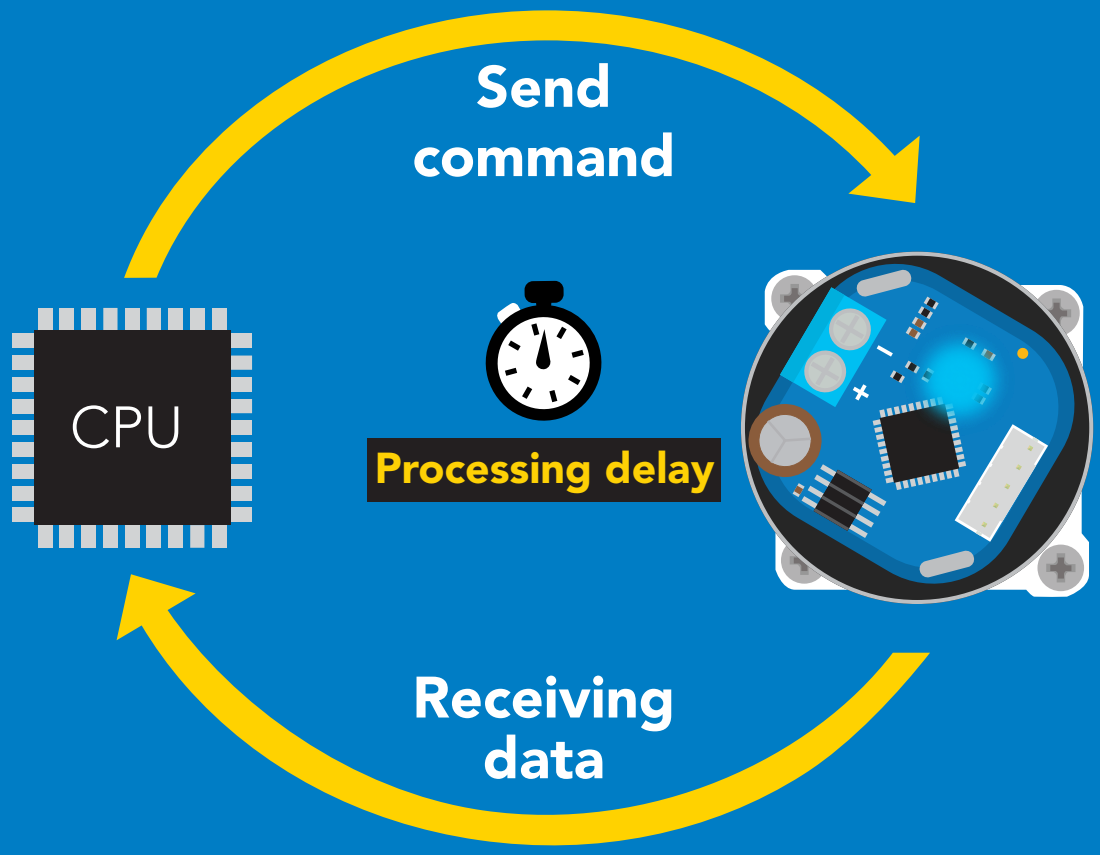
Response codes

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;
```

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

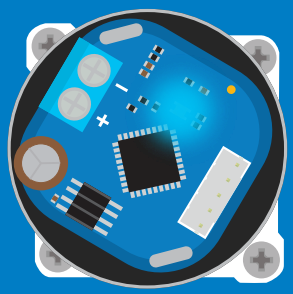
Response codes

Single byte, not string

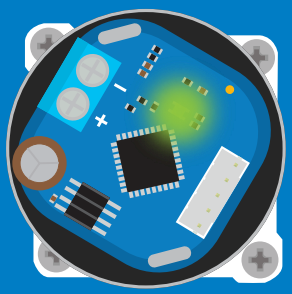
255	no data to send
254	still processing, not ready
2	syntax error
1	successful request

Atlas Scientific Environmental Robotics

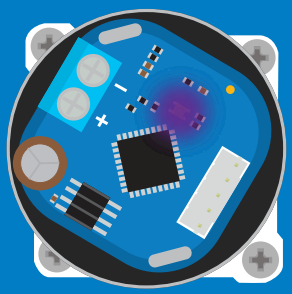
LED color definition



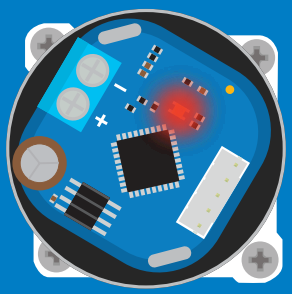
Blue
I²C standby



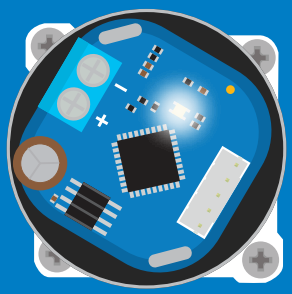
Green
Taking reading



Purple
Changing I²C address



Red
Command not understood



White
Find

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

I²C mode
command quick reference

All commands are ASCII strings or single ASCII characters.

Command	Function	
Baud	switch back to UART mode	pg. 77
Cal	performs calibration	pg. 67
D	dispense modes	pg. 56 – 62
Factory	enable factory reset	pg. 76
Find	finds device with blinking white LED	pg. 54
i	device information	pg. 71
I2C	change I²C address	pg. 75
Invert	invert dispensing direction	pg. 65
L	enable/disable LED	pg. 53
Name	set/show name of device	pg. 70
O	enable/disable parameters	pg. 68
P	pauses the pump during dispensing	pg. 63
Plock	enable/disable protocol lock	pg. 74
Pv	check pump voltage	pg. 69
R	returns a single reading	pg. 55
Sleep	enter sleep mode/low power	pg. 73
Status	retrieve status information	pg. 72
Tv	total volume dispensed	pg. 66
X	stop dispensing	pg. 64

LED control

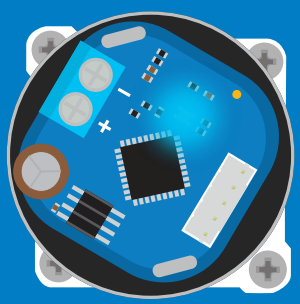
Command syntax

300ms processing delay

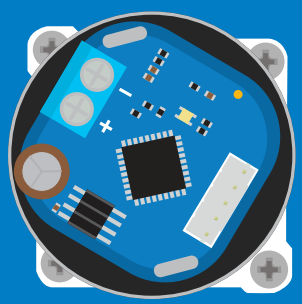
L,1	LED on	default
L,0	LED off	
L,?	LED state on/off?	

Example Response

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** Wait 300ms → 1 Dec, ?L,0 ASCII, 0 Null



L,1



L,0

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Find

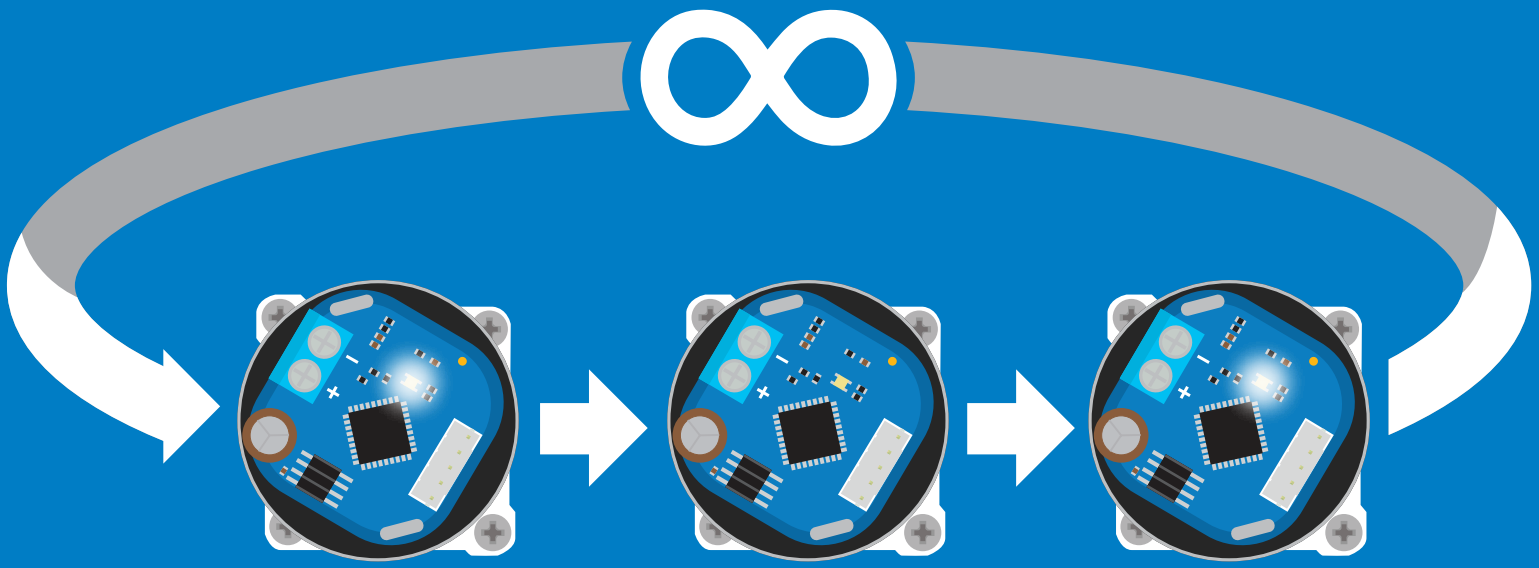
300ms processing delay

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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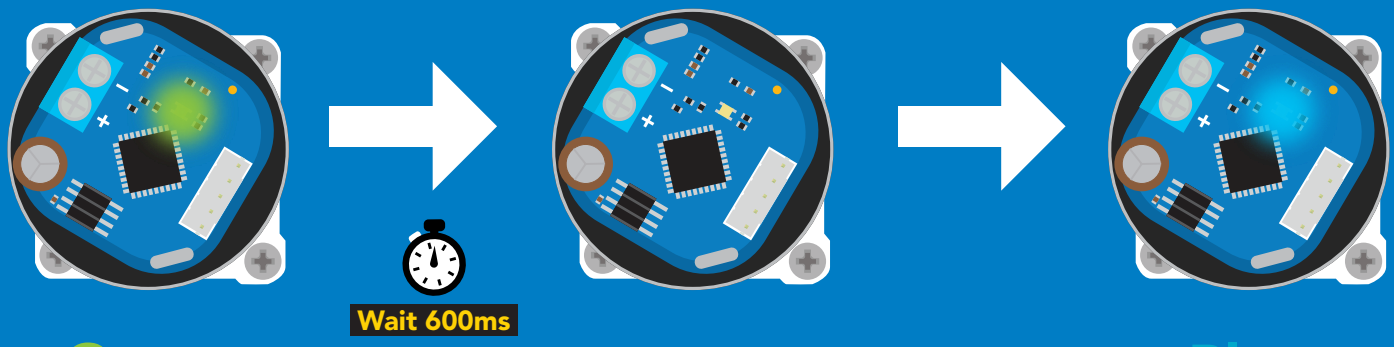
Single report mode

Command syntax

300ms processing delay

R returns a single value showing dispensed volume

Example	Response
R	Wait 300ms — 1 (Dec) 25 (ASCII) 0 (Null) — (If issued half way through dispensing 50ml)
	Wait 300ms — 1 (Dec) 50 (ASCII) 0 (Null) — (If issued once dispensing has stopped)



Green
Taking reading

Transmitting

Blue
Standby

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Continuous dispensing

Pump on/pump off

300ms processing delay

Command syntax

After running in continuous mode for 20 days the EZO-PMP-L™ will reset.

D,*	dispense until the stop command is given
D,-*	dispense in reverse until the stop command is given
D,?	dispense status

Example	Response
D,*	Wait 300ms — 1 (Dec) 0 (Null) — pump will continuously run at ~750ml/min (with supplied tubing)
D,-*	Wait 300ms — 1 (Dec) 0 (Null) — pump will continuously run in reverse at ~750ml/min (with supplied tubing)
D,?	Wait 300ms — 1 (Dec) ?D,*,1 (ASCII) 0 (Null)

Response breakdown

?D,*,1

- ? — last volume requested
- * — pump on

Atlas Scientific™ Environmental Robotics

Volume dispensing

Pump a specific volume

300ms processing delay

Command syntax

where [ml] is any volume in millimeters >= 0.5

D,[ml]	dispense [this specific volume]
D,[-ml]	dispense [*in reverse* this specific volume]
D,?	dispense status

Example	Response
D,15	Wait 300ms → 1 (Dec) 0 (Null) — 15 ml will be dispensed
D,-40	Wait 300ms → 1 (Dec) 0 (Null) — 40 ml will be dispensed *in reverse*
D,?	Wait 300ms → 1 (Dec) ?D,-40,0 (ASCII) 0 (Null)

Response breakdown

?D,-40,0

- -40 ↑ last volume dispensed
- 0 ↑ pump off

Atlas Scientific™ Environmental Robotics

Dose over time

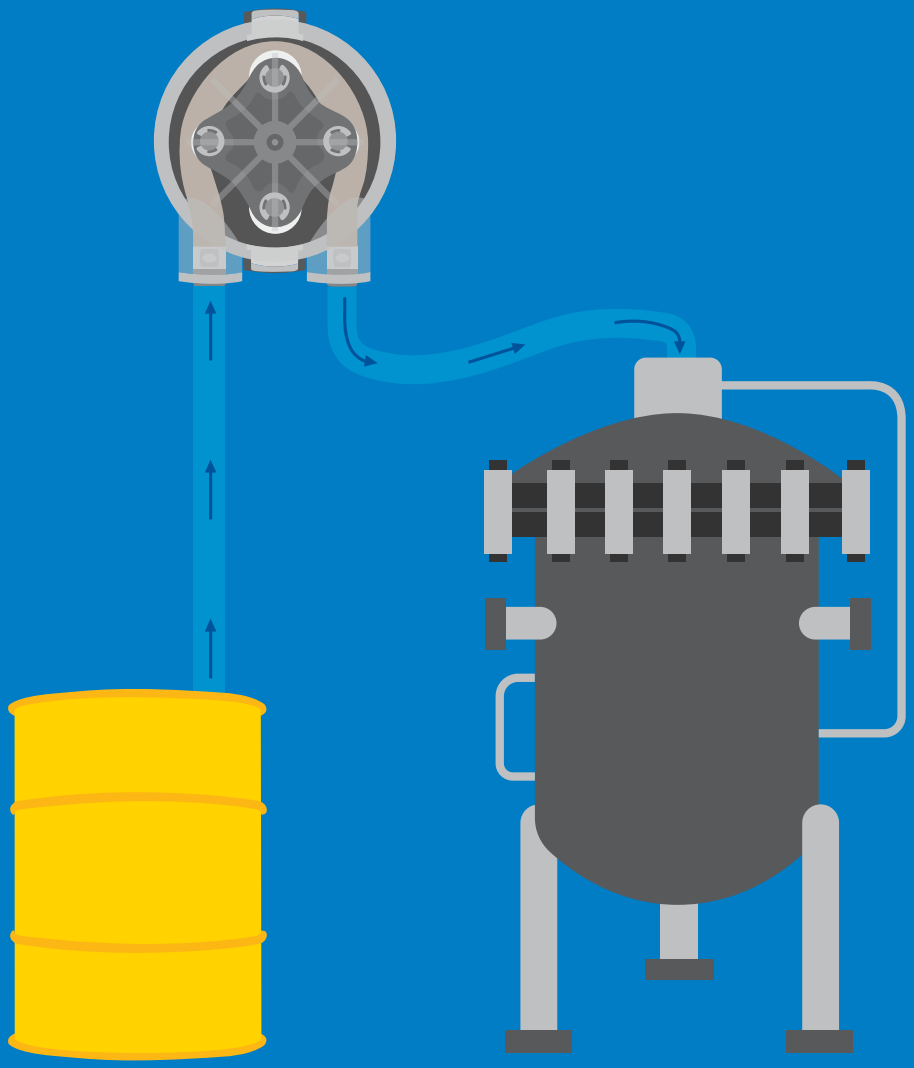
Pump a fixed volume over a fixed time

Command syntax

300ms processing delay

D,[ml],[min] Dispense [this volume], [over this many minutes]

Example	Response
D,7000,20	Wait 300ms; 1 Dec; 0 Null; Dispense 7000ml over 20 mins



AtlasScientific™ Environmental Robotics

Constant flow rate

Maintain a constant flow rate

300ms processing delay

Command syntax

After running in continuous mode for 20 days the EZO-PMP-L™ will reset.

DC,[ml/min], [min or *] [maintain this rate], [for this much time]

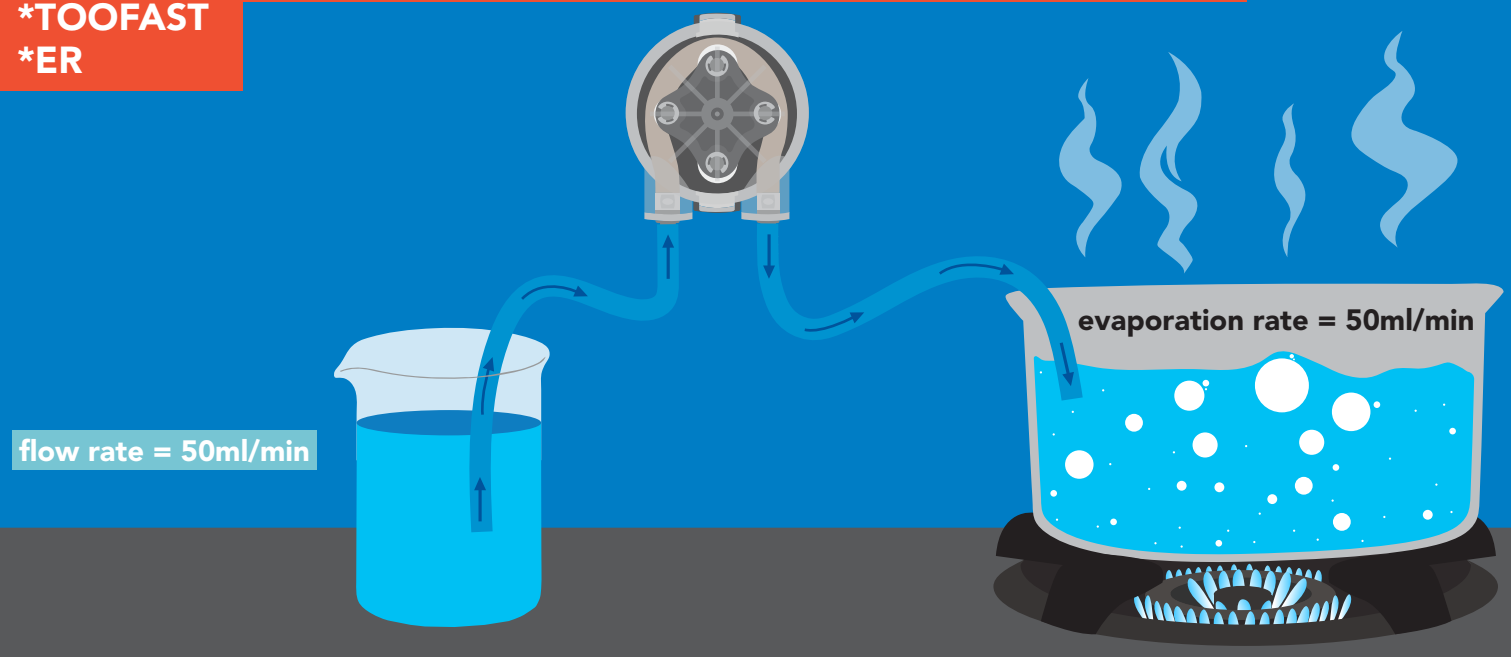
DC,? reports maximum possible flow rate

[ml/min] = a single number (int or float) representing the desired flow rate
[min or *] = the number of minutes to run or (*) indefinitely
A negative value for ml/min = reverse

Example	Response
DC,50,40	Wait 300ms → 1 (Dec) 0 (Null) — Dispense 50ml per minute for 40 minutes
DC,?	Wait 300ms → 1 (Dec) ?maxrate,385 (ASCII) 0 (Null)

The maximum flow rate is determined after calibration.
If the flowrate entered is too fast the EZO-PMP-L™ will send an error.

*TOOFAST
*ER



Dispense at startup

Pump a specific volume at startup and then stop

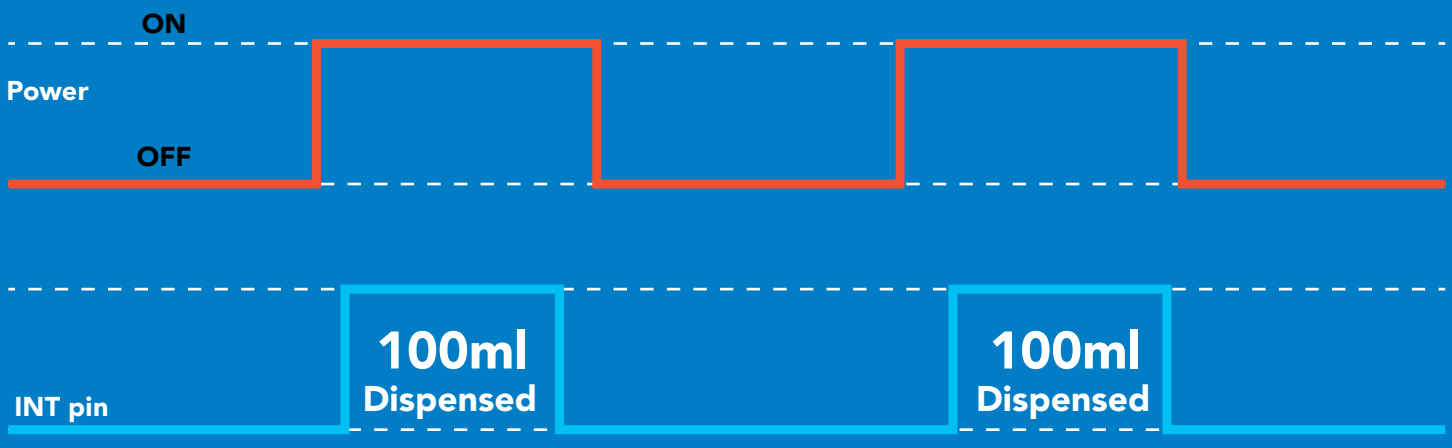
Use this command to make a simple fixed-volume pump

Command syntax

300ms processing delay

Dstart,[ml]	dispense [this specific volume] at startup
Dstart,off	disables dispense at startup mode
Dstart,?	startup dispense status

Example	Response
Dstart,100	Wait 300ms · 1 (Dec) · 0 (Null)
Dstart,off	Wait 300ms · 1 (Dec) · 0 (Null)
D,?	Wait 300ms · 1 (Dec) · ?Dstart,100 (ASCII) · 0 (Null) or Wait 300ms · 1 (Dec) · ?Dstart,0 (ASCII) · 0 (Null)



Atlas Scientific Environmental Robotics

Continuous dispensing at startup

Pump on & continuously dispense

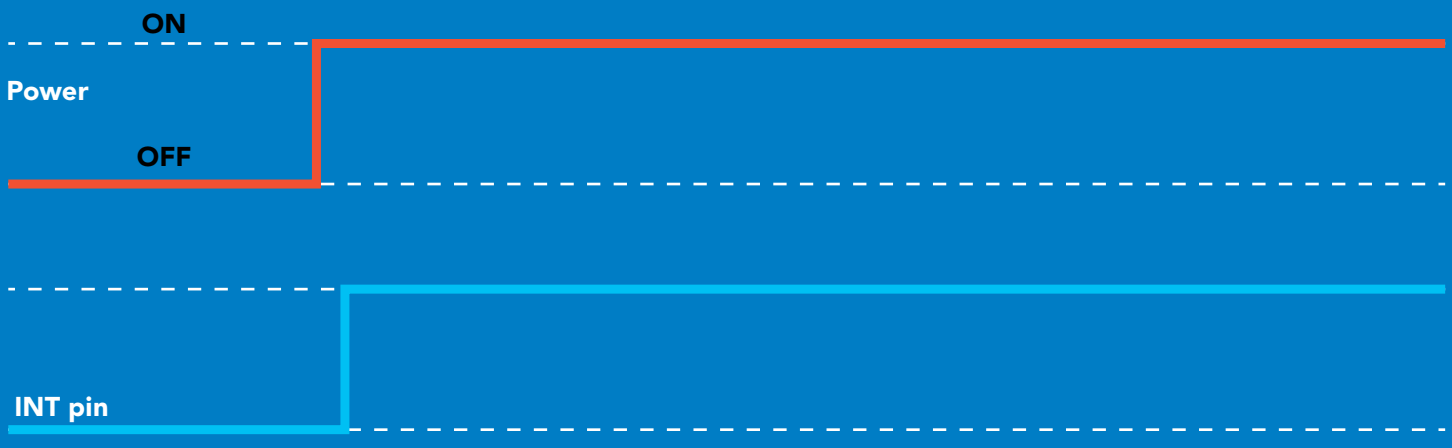
300ms processing delay

Command syntax

After running in continuous mode for 20 days the EZO-PMP-L™ will reset.

Dstart,*	dispense at startup until the stop command is given
Dstart,-*	dispense in reverse at startup until the stop command is given
Dstart,?	startup dispense status

Example	Response	
Dstart,*	Wait 300ms	1 (Dec) 0 (Null) — Pump will startup and continuously run at ~750ml/min (with supplied tubing)
Dstart,-*	Wait 300ms	1 (Dec) 0 (Null) — Pump will startup and continuously run in reverse at ~750ml/min (with supplied tubing)
Dstart,?	Wait 300ms	1 (Dec) ?Dstart,* (ASCII) 0 (Null)



Atlas Scientific Environmental Robotics

Dose Over time at startup

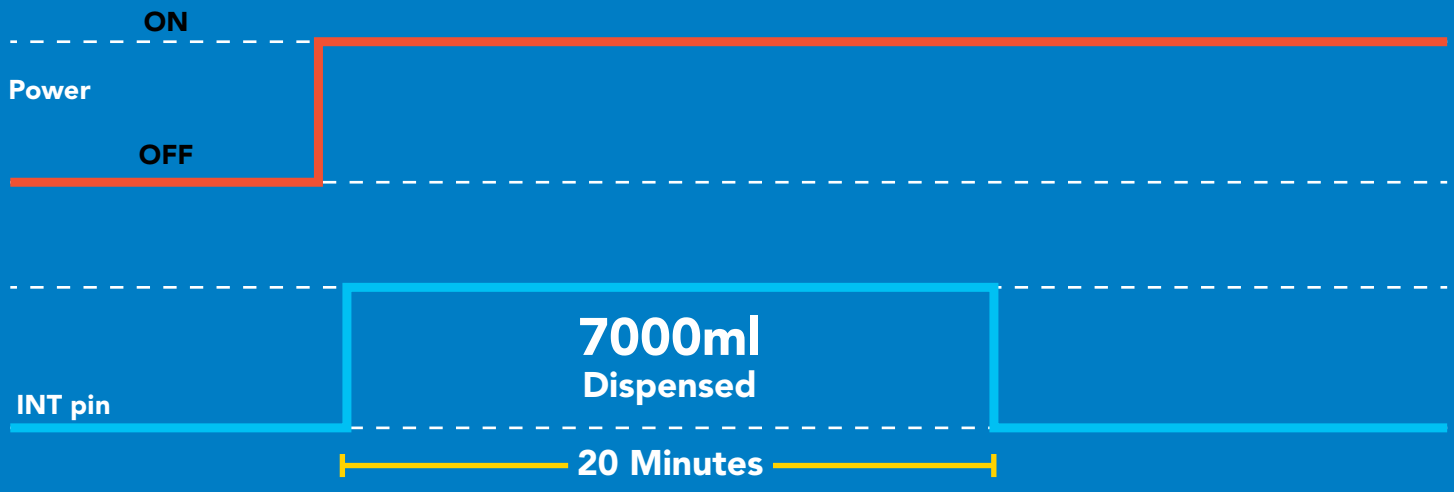
Pump a fixed volume over a fixed time at startup

Command syntax

300ms processing delay

Dstart[ml],[min]	Dispense [volume], [over this many minutes] at startup

Example	Response
Dstart,7000,20	Wait 300ms; 1 (Dec); 0 (Null) — Pump will startup and dispense 7000ml over 20 minutes
Dstart,?	Wait 300ms; 1 (Dec); ?Dstart,7000,10.00 (ASCII); 0 (Null)



AtlasScientific™ Environmental Robotics

Pause dispensing

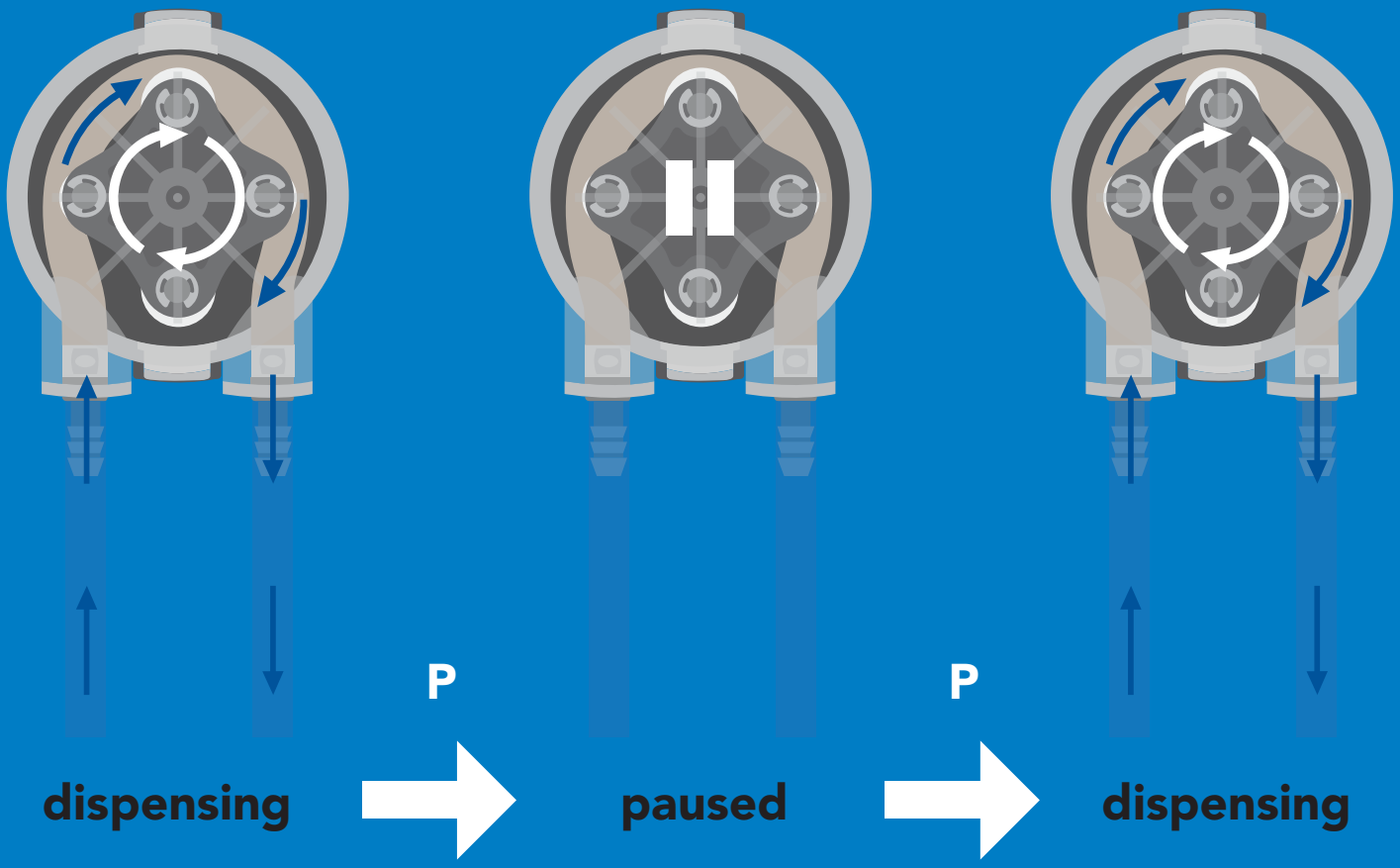
Command syntax

300ms processing delay

Issue the command again to resume dispensing

P	pauses the pump during dispensing
P,?	pause status

Example	Response
P	Wait 300ms → 1 (Dec) 0 (Null)
P,?	Wait 300ms → 1 (Dec) ?P,1 (ASCII paused) 0 (Null) **or** Wait 300ms → 1 (Dec) ?P,0 (ASCII unpaused) 0 (Null)



AtlasScientific™ Environmental Robotics

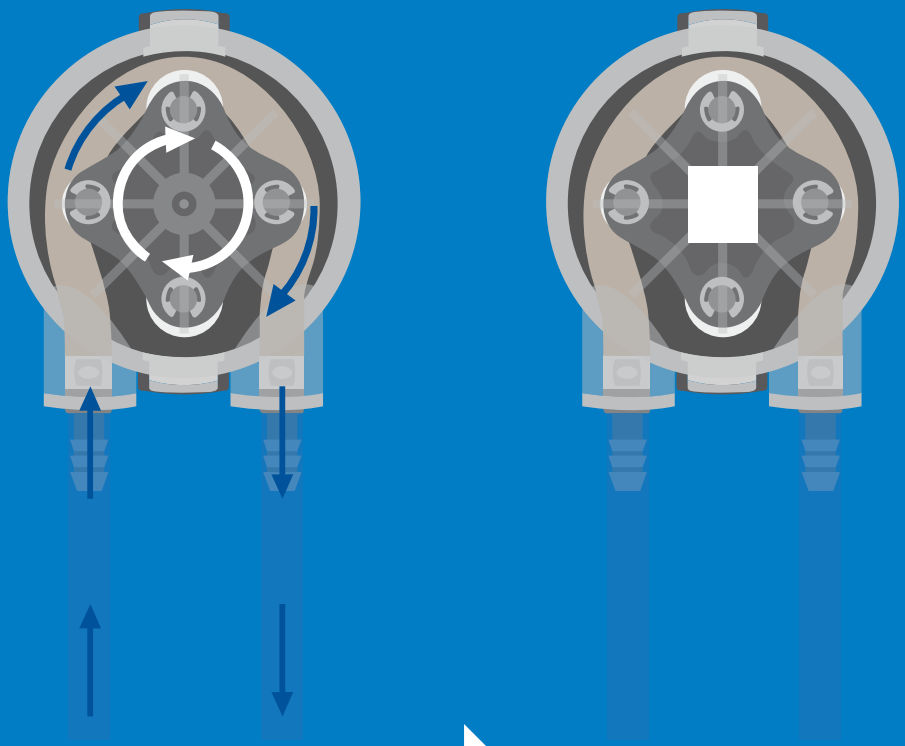
Stop dispensing

Command syntax

300ms processing delay

X stop dispensing

Example	Response
X	Wait 300ms (1 Dec) *DONE,v (ASCII) 0 (Null) — v = volume dispensed



X
dispensing

→

*DONE,645.8
Stopped

AtlasScientific™
Environmental Robotics
r 0.1

Invert dispensing direction

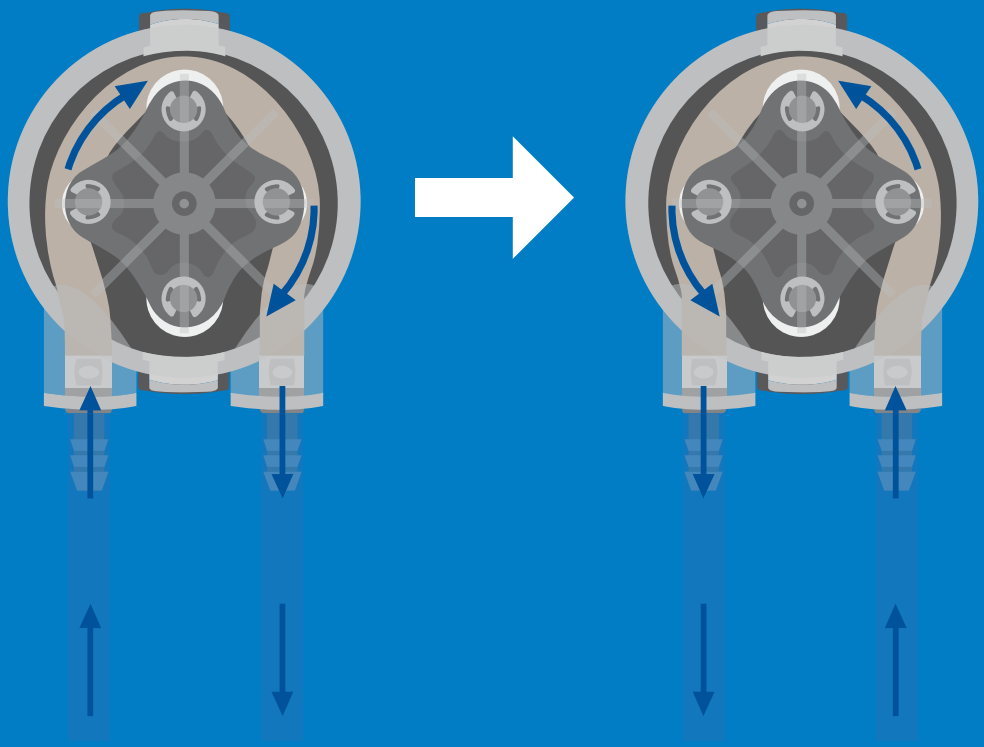
300ms processing delay

Command syntax

Invert direction will be retained if power is cut

Invert	changes dispensing direction of pump

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



AtlasScientific™ Environmental Robotics

Total volume dispensed

Command syntax

300ms processing delay

TV,?	shows total volume dispensed
ATV,?	absolute value of the total volume dispensed
Clear	clears the total dispensed volume

Example	Response
TV,?	Wait 300ms — 1 Dec — ?TV,623.00 ASCII — 0 Null
ATV,?	Wait 300ms — 1 Dec — ?ATV,434.50 ASCII — 0 Null
clear	Wait 300ms — 1 Dec — 0 Null — total now 0.00

This data will be lost if the power is cut.

Atlas Scientific Environmental Robotics

Calibration

Command syntax

300ms processing delay

Calibrate to the actual volume dispensed.

Cal,v	v = corrected volume
Cal,clear	delete calibration data
Cal,?	device calibrated?

Example	Response
Cal,146.2	Wait 300ms → 1 (Dec) 0 (Null)
Cal,clear	Wait 300ms → 1 (Dec) 0 (Null)
Cal,?	Wait 300ms → 1 (Dec) ?Cal,1 (ASCII, fixed volume) 0 (Null) or Wait 300ms → 1 (Dec) ?Cal,2 (ASCII, volume/time) 0 (Null) Wait 300ms → 1 (Dec) ?Cal,3 (ASCII, both) 0 (Null) or Wait 300ms → 1 (Dec) ?Cal,0 (ASCII, uncalibrated) 0 (Null)

Click here for more information on the calibration procedure.

Atlas Scientific Environmental Robotics

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,V,1	Wait 300ms · 1 Dec · 0 Null — enable volume being pumped
O,TV,0	Wait 300ms · 1 Dec · 0 Null — disable total volume pumped
O,ATV,1	Wait 300ms · 1 Dec · 0 Null — enable absolute volume pumped
O,?	Wait 300ms · 1 Dec · ?,O,V,TV,ATV ASCII · 0 Null — if all three are enabled

Atlas Scientific Environmental Robotics

Pump voltage

Command syntax

300ms processing delay

PV,? check pump voltage

Example

PV,?

Response

Wait 300ms

1	?PV,24.67	0
Dec	ASCII	Null

Response breakdown

?PV, 24.67

Pump input voltage

Naming device

300ms processing delay

Command syntax

Do not use spaces in the name

Name,n	set name
Name,	clears name
Name,?	show name

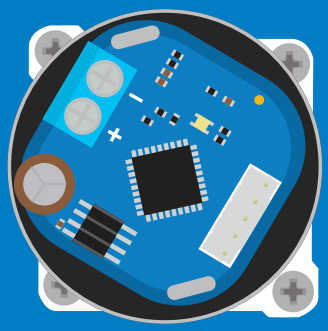
n = _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _

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

Up to 16 ASCII characters

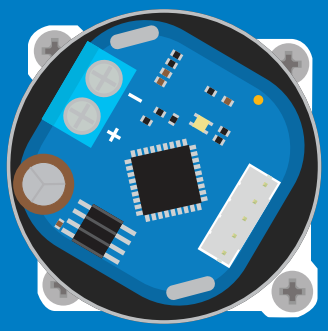
Example	Response
Name,	Wait 300ms — 1 Dec — 0 Null — name has been cleared
Name,zzt	Wait 300ms — 1 Dec — 0 Null
Name,?	Wait 300ms — 1 Dec — ?Name,zzt ASCII — 0 Null

Name,zzt



1 0

Name,?



1 ?Name,zzt 0

Atlas Scientific Environmental Robotics

Device information

Command syntax

300ms processing delay

i device information

Example

i

Response

1 Dec

?i,PMPL, 1.1 ASCII

0 Null

Response breakdown

?i, PMPL, 1.1

PMPL: Device

1.1: Firmware

Reading device status

Command syntax

300ms processing delay

Status voltage at Vcc pin and reason for last restart

Example

Status

Response

1	?Status,P,5.038	0
Dec	ASCII	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

Atlas Scientific Environmental Robotics

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	13.4 mA	0.415 mA
3.3V	12.4 mA	0.13 mA

Standby

Sleep

AtlasScientific™ Environmental Robotics

Protocol lock

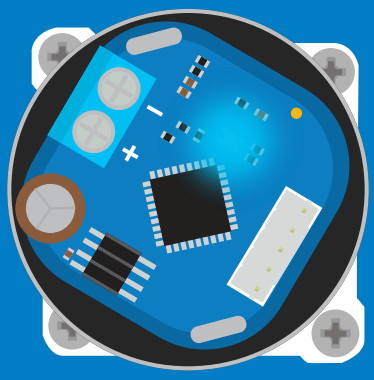
Command syntax

300ms processing delay

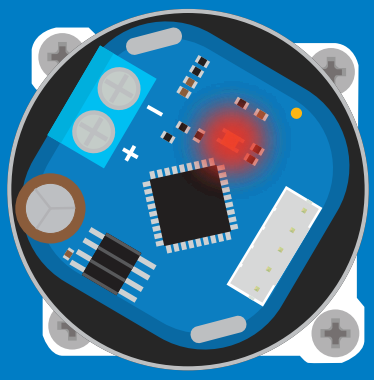
Plock,1	enable Plock	Locks device to I²C mode.
Plock,0	disable Plock	default
Plock,?	Plock on/off?	

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

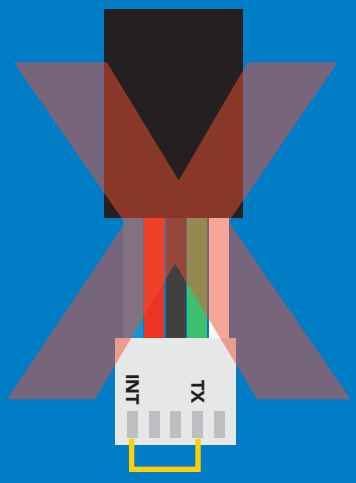
Plock,1



Baud, 9600



cannot change to UART



cannot change to UART

Atlas Scientific™ Environmental Robotics

I²C address change

Command syntax

300ms processing delay

I2C,n sets I²C address and reboots into I²C mode

Example	Response
I2C,101	device reboot (no response given)

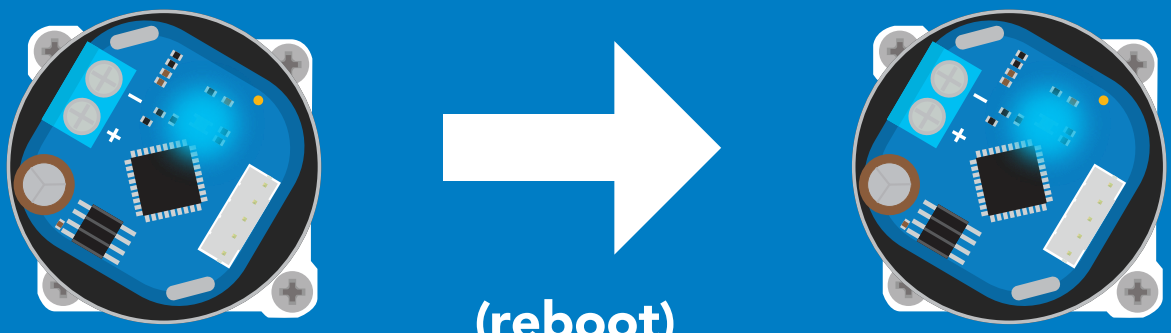
n = any number 1 – 127

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 109 (0x6D.

I2C,101



Atlas Scientific Environmental Robotics

Factory reset

Command syntax

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

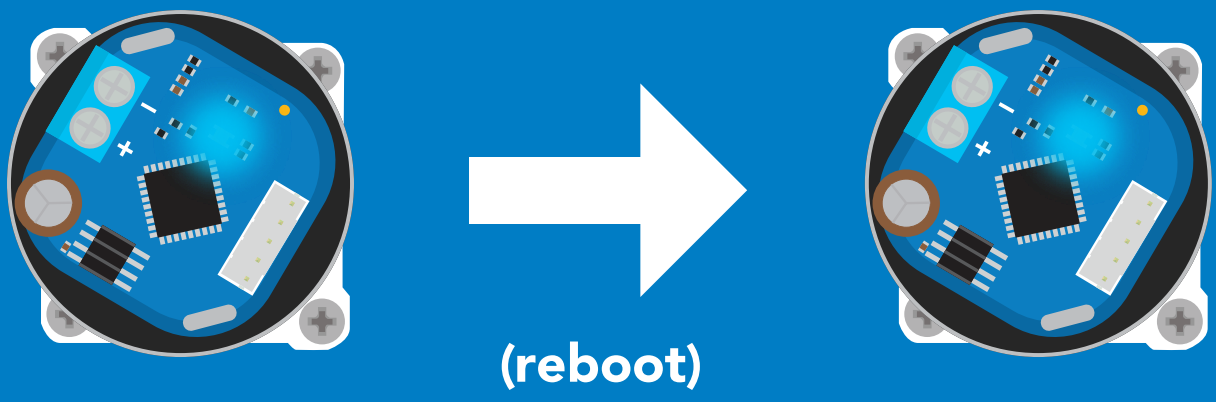
Factory enable factory reset

I²C address will not change

Example	Response
Factory	device reboot (no response given)

Clears calibration
LED on
Response codes enabled

Factory



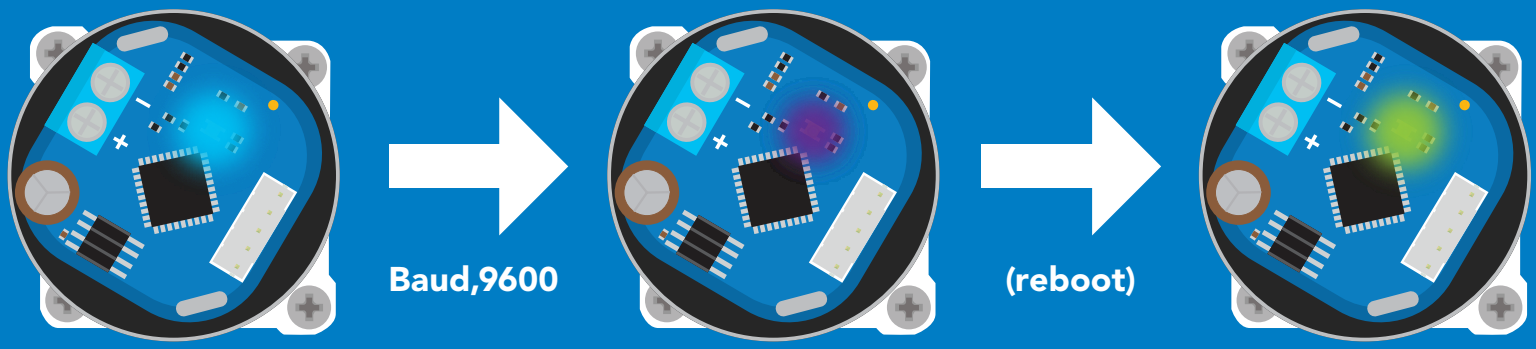
Change to UART mode

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

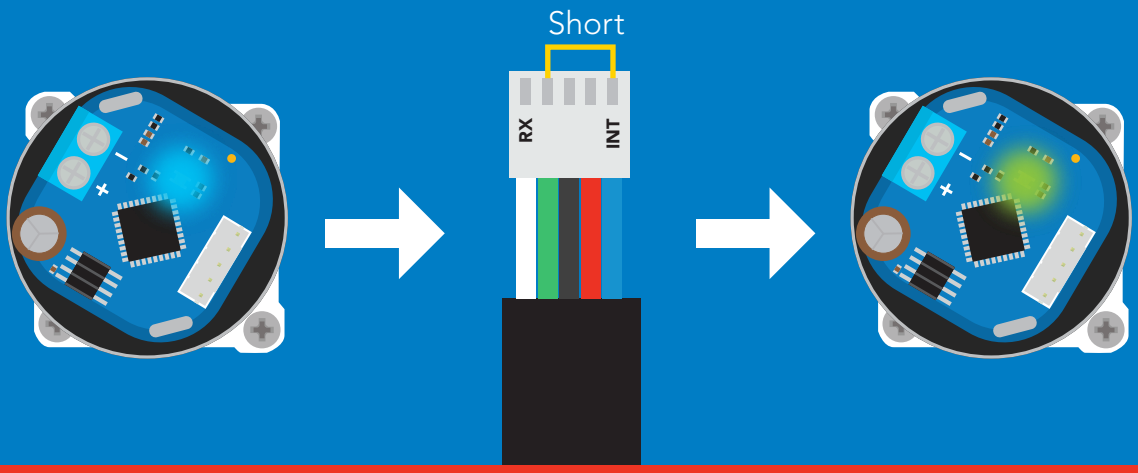


Changing to UART mode

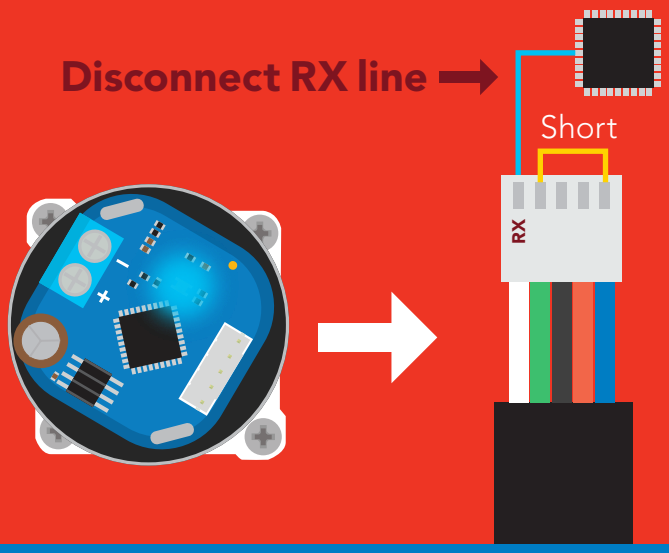
Manual switching to UART

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

Example



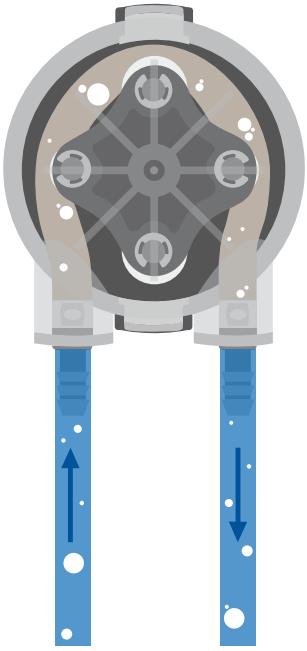
Wrong Example

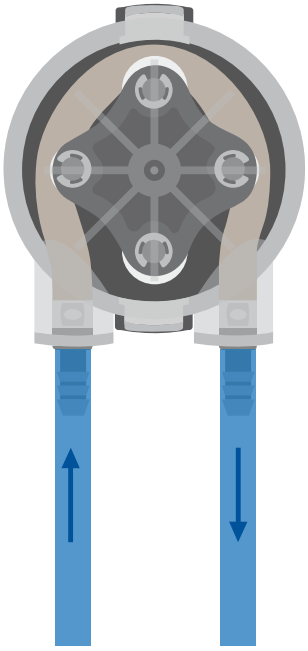


Calibration theory

Before calibration is attempted all the air bubbles should be removed from the tubing. This is done by running the pump while tapping the tubing. If air bubbles are not removed from the tubing they will slowly group together into larger air bubbles. Over time this will lead to accuracy issues.

Not ready for calibration X





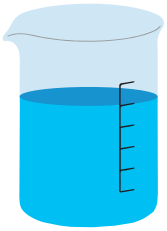
✓ **Ready for calibration**

Calibration types

Volume calibration
Volume over time calibration

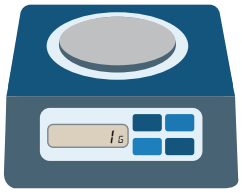
Calibration is optional. Both types of calibration are independent of each other and can be done at any time. Calibration can be done at any volume however; Atlas Scientific recommends using volumes above 150ml.

Equipment needed for calibration



An accurate beaker of at least 250ml.

Or



An accurate scale with a resolution of at least 1 gram.

1 gram of water = 1ml
250 grams of water = 250ml

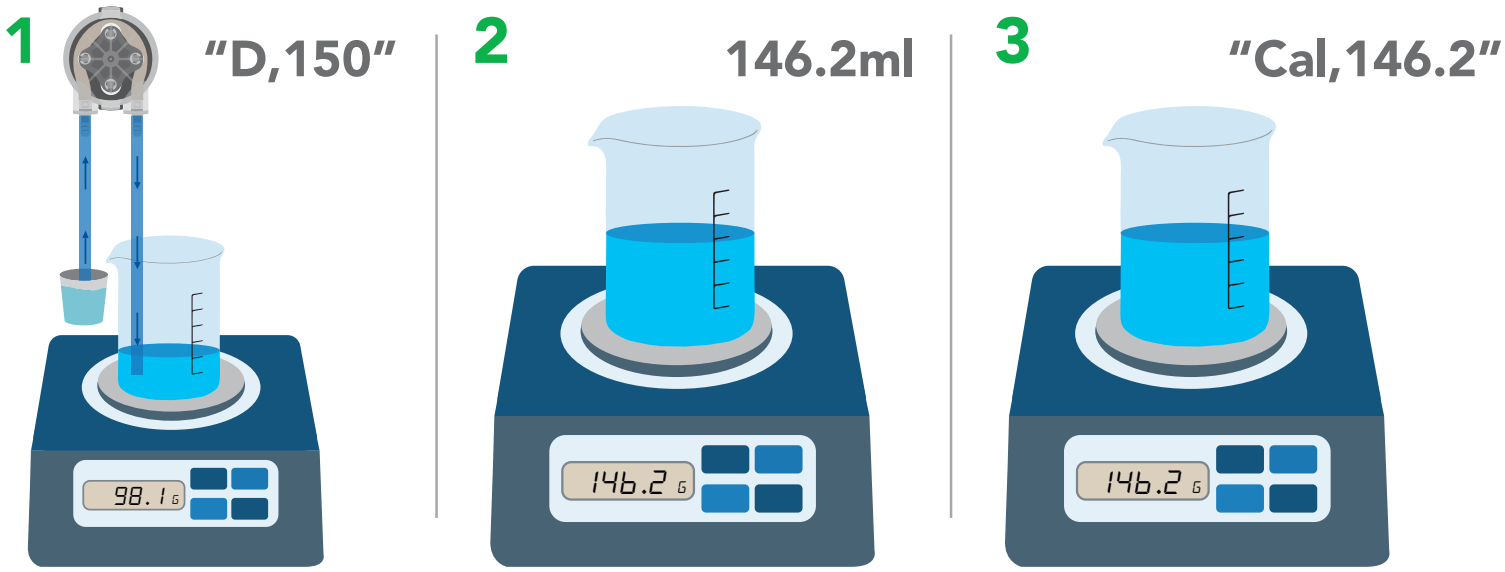
Calibration procedure

Calibration should be done with water and not a chemical

Make sure the tubing is full of water and has no bubbles before calibrating.

1. Instruct the pump to dispense a volume of water.
2. Measure the dispensed amount to determine how much water was actually dispensed.
3. Calibrate the pump by sending it the volume of liquid you have measured.

Example
Calibrate the pump by dispensing 150ml.



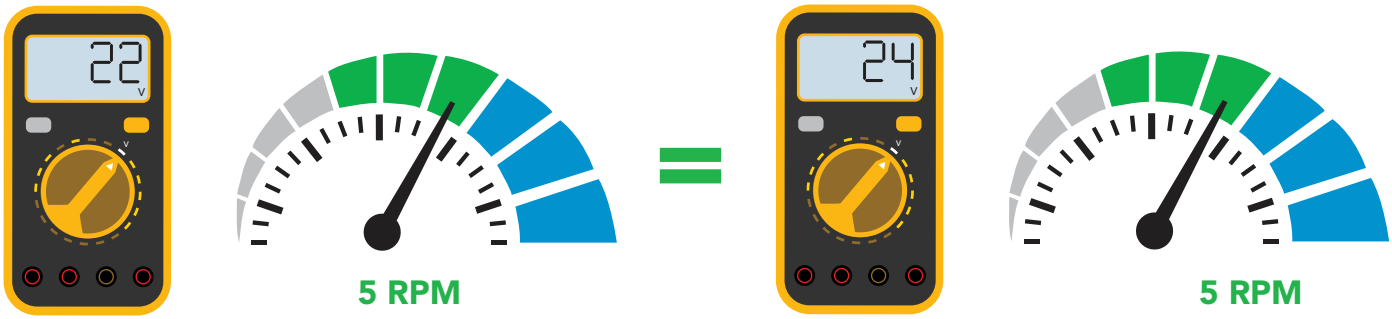
1. Instruct the pump to dispense 150ml into a beaker on a scale.
2. Measure the amount of liquid that was actually dispensed.
3. Inform the pump how much liquid was actually dispensed.
4. Calibration is now complete.

Once the pump has been calibrated it will accurately dispense any volume of liquid. It has not been calibrated specifically to the volume used during the calibration procedure (150ml). It has now been calibrated to all volumes.

Use the same procedure to perform a volume over time calibration.

Pump speed vs. voltage

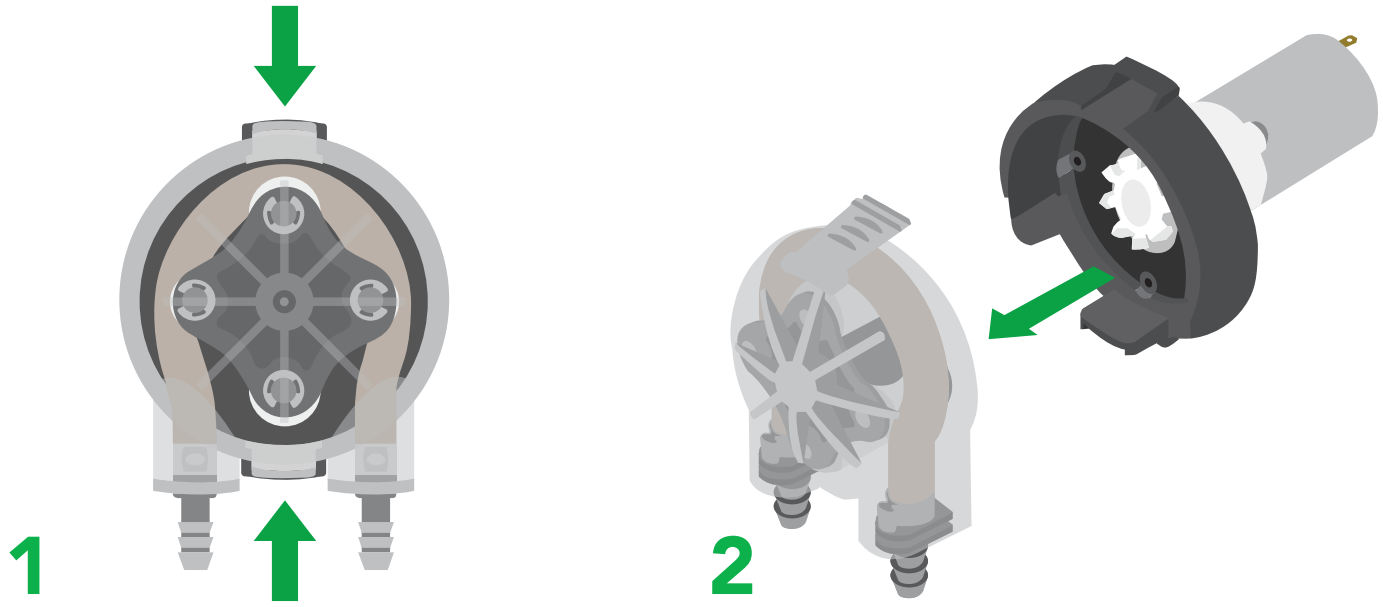
There is no change in pump speed at different voltages.



Interrupt pin

When the pump is dispensing the interrupt pin goes high.

Removing cassette



Press both release tabs on the cassette.

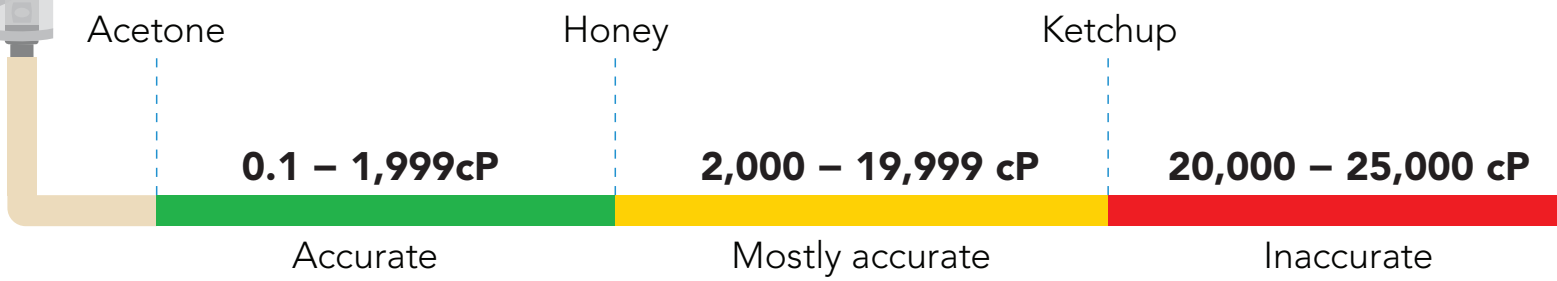
Pull the cassette off of the motor.

Viscosity

The EZO-PMP-L™ is capable of pumping liquids within a viscosity range of **0.1 – 20,000 cP**.

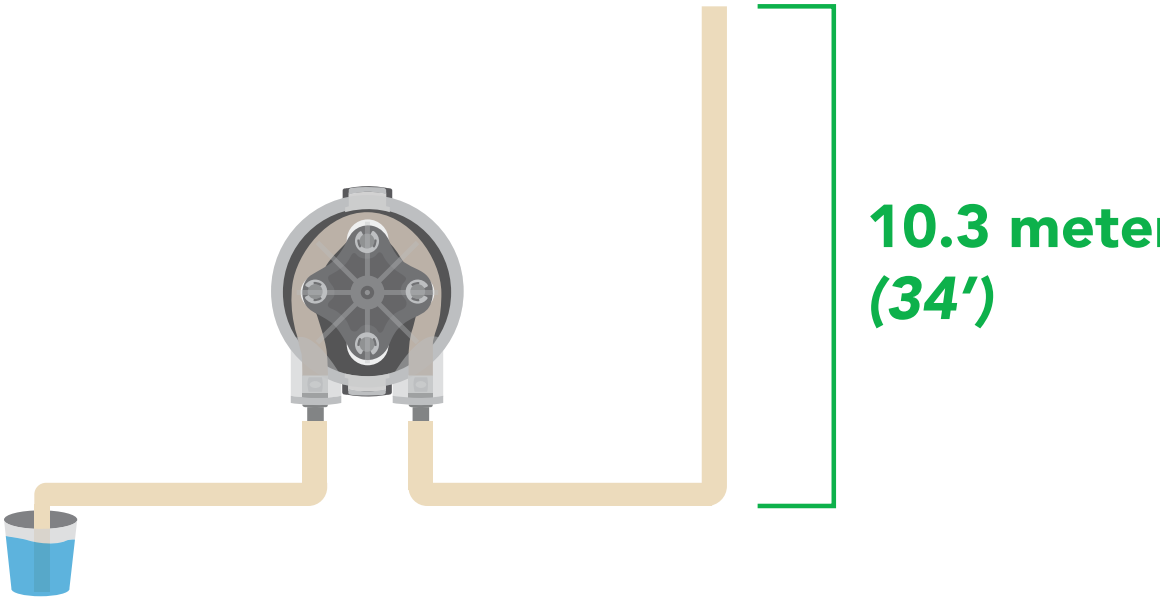
0.6	=	Acetone
1	=	Water
100	=	Corn Syrup
200	=	Maple Syrup
2,000	=	Honey
10,000	=	Hershey Chocolate Syrup
20,000	=	Ketchup

Dispense accuracy



Pump head

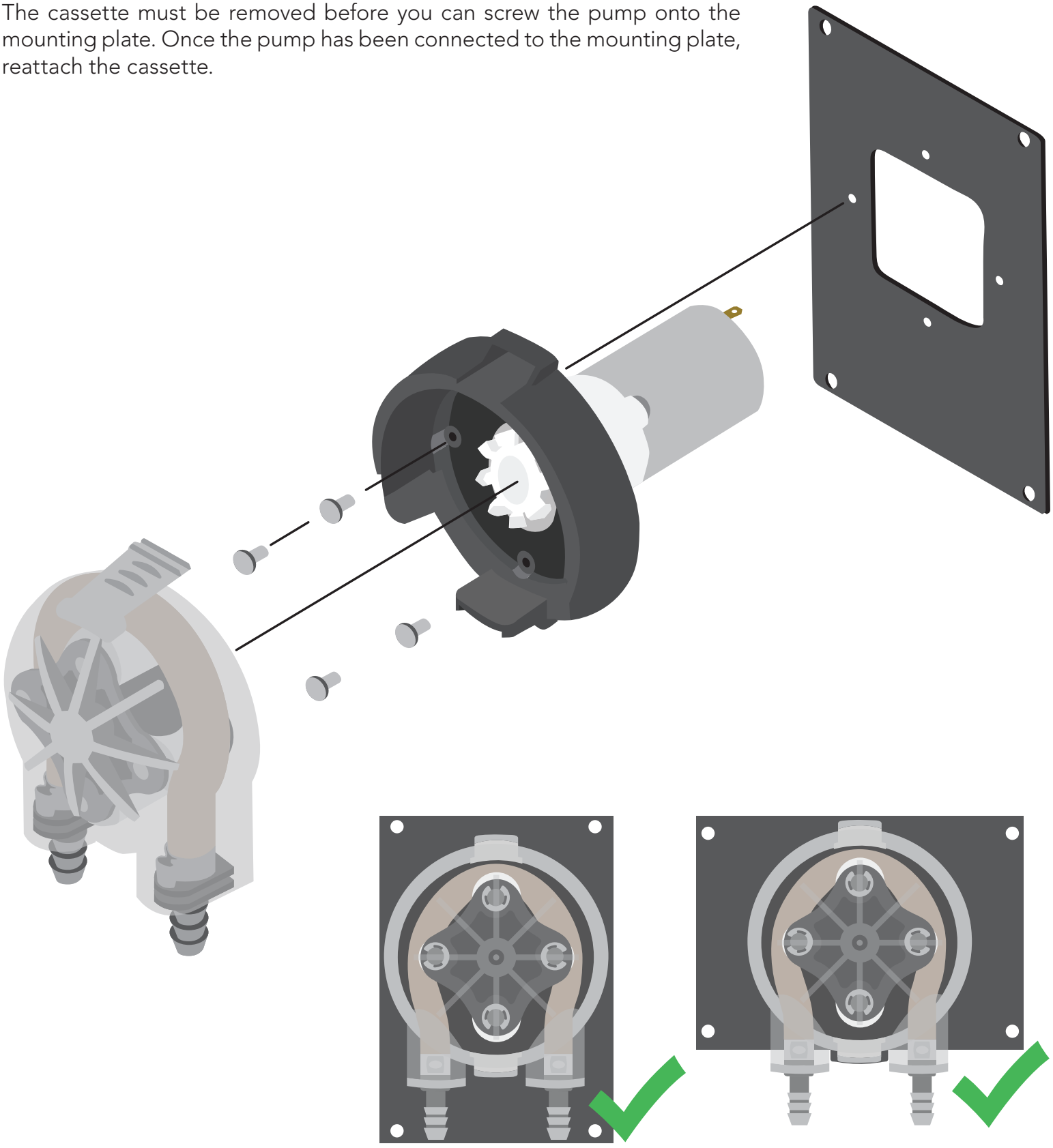
Pump head refers to the maximum vertical height a pump can dispense.
The EZO-PMP-L™ has a pump head of 10.3 meters *(34')*.



AtlasScientific™ Environmental Robotics

Mounting plate *(optional)*

The cassette must be removed before you can screw the pump onto the mounting plate. Once the pump has been connected to the mounting plate, reattach the cassette.



Datasheet change log

Datasheet V 1.6

Added Viscosity information on page 82.

Datasheet V 1.5

Revised artwork on page 7.

Datasheet V 1.4

Added a new page about power supplies on page 8.

Datasheet V 1.3

Revised table of contents and added invert dispensing direction command on pages 30 & 64.

Datasheet V 1.2

Revised naming device info on pages 36 & 67.

Datasheet V 1.1

Added Mounting plate info on pg. 9

Datasheet V 1.0

New Datasheet.

Firmware updates

V1.0 – Initial release (March, 2021)

V1.01 - (May 26, 2021)
- Changed minimum voltage for activation

V1.02 - (Feb 15, 2022)
- Internal update for new part compatibility.

V1.03 - (April 20, 2022)
- Expands dstart command with * and dispense over time

Warranty

Atlas Scientific™ Warranties the EZO-PMP-L™ Large Embedded Dosing Pump to be free of defect during the debugging phase of device implementation, or 30 days after receiving the EZO-PMP-L™ Large Embedded Dosing Pump (which ever comes first).

The debugging phase

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

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