EZO-PMP-L™

Large Embedded Dosing Pump

Flow rate	**10ml to 750ml/min**
Accuracy	**+/- 2%, +/-2ml**
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 & I^{2}C**
Default I^{2}C 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

This is an evolving document, check back for updates.

Table of contents

Attention

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

24V
to drive the motor
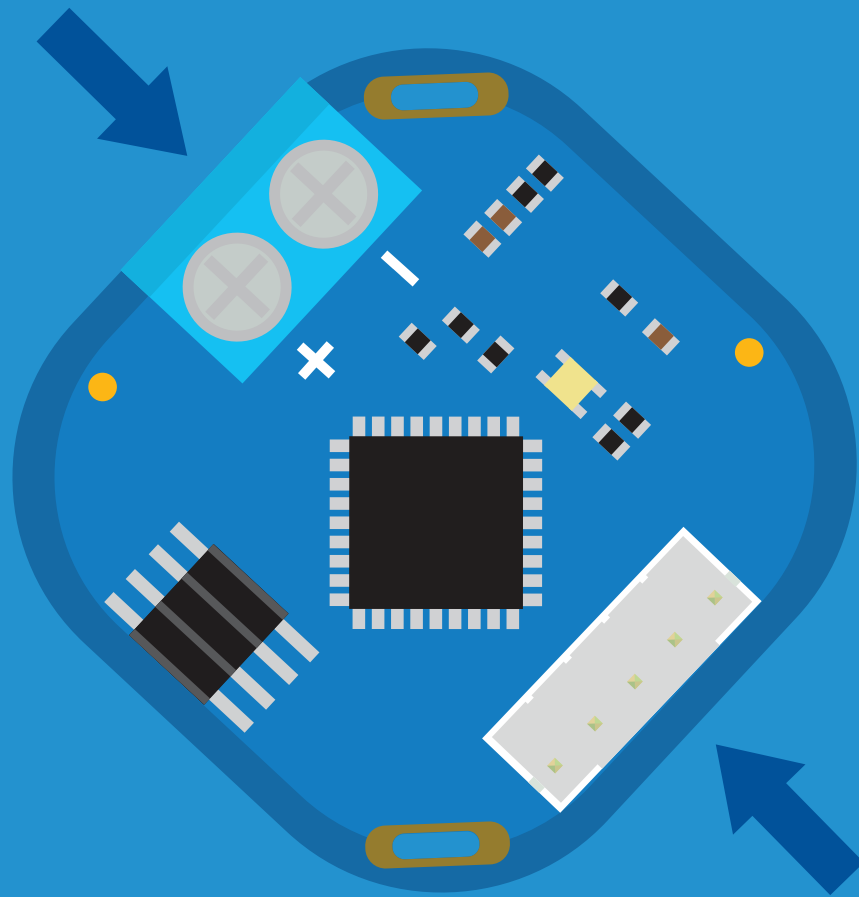
Control system
(Back side of dosing pump)

3.3V – 5.5V
for the control system

Atlas**Scientific**
Environmental Robotics

EZO-PMP-L™ dimensions

48mm   **91mm**

40mm   **Ø 36mm**

2mm

139mm

88mm

99mm

46mm
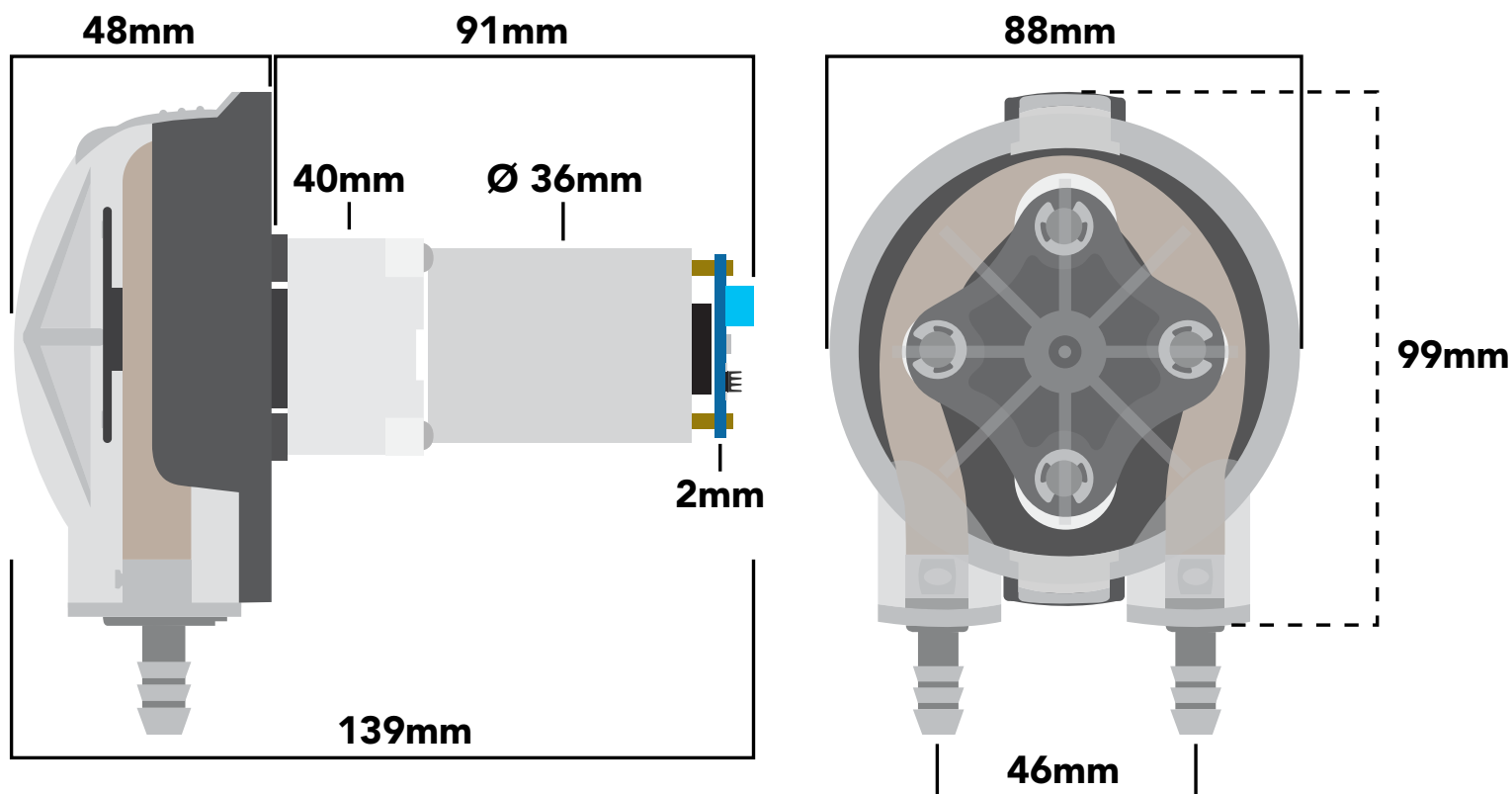
Weight 405g

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

AtlasScientific™
Environmental Robotics

r 0.1

EZO-PMP-L™ tubing

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 ✓

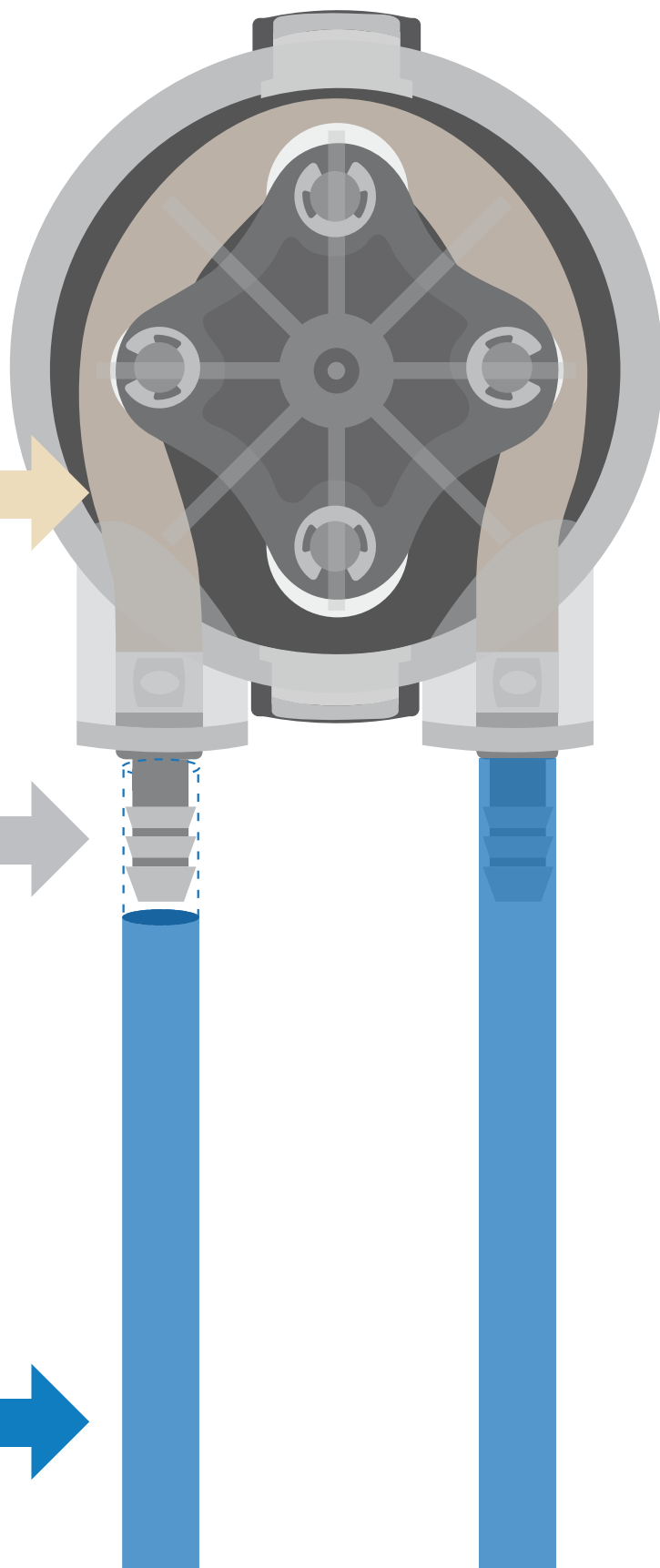**Blue tubing**
Silicone
Length: 2x 30.48cm
Outer diameter: 8mm
Inner diameter: 6mm
Bend radius: 24mm
Temperature -67°C to 200°C
Max pressure: 34 kPa (5 PSI)

Food safe ✓

AtlasScientific™
Environmental Robotics

Operating principle

✔ Self-priming
✔ Run dry

A   **B**   **C**

Max input
vacuum
-101.3 kPa

Max output
pressure
101.3 kPa
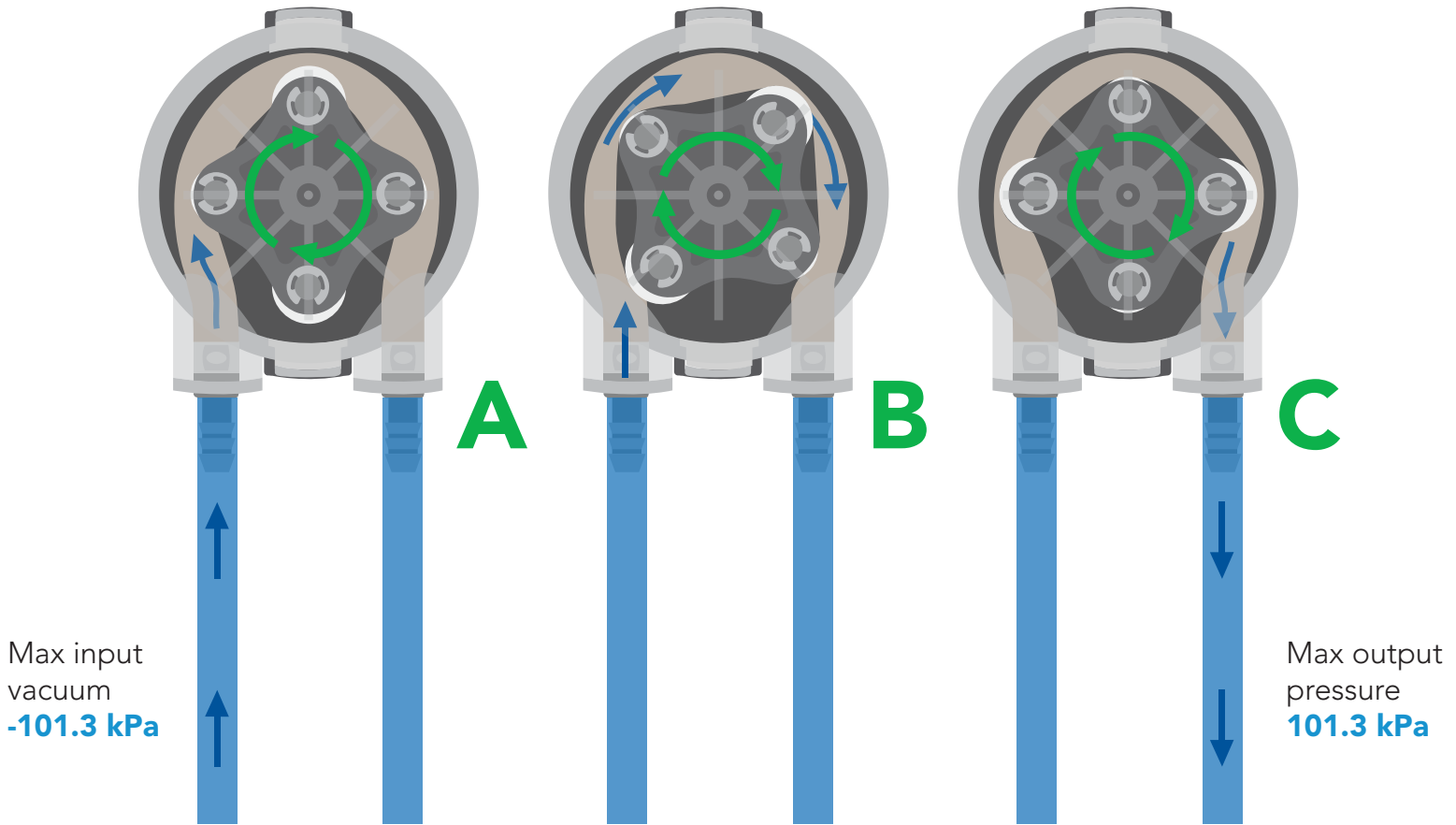
Operating modes

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

AtlasScientific™
Environmental Robotics
r 0.1

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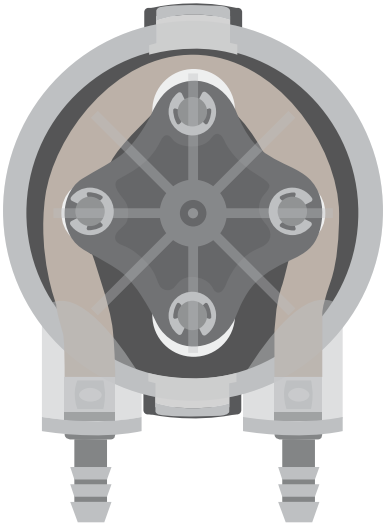
Cassette

Cassettes can be autoclave sterilized
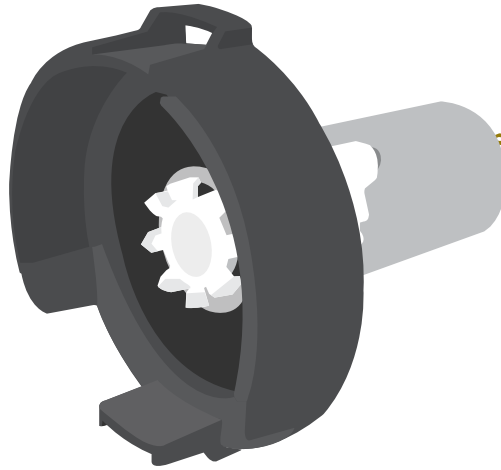
24 volt motor
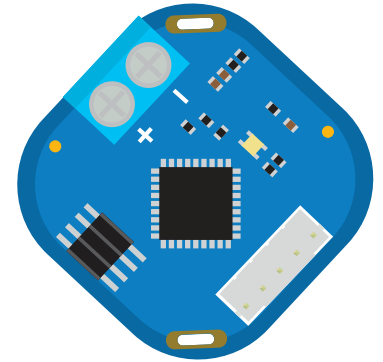
Control system

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.
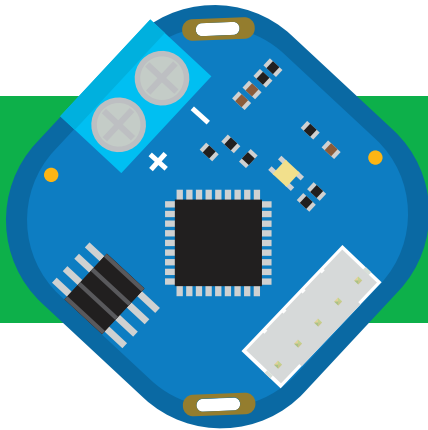
The control system has three main components

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

r 0.1

Power supplies
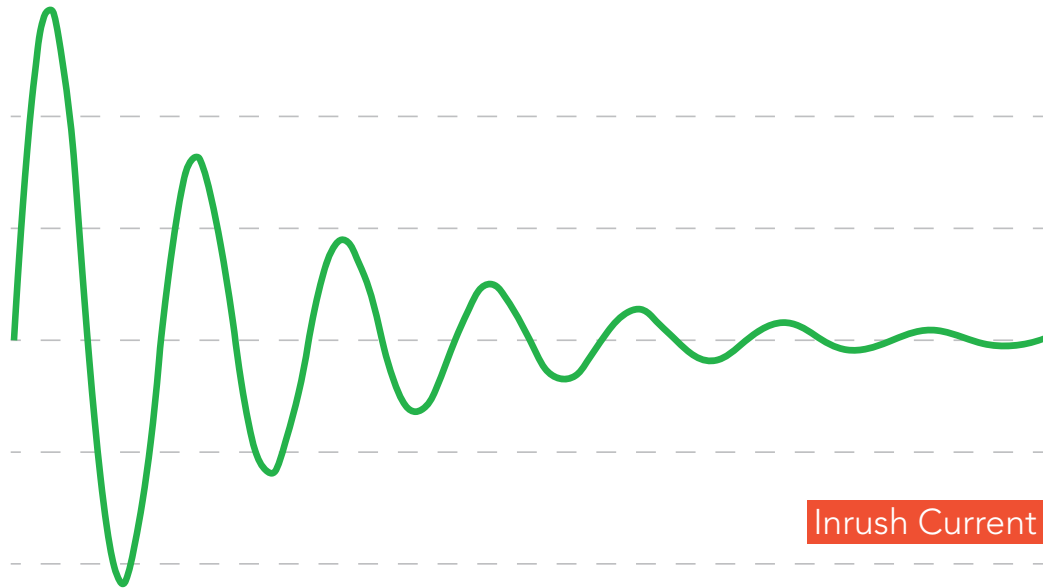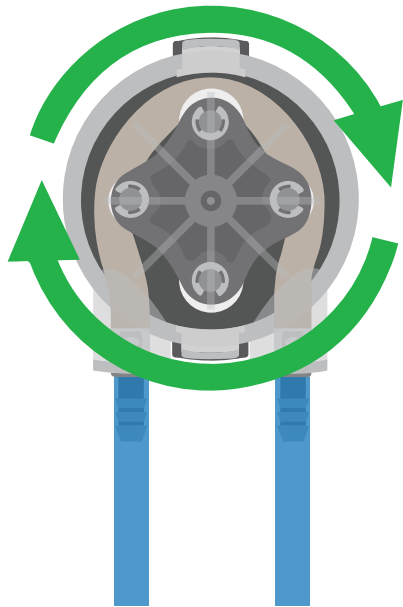
Inrush Current

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

Mean Well #EDR-120-24

Included with the EZO-PMP-L™ Kit

AtlasScientific™
Environmental Robotics

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

MCU

Dispense 22ml

✓ OK, 22ml

MCU

Dispense 56.78ml

✓ OK, 56ml
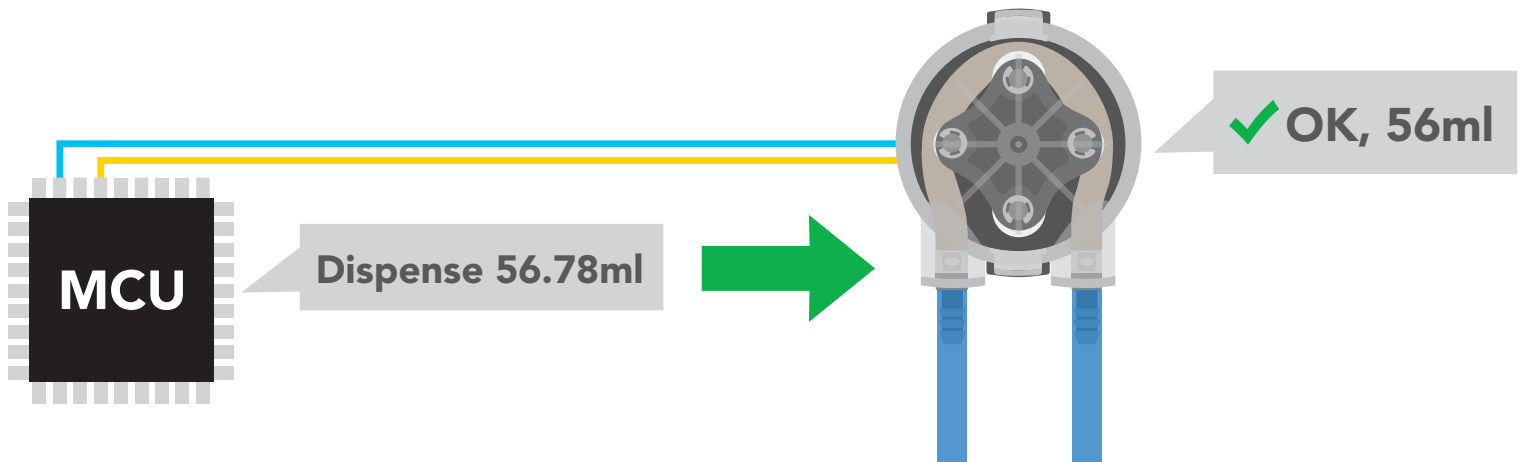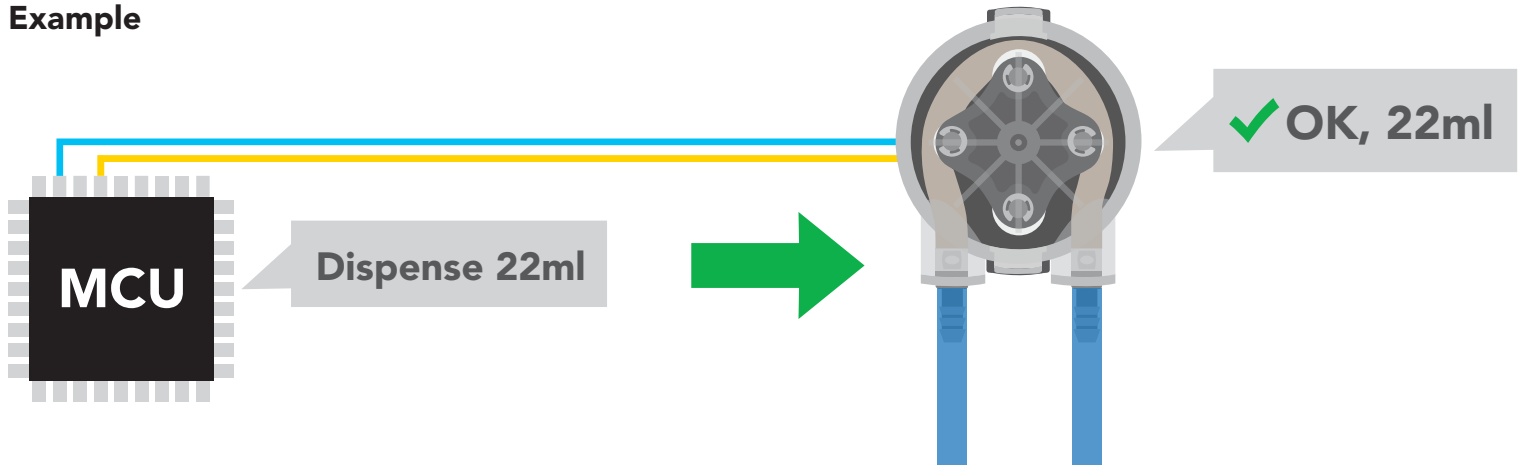
The minimum volume the EZO-PMP-L™ can dispense is 10 ml.

Example

MCU

Dispense 9ml
Dispense 10ml
Dispense 11ml
Dispense 18ml
Dispense 1453.15ml

X Too small, 9ml
✓ OK, 10ml
✓ OK, 11ml
✓ OK, 18ml
✓ OK, 1453ml

AtlasScientific™
Environmental Robotics
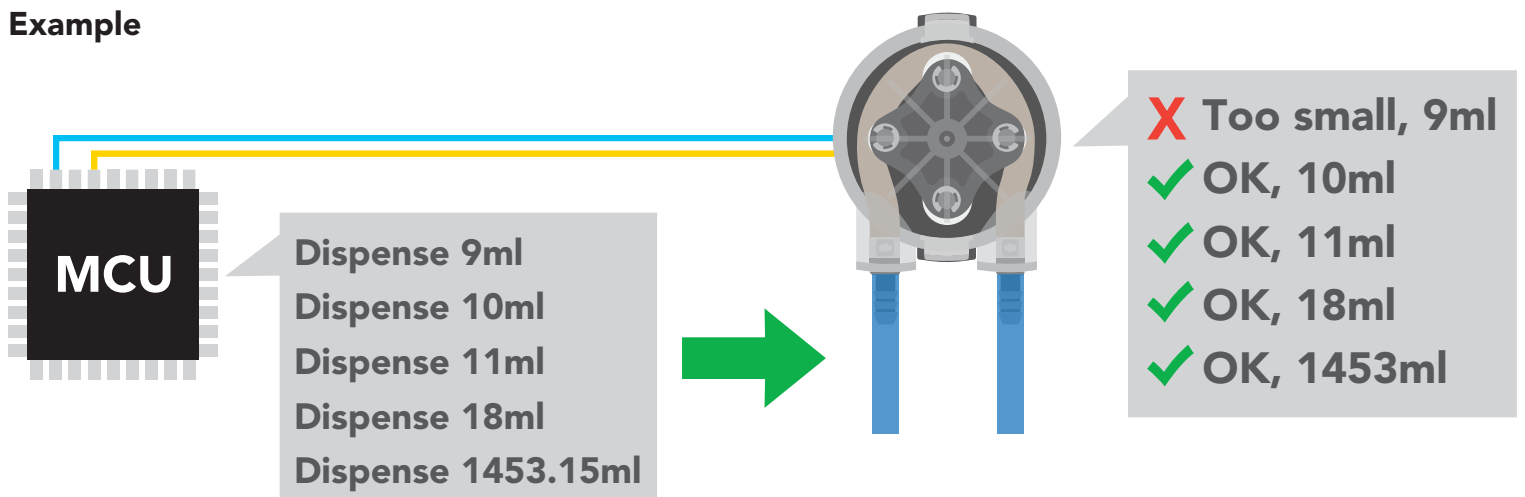
✓ Available data protocols

UART

Default

I²C

✗ Unavailable data protocols

SPI

Analog

RS-485

Mod Bus

4–20mA

Atlas Scientific
Environmental Robotics
r 0.1

Default state
UART mode

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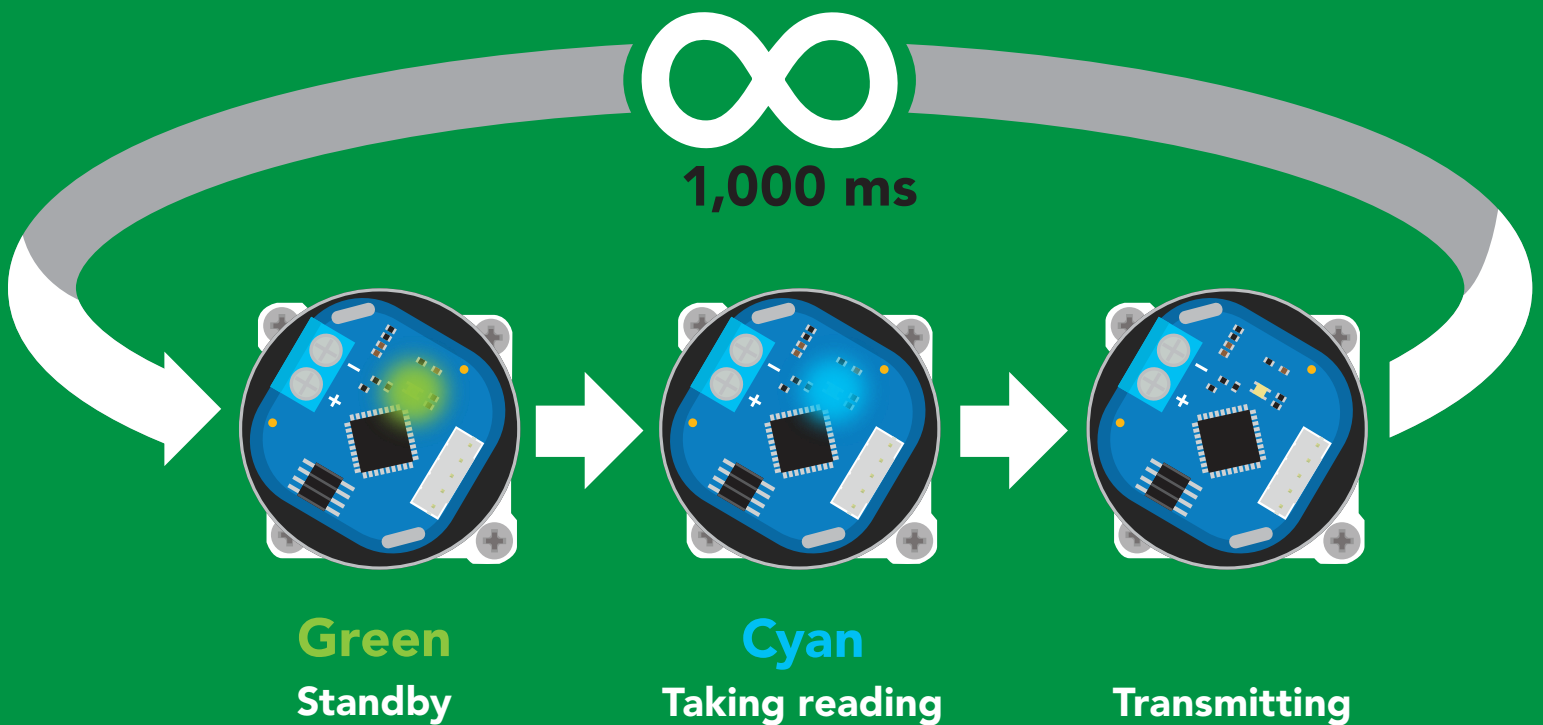
∞

1,000 ms

Green
Standby

Cyan
Taking reading

Transmitting

UART mode

AtlasScientific
Environmental Robotics

r 0.2

UART mode

8 data bits   no parity
1 stop bit   no flow control

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

RX
Data in

TX
Data out

Vcc   3.3V – 5.5V

VCC

0V   0V

TX → RX ✓   RX ← TX ✓

RX   TX

CPU

Data format

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

AtlasScientific
Environmental Robotics
r 0.1

Receiving data from device

2 parts

ASCII data string	Carriage return <cr>
Command	**Terminator**

9,600 baud (default)

RX ← TX ✓

TX → RX ✓

CPU

TX

RX

Sender

RX
TX

Receiver

413 <cr>

Advanced

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

AtlasScientific™
Environmental Robotics
r 0.1

Sending commands to device

2 parts

Command (not case sensitive)

ASCII data string

Carriage return <cr>

Terminator

RX ⟵ TX ✓

TX ⟶ RX ✓

TX

CPU

RX

Receiver

Sender

Sleep <cr>

Advanced

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

AtlasScientific™
Environmental Robotics
r 0.1

LED color definition

Green	**Cyan**	**Purple**	**Red**	**White**
UART standby	Taking reading	Changing baud rate	Command not understood	Find

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

AtlasScientific™
Environmental Robotics
r 0.1

UART mode
command quick reference

All commands are ASCII strings or single ASCII characters.

Command	Function		Default state
Baud	change baud rate	pg. 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 I^{2}C 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

r 0.1

LED control

Command syntax

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

L,0 <cr> **LED off**

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

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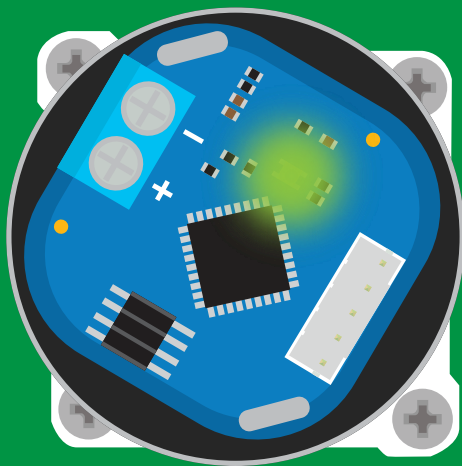
L,1
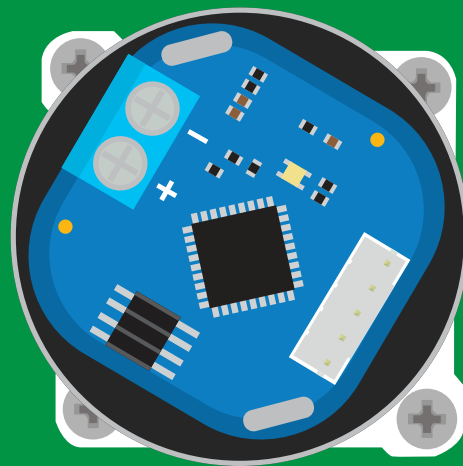
L,0

AtlasScientific™
Environmental Robotics
r 0.1

Find

Command syntax

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

Example | Response

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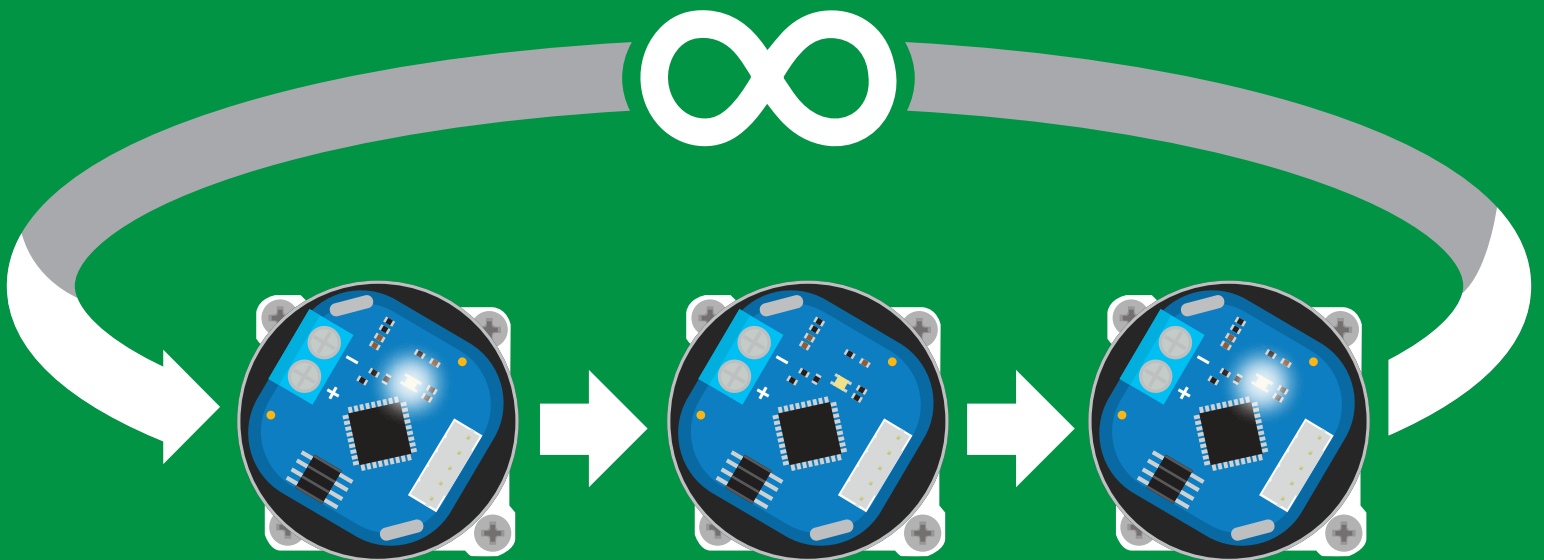
Continuous mode

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>

AtlasScientific

Environmental Robotics

r 0.1

Single reading mode

Command syntax

R <cr> **returns a single value showing dispensed volume**

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

Continuous dispensing
Pump on/pump off

Command syntax

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

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 ↑

AtlasScientific ™
Environmental Robotics
r 0.1

Volume dispensing

Pump a specific volume

Command syntax

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

Copyright © Atlas Scientific LLC

AtlasScientific
Environmental Robotics
r 0.1

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

AtlasScientific
Environmental Robotics
r 0.1

Constant flow rate

Maintain a constant flow rate

Command syntax

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

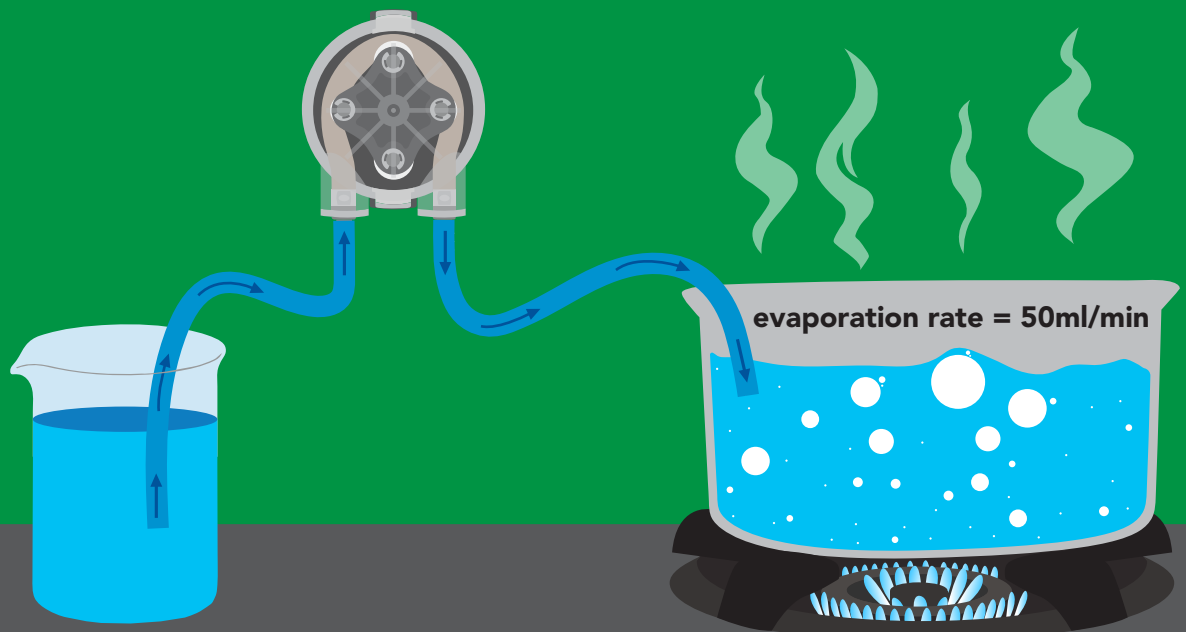| Example	Response
DC,50,40 <cr>	*OK <cr> Dispense 50ml per minute for 40 minutes
DC,? <cr>	?MAXRATE,385 <cr> *OK <cr>

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>

evaporation rate = 50ml/min

flow rate = 50ml/min

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>

ON

Power

OFF

INT pin

100ml
Dispensed

100ml
Dispensed

AtlasScientific™
Environmental Robotics
r 0.1
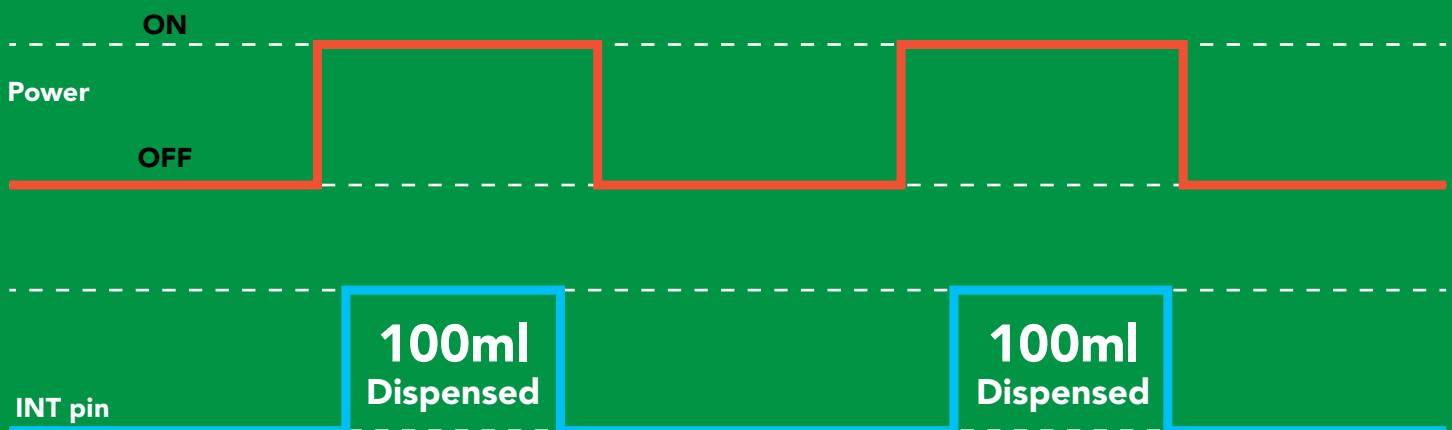
Continuous dispensing at startup

Pump on & continuously dispense

Command syntax

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>	

ON

Power

OFF

INT pin

AtlasScientific™
Environmental Robotics
r 0.1

Dose Over time at startup

Pump a fixed volume over a fixed time at startup

Command syntax

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

Example

Response

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

ON

Power

OFF

INT pin

7000ml
Dispensed

20 Minutes

AtlasScientific
Environmental Robotics
r 0.1

Pause dispensing

Command syntax

P <cr>　　　pauses the pump during dispensing

P,? <cr>　　pause status

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

dispensing　　**P** →　　paused　　**P** →　　dispensing

Copyright © Atlas Scientific LLC

AtlasScientific
Environmental Robotics
r 0.1

Stop dispensing

Command syntax

X <cr> stop dispensing

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

X
dispensing

*DONE,645.8
Stopped

AtlasScientific
Environmental Robotics
r 0.1

Invert dispensing direction

Command syntax

Invert <cr> changes dispensing direction of pump

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

AtlasScientific
Environmental Robotics

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.

AtlasScientific
Environmental Robotics
r 0.1

Calibration

Command syntax

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>` or ?Cal,2 `<cr>` or fixed volume volume/time ?Cal,3 `<cr>` or ?Cal,0 `<cr>` both uncalibrated *OK `<cr>`

AtlasScientific
Environmental Robotics
r 0.1

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

AtlasScientific™
Environmental Robotics
r 0.1

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

Copyright © Atlas Scientific LLC

AtlasScientific
Environmental Robotics
r 0.1

Naming device

Command syntax

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

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

Up to 16 ASCII characters

Example   Response

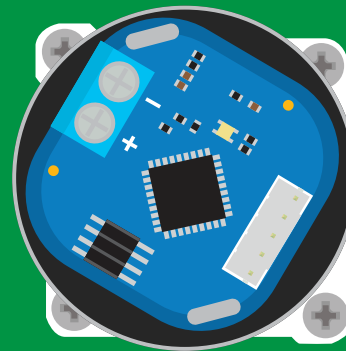| Name,   <cr> | *OK <cr>   name has been cleared |
| Name,zzt <cr> | *OK <cr> |
| Name,?   <cr> | ?Name,zzt <cr>
*OK   <cr> |

Name,zzt

Name,?

*OK <cr>

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

AtlasScientific
Environmental Robotics
r 0.2
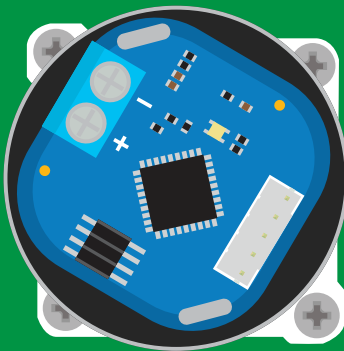
Device information

Command syntax

i **<cr>** device information

Example

i **<cr>**

Response

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

Response breakdown

?i, PMPL, 1.1
  Device   Firmware

AtlasScientific
Environmental Robotics
r 0.1

Response codes

Command syntax

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

Example | Response

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

AtlasScientific
Environmental Robotics
r 0.1

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

AtlasScientific
Environmental Robotics
r 0.1

Sleep mode/low power

Command syntax

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

AtlasScientific
Environmental Robotics
r 0.1
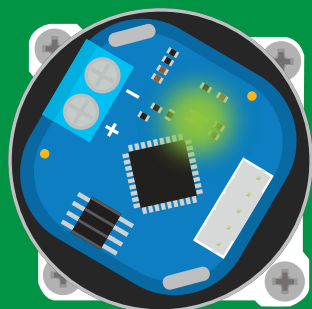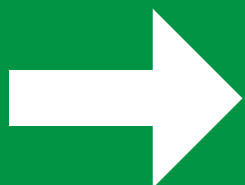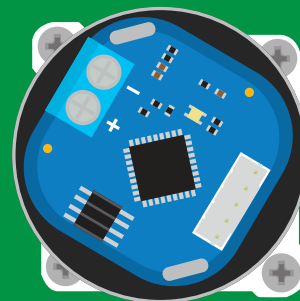
Change baud rate

Command syntax

Baud,n <cr> change baud rate

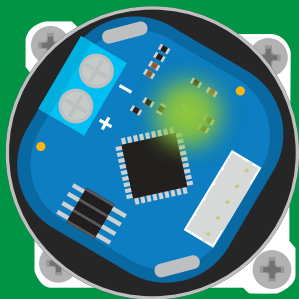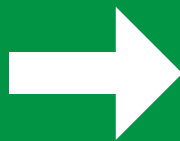| Example	Response
Baud,38400 <cr>	***OK** <cr>
Baud,? <cr>	**?Baud,38400** <cr> ***OK** <cr>

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

Standby

Baud,38400 <cr>
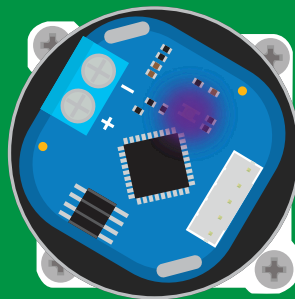
Changing baud rate

*OK <cr>
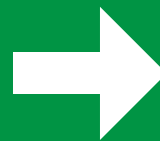
(reboot)
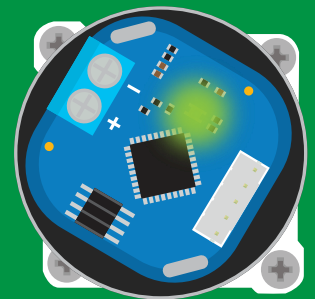
Standby

AtlasScientific
Environmental Robotics
r 0.1

Protocol lock

Command syntax

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

Example   Response

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

Plock,1
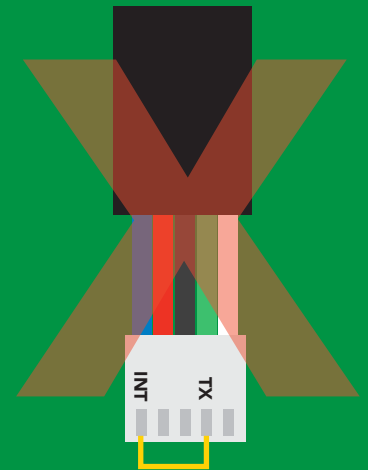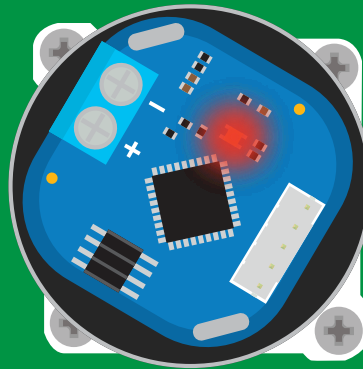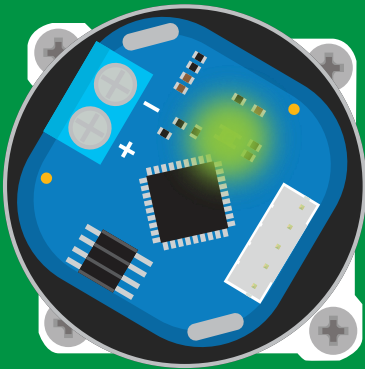
*OK <cr>

I2C,100

cannot change to I²C
*ER <cr>

cannot change to I²C

AtlasScientific
Environmental Robotics
r 0.1

Factory reset

Command syntax

Factory <cr> enable factory reset

Example   Response

| Factory <cr> | *OK <cr> |

Factory <cr>
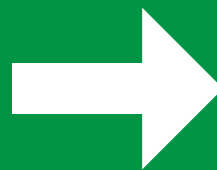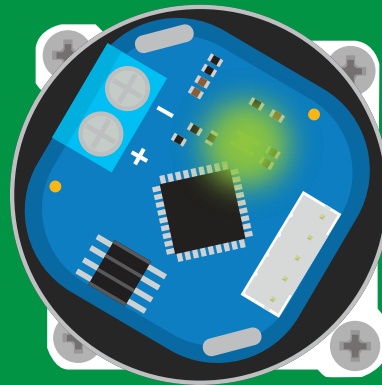
(reboot)

*OK <cr>   *RS <cr>
                                      *RE <cr>

Baud rate will not change

AtlasScientific
Environmental Robotics
r 0.1

Change to I²C mode
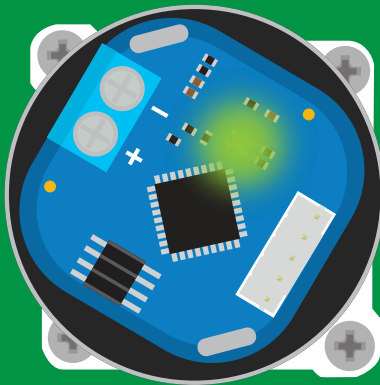
Command syntax

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
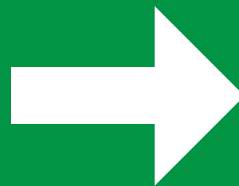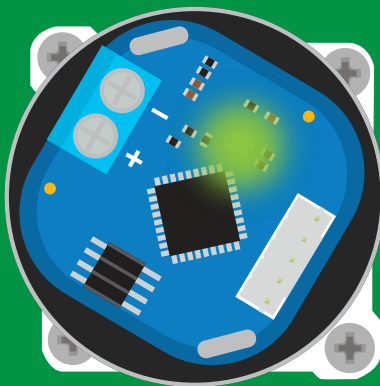
(reboot)
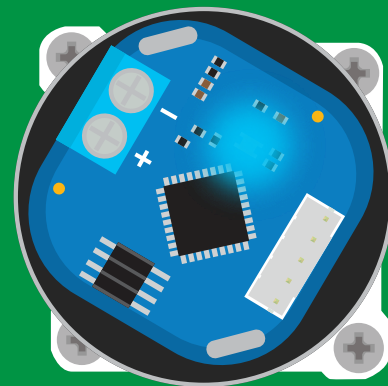
Green
*OK <cr>

Blue
now in I²C mode

AtlasScientific
Environmental Robotics
r 0.1

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

Short

TX   INT

Wrong Example

Disconnect RX line ➡

Short

RX

AtlasScientific ™
Environmental Robotics
r 0.1
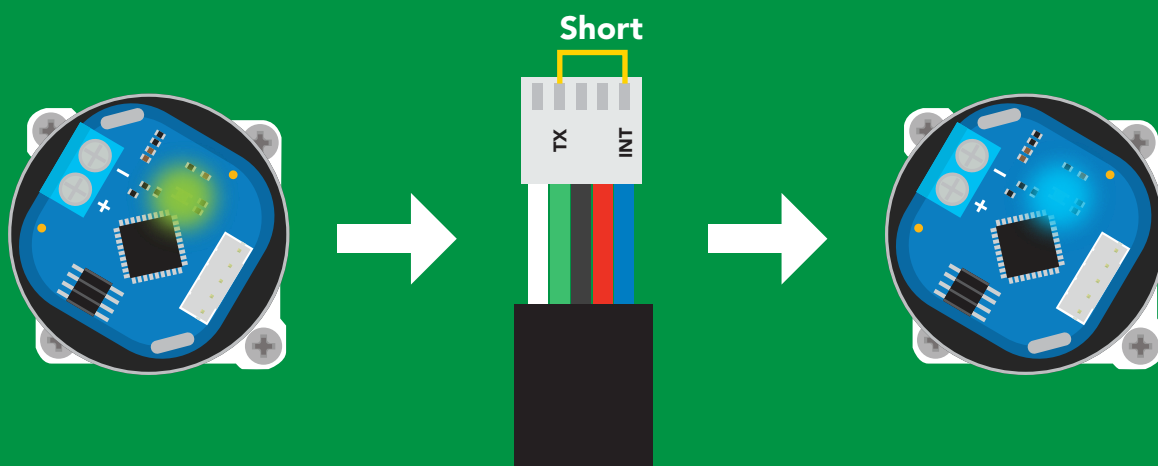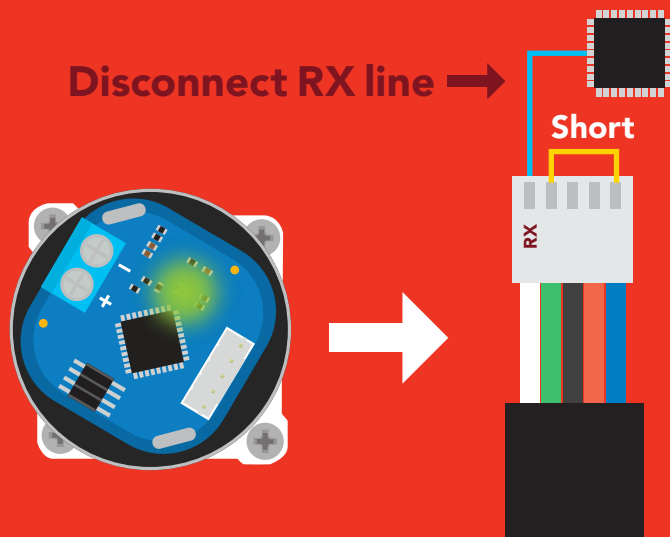
I²C mode

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

AtlasScientific
Environmental Robotics

r 0.2

I²C mode

I²C address
(0x01 – 0x7F)
109 (0x6D) default

Vcc
3.3V – 5.5V

Clock speed
100 – 400 kHz

SDA

SCL

← VCC

0V   0V

SCL
SDA

4.7k resistor
may be needed

VCC   VCC

SCL ← SCL ✓   SDA ← SDA ✓

SCL   SDA

CPU
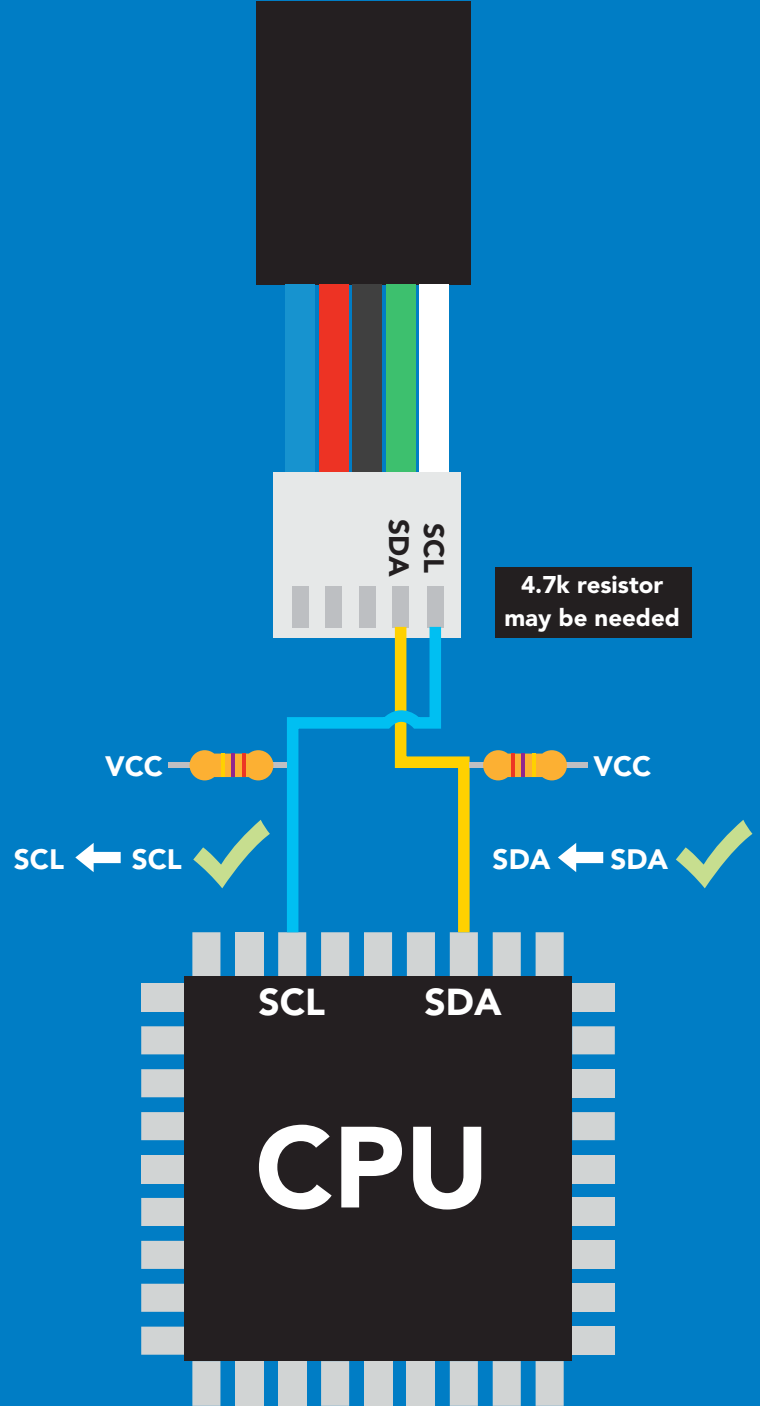
Data format

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

47 Copyright © Atlas Scientific LLC

AtlasScientific
Environmental Robotics
r 0.1

Sending commands to device

5 parts

Start	I²C address	Write	Command (not case sensitive)	Stop

109 (0x6D)   ASCII command string

Example

Start	109 (0x6D)	Write	Sleep	Stop

I²C address   Command

SDA ← SDA ✓

SCL ← SCL ✓

SCL
SDA

SDA

CPU

SCL

Advanced

Address bits   The entire command as ASCII with all arguments

SDA
SCL

| A6 | A5 | A4 | A3 | A2 | A1 | A0 | W | ACK | First letter of command | ACK | ... | Last letter of command | ACK |

Start   W = low   Stop

AtlasScientific
Environmental Robotics
r 0.1

Requesting data from device

7 parts

Start	I²C address	Read	Response code	Data string	Null	Stop
	109 (0x6D)		1 byte	"413"	Terminator (Dec 0)	

413

| SCL |
| SDA |

SDA ← SDA ✓

SCL ← SCL ✓

SDA

CPU

SCL

Advanced

Address bits

N bytes of data

All bytes after data are Null

R = High

SDA

SCL

Start | A6 – A0 | R | ACK | Response code | ACK | Data | ACK | ... | Data N | ACK | Null | ACK | ... | Null | NACK | Stop

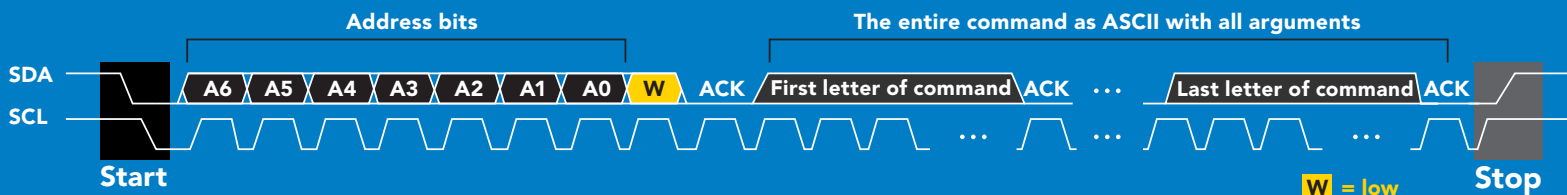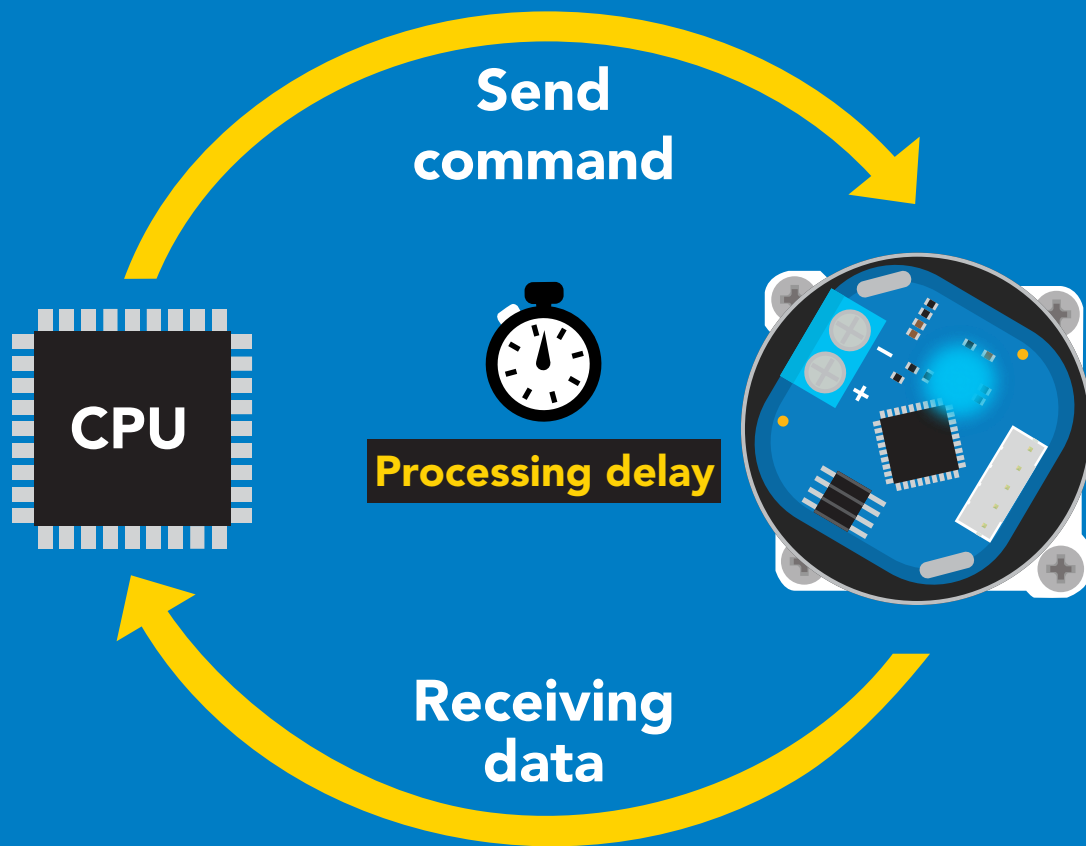| 1	52	49	51	0	= 413
Dec		ASCII		Dec	

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

CPU

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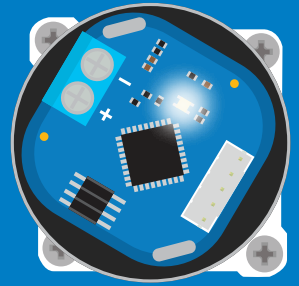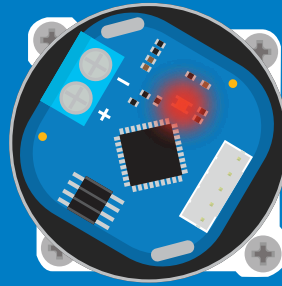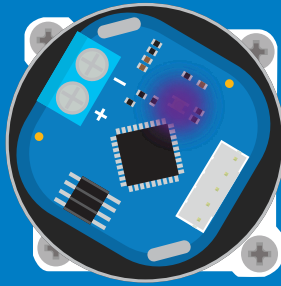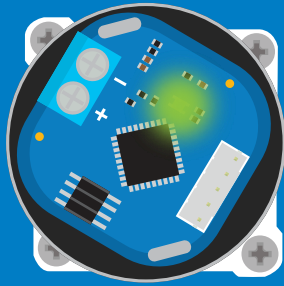
If there is no processing delay or the processing delay is too short, the response code will always be 254.

Response codes

Single byte, not string

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

AtlasScientific™
Environmental Robotics
r 0.2

LED color definition
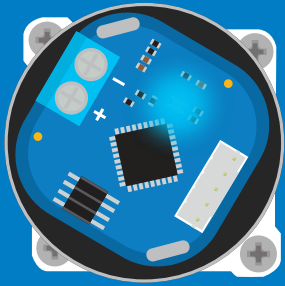
Blue

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**

AtlasScientific
Environmental Robotics
r 0.1

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

AtlasScientific™
Environmental Robotics
r 0.1

LED control

Command syntax

L,1   LED on   `default`

L,0   LED off

L,?   LED state on/off?

Example   Response

L,1

⏱ **Wait 300ms**   `1` Dec   `0` Null

L,0

⏱ **Wait 300ms**   `1` Dec   `0` Null

L,?

⏱ **Wait 300ms**   `1` Dec   `?L,1` ASCII   `0` Null   **or**   ⏱ **Wait 300ms**   `1` Dec   `?L,0` ASCII   `0` Null

L,1   **L,0**

AtlasScientific
Environmental Robotics
r 0.1
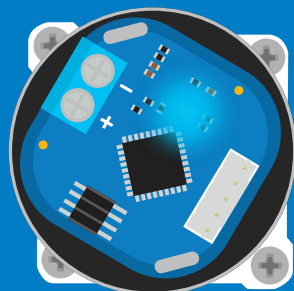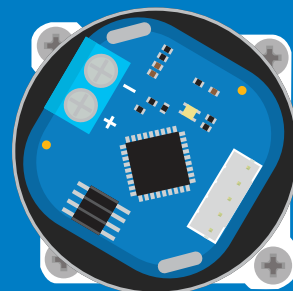
Find

Command syntax

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

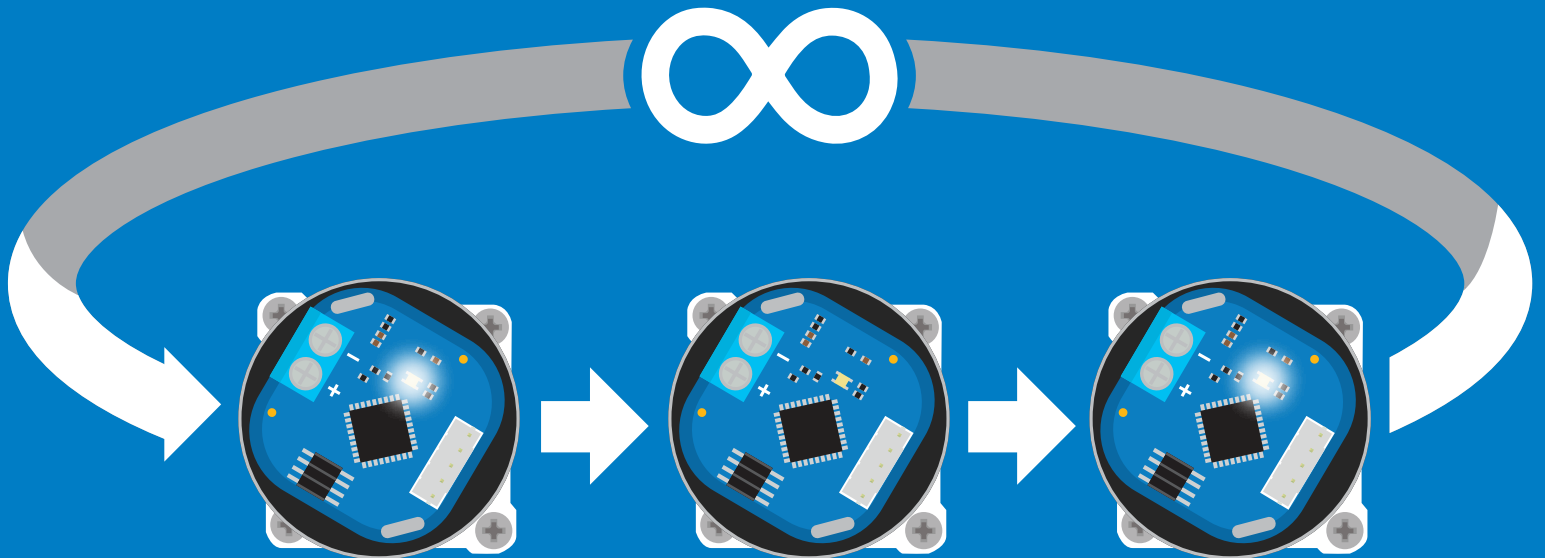| Find	LED rapidly blinks white, used to help find device

Example   Response

Find	⏱ **Wait 300ms** **1** Dec **0** Null

AtlasScientific
Environmental Robotics
r 0.1

Single report mode

Command syntax

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)**
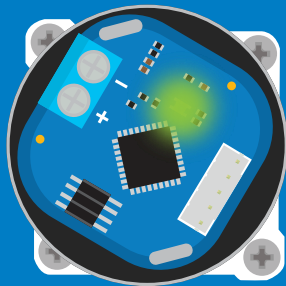
Green
Taking reading
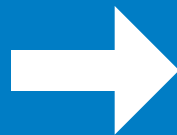
⏱ **Wait 600ms**
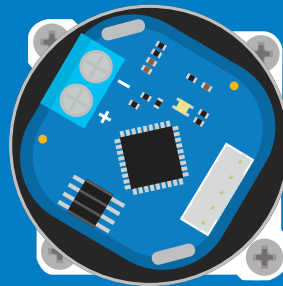
Transmitting

Blue
Standby

AtlasScientific™
Environmental Robotics
r 0.1
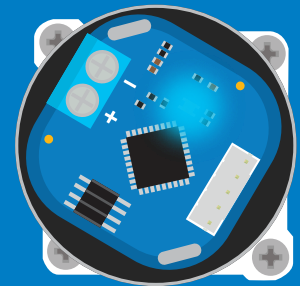
Continuous dispensing

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

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

Copyright © Atlas Scientific LLC

Atlas Scientific ™
Environmental Robotics
r 0.1

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

↑ last volume dispensed   ↑ pump off

Atlas Scientific
Environmental Robotics
r 0.1

Dose over time

Pump a fixed volume over a fixed time

Command syntax

300ms processing delay

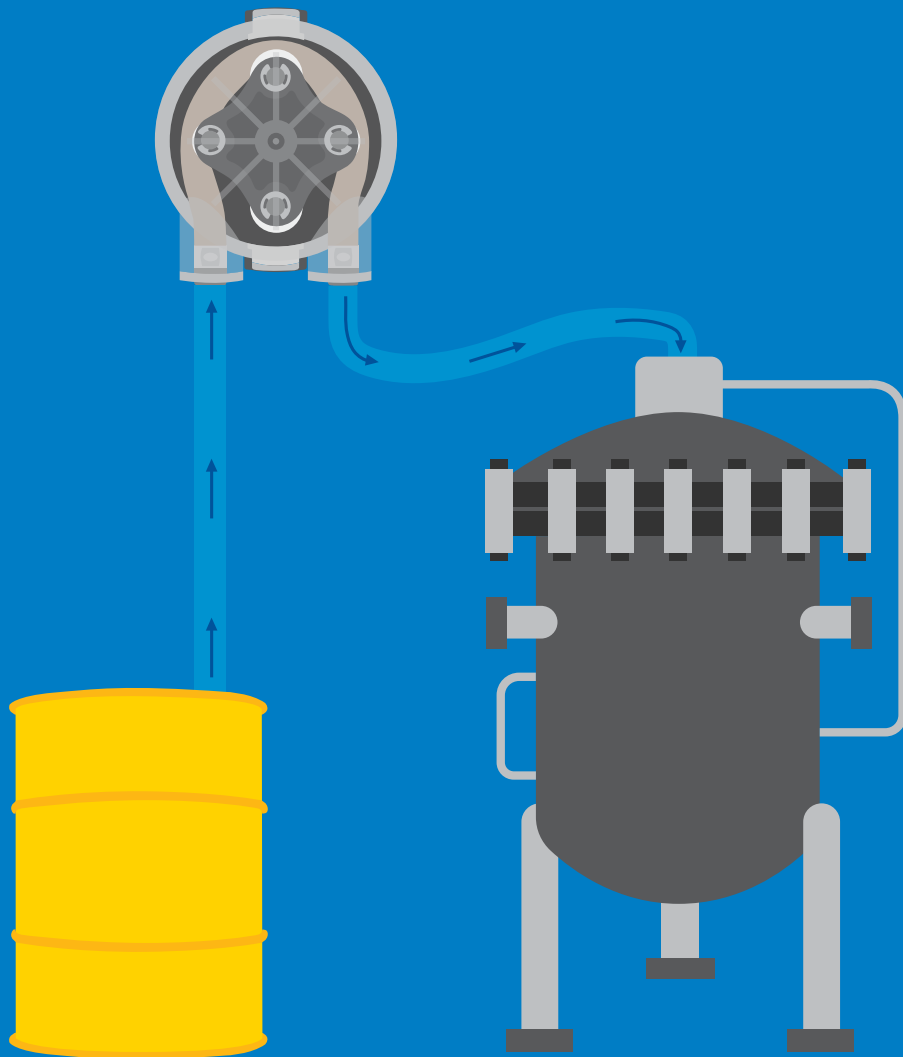**D,[ml],[min]   Dispense [this volume], [over this many minutes]**

Example   Response

D,7000,20

Wait 300ms   **1** Dec   **0** Null   **Dispense 7000ml over 20 mins**

AtlasScientific
Environmental Robotics
r 0.1

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 *]   [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

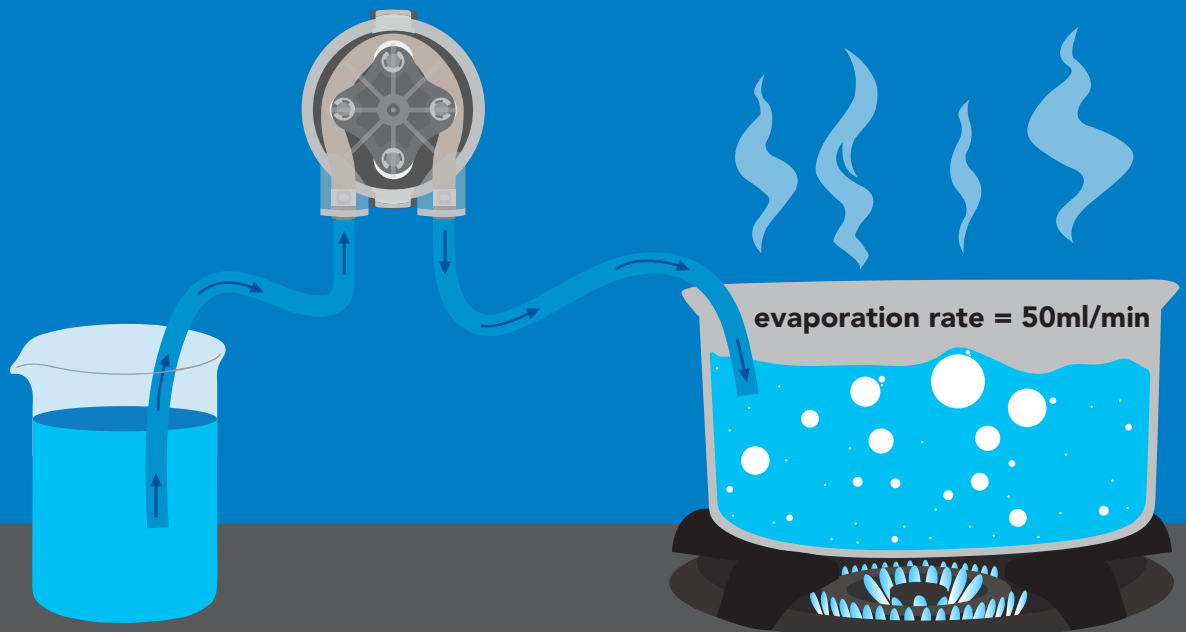| Example	Response			
DC,50,40	⏱ Wait 300ms	**1** Dec	**0** Null	Dispense 50ml per minute for 40 minutes
DC,?	⏱ Wait 300ms	**1** Dec	**?maxrate,385** ASCII	**0** Null — reports maximum possible flow rate

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

flow rate = 50ml/min

evaporation rate = 50ml/min

r 0.1

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

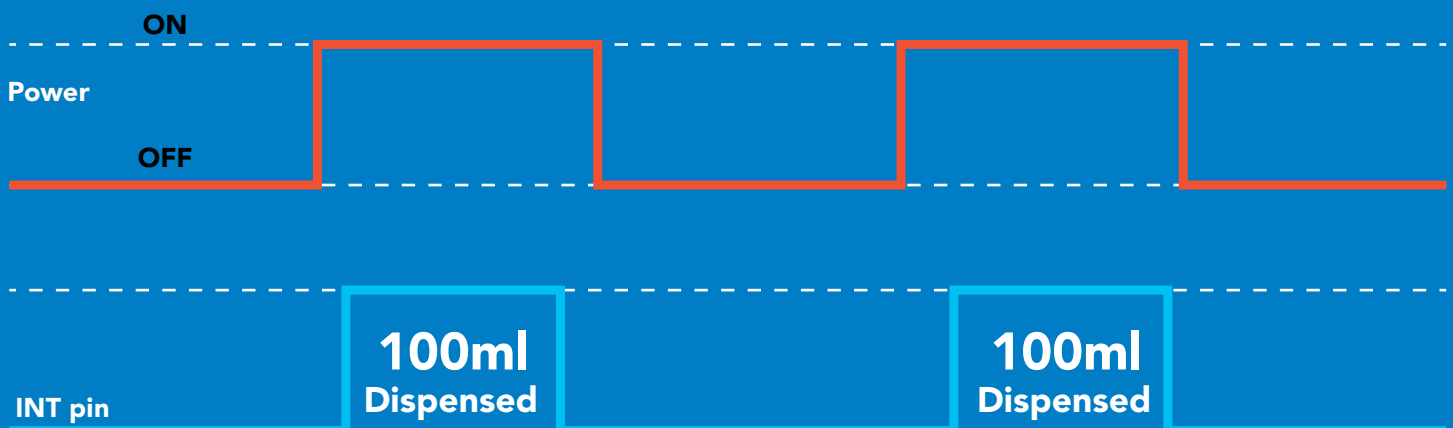|	
Dstart,[ml]	dispense [this specific volume] at startup
Dstart,off	disables dispense at startup mode
Dstart,?	startup dispense status

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

Power — ON / OFF

INT pin

100ml Dispensed   **100ml Dispensed**

AtlasScientific
Environmental Robotics

Continuous dispensing at startup

Pump on & continuously dispense

300ms processing delay

Command syntax

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

Power
ON
OFF

INT pin

Copyright © Atlas Scientific LLC

AtlasScientific
Environmental Robotics

Dose Over time at startup

Pump a fixed volume over a fixed time at startup

Command syntax

300ms ⏱ **processing delay**

D,[ml],[min]	Dispense [this 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

ON
Power
OFF

INT pin

7000ml
Dispensed

20 Minutes

Pause dispensing

Command syntax

Issue the command again to resume dispensing

P   pauses the pump during dispensing

P,?   pause status

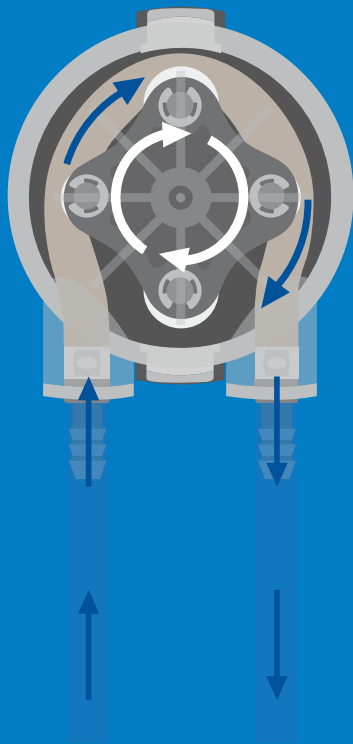## Example   Response

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

P   **P**

dispensing ➡ paused ➡ dispensing

AtlasScientific™
Environmental Robotics
r 0.1
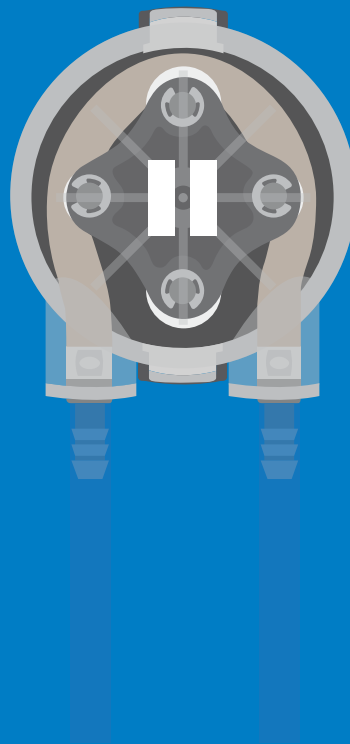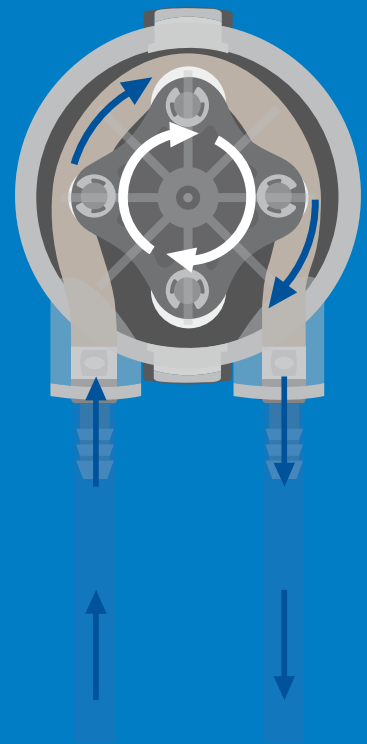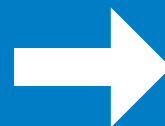
Stop dispensing

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
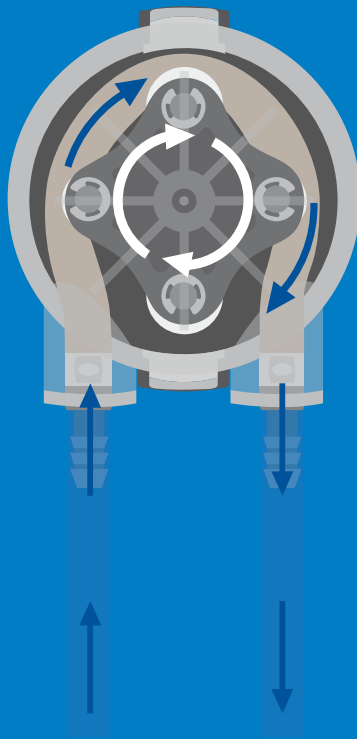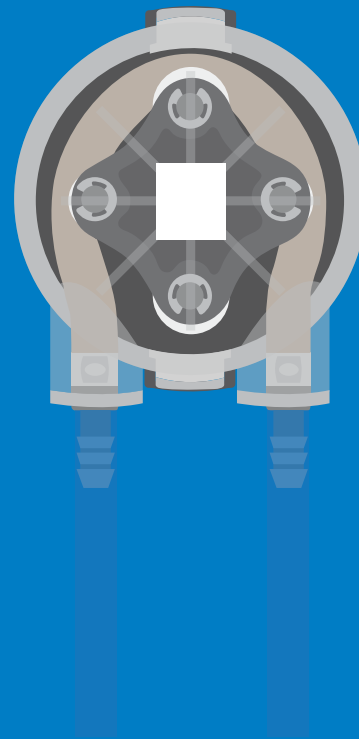
Invert dispensing direction

300ms ⏱ **processing delay**

Command syntax

Invert direction will be retained if power is cut

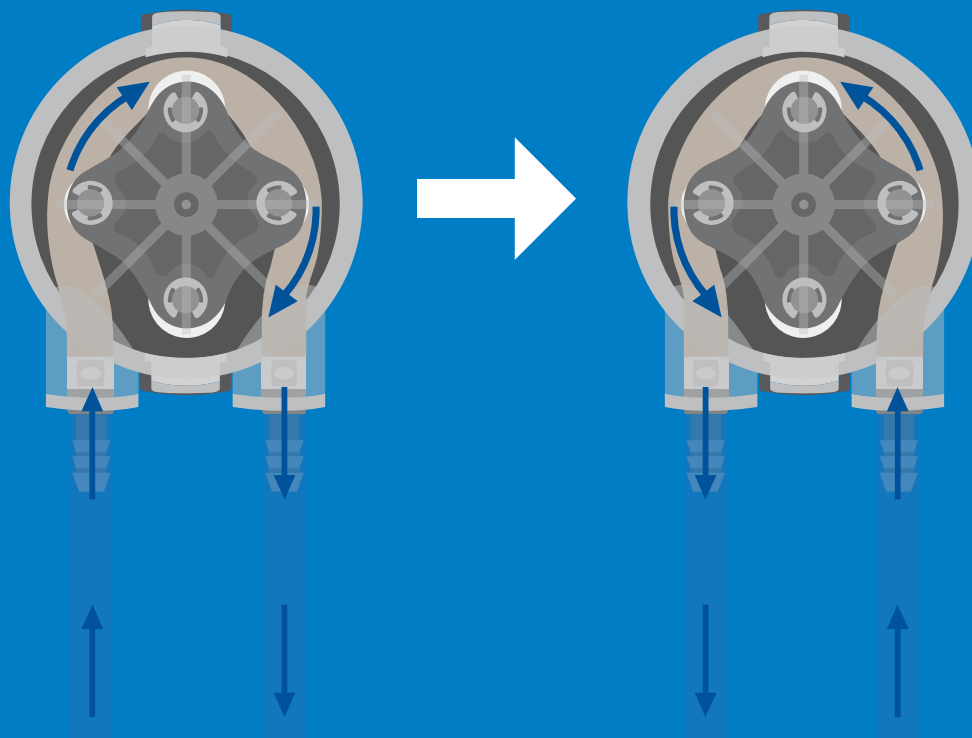| Invert	changes dispensing direction of pump

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.

AtlasScientific
Environmental Robotics
r 0.1

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

AtlasScientific™
Environmental Robotics
r 0.1

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

AtlasScientific
Environmental Robotics
r 0.1

Pump voltage

PV,? check pump voltage

Example

Response

PV,?

⏱ **Wait 300ms** **1** Dec **?PV,24.67** ASCII **0** Null

Response breakdown

?PV, 24.67
↑
Pump input voltage

AtlasScientific
Environmental Robotics
r 0.1

Naming device

300ms ⏱ processing delay

Command syntax

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

Example / Response

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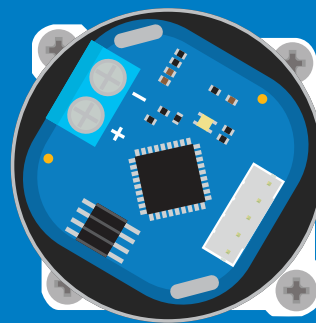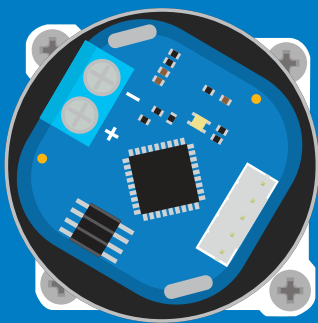
Name,zzt → **Name,?**

1 **0**

1 **?Name,zzt** **0**

Atlas**Scientific**
Environmental Robotics

Device information

Command syntax

i device information

Example   Response

i

⏱ **Wait 300ms**   **1** Dec   **?i,PMPL, 1.1** ASCII   **0** Null

Response breakdown

?i, PMPL, 1.1
↑ Device   ↑ Firmware

AtlasScientific
Environmental Robotics
r 0.1

Reading device status

Command syntax

300ms processing delay

Status   voltage at Vcc pin and reason for last restart

Example   Response

Status

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

Response breakdown

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

Restart codes

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

AtlasScientific
Environmental Robotics
r 0.1

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	**Do not read status byte after issuing sleep command.**
Any command	wakes up device	
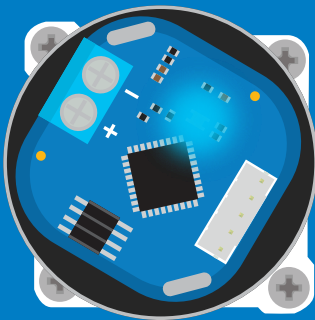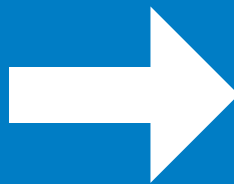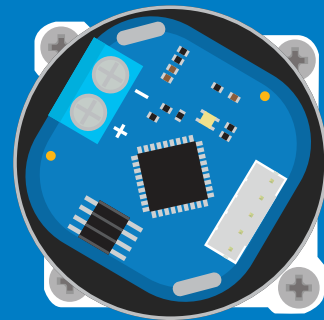
		STANDBY	SLEEP
5V		**13.4 mA**	**0.415 mA**
3.3V		**12.4 mA**	**0.13 mA**

Sleep

Standby   **Sleep**

AtlasScientific
Environmental Robotics
r 0.1

Protocol lock

Command syntax

Plock,1   enable Plock

Plock,0   disable Plock   `default`

Plock,?   Plock on/off?

`Locks device to I²C mode.`

Example   Response

Plock,1	⏱ **Wait 300ms**	**1** Dec	**0** Null	
Plock,0	⏱ **Wait 300ms**	**1** Dec	**0** Null	
Plock,?	⏱ **Wait 300ms**	**1** Dec	**?Plock,1** ASCII	**0** Null

Plock,1   **Baud, 9600**
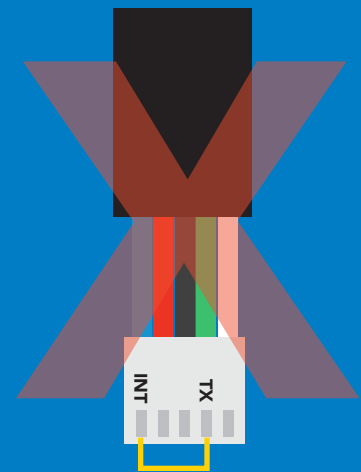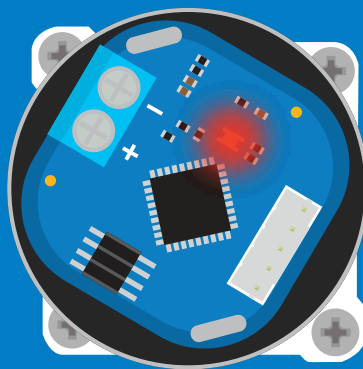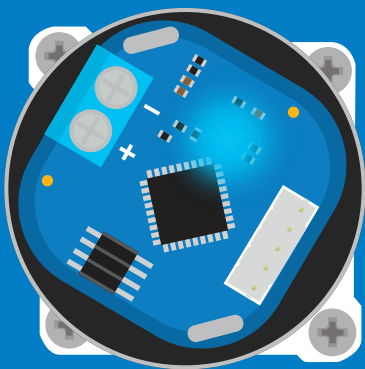
cannot change to UART   **cannot change to UART**

AtlasScientific™
Environmental Robotics
r 0.1

I²C address change

Command syntax

300ms ⏱ processing delay

I2C,n   sets I²C address and reboots into I²C mode

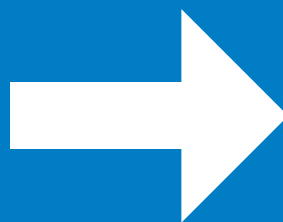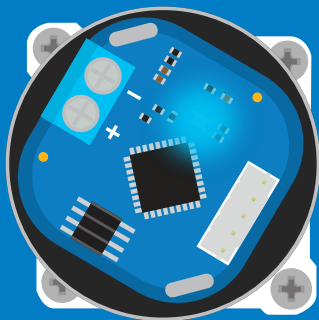| Example	Response
I2C,101	device reboot (no response given)

Warning!

Changing the I²C address will prevent communication between the circuit and the CPU until the CPU is updated with the new I²C address.
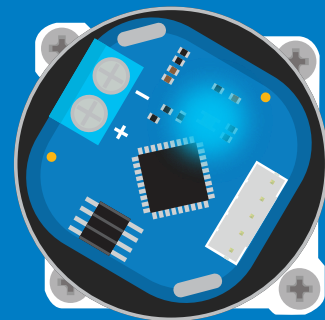
Default I²C address is 109 (0x6D.

n = any number 1 – 127

I2C,101

(reboot)

AtlasScientific™
Environmental Robotics
r 0.2

Factory reset

Command syntax

Factory   enable factory reset

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

Clears calibration
LED on
Response codes enabled

Factory

(reboot)

AtlasScientific
Environmental Robotics
r 0.1
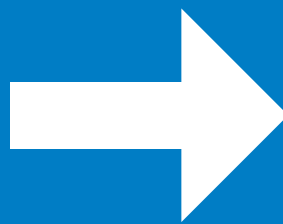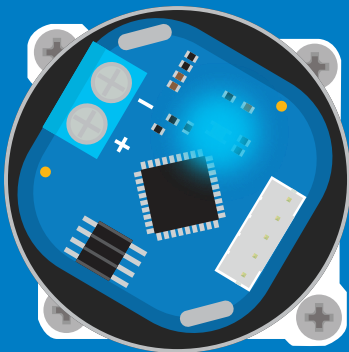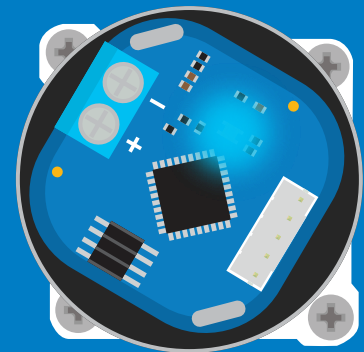
Change to UART mode

Command syntax

Baud,n   switch from I²C to UART

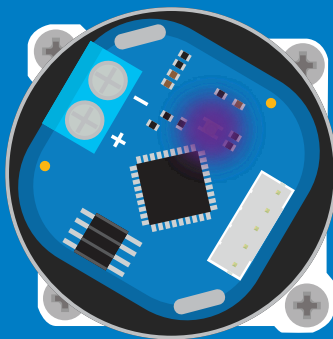| Example	Response
Baud,9600	**reboot in UART mode** **(no response given)**

$$n = \begin{cases} 300 \\ 1200 \\ 2400 \\ 9600 \\ 19200 \\ 38400 \\ 57600 \\ 115200 \end{cases}$$
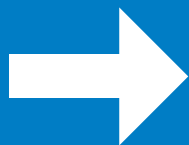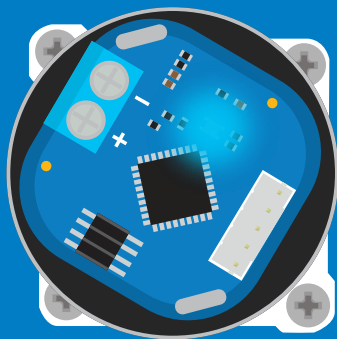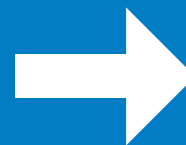
Baud,9600   **(reboot)**

Changing to UART mode
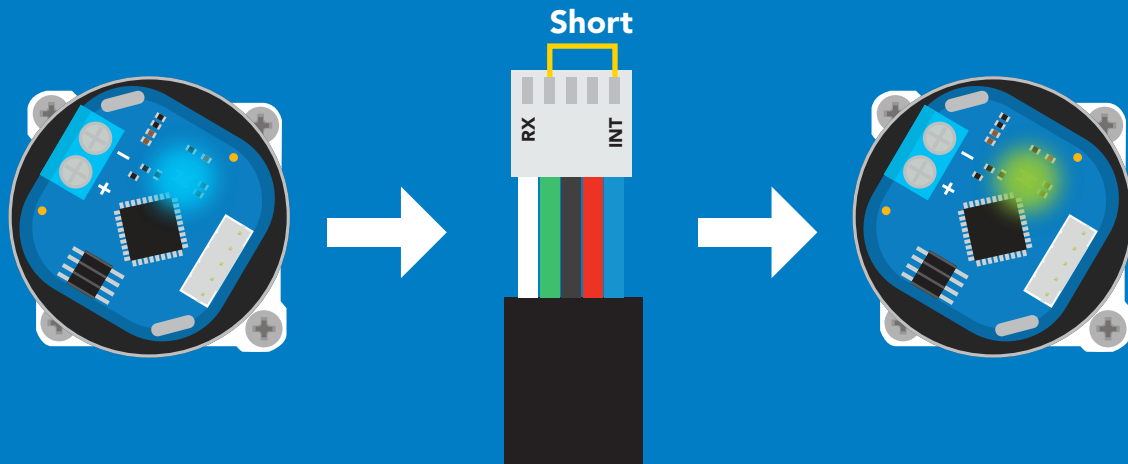
AtlasScientific
Environmental Robotics
r 0.1
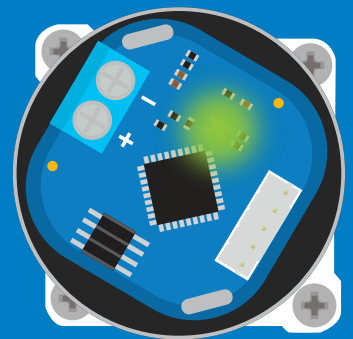
Manual switching to UART

- **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

Short

RX   INT

Wrong Example

Disconnect RX line ➡

Short

RX

Copyright © Atlas Scientific LLC

AtlasScientific
Environmental Robotics
r 0.1
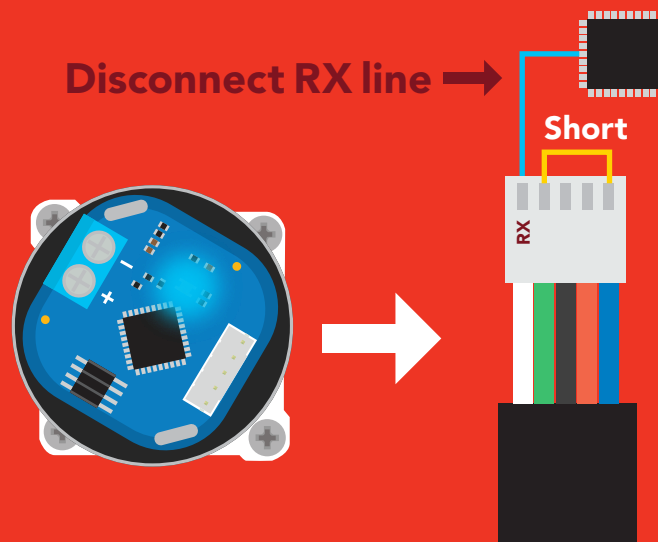
Calibration theory

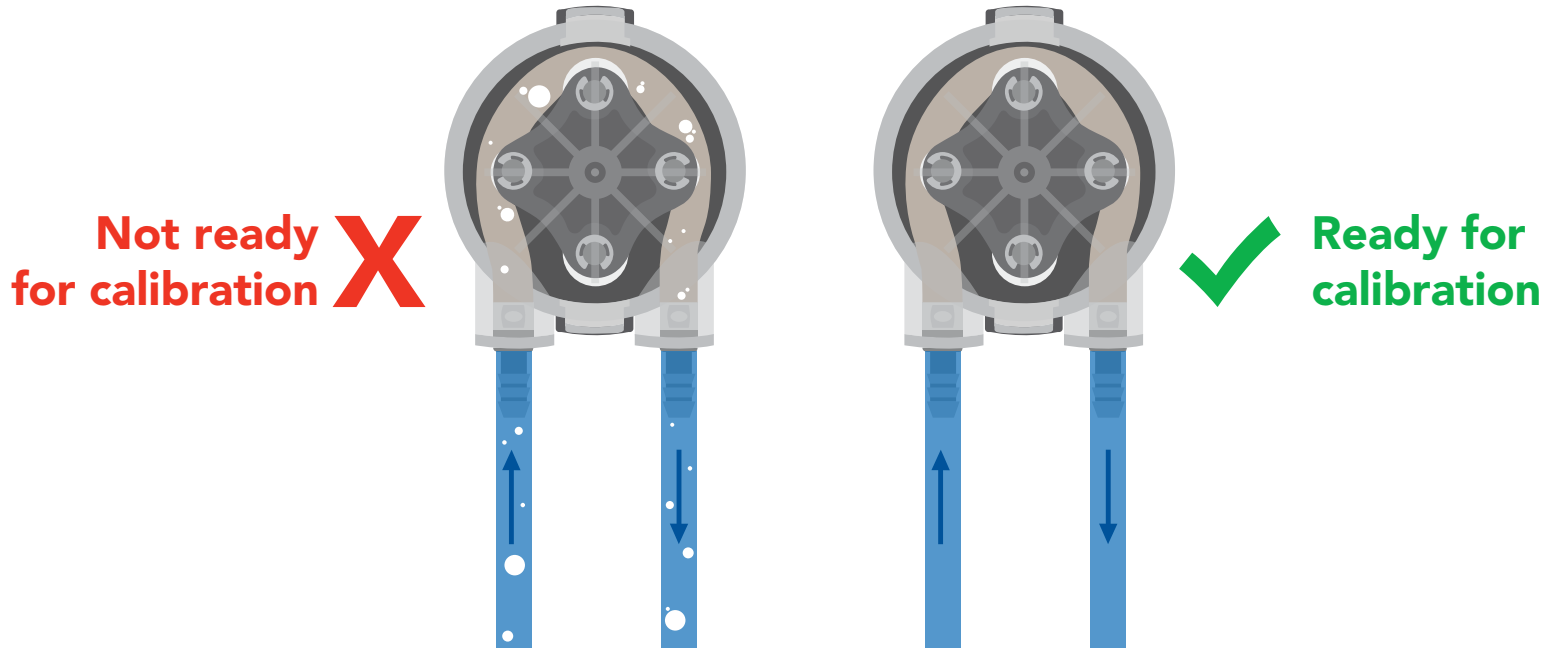**Before calibration is attempted** all the air bubbles should be removed from the tubing. This is done by running the pump while tapping the tubing. If air bubbles are not removed from the tubing they will slowly group together into larger air bubbles. Over time this will lead to accuracy issues.


Not ready for calibration ✗

✓ **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
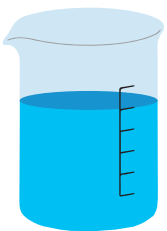
Or
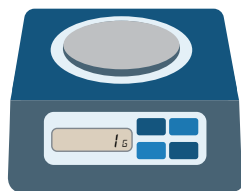
An accurate beaker of at least 250ml.

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

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

AtlasScientific™
Environmental Robotics

Calibration procedure

Make sure the tubing is full of water and has no bubbles before calibrating.
1. Instruct the pump to dispense a volume of water.
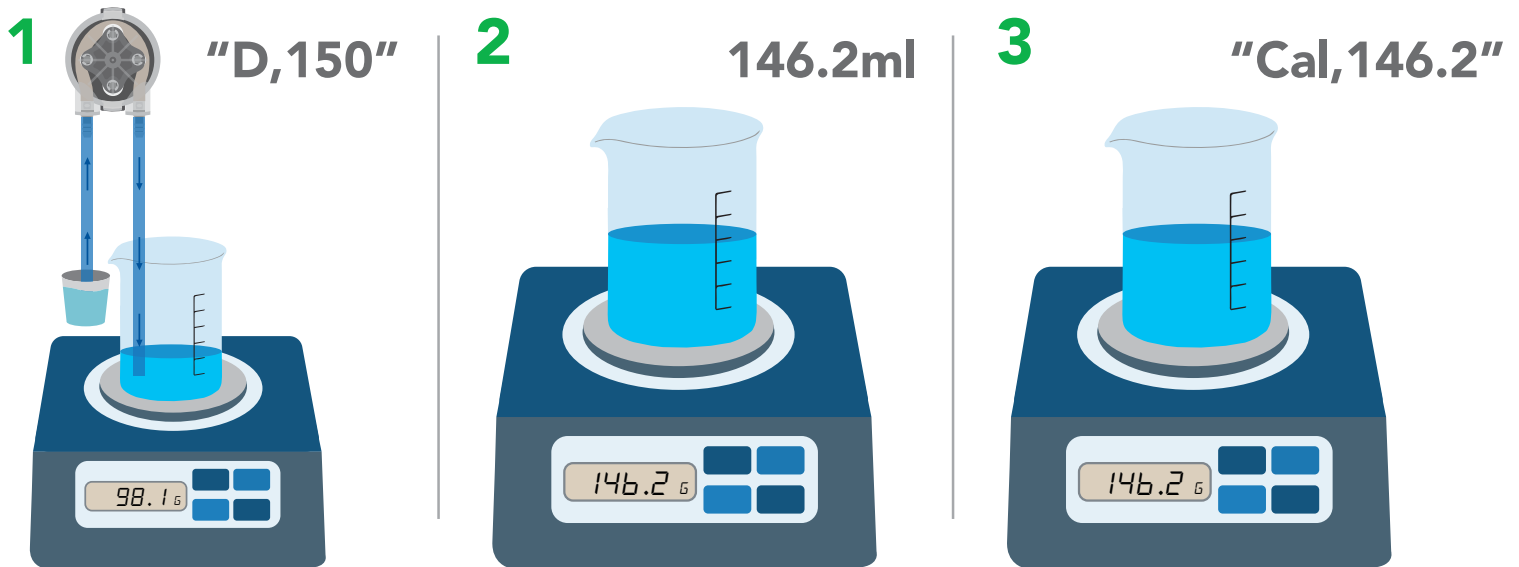**2.** Measure the dispensed amount to determine how much water was actually dispensed.
3. Calibrate the pump by sending it the volume of liquid you have measured.

Example
Calibrate the pump by dispensing 150ml.

1 "D,150" **2** 146.2ml **3** "Cal,146.2"

98.1 G   146.2 G   146.2 G

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.

AtlasScientific
Environmental Robotics
r 0.2

Pump speed vs. voltage

There is no change in pump speed at different voltages.

5 RPM = 5 RPM

Interrupt pin

When the pump is dispensing the interrupt pin goes high.

"D,150"

INT

*Done

Removing cassette

1
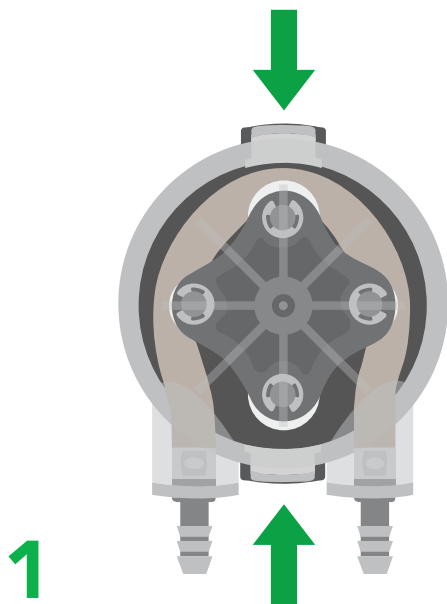
Press both release tabs on the cassette.

2
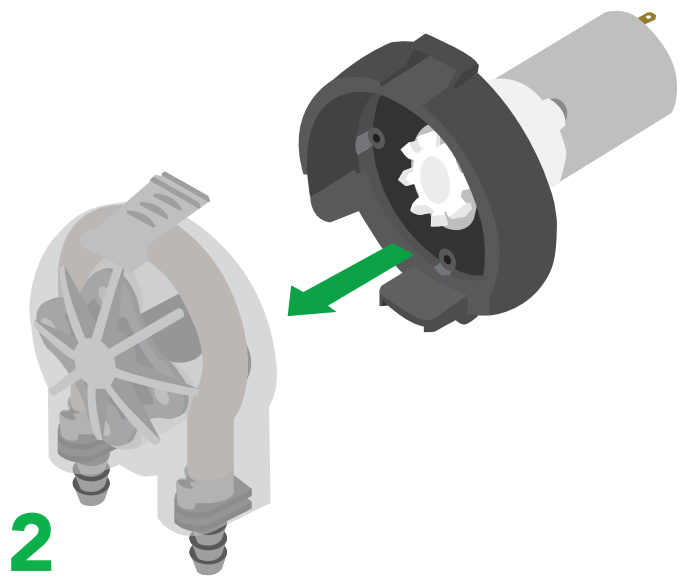
Pull the cassette off of the motor.

AtlasScientific™
Environmental Robotics
r 0.1

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.

Copyright © Atlas Scientific LLC

AtlasScientific
Environmental Robotics
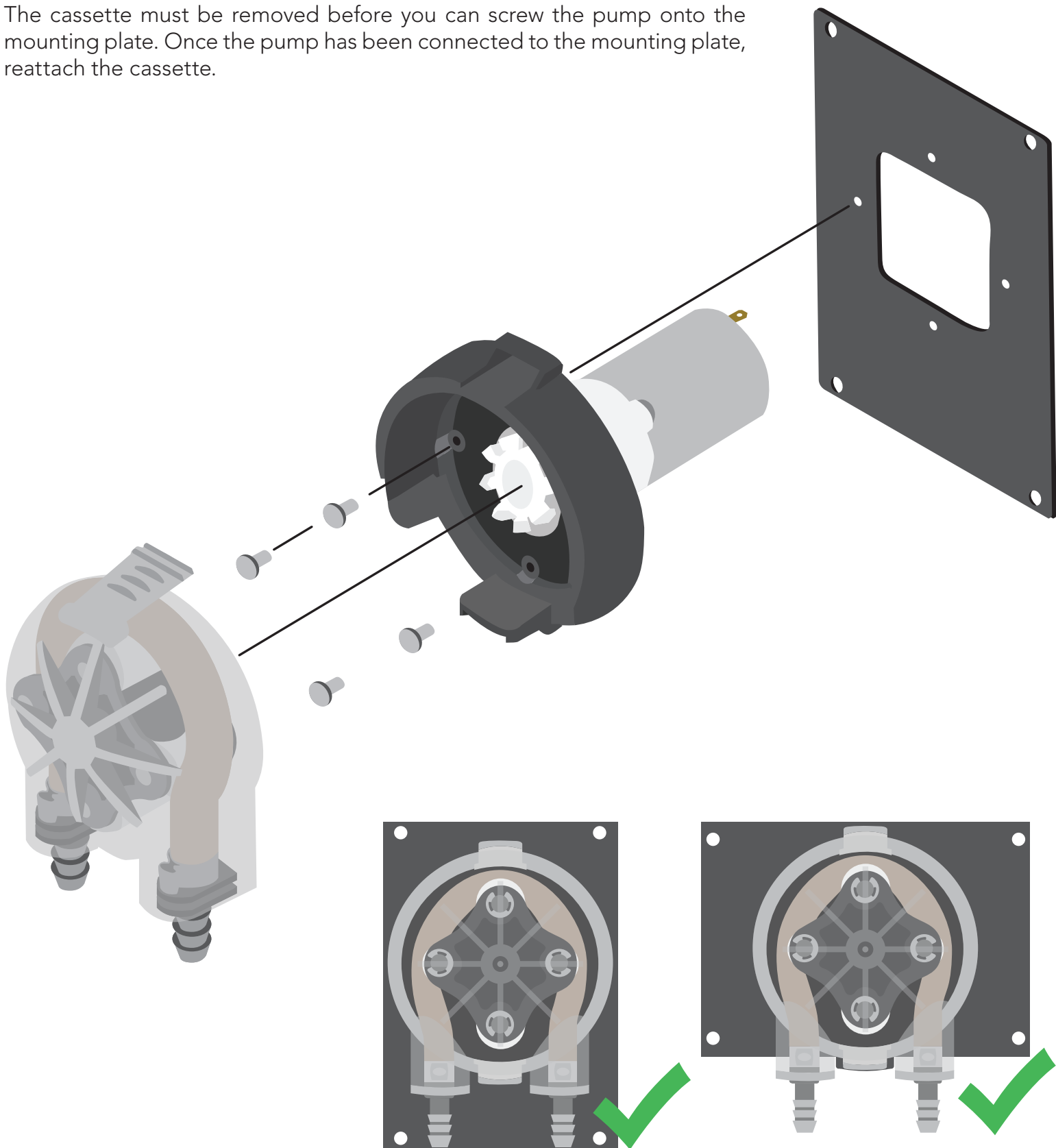
Datasheet change log

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

AtlasScientific
Environmental Robotics

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.**

Copyright © Atlas Scientific LLC

AtlasScientific™
Environmental Robotics
r 0.1

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.

AtlasScientific™
Environmental Robotics
r 0.1