EZO-PMP™

Embedded Dosing Pump

Flow rate	**0.5ml to 105ml/min**
Accuracy	**+/- 1%**
Viscocity	**0.1 – 2,000 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 5mm O.D. tubing**
Data protocol	**UART & I²C**
Default I²C address	**103 (0x67)**
Operating voltage	**3.3V – 5V (logic)**
	12V – 24V (motor)
Pump head	**8.1 meters (26.5')**
Data format	**ASCII**
Food Safe	**Yes**

RoHS COMPLIANT

This is an evolving document, check back for updates.

Table of contents

UART

I²C

Attention

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

12V – 24V
to drive the motor

3.3V – 5.5V
for the control system
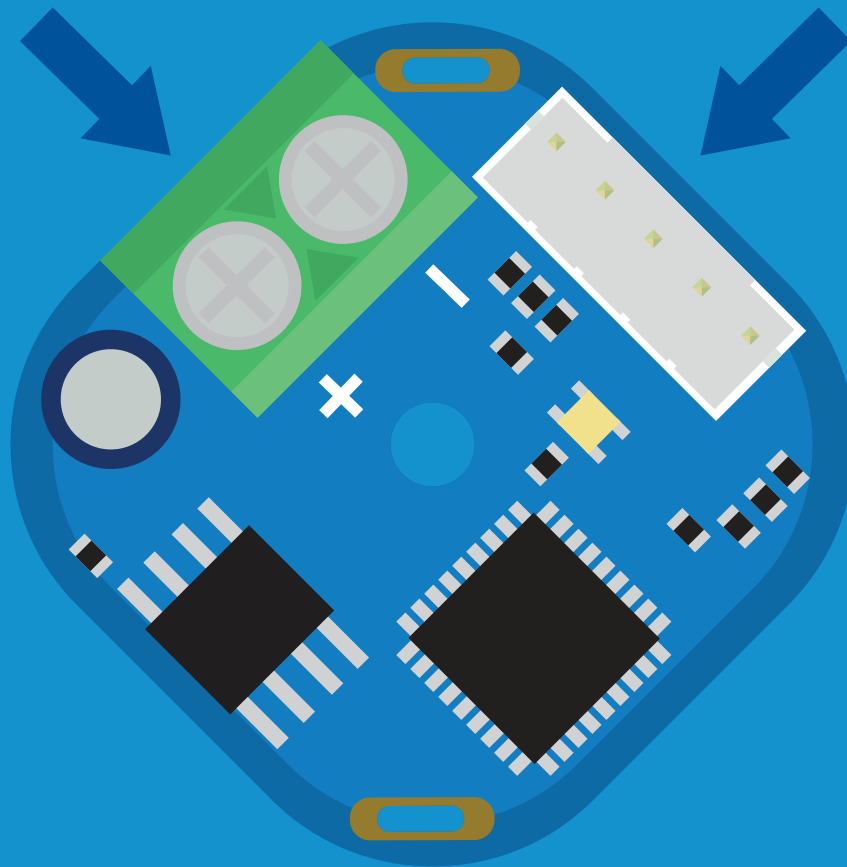
Control system
(Back side of dosing pump)

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EZO-PMP™ dimensions

26mm

85.75mm

30.5mm

27.5mm

1.6mm

Side

1.16mm

37.5mm

48mm

54mm

3.3mm

Front

Back

Mounting screw

1/4"

3/32"

0.211"

0.086"

1/2"

0.112"

#1 Drive

#4-40 thread

Inline tubing connectors

8mm

27.25mm

4.8mm

2.8mm
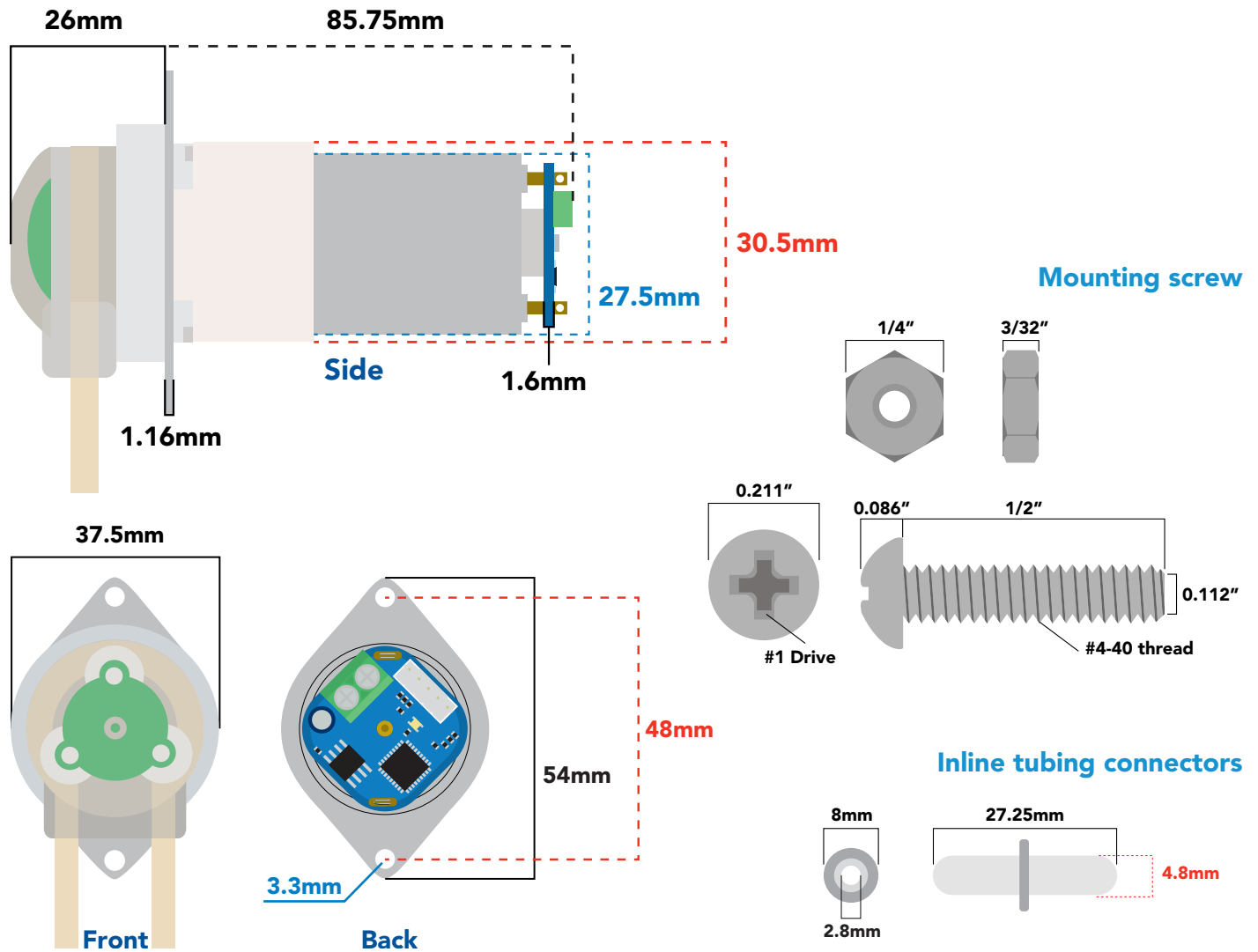
Power consumption

	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	12V = ~400mA		24V = ~200mA	

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™)	-65 °C		125 °C
Operational temperature (EZO-PMP™)	-40 °C	25 °C	85 °C
VCC	3.3V	5V	5.5V
Motor	10.8V	12V	24V
Max input / output pressure			80 kPa

EZO-PMP™ tubing
NSF/ANSI 51 Compliant

Tan tubing
Saint-Gobain™ PharMed™ BPT tubing
Length: 15.24cm
Outer diameter: 5mm
Inner diameter: 3mm

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

Food safe ✔

Inline tubing connectors
HDPE
Length: 2.54cm
Outer diameter: 8mm
Inner diameter: 2.8mm

Food safe ✔
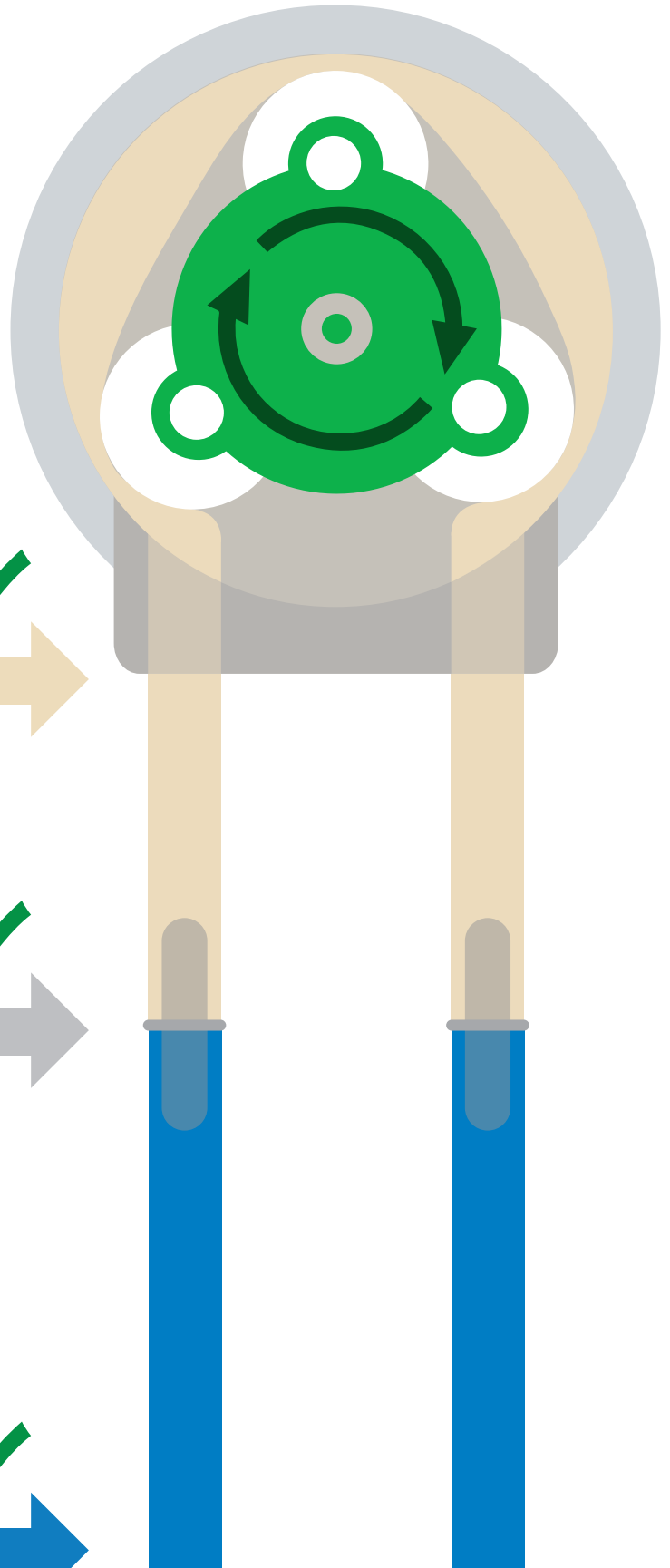
Blue tubing
Silicone
Length: 2x 30.48cm
Outer diameter: 5mm
Inner diameter: 3mm
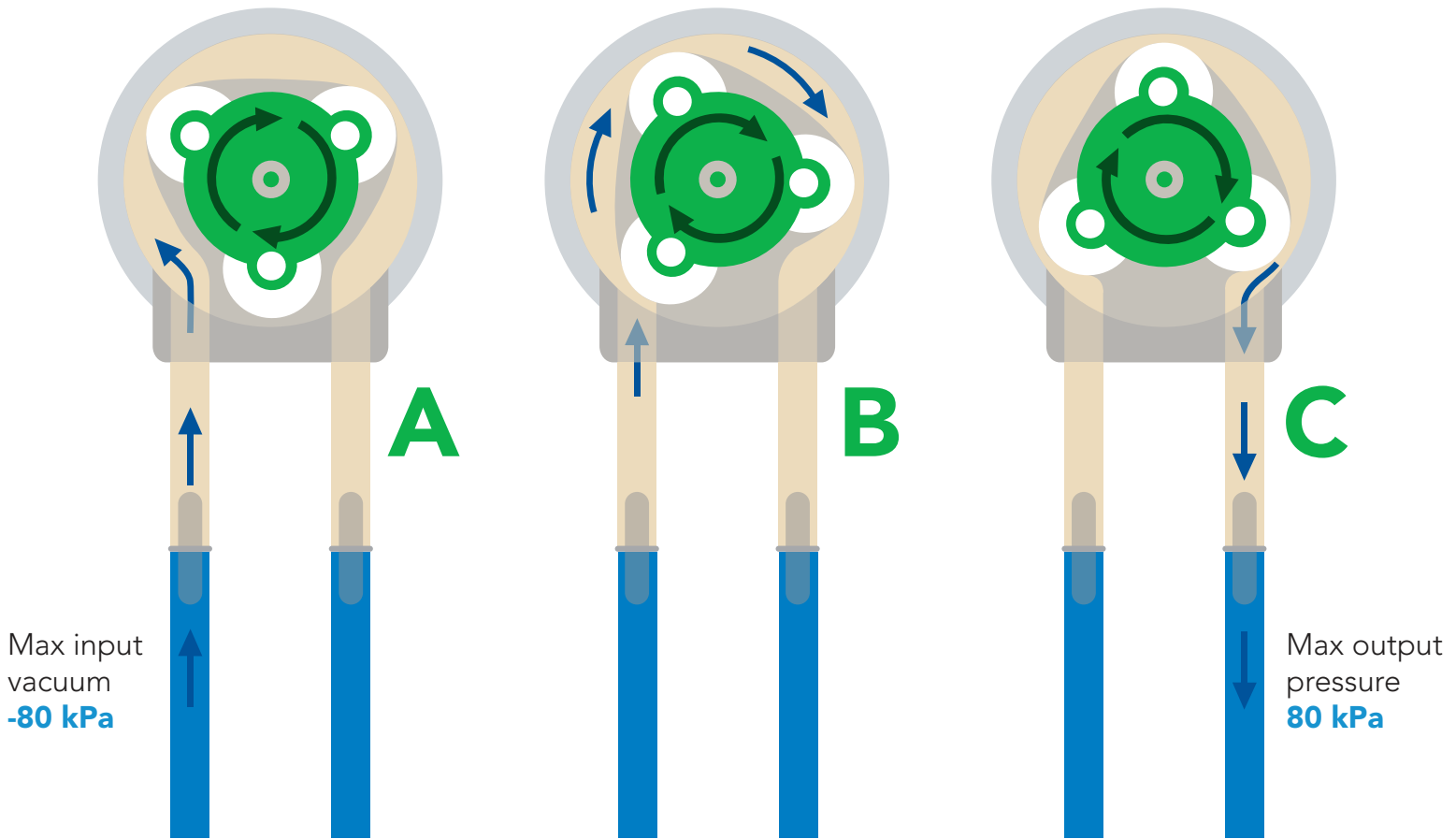Bend radius: 15mm
Temperature -67°C to 200°C
Max pressure: 69 kPa (10 PSI)

Food safe ✔

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Operating principle

✔ Self-priming
✔ Run dry

A

B

C

Max input
vacuum
-80 kPa

Max output
pressure
80 kPa

Operating modes

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

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

Volume dispensing
Pump a specific volume
(Smallest possible volume is 0.5 ml)

Volume is always in ml.

Dose over time
Pump a specific volume over a set time

Constant flow rate
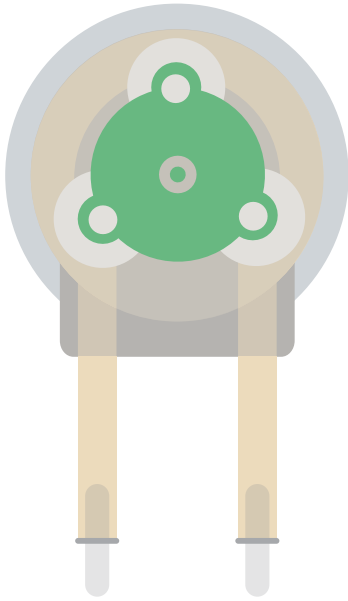Pump a specific volume per minute

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

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The Atlas Scientific EZO-PMP™ consists of three main components.
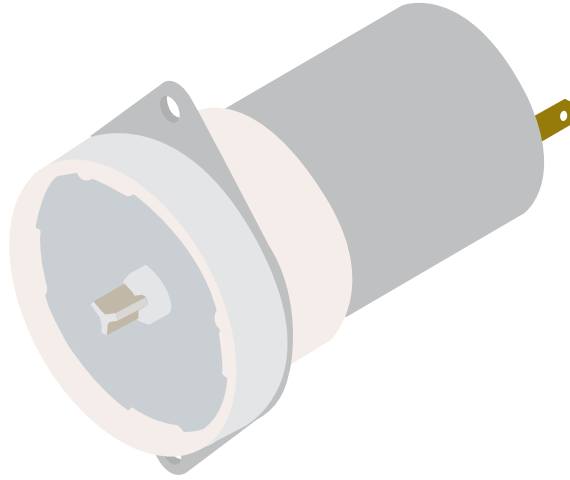
Cassette   # 12 volt motor   # Control system
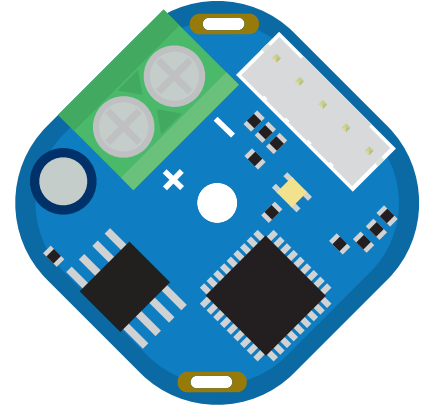
The actual peristaltic pumping is done within the cassette. It has been designed to be easily detached from the motor and disassembled.

The 12 volt motor and control system have been soldered together. Both components are designed to operate as one single unit.
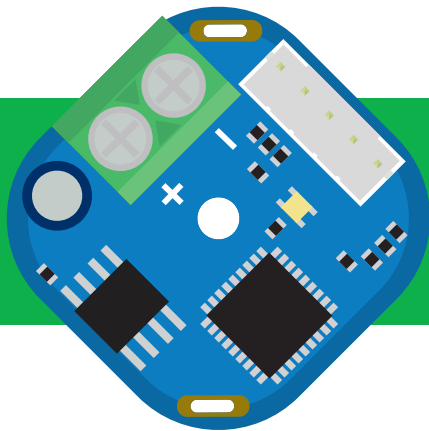
The control system has three main components

Keyed data and power connector
12 – 24 volt power input
Status indicator LED

Data and power cable pinout

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

✓ Available data protocols

UART

Default

I²C

✗ Unavailable data protocols

SPI

Analog

RS-485

Mod Bus

4–20mA

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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

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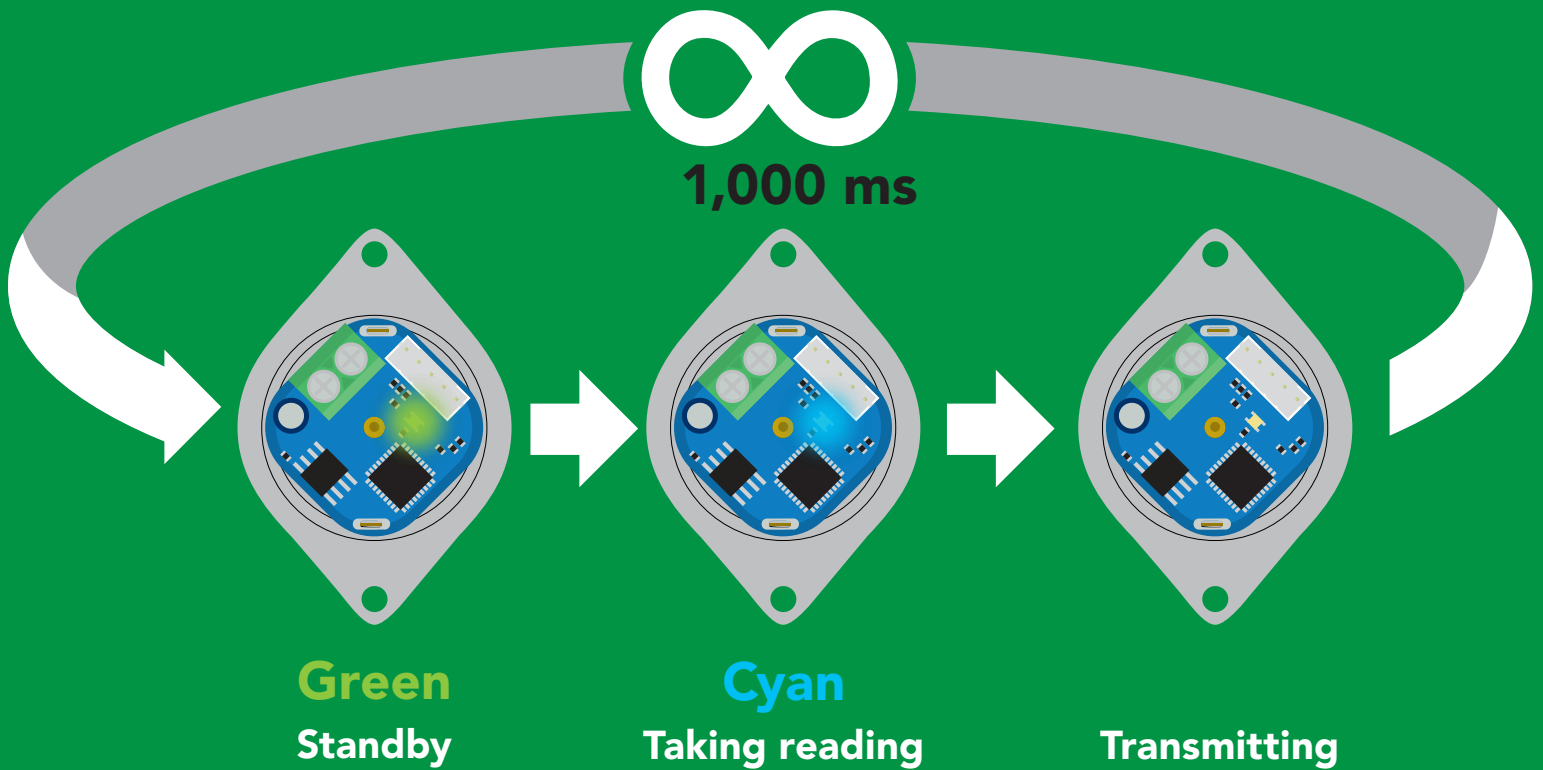
UART mode

Settings that are retained if power is cut

Baud rate
Calibration
Continuous mode
Device name
Enable/disable parameters
Enable/disable response codes
Hardware switch to I²C mode
Invert
LED control
Protocol lock
Software switch to I²C mode

Settings that are *NOT* retained if power is cut

Absolute total volume
Find
Sleep mode
Total volume

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UART mode

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

RX TX

TX ➡ RX ✓   RX ⬅ TX ✓

RX   TX

CPU
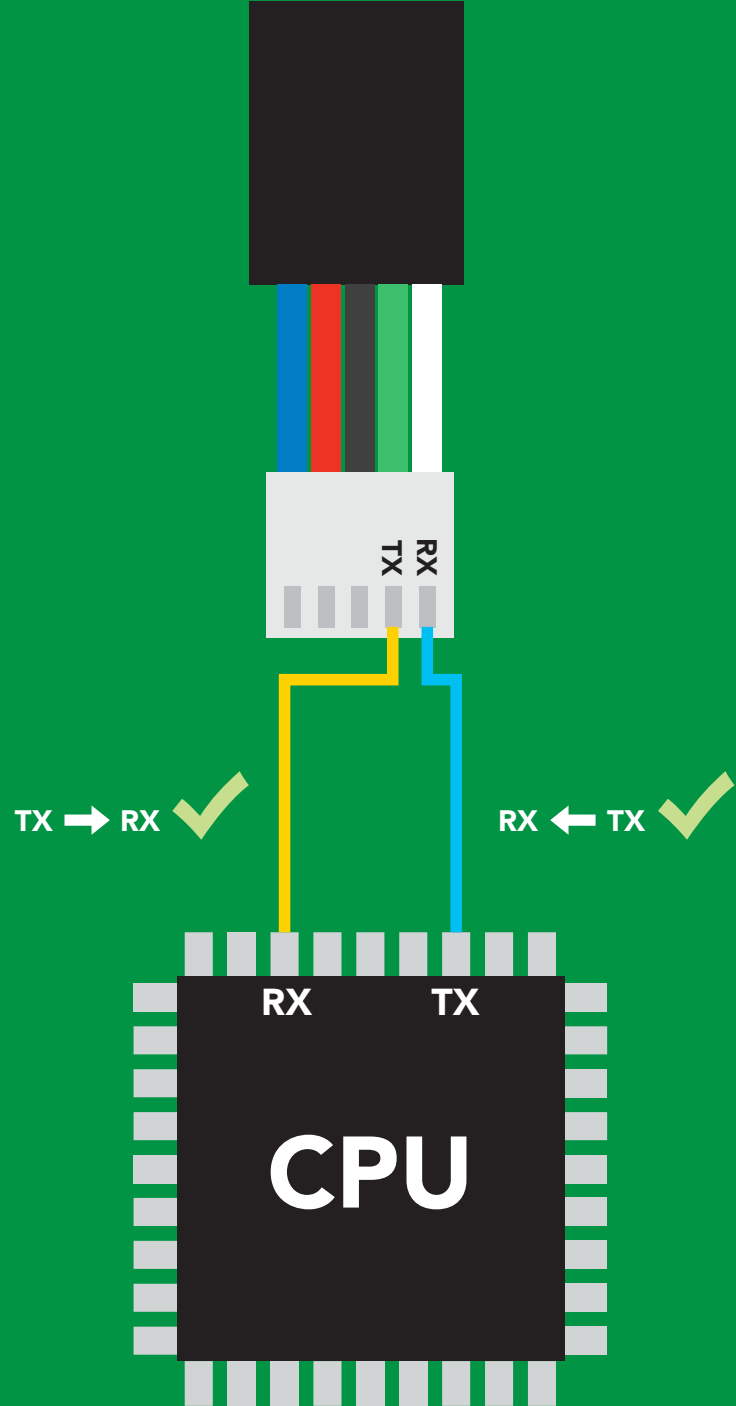
Data format

Output	volume	**Terminator**	carriage return
Units	ml	**Data type**	floating point
Encoding	ASCII	**Decimal places**	2
Format	string	**Smallest string**	3 characters
		Largest string	39 characters

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Receiving data from device

2 parts

ASCII data string
Command

Carriage return <cr>
Terminator

9,600 baud (default)

RX ← TX ✓

RX
TX

TX → RX ✓

TX

CPU

RX

Sender

Receiver

413 <cr>
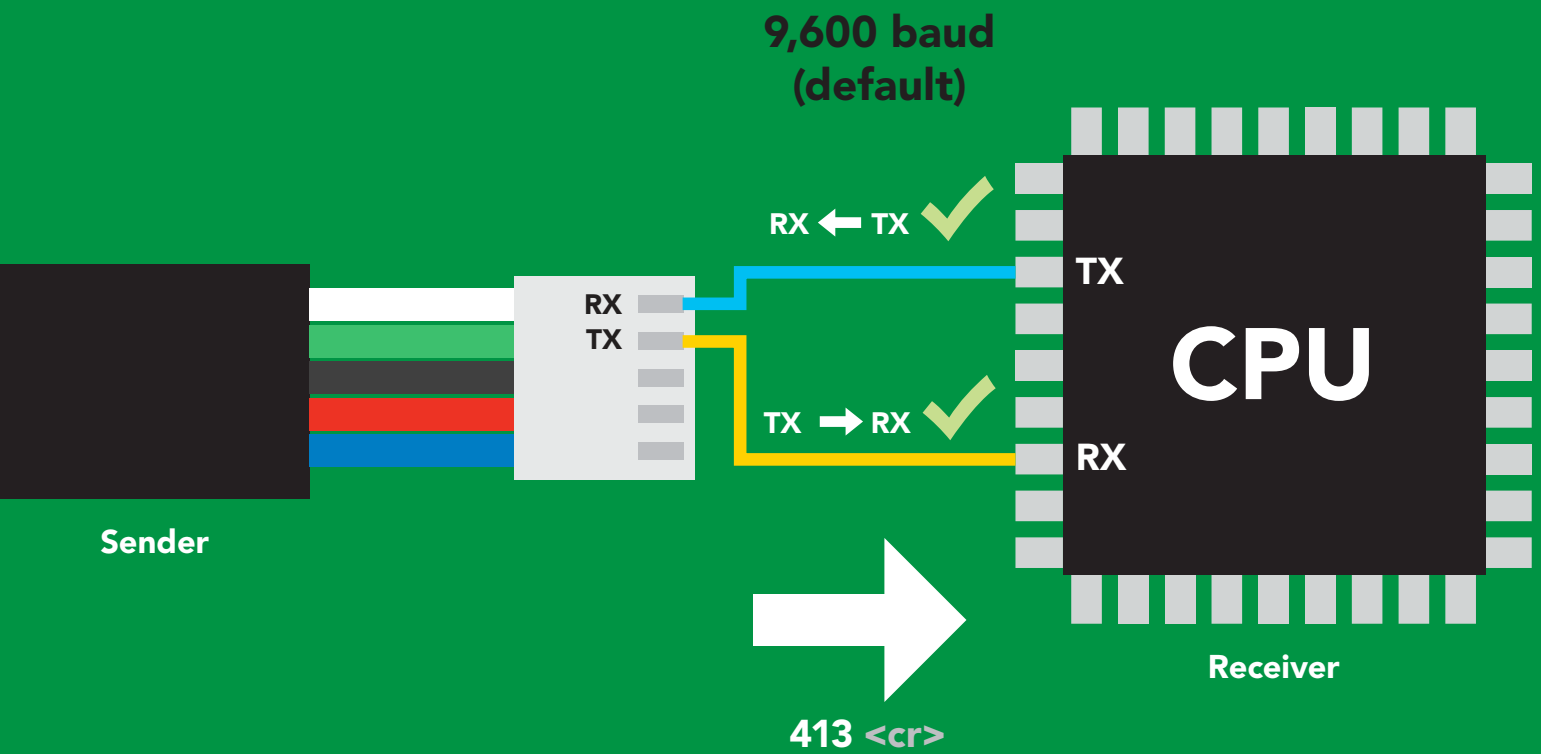
Advanced

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

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Sending commands to device

2 parts

Command (not case sensitive)

ASCII data string

Carriage return <cr>

Terminator

RX ← TX

TX

CPU

RX

TX → RX

Receiver

Sender

Sleep <cr>
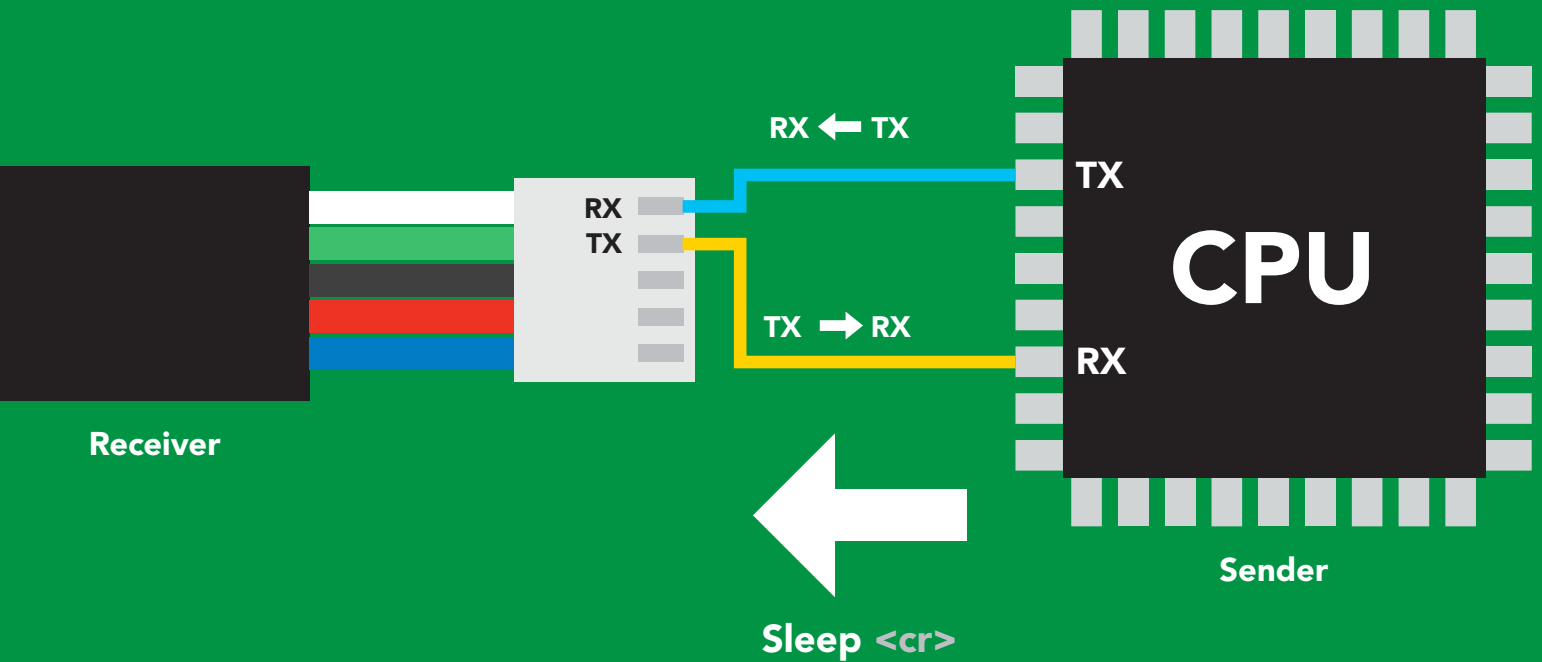
Advanced

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

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LED color definition

Green
UART standby

Cyan
Taking reading
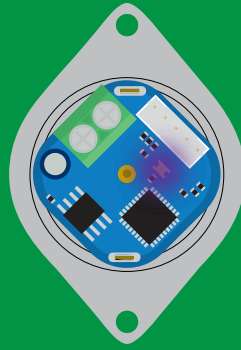
Purple
Changing
baud rate

Red
Command
not understood

White
Find

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

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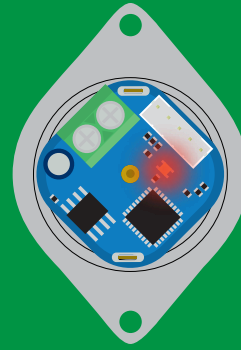
UART mode
command quick reference

All commands are ASCII strings or single ASCII characters.

Command	Function		Default state
Baud	change baud rate	pg. 39	9,600
C	enable/disable continuous mode	pg. 18	enabled
Cal	performs calibration	pg. 31	n/a
D	dispense modes	pg. 20 – 26	n/a
Factory	enable factory reset	pg. 41	n/a
Find	finds device with blinking white LED	pg. 17	n/a
i	device information	pg. 35	n/a
Invert	invert dispensing direction	pg. 29	n/a
I2C	change to I^{2}C mode	pg. 42	not set
L	enable/disable LED	pg. 16	enabled
Name	set/show name of device	pg. 34	not set
O	enable/disable parameters	pg. 32	all enabled
P	pause dispensing	pg. 27	n/a
Plock	enable/disable protocol lock	pg. 40	disabled
Pv	check pump voltage	pg. 33	n/a
R	returns a single reading	pg. 19	n/a
Sleep	enter sleep mode/low power	pg. 38	n/a
Status	retrieve status information	pg. 37	enable
Tv	total volume dispensed	pg. 30	n/a
X	stop dispensing	pg. 28	n/a
*OK	enable/disable response codes	pg. 36	enable

LED control

Command syntax

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

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

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

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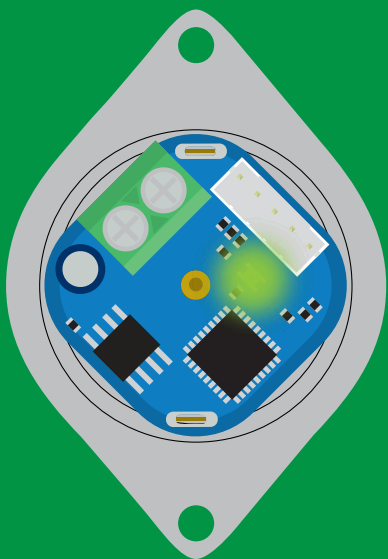
L,1
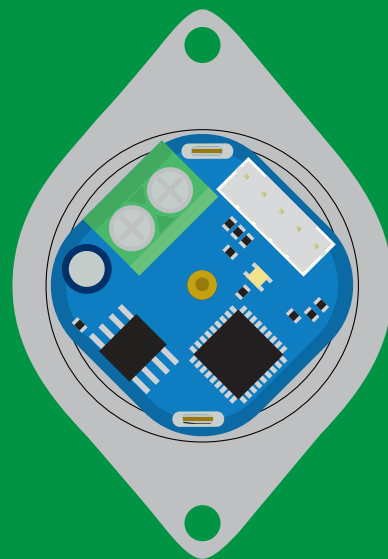
L,0

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Find

Command syntax

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

Example   Response

Find <cr>   *OK <cr>

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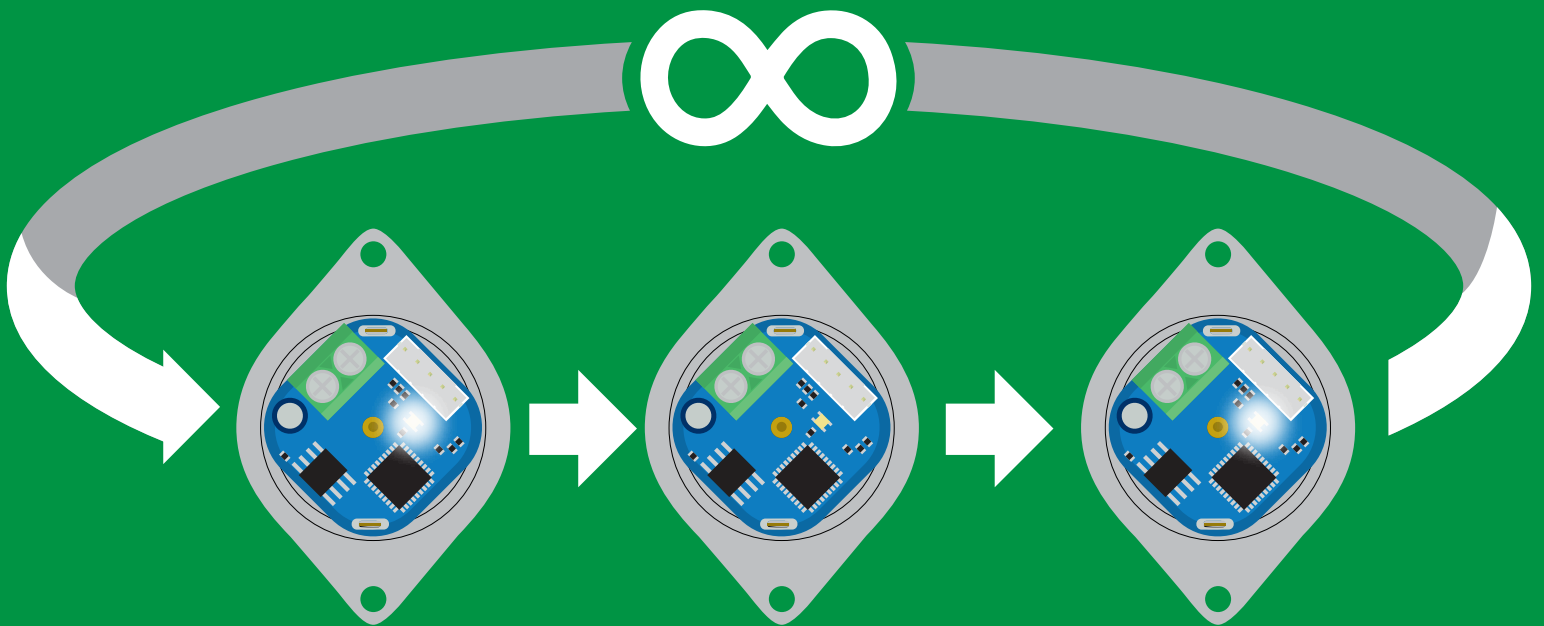
Continuous mode

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 3ml **C,* <cr>**	1.2 <cr> 3.0 <cr> *Done,3.00 <cr> 3.0 <cr> 3.0 <cr>
C,1 <cr>	1.2 <cr> 3.0 <cr> *Done,3.00 <cr>
C,0 <cr>	*Done,3.00 <cr>
C,? <cr>	?C,1 <cr> or ?C,0 <cr> or ?C,* <cr> *OK <cr>

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Single reading mode

Command syntax

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

Example	Response	
R <cr>	2.50 <cr> *OK <cr>	(If issued half way through dispensing 5ml)
	5.00 <cr> *OK <cr>	(If issued once dispensing has stopped)

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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 ~105ml/min (with supplied tubing)
D,-* <cr>	***OK** <cr>	pump will continuously run in reverse at ~105ml/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

Example	Response
D,15 <cr>	***OK** <cr> **15 ml will be dispensed**
D,-40.5 <cr>	***OK** <cr> **40.5 ml will be dispensed** *in reverse*
D,? <cr>	**?D,-40.50,0** <cr> ***OK** <cr>

Response breakdown

?D,-40.50,0

↑ 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,85,10 <cr>	***OK <cr>**	**Dispense 85ml over 10 minutes**

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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

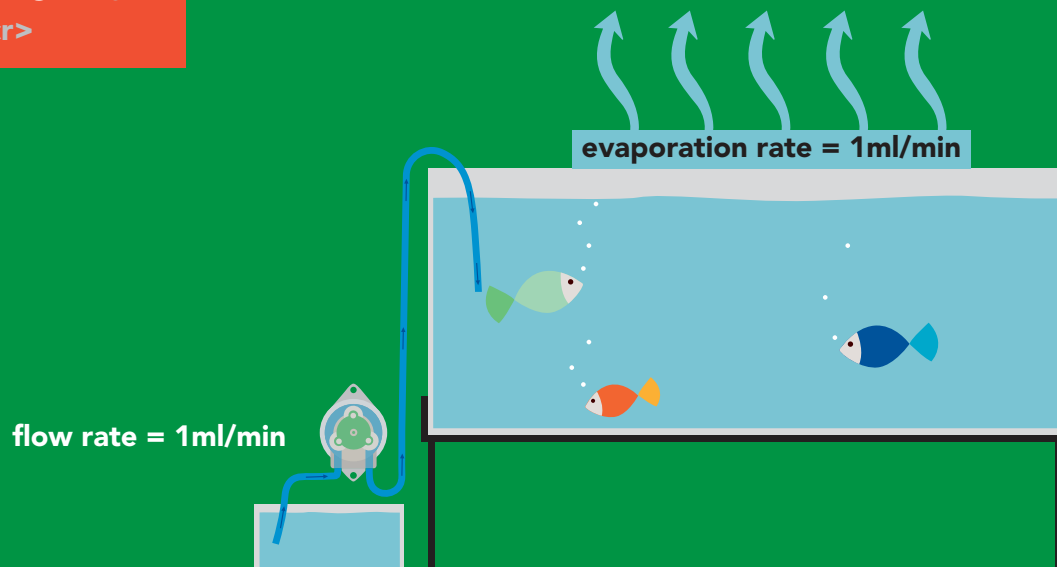| Example	Response
DC,25,40 <cr>	*OK <cr> Dispense 25ml per minute for 40 minutes
DC,? <cr>	?MAXRATE,58.5 <cr> *OK <cr>

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

*TOOFAST <cr>
*ER <cr>

evaporation rate = 1ml/min

flow rate = 1ml/min

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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,10 <cr>	*OK <cr>
Dstart,off <cr>	*OK <cr>
Dstart,? <cr>	?Dstart,10 <cr> or ?Dstart,0 <cr> *OK <cr>

ON

Power

OFF

INT pin

10ml
Dispensed

10ml
Dispensed

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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

Example	Response	
Dstart,* <cr>	*OK <cr>	Pump will startup and continuously run at ~105ml/min (with supplied tubing)
Dstart,-* <cr>	*OK <cr>	Pump will startup and continuously run in reverse at ~105ml/min (with supplied tubing)
Dstart,? <cr>	?Dstart,* <cr>	

ON

Power

OFF

INT pin

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Dose Over time at startup

Pump a fixed volume over a fixed time at startup

Command syntax

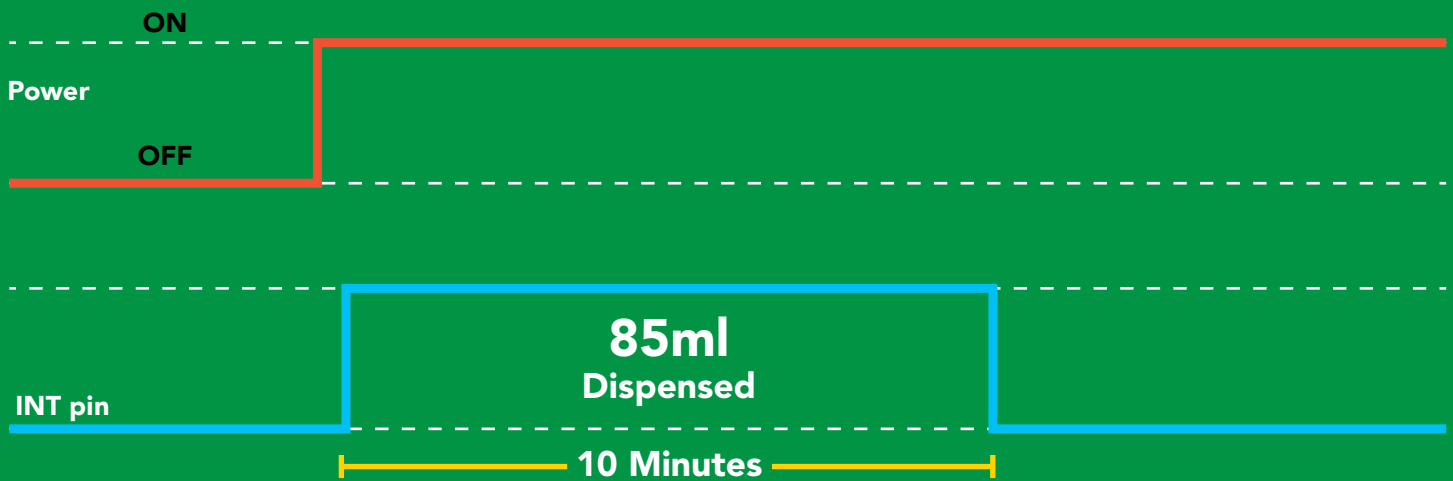**D,[ml],[min]** <cr>   Dispense [this volume], [over this many minutes] at startup

Example | Response

Dstart,85,10 <cr> | ***OK** <cr> **Pump will startup and dispense 85ml over 10 minutes**

Dstart,? <cr> | **?Dstart,85.00,10.00** <cr>

ON

Power

OFF

INT pin

85ml
Dispensed

10 Minutes

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Pause dispensing

Command syntax

P <cr>   pauses the pump during dispensing

P,? <cr>   pause status

Example

Response

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

dispensing → paused → dispensing

P   P

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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,10.15
Stopped

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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>
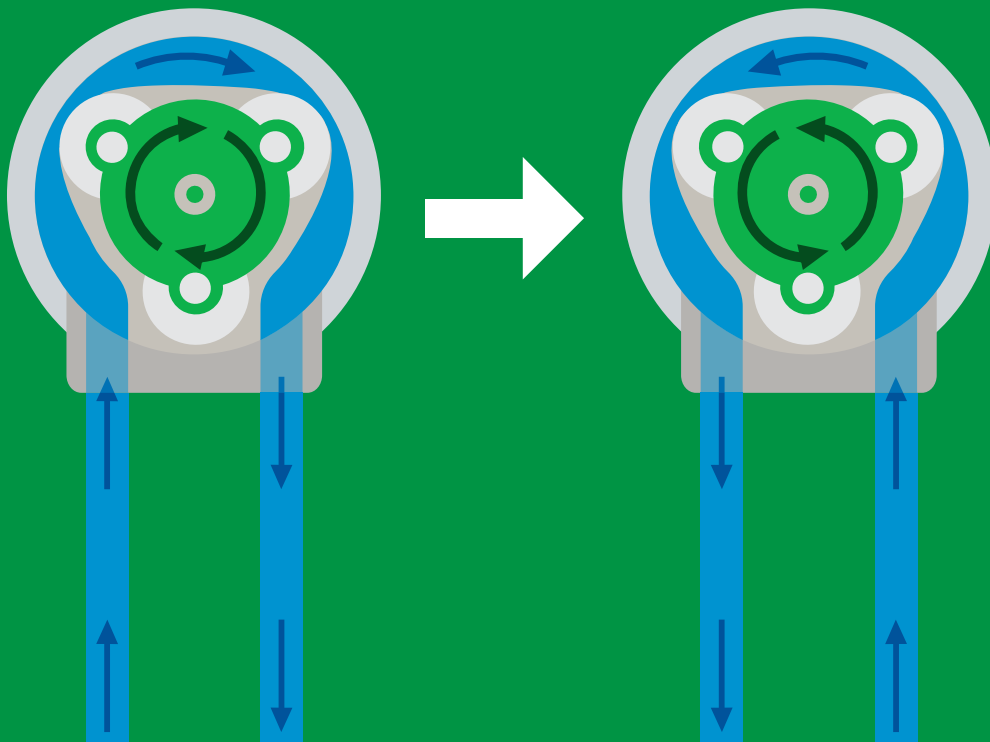
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Total volume dispensed

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.

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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,24.01 `<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>`

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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

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Pump voltage

Command syntax

PV,? <cr> check pump voltage

Example

Response

PV,? <cr>

?PV,13.86 <cr>
*OK <cr>

Response breakdown

?PV,   13.86
          ↑
     Pump input voltage

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

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>`

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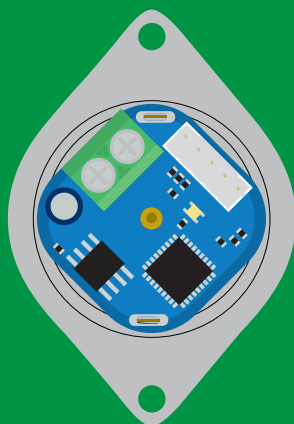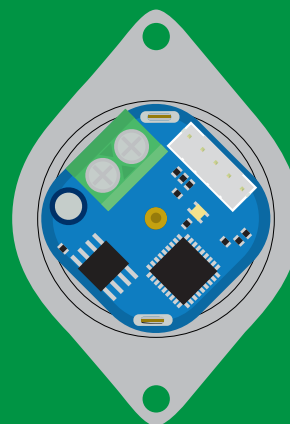
Device information

Command syntax

i **<cr>** device information

Example

i **<cr>**

Response

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

Response breakdown

?i, PMP, 1.1
    ↑   ↑
   Device Firmware

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Response codes

Command syntax

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

Example	Response
R <cr>	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

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Reading device status

Command syntax

Status **<cr>** voltage at Vcc pin and reason for last restart

Example

Example	Response
Status **<cr>**	?Status,P,5.038 **<cr>** *OK **<cr>**

Response breakdown

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

Restart codes

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

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Sleep mode/low power

Command syntax

Sleep <cr> enter sleep mode/low power

Example

Response

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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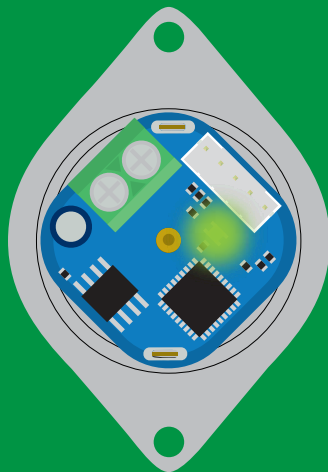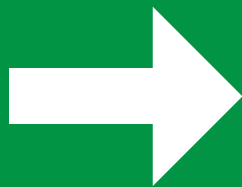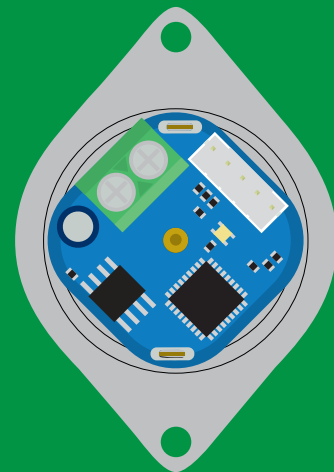
Change baud rate

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
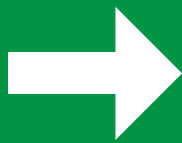
Baud,38400 <cr>

Changing baud rate

*OK <cr>
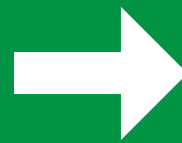
(reboot)

Standby

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Protocol lock

Command syntax

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

I2C,100

*OK <cr>

cannot change to I²C
*ER <cr>
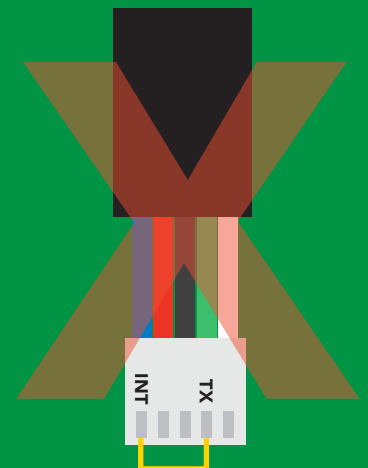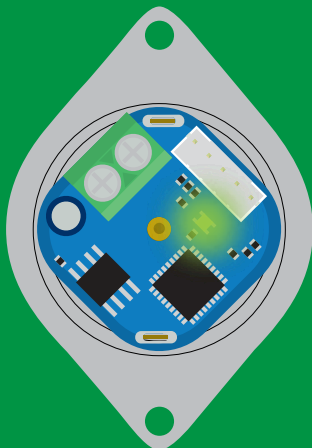
cannot change to I²C

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Factory reset

Command syntax

Factory <cr> enable factory reset

Example   Response

Factory <cr>   *OK <cr>

Factory <cr>
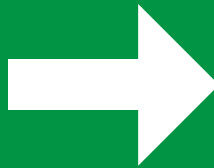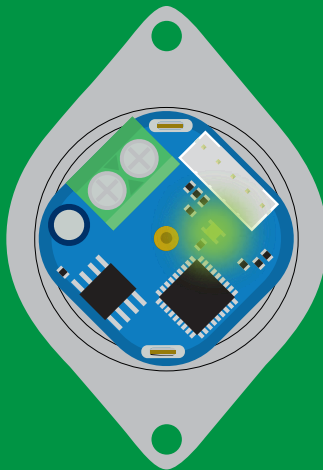
(reboot)

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

Baud rate will not change

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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
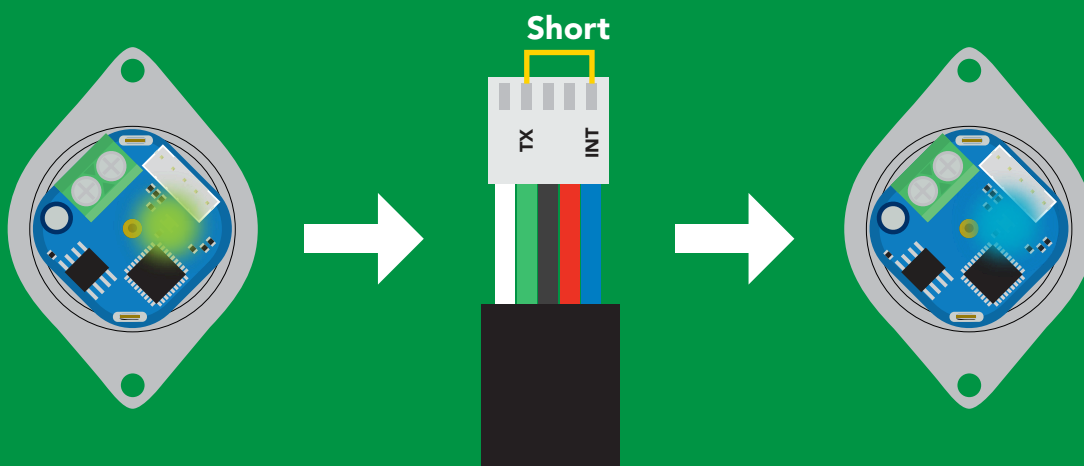
I2C,139 <cr> **n ≯ 127**   ***ER** <cr>

I2C,100

(reboot)

Green
***OK** <cr>

Blue
now in I²C mode

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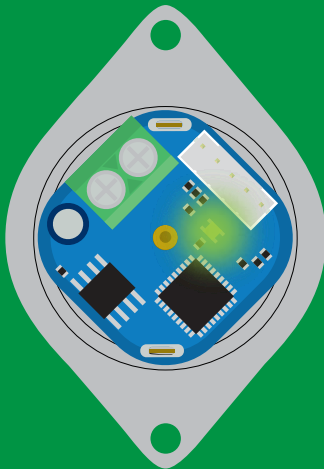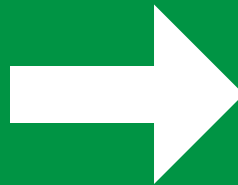
Manual switching to I²C

- **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 103 (0x67)

Example

Short

TX INT

Wrong Example

Disconnect RX line ➡

Short

RX

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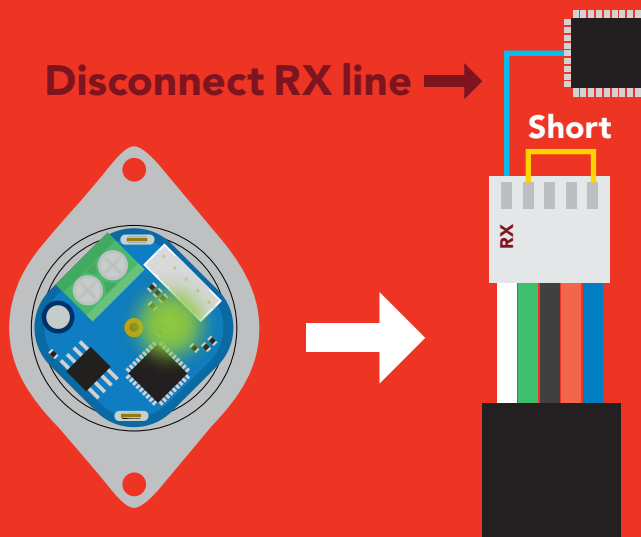
I²C mode

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™ 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

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I²C mode

I²C address   (0x01 – 0x7F)

103 (0x67) 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
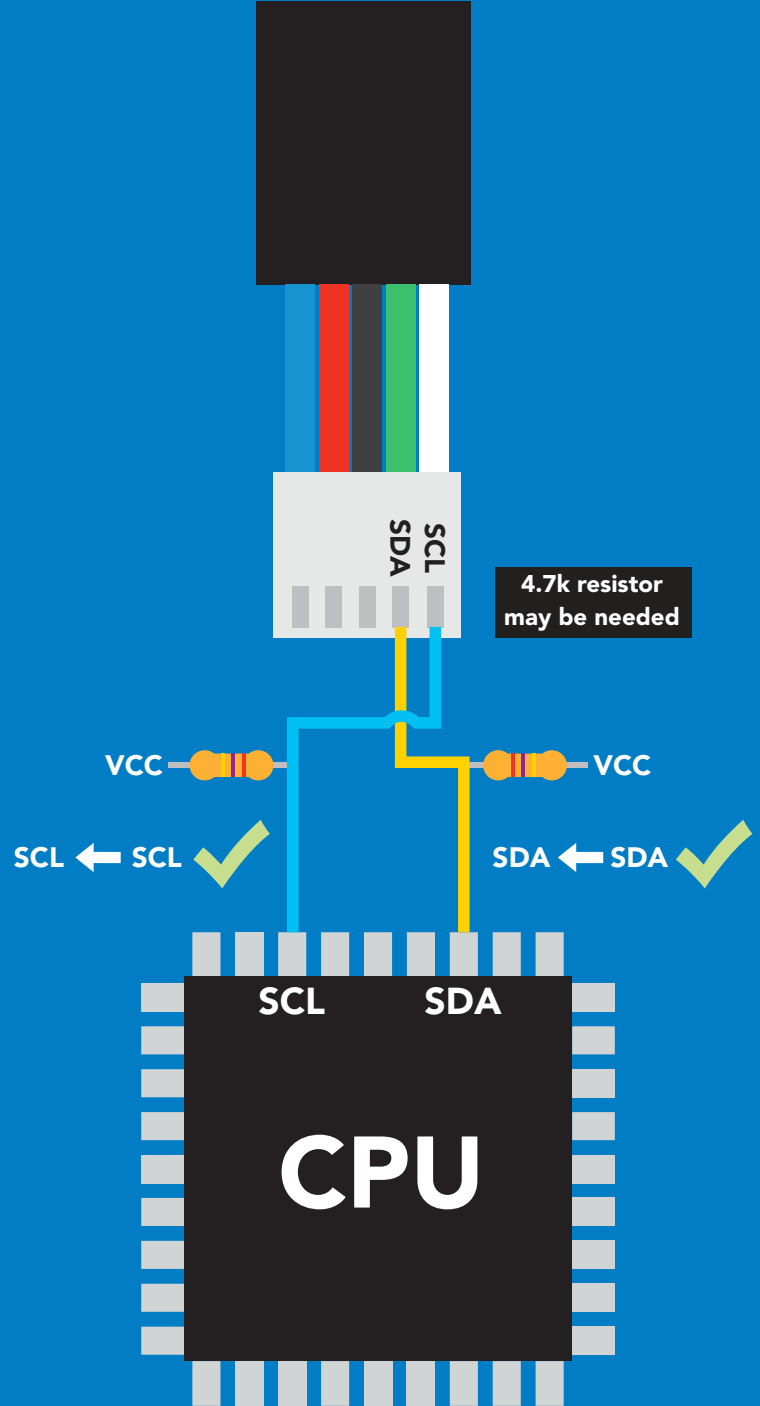
Data format

Reading	volume		**Data type**	floating point
Units	ml		**Decimal places**	2
Encoding	ASCII		**Smallest string**	3 characters
Format	string		**Largest string**	39 characters

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Sending commands to device

5 parts

Start	I²C address	Write	Command (not case sensitive)	Stop
	103 (0x67)		ASCII command string	

Example

Start	103 (0x67)	Write	Sleep	Stop
	I²C address		Command	

SDA ← SDA ✓

SCL
SDA

CPU

SDA

SCL

SCL ← 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

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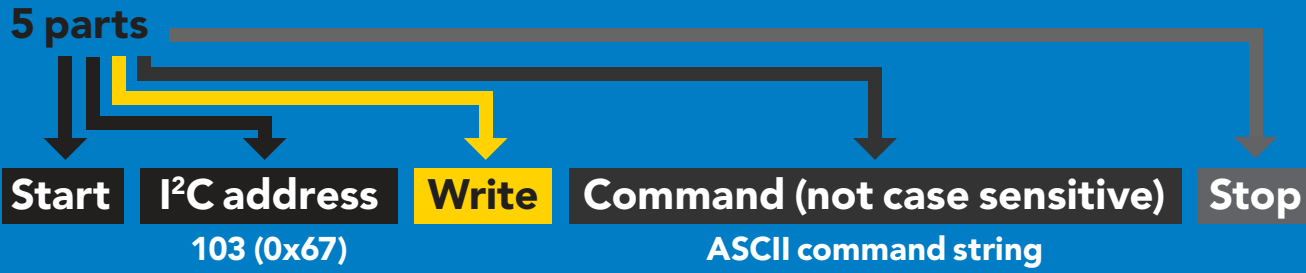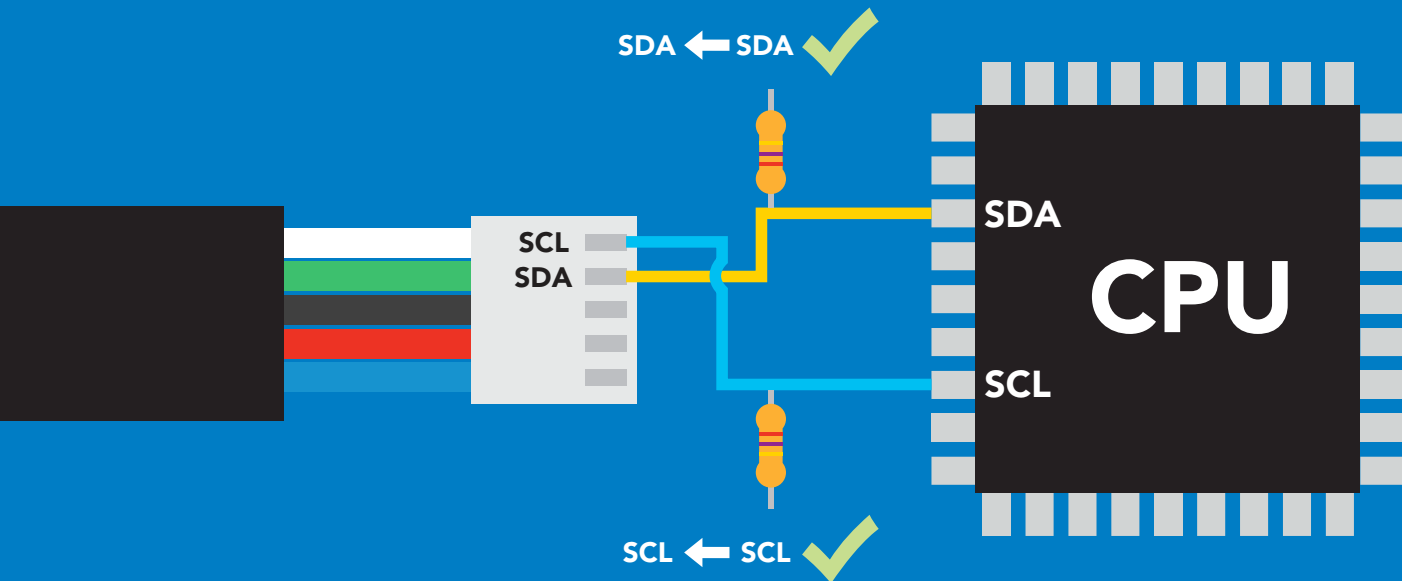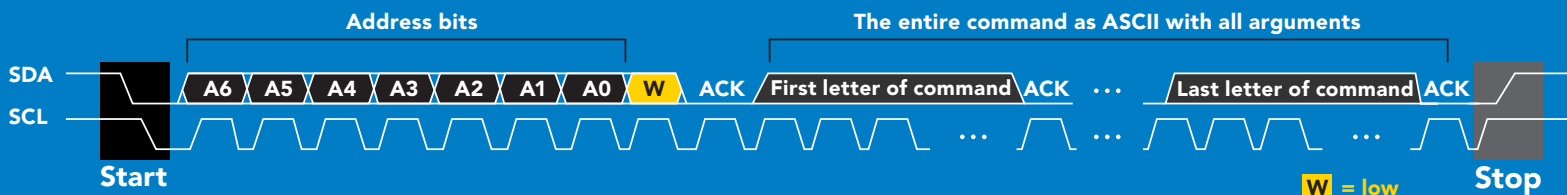
Requesting data from device

7 parts

| Start | I²C address | Read | Response code | Data string | Null | Stop |

103 (0x67)   1 byte   "413"   Terminator (Dec 0)

413

SDA ← SDA ✓

SCL ← SCL ✓

SCL
SDA

SDA

CPU

SCL

Advanced

Address bits

N bytes of data

All bytes after data are Null

R = High

SDA

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

SCL
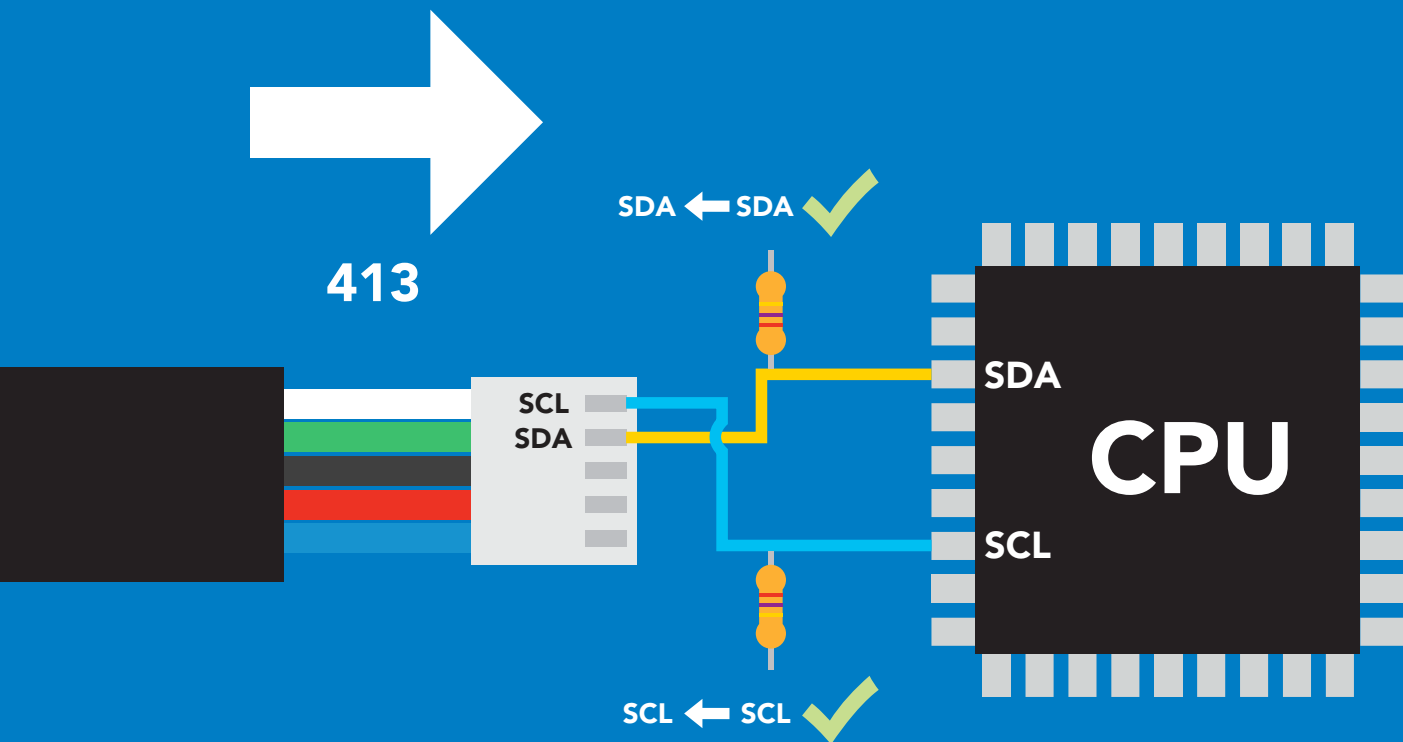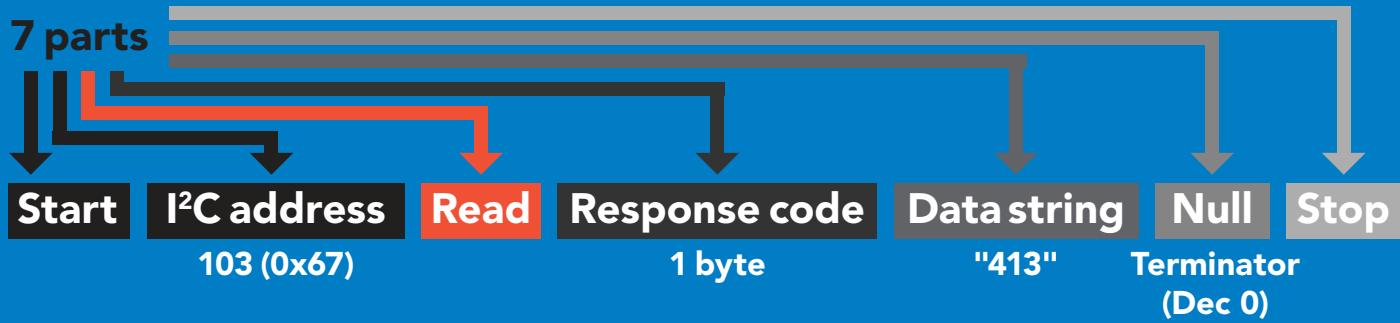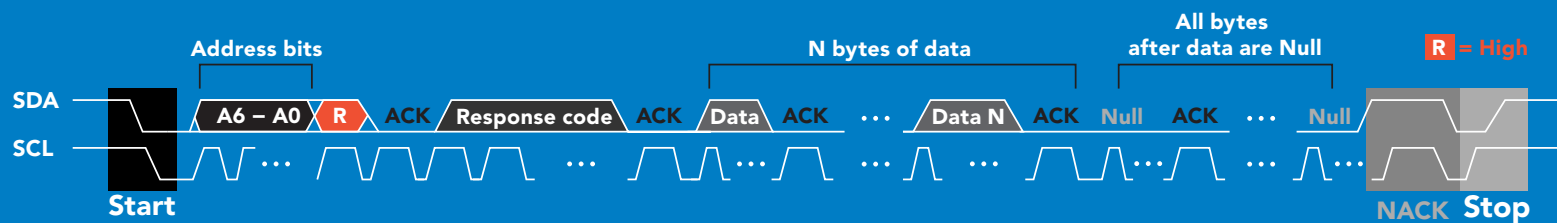
| 1 | 52 | 49 | 51 | 0 | = 413 |

Dec   ASCII   Dec

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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.

Send command

Processing delay

CPU

Receiving data
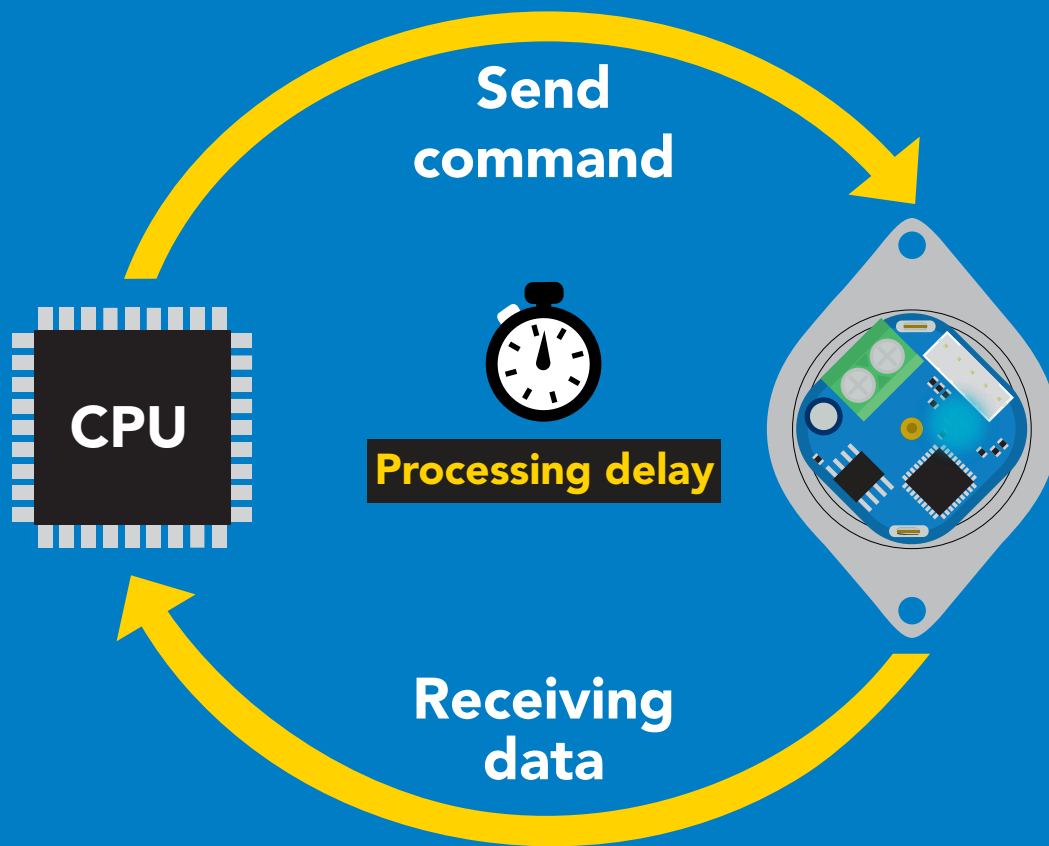
Example

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

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LED color definition
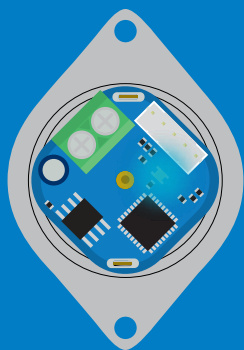
Blue
I²C standby
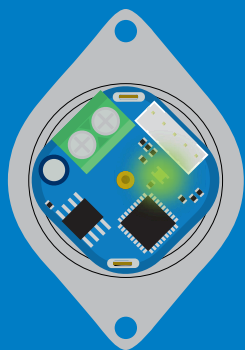
Green
Taking reading
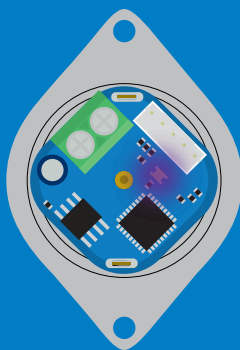
Purple
Changing
I²C address

Red
Command
not understood

White
Find

	LED ON
5V	**+2.5 mA**

3.3V	**+1 mA**

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r 0.1
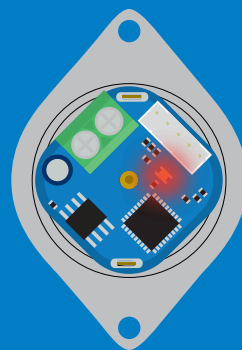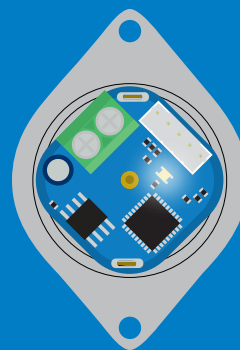
I²C mode
command quick reference

All commands are ASCII strings or single ASCII characters.

Command	Function	
Baud	switch back to UART mode	pg. 75
Cal	performs calibration	pg. 65
D	dispense modes	pg. 54 – 60
Factory	enable factory reset	pg. 74
Find	finds device with blinking white LED	pg. 52
i	device information	pg. 69
Invert	invert dispensing direction	pg. 63
I2C	change I²C address	pg. 73
L	enable/disable LED	pg. 51
Name	set/show name of device	pg. 68
O	enable/disable parameters	pg. 66
P	pauses the pump during dispensing	pg. 61
Plock	enable/disable protocol lock	pg. 72
Pv	check pump voltage	pg. 67
R	returns a single reading	pg. 53
Sleep	enter sleep mode/low power	pg. 71
Status	retrieve status information	pg. 70
Tv	total volume dispensed	pg. 64
X	stop dispensing	pg. 62

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LED control

Command syntax

300ms ⏱ processing delay

L,1 LED on `default`

L,0 LED off

L,? LED state on/off?

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

L,1

L,0

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r 0.1
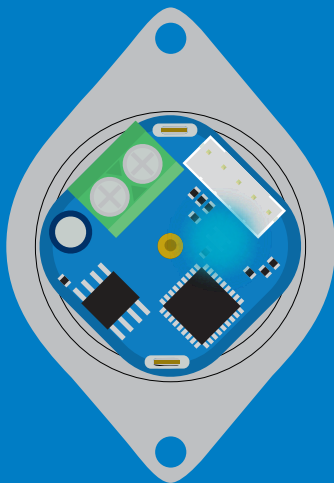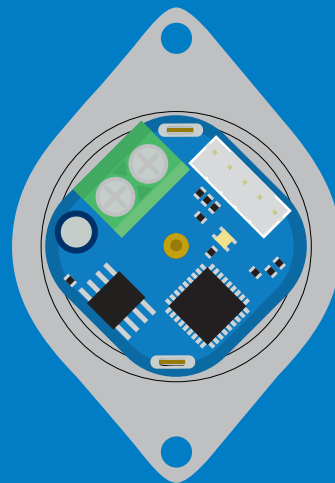
Find

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

∞

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r 0.1
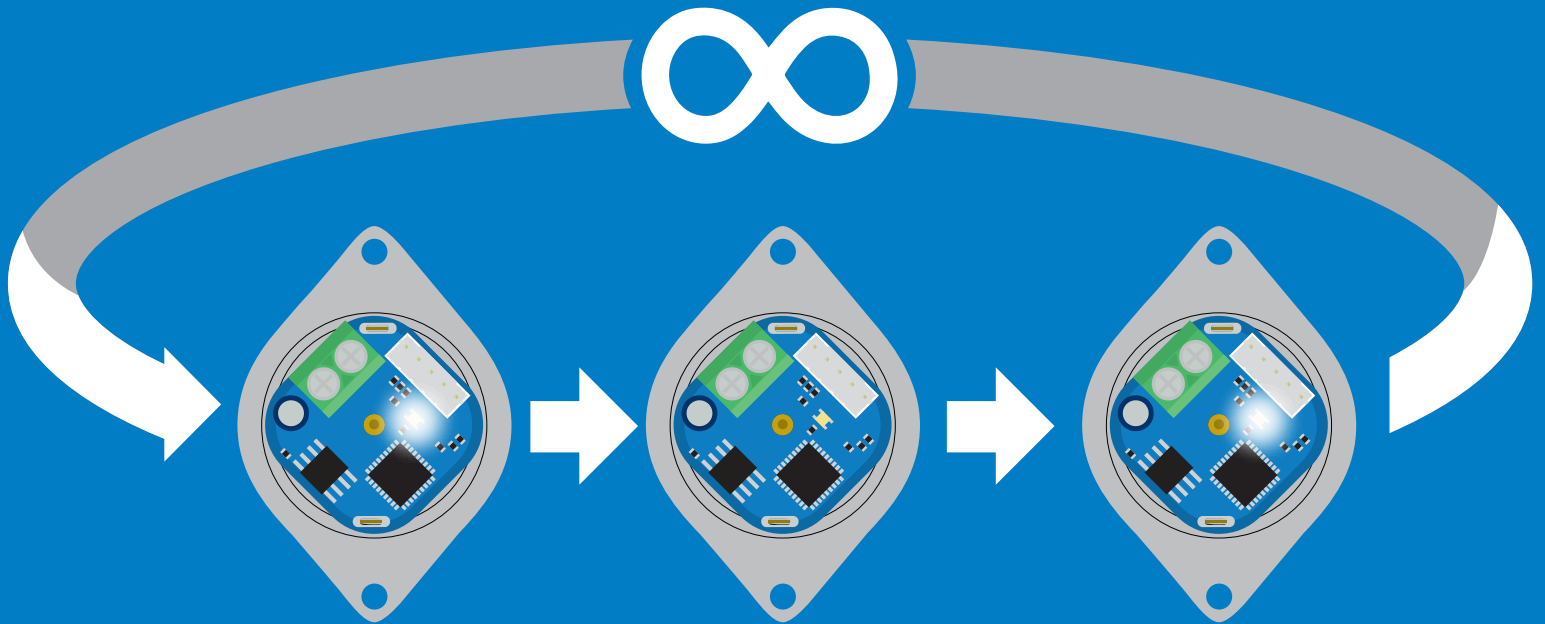
Single report mode

Command syntax
300ms ⏱ processing delay

R   returns a single value showing dispensed volume

Example   Response

R

⏱ **Wait 300ms**   **1** Dec   **2.50** ASCII   **0** Null   **(If issued half way through dispensing 5ml)**

⏱ **Wait 300ms**   **1** Dec   **5.00** ASCII   **0** Null   **(If issued once dispensing has stopped)**

Green
Taking reading

Wait 600ms ⏱
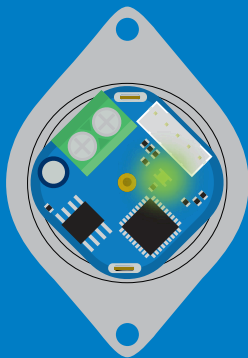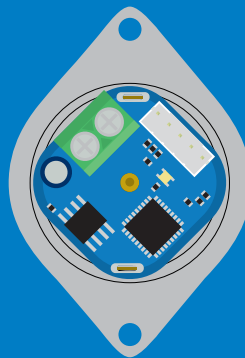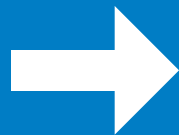
Transmitting

Blue
Standby

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r 0.1
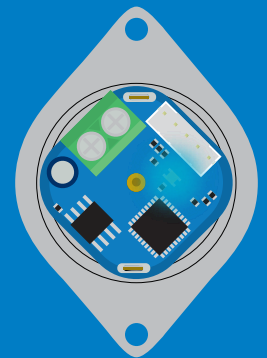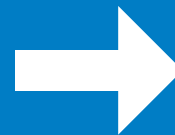
Continuous dispensing

Pump on/pump off

300ms processing delay

Command syntax

After running in continuous mode for 20 days the EZO-PMP™ 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 ~105ml/min (with supplied tubing)**
D,-*	Wait 300ms	**1** Dec	**0** Null	**pump will continuously run in reverse at ~105ml/min (with supplied tubing)**
D,?	Wait 300ms	**1** Dec	**?D,10.00,1** ASCII	**0** Null

Response breakdown

?D,*,1

↑ last volume requested   ↑ pump on

Volume dispensing

Pump a specific volume

300ms ⏱ processing delay

Command syntax

D,[ml]   dispense [this specific volume]

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

D,?   dispense status

Example   Response

Example	Response			
D,15	Wait 300ms	**1** Dec	**0** Null	**15 ml will be dispensed**
D,-40.5	Wait 300ms	**1** Dec	**0** Null	**40.5 ml will be dispensed** *in reverse*
D,?	Wait 300ms	**1** Dec	**?D,-40.50,0** ASCII	**0** Null

Response breakdown

?D,-40.50,0

↑ last volume dispensed   ↑ pump off

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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,85,10

⏱ **Wait 300ms**

1 Dec   **0** Null   **Dispense 85ml over 10 mins**

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Constant flow rate

Maintain a constant flow rate

300ms ⏱ **processing delay**

Command syntax

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,25,40

⏱ **Wait 300ms** | **1** Dec | **0** Null | **Dispense 25ml per minute for 40 minutes**

DC,?

⏱ **Wait 300ms** | **1** Dec | **?maxrate,58.5** ASCII | **0** Null |

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

***TOOFAST
*ER**

evaporation rate = 1ml/min

flow rate = 1ml/min

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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

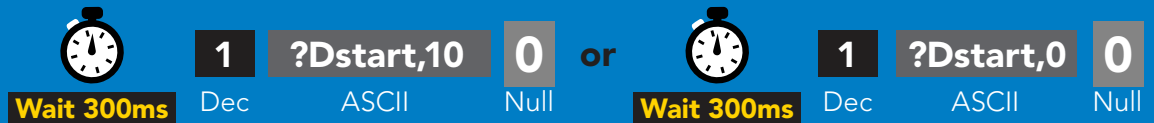|	
Dstart,[ml]	dispense [this specific volume] at startup
Dstart,off	disables dispense at startup mode
Dstart,?	startup dispense status

Example   Response

Dstart,10

Wait 300ms   1 Dec   0 Null

Dstart,off

Wait 300ms   1 Dec   0 Null

D,?

Wait 300ms   1 Dec   ?Dstart,10 ASCII   0 Null   or   Wait 300ms   1 Dec   ?Dstart,0 ASCII   0 Null

ON

Power

OFF

INT pin   10ml Dispensed   10ml Dispensed

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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 ~105ml/min (with supplied tubing)

Dstart,-*

⏱ Wait 300ms | **1** Dec | **0** Null

Pump will startup and continuously run in reverse at ~105ml/min (with supplied tubing)

Dstart,?

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

Power — ON / OFF

INT pin

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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,85,10

⏱ **Wait 300ms** | **1** Dec | **0** Null | **Pump will startup and dispense 85ml over 10 minutes**

Dstart,?

⏱ **Wait 300ms** | **1** Dec | **?Dstart,85.00,10.00** ASCII | **0** Null

ON

Power

OFF

INT pin

85ml
Dispensed

10 Minutes

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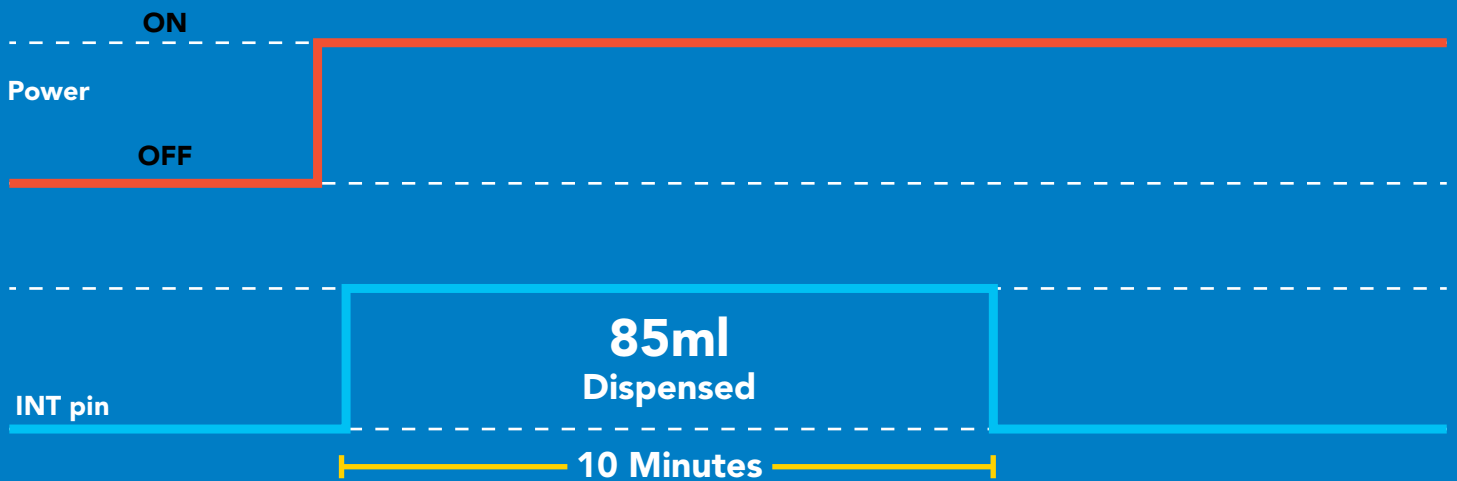
Pause dispensing

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
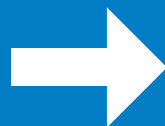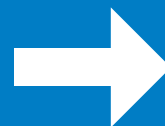
dispensing ➡ paused ➡ dispensing

               P   P

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Stop dispensing

Command syntax

X   stop dispensing

Example   Response

X

⏱ **Wait 300ms** | **1** Dec | ***DONE,v** ASCII | **0** Null | **v = volume dispensed**

X
dispensing

➡ ***DONE,10.15**
Stopped

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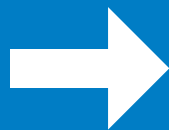
Invert dispensing direction

300ms ⏱ processing delay

Command syntax

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

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Total volume dispensed

Command syntax

TV,?   shows total volume dispensed

ATV,?   absolute value of the total volume dispensed

Clear   clears the total dispensed volume

Example   Response

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.

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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,24.01

⏱ 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

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Enable/disable parameters from output string

Command syntax

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**

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Pump voltage

Command syntax

PV,?   check pump voltage

Example   Response

PV,?

⏱ **Wait 300ms**   **1** Dec   **?PV,13.86** ASCII   **0** Null

Response breakdown

?PV,   13.86
↑
Pump input voltage

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Naming device

Command syntax

Do not use spaces in the name

Name,n   set name

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

Name,   clears name

Up to 16 ASCII characters

Name,?   show name

Example | Response

Name,

⏱ **Wait 300ms**   `1` Dec   `0` Null   **name has been cleared**

Name,zzt

⏱ **Wait 300ms**   `1` Dec   `0` Null

Name,?

⏱ **Wait 300ms**   `1` Dec   `?Name,zzt` ASCII   `0` Null

Name,zzt   **Name,?**

`1`   `0`   `1`   `?Name,zzt`   `0`

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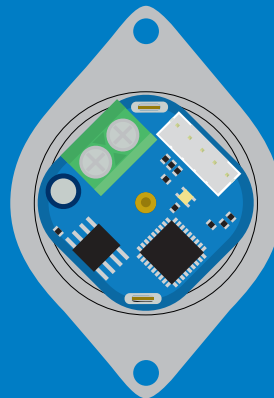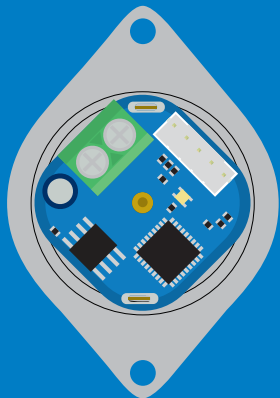
Device information

Command syntax

300ms processing delay

i   device information

Example

i

Response

Wait 300ms | **1** Dec | **?i,PMP, 1.1** ASCII | **0** Null

Response breakdown

?i,   **PMP,**   **1.1**

Device   Firmware

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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

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Sleep mode/low power

Command syntax

Sleep	enter sleep mode/low power	Send any character or command to awaken device.

Example	Response	
Sleep	no response	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**

Standby → **Sleep**

Sleep

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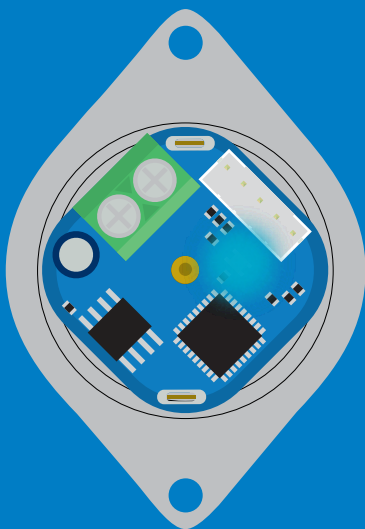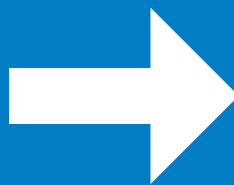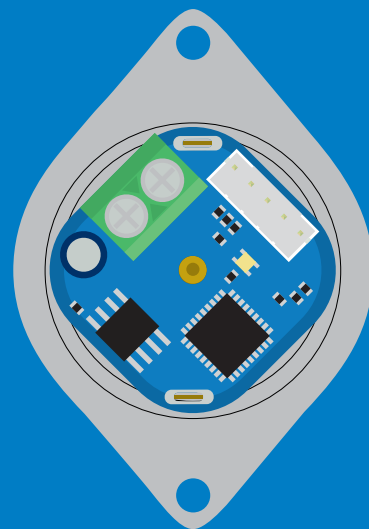
Protocol lock

Command syntax

300ms ⏱ processing delay

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

Locks device to I²C mode.

Example   Response

Plock,1

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

Plock,0

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

Plock,?

⏱ **Wait 300ms**   **1** Dec   **?Plock,1** ASCII   **0** Null
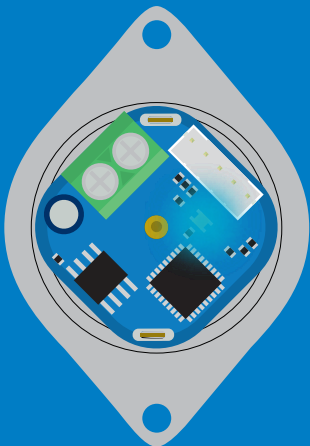
Plock,1   **Baud, 9600**
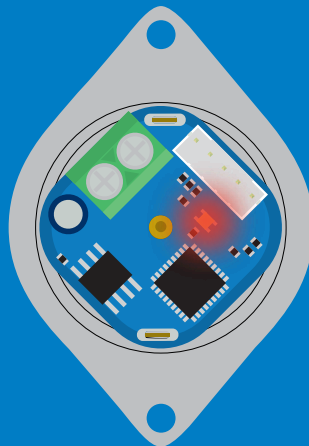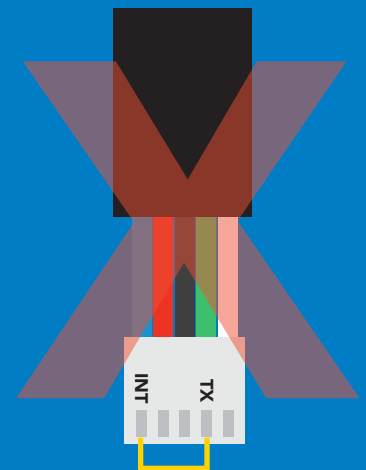
cannot change to UART   **cannot change to UART**

INT   TX

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I²C address change

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.
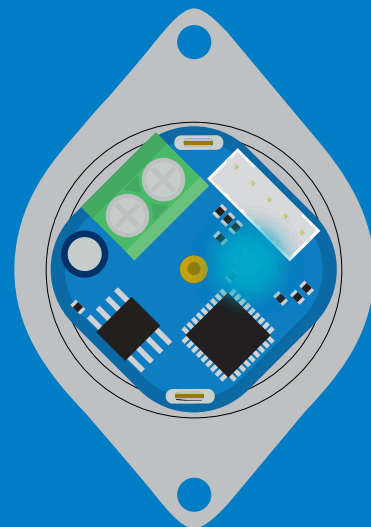
Default I²C address is 103 (0x67).

n = any number 1 – 127

I2C,101
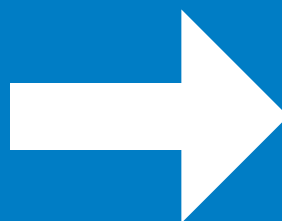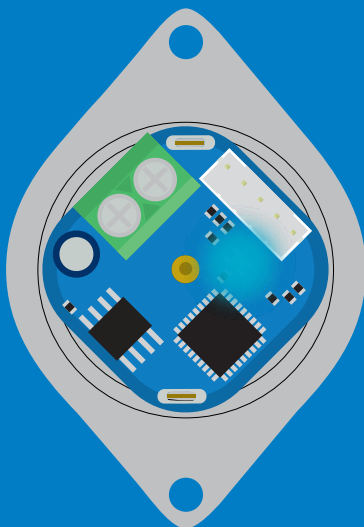
(reboot)

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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)

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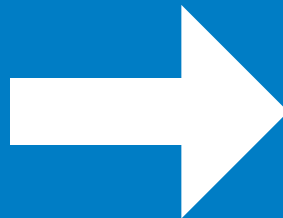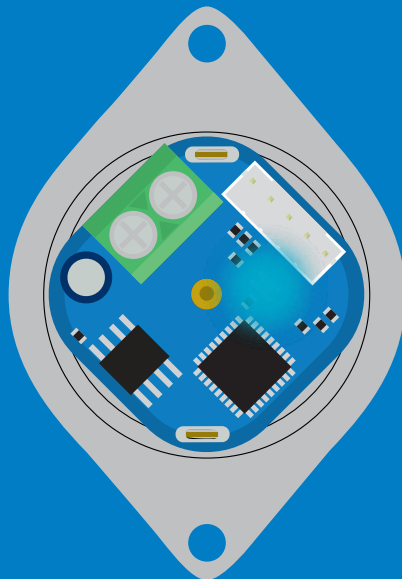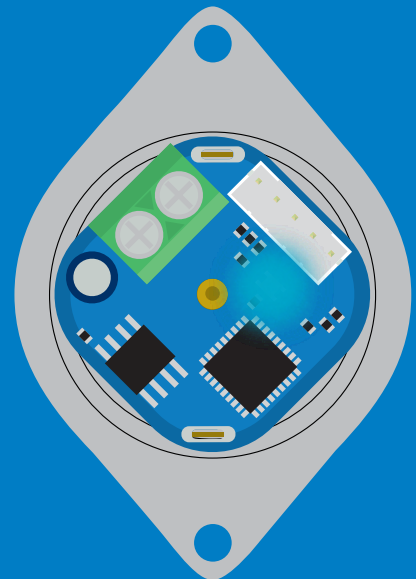
Change to UART mode

Command syntax

Baud,n   switch from I²C to UART

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

$$n = \begin{cases} 300 \\ 1200 \\ 2400 \\ 9600 \\ 19200 \\ 38400 \\ 57600 \\ 115200 \end{cases}$$

Baud,9600

Changing to UART mode

(reboot)

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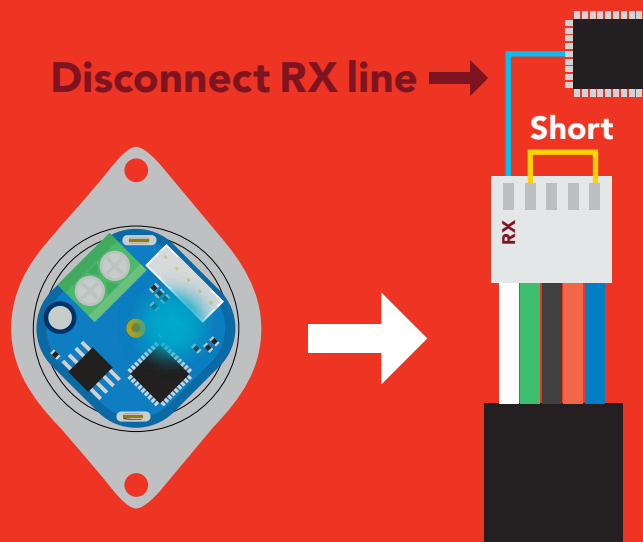r 0.1
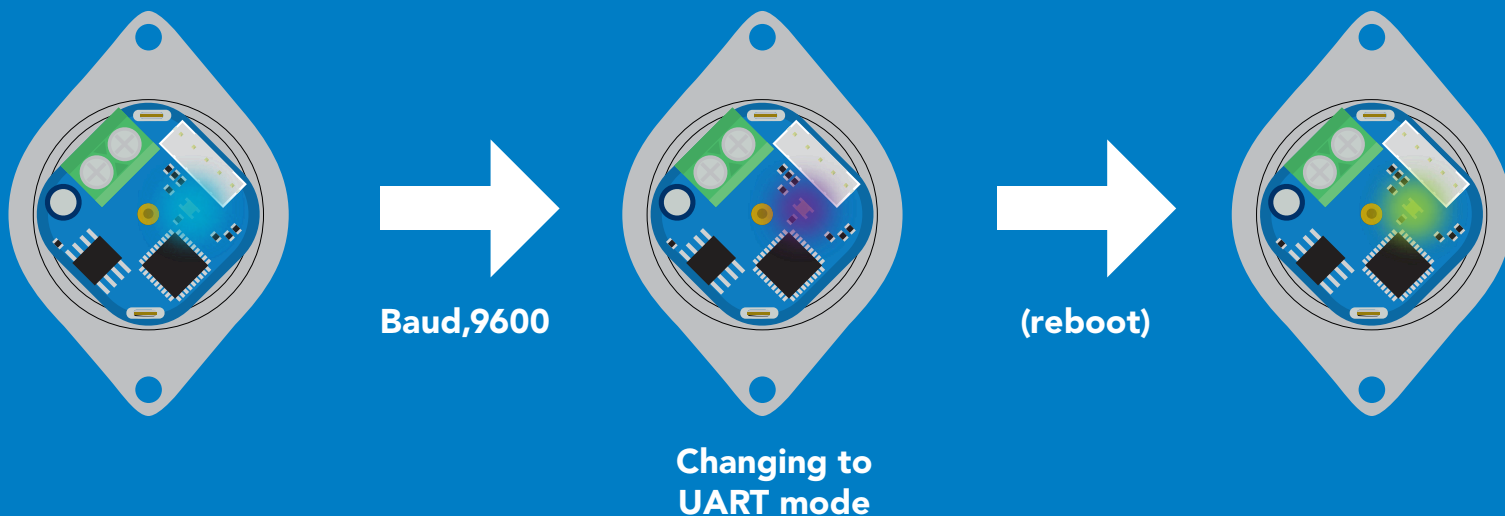
Manual switching to UART

- **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

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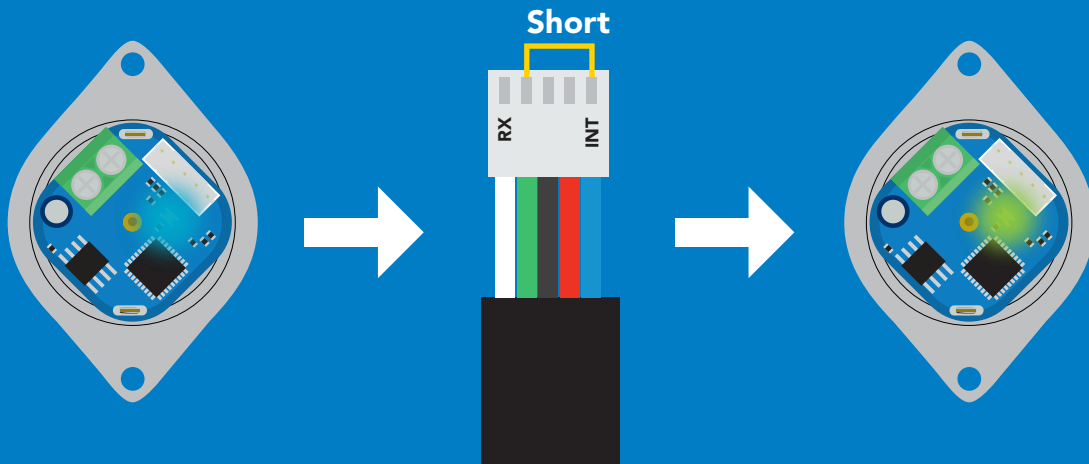
Calibration theory

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 ✓
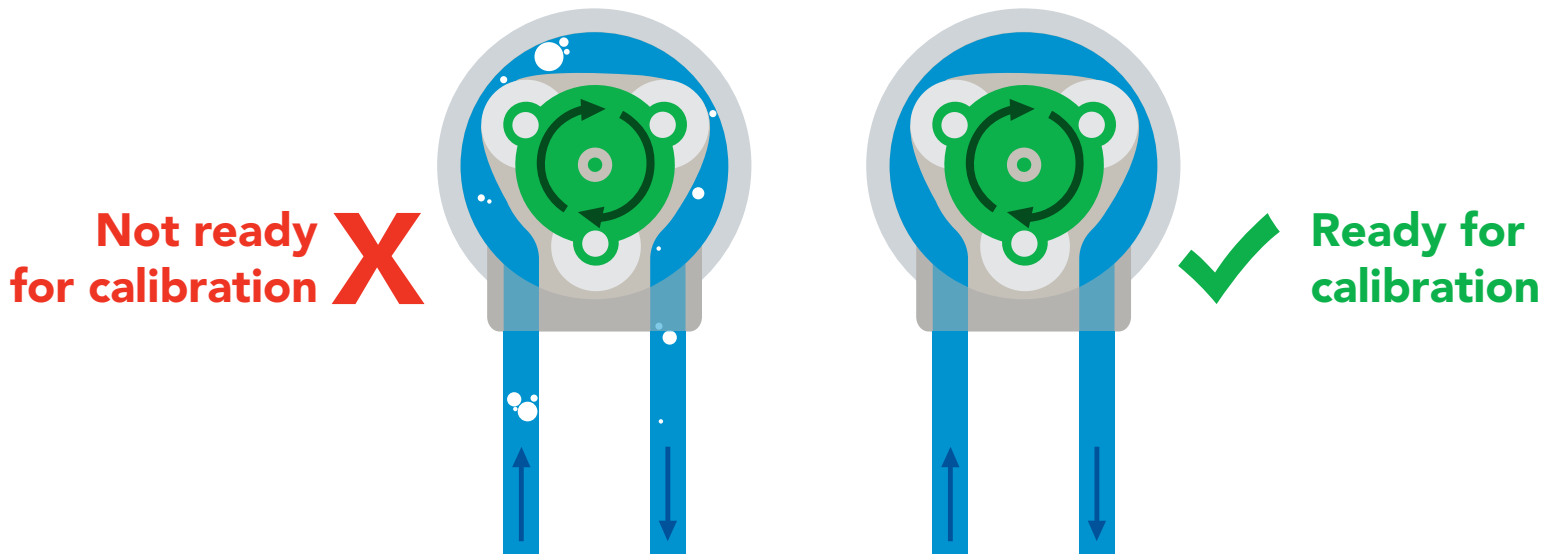
Calibration types

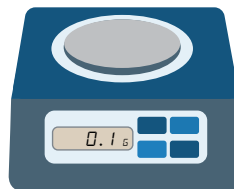**Volume calibration**
Volume over time calibration

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 5ml.

Equipment needed for calibration

1 gram of water = 1ml
23.56 grams of water = 23.56ml
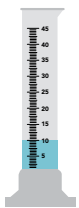
An accurate graduated cylinder of at least 10ml.

Or

An accurate scale with a resolution of at least 0.1 grams

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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 10ml

**1** "D,10"   **2** 9.8 mL   **3** "Cal,9.8"
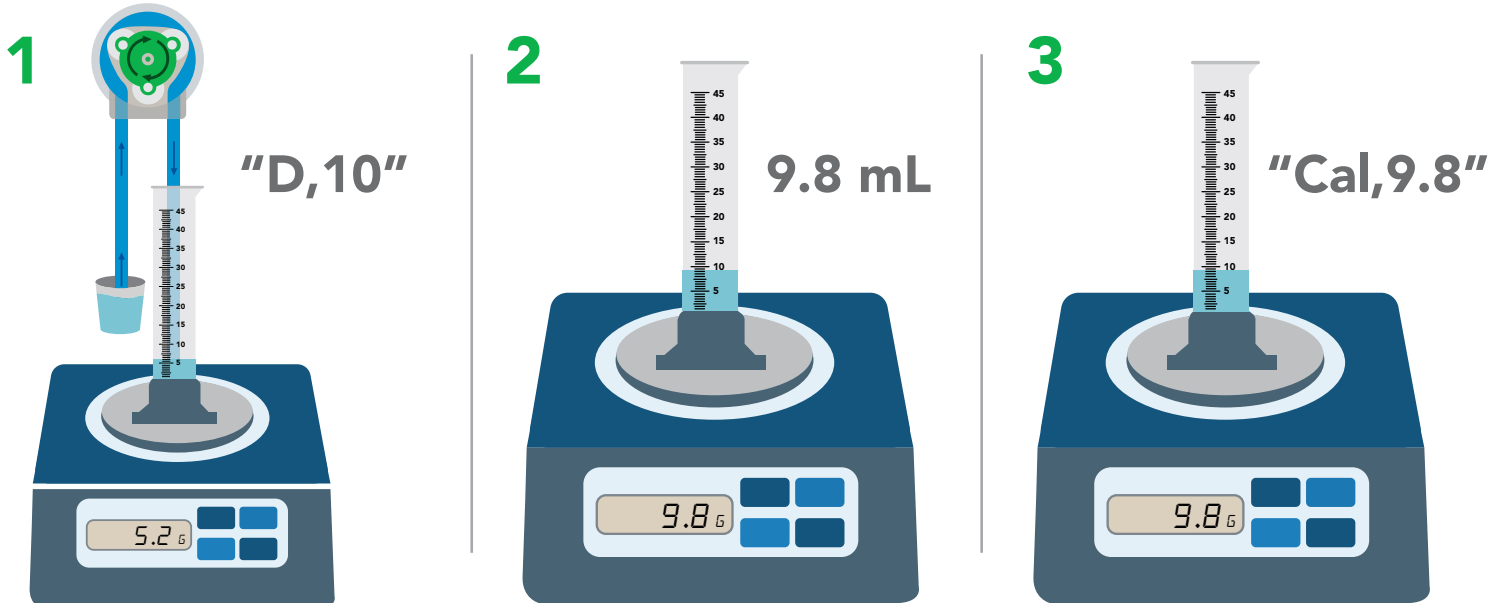
1. Instruct the pump to dispense 10ml into a graduated cylinder or beaker on a scale.
2. Measure the amount of liquid that was actually dispensed.
3. Inform the pump how much liquid was actually dispensed.
4. Calibration is now complete.

Once the pump has been calibrated, it will accurately dispense any volume of liquid.
Use the same procedure to perform a volume over time calibration.

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Pump speed vs. voltage

There is no change in pump speed at different voltages.

5 RPM = 5 RPM
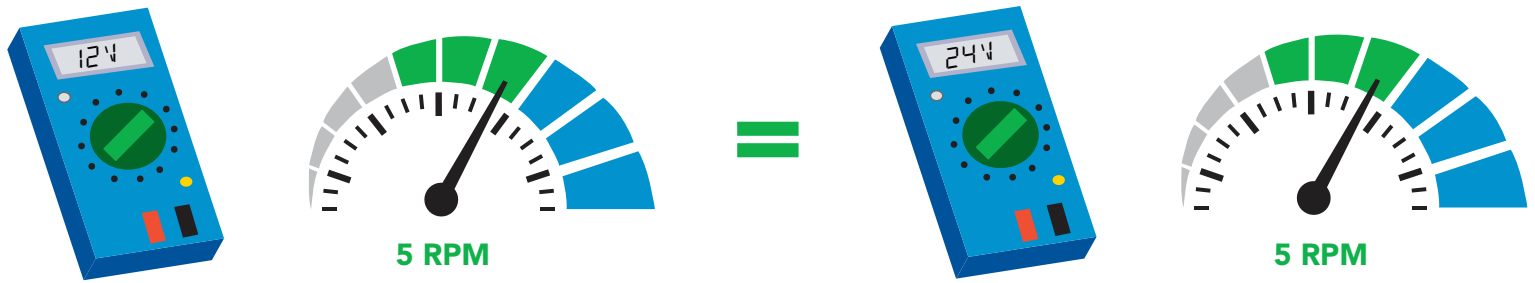
Interrupt pin

When the pump is dispensing the interrupt pin goes high.
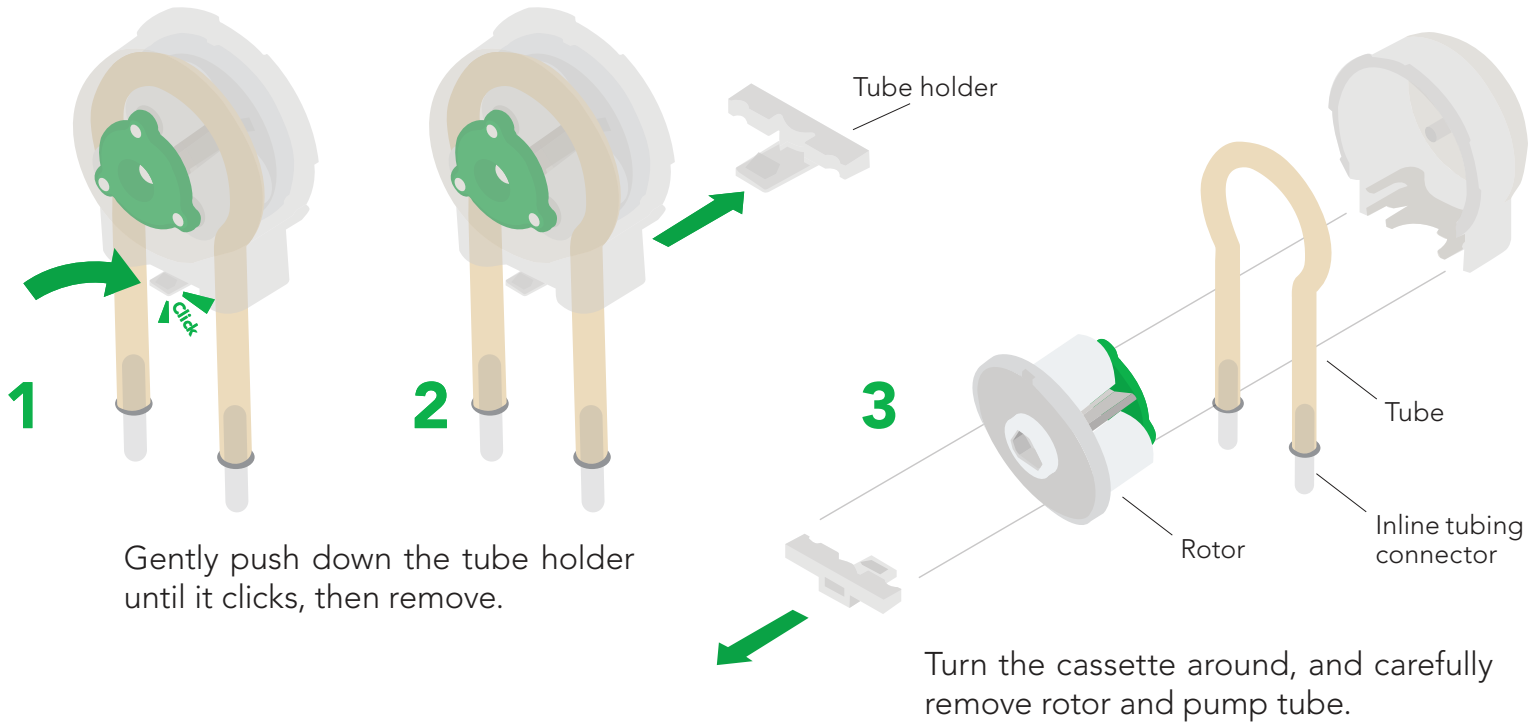

"D,10"

INT

*Done

Removing cassette
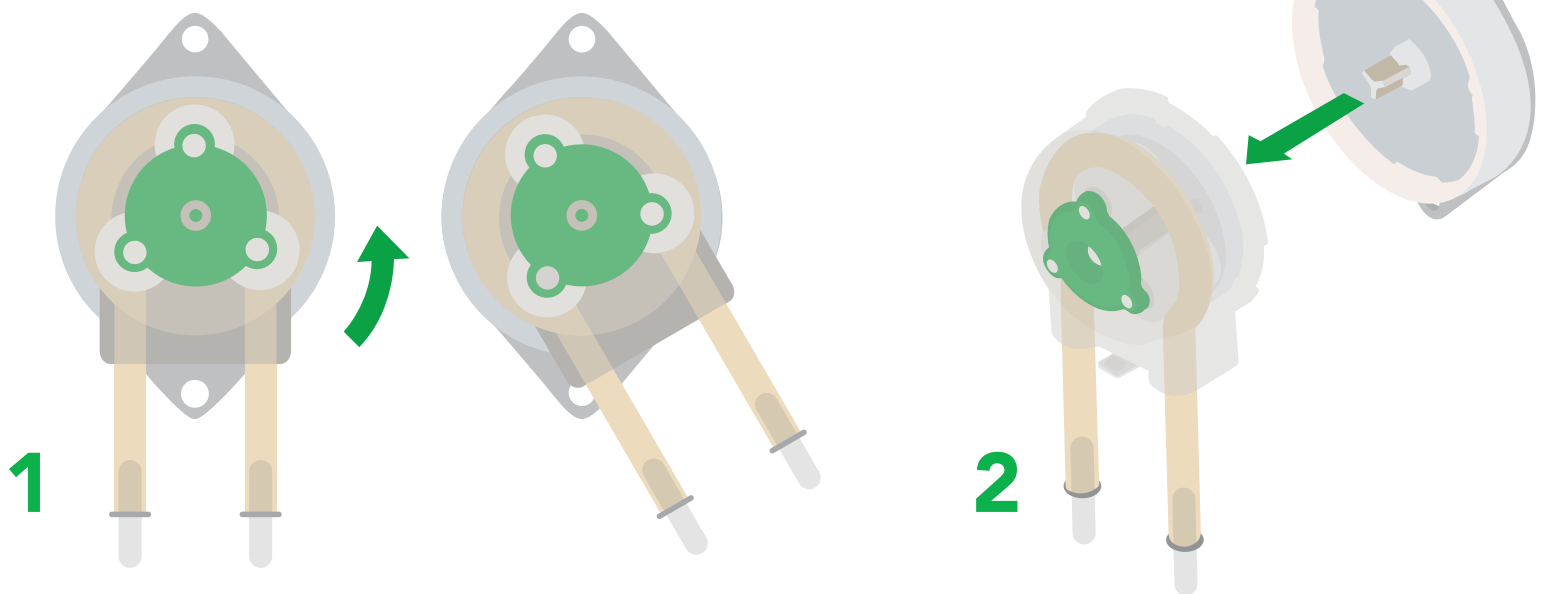
1

Turn cassette counterclockwise until it stops.

2

Pull cassette off the motor.

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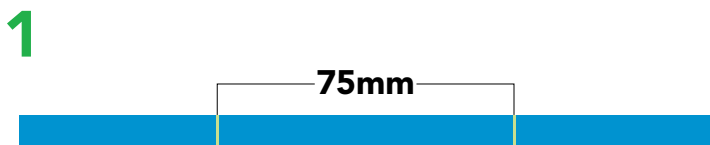
Removing tube assembly

The inner workings of the cassette are fragile and must be dismantled by hand. Using tools can damage or break the cassette.

1

Click

2

Tube holder

3

Tube

Inline tubing connector

Rotor

Gently push down the tube holder until it clicks, then remove.

Turn the cassette around, and carefully remove rotor and pump tube.

Installing new tube assembly

1

75mm

Measure 75mm of pump tubing, and mark both ends with a soft-tip pen or marker.
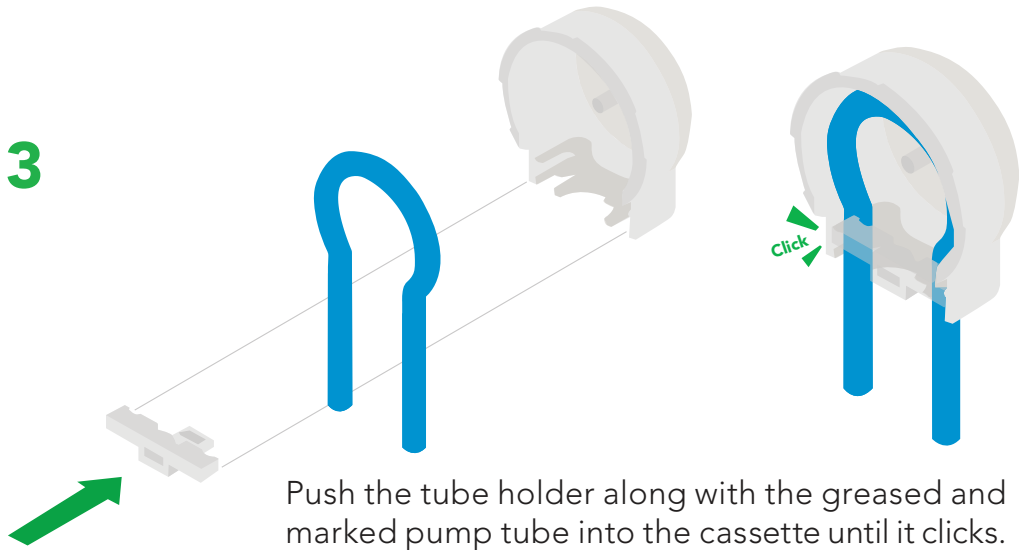
2

Apply grease

75mm mark
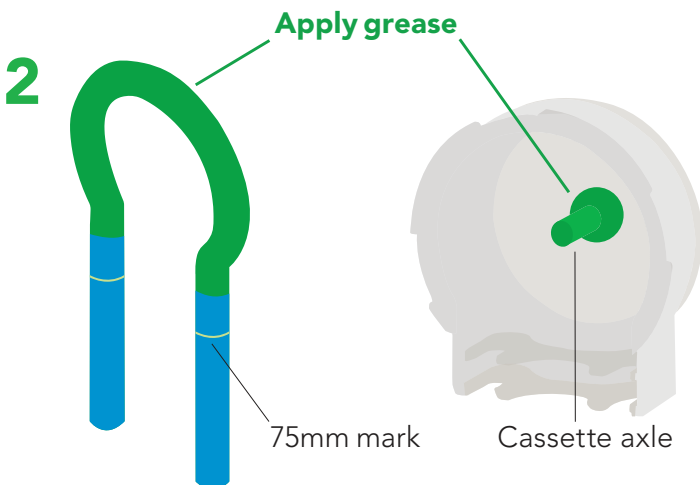
Cassette axle

Apply silicone lubricating grease to the marked areas on both the tubing and cassette axle.

Do not operate this device without lubrication!

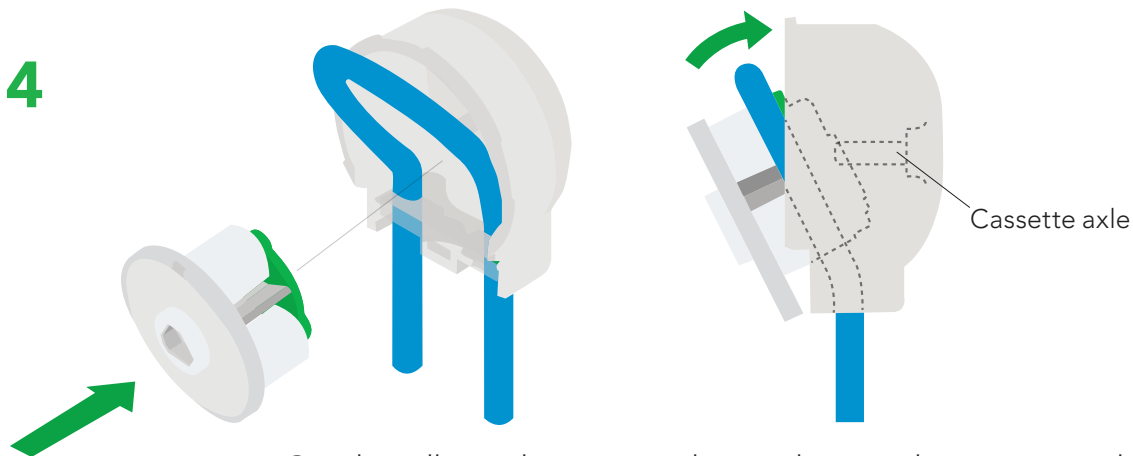*Atlas Scientific recommends using **Super Lube** silicone lubricating grease.*

Super Lube®

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3

Push the tube holder along with the greased and marked pump tube into the cassette until it clicks.

Click

4

Cassette axle

Gently pull out the pump tube, and insert the rotor into the pump tube. Align pump tube and rotor with the cassette axle.
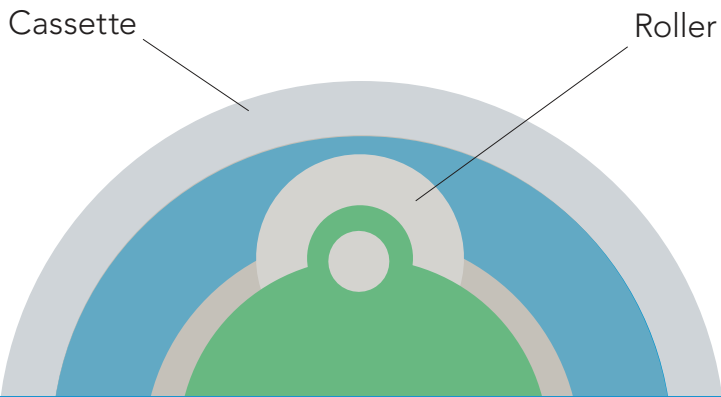
Cassette

Roller

Make sure the pump tube is held between the roller and cassette.

✔ **Correct**
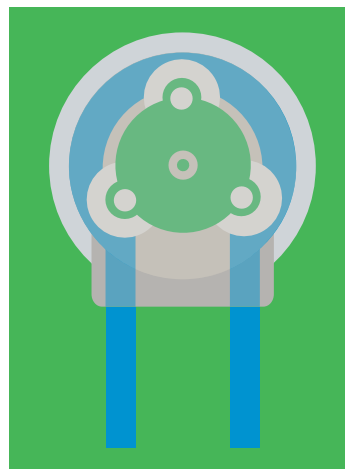
✗ **Incorrect**

Once the tubing has been replaced, run the pump for 3–5 minutes to break in the new tubing. **Remember, this pump can be run dry and does not need to pump liquid for the 3–5 minute break in period.**

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Accuracy

Volume dispensing mode
calibrated at 10ml

Percent error

- 2%
- 1%
- 0%

Dose in ml: 0, 100, 200, 300, 400, 500
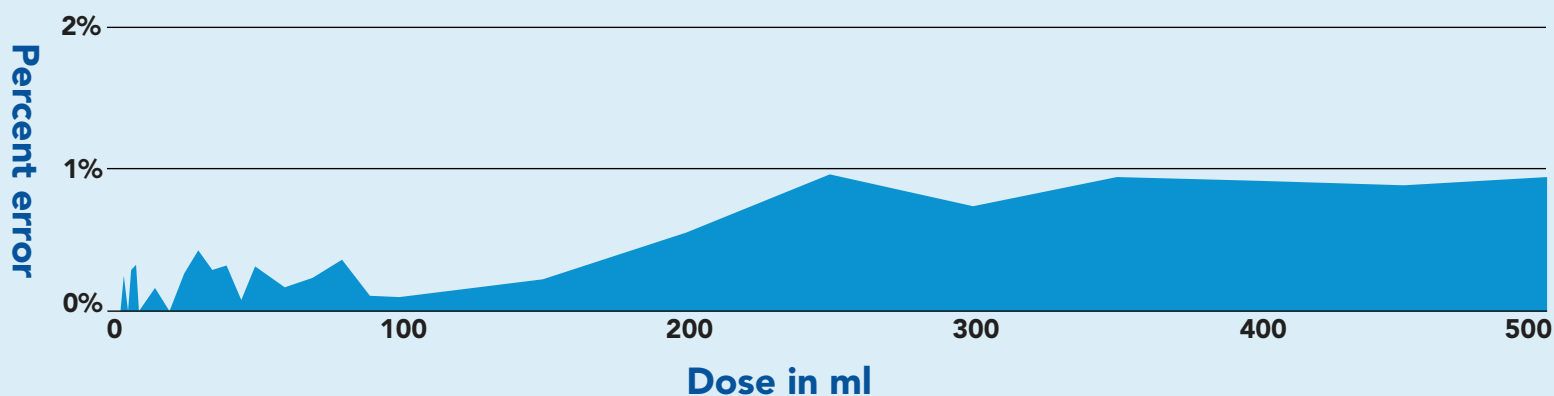
Dose over time mode
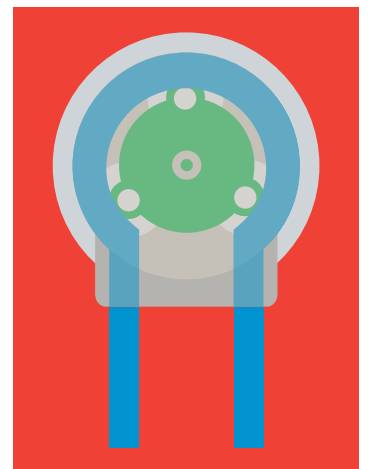calibrated at 10ml over 90 seconds

Percent error

- 2%
- 1%
- 0%

Time in minutes	Percent error
1	0.80%
2	0.00%
3	0.50%
4	0.87%
5	0.30%
6	0.67%
7	0.33%
8	0.50%
9	0.67%
10	0.43%

Time in minutes

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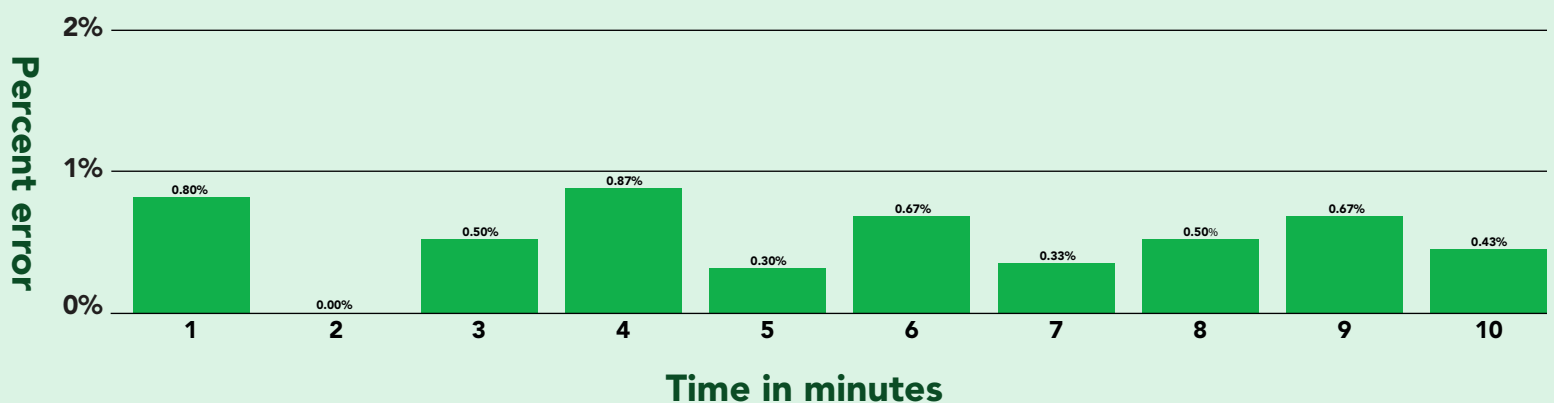
Viscosity

The EZO-PMP™ is capable of pumping liquids within a viscosity range of **0.1 – 2,000 cP**.

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

Dispense accuracy

Acetone	Maple Syrup	Honey
0.1 – 199cP	**200 – 1,999 cP**	**2,000 – 25,000 cP**
Accurate	Mostly accurate	Inaccurate
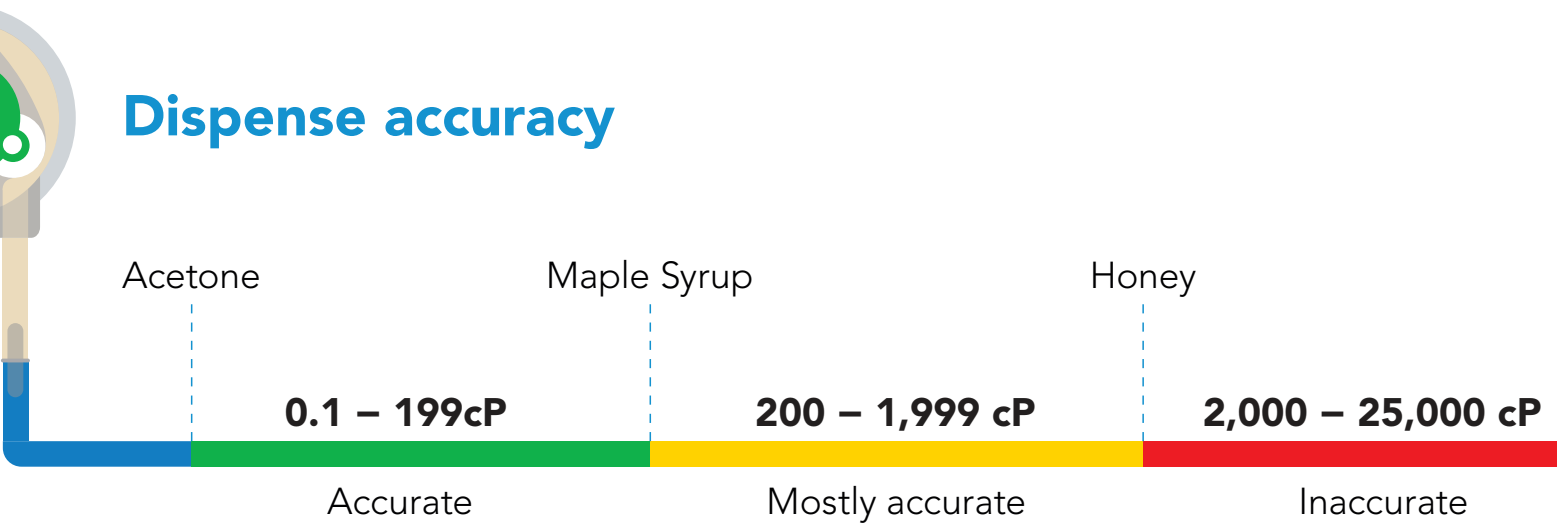
Pump head

Pump head refers to the maximum vertical height a pump can dispense. The EZO-PMP™ has a pump head of 8.1 meters *(26.5')*.

8.1 meters (26.5')

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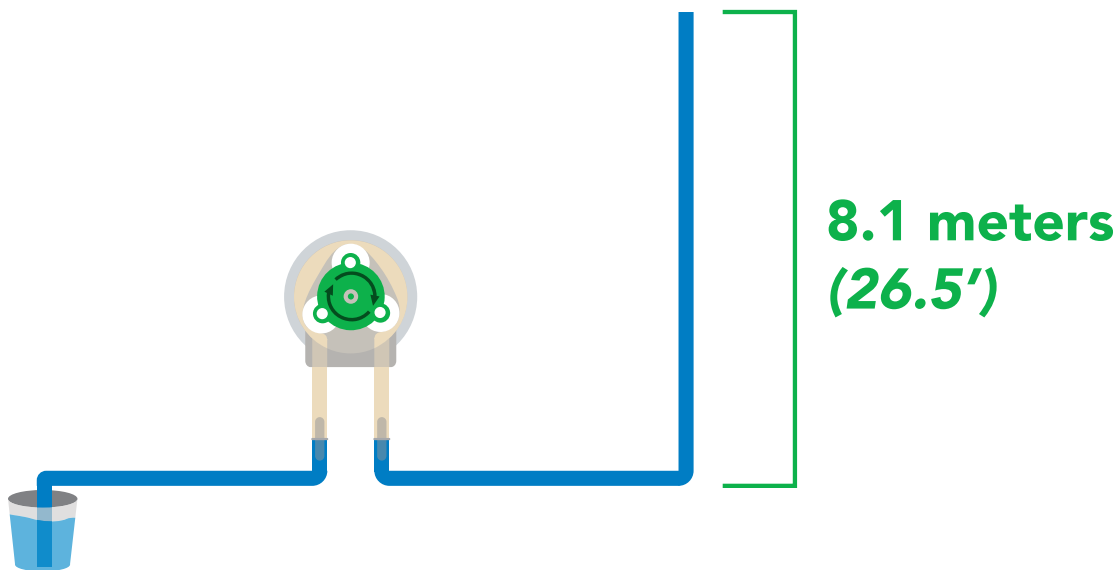
Mounting the EZO-PMP™

There are a many different ways to mount the EZO-PMP™ Embedded Dosing Pump. If you have a 3D printer you can use the dosing pump stand we created, by clicking here. The dosing pump stand has been measured to perfectly fit the EZO-PMP™ and even has screw holes in place for you to help mount the dosing pump to the stand. Feel free to modify this stand design as needed.
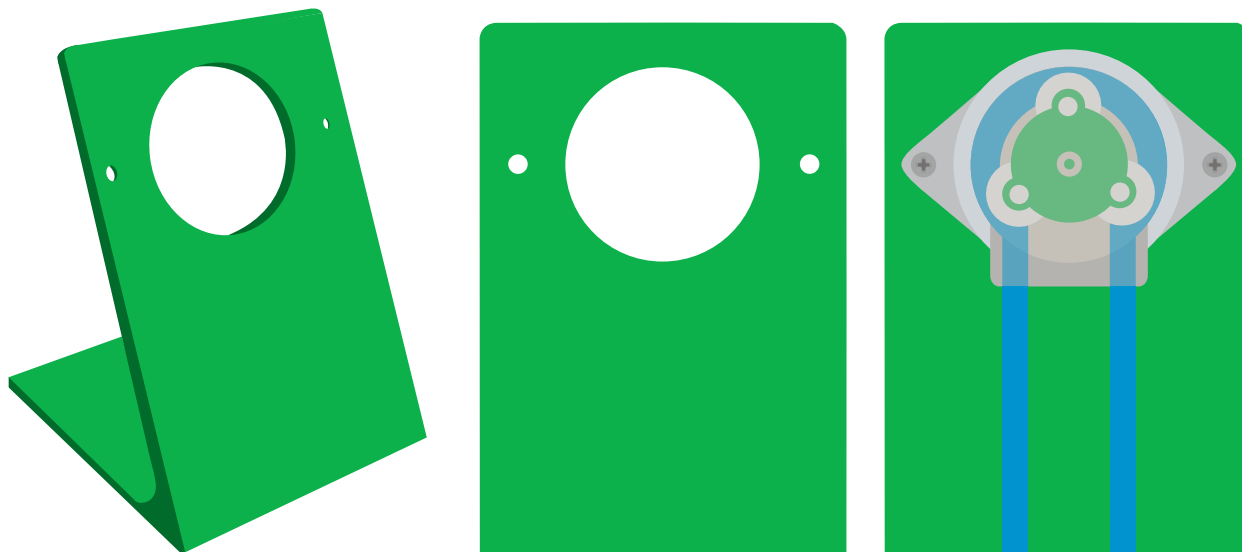

However, if you would like to mount the EZO-PMP™ Embedded Dosing Pump into other materials, you will need the following tools:

1 1/4"
Hole Saw

OR

Stop here

1 3/8"
Step Bit

1/8"
Drill Bit
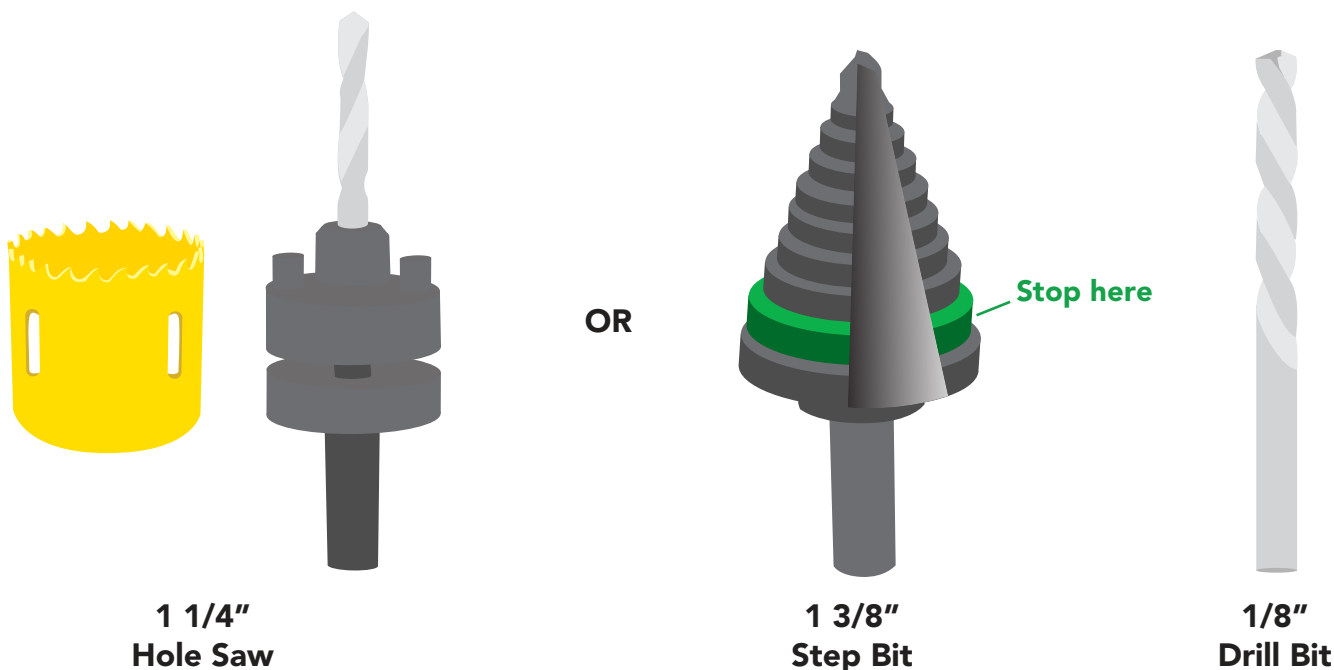
Either are fine to make the larger hole.

Perfect for screw holes.

Datasheet change log

Datasheet V 2.9
Revised table of contents and added invert dispensing direction command on pages 29 & 63.

Datasheet V 2.8
Revised naming device info on pages 38 & 69.

Datasheet V 2.7
Revised pump head information on pg 14.

Datasheet V 2.6
Revised settings that remain when power is cut on pages 17 & 48.

Datasheet V 2.5
Revised Total Volume Dispensed commands on pages 34 & 65.

Datasheet V 2.4
Added new dispensing mode:
"Dispense at startup" see pages 31 (UART) & 62 (I^2C).

Datasheet V 2.3
Added motor life span on pg 4.

Datasheet V 2.2
Added page explaining the power supply needs of the EZO-PMP on pg 3.

Datasheet V 2.1
Moved Default state to pg 14.

Datasheet V 2.0
Revised response for the sleep command in UART mode on pg 40.

Datasheet V 1.9
Added section on viscosity on page 13.

Datasheet V 1.8
Added Find command on pages 22 & 53.

Datasheet V 1.7
Added information on pump tubing on pg 4.

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Datasheet change log

Datasheet V 1.6

Added life span of tubing and cassette on pg 3.

Datasheet V 1.5

Added max input / output pressure info to pg 3 and pg 4.

Datasheet V 1.4

Revised definition of response codes on pg 47.

Datasheet V 1.3

Revised art and added pump head information on pg 11.

Datasheet V 1.2

Revised Plock pages to show default value.

Datasheet V 1.1

Added mounting information on pg 70.

Firmware updates

V1.0 – Initial release (April 28, 2017)

V1.01 – (May 9, 2017)
• Fixed bug where the circuit wakes up on I2C commands sent to other addresses

V1.02 – (July 28, 2017)
• Fixed undervolt output typo

V1.03 – (June 26, 2020)
• Added command dstart, which lets the pump automatically dispense a dose on startup

V1.04 – (March 2, 2021)
• Added commands for ease of manufacturing

V1.05 (April 5, 2022)
• Expands dstart command with * and dispense over time

Warranty

Atlas Scientific™ Warranties the EZO-PMP™ Embedded Dosing Pump to be free of defect during the debugging phase of device implementation, or 30 days after receiving the EZO-PMP™ 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™ Embedded Dosing Pump is inserted into a bread board, or shield. If the EZO-PMP™ Embedded Dosing Pump is being debugged in a bread board, the bread board must be devoid of other components. If the EZO-PMP™ Embedded Dosing Pump is being connected to a microcontroller, the microcontroller must be running code that has been designed to drive the EZO-PMP™ Embedded Dosing Pump exclusively and output the EZO-PMP™ 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™ Embedded Dosing Pump warranty:

- **Soldering any part of the EZO-PMP™ Embedded Dosing Pump.**

- **Running any code, that does not exclusively drive the EZO-PMP™ Embedded Dosing Pump and output its data in a serial string.**

- **Embedding the EZO-PMP™ Embedded Dosing Pump into a custom made device.**

- **Removing any potting compound.**

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Reasoning behind this warranty

Because Atlas Scientific™ does not sell consumer electronics; once the device has been embedded into a custom made system, Atlas Scientific™ cannot possibly warranty the EZO-PMP™ Embedded Dosing Pump, against the thousands of possible variables that may cause the EZO-PMP™ 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™ Embedded Dosing Pumps continued operation. This is because that would be equivalent to Atlas Scientific™ taking responsibility over the correct operation of your entire device.

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