AtlasScientific™
Environmental Robotics

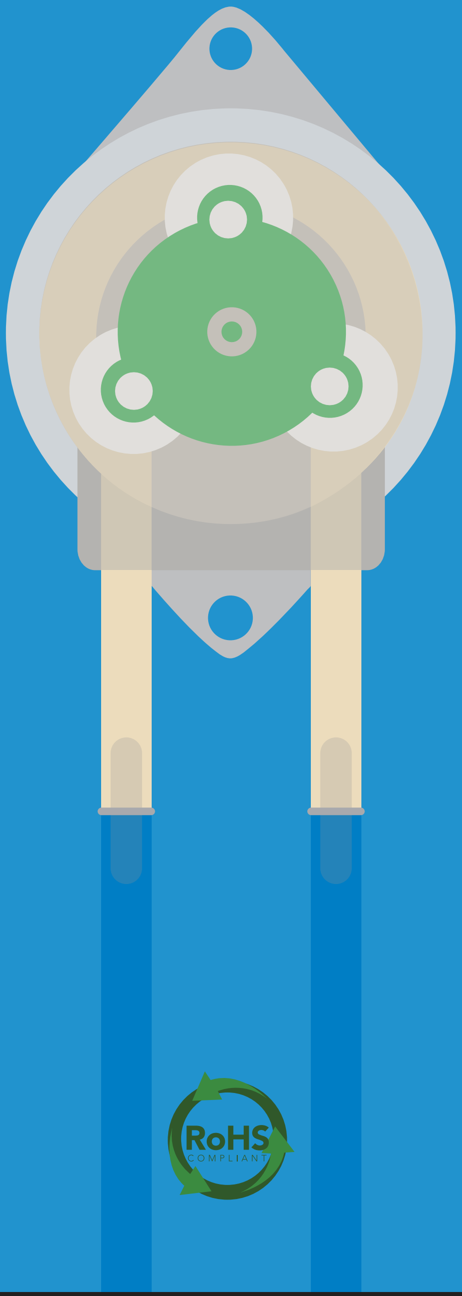
V 2.9

Revised 4/22

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**



Written by Jordan Press
Designed by Noah Press

This is an evolving document, check back for updates.

Table of contents

UART

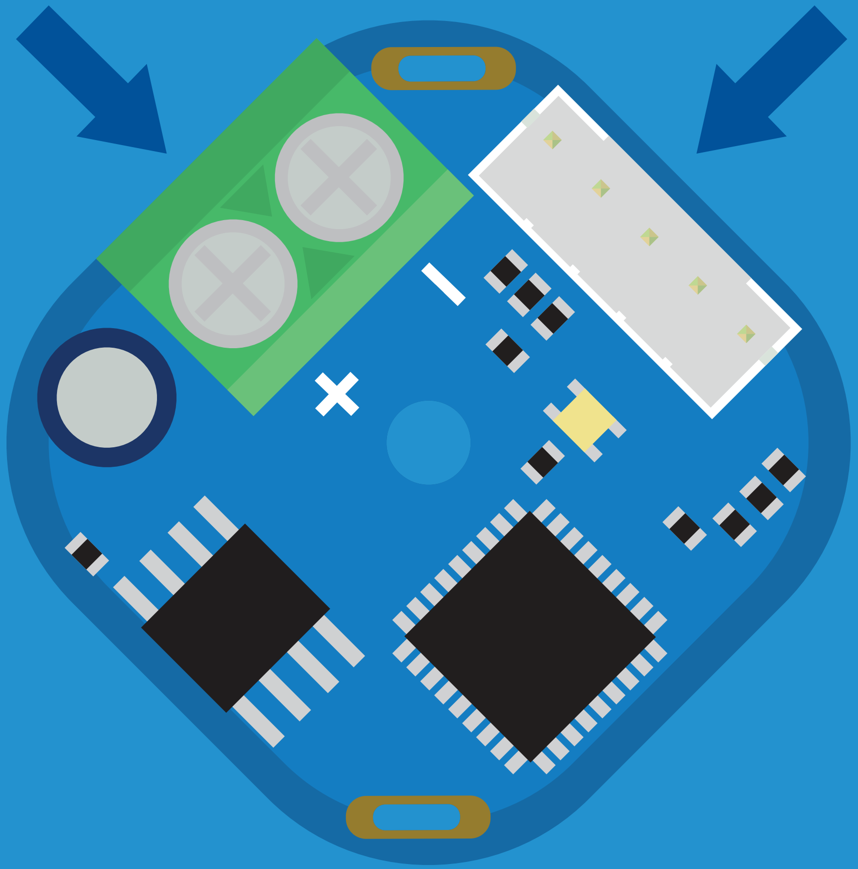
I^{2}C

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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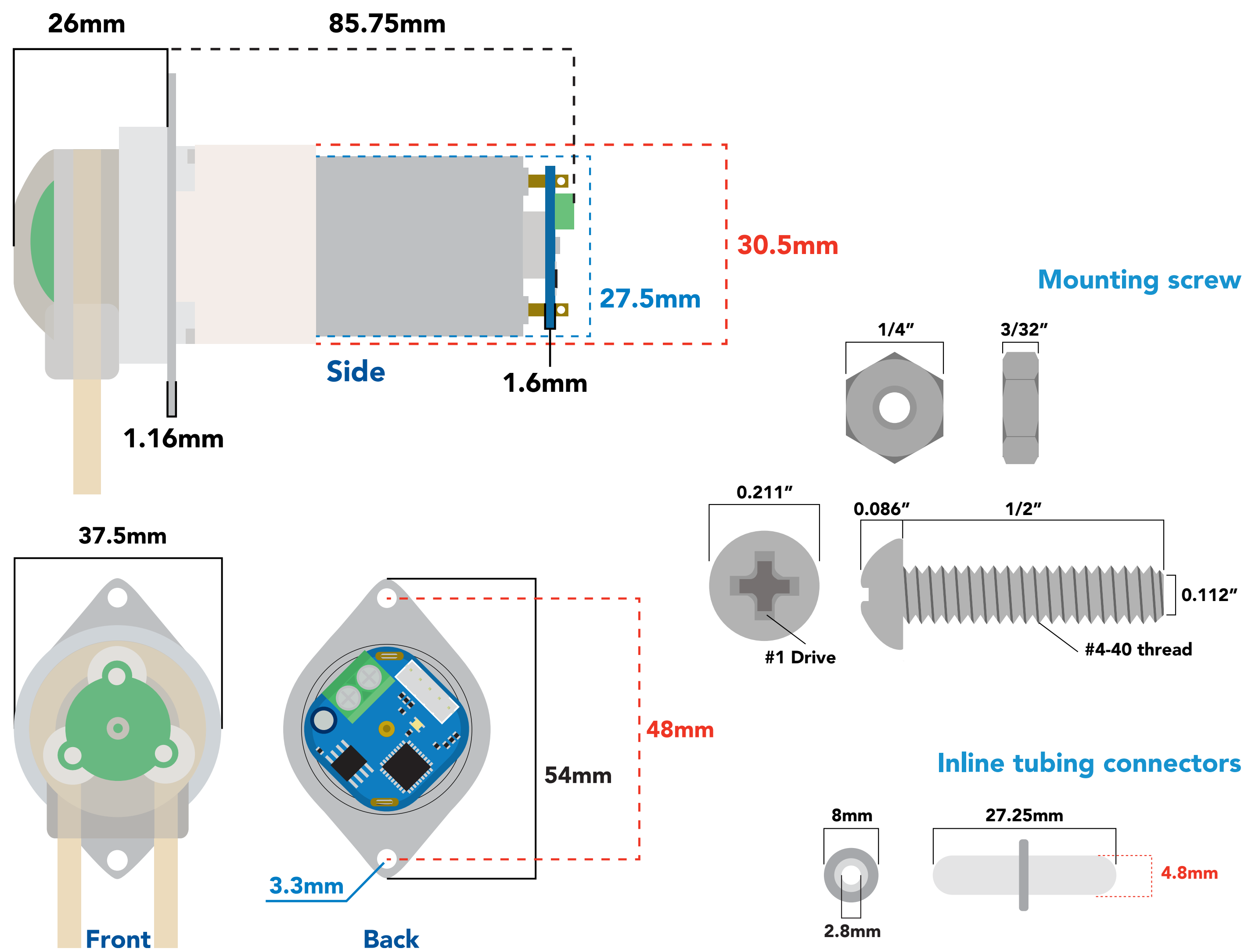
EZO-PMP™ dimensions



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

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

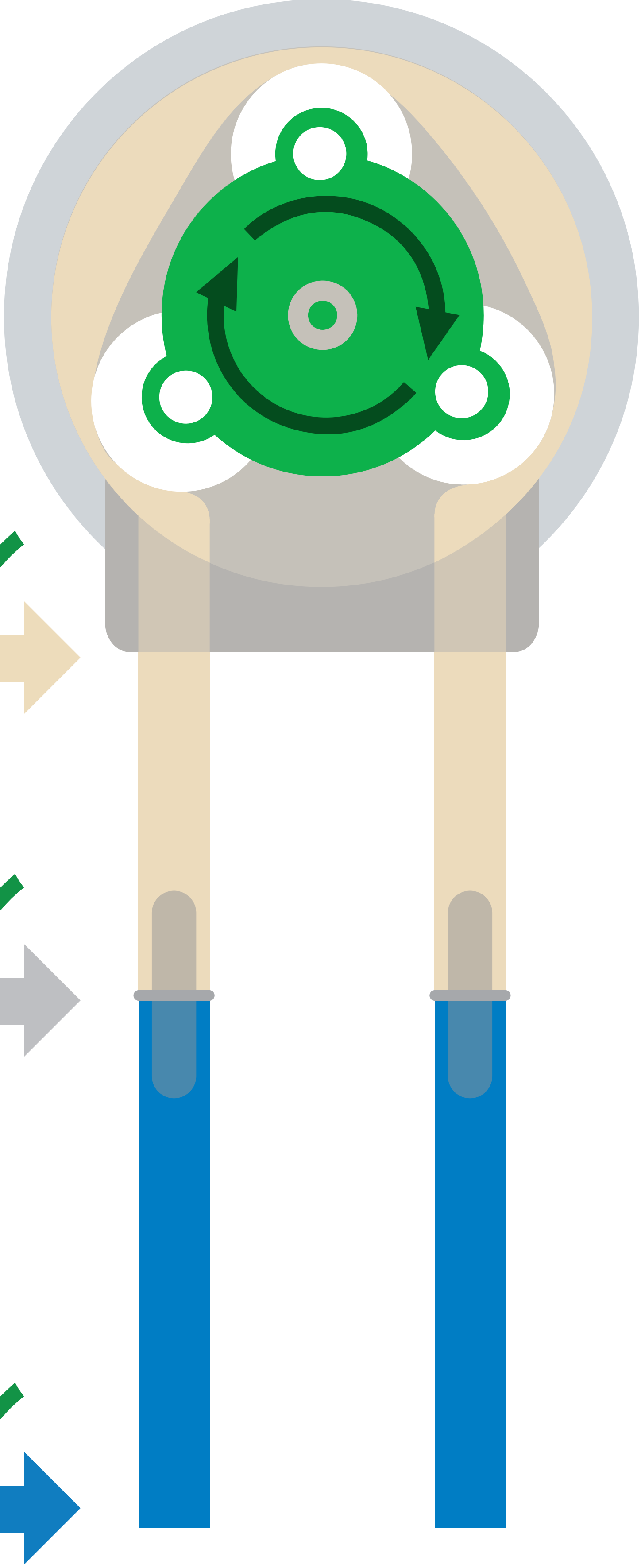
HDPE
Length: 2.54cm
Outer diameter: 8mm
Inner diameter: 2.8mm

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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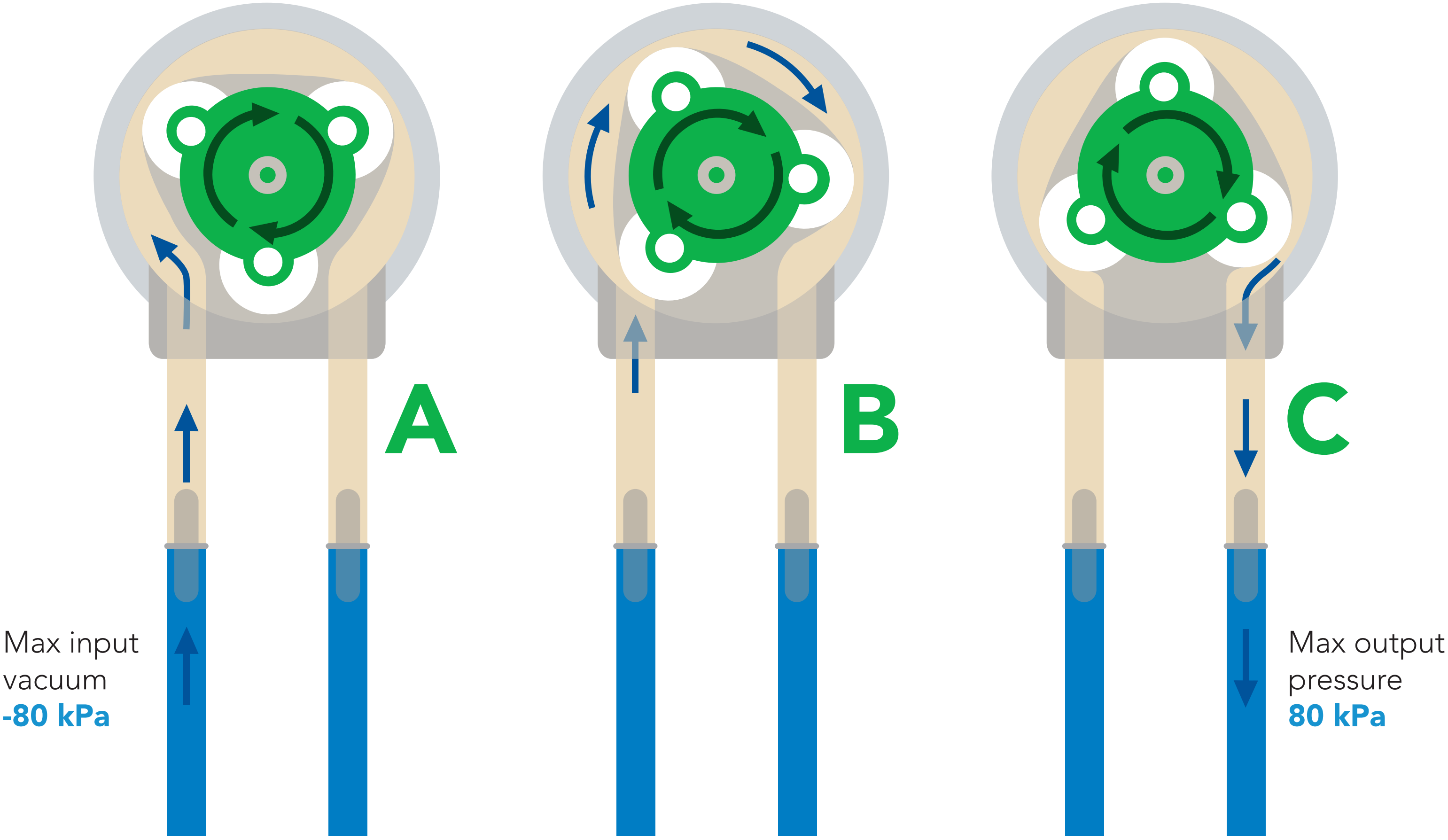
Operating principle

✓ Self-priming
✓ Run dry



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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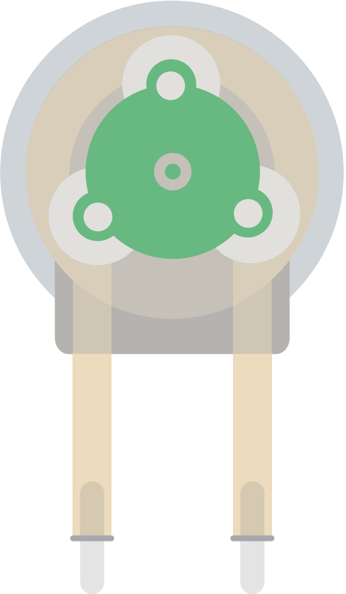
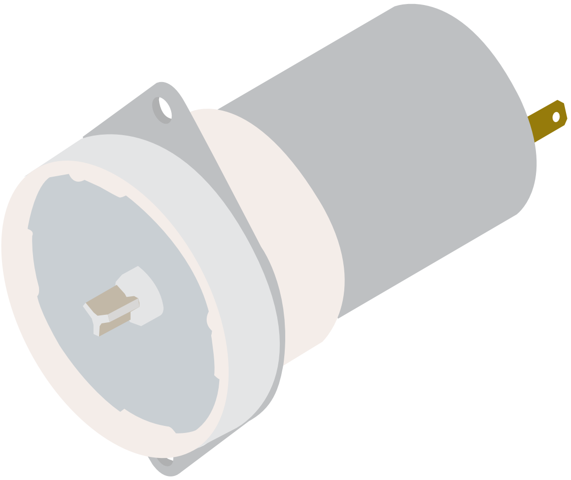
This device requires two power supplies
3.3V–5.5V for the control system
12V–24V to drive the motor

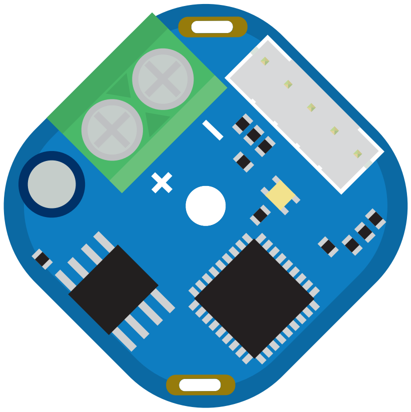
The Atlas Scientific EZO-PMP™ consists of three main components.



Cassette



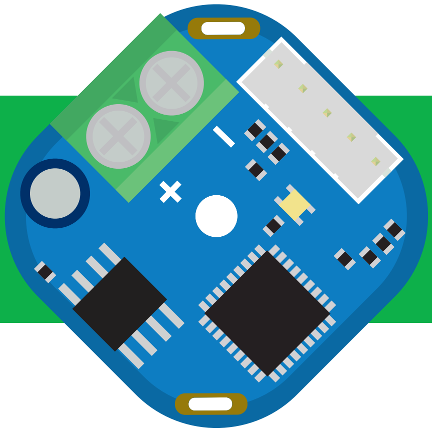
12 volt motor



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.

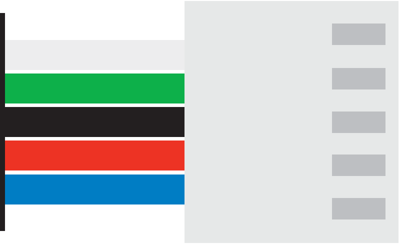


The control system has three main components

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

I^2C

✗ Unavailable data protocols

SPI

Analog

RS-485

Mod Bus

4–20mA

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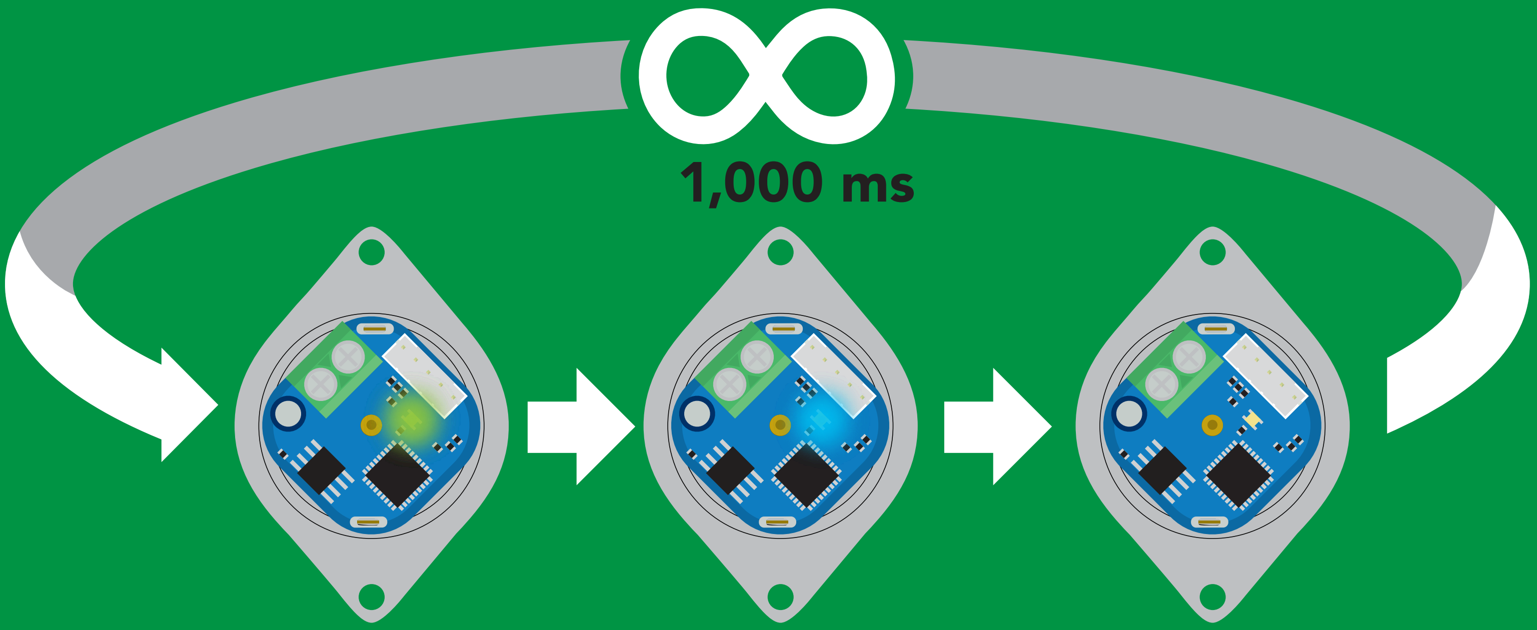
Default state

UART mode

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



1,000 ms

Green
Standby

Cyan
Taking reading

Transmitting

UART mode

Settings that are retained if power is cut

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

Settings that are *NOT* retained if power is cut

Absolute total volume
Find
Sleep mode
Total volume

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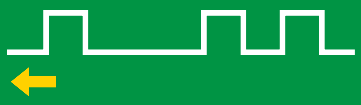
UART mode

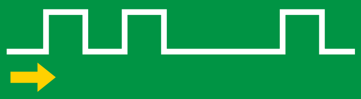
8 data bits	no parity
1 stop bit	no flow control

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

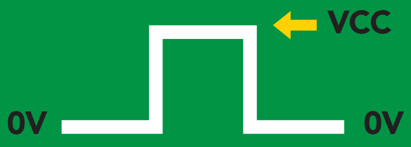
RX
Data in

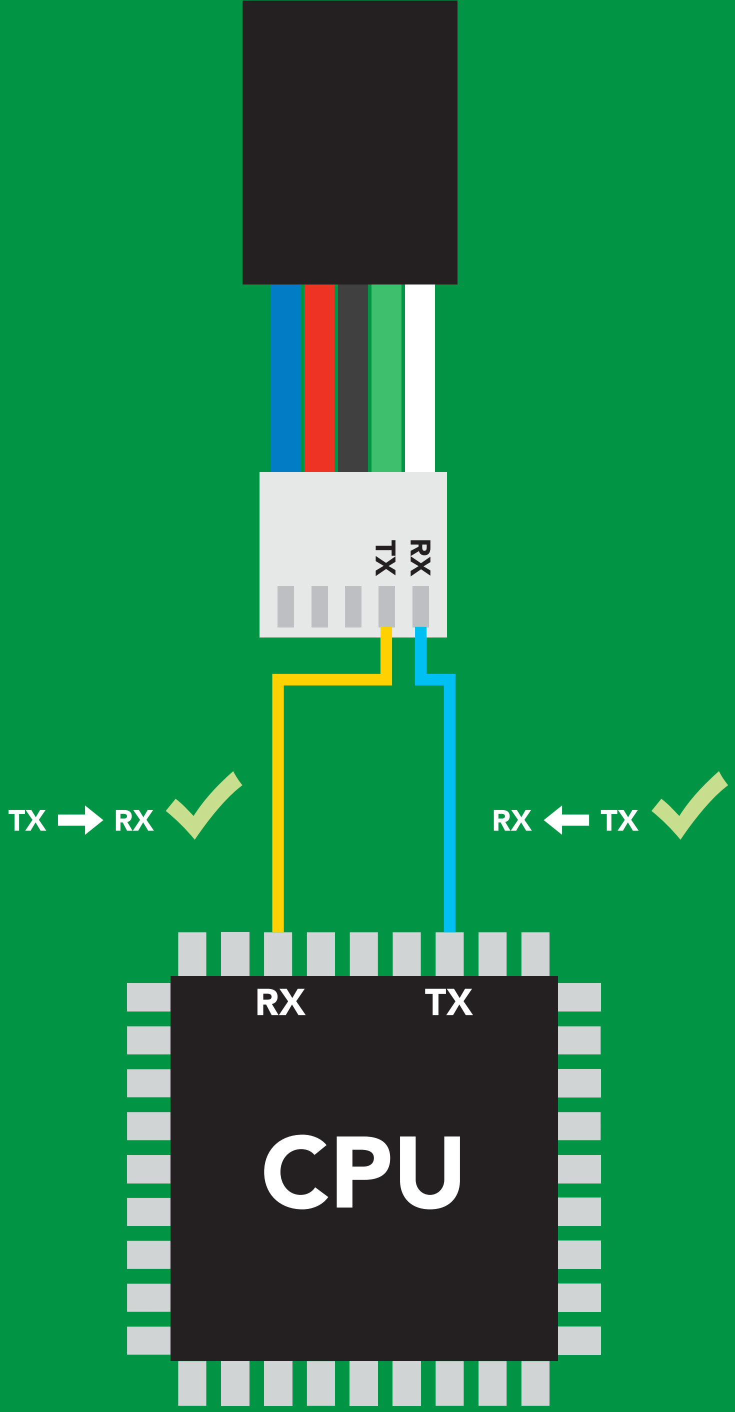


TX
Data out



Vcc 3.3V – 5.5V





Data format

Output	volume	**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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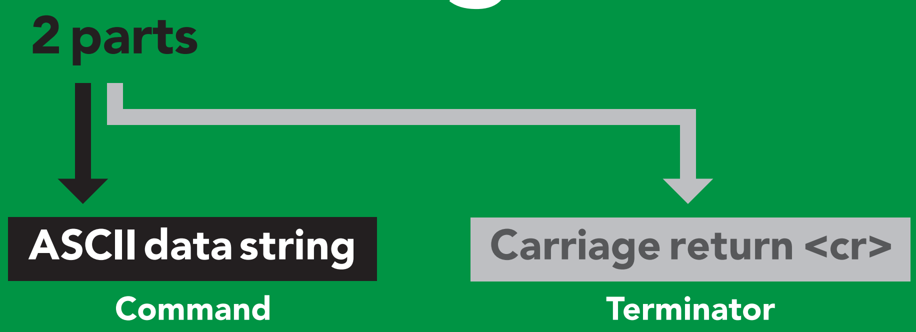
Receiving data from device



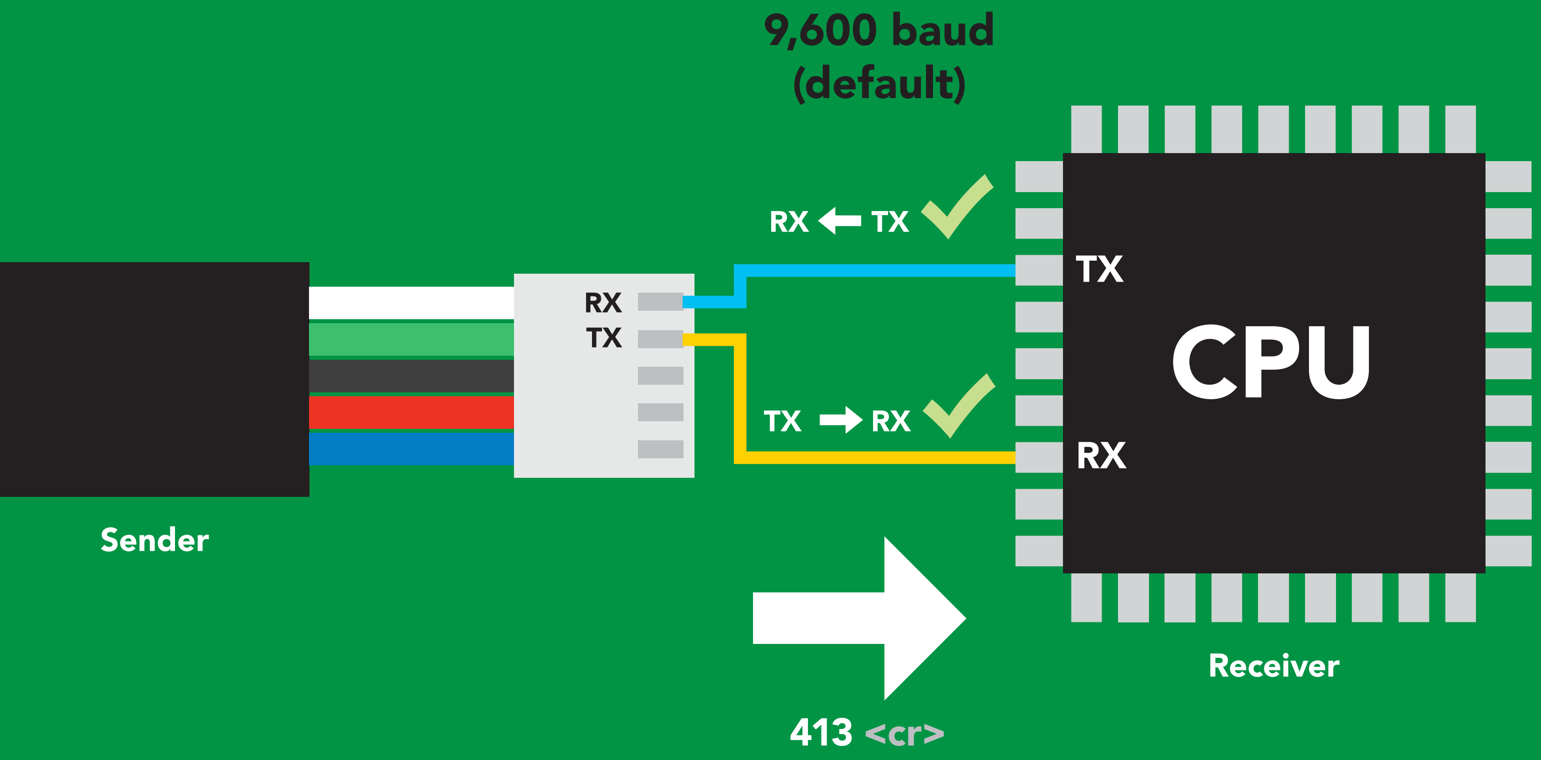
2 parts

ASCII data string

Command

Carriage return <cr>

Terminator



9,600 baud
(default)

Advanced

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

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Sending commands to device

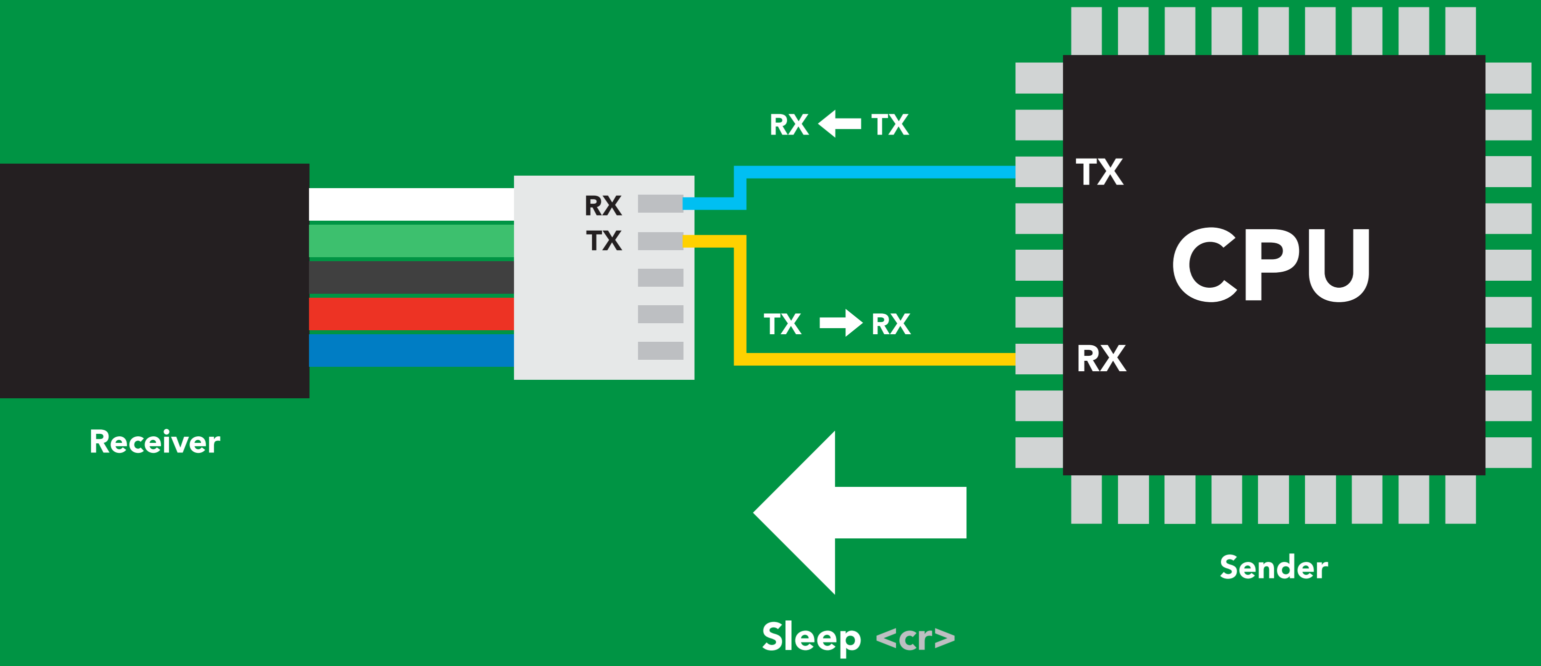
2 parts

Command (not case sensitive)

ASCII data string

Carriage return <cr>

Terminator



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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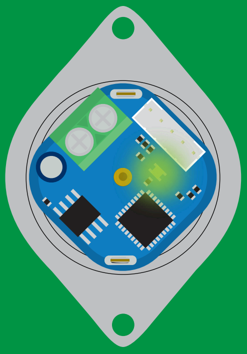
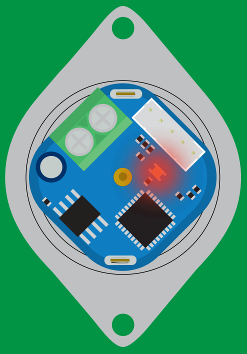
LED color definition



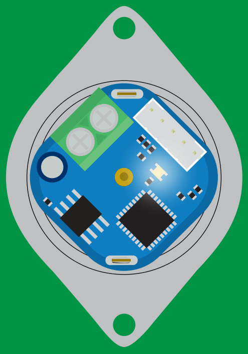
Green
UART standby

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

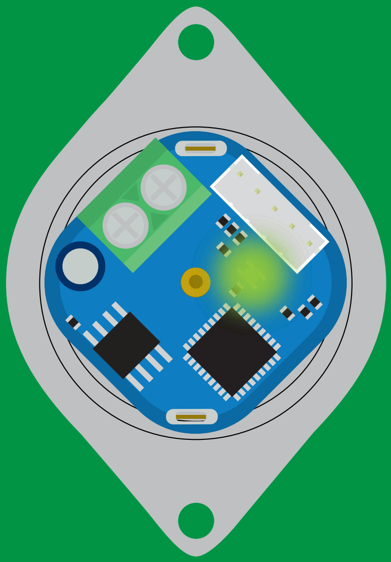
r 0.3

LED control

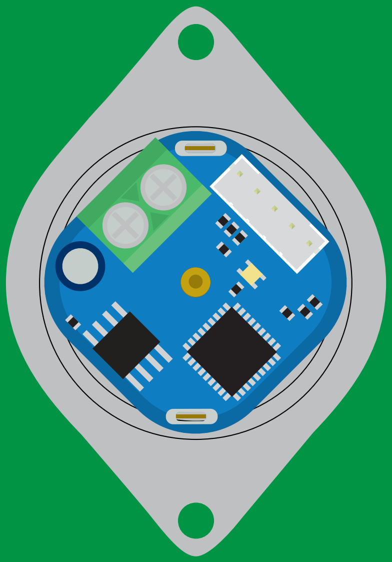
Command syntax

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

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



L,1



L,0

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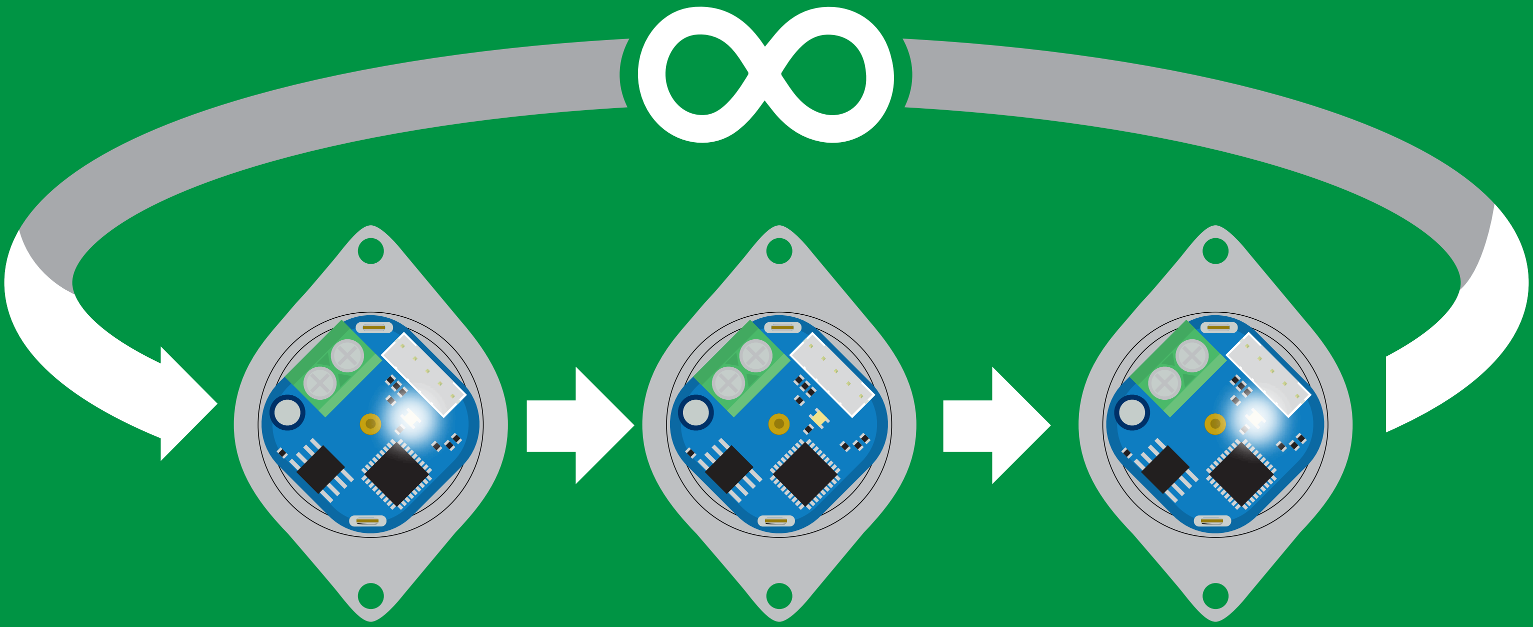
Find

Command syntax

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

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

Example	Response
Find <cr>	*OK <cr>



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

Continuous dispensing

Pump on/pump off

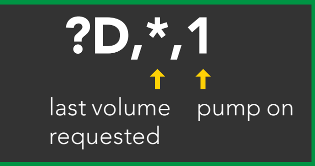
Command syntax

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

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

Example	Response	
D,* <cr>	*OK <cr>	pump will continuously run at ~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

Volume dispensing

Pump a specific volume

Command syntax

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

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

Example	Response
D,15 <cr>	*OK <cr> 15 ml will be dispensed
D,-40.5 <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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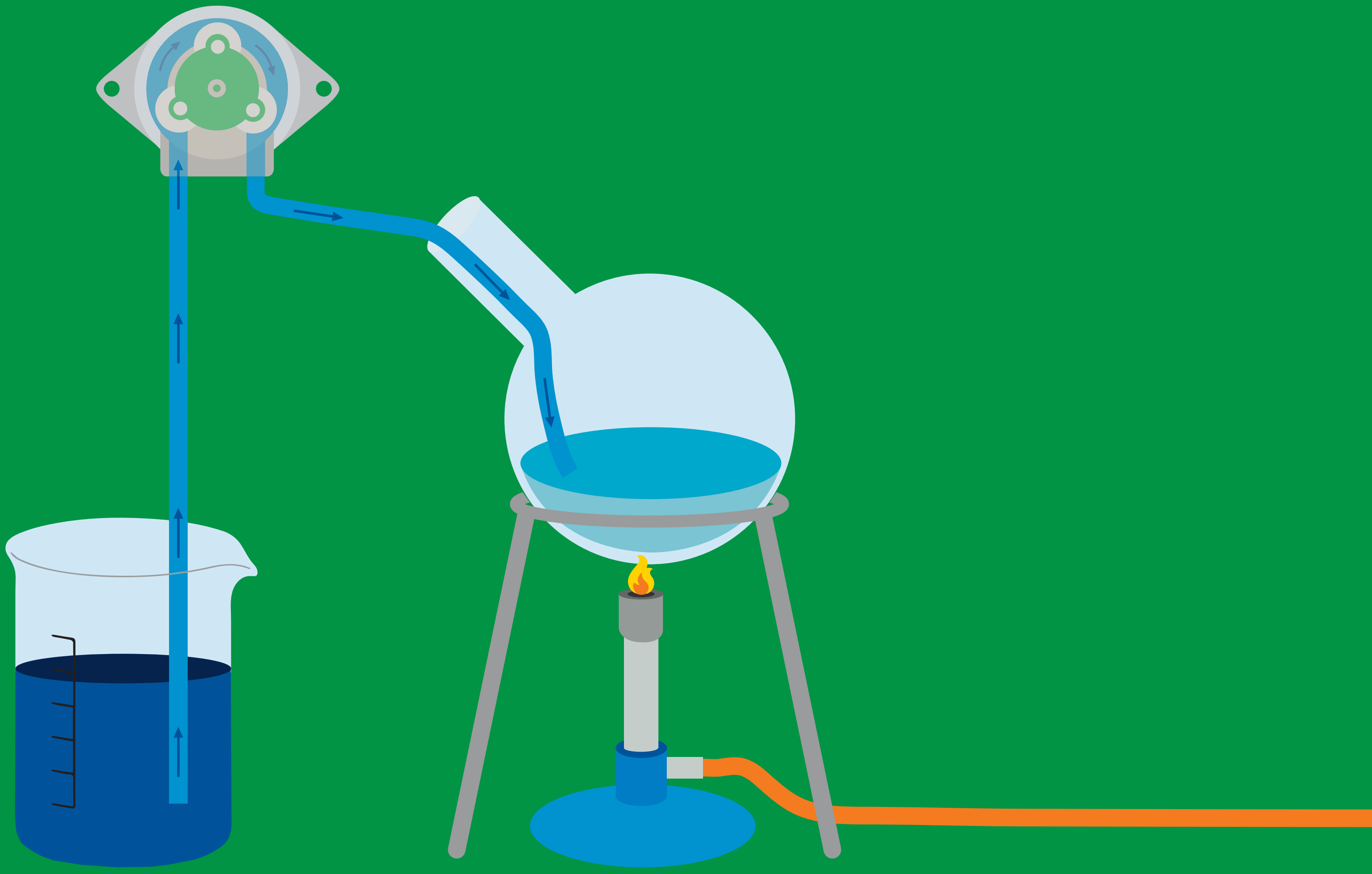
Dose over time

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



Constant flow rate

Maintain a constant flow rate

Command syntax

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

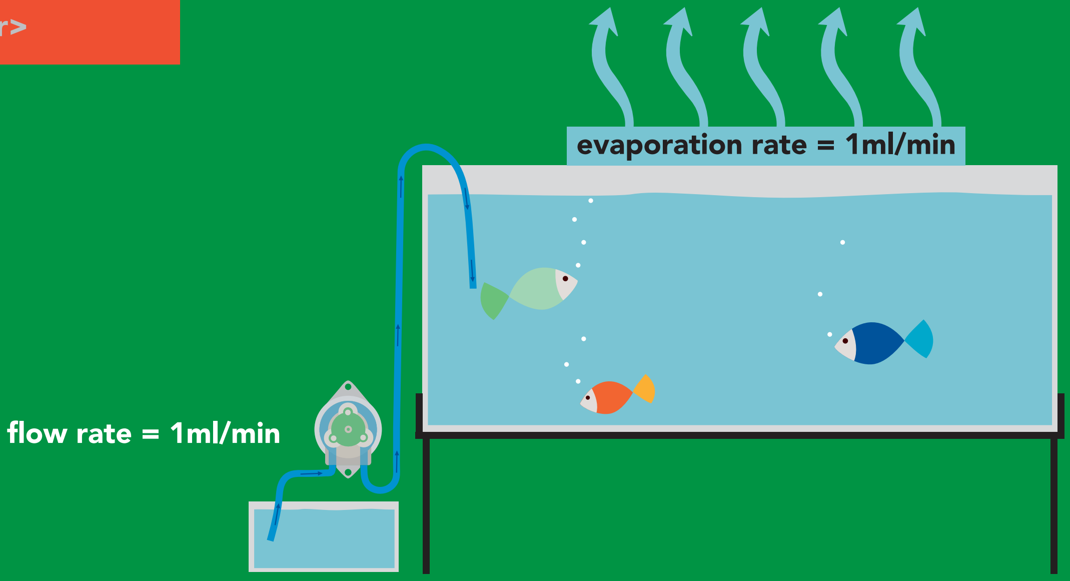
```
DC,[ml/min],[min or *] <cr>     [maintain this rate],[for this much time]
DC,? <cr>                       reports maximum possible flow rate
```

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

Example	Response
DC,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>
```



Dispense at startup

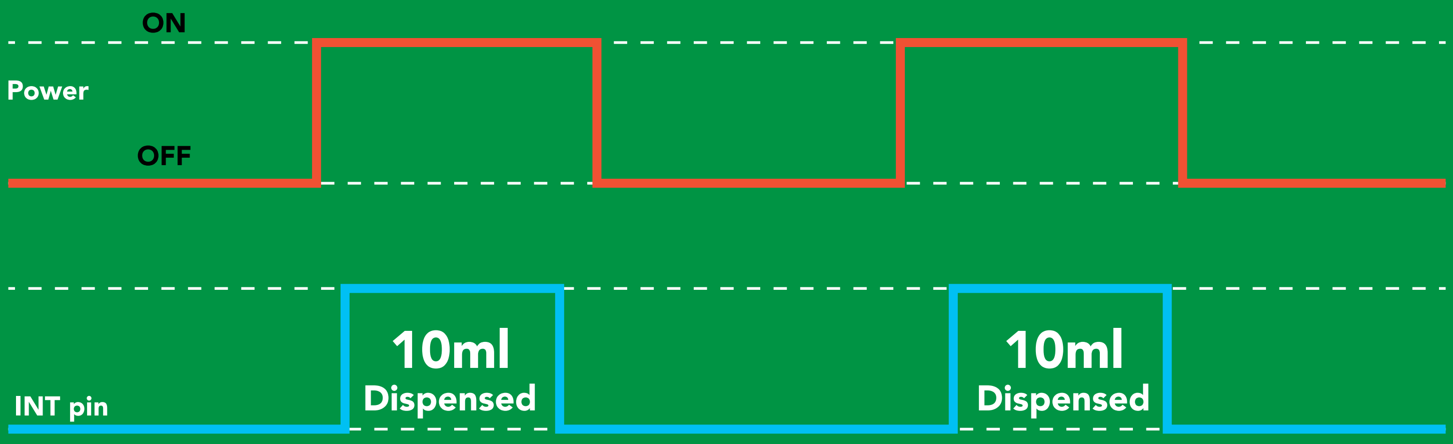
Pump a specific volume at startup and then stop

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>



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Continuous dispensing at startup

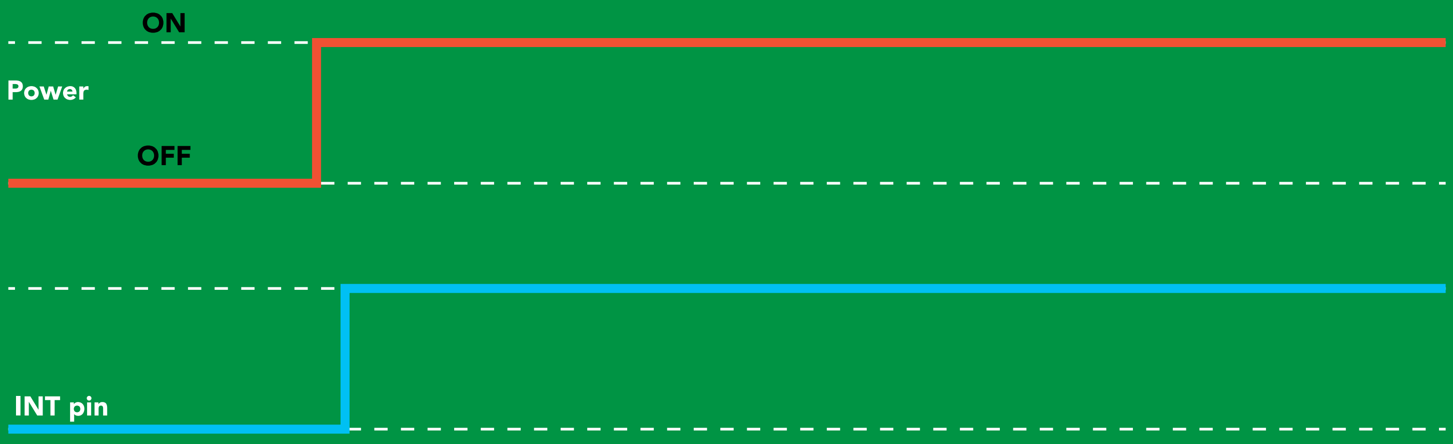
Pump on & continuously dispense

Command syntax

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

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

Example	Response	
Dstart,* <cr>	*OK <cr>	Pump will startup and continuously run at ~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>	



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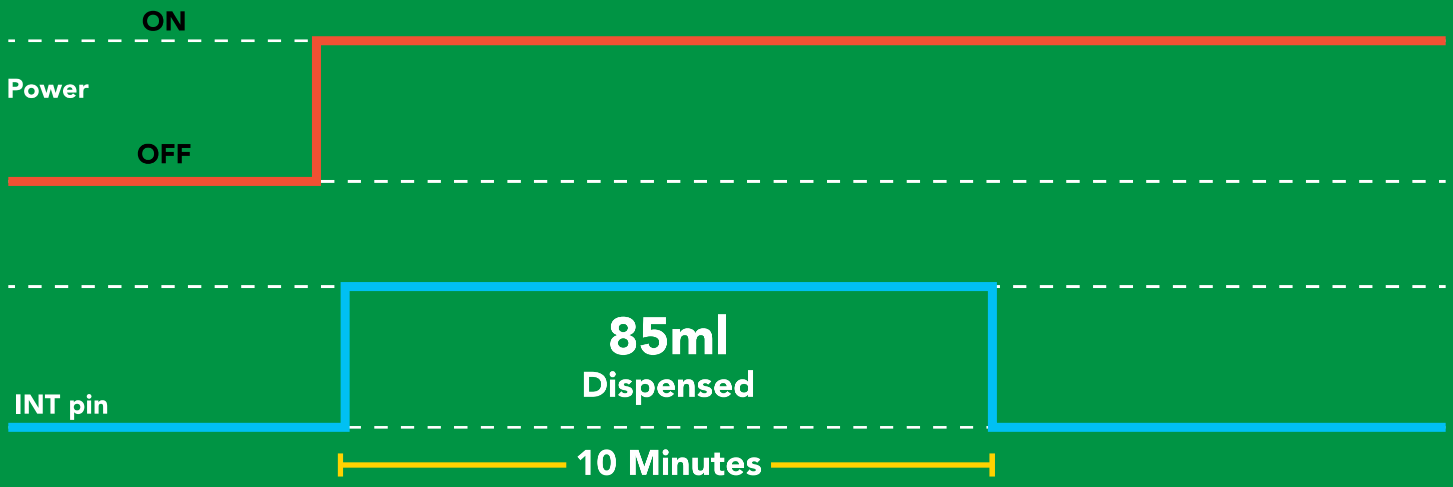
Dose Over time at startup

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>



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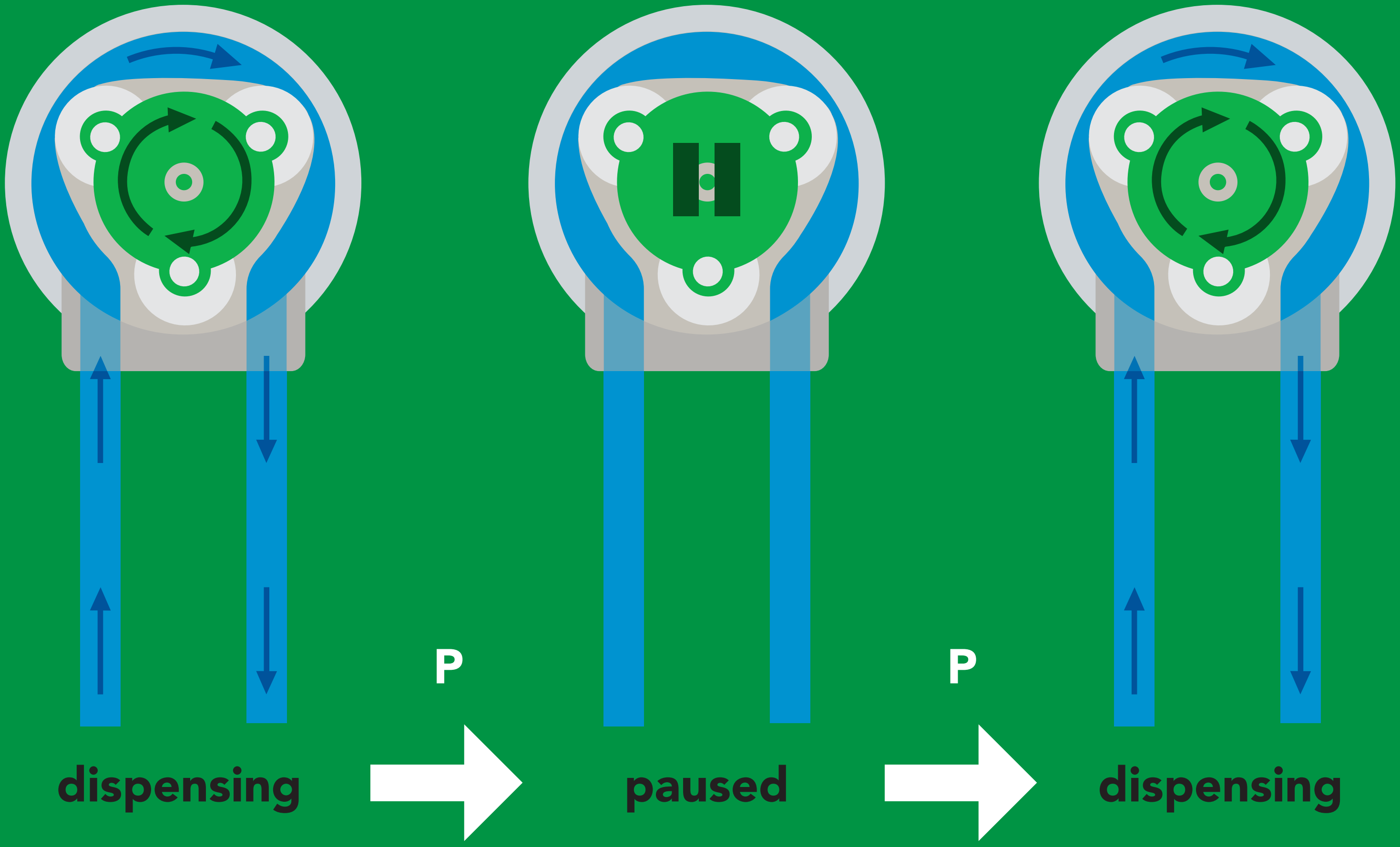
Pause dispensing

Command syntax

Issue the command again to resume dispensing

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

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

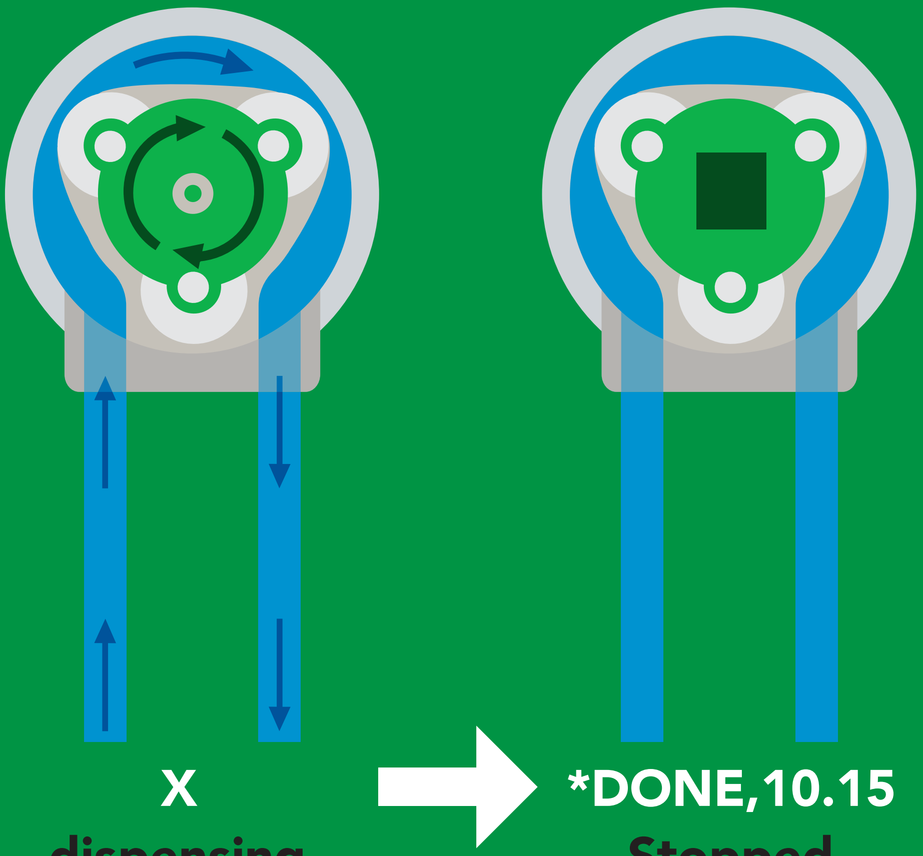


Stop dispensing

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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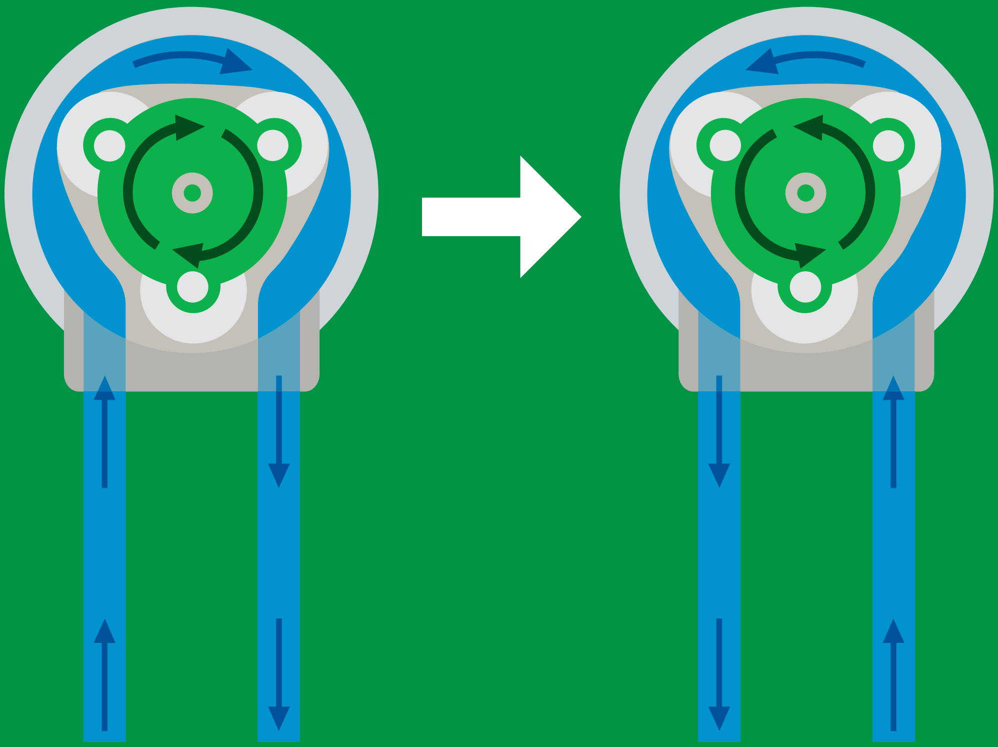
Invert dispensing direction

Command syntax

Invert direction will be retained if power is cut

Invert <cr> changes dispensing direction of pump

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



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

Calibrate to the actual volume dispensed.

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

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

Example		Response
Cal,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
```

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Naming device

Command syntax

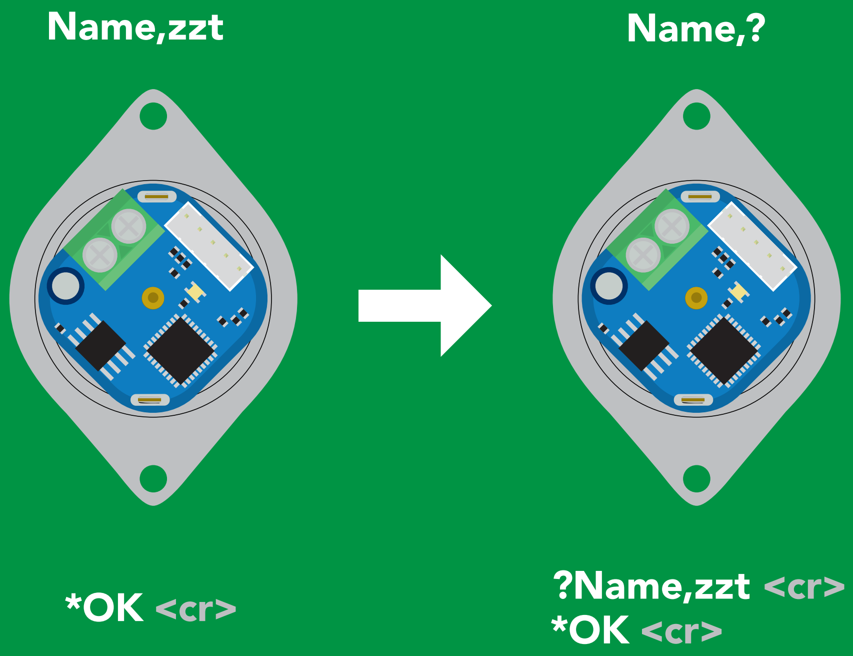
Do not use spaces in the name

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

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

Up to 16 ASCII characters

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



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Device information

Command syntax

```
i <cr> device information
```

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

Response breakdown

```
?i,  PMP,      1.1
      ↑         ↑
    Device   Firmware
```

Response codes

Command syntax

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

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

Response breakdown

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

Restart codes

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

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Sleep mode/low power

Command syntax

Send any character or command to awaken device.

Sleep <cr> enter sleep mode/low power

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

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

Sleep <cr>

Standby
13.4 mA

Sleep
0.415 mA

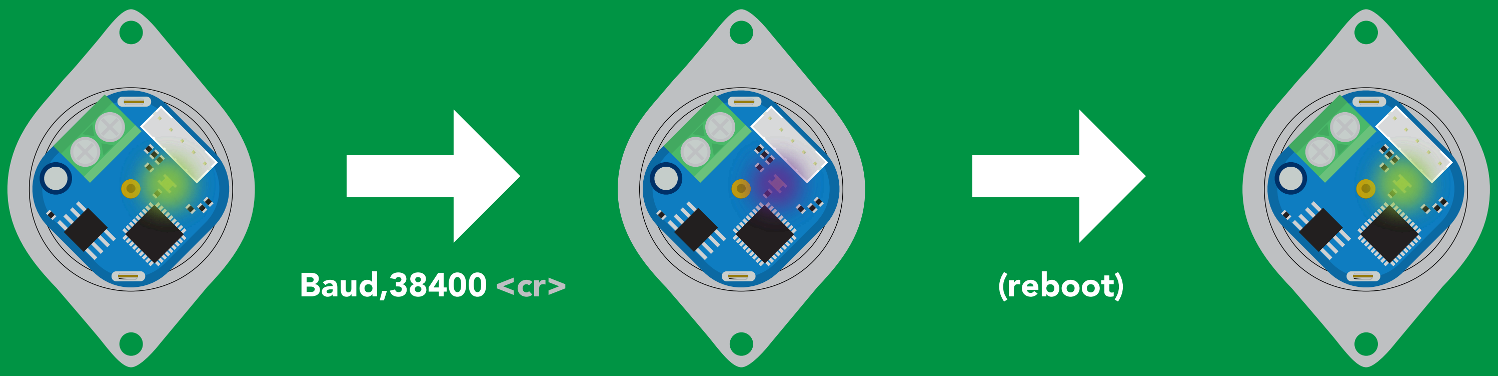
Change baud rate

Command syntax

Baud,n <cr> **change baud rate**

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

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



Baud,38400 <cr>

(reboot)

Standby

Changing baud rate

*OK <cr>

Standby

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Protocol lock

Command syntax

Locks device to UART mode.

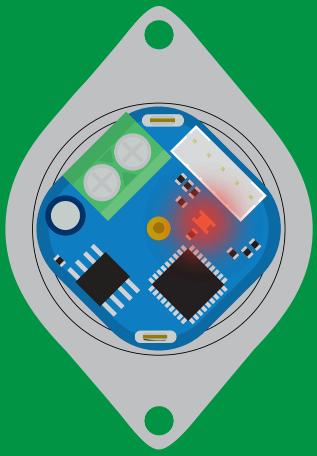
Plock,1	<cr>	enable Plock	
Plock,0	<cr>	disable Plock	default
Plock,?	<cr>	Plock on/off?	

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

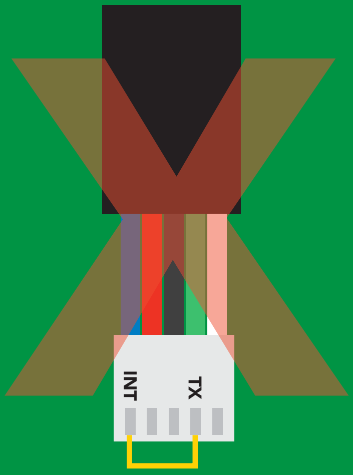
Plock,1

*OK <cr>

I2C,100



cannot change to I²C
*ER <cr>



cannot change to I²C

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Factory reset

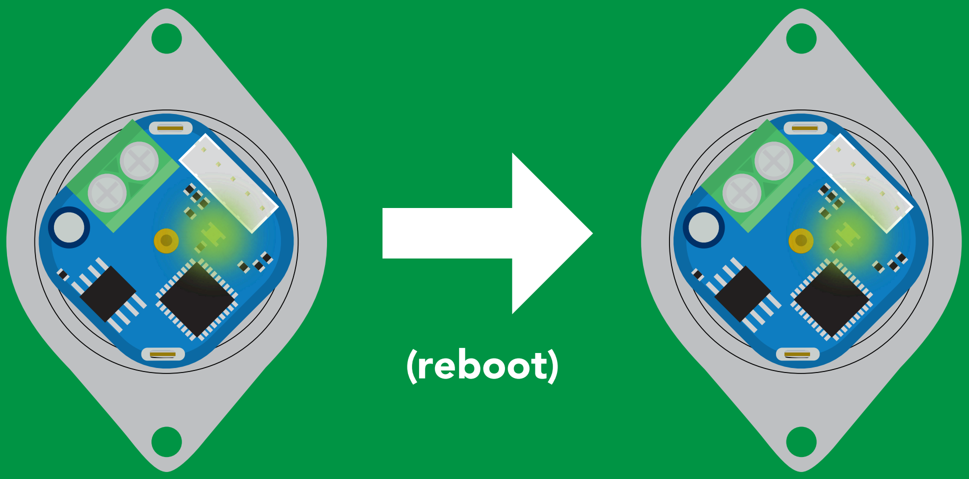
Command syntax

Clears calibration
LED on
"*OK" enabled

Factory <cr> **enable factory reset**

Example	Response
Factory <cr>	*OK <cr>

Factory <cr>



(reboot)

*OK <cr>

*RS <cr>
*RE <cr>

Baud rate will not change

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Change to I^{2}C mode

Command syntax

Default I^{2}C address 103 (0x67)

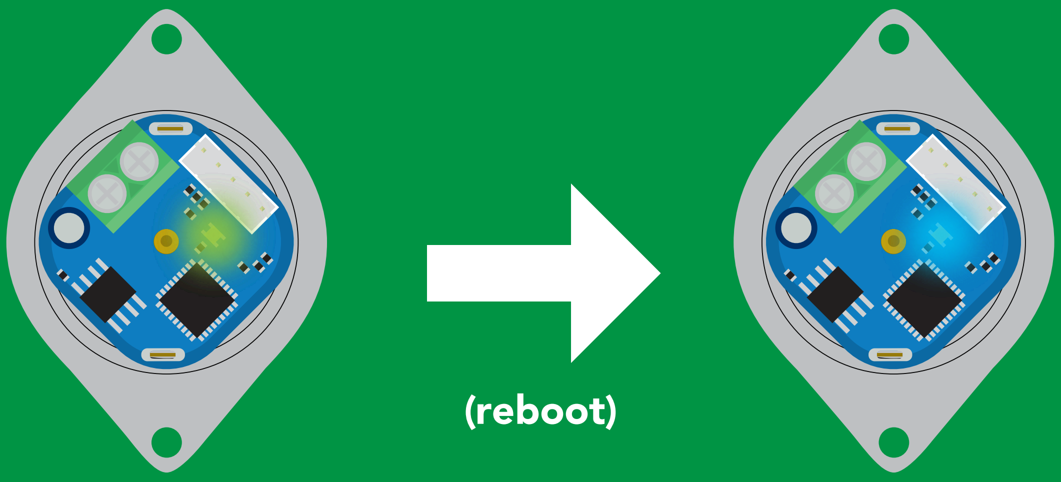
I2C,n <cr> sets I^{2}C address and reboots into I^{2}C mode

n = any number 1 – 127

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

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

I2C,100



Green
*OK <cr>

Blue
now in I^{2}C mode

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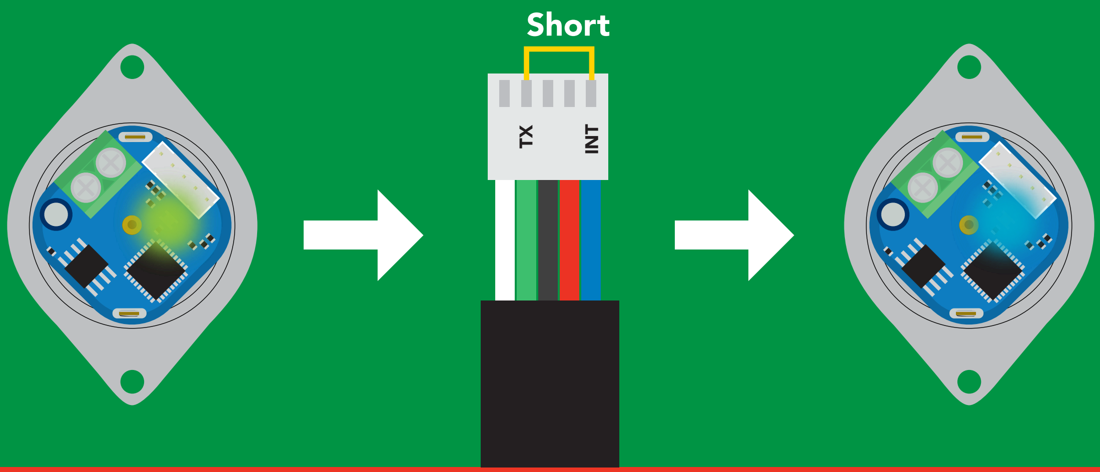
Manual switching to I^{2}C

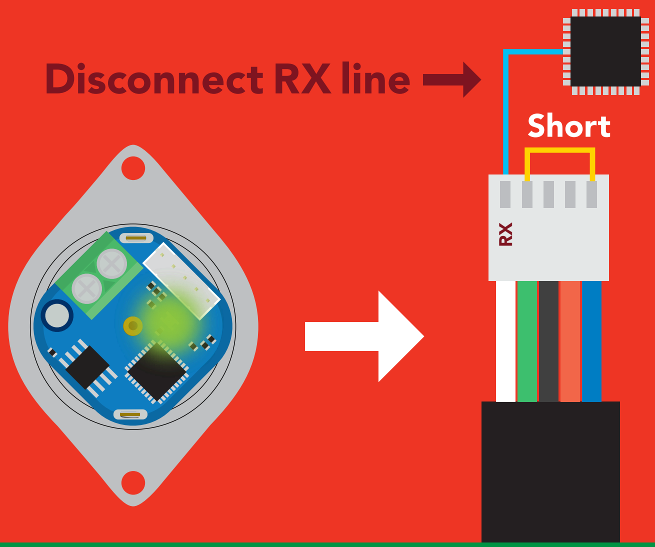
- Disconnect ground (power off)
- Disconnect TX and RX
- Connect TX to INT
- Confirm RX is disconnected
- Connect ground (power on)
- Wait for LED to change from Green to Blue
- Disconnect ground (power off)
- Reconnect all data and power

Manually switching to I^{2}C will set the I^{2}C address to 103 (0x67)

Example



Wrong Example



I^2C mode

The I^2C 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 I^2C mode click here

Settings that are retained if power is cut

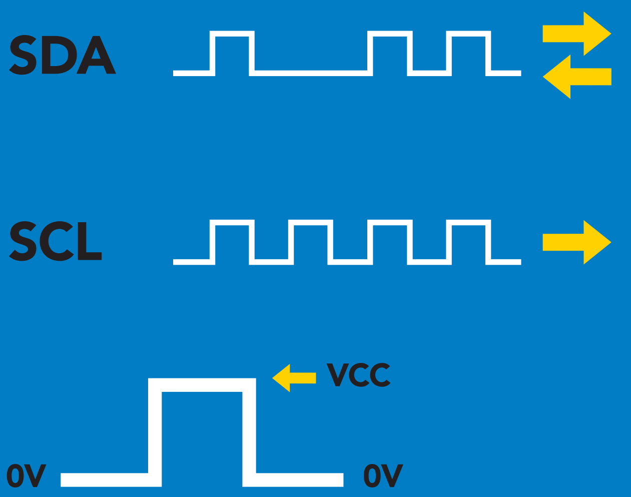
Calibration
Change I^2C address
Enable/disable parameters
Hardware switch to UART mode
Invert
LED control
Protocol lock
Software switch to UART mode

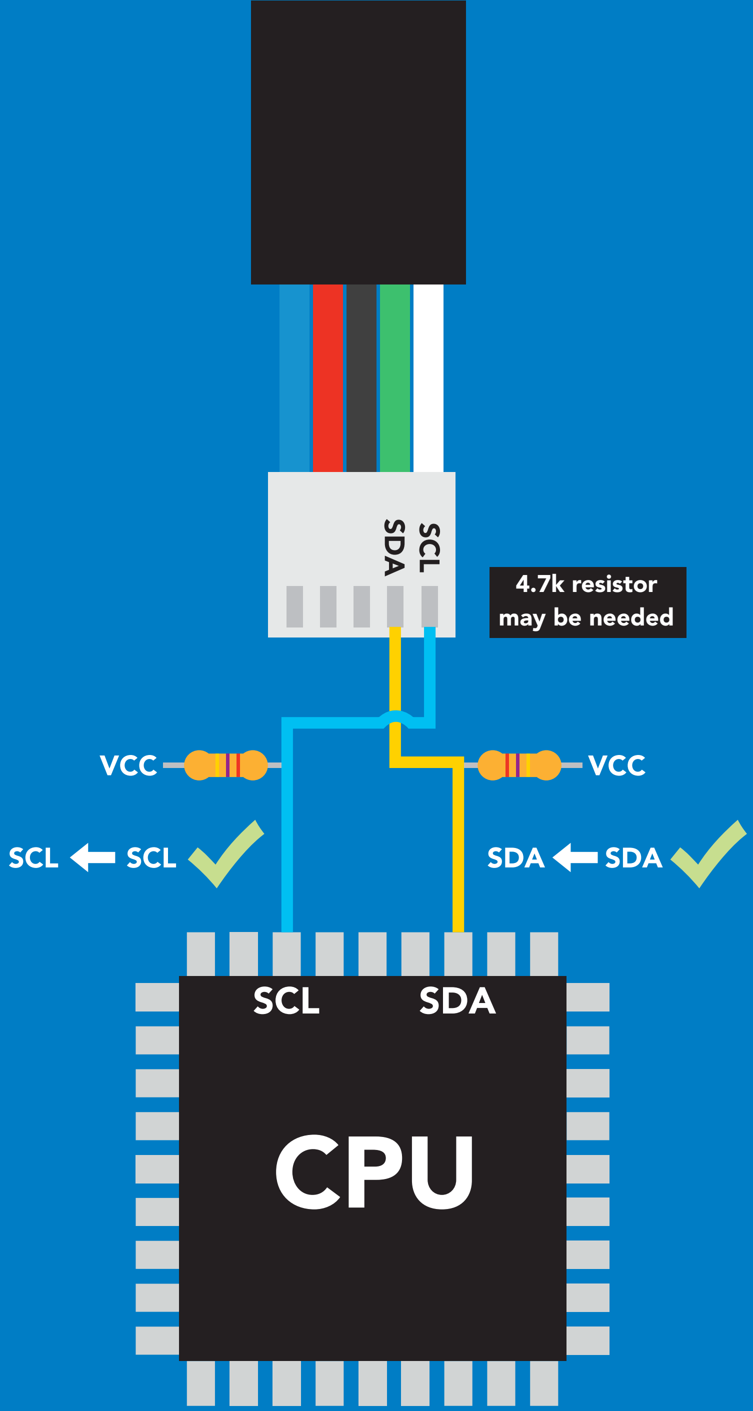
Settings that are *NOT* retained if power is cut

Absolute total volume
Find
Sleep mode
Total volume

I^{2}C mode

I^{2}C address	(0x01 – 0x7F) 103 (0x67) default
Vcc	3.3V – 5.5V
Clock speed	100 – 400 kHz

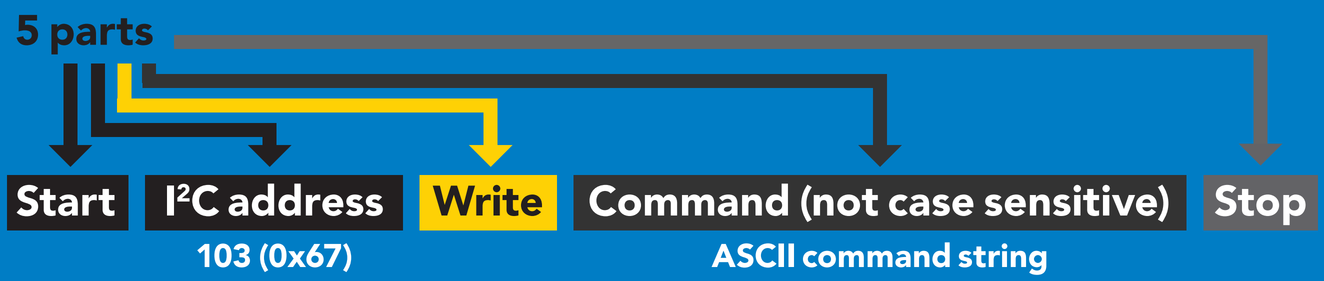




Data format

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

Sending commands to device



5 parts

Start | I^{2}C address | Write | Command (not case sensitive) | Stop

103 (0x67)

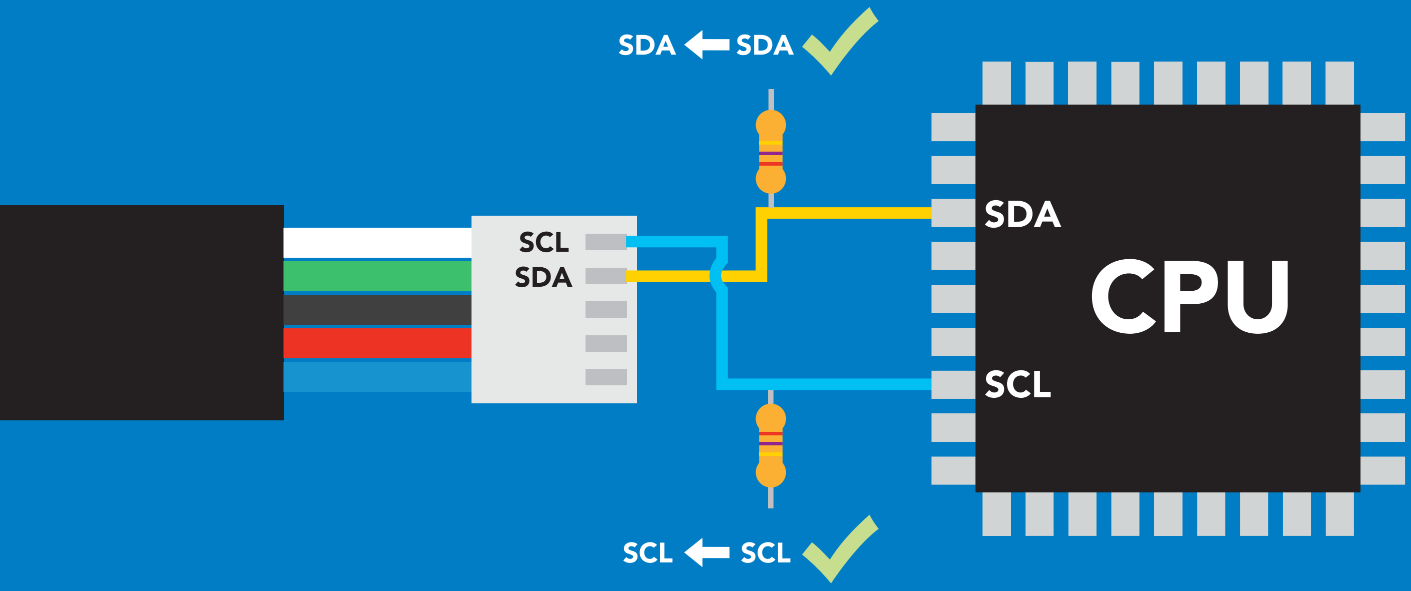
ASCII command string

Example

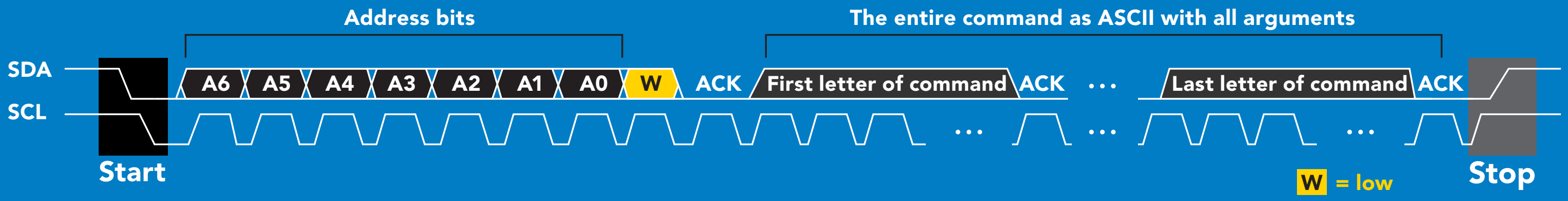
Start | 103 (0x67) | Write | Sleep | Stop

I^{2}C address

Command



Advanced



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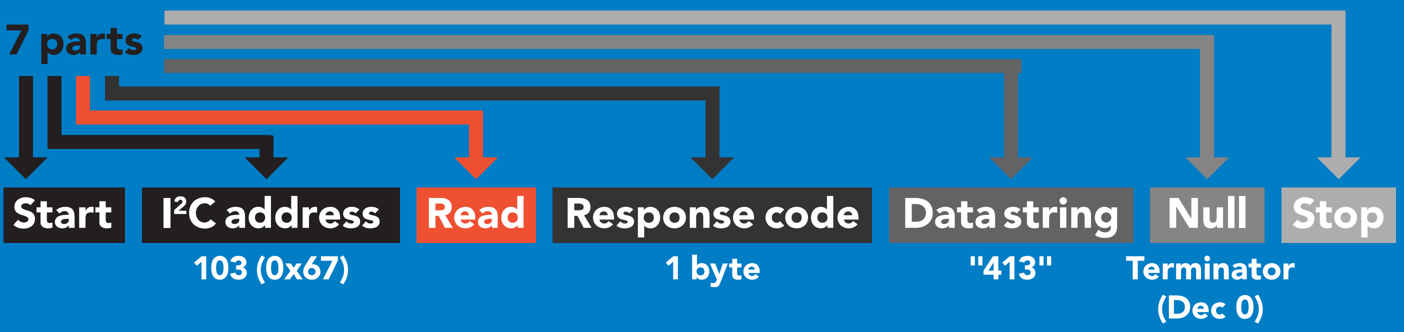
Requesting data from device



7 parts

Start

I^{2}C address
103 (0x67)

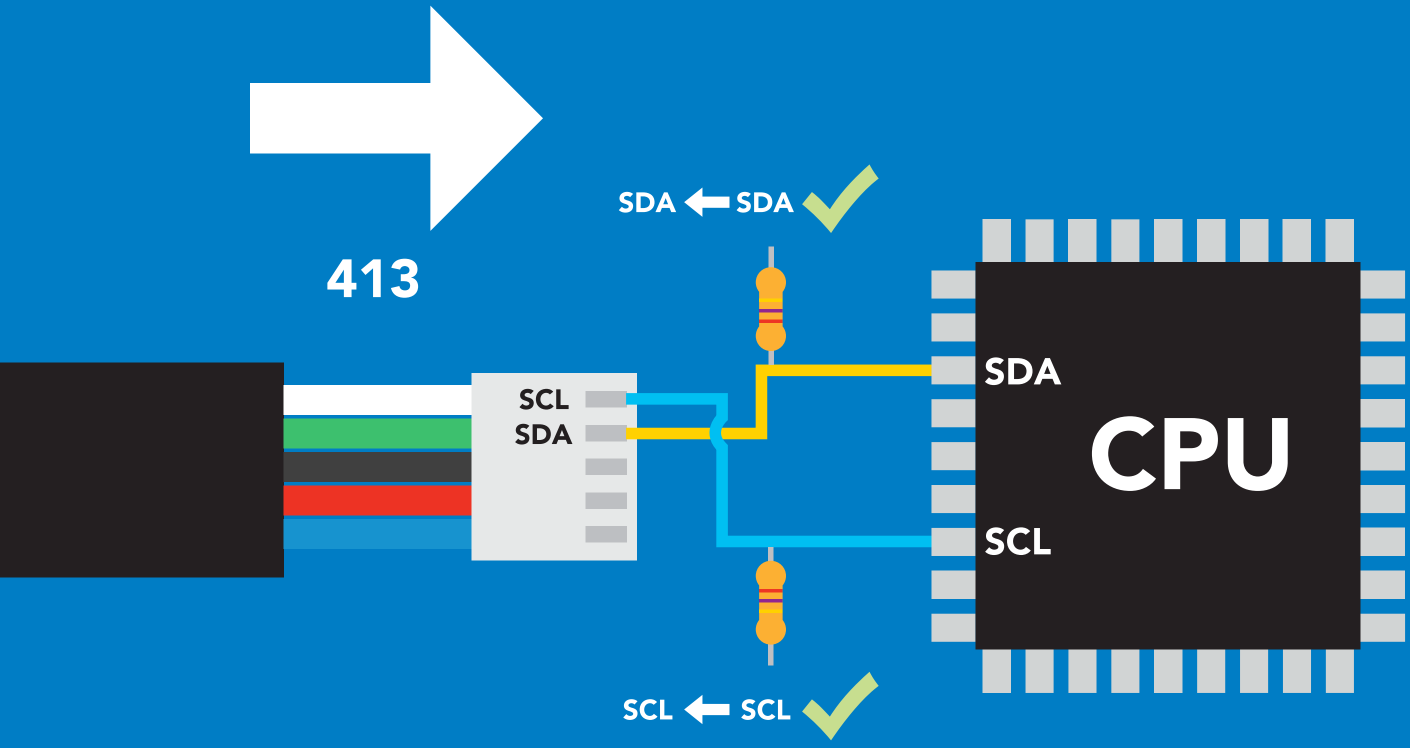
Read

Response code
1 byte

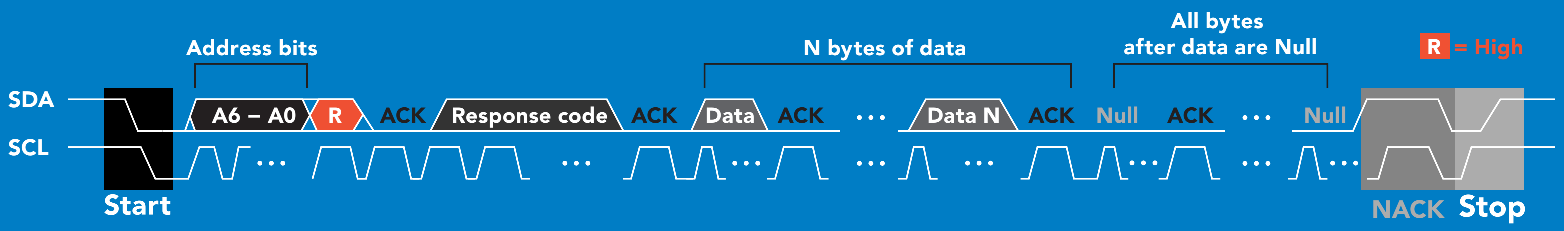
Data string
"413"

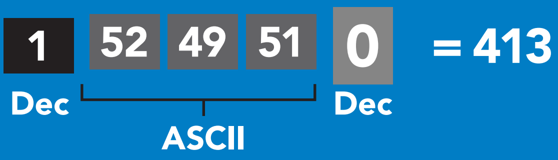
Null
Terminator
(Dec 0)

Stop



Advanced





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

Dec | ASCII | Dec

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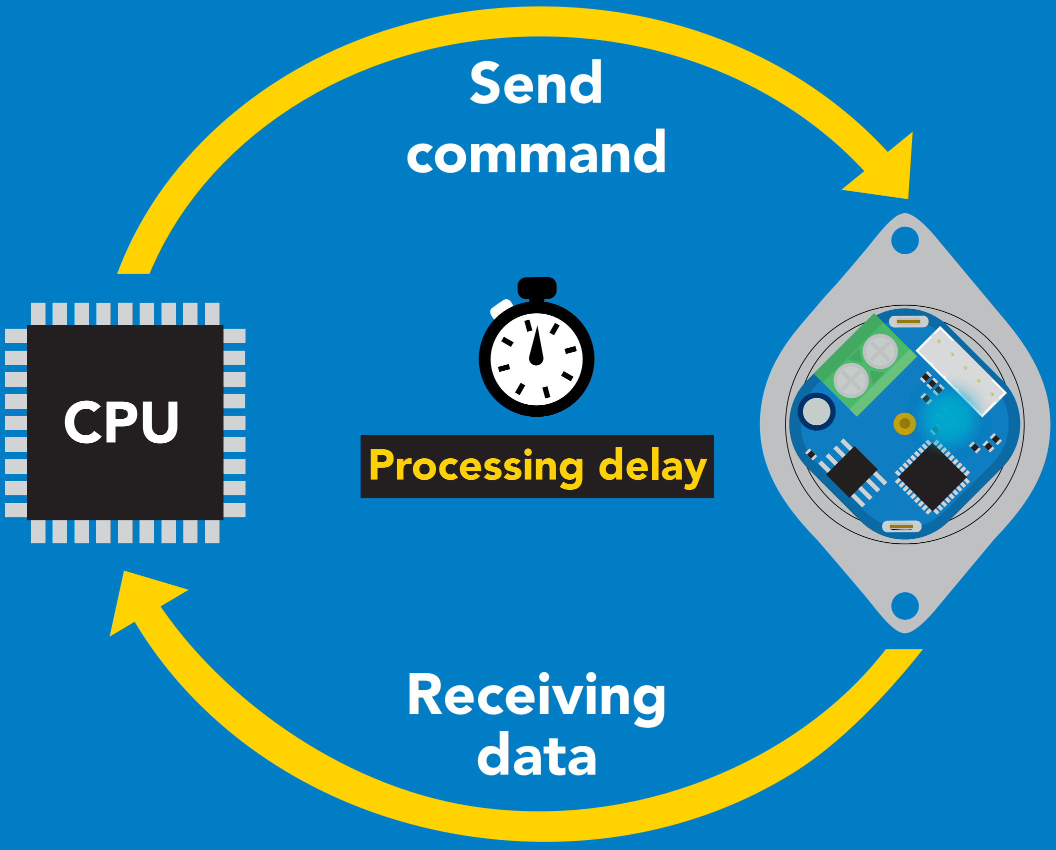
Response codes

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

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

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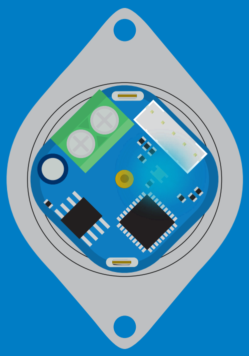
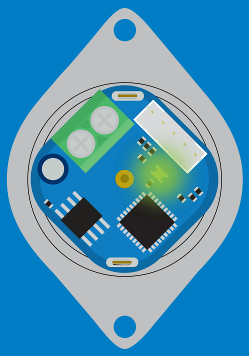
LED color definition



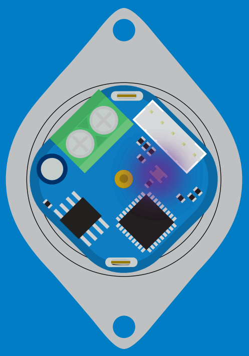
Blue

I^2C standby



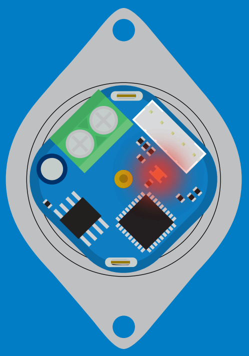
Green

Taking reading



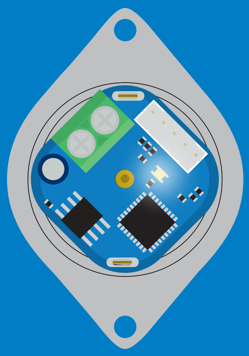
Purple

Changing I^2C address



Red

Command not understood



White

Find

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

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I^{2}C mode

command quick reference

All commands are ASCII strings or single ASCII characters.

Command	Function	
Baud	switch back to UART mode	pg. 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 I^{2}C 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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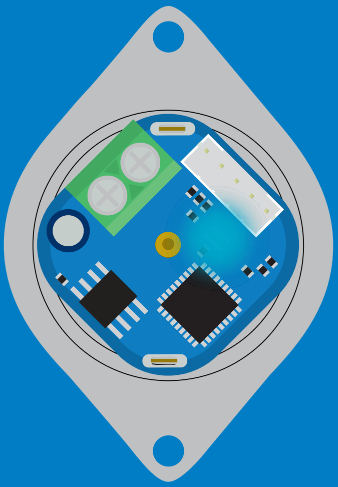
LED control

Command syntax

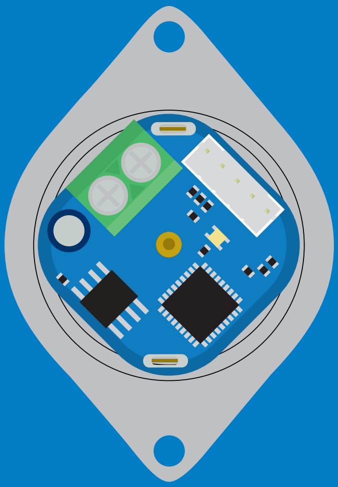
300ms processing delay

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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Find

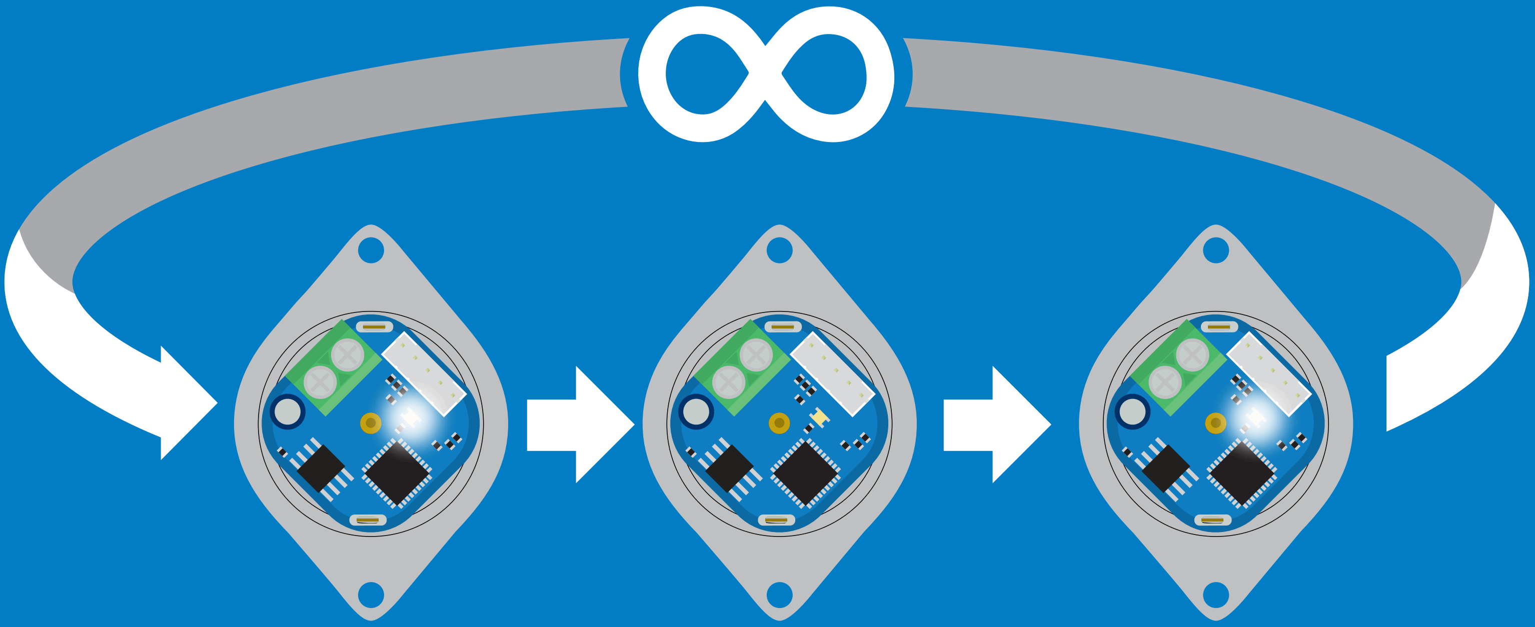
300ms ⏱ processing delay

Command syntax

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

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

Example	Response
Find	⏱ Wait 300ms 1 0 Dec Null



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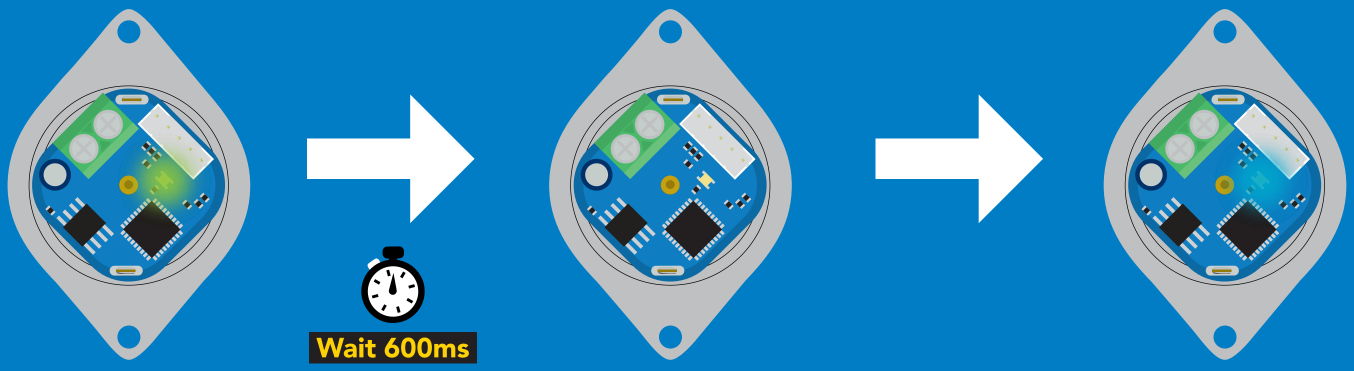
Single report mode

Command syntax

300ms ⏱ processing delay

R returns a single value showing dispensed volume

Example	Response
R	⏱ Wait 300ms — **1** Dec **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 → Transmitting → **Blue** — Standby

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Continuous dispensing

Pump on/pump off

300ms processing delay

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

Command syntax

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

Example	Response
D,*	Wait 300ms 1 Dec 0 Null pump will continuously run at ~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

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,-40.5	⏱ 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

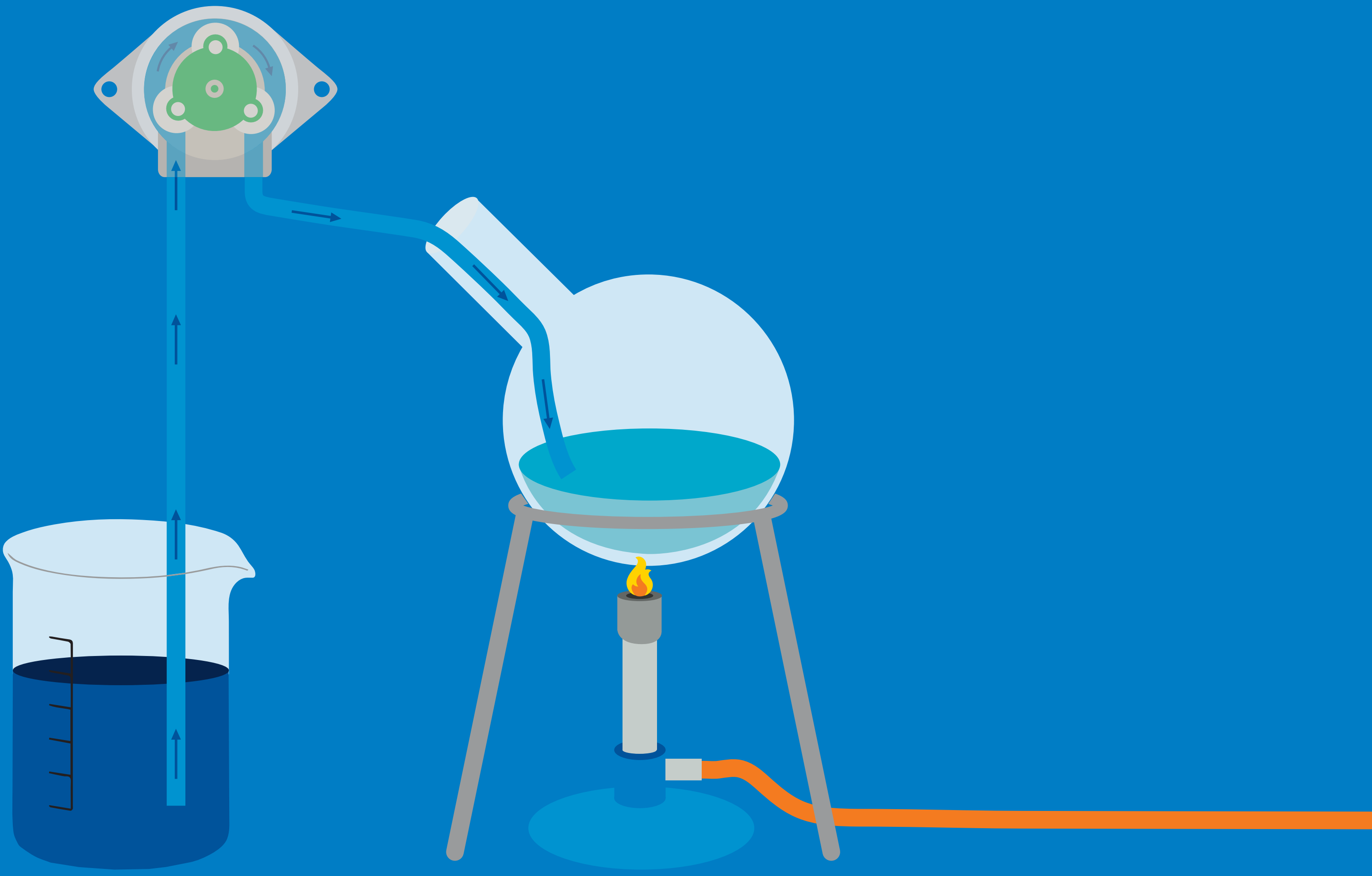
Pump a fixed volume over a fixed time

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

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

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

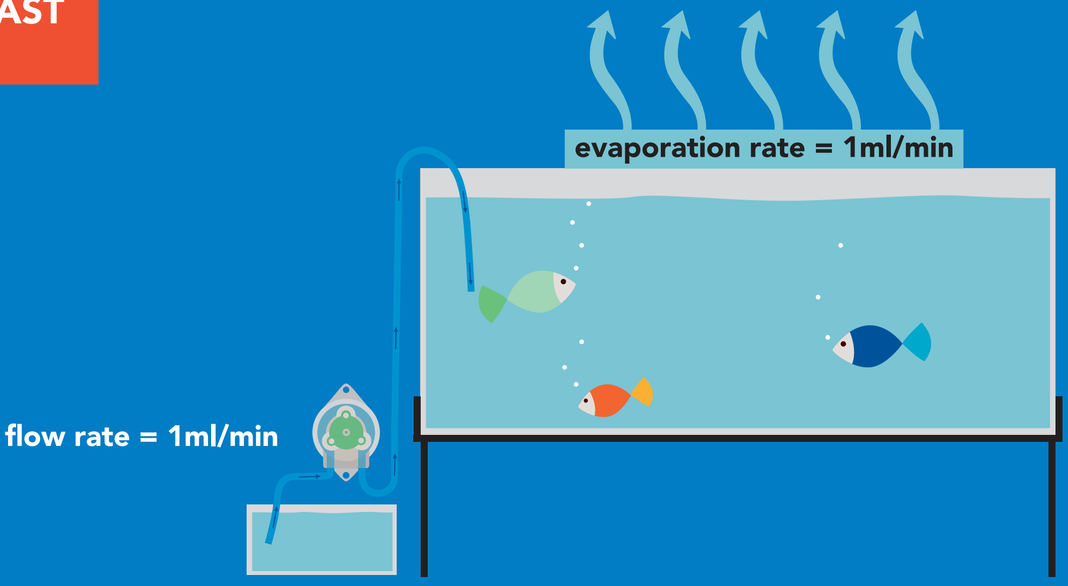
DC,? reports maximum possible flow rate

[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,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



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Dispense at startup

Pump a specific volume at startup and then stop

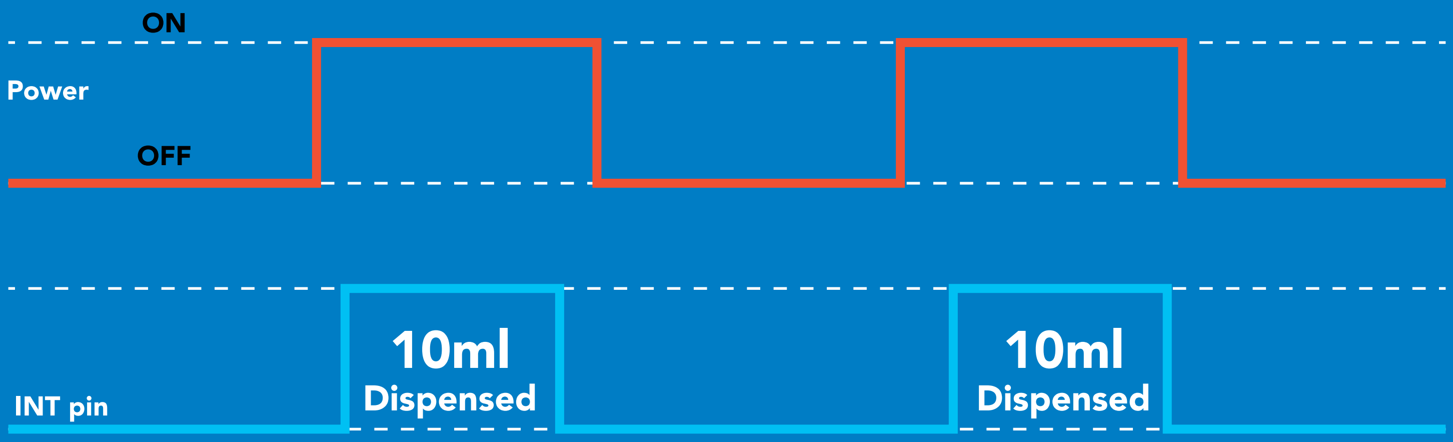
Use this command to make a simple fixed-volume pump

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



Continuous dispensing at startup

Pump on & continuously dispense

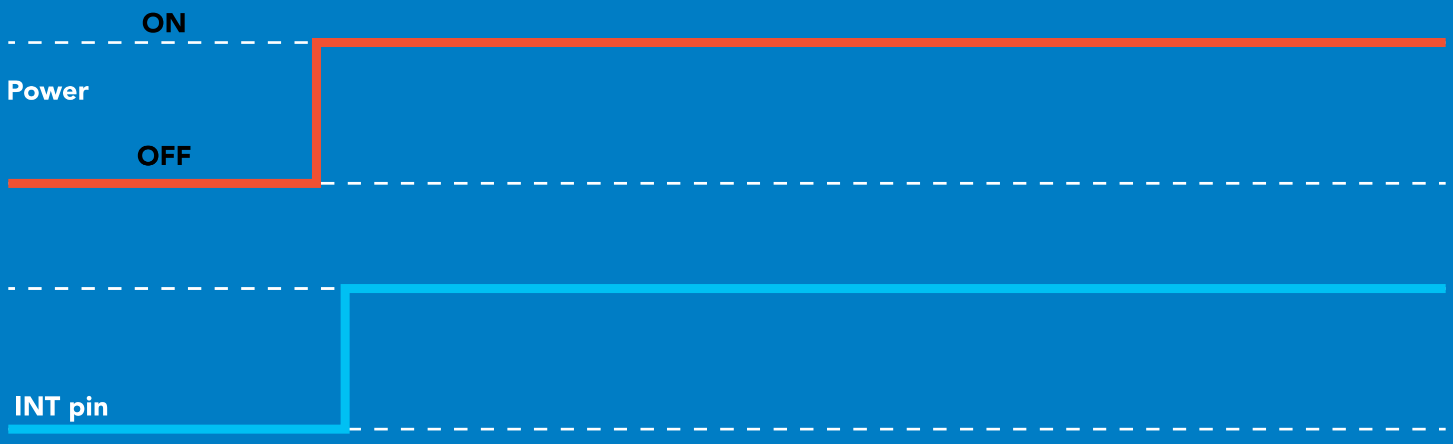
300ms ⏱ processing delay

Command syntax

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

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

Example	Response				
Dstart,*	⏱ Wait 300ms	1 Dec	0 Null		Pump will startup and continuously run at ~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	



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Dose Over time at startup

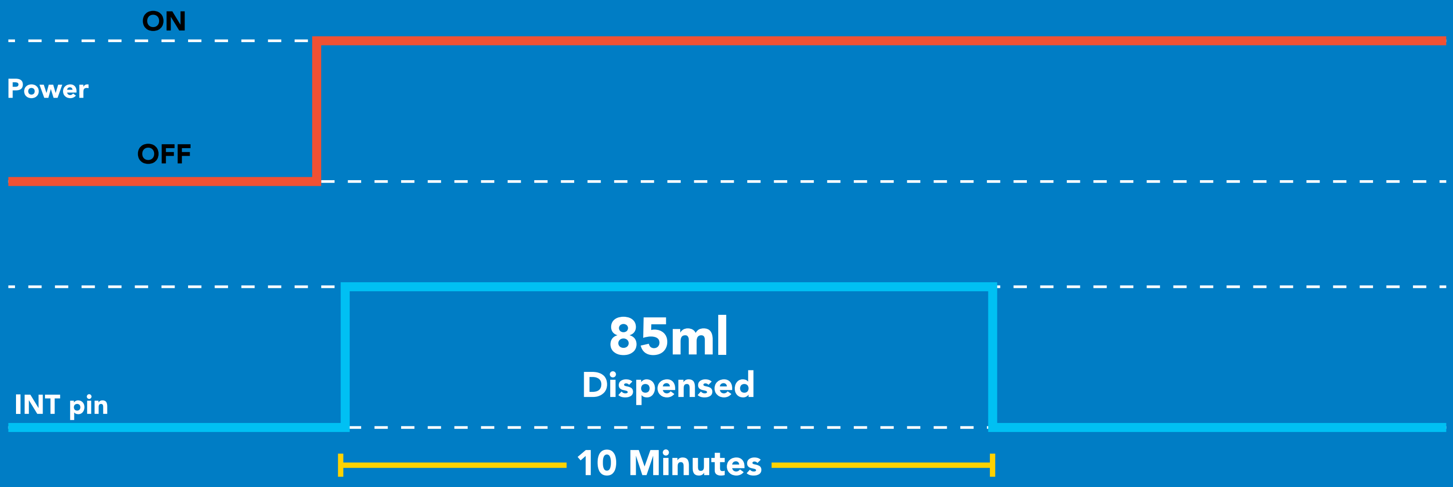
Pump a fixed volume over a fixed time at startup

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



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Pause dispensing

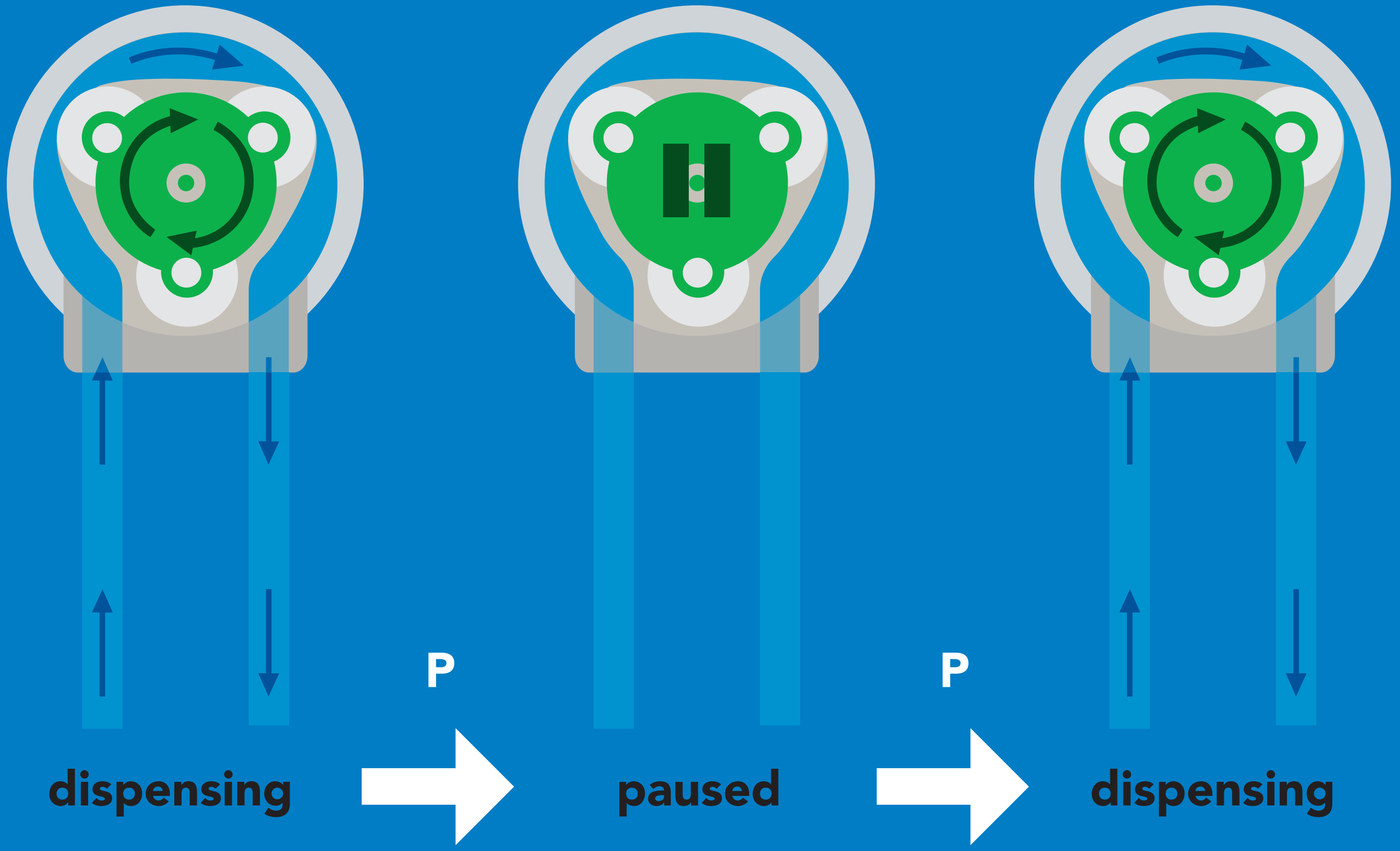
300ms ⏱ processing delay

Issue the command again to resume dispensing

Command syntax

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



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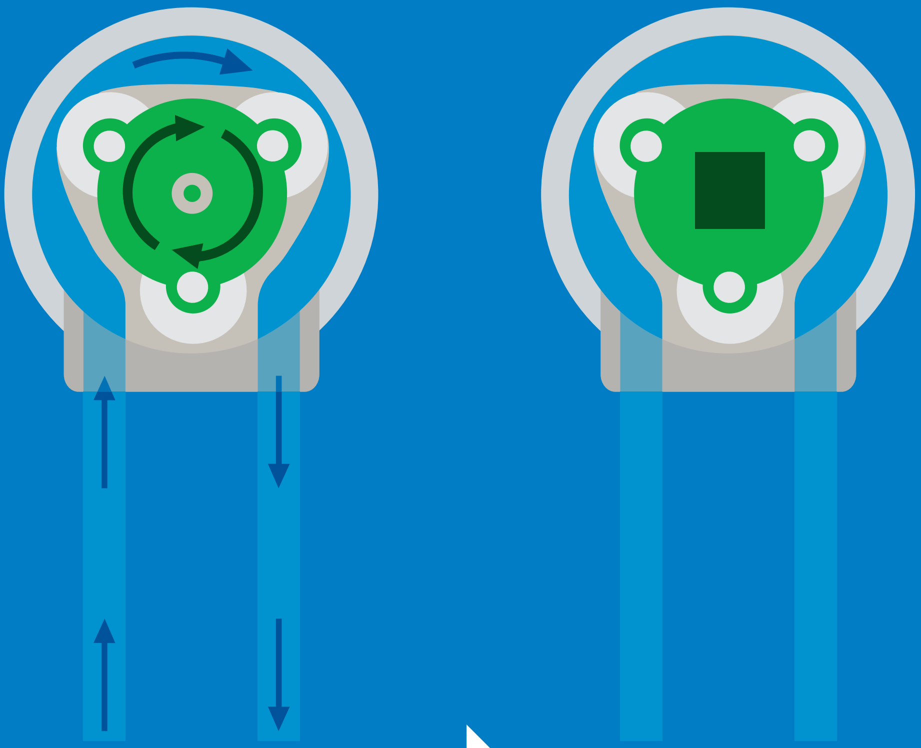
Stop dispensing

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,10.15
Stopped

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Invert dispensing direction

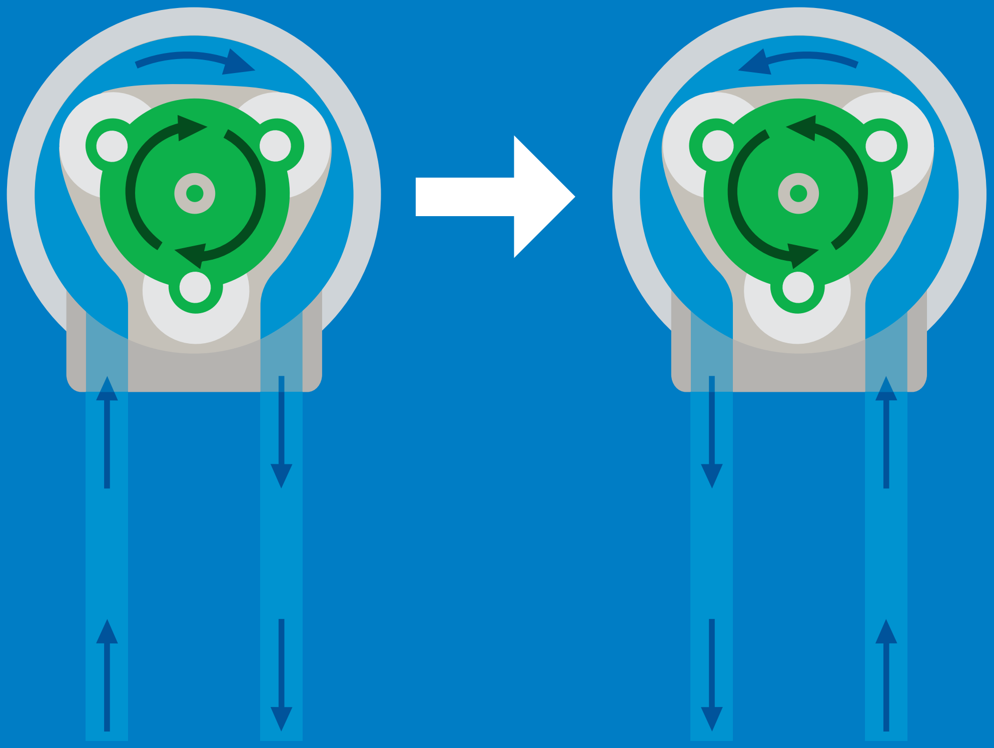
300ms processing delay

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



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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.

Calibration

300ms ⏱ processing delay

Calibrate to the actual volume dispensed.

Command syntax

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) 0 (Null) — fixed volume or ⏱ Wait 300ms → 1 (Dec) ?Cal,2 (ASCII) 0 (Null) — volume/time or ⏱ Wait 300ms → 1 (Dec) ?Cal,3 (ASCII) 0 (Null) — both or ⏱ Wait 300ms → 1 (Dec) ?Cal,0 (ASCII) 0 (Null) — uncalibrated

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Enable/disable parameters from output string

Command syntax

300ms ⏱ processing delay

O, [parameter],[1,0]	enable or disable output parameter
O,?	enabled parameter?

Example	Response				
O,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

300ms ⏱ processing delay

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

300ms ⏱ processing delay

Command syntax

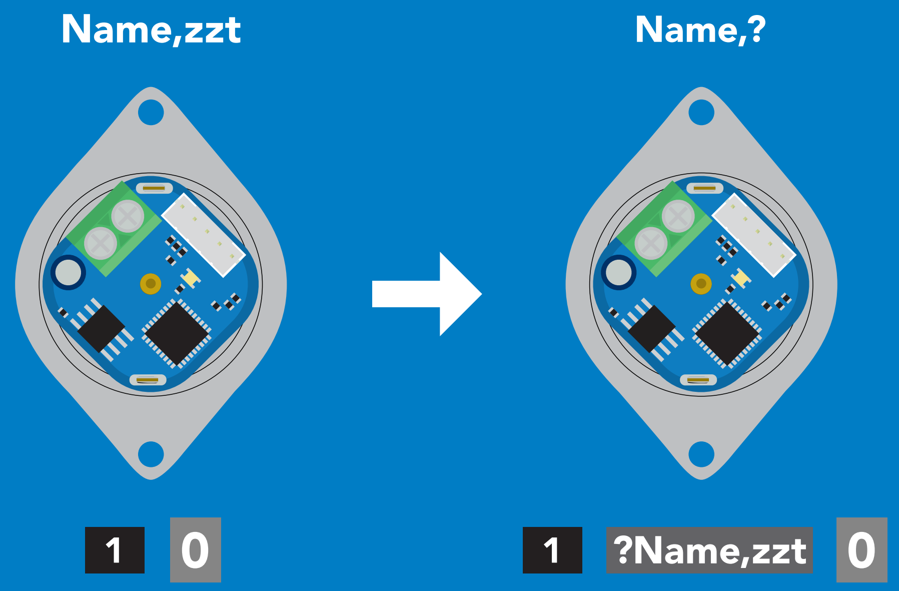
Do not use spaces in the name

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

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

Up to 16 ASCII characters

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



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Device information

Command syntax

300ms ⏱ processing delay

i device information

Example	Response
i	⏱ Wait 300ms · 1 (Dec) · ?i,PMP, 1.1 (ASCII) · 0 (Null)

Response breakdown

?i,	PMP,	1.1
	↑ Device	↑ Firmware

Reading device status

Command syntax

300ms ⏱ processing delay

Status voltage at Vcc pin and reason for last restart

Example

Status

Response

⏱ Wait 300ms

1	?Status,P,5.038	0
Dec	ASCII	Null

Response breakdown

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

Restart codes

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

Sleep mode/low power

Command syntax

Sleep enter sleep mode/low power

Send any character or command to awaken device.

Example	Response
Sleep	no response
Any command	wakes up device

Do not read status byte after issuing sleep command.

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

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Protocol lock

Command syntax

300ms ⏱ processing delay

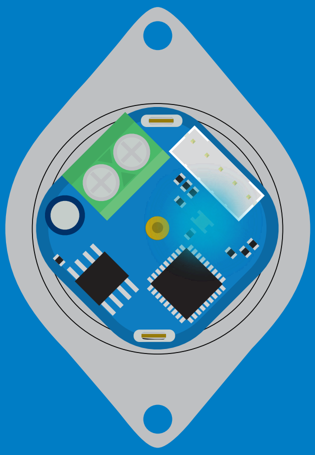
Plock,1	enable Plock	
Plock,0	disable Plock	default
Plock,?	Plock on/off?	

Locks device to I²C mode.

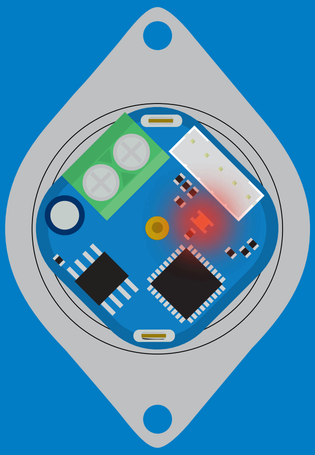
Example / Response

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)

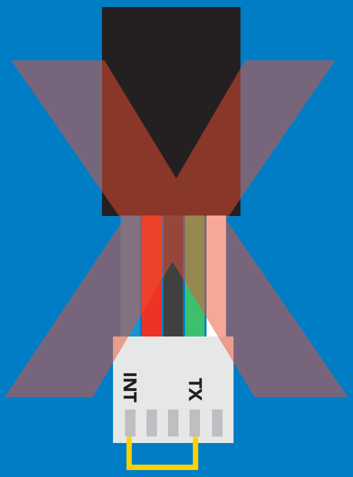
Plock,1



Baud, 9600



cannot change to UART



cannot change to UART

I^{2}C address change

Command syntax

300ms ⏱ processing delay

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

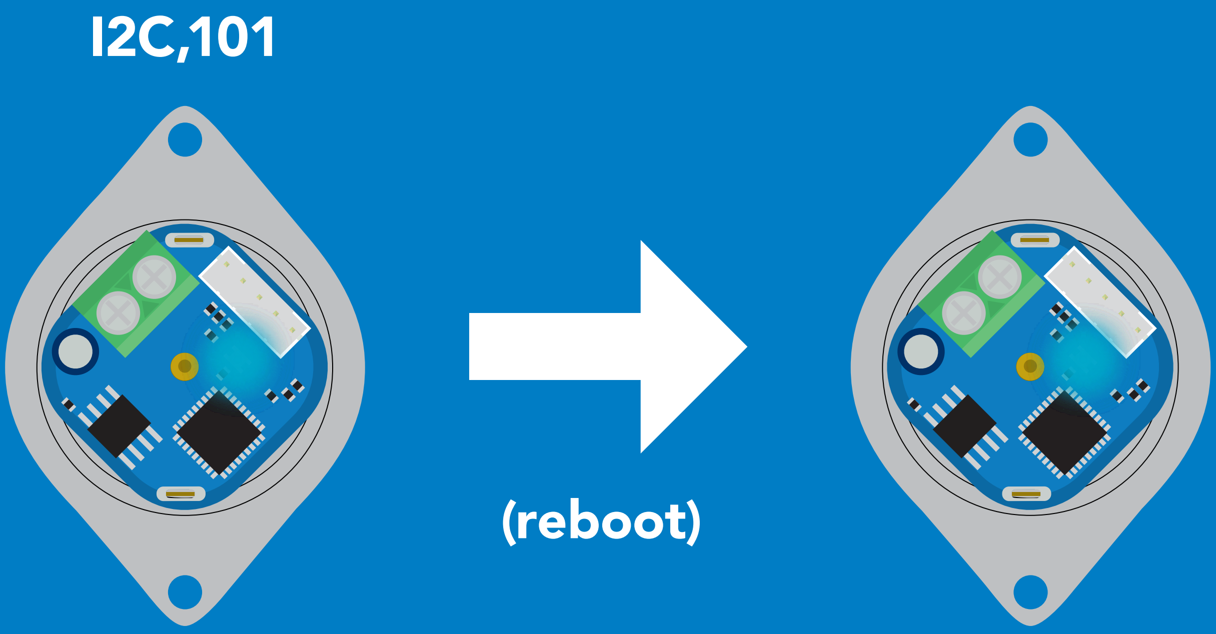
Example	Response
I2C,101	device reboot (no response given)

Warning!

Changing the I^{2}C address will prevent communication between the circuit and the CPU until the CPU is updated with the new I^{2}C address.

Default I^{2}C address is 103 (0x67).

n = any number 1 – 127



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r 0.2

Factory reset

Command syntax

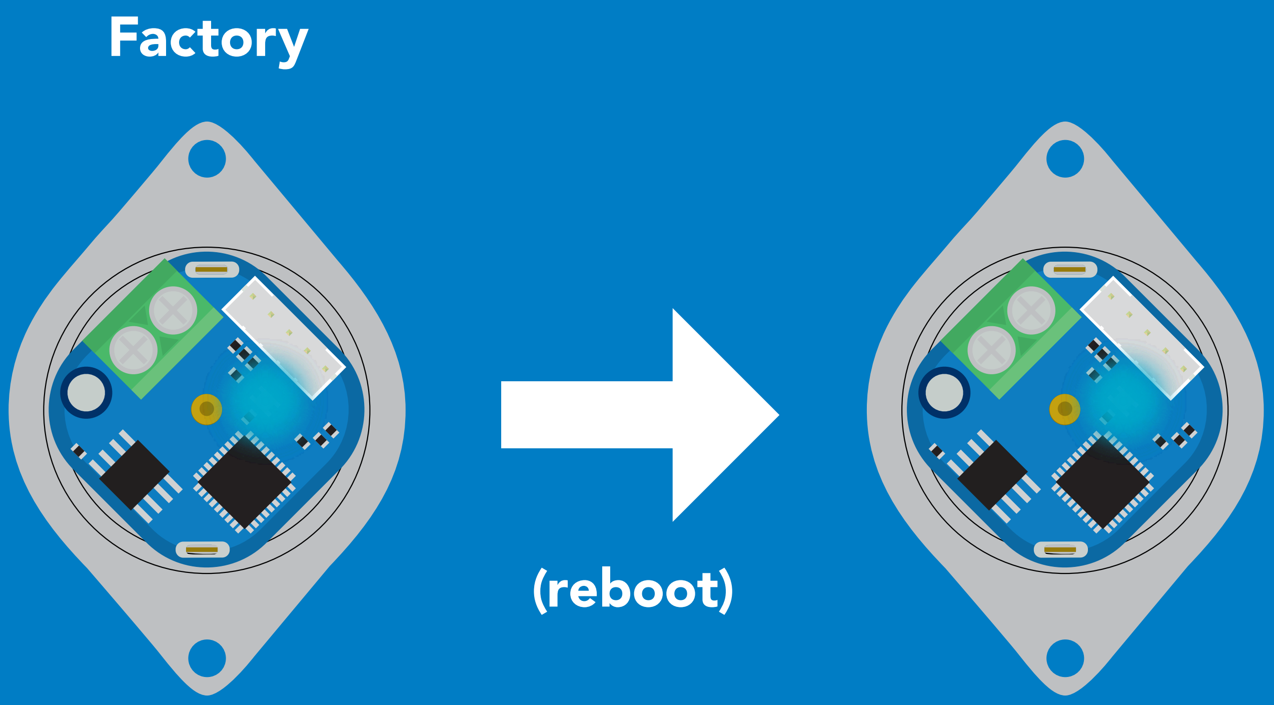
Factory reset will not take the device out of I^2C mode.

Factory	enable factory reset

I^2C address will not change

Example	Response
Factory	device reboot (no response given)

Clears calibration
LED on
Response codes enabled



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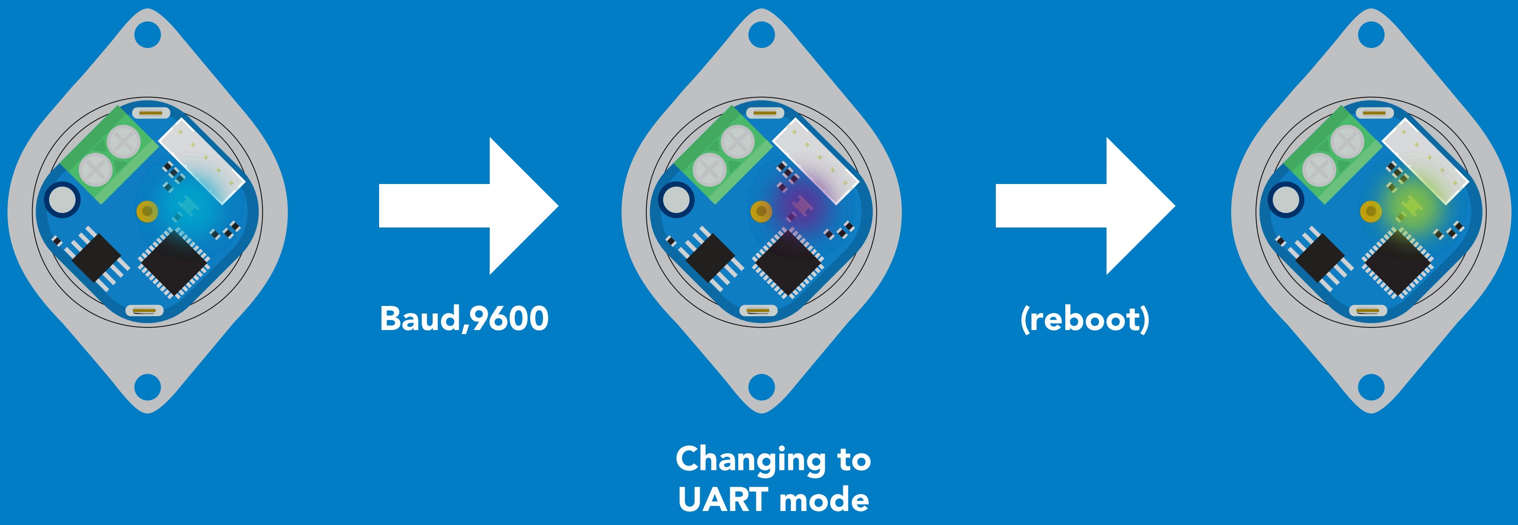
Change to UART mode

Command syntax

Baud,n	**switch from I^2C to UART**

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

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



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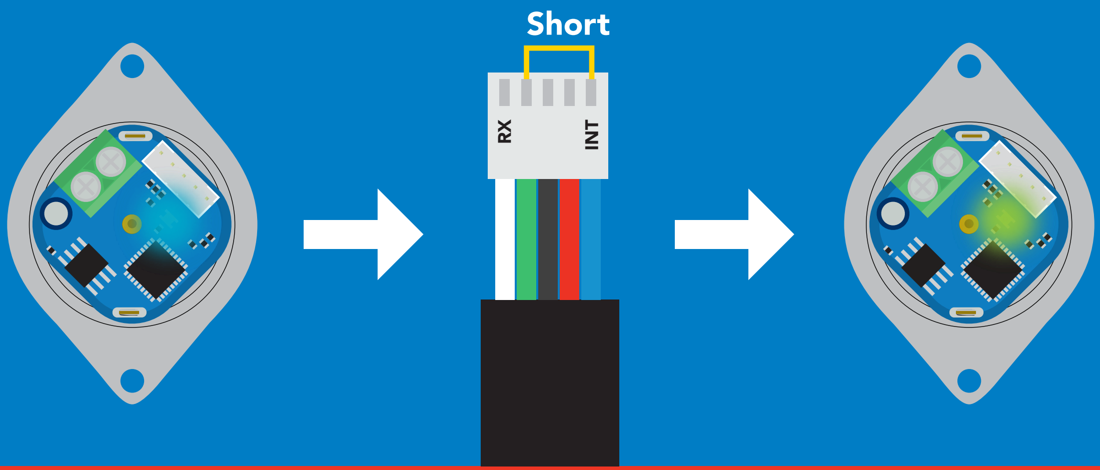
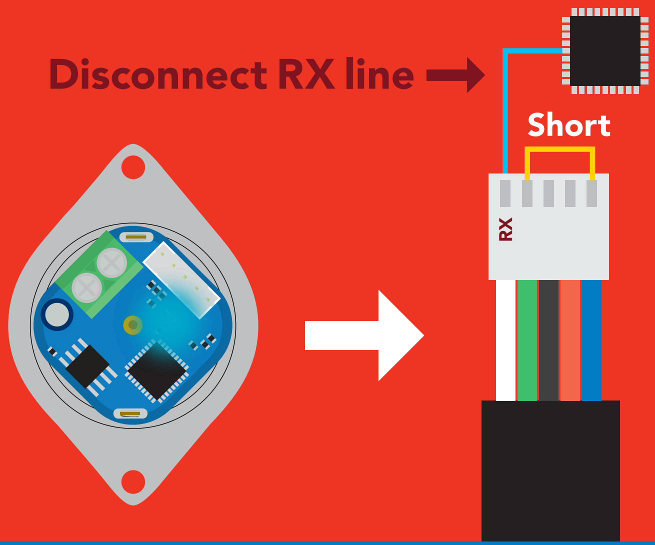
Manual switching to UART

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

Example



Wrong Example



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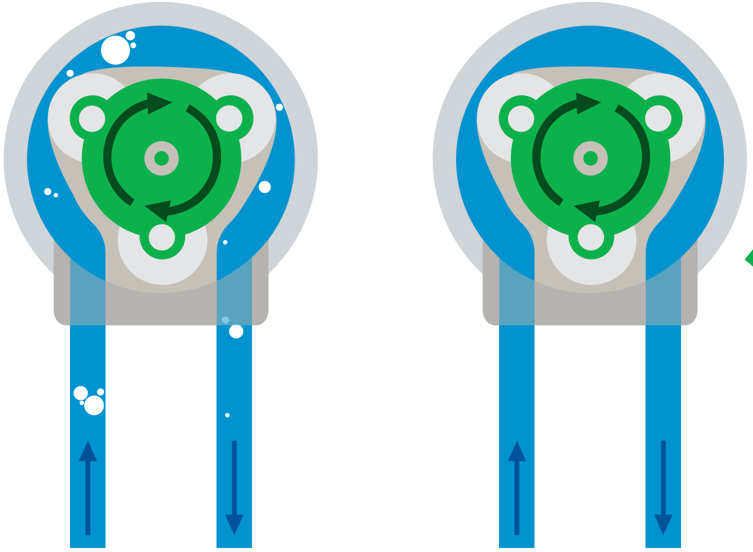
Calibration theory

Uncalibrated accuracy +/- 5%
Calibrated accuracy +/- 1%

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 ✗



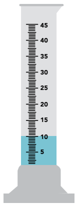
✓ Ready for calibration

Calibration types

Volume calibration
Volume over time calibration

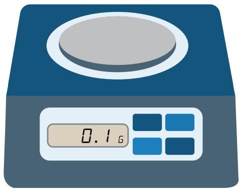
Calibration is optional. Both types of calibration are independent of each other and can be done at any time. Calibration can be done at any volume however; Atlas Scientific recommends using volumes above 5ml.

Equipment needed for calibration



An accurate graduated cylinder of at least 10ml.

Or



An accurate scale with a resolution of at least 0.1 grams

1 gram of water = 1ml
23.56 grams of water = 23.56ml

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Calibration procedure

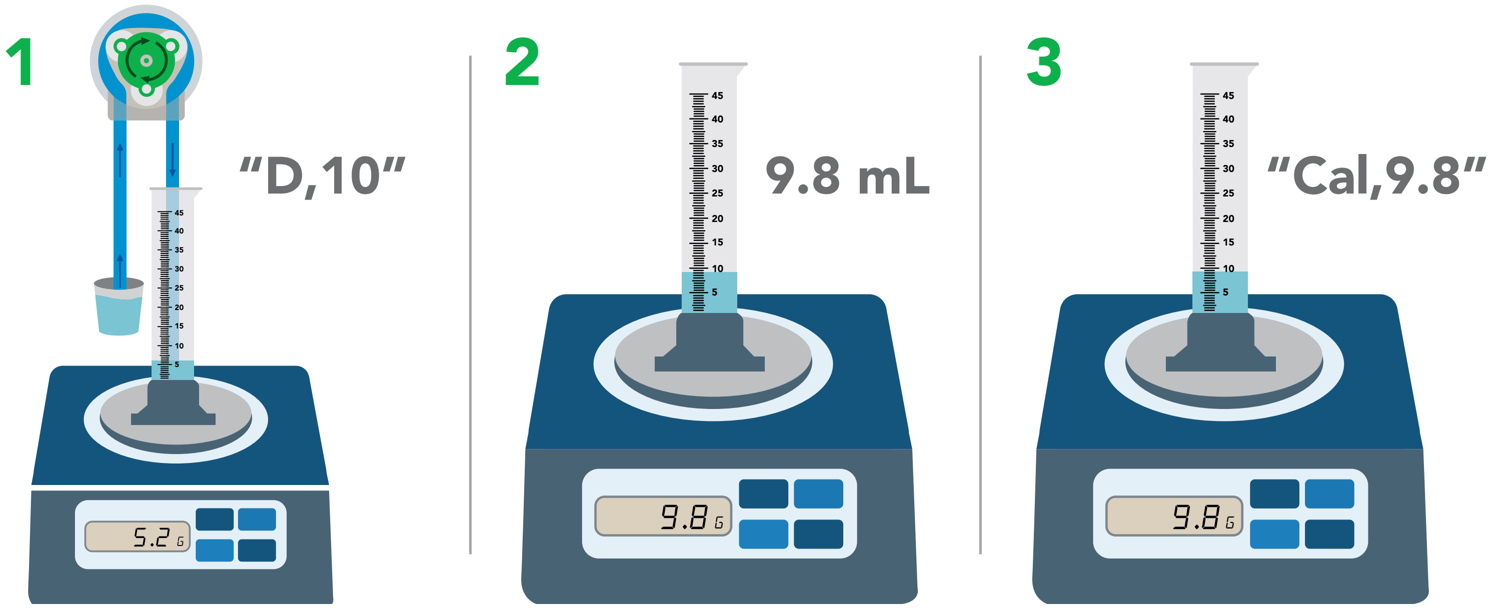
Calibration should be done with water and not a chemical

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

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

Example

Calibrate the pump by dispensing 10ml

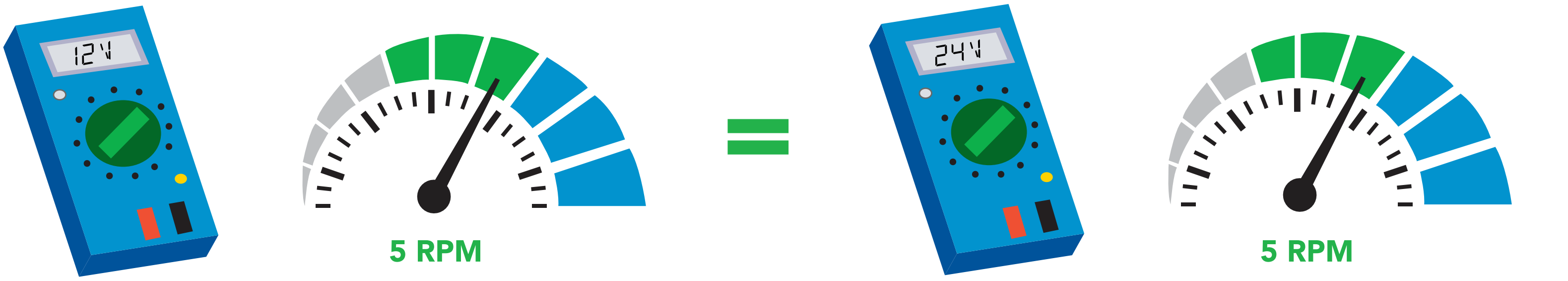


1. Instruct the pump to dispense 10ml into a graduated cylinder or beaker on a scale.
2. Measure the amount of liquid that was actually dispensed.
3. Inform the pump how much liquid was actually dispensed.
4. Calibration is now complete.

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.

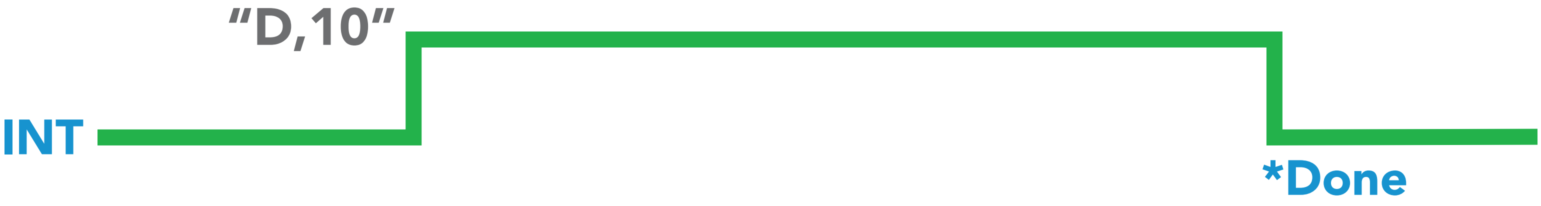
Pump speed vs. voltage

There is no change in pump speed at different voltages.

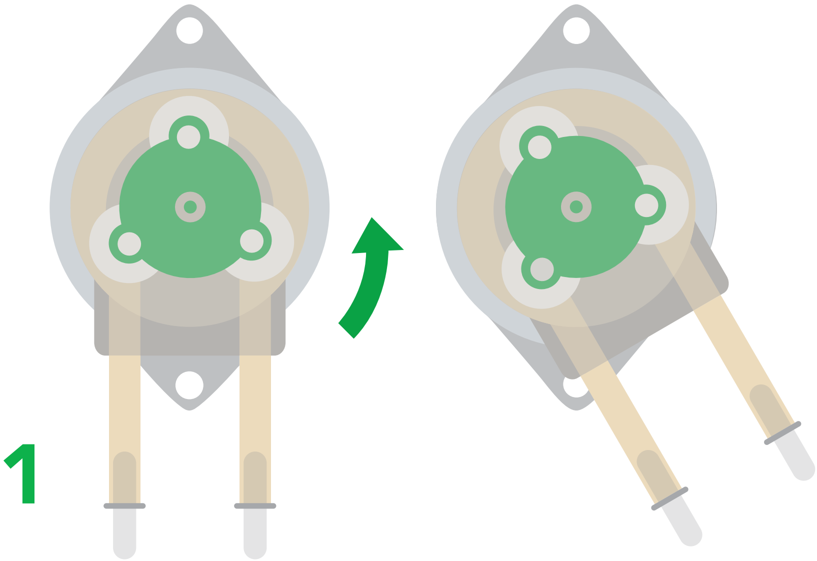


Interrupt pin

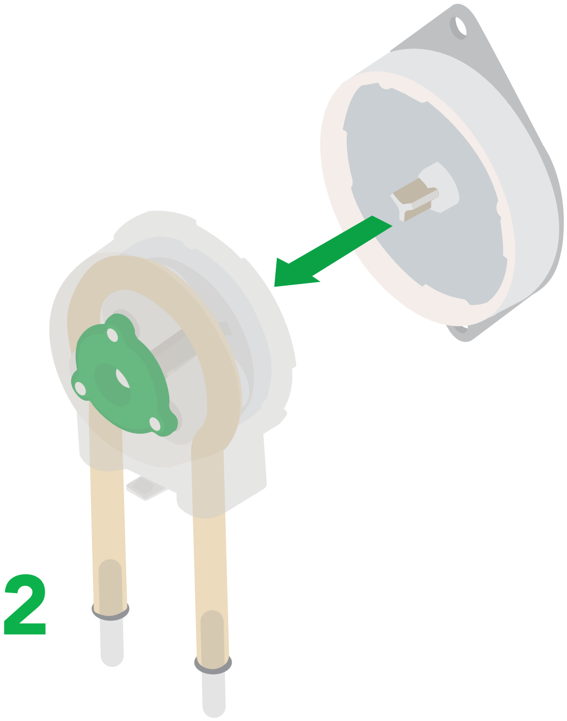
When the pump is dispensing the interrupt pin goes high.



Removing cassette



Turn cassette counterclockwise until it stops.



Pull cassette off the motor.

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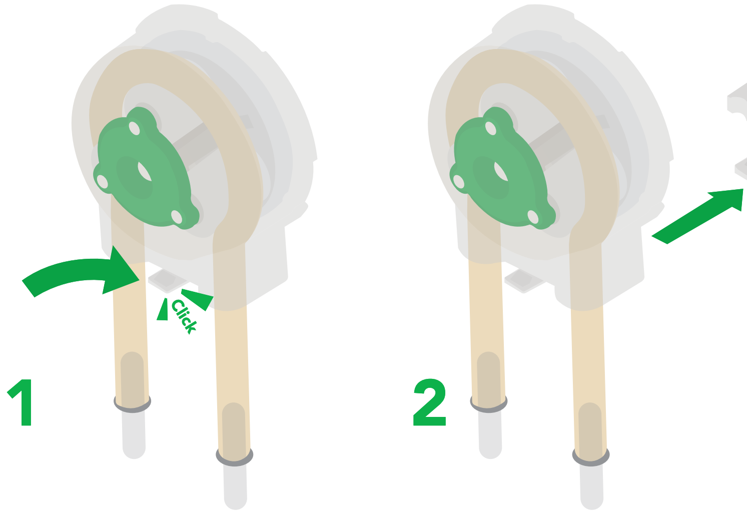
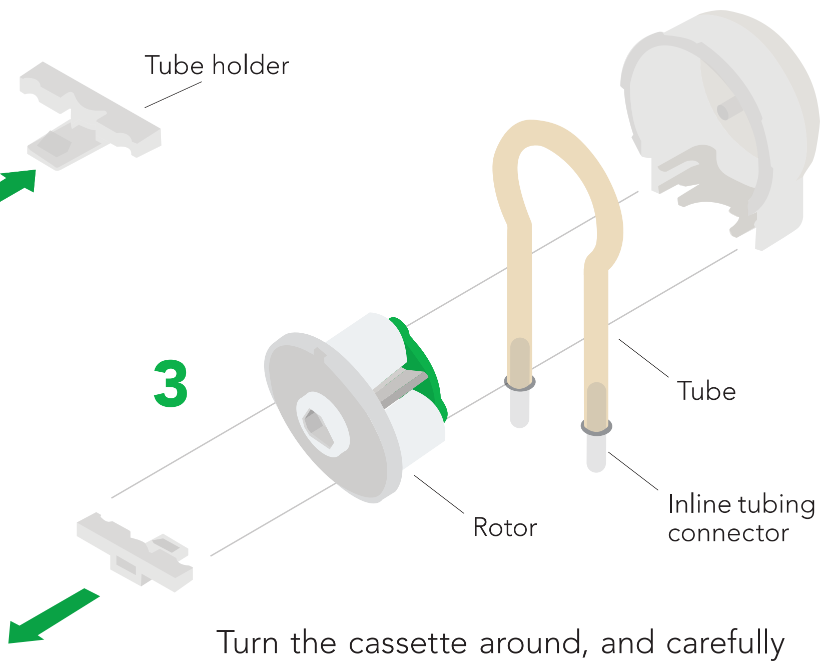
Removing tube assembly

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



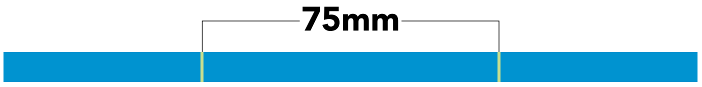
Gently push down the tube holder until it clicks, then remove.



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

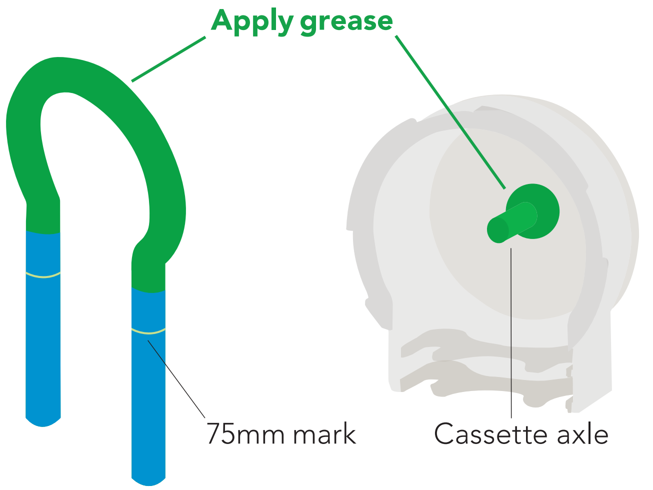
Installing new tube assembly

1



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

2

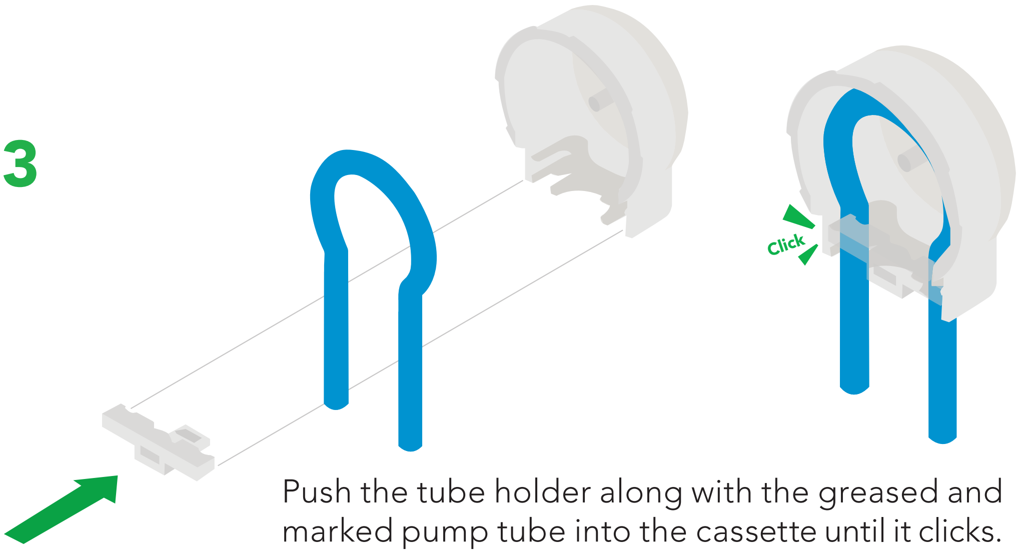


Apply silicone lubricating grease to the marked areas on both the tubing and cassette axle.

Do not operate this device without lubrication!

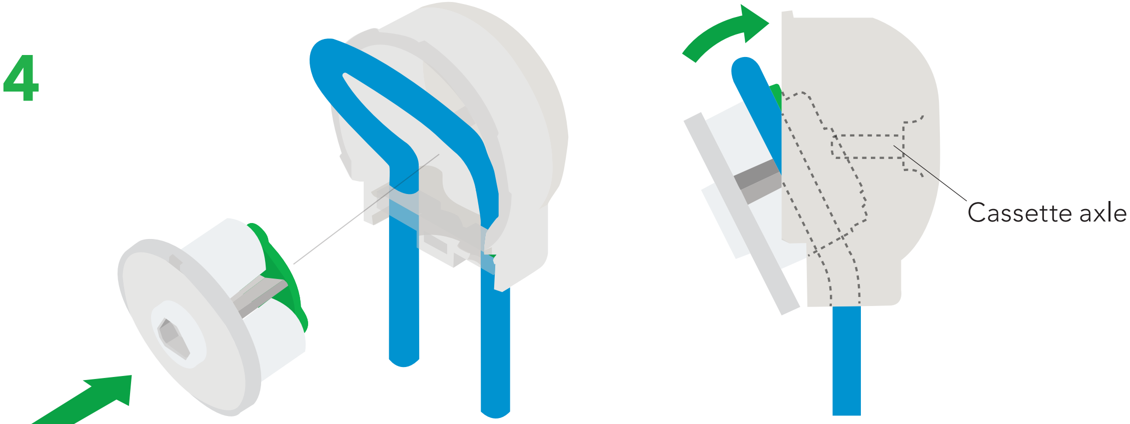
Atlas Scientific recommends using ***Super Lube*** *silicone lubricating grease.*

3

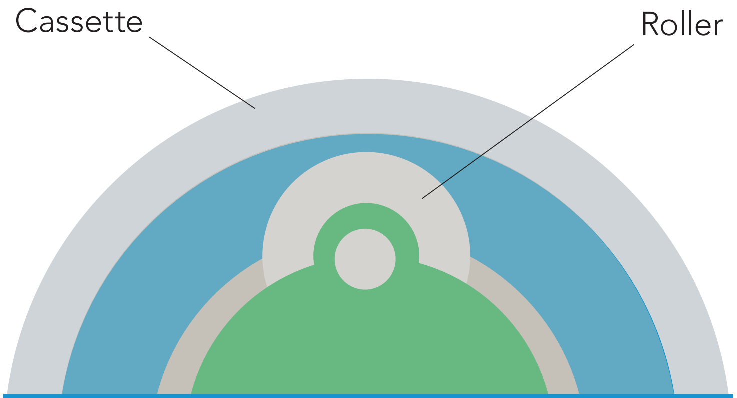


Push the tube holder along with the greased and marked pump tube into the cassette until it clicks.

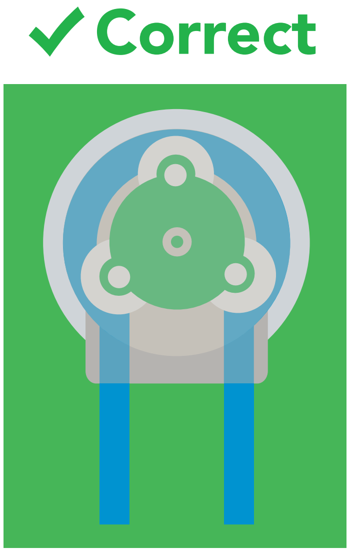
4

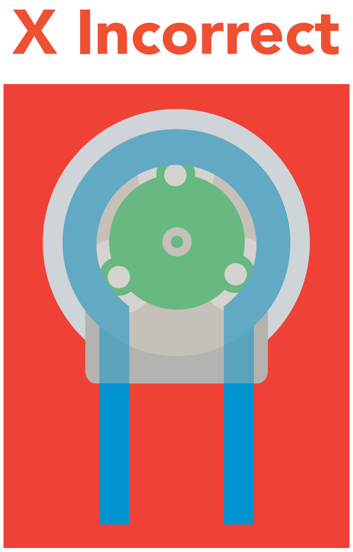


Gently pull out the pump tube, and insert the rotor into the pump tube. Align pump tube and rotor with the cassette axle.



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





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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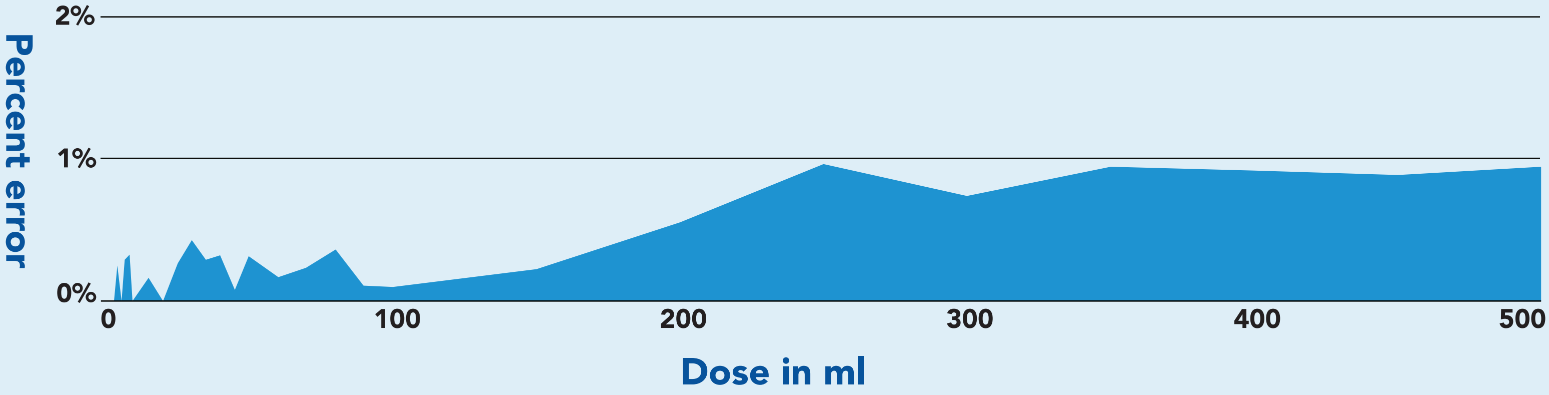
Accuracy

Uncalibrated accuracy +/- 5%
Calibrated accuracy +/- 1%

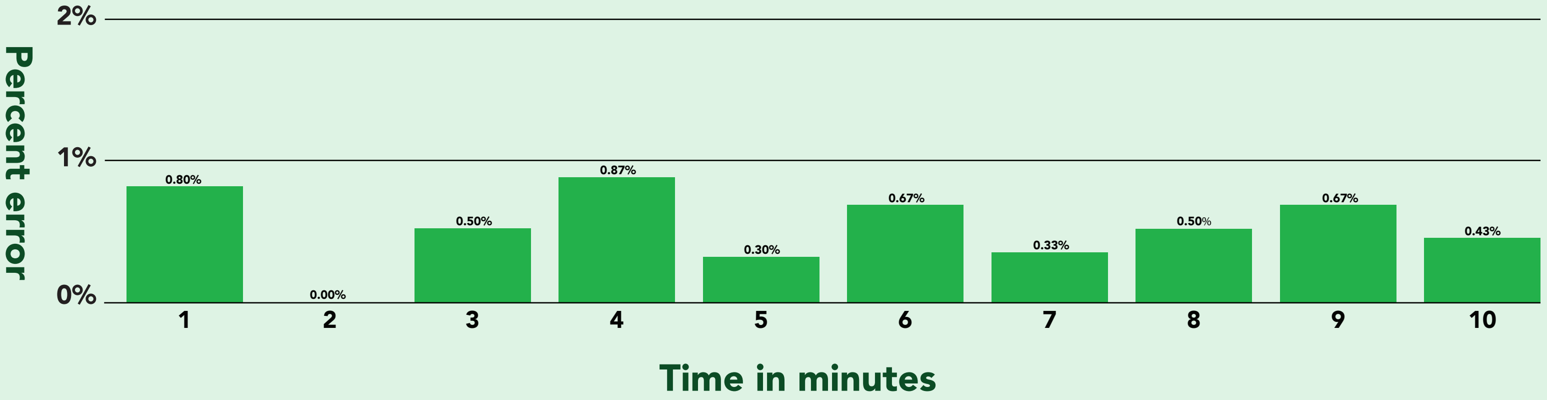
Volume dispensing mode

calibrated at 10ml



Dose over time mode

calibrated at 10ml over 90 seconds



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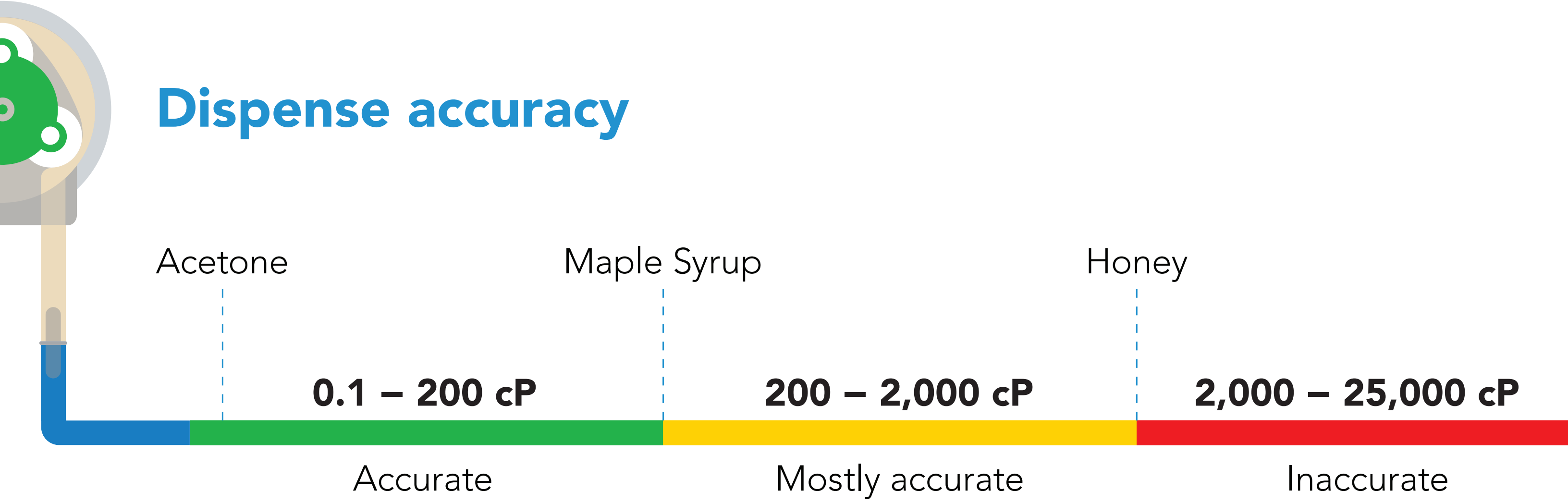
Viscosity

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

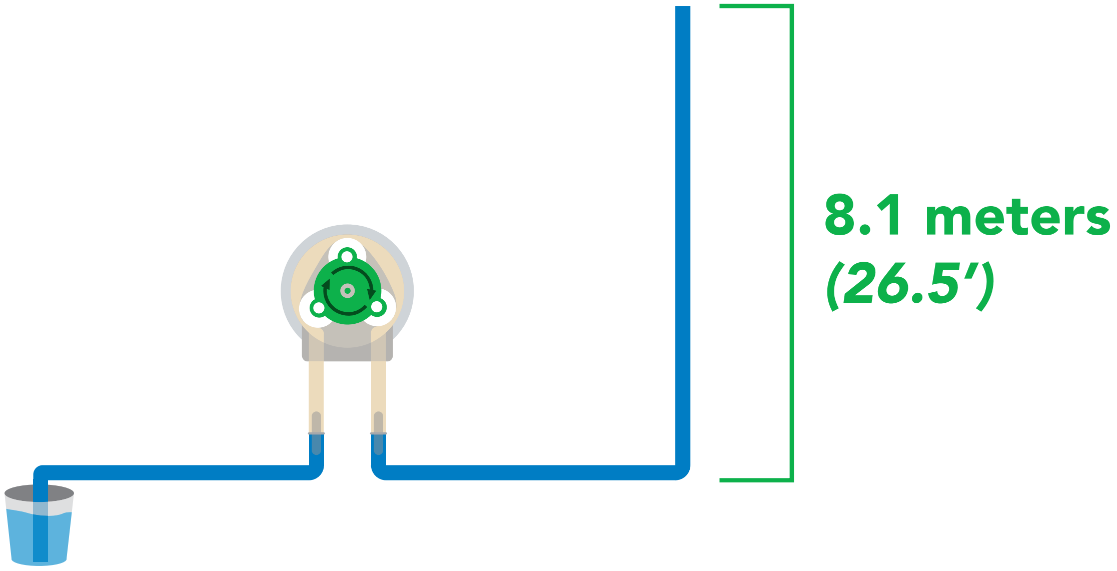
0.6	=	Acetone
1	=	Water
10	=	Kerosene
100	=	Corn Syrup
200	=	Maple Syrup
2,000	=	Honey
10,000	=	Hershey Chocolate Syrup

Dispense accuracy



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').*



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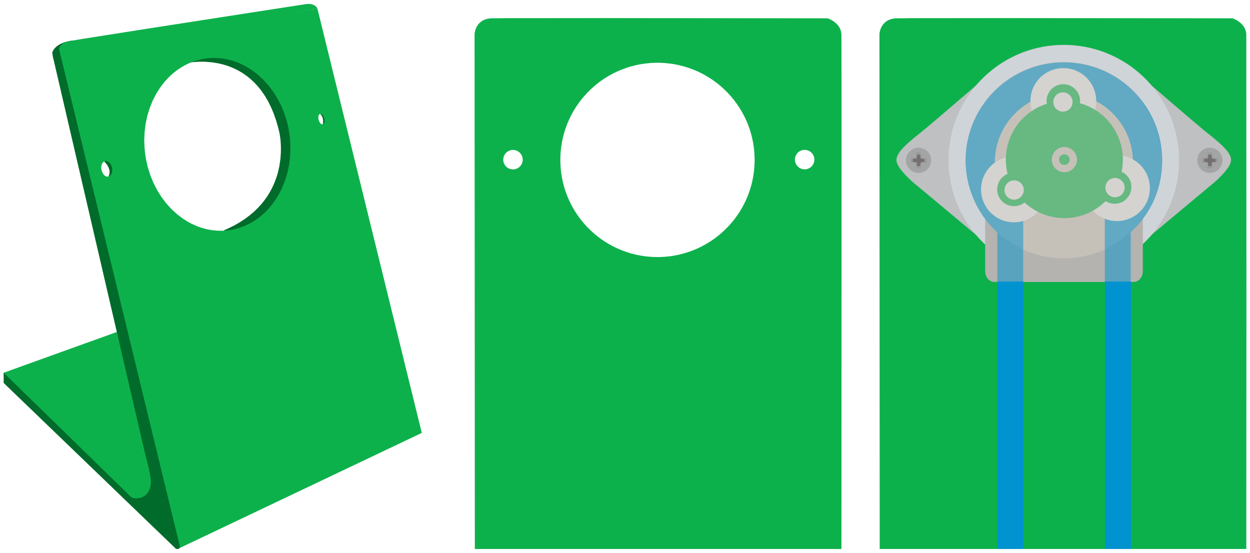
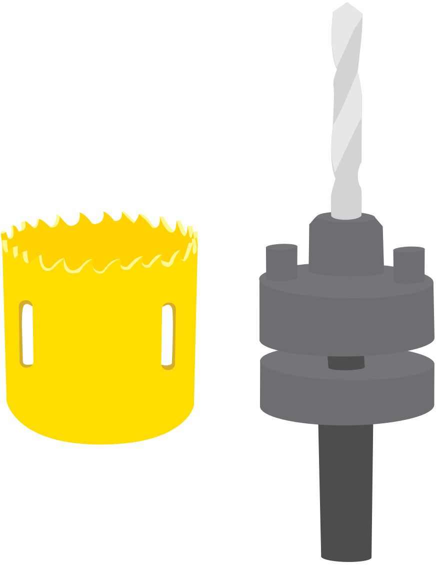
Mounting the EZO-PMP™

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.

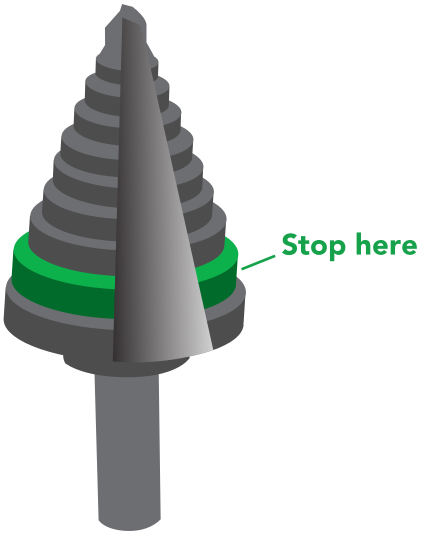


However, if you would like to mount the EZO-PMP™ Embedded Dosing Pump into other materials, you will need the following tools:



1 1/4"
Hole Saw

OR



1 3/8"
Step Bit

Either are fine to make the larger hole.

1/8"
Drill Bit

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.

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.**

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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