# Universal flow meter totalizer

**EZO™**

Revised 7/13/16

# EZO™ class universal flow meter totalizer

**V 1.3**

This is an evolving document
check back for updates.

## Features

**Reads**

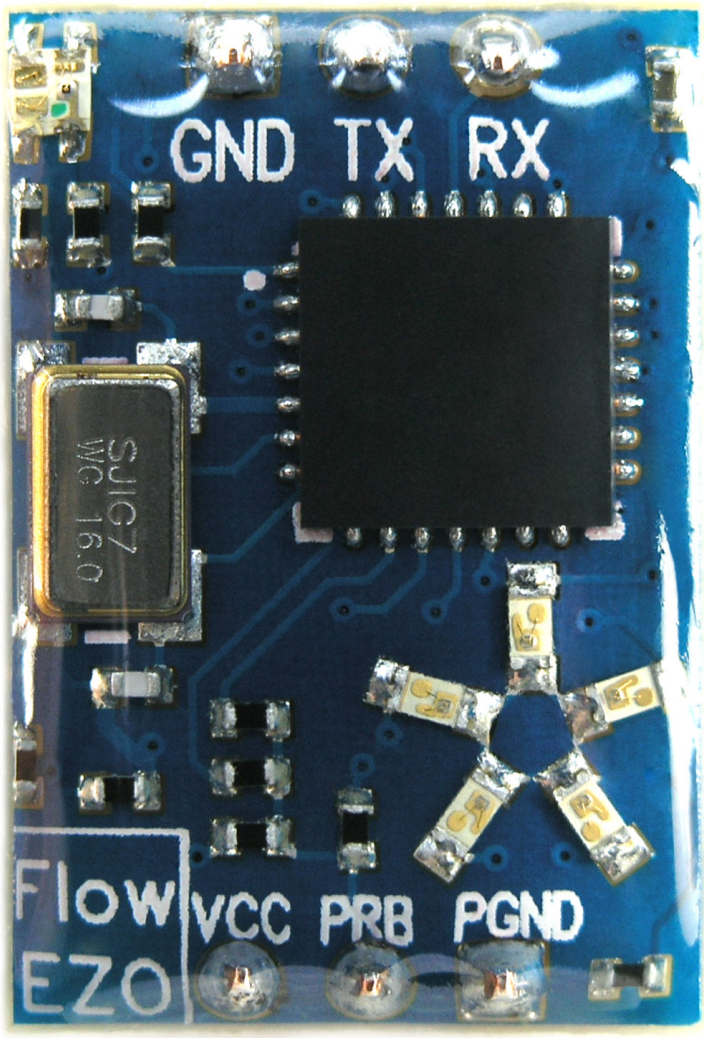
- Reads flow rate per second, minute, hour and total flow.
- Works with any off the shelf pulsed DC flow meter regardless of manufacture
- Works with any DC pulse per volume flow meter
- Works with any DC pulse frequency to volume flow meter
- Programmable with up to 16 integer or floating point K factors
- On the fly linear interpretation between K-factors for maximum accuracy
- Visual display indicating real time turbine rotation
- 1K, 10k or 100k on board pull-up or pull-down resistors *(for flow meters that require external pull-up or pull-down)*
- Comes preprogrammed with 4 different Atlas Scientific flow meters
- **Data format is ASCII**

**Data protocol**

- UART asynchronous serial connectivity
- (RX/TX voltage swing 0-VCC)
- Operating voltage: 3.3V to 5

**Sleep mode power consumption**

- 2.1mA at 3.3V




Patent pending

## Description

Accurate liquid flow monitoring requires two major components, a precision flow meter and a well-designed totalizer. The most accurate flow meter in the world is nothing if the totalizer misses pulses or does not compute flow rates properly. The Atlas Scientific™ EZO™ class universal flow meter totalizer is a user programmable device that will interface with any off the shelf pulsed DC output flow meter.

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# STOP

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

**This device has been designed to be soldered and can be soldered at any time. Once that decision has been made, Atlas Scientific no longer assumes responsibility for the device's continued operation. The embedded systems engineer is now the responsible party.**

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# Universal flow meter totalizer

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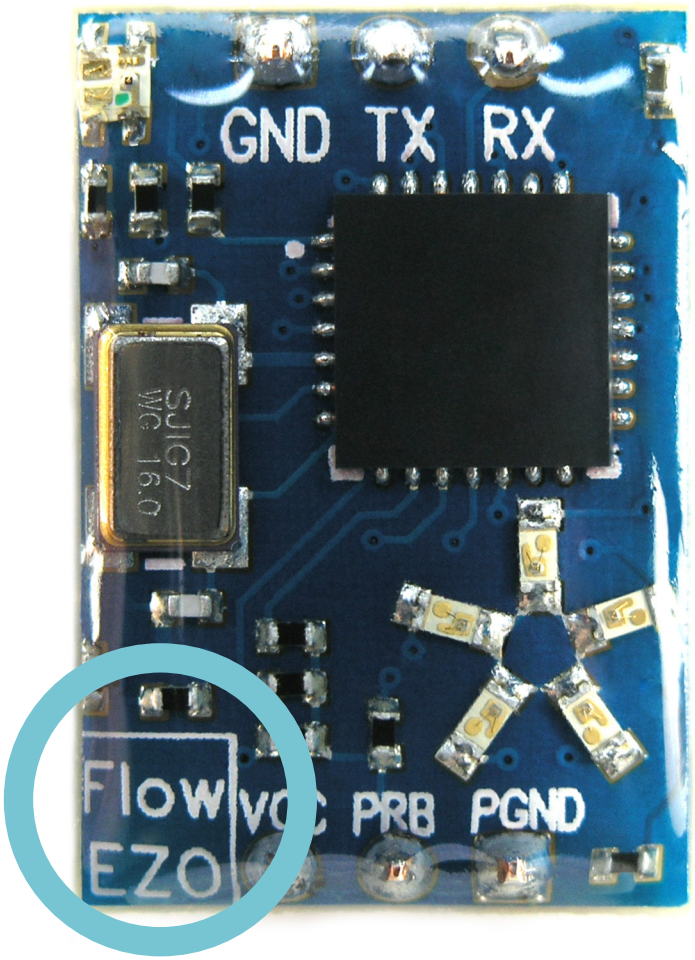
## Contents



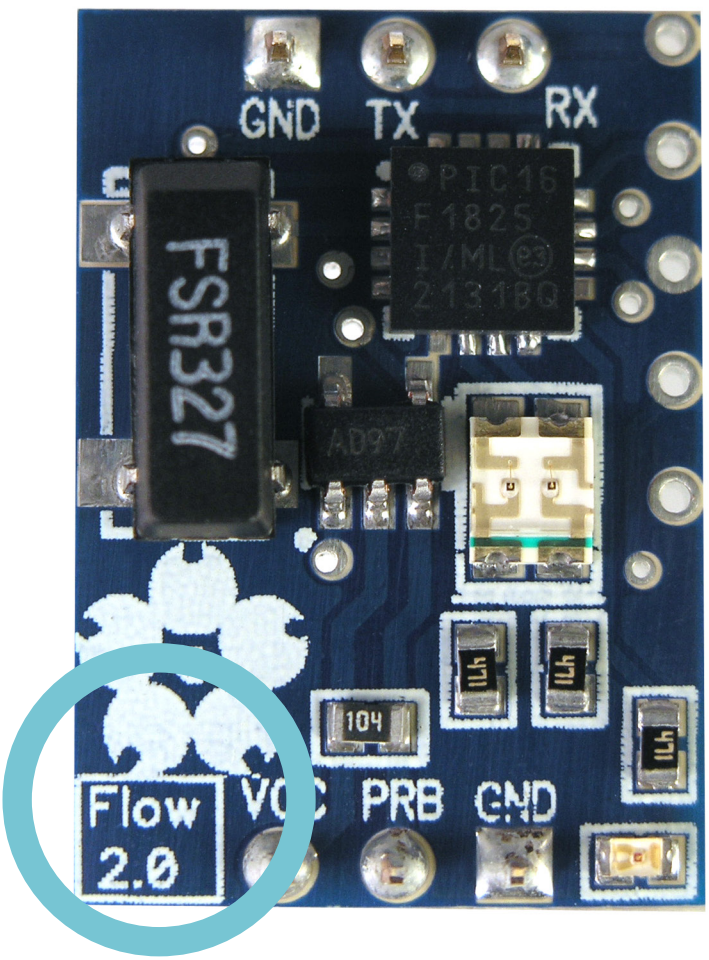
## UART Mode

# Circuit identification




**EZO™ Class Circuit**

If your Atlas Scientific™ Flow Circuit says "Flow EZO" you are viewing the correct datasheet.




**Legacy Circuit**

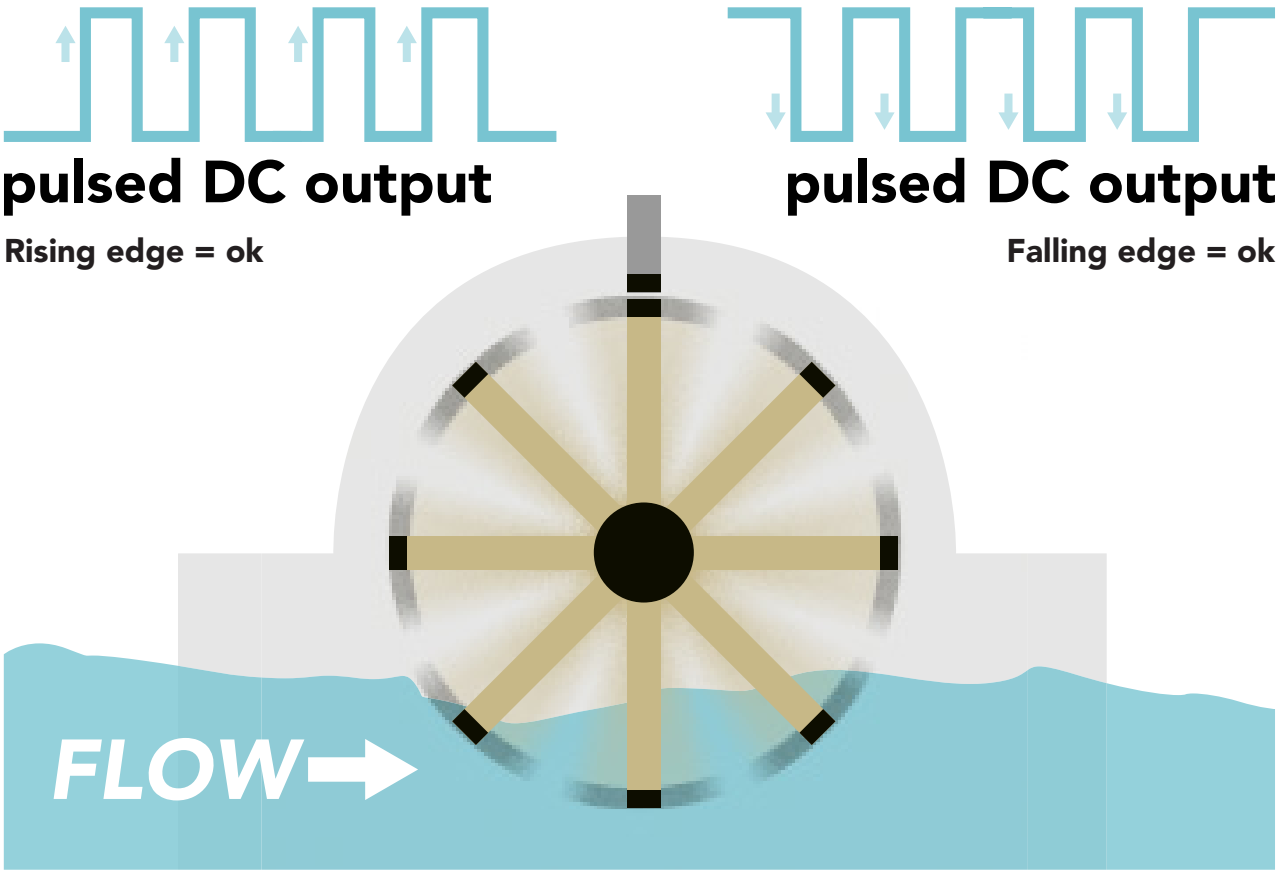
If your Atlas Scientific™ Flow Circuit says "Flow 2.0" you are viewing the *incorrect datasheet*. Many functions will not will not work on legacy circuits.

To view the legacy datasheet **click here**.

# System overview

The Atlas Scientific™ EZO™ class flow meter totalizer, is a small footprint computer system that is specifically designed to be used in robotics applications where the embedded systems engineer requires accurate and precise measurements from a pulsed DC output liquid flow meter.

This device is designed to work exclusively with flow meters that have a pulsed DC output. It will not work with flow meters that have a different output.




A pulsed DC flow meter can work one of two ways:

| | |
|---|---|
| Pulse per volume | 1 pulse = 0.67 ml |
| Frequency to volume | 37Hz = 21 ml/min |

# K-factor

The total number of pulses corresponding to one unit of flow is known as the flow meters k-factor.

### Pulse per volume flow meters

Smaller flow meters typically have a single K-factor. In this document, this type of flow meter is referred to as a pulse per volume flow meter. Where one pulse is equaled to a specific volume.

**0.367mL = 1 pulse**

### Frequency to volume flow meters

Larger flow meters will have many K-factors. In this document, this type of flow meter is referred to as a frequency to volume flow meter. Where a frequency in Hz is equaled to a specific volume. Hz means cycles per second however, this does not mean the units of flow will be measured in volume per second. It could be volume per second but, it could also be volume per minute or volume per hour. It all depends on the manufacture of the flow meter.

**5 GPM = 24 Hz**
**10 GPM = 61 Hz**
**15 GPM = 93 Hz**

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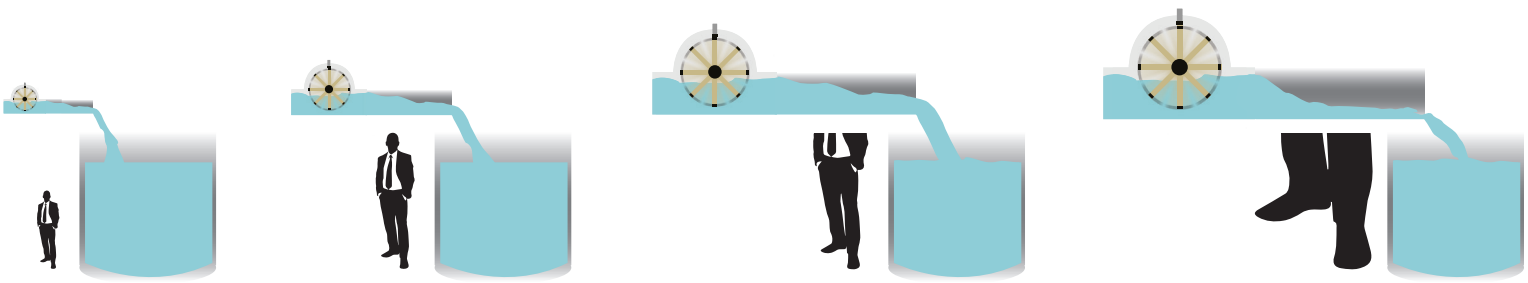
Every flow meter must give its K-factor information in the device's data sheet. **This information may not be referred to as the K-factor. Just look for what a pulse equals, it either will be a single value or table of multiple values at different frequencies.**

The Atlas Scientific™ EZO™ class flow meter totalizer can be programed with up to 16 integer or floating point K-values for a single flow meter. The totalizer will constantly monitor the flow meter and precisely calculate the total flow and the flow rate per second, per minute and per hour.



**Total flow** **Flow per hour** **Flow per minute** **Flow per second**

An LED indicator on the front of the circuit shows the user the real time status of the flow meters turbine.

Some flow meters will require a pull-up or pull-down resistor. The Atlas Scientific™ EZO™ class flow meter totalizer has the ability to enable its on board 1K, 10K or 100K pull-up/down resistors.

# Power consumption

| | LED | MAX | STANDBY | SLEEP |
|---|---|---|---|---|
| **5V** | ON | 21.0 mA | 20.5 mA | 3.1 mA |
| | OFF | 17.0 mA | 16.5 mA | |
| **3.3V** | ON | 16.6 mA | 16.1 mA | 2.1 mA |
| | OFF | 15.0 mA | 15.0 mA | |

# Absolute maximum ratings*

| Parameter | MIN | TYP | MAX |
|---|---|---|---|
| Storage temperature (EZO™ Flow circuit) | -40 °C | | 125 °C |
| Operational temperature (EZO™ Flow circuit) | -30 °C | 25 °C | 100 °C |
| VCC | 3.3V | 5.0V | 5.5V |

***Note:** Stresses above those listed under "Absolute Maximum Ratings" may cause permanent damage to the device. Exposure to maximum rating conditions for extended periods may affect device reliability.

# Pin Out

**GND** Return for the DC power supply

**Vcc** Operates on 3.3V – 5.5V

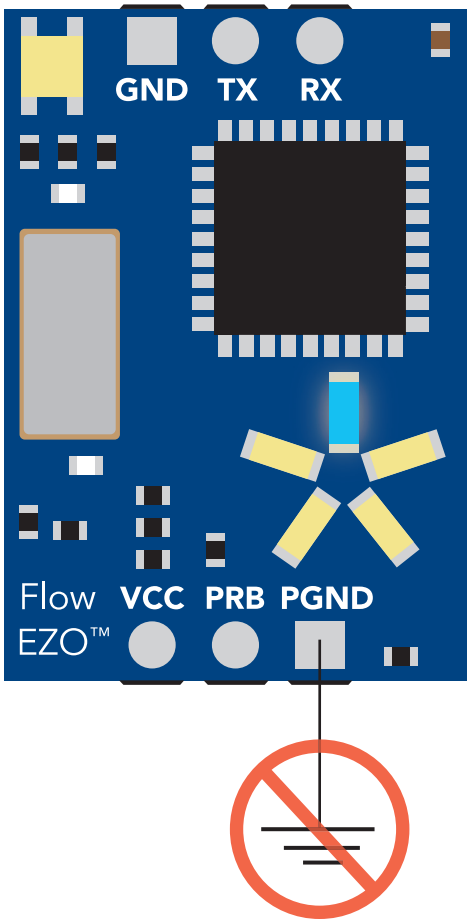
**TX** This pin acts as the transmit (TX) line. The default baud rate is 9600, 8 bits, no parity, no flow control, one stop bit. If standard RS232 voltage levels are desired, connect an RS232 converter such as a MAX232.

**RX** This pin acts as the receive (RX) line.

**PRB** This pin connects to the output lead of a flow meter

**PGND** This pin connects to the ground lead of a flow meter

This pin is not ground.
Do not tie this pin to system ground



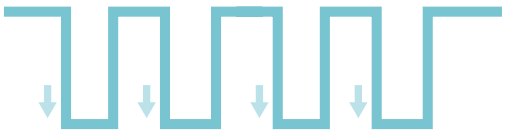

The top LED of the turbine rotation indicator ring will be blinking if the device has not been programmed. All readings will always be 0,0 until programmed.

# Flow meter theory

The most common type of flow meter on the market today is the pulsed DC output flow meter. This type of flow meter will output a DC pulse for each turn of a turbine blade located inside the flow meter.

**pulsed DC output**

**Rising edge = ok**



**pulsed DC output**

**Falling edge = ok**

A pulse from a flow meter can be defined as a rising edge followed by a falling edge or a falling edge followed by a rising edge. **The EZO™ class flow meter totalizer can work with both types.**

## Pull-up/pull-down Resistor

It is very common for a flow meter to require a pull-up or pull-down resistor on the pulse-out lead of the flow meter. The EZO™ class flow meter totalizer has 3 different internal pull-up or pull-down resistors that can be used (1K, 10K and 100K). By default, the resistors are disabled.

## Pulse Type And K-Factor

A pulse from a flow meter can have two different meanings. Smaller flow meters typically have a pulse that represents some fixed volume of liquid, such as: 1 pulse = 0.67 mL. Larger flow meters typically operate using frequency and have many values associated with them such as:

.5 LPM at 15 Hz
1 LPM at 34 Hz
1.5 LPM at 54 Hz

No matter what type of flow meter you have these values are known as the flow meters K-factor. A flow meter that has a single K-factor will always be the "pulse per volume type". Where each pulse is equaled to a fixed amount of fluid.

**Example**
1 pulse = 2.2 ml

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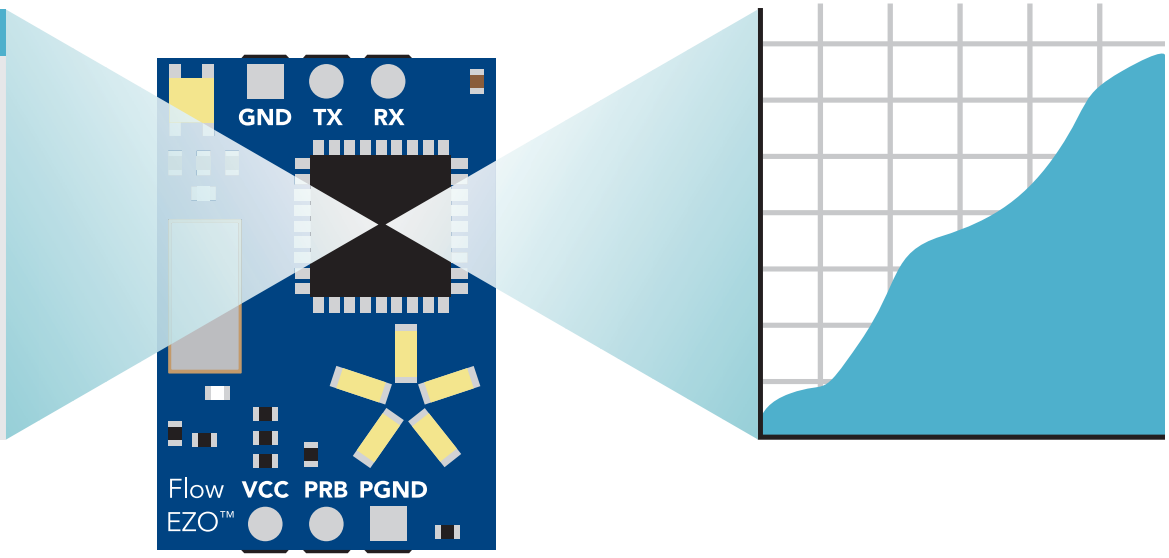
A flow meter that has many flow values will always be a frequency to volume flow meter.

The Atlas Scientific™ EZO™ class flow meter totalizer can accept up to 16 integer or floating point K-values for a single flow meter. These values are stored in EEPROM and will not be lost if power is cut.

| # | Volume | Hz |
|---|---|---|
| 1 | 0.1 | 13 |
| 2 | 0.25 | 14 |
| 3 | 0.50 | 90 |
| 4 | 0.75 | 137 |
| 5 | 1.0 | 186 |
| 6 | ... | ... |
| 7 | ... | ... |




Programming the device with a single K-value will automatically put the EZO™ class flow meter totalizer in pulse mode where a single pulse equals a fixed volume. Programming the device with more than one K-value will automatically place it in frequency mode.

## Units To Define Volume

What the units mean is entirely up to the embedded systems engineer programming the device.

1 pulse = 45

What 45 represents is for you decide. It is important to keep in mind that the units must always be the same.

15 Hz = 45ml/min
50Hz = 2,000ml/min

**Correct**

15 Hz = 45 ml/min
50 Hz = 2L /min

**Incorrect**

# Units to define time

## (For frequency to volume flowmeter only)

The Atlas Scientific Universal Flow Meter Totalizer does not know what time base a flow meters K-values are in. By default the time base is set to volume per minute. The time base can be changed at any time. Either before the K-values are entered in, after the K-values are entered in or even during operation. For the Universal Flow Meter Totalizer to operate properly it is imperative that the correct time base be set.

There are 3 different time bases that can be selected:

**Volume per second**
**Volume per minute**
**Volume per hour**

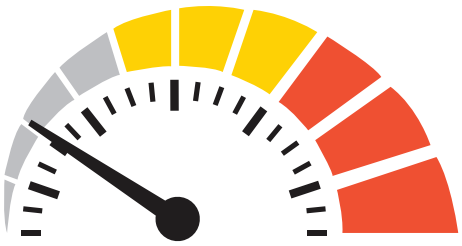
| # | Volume | Hz |
|---|---|---|
| 1 | 0.1 | 13 |
| 2 | 0.25 | 14 |
| 3 | 0.50 | 90 |
| 4 | 0.75 | 137 |
| 5 | 1.0 | 186 |
| 6 | ... | ... |
| 7 | ... | ... |

According to this table a frequency of 13 Hz means the flow meter will output a volume of 0.1 every [second?, minute?, hour?]

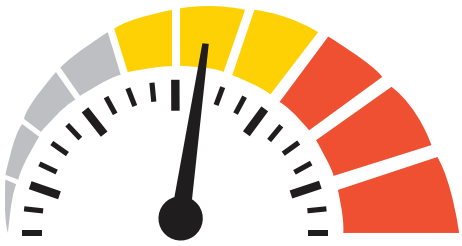
The table of K-factors that come with your flow meter will define what the time base is. The most common time base is flow rate per minute. The default time base for the Universal Flow Meter Totalizer is flow per minute.

# Frequency range

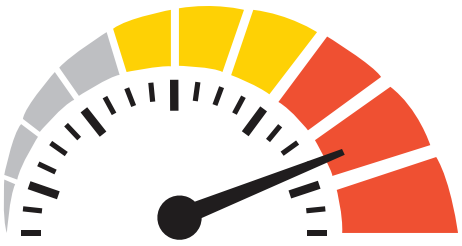
The Atlas Scientific™ EZO™ class flow meter totalizer can accurately and continuously monitor and calculate a flowmeters performance up to a maximum frequency of 8KHz.



0Hz to 5 KHz



5 KHz to 8 KHz



+8 KHz

Operating the device at or above red line will NOT damage the EZO™ class flow meter totalizer. At or above red line, the readings are no longer guaranteed to be accurate. If readings are no longer guaranteed to be accurate the EZO™ class flow meter totalizer will still try and output flow data however the output will also include the waring "*SPEED".

**Example**
400,900<CR>
*SPEED<CR>

# Device operation

When an EZO™ class flow meter totalizer circuit is first powered up the boot sequence will begin. This is indicated by the LED moving from **Red** to **Green** to **Blue** and the turbine rotation indicator will spin once forwards and once backwards. The boot up sequence takes 2s. Once the device has booted up the circuit will output:

*RS<CR>
*RE<CR>
Indicating the device is ready for operation.

The **Green** LED will blink on/off with each transmission of a data packet, indicating that the EZO™ class circuit is now operational in its default state.

# Default state

**Mode**
UART

**Baud rate**
9600 bps
8 data bits
1 stop bit
no parity
no flow control

**Reading time**
1 reading every second

**Flow meter type**
None set

**LEDs:**
Enabled
Steady **Green**= Power on/ standby
**Red** double blink = Command received and not understood
**Green** double blink per data packet = Continuous data streaming
**Blue** LED in the turbine rotation ring blinking = No flow meter set

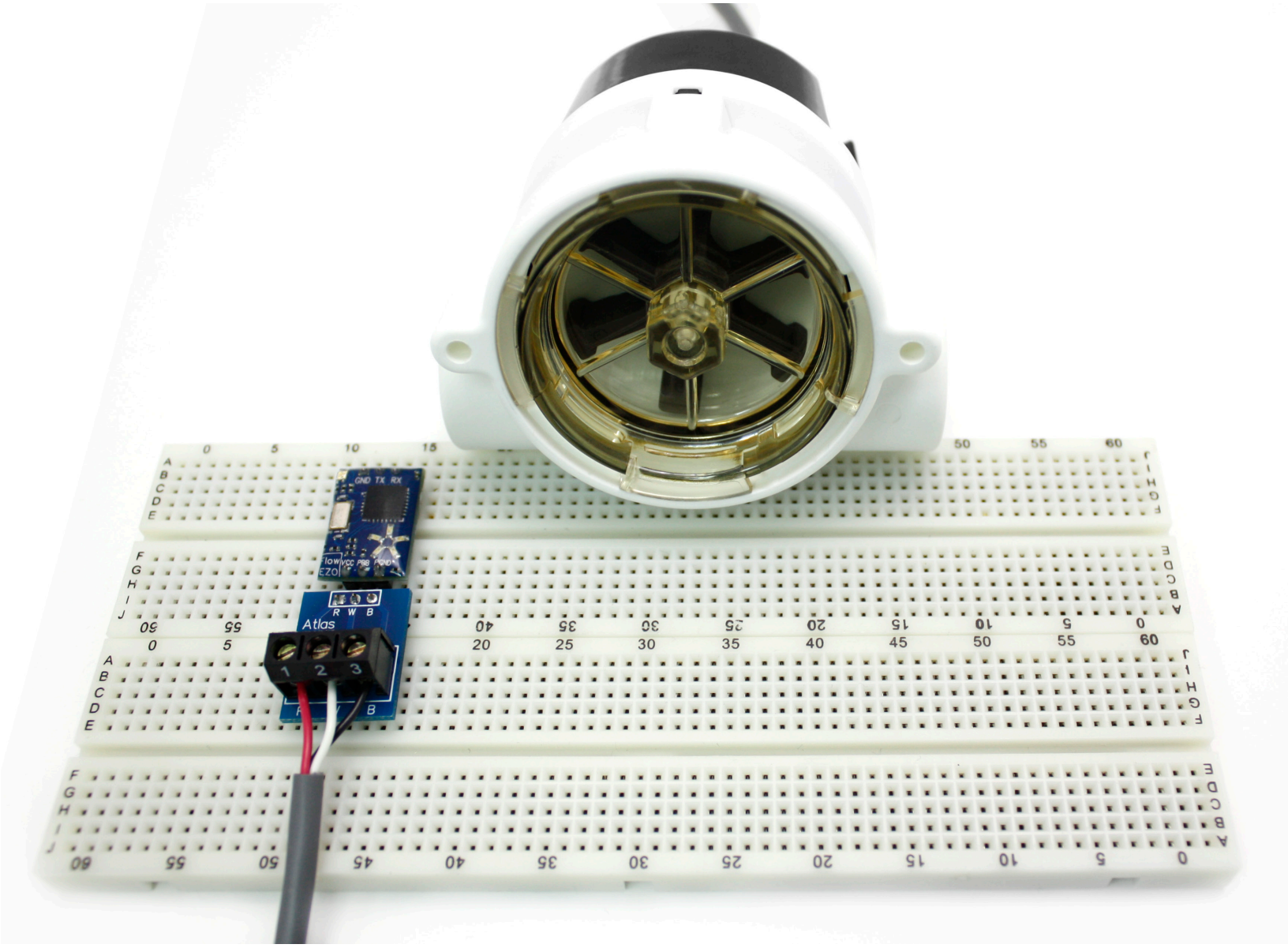
**Data output**
Total flow, flow rate per minute

| Units | Data Type | Format |
|---|---|---|
| Undefined, it depends on the flow meter being used | Floating point | CSV string |

**Encoding**
ASCII characters followed by a carriage return <CR>
Maximum string length: 48 characters

If the response code is enabled the EZO™ class circuit will respond "*OK<CR>" after a command is acknowledged. If an unknown command is sent the Flow Circuit will respond "*ER<CR>" This will happen whether or not response codes are enabled.

# Proper configuration for debugging




Atlas Scientific strongly recommends to use this configuration to become familiar with, and debug your flow monitoring setup.

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**Universal flow meter totalizer**

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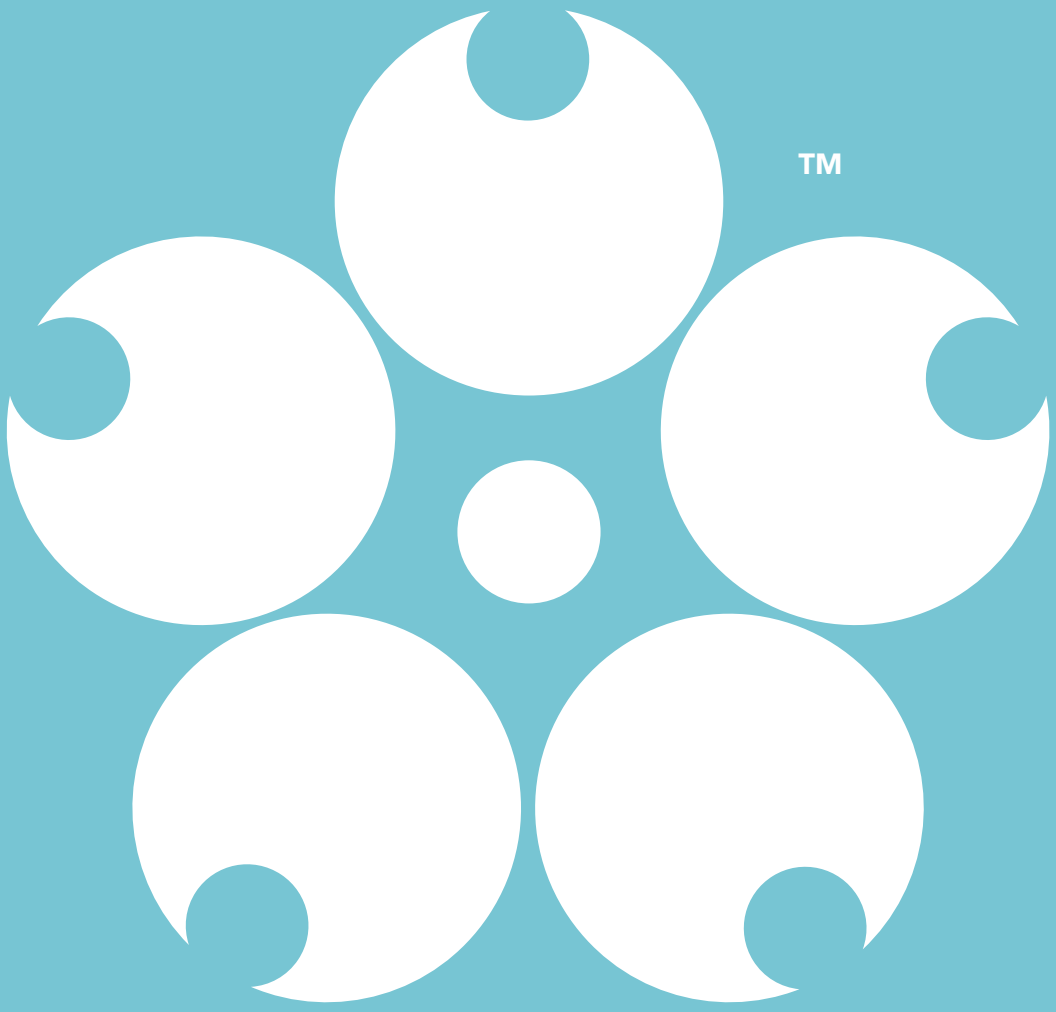
# UART Mode



# UART mode command quick reference

There are a total of 16 different commands that can be given to the EZO™ class Universal flow meter totalizer.

**All commands are ASCII strings or single ASCII characters**

| Command | Function | Default state |
|---|---|---|
| C | Enable / Disable or Query continuous readings (pg.19) | Enabled |
| Clear | Clear the total volume counter (pg.21) | N/A |
| Factory | Factory reset (pg.43) | N/A |
| I | Device information (pg.38) | N/A |
| K | Programing (pg.22) | N/A |
| L | Enable / Disable or Query the LEDs (pg.18) | LEDs Enabled |
| Name | Set or Query the name of the device (pg.37) | Not set |
| P | Set on board onboard pull-up or pull-own resistors (pg.27) | Not set |
| PRE | Set a predefined flow meter (pg.30) | Not set |
| R | Returns a single reading (pg.20) | N/A |
| Response | Enable / Disable or Query response code (pg.39) | Enabled |
| Serial | Set the baud rate (pg.42) | 9600 |
| Sleep | Enter low power sleep mode (pg.41) | N/A |
| Status | Retrieve status information (pg.40) | N/A |
| TK | Set the time base for programmed K-value (pg.25) | Volume per minute |
| TO | Change the flow per time output (pg.36) | Flow per minute |

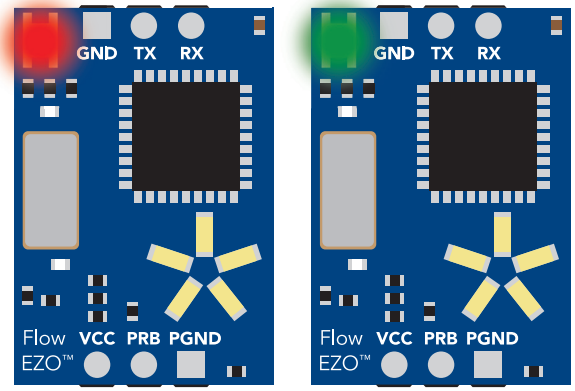
# UART command definitions

**<CR> represents a carriage return (ASCII 13). The user does not transmit the literal string "<CR>". Commands are not case sensitive.**

## LED control

Disabling the LEDs will also disable the turbine rotation LEDs

UART mode LED color definitions:
Steady **Green** = Power on/ standby
**Red** double blink = Command received and not understood
**Green** blink = Data transmission sent




### Command syntax

L,1<CR> LED enable
L,0<CR> LED disable
L,? <CR> Query the LED

### Device response

L,1 <CR>
(If the response code is enabled, the EZO™ class circuit will respond "*OK<CR>")
The Led will be enabled and the green power on/ standby LED will turn on

L,0 <CR>
(If the response code is enabled, the EZO™ class circuit will respond "*OK<CR>")
The Led will be disabled

L,? <CR>
(If the response code is enabled, the EZO™ class circuit will respond "*OK<CR>")
?L,1<CR> if the LED is enabled
?L,0<CR> if the LED is disabled

**<CR> represents a carriage return (ASCII 13). The user does not transmit the literal string "<CR>". Commands are not case sensitive.**

# Continuous reading mode

All EZO™ class circuits are capable of continuous mode operation. In continuous mode, the device will output its readings, one after the other continuously until the continuous mode disable command has been issued. All EZO™ class circuits are defaulted to operate in continuous mode. If the LEDs are enabled, each time a data transmission occurs the green LED will blink.

## Command syntax

C,1<CR> Continuous mode enable
C,0<CR> Continuous mode disable
C,?<CR> Query continuous mode

## Device response

C,1 <CR>
(If the response code is enabled, the EZO™ class circuit will respond "*OK<CR>")
The EZO™ class flow meter totalizer will output a CSV string containing all enabled values once per second.

Total flow, flow rate per time base<CR> (1 second)
Total flow, flow rate per time base<CR> (2 second)
Total flow, flow rate per time base<CR> (n* second)

The output will always be two comma separated values. Total flow, flow rate per time base. The default time base is flow per minute. This can be changed at any time to see flow rate per second or flow rate per hour.

C,0 <CR>
(If the response code is enabled, the EZO™ class circuit will respond "*OK<CR>")
Continuous data transmission will cease.

C,? <CR>
(If the response code is enabled, the EZO™ class circuit will respond "*OK<CR>")
?C,1<CR> if continuous mode is enabled.
?C,0<CR> if continuous mode is disabled.

**<CR> represents a carriage return (ASCII 13). The user does not transmit the literal string "<CR>". Commands are not case sensitive.**

# Single reading mode

All EZO™ class circuits are capable of taking a single reading upon request. If the LEDs are enabled, each time a data transmission occurs, the green LED will blink.

### Command syntax

R<CR> Returns a single reading

### Device response

(If the response code is enabled the EZO™ class circuit will respond "*OK<CR>")
The EZO™ class flow meter totalizer will output a CSV string containing all enabled values.

Total flow, flow rate per time base<CR>

The output will always be two comma separated values. Total flow, flow rate per time base. The default time base is flow per minute. This can be changed at any time to see flow rate per second or flow rate per hour.

**<CR> represents a carriage return (ASCII 13). The user does not transmit the literal string "<CR>". Commands are not case sensitive.**

# Clearing the total volume

As a liquid flows through the flow meter the total volume will continue to increase. To reset the total volume counter to 0.00 use the clear command.

### Command syntax
CLEAR<CR>

### Device response
(If the response code is enabled the EZO™ class circuit will respond "*OK<CR>")
The total volume counter will now be reset to 0.00

### Example

| | |
|---|---|
| Device output | 12345,1.23 <CR> |
| Send clear command | CLEAR<CR> |
| Device output | 0.00,1.23 <CR> |

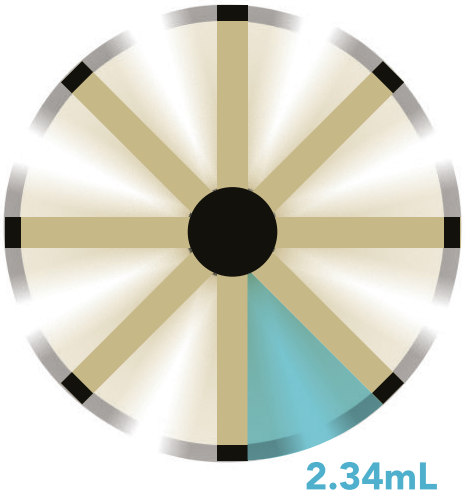
Once this command has been issued the total volume will be reset to 0.00. There is no way to retrieve what the total volume was just before the clear command was issued.

**<CR> represents a carriage return (ASCII 13). The user does not transmit the literal string "<CR>". Commands are not case sensitive.**

# Programming a custom flow meter

The Atlas Scientific™ EZO™ class universal flow meter totalizer has been preprogrammed with 4 different types of flow meters. This section explains how to program the device to a flow meter that has not been preprogrammed. When the device is not programed the top LED of the turbine rotation indicator ring will blink once per second and all readings will always be 0. The turbine rotation indicator will still spin if it is connected to a flow meter but the readings will always be 0.

### Programming a pulse per volume flow meter




The pulse per volume flow meter is the simplest kind of flow meter. This type of flow meter's K-value will have a fixed volume of fluid attached to each pulse.

### Example

2.34ml = 1 pulse

### Command syntax

| | |
|---|---|
| K,[volume per pulse],[number of pulses]<CR> | Set the K-value for a flow meter |
| K,?<CR> | Query the K-value |
| K,clear<CR> | Clear the programmed flow meter |

Using the example above
K,2.34,1<CR>

This would tell the device that the K-value for the flow meter is 2.34ml per pulse.

**<CR> represents a carriage return (ASCII 13). The user does not transmit the literal string "<CR>". Commands are not case sensitive.**

### Device response

K,2.34,1<CR>
(If the response code is enabled, the EZO™ class circuit will respond "*OK<CR>")
If the device was not previously programmed the top LED of the turbine rotation indicator ring will turn off. There is no other output associated with this command
K,?<CR>
(If the response code is enabled, the EZO™ class circuit will respond "*OK<CR>")
?K,2.34,1<CR>

?1:K,2.34,1<CR>
Where 1: represents the number of K values entered

K,CLEAR<CR>
(If the response code is enabled, the EZO™ class circuit will respond "*OK<CR>")
This will revert the device to its unprogrammed state.

## Programming a frequency per volume flow meter

A frequency based flow meter will have more than one K-value. The EZO™ class universal flow meter totalizer will automatically sort the K-values entered according to frequency. The device does not need to be programmed in order.

### Command syntax

| | |
|---|---|
| K,[volume at frequency],[frequency in Hz]<CR> | Set the K-value for a flow meter |
| K,?<CR> | Query the K-value |
| K,clear<CR> | Clear all of the programmed K-values |
| K,clear,[number] | Clear a single K-value entry |

### Example K-values to program

| LPM | Hz | |
|---|---|---|
| 0.1 | 13 | K,0.1,13<CR> |
| 0.25 | 41 | K,0.25,41<CR> |
| 0.5 | 90 | K,0.5,90<CR> |
| 0.75 | 137 | K,1.0,186<CR> |
| 1.0 | 186 | K,0.75,137<CR> |

(If the response code is enabled, the EZO™ class circuit will respond "*OK<CR>") There is no other output associated with this command.

Intentionally placed out of order.
All values entered will be stored in frequency order.

**<CR> represents a carriage return (ASCII 13). The user does not transmit the literal string "<CR>". Commands are not case sensitive.**

K,?<CR> To recall and confirm programmed K-values
(If the response code is enabled, the EZO™ class circuit will respond "*OK<CR>")

?1:K,0.1,13<CR>
?2:K,0.25,41<CR>
?3:K,0.5,90<CR>
?4:K,0.75,137<CR> K-values entered out of order will
?5:K,1.0,186<CR> be returned in frequency order

**How to correct errors**
Each K value entered in is assigned a number from 1 to 16. To remove an incorrect entry use the K,clear,[number] command.

**Example**
K,clear,3<CR>
This would remove the third entry:
3:K,0.5,90

**<CR> represents a carriage return (ASCII 13). The user does not transmit the literal string "<CR>". Commands are not case sensitive.**

# Setting the time base

In the example given on page 21 we show how to program the device with a table of K-values.

| LPM | Hz |
|---|---|
| 0.1 | 13 |
| 0.25 | 41 |
| 0.5 | 90 |
| 0.75 | 137 |
| 1.0 | 186 |

In this table of values we see two columns of points, volume and frequency. The volume is in liters per minute (LPM) however, not every flow meter will have its output in LMP. Some flow meters could give their K-values is gallons per hour or milliliters per second.

Remember the units that the volume is measured in is irrelevant.

**Example**

0.1 = milliliters?
0.1 = gallons?
0.1 = Pints?
0.1 = gills?

It does not matter what the units are called

What does matter is the time base. The Atlas Scientific™ EZO™ class universal flow meter totalizer has its default time base set as volume per minute. The time base can be change to volume per second, volume per minute, or volume per hour.

If the flow meter being programmed into the device lists its table of K-values in volume per second or volume per hour the time base must be changed to get accurate readings. The time base can be changed at any time.

**<CR> represents a carriage return (ASCII 13). The user does not transmit the literal string "<CR>". Commands are not case sensitive.**

## Command syntax

| | |
|---|---|
| TK,S<CR> | Set the time base of the K-values to be volume per second |
| TK,M<CR> | Set the time base of the K-values to be volume per minute |
| TK,H<CR> | Set the time base of the K-values to be volume per hour |
| | |
| TK,?<CR> | Query the set time base |

## Device response

TK,S<CR>
(If the response code is enabled, the EZO™ class circuit will respond "*OK<CR>")
There is no other output associated with this command

TK,?<CR>
(If the response code is enabled, the EZO™ class circuit will respond "*OK<CR>")
?TK,S<CR>

**<CR> represents a carriage return (ASCII 13). The user does not transmit the literal string "<CR>". Commands are not case sensitive.**

# Setting the onboard pull-up or pull-own resistors

By default the on board pull-up/pull-down resistor is disabled

Some flow meters will require a pull-up or pull-down resistor to help drive the DC pulses coming off of the flow meter. The pull-up or pull-down resistors connect the system ground or VCC through a resistor to the PRB pin. There are 3 different values of pull-up or pull-down resistor that can be selected.

1KΩ 

10kΩ 

100KΩ 

To enable a pull-up / pull-down resistor

**Command syntax**

| | |
|---|---|
| P,0<CR> | Disable the pull-up/ pull-down resistor |
| P,1<CR> | Enable a 1KΩ on board pull-up resistor |
| P,-1<CR> | Enable a 1KΩ on board pull-down resistor |
| P,10<CR> | Enable a 10KΩ on board pull-up resistor |
| P,-10<CR> | Enable a 10KΩ on board pull-down resistor |
| P,100<CR> | Enable a 100KΩ on board pull-up resistor |
| P,-100<CR> | Enable a 100KΩ on board pull-down resistor |
| P,? | Query the pull-up/pull-down resistor |

**<CR> represents a carriage return (ASCII 13). The user does not transmit the literal string "<CR>". Commands are not case sensitive.**

### Device response

P,1<CR>
(If the response code is enabled, the EZO™ class circuit will respond "*OK<CR>")
There is no other output associated with this command
P,?<CR>
(If the response code is enabled, the EZO™ class circuit will respond "*OK<CR>")
?P,1<CR>

# Step by step flow meter programming

Pulse per volume flow meter:

### Example flow meter

No pull-up or pull-down resistor required
5ml = 1 pulse

**Step 1** Take the device out of continues mode
C,0<CR>

**Step 2** Enter in K-value
K,5,1<CR>

**Step 3** confirm
K,?<CR>

Response should be
?1:K,5.000,1.00

The Universal flow meter totalizer is ready for operation. These values have been stored to EEPROM and will not be lost is the power is cut.

**<CR> represents a carriage return (ASCII 13). The user does not transmit the literal string "<CR>". Commands are not case sensitive.**

Frequency to volume flow meter

**Example flow meter**
1K pull-up resistor required

| Flow rate (mL per second) | Frequency |
|---|---|
| .02 | 7 Hz |
| .09 | 24 Hz |
| .14 | 29 Hz |
| .23 | 38 Hz |

**Step 1** Take the device out of continues mode
C,0<CR>

**Step 2** Enter in K-values
K,0.02,7<CR>
K,0.09,24<CR>
K,0.14,29<CR>
K,0.23,38<CR>

**Step 3** confirm
K,?<CR>

Response should be
?1:K,0.02,7<CR>
?2:K,0.09,24<CR>
?3:K,0.14,29<CR>
?4:K,0.23,38<CR>

**Step 4** Set time base to volume per second
TK,S<CR>

**Step 5** Enable 1K pull-up resistor
P,1<CR>

The Universal flow meter totalizer is ready for operation. These values have been stored to EEPROM and will not be lost if the power is cut.

**<CR> represents a carriage return (ASCII 13). The user does not transmit the literal string "<CR>". Commands are not case sensitive.**

# Programming a predefined flow meter

Atlas Scientific offers 4 different types of flow meters to embedded systems engineers to use. These flow meters are very high accuracy devices made for long term, continuous use. Once a predefined flowmeter has been enabled no other settings (such as time base or pull-up resistors) need to be adjusted. These setting are stored to EEPROM and will not be lost is the power is cut.

Refer to the flow meters individual data sheet for the specifications of each flow meter.

## Programming a 3/8" flow meter

The flow meter will output its volume in liters and liters per second.

**(5,0.1)**

**Liters per second**

**Total volume in liters**

Use the "TO" command to change per second to liters per min or liters per hour.

### Command syntax

| | |
|---|---|
| PRE,T<CR> | Set the flowmeter type to a Turbo flow |
| K,?<CR> | Query the flowmeter connected |

### Device response

PRE,T<CR>
(If the response code is enabled, the EZO™ class circuit will respond "*OK<CR>")
There is no other output associated with this command.

K,?<CR>
(If the response code is enabled, the EZO™ class circuit will respond "*OK<CR>")
*INFO:Turbo flow (L/p)
?1:K,1.000,2724.33

**<CR> represents a carriage return (ASCII 13). The user does not transmit the literal string "<CR>". Commands are not case sensitive.**

# Programming a 1/4" flow meter

The flow meter will output its volume in milliliters / second

**(25,0.1)**

**Milliliters per second**

**Total volume in milliliters**

Use the "TO" command to change per second to milliliters per min or milliliters per hour.

## Command syntax

| | |
|---|---|
| PRE,S<CR> | Set the flowmeter type to a small flowmeter |
| PRE,SL<CR> | Set the flowmeter type to a small flowmeter with low flow adapter |
| K,?<CR> | Query the flowmeter connected |

## Device response

PRE,S<CR> or PRE,SL<CR>
(If the response code is enabled, the EZO™ class circuit will respond "*OK<CR>")
There is no other output associated with this command.

**<CR> represents a carriage return (ASCII 13). The user does not transmit the literal string "<CR>". Commands are not case sensitive.**

## Device response

K,?<CR> (for small flow meter without the low flow adapter)
(If the response code is enabled, the EZO™ class circuit will respond "*OK<CR>")

*INFO:Small flow (mL/s)
?1:K,31.541,15.00
?2:K,63.082,34.00
?3:K,94.625,54.00
?4:K,126.166,73.00
?5:K,157.707,90.00
?6:K,189.250,110.00
?7:K,220.791,128.00
?8:K,252.332,148.00
?9:K,283.875,168.00
?10:K,315.416,185.00

K,?<CR> (for small flow meter with the low flow adapter)
(If the response code is enabled, the EZO™ class circuit will respond "*OK<CR>")

*INFO:Small low flow (mL/s)
?1:K,6.307,13.00
?2:K,15.770,41.00
?3:K,31.541,90.00
?4:K,47.312,137.00
?5:K,63.082,186.00

**<CR> represents a carriage return (ASCII 13). The user does not transmit the literal string "<CR>". Commands are not case sensitive.**

# Programming a 1/2" flow meter

The flow meter will output its volume in milliliters / second

**(25,0.1)**

**Milliliters per second**

**Total volume in milliliters**

Use the "TO" command to change per second to milliliters per min or milliliters per hour.

## Command syntax

| | |
|---|---|
| PRE,M<CR> | Set the flow meter type to a medium flow meter |
| PRE,ML<CR> | Set the flow meter type to a medium flow meter with low flow adapter |
| K,?<CR> | Query the flowmeter connected |

## Device response

PRE,M<CR> or PRE,ML<CR>
(If the response code is enabled, the EZO™ class circuit will respond "*OK<CR>")
There is no other output associated with this command.

**<CR> represents a carriage return (ASCII 13). The user does not transmit the literal string "<CR>". Commands are not case sensitive.**

## Device response

K,?<CR> (for medium flow meter without the low flow adapter)
(If the response code is enabled, the EZO™ class circuit will respond "*OK<CR>")

*INFO:Medium flow (mL/s)
?1:K,252.360,34.00
?2:K,315.450,44.80
?3:K,378.540,55.00
?4:K,441.631,65.90
?5:K,504.721,76.00
?6:K,567.811,87.50
?7:K,630.901,99.00
?8:K,693.991,110.00
?9:K,757.081,122.00
?10:K,820.172,135.00
?11:K,883.262,147.00
?12:K,946.352,158.00
?13:K,1009.442,170.00
?14:K,1072.532,183.00

K,?<CR> (for medium flow meter with the low flow adapter)
(If the response code is enabled, the EZO™ class circuit will respond "*OK<CR>")

*INFO:Medium low flow (mL/s)
?1:K,94.625,17.00
?2:K,126.166,25.90
?3:K,157.708,34.00
?4:K,189.250,43.90
?5:K,252.333,60.00
?6:K,315.416,76.70
?7:K,378.500,94.00
?8:K,441.583,111.00
?9:K,504.666,129.00
?10:K,567.750,147.00
?11:K,630.833,165.00
?12:K,693.916,185.00
?13:K,757.000,204.00

**<CR> represents a carriage return (ASCII 13). The user does not transmit the literal string "<CR>". Commands are not case sensitive.**

# Programming a 3/4" flow meter

The flow meter will output its volume in liters / second

**(30,0.8)**

**Liters per second**

**Total volume in liters**

Use the "TO" command to change per second to milliliters per min or milliliters per hour.

## Command syntax

| | |
|---|---|
| PRE,L<CR> | Set the flowmeter type to a large flowmeter |
| K,?<CR> | Query the flowmeter connected |

## Device response

PRE,L<CR>
(If the response code is enabled, the EZO™ class circuit will respond "*OK<CR>")
There is no other output associated with this command
K,?<CR>
(If the response code is enabled, the EZO™ class circuit will respond "*OK<CR>")

*INFO:Large flow (L/s)
?1:K,0.315,24.00
?2:K,0.630,61.00
?3:K,0.946,93.00
?4:K,1.261,128.00
?5:K,1.577,163.00
?6:K,1.892,196.00

**<CR> represents a carriage return (ASCII 13). The user does not transmit the literal string "<CR>". Commands are not case sensitive.**

# Changing parameters from the output string

The Atlas Scientific™ EZO™ class Universal flow meter totalizer will always output a CSV string, containing two parameters.

### Example
Total flow, flow rate per minute<CR>

Using the "TO" command, you are able to control the time output parameter. Total flow will always be the 1st value of the output string. You are not able to control the order.

The time output can be changed to flow rate per second, flow rate per minute (default) or flow rate per hour.

### Command syntax

| | |
|---|---|
| TO,[S,M,H] | Change the time output |
| TO,? | Query the time output |

Where [S,M,H] is
S  Flow rate per second
M flow rate per minute
H flow rate per hour

### Example
TO,S<CR>
This will change the output string to give total flow and the flow rate per second.
This will disable the Volume Per Min

**<CR> represents a carriage return (ASCII 13). The user does not transmit the literal string "<CR>". Commands are not case sensitive.**

### Device response

TO,S<CR>
(If the response code is enabled, the EZO™ class circuit will respond "*OK<CR>")
There is no other output associated with this command

TO,?<CR>
(If the response code is enabled, the EZO™ class circuit will respond "*OK<CR>")
?TO,S

# Device Identification

All EZO™ class circuits are capable of being assigned a name. This is a simple way to identify the device in a system that consists of multiple EZO™ class circuits. A name can consist of any combination of ASCII characters, with a length of 1 to 16 characters long, ***no blank spaces***.

### Command syntax

| | |
|---|---|
| NAME,nnn<CR> | Sets the device name, where nnn is the given name. |
| NAME,?<CR> | Query the device name |

### Device response

NAME,DEVICE_1<CR>
(If the response code is enabled, the EZO™ class circuit will respond "*OK<CR>")
There is no other output associated with this command.

NAME,?<CR>
(If the response code is enabled, the EZO™ class circuit will respond "*OK<CR>")
?NAME, DEVICE_1<CR>

**<CR> represents a carriage return (ASCII 13). The user does not transmit the literal string "<CR>". Commands are not case sensitive.**

# Device information

The EZO™ class circuit can identify itself by device type and firmware version.
This is done by transmitting the "I" command.

### Command syntax

I<CR>  Device information

### Device response

?I,FLO,1.0
(If the response code is enabled, the EZO™ class circuit will respond "*OK<CR>")

Where FLO = device type
1.0 = firmware version number

**<CR> represents a carriage return (ASCII 13). The user does not transmit the literal string "<CR>". Commands are not case sensitive.**

# Response codes

The Atlas Scientific EZO™ class circuits, have 7 response codes to help the user understand how the device is operating, and to aid in the construction of a state machine to control the EZO™ class circuit. All EZO™ class devices indicate a response code has been triggered, by transmitting a string with the prefix "*" and ending with a carriage return <CR>.

## A list of response codes

| | |
|---|---|
| ***ER** | An unknown command has been sent |
| ***OV** | The circuit is being overvolted (VCC>=5.5V) |
| ***UV** | The circuit is being undervolted (VCC<=3.1V) |
| ***RS** | The circuit has reset |
| ***RE** | The circuit has completed boot up |
| ***SL** | The circuit has been put to sleep |
| ***WA** | The circuit has woken up from sleep |
| ***SPEED** | The flow meeter is spinning faster then the systems ability to compute (+8KHz) |

Only the response code "*OK" can be disabled.
Disabling this response code is done using the "response" command.

### Command syntax

| | |
|---|---|
| RESPONSE,1<CR> | Enable response code (default) |
| RESPONSE,0<CR> | Disable response code |
| RESPONSE,?<CR> | Query the response code |

### Device response

RESPONSE,1<CR>
EZO™ class circuit will respond "*OK<CR>"

RESPONSE,0<CR>
There is no response to this command

RESPONSE,?<CR>

?RESPONSE,1<CR> If the response code is enabled
?RESPONSE,0<CR> If the response code is disabled

**<CR> represents a carriage return (ASCII 13). The user does not transmit the literal string "<CR>". Commands are not case sensitive.**

# Reading the status of the device

The Atlas Scientific™ EZO™ class circuit, is able to report its voltage and reason the device was last restarted, at the VCC pin.

## Restart codes

**P** power on reset
**S** software reset
**B** brown out reset
**W** watchdog reset
**U** unknown

### Command syntax
STATUS<CR>

### Device response
(If the response code is enabled, the EZO™ class circuit will respond "*OK<CR>")

?STATUS,P,5.038<CR>

Where: P is the reason for the last reset event
Where: 5.038 is its voltage at the VCC pin

**<CR> represents a carriage return (ASCII 13). The user does not transmit the literal string "<CR>". Commands are not case sensitive.**

# Low power state

To conserve energy in between readings, the Atlas Scientific™ EZO™ class circuit, can be put into a low power sleep state. This will turn off the LEDs and shut down almost all of the internal workings of the EZO™ class circuit. The power consumption will be reduced to 3.1 mA at 5V and 2.1 mA at 3.3V. **To wake the EZO™ class circuit, send it any character.**

## Command syntax

SLEEP<CR> Enter low power sleep state

## Device response

(If the response code is enabled, the EZO™ class circuit will respond "*OK<CR>")
*SL<CR>

Device response to wake up:
*WA<CR>

**<CR> represents a carriage return (ASCII 13). The user does not transmit the literal string "<CR>". Commands are not case sensitive.**

# Change baud rate

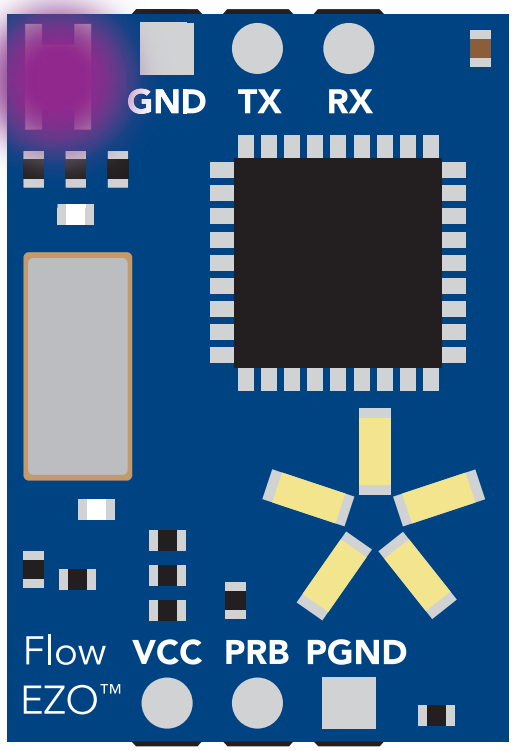
The Atlas Scientific EZO™ class circuit, has 8 possible baud rates it can operate at.
The default baud rate is

**9600 bps**
**8 data bits**
**1 stop bit**
**no parity**
**no flow control**

**Baud rate changes will be retained even if power is cut.**

Data bits, stop bits, parity and flow control are fixed and cannot be changed.

1. 300 bps
2. 1200 bps
3. 2400 bps
4. 9600 bps
5. 19200 bps
6. 38400 bps
7. 57600 bps
8. 115200 bps




## Command syntax

(Using an example baud rate of 38400)
SERIAL,38400<CR>

## Device response

(If the response code is enabled, the EZO™ class circuit will respond "*OK<CR>") The EZO™ class circuit will respond with a **Purple** LED double blink. The EZO™ class circuit will then restart at the new baud rate.

The LED blink will happen even if the LEDs are disabled.

**<CR> represents a carriage return (ASCII 13). The user does not transmit the literal string "<CR>". Commands are not case sensitive.**

# Factory reset

All EZO™ class circuits, are capable of resetting themselves to the original factory settings. Issuing a factory reset will:

Clear all flow meter data
Set debugging LED to on
Enable response codes

**This command will not change the set baud rate.**

## Command syntax

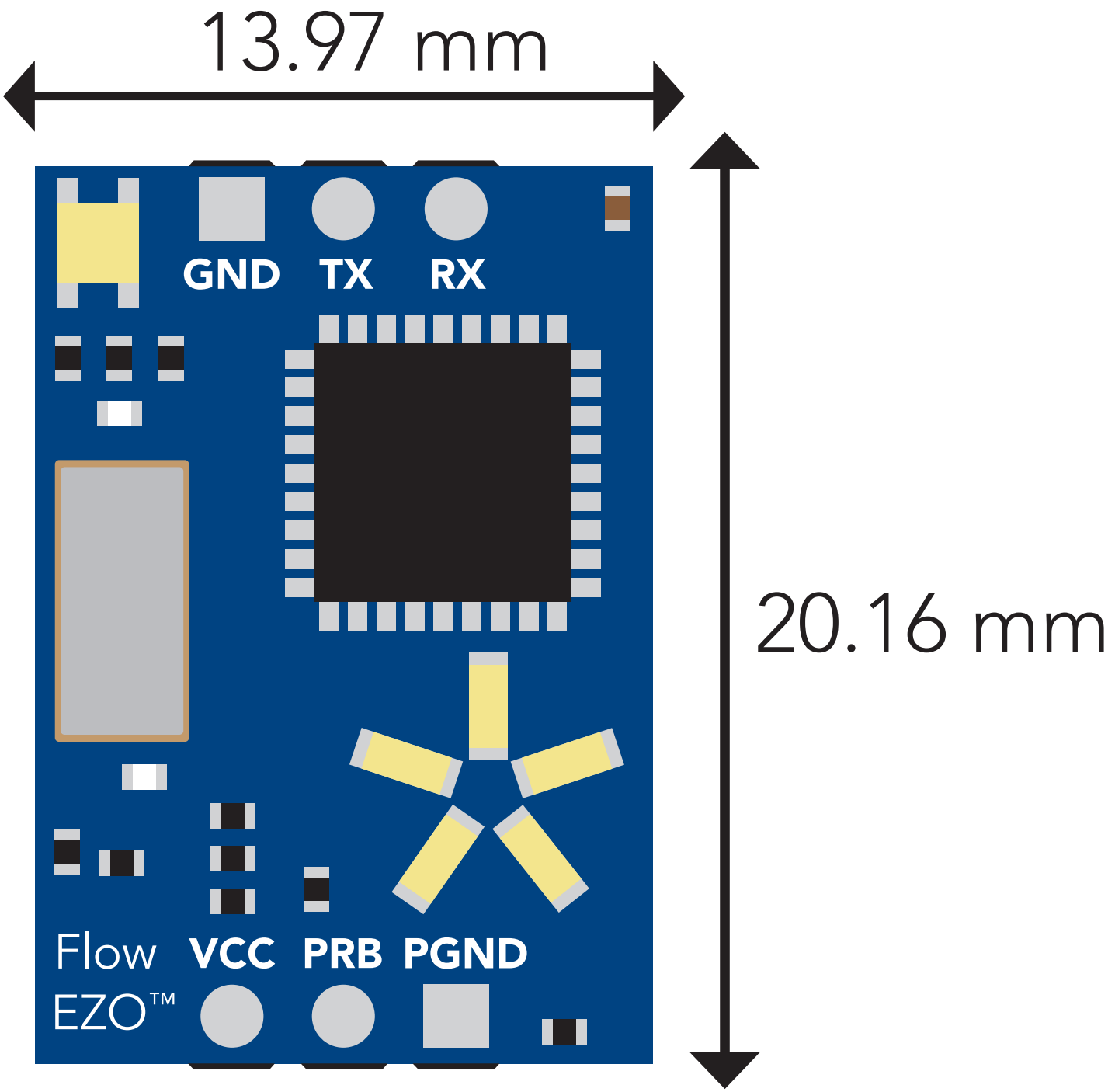
Factory<CR>  Factory reset

## Device response

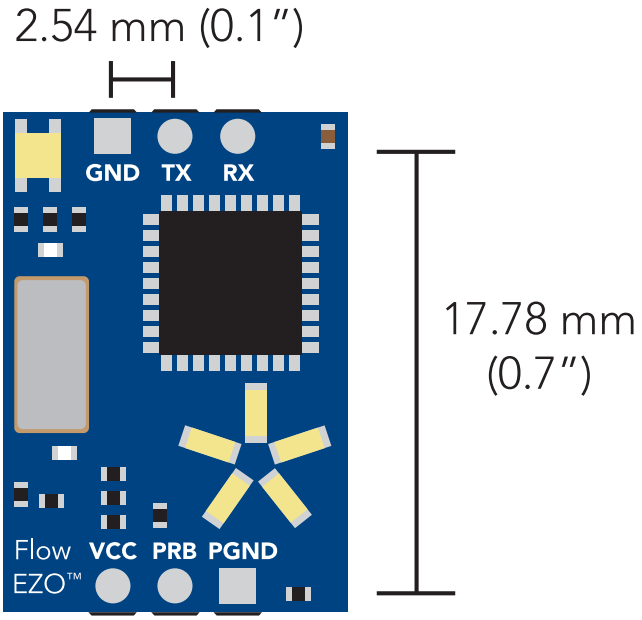
(If the response code is enabled, the EZO™ class circuit will respond "*OK<CR>")
The EZO™ class circuit, will respond:

*RS<CR>
*RE<CR>

# Circuit dimensions

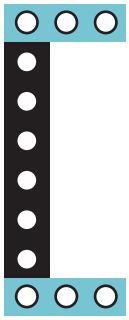


# How to make a footprint for the Atlas Scientific™ EZO™ Universal flow meter totalizer

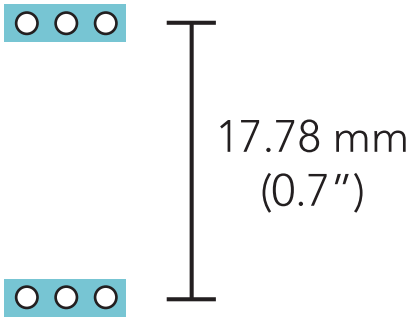



1. In your CAD software place an 8 position header.

2. Place a 3 position header at both top and bottom of the 8 position header as shown.

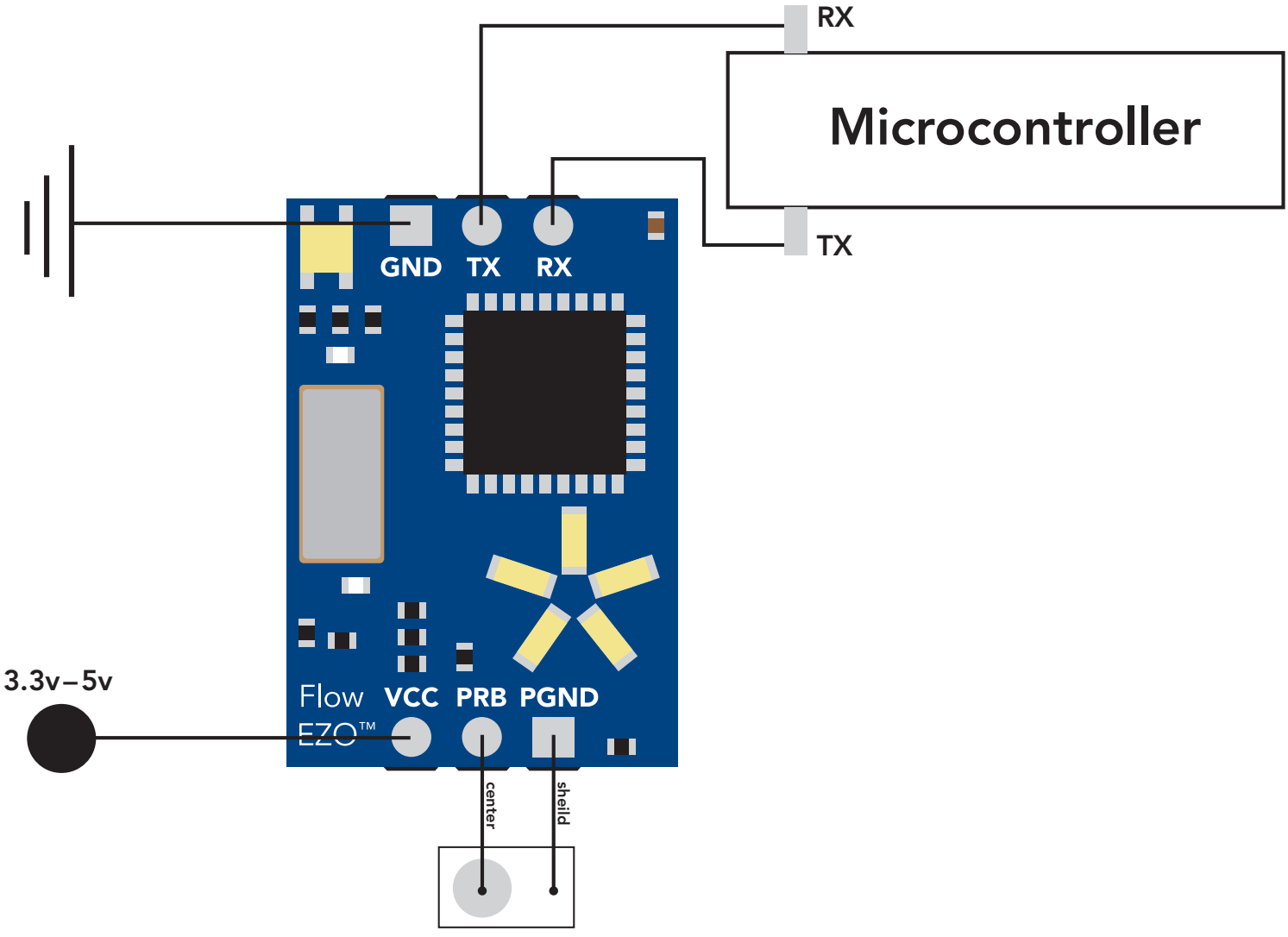


3. Once this is done, you can delete the 8 position header. Make sure that the two 3 position headers are 17.78mm (0.7”) apart from each other.



# Wiring diagram

- To connect the Circuit to your microcontroller, follow the diagram below.
- Make sure your Circuit and micrototalizer share a common ground.
- TX on your Circuit connects to RX on your microcontroller.



# Warranty

Atlas Scientific™ Warranties the EZO™ class Universal flow meter totalizer to be free of defect during the debugging phase of device implementation, or 30 days after receiving the EZO™class Universal flow meter totalizer (whichever comes first).

# The debugging phase

The debugging phase as defined by Atlas Scientific™, is the time period when the EZO™ class Universal flow meter totalizer is inserted into a bread board, or shield, and is connected to a micrototalizer according to the wiring diagram on pg. 47. Reference this wiring diagram for a connection to USB debugging device, or if a shield is being used, when it is connected to its carrier board.

If the EZO™ class Universal flow meter totalizer is being debugged in a bread board, the bread board must be devoid of other components. If the EZO™ class Universal flow meter totalizer is being connected to a micrototalizer, the micrototalizer must be running code that has been designed to drive the EZO™ class Universal flow meter totalizer exclusively and output the EZO™ class Universal flow meter totalizer data as a serial string.

**It is important for the embedded systems engineer to keep in mind that the following activities will void the EZO™ class Universal flow meter totalizer warranty:**

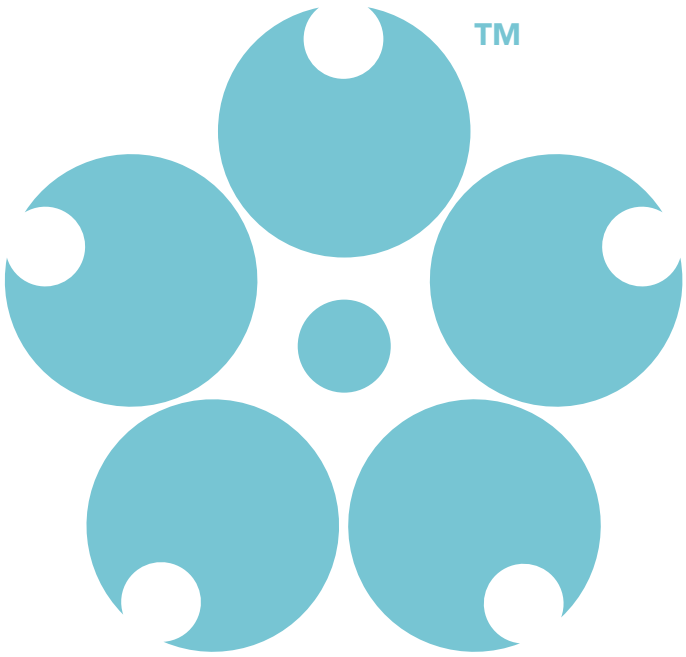
- **Soldering any part of the EZO™ class Universal flow meter totalizer**
- **Running any code, that does not exclusively drive the EZO™ class Universal flow meter totalizer and output its data in a serial string**
- **Embedding the EZO™ class Universal flow meter totalizer into a custom made device**
- **Removing any potting compound**

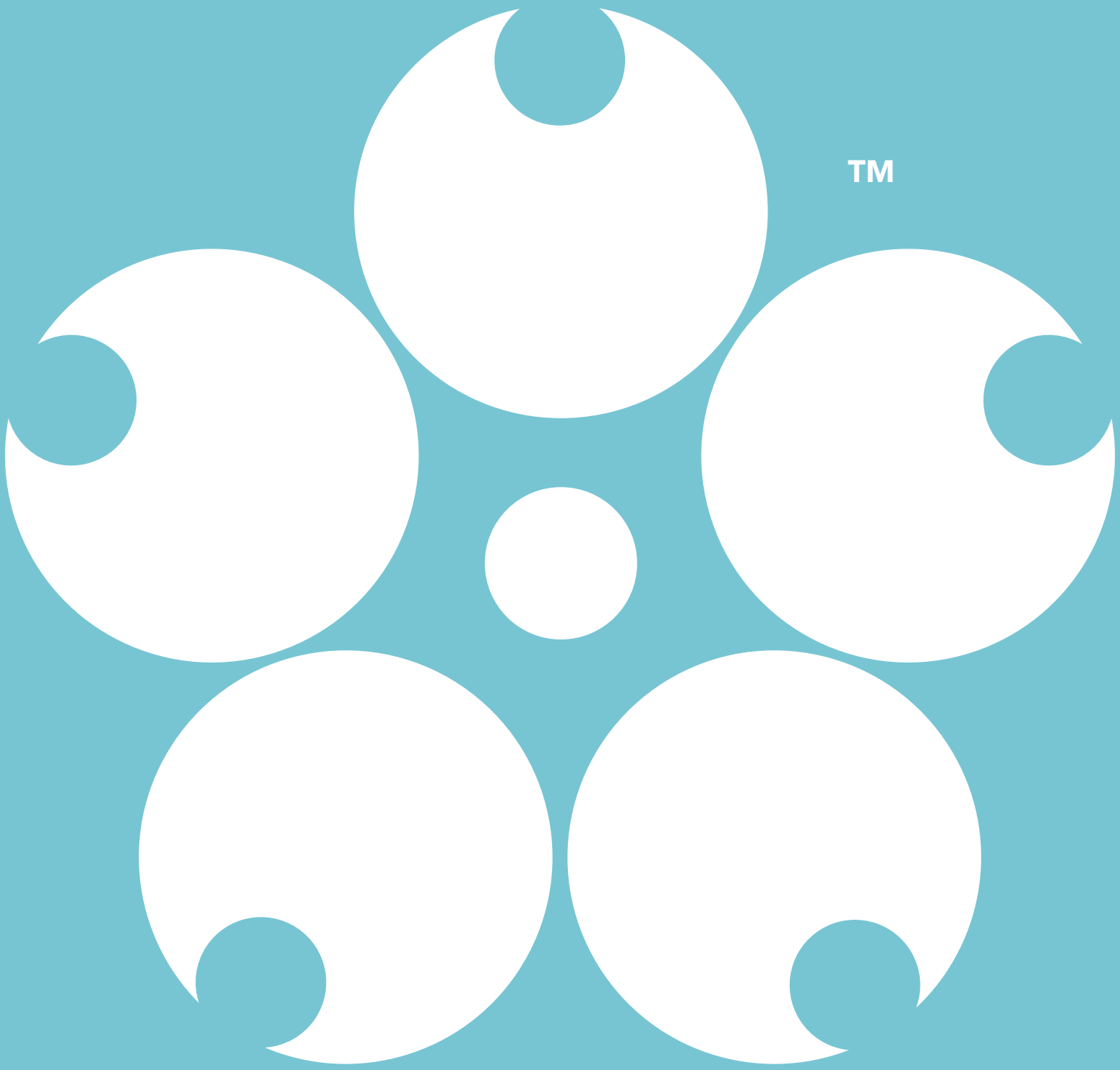
# Reasoning behind this warranty

Because Atlas Scientific™ does not sell consumer electronics; once the device has been embedded into a custom made system, Atlas Scientific™ cannot possibly warranty the EZO™ class Universal flow meter totalizer, against the thousands of possible variables that may cause the EZO™ class Universal flow meter totalizer to no longer function properly. Please keep this in mind:

1. **All Atlas Scientific™ devices have been designed to be embedded into a custom made system by you, the embedded systems engineer.**
2. **All Atlas Scientific™ devices have been designed to run indefinitely without failure in the field.**
3. **All Atlas Scientific™ devices can be soldered into place, however you do so at your own risk.**

Atlas Scientific™ is simply stating that once the device is being used in your application, Atlas Scientific™ can no longer take responsibility for the EZO™ class circuits continued operation. This is because that would be equivalent to Atlas Scientific™ taking responsibility over the correct operation of your entire device.




TM