MILONE

Technologies

eTape™

Continuous Fluid Level Sensor

Operating Instructions and Application Notes

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1.0 SPECIFICATIONS

Sensor Length: 14.3" (197 mm)

Width: 1.0" (25.4mm)

Thickness: 0.015" (0.208 mm)

Resistance Gradient: 55Ω / inch (22Ω / cm), ± 15%

Active Sensor Length: 12.6" (320.7 mm)

Substrate: Polyethylene Terephthalate (PET)

Sensor Output: 700Ω empty, 85Ω full, ± 15%

Actuation Depth: Nominal 1 inch (25.4 mm)

Resolution: 1/32 inch (0.794 mm)

Temperature Range: 15°F - 140°F (-9°C - 60°C)

2.0 THEORY OF OPERATION

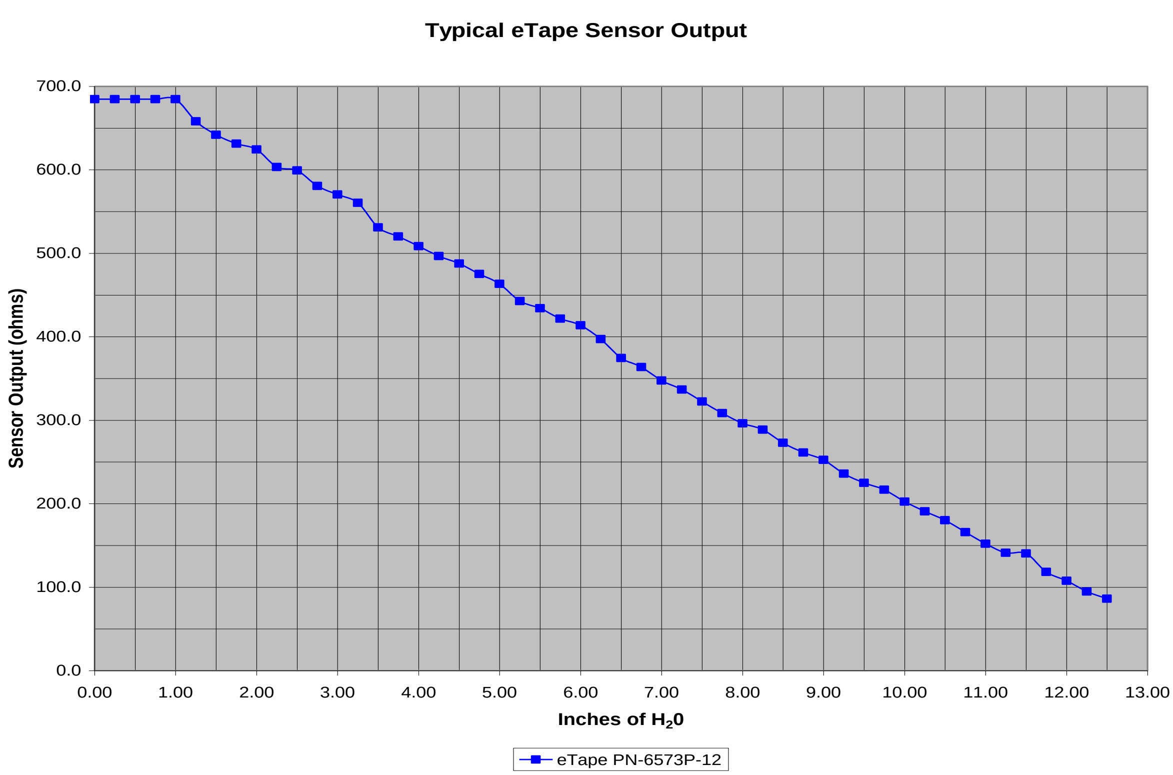
The Milone eTape liquid level sensor is an innovative solid state sensor that makes use of printed electronics instead of moving mechanical floats. The eTape's envelope is compressed by hydrostatic pressure of the fluid in which it is immersed resulting in a change in resistance which corresponds to the distance from the top of the sensor to the fluid surface.

The eTape can be modeled as a variable resistor (60 – 550 Ω ± 20%). In operation, as the liquid level rises and falls, the measured resistance decreases and increases, respectively. It is important to remember this basic principle of operation:

The lower the liquid level, the higher the resistance.

The higher the liquid level, the lower the resistance.

The typical output characteristics of the eTape sensor are show in the figure below:



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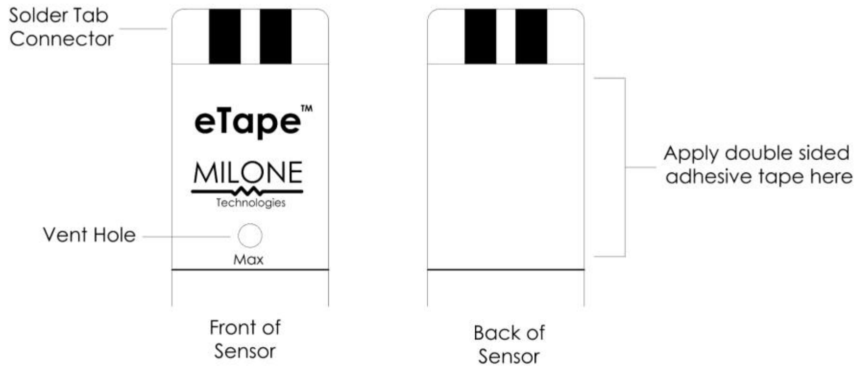
3.0 CONNECTION AND INSTALLATION

Connect to the eTape by attaching alligator clips or by soldering leads or pins to the gold plated solder tab connector. Suspend the eTape sensor in the fluid to be measured. To work properly the sensor must not be bent vertically or longitudinally. Double sided adhesive tape may be applied to the upper back portion of the sensor to adhere the sensor to the inside wall of the container to be measured. Only apply tape to the upper back portion of the sensor as shown in the figure below. If adhesive tape is applied to any other portion of the sensor it may not work properly. Do not submerge the sensor beyond the "Max" line to prevent the vent hole from being submerged. The vent hole allows the eTape to equilibrate with atmospheric pressure and must not be submerged in the fluid to work properly. The vent hole is fitted with a hydrophobic filter membrane to prevent the eTape from being swamped if inadvertently submerged.



4.0 TECHNICAL SUPPORT

If you require technical support for the eTape liquid level sensor Please contact our technical support department by email at: techsupport@milonetech.com.

5.0 USING eTape WITH THE PARALLAX BASIC STAMP

The eTape can be used in a variety of applications and experiments with the Parallax Basic Stamp. The eTape can be modeled as a variable resistor. There are several methods to measure varying resistance.

5.1 RC Time Circuit

One common approach is to measure the varying time it takes to charge or discharge voltage in an RC circuit. The Parallax BASIC Stamp has a built in function called RCTIME that makes use of this method to measure resistance in an RC circuit.

In an RC circuit, the time it takes to charge or discharge the capacitor is related to the value of the resistor by the equation:

$\tau = R \times C$, where τ (tau) is the RC time constant.

The RCTIME function measures the time to charge or discharge an RC circuit. Given a fixed value for a capacitor, the range of values of a variable resistor can be determined by measuring the varying time for different resistor settings.

The Milone eTape sensor can be used in an RC circuit as shown in Figure 1.

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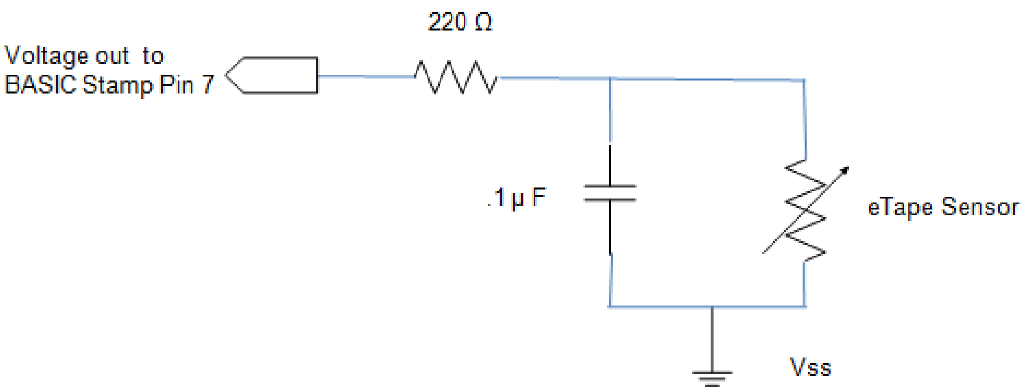

Figure 1. RC Circuit using eTape as a variable resistor

Sample code for the Parallax BASIC Stamp to be used with the circuit in Figure 1 is listed below in Figure 2. The program runs a loop, repeatedly measuring the time to discharge the voltage in the RC circuit. The time is displayed in the debug terminal, facilitating the display of time for various measurements by the eTape sensor. Lower values of time result from higher liquid levels, and higher values of time result from lower liquid levels.

The HIGH command charges the circuit (connected via Pin 7). The program pauses to permit sufficient time for the capacitor to completely charge. The RCTIME command measures the time it takes for the voltage measured at Pin 7 to drop below a threshold level (approx 1.4 V).

```
'{$STAMP BS2}
'{$PBASIC 2.5}
'===================================================================

 '-------------------I/O pin definitions---------------------------

  RC_Measure      PIN     7        ' connection to RC circuit

 '-------------------- variables ----------------------------------

  time            VAR    Word      ' holds measure time for

 '----------------------------------------------------------------

 '  --- Main routine
   DO

    HIGH RC_Measure
    PAUSE 1000
    RCTIME RC_Measure,1, time
    DEBUG HOME, "time -           "
    DEBUG HOME, "time - ", DEC time
    PAUSE 200


  LOOP
  END
```

Figure 2. Sample BASIC Stamp Code for RC Circuit Time Measurement

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5.2 Additional Experiments

Sample code is included for two additional experiments. In each of these experiments, a separate "sensor" circuit to convert the eTape output from resistance to voltage is utilized. The two experiments are:

1. A passive voltage divider.
2. An active circuit with inverting op amp and virtual ground

In both of these experiments, a common set up that makes use of the Parallax Basic Stamp, a coprocessor, and LED display is utilized.

In these examples, several components available from Parallax are used. The major components in the common set up include:

BASIC Stamp

Parallax Board of Education USB (#28850)

Parallax Serial LCD (4 rows x 20 Characters Backlit (#27979)

Micromega Corporation uM-FPU V3 floating point coprocessor

Push button switch (4 leg PN 400-00002)

5.2.1 Basic Stamp with Coprocessor

These examples make use of the Micromega Corporation coprocessor to simplify the calculations involved in the computation of liquid levels. The coprocessor is also used to convert voltage from an analog value to a digital value so that the Basic Stamp can perform calculations on the sensor output.

Figure 3 depicts the configuration of the um-FPU V3 coprocessor. It is configured per the "Using uM-FPU V3 with the BASIC Stamp" documentation from Micromega Corporation.

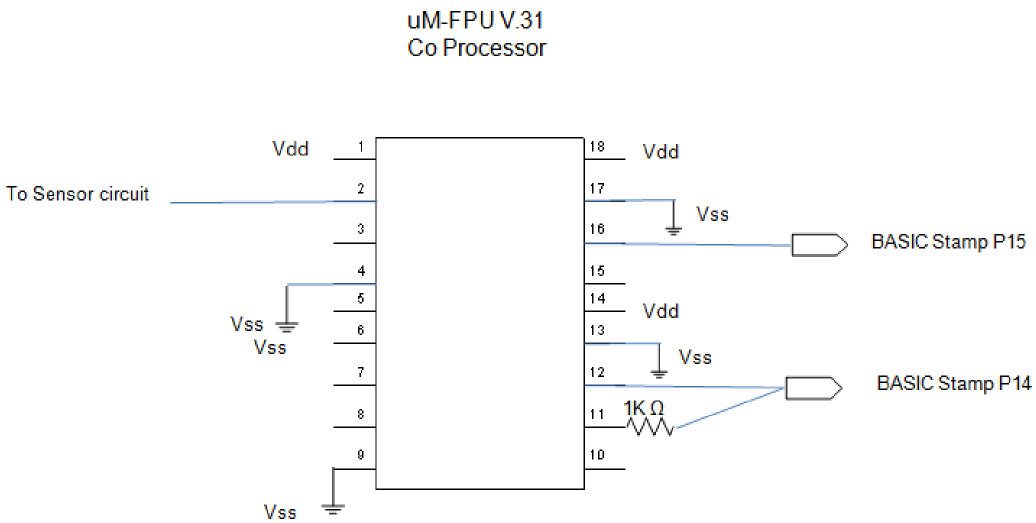

Figure 3. Configuration of Coprocessor

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5.2.2 LCD Display

A four row LCD display is utilized to display the digital values of the liquid volumes measured. Figure 4 depicts the connection of the LCD display to the BASIC Stamp. The device used in this sample code is from Parallax.

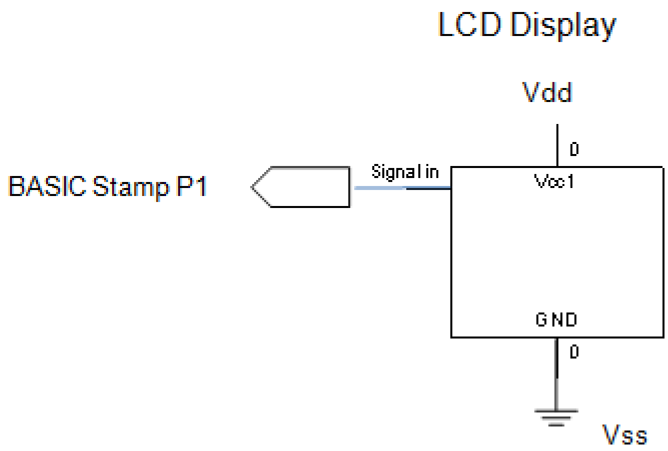

Figure 4. LED Connections

5.2.3 Calibration Button

Figure 5 depicts a simple push button. This push button is used to permit the real time calibration of the sensor circuit without changing parameters in the BASIC Stamp code. In both examples, if the push button is depressed while the program is running, the calibration routine executes and displays instructions on the LCD. The calibration routine captures the actual measured minimum and maximum digital voltage values from the circuit, minimizing the need to change hard coded values for variations in sensor or circuit.

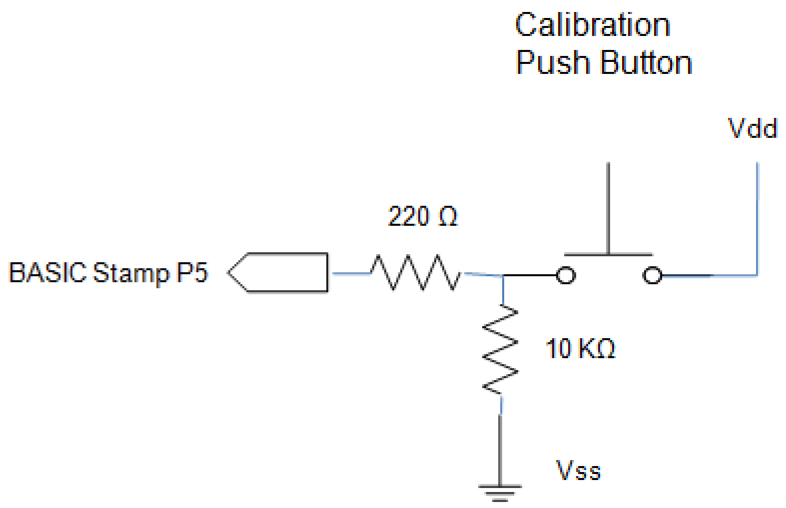

Figure 5. Push Button Connections

5.2.4 Experiment 1 - Voltage Divider

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The first experiment makes use of a simple voltage divider circuit to convert the varying resistance values of the eTape sensor to a voltage that can be measured and converted by the coprocessor A/D converter. The sample code for this experiment is contained in the file "eTape_exp_1.bs2". The code is written for a cylindrical tank with a 5.5 cm diameter. This value can be changed. Default values for Minimum and Maximum digital voltages are contained in the code. If the actual characteristics of the eTape sensor or the circuit cause these values to be incorrect, the calibration routine can be executed by depressing the push button while the program is running. The LCD displays the volume of the liquid in the tank in cups, ounces and ml. The sensor circuit for this Voltage divider experiment is shown in Figure 6.

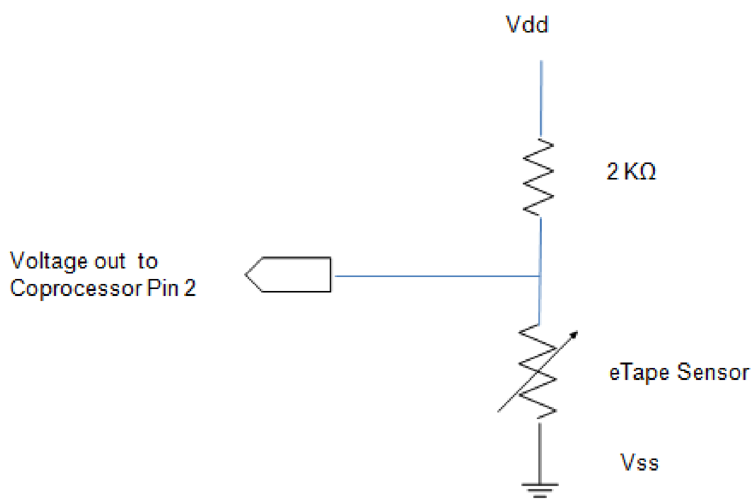

Figure 6. Voltage Divider Circuit

In this circuit, the voltage is directly proportional to the resistance of the eTape sensor.

$$V \text{ at Pin } 2 = [Vdd \times R\ eTape] / [2K\Omega + R\ eTape]$$

The eTape sensor has lower resistance at higher liquid levels and higher resistance at lower liquid levels. Therefore the maximum digital Voltage reading corresponds to an empty tank and minimum digital Voltage reading corresponds to a full tank. Figure 7 depicts this relationship.

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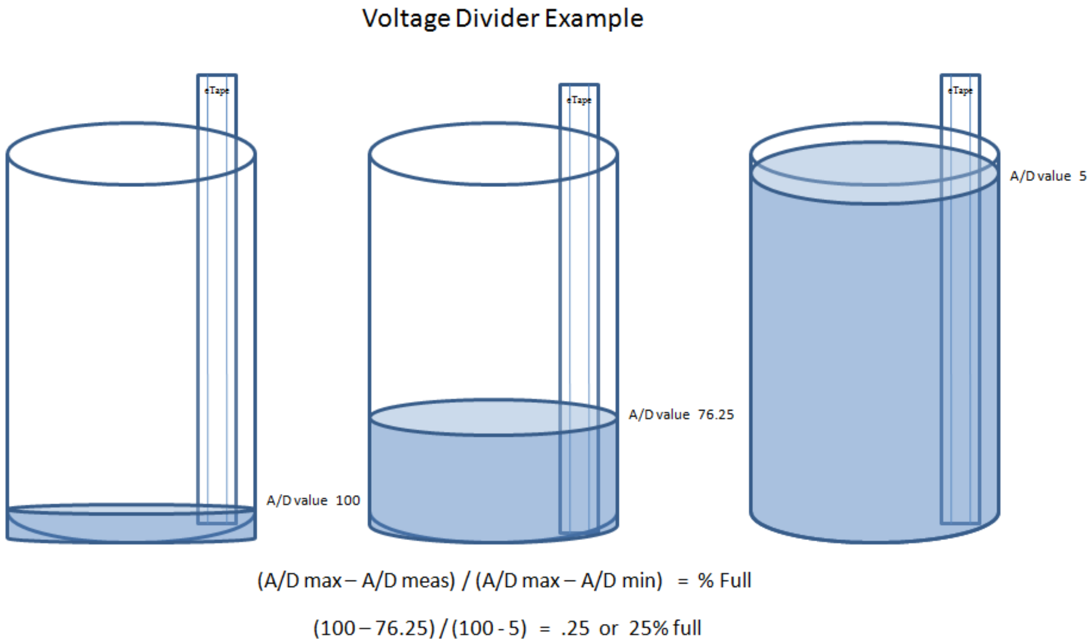

Figure 7. Using eTape and a Voltage Divider Circuit to Compute Percent Full

The Program performs the following sequence of steps:

1. Start a loop to continuously perform the following steps
2. Take measurement, convert analog voltage to a digital value.
3. Subtract the measured digital value from the maximum digital value of the circuit (empty tank) and divide by range (maximum – minimum digital values) – this gives percent full.
4. Multiply the sensor length by the percent full value to get liquid level in cm.
5. Compute volumes.
6. Display the results to the LCD
7. Repeat

5.2.5 Experiment 2 - Inverting Op Amp and Virtual Ground

The second experiment makes use of a and active op amp circuit to convert the varying resistance values of the eTape sensor to a voltage that can be measured and converted by the coprocessor A/D converter. The circuit used is an Inverting Op Amp. An inverting op amp generally requires both positive and negative voltage sources. A virtual ground circuit is utilized to permit use of this circuit where only a positive voltage source is available.

The sample code for this experiment is contained in the file "eTape_exp_2.bs2". The code is written for a cylindrical tank with a 5.5 cm diameter. This value can be changed. Default values for Minimum and Maximum digital voltages are contained in the code. If the actual characteristics of the eTape sensor or

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the circuit cause these values to be incorrect, the calibration routine can be executed by depressing the push button while the program is running.

The LCD displays the volume of the liquid in the tank in cups, ounces and ml. The sensor circuit for this Inverting Op Amp experiment is shown in Figure 8 below.

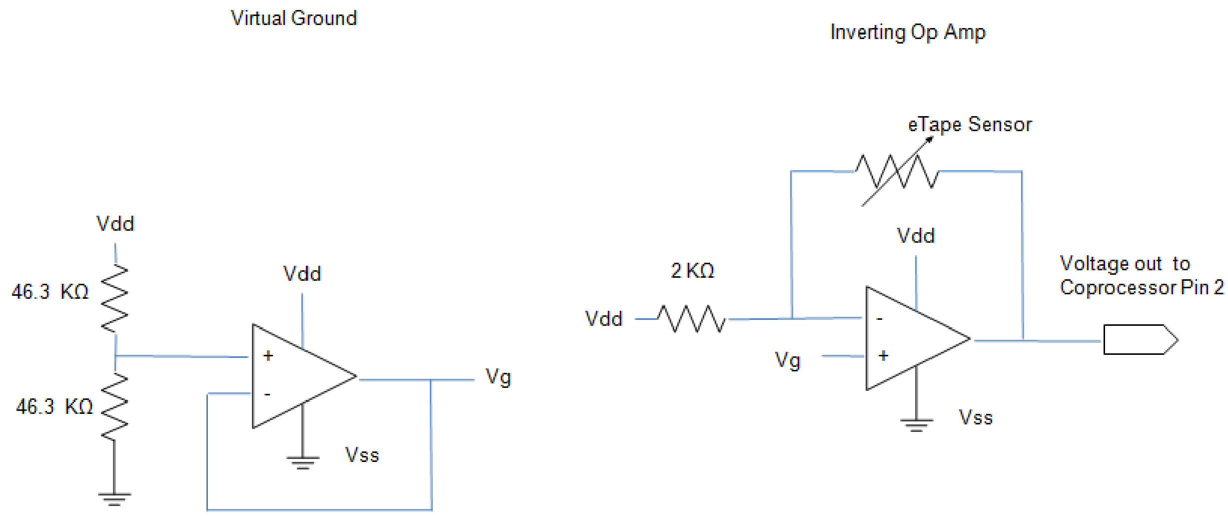

Figure 8. Active Voltage Converter Circuit using an Inverting Op Amp and Virtual Ground

In this circuit, the voltage is directly proportional to the opposite of the resistance of the eTape sensor.

$$V \text{ at Pin } 2 \approx Vdd \times [-R\ eTape] / [2K\Omega]$$

The eTape sensor has lower resistance at higher liquid levels, and higher resistance at lower liquid levels. Therefore the maximum digital Voltage reading corresponds to a full tank and minimum digital Voltage reading corresponds to an empty tank. (Inverting circuit and an inverting sensor…). Figure 9 depicts this relationship.

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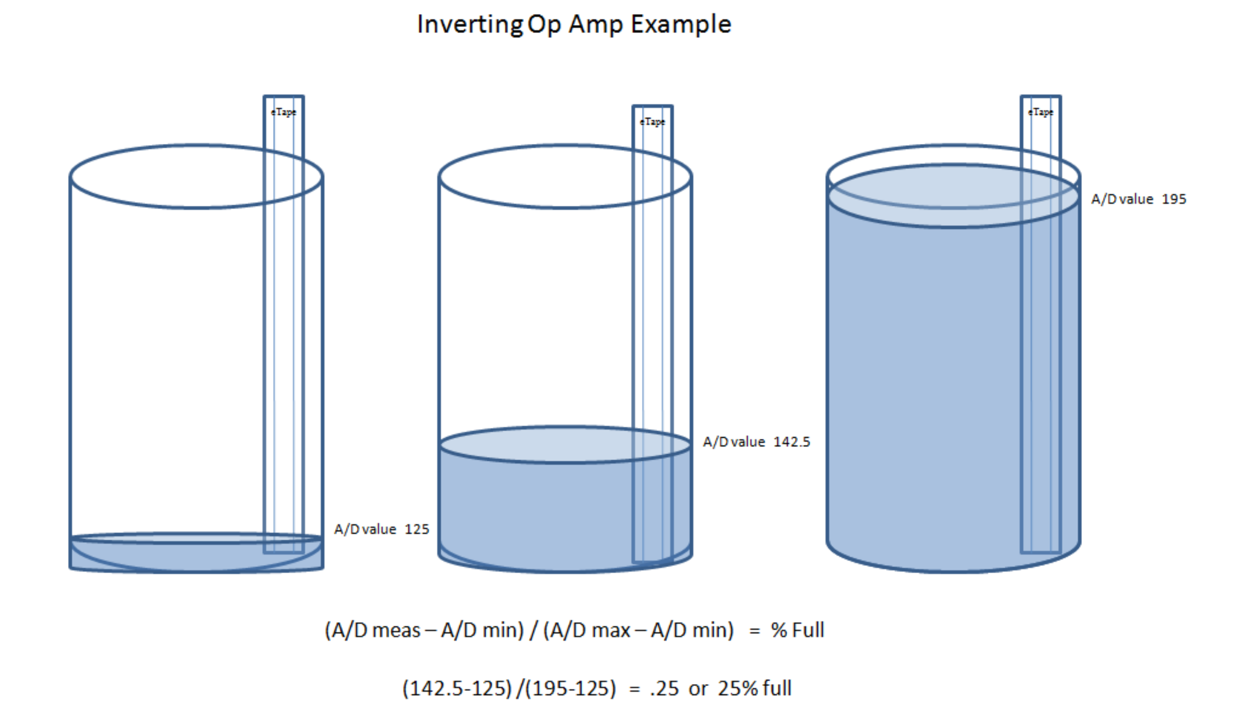

Figure 9. Using eTape and an Inverting Op Amp Circuit to Compute Percent Full

The Program performs the following sequence of steps:

1. Start a loop to continuously perform the following steps
2. Take measurement, convert analog voltage to a digital value.
3. Subtract the minimum digital value (empty tank) from the measured digital value of the circuit and divide by range (maximum – minimum digital values) – this gives percent full.
4. Multiply the sensor length by the percent full value to get liquid level in cm.
5. Compute volumes.
6. Display the results to the LCD
7. Repeat

A plot of liquid volume measurements taken using experiments 1 and 2 is provided below**.**

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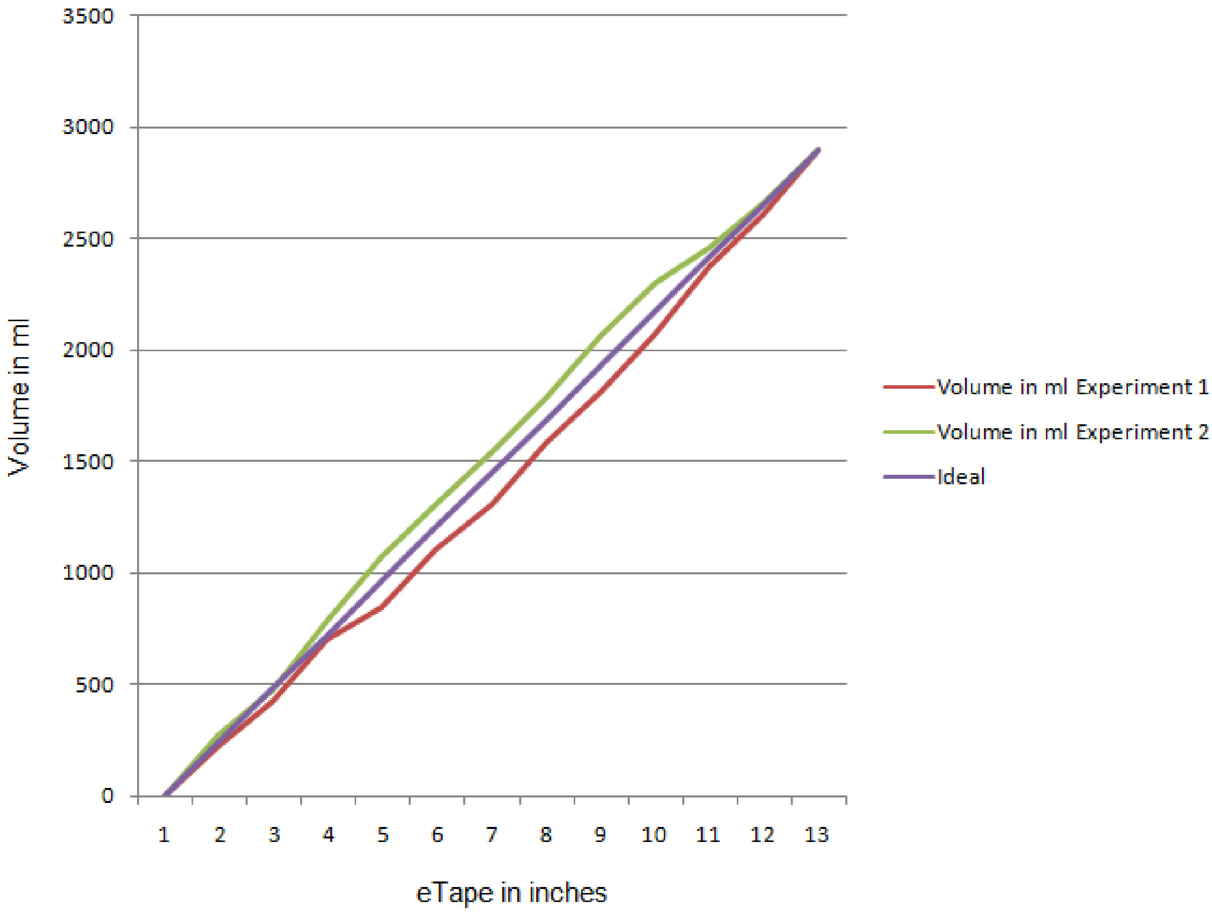

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