WLD Servo Meter Calibration

Theory and Procedure.

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1. Introduction.

When the servo is mounted onto the meter scale, it needs to be calibrated and scaled in order to convert temperature and humidity to a servo position number that reads out the correct value. Since every servo is a little bit different, each servo should be calibrated and the calibration values should be recorded and placed into named constants within the WLD firmware.

In order to calibrate your servo using the procedure in this document, you will need to build the WLD printed circuit board, per the instructions at:

https://github.com/TeamPracticalProjects/WaterLeakSensor/blob/master/Documentation/PCB%20Assembly%20Instructions.pdf

You will also need to mount your servo to the faceplate (bezel) and attach an indicator (servo horn) to the servo shaft so that you can read the servo position on the meter scale. This step varies slightly with the type of enclosure that you are building. Typical instructions can be found in the document:

https://github.com/TeamPracticalProjects/WaterLeakSensor/blob/master/Documentation/Enclosure%20Build%20Instructions%20Plastic%20Case.pdf

Finally, you should complete the build of your WLD, flash the WLD firmware to the Photon on the PCB, and test out you WLD per the "WLD Installation and User Manual":

https://github.com/TeamPracticalProjects/WaterLeakSensor/blob/master/Documentation/WLD_Installation_and_User_Manual.pdf.

Once you have completed building the testing your WLD, you may proceed to calibrate the servo meter using the procedure described below. Note that calibrating the servo require you to flash a different program to the Photon which is used to obtain calibrations values, then modify the WLD Firmware using these calibration values in lieu of the default values, and re-flashing the WLD Firmware back to your Photon.

2. Servo Calibration Procedure.

Once you have a completed and working WLD, you will need to flash a servo calibration program onto your WLD Photon. You will use this program to obtain calibration values that you can copy into the WLD Firmware in lieu of the defaults that we supply. You then recompile the WLD Firmware and flash it to your Photon so that your WLD is again operational but with calibrated servo meter values.

The program used to calibrate the servo meter is called *ServoCal.ino*. You can find this program

at:

https://github.com/TeamPracticalProjects/WaterLeakSensor/blob/master/Firmware/ServoCal/src/ServoCal.ino

You need to compile this program for your WLD Photon and flash it to the Photon using either the Particle Dev IDE (local) or the Particle Web IDE, whichever you prefer. You will already be familiar with this procedure by virtue of building and testing your WLD. After flashing *ServoCal.ino* to your Photon, make sure that the flashing was completed and that the Photon is breathing cyan, indicating that the firmware has been loaded, the Photon is talking to the Particle cloud and that it is ready for you to communicate with.

After compiling and flashing *ServoCal.ino to your Photon,* this program will set the servo near the center of the scale. Place a servo horn on the servo in the best possible position for indication of the center of the meter scale.

Next, open a web browser and go to the Particle.io web site (www.particle.io). Select "console" from the options of the top of this web page. You will be presented with a login screen. Use this screen to log in to your Particle.io account. After successful login, you will be presented with the Particle Console screen.

On the left hand side of the Console screen, you will see the Particle logo and some symbols below it. The first symbol below it looks like a little cube and mousing over this symbol will display "My Devices". Click on this symbol and you will be on the "Devices" screen of the Particle Console.

Find your WLD Photon in the device list and click on it. This will open the "View Device" screen. On the right side of this screen, you will see a box called "Functions". Inside this box will be "Servo". Under "Servo" will be a text box labeled "Argument" and a button labeled "Call" to the right of the text box. If you don't see the "Servo" function on the Console screen, make sure that you have selected the correct device and that you have flashed the correct firmware to this Photon device and that the Photon is "breathing cyan".

At this point, you will be able to type numerical values into the textbox labeled "Argument" and click the "Call" button. This will send the value to the Photon which will use this value to move the servo per the value that you typed in. If the function executed successfully, the label "Servo" will change to "Servo = *number*" where *number* is the value that you typed into the Argument text box. NOTE: make sure that you type only numbers into the Argument text box. If you type some non-numeric character string into this box, you will see "Servo = *some strange value*".

To calibrate your servo meter, first enter "170" into "Argument" and click "Call". The servo should move to the left side of the meter scale, near 40 deg F / 0 %RH. You can play with this

number in small increments until you determine the exact servo value that indicates 40 deg F / 0 %RH. Record this value as "MAX_POS". Then enter "20" into "Argument" and click "Call". Once again note the position of the servo. It should be near 120 deg F / 100 %RH. You can play with this number in small increments until you determine the exact servo value that indicates 120 deg F / 100 %RH. Record this value as "MIN_POS".

You can test your MAX_POS and MIN_POS calibration values using a hand calculation of various intermediate values, as demonstrated in the examples in the "Theory of Servo Calibration", below.

Keep your MAX_POS and MIN_POS calibration values handy. You will need to modify the default values in the WLD firmware to correspond to your servo calibration values when you compile and flash the operational firmware to your Water Leak Detector Photon.

Log out from the Particle Console. Follow the instructions in the WLD Firmware Installation document at:

https://github.com/TeamPracticalProjects/WaterLeakSensor/blob/master/Documentation/WLD_Firmware_Installation.pdf

Before compiling this firmware, change the values of MAX_POS and MIN_POS (somewhere around line 70 of the WLD Firmware) to those that you obtained by running this calibration procedure. Then compile and flash this code to your WLD Photon. The WLD servo meter should then operate with your calibrated values.

3. Theory of Servo Calibration.

This section provides the theory behind the servo calibration procedure and some example calculations of sero position command for various temperature and humidity values.

3.1. Servo end points calibration.

When the servo is mounted onto the meter scale, a servo position of zero is fully clockwise, beyond the 100% RH and 120 deg F markings. Conversely, the servo position of 180 degrees is fully counterclockwise, beyond 0% RH and 40 deg F.

The value given to the servo that corresponds to 100% RH / 120 deg F must be determined by trial and error. Let us call this value MAX_POS. Likewise, the value given to the servo that corresponds to 0% RH / 40 deg F must be determined by trial and error. Let us call this value MIN_POS. MAX_POS and MIN_POS are the servo calibration values for any given servo device.

3.2. Servo position calculation for temperature.

Once the end point calibration values are determined, the servo position increment for each degree value of temperature can be determined. The full scale temperature range is 120 – 40 = 80 degrees F. The full scale of servo position values is MAX_POS – MIN_POS. Therefore, each degree of temperature requires an increment of servo position of:

Servo position increment per degree = (MAX_POS – MIN_POS) / 80

The minimum temperature on the scale is 40 deg F. Therefore, the indicated temperature is:

Indicated temperature = actual temperature – 40

The servo movement value is:

*Servo mve = Indicated temperature * Servo position increment per degree =*

*(actual temperature – 40) * (MAX_POS – MIN_POS) / 80*

Since the servo is mounted "upside down" so that MAX_POS represents the minimum counterclockwise position for the meter, the servo command must be the MAX_POS – (servo mve):

Servo cmd = MAX_POS – (servo mve)

For example: suppose that MAX_POS = 170 and MIN_POS = 20. Then:

*Servo mve = (temp – 40) * (170 – 20)/80 = (temp – 40) * (150/80) =*

*(temp – 40) * 1.875.*

Therefore:

*Servo cmd = 170 – (int)((temp – 40)*1.875)*

Examples:

For Temp = 40 deg F, *Servo cmd* = 170 – 0 = 170
For Temp = 60 deg F, Servo cmd = 170 – (20*1.875) = 132
For Temp = 85 deg F, Servo cmd = 170 – (45*1.875) = 86
For Temp = 95 deg F, Servo cmd = 170 – (55*1.875) = 67
For Temp = 115 deg F, Servo cmd = 170 – (75*1.875) = 29
For Temp = 120 deg F, Servo cmd = 170 – (80*1.875) = 20

3.3. Servo position calculation for humidity.

Similarly, the servo position command to indicate relative humidity (RH) can be determined as follows. The full scale RH range is 100 – 0 = 100. Therefore,

Servo position increment per RH = (MAX_POS – MIN_POS) / 100

The minimum RH on the scale is 0. Therefore, the indicated RH is:

Indicated RH = actual RH – 0 = actual RH

The servo movement value is:

*Servo mve = Indicated RH * Servo position increment per RH =*

*(actual RH) * (MAX_POS – MIN_POS) / 100*

Since the servo is mounted "upside down" so that MAX_POS represents the minimum counterclockwise position for the meter, the servo command must be the MAX_POS – (servo mve):

Servo cmd = MAX_POS – (servo mve)

For example: suppose that MAX_POS = 170 and MIN_POS = 20. Then:

*Servo mve = (RH) * (170 – 20)/100 = (RH) * (150/100) =*

*RH * 1.5*

Therefore:

*Servo cmd = 170 – (int)(RH * 1.5)*

Examples:

For RH = 0%, *Servo cmd* = 170 – 0 = 170
For RH = 15%, Servo cmd = 170 – (15 * 1.5) = 147
For RH = 25%, Servo cmd = 170 – (25 * 1.5) = 132
For RH = 50%, Servo cmd = 170 – (50 * 1.5) = 95
For RH = 75% deg F, Servo cmd = 170 – (75*1.5) = 57
For RH = 90% deg F, Servo cmd = 170 – (90*1.5) = 35
For RH = 100% deg F, Servo cmd = 170 – (100*1.5) = 20