# Servo Meter Calibration

*Theory and Procedure.*
*By: Team Practical Projects; 10 June 2017*

## Theory.

### 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 the 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 firmware.

### 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.

### 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

## 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

## Procedure.

The servo must first be mounted onto the meter scale and an indicator affixed to it. The servo must be connected to the Photon through a 3.3 volt to 5 volt convertor, per the Water Leak Detector schematic. The program called *ServoCal.ino* is then flashed to the Photon. Initially, this firmware program will set the servo near the center of the scale.

Next, launch the web program *Shrimpware.com/SIS/DebugSIS.html* from any web browser. Log into your Particle account and select the Photon being used for the calibration and testing. Under "Attributes", you should see one function: "Call Servo". You type a value into the box labeled "Input:" and then click on "Call Servo". The servo meter will move and you note its position on the scale, either in temperature or in RH, depending upon what you are testing. The "RtnCode:"

will be the same value that you entered, as long as it was a number (integer) in the range of 5 to 175.

To calibrate your servo meter, first, enter "170" and note the position of the servo meter. It should be 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" and again note the position of the servo. It should be near 120 deg F / 100 %RH. You can play with this number is small increments until you determine the exact servo value that indicates 120 deg F / 100 %RH. Record this value as MIN_POS.

Test your MAX_POS and MIN_POS calibration values using a hand calculation of various intermediate values, as demonstrated in the examples above.

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

---