

# Introduction to Sensors, Measurement and Instrumentation

Lab 4: Using Capacitors to Measure Humidity

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February 21, 2023

## Circuit Output

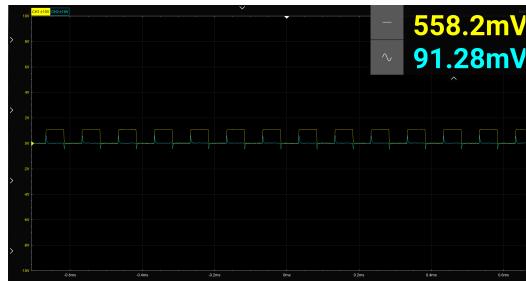


Figure 1:  $V_{RMS}$  output cycles for a 100pF Capacitor in the CR circuit using Wave Generation.

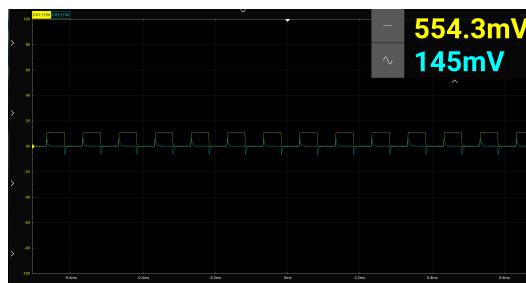


Figure 2:  $V_{RMS}$  output cycles for a 220pF Capacitor in the CR circuit using Wave Generation.

## Calibration Curve Plot

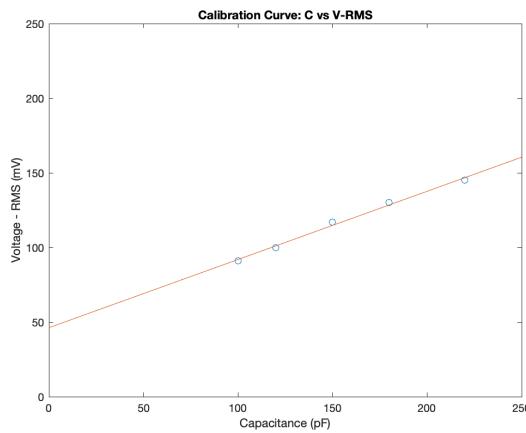


Figure 3: Calibration Curve (Capacitance(pF) vs  $V_{RMS}$ (mV) - The amplitude of  $V_{RMS}$  is plotted against the capacitance in a Wave Generation-CR circuit.

# Measurement Curve

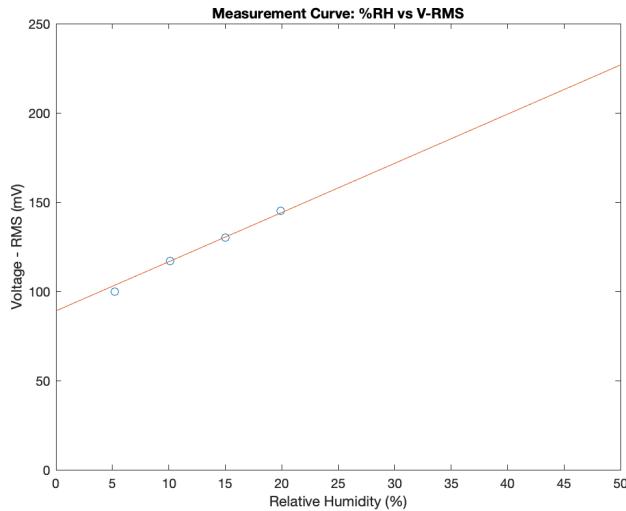


Figure 4: Measurement Curve (Relative Humidity(%)) vs  $V_{RMS}$ (mV) - The circuit behavior for the Wave Generation circuit with a relative humidity sensor is plotted. The %Relative Humidity is obtained as a function of Capacitance.

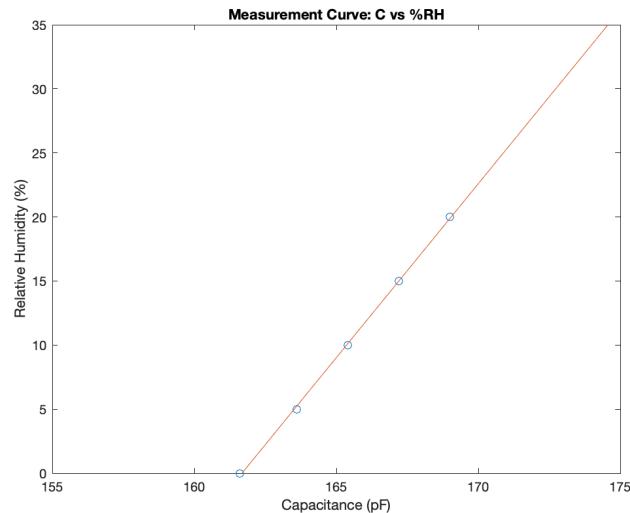


Figure 5: Measurement Curve (Capacitance(pF)) vs Relative Humidity(%) - The sensor's behavior is plotted, demonstrating the variation in the %RH measurement in the sensor w.r.t. Capacitance.

## Analysis of Relative Humidity (%)

The  $V_{RMS}$  amplitude obtained from using the relative humidity sensor in the circuit is 133 mV.

This reading corresponds to approx. 18% relative humidity from the measurement curve.

The result seems reasonable considering the weather conditions in Needham, MA, on 21st February 2023, as it snowed outside and the central heating inside the room is increased to stay warm. This causes a decrease in humidity.

## Circuit Diagram and Photo

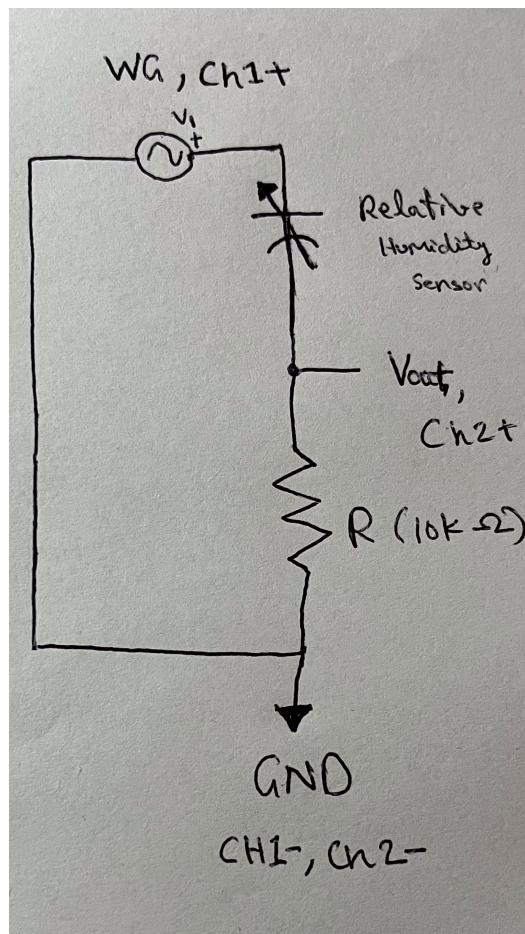


Figure 6: The Circuit Diagram for a voltage-divider, wave generation, CR circuit consisting of a relative humidity sensor.

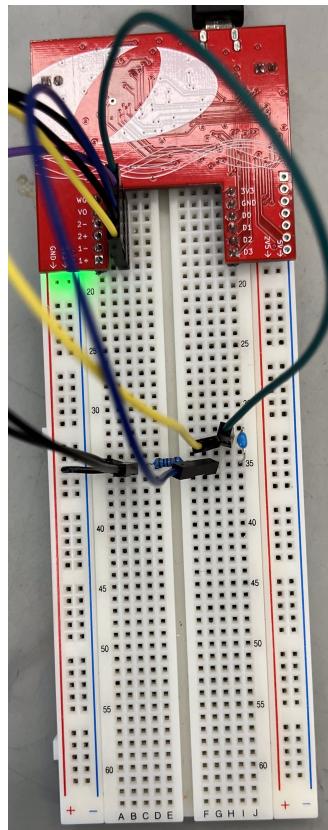


Figure 7: O-scope Circuit Connections Photo

## Implementation of Calibration curve

```

1 % Calibration curve data points
2
3 x = [100,120,150,180,220]
4 y = [91,100,117,130,145]
5 p = polyfit(x,y,1)
6
7 % Plot calibration curve
8 x1 = linspace(0,250);
9 y1 = polyval(p,x1);
10 figure
11 plot(x,y,'o')
12 ylim([0,250]);
13 hold on
14 plot(x1,y1)
15 hold off
16 xlabel('Capacitance (pF)')
17 ylabel('Voltage - RMS (mV)')
18 title('Calibration Curve: C vs V-RMS')
```

## Implementation of Measurement curve

```
19 % Measurement curve calculation
20
21 rh = [0,5,10,15,20]
22 c = [161.6,163.6,165.4,167.2,169]
23 p_c = polyfit(c,rh,1)
24
25 x = -439.1356 + 2.7161.*c
26 y = [91,100,117,130,145]
27 p = polyfit(x,y,1)
28
29 % Plot measurement curve (%RH vs V-RMS)
30 x1 = linspace(0,200);
31 y1 = polyval(p,x1);
32 figure
33 plot(x,y,'o')
34 xlim([0 50])
35 ylim([0 250])
36 hold on
37 plot(x1,y1)
38 hold off
39 xlabel('Relative Humidity (%)')
40 ylabel('Voltage - RMS (mV)')
41 title('Measurement Curve: %RH vs V-RMS')
42
43 % Plot measurement curve (C vs %RH)
44 c = [161.6,163.6,165.4,167.2,169]
45 rh = [0,5,10,15,20]
46 p_c = polyfit(c,rh,1)
47
48 x1 = linspace(0,200);
49 y1 = polyval(p_c,x1);
50 figure
51 plot(c,rh,'o')
52 xlim([155 175])
53 ylim([0 35])
54 hold on
55 plot(x1,y1)
56 hold off
57 xlabel('Capacitance (pF)')
58 ylabel('Relative Humidity (%)')
59 title('Measurement Curve: C vs %RH')
```