A Fully Printed Carbon Nanotube (CNT) Based Thermistor

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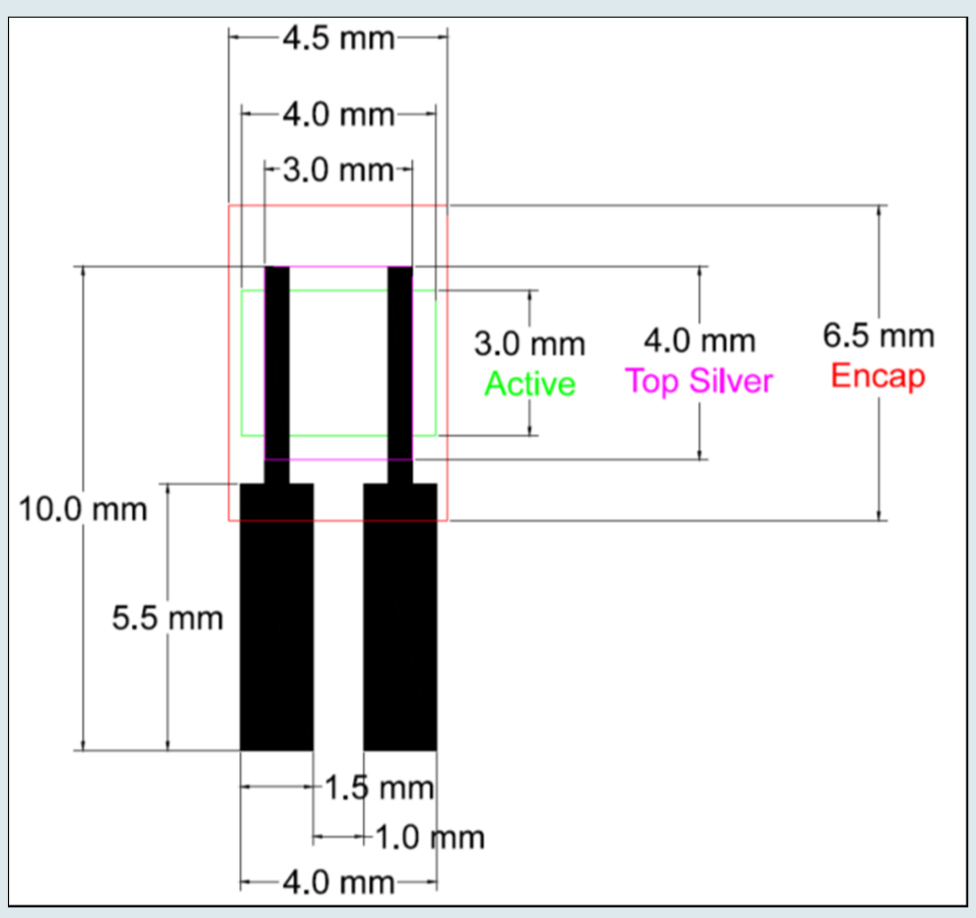
ABSTRACT

A fully printed carbon nanotube (CNT) based thermistor has been successfully fabricated on flexible polyethylene terephthalate (PET) substrate using screen and gravure printing processes. The thermistor consists of screen printed bottom silver electrodes, a gravure printed active layer (CNT) on top of the bottom silver electrode, a screen printed organic encapsulation layer on top of the active layer, and a secondary screen printed silver based encapsulation layer on top of the organic encapsulation layer. The capability of the fabricated thermistor was investigated by measuring its response towards varying temperatures and relative humidity (RH). The resistive response of the thermistor demonstrated a linear relationship for temperatures varying from 30 °C to 100 °C. An average sensitivity of 2 kΩ/°C, with a correlation coefficient of 0.99, was obtained for the printed thermistor. In addition, a maximum change of 0.27% and 0.21% at 60 %RH and 50 %RH for temperatures at 30 °C and 50 °C, respectively when compared to the base resistance at 20% RH was obtained for humidity varying from 20% RH to 70% RH in steps of 10% RH.

INTRODUCTION

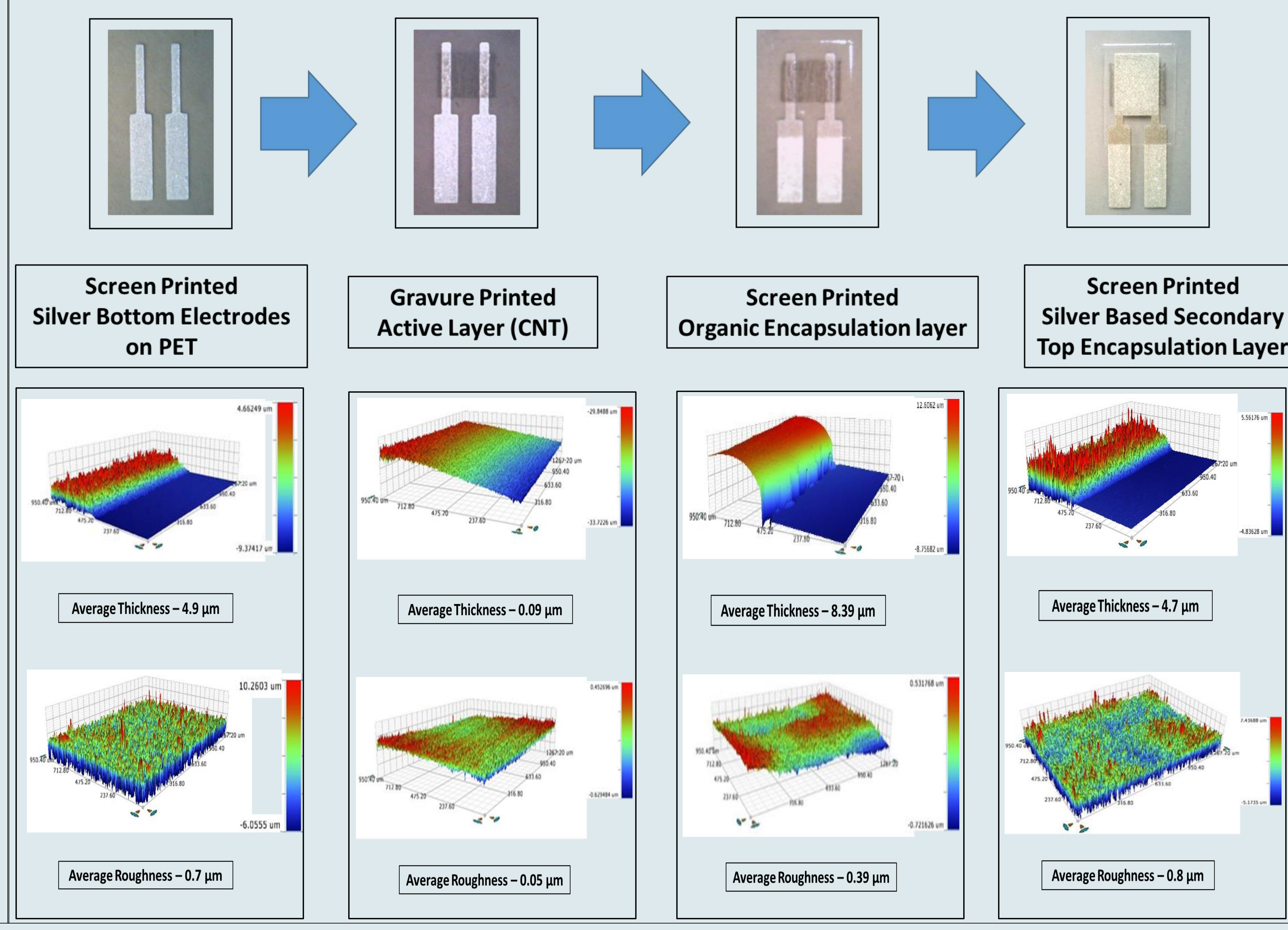
- Temperature is one of the critical and widely measured parameters in the modern industrial environment for application in the aerospace, automotive and environmental industries.
- Temperature sensors are typically manufactured using conventional silicon based processes which are often expensive and fabricated on rigid substrates. Moreover, none of these configurations offer the high flexibility and conformability required for various temperature sensing applications.
- A continuous layer-on-layer configuration along with the use of traditional printing processes, which has advantages such as improved cost efficiency, reduction of material wastage during fabrication, flexibility in the substrate and low manufacturing temperatures, is envisioned as a promising approach that will overcome the drawbacks associated with conventional silicon technology which involves high-vacuum and high-temperature deposition processes along with sophisticated photolithographic patterning techniques.
- In this work, a novel thermistor is successfully developed by depositing functional inks using screen and gravure printing processes on a flexible PET substrate. The capability of the fabricated thermistor was demonstrated by investigating the resistive response based on varying temperatures.

Device Fabrication and Characterization

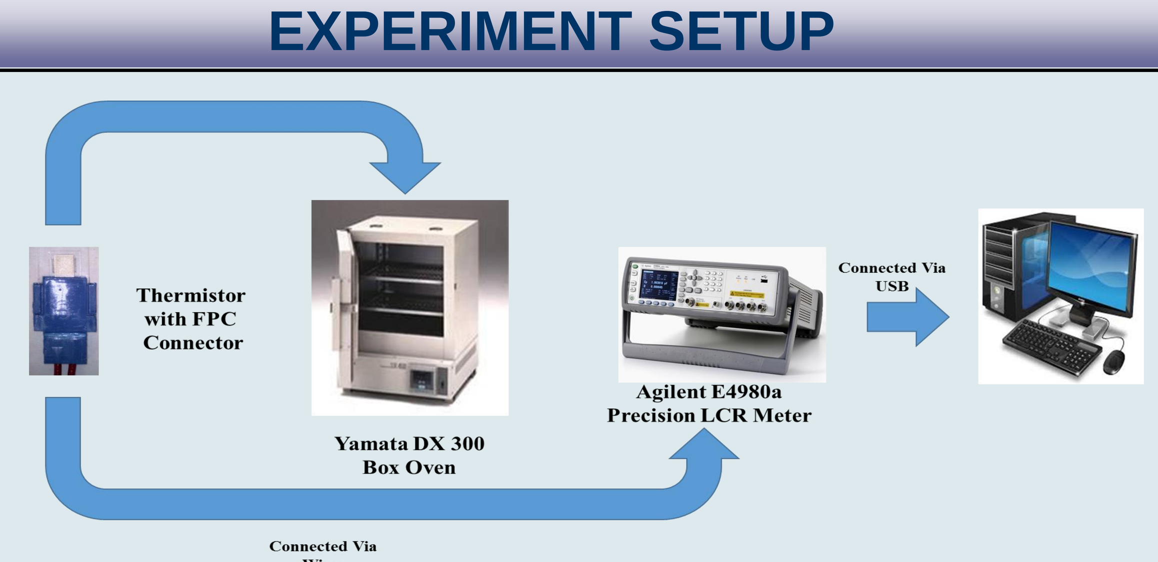


Thermistor Design layout

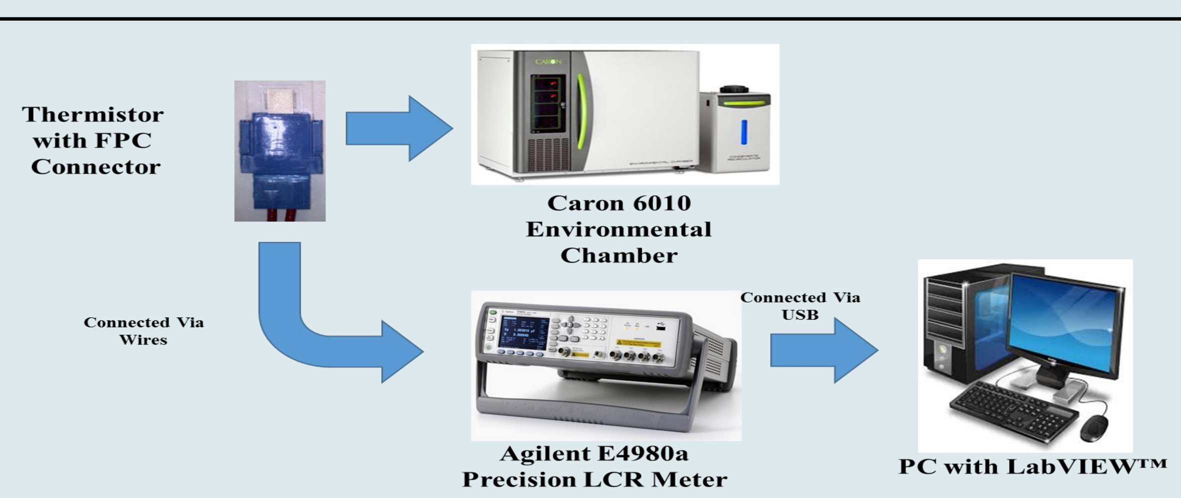
Thermistor Configuration



EXPERIMENT SETUP

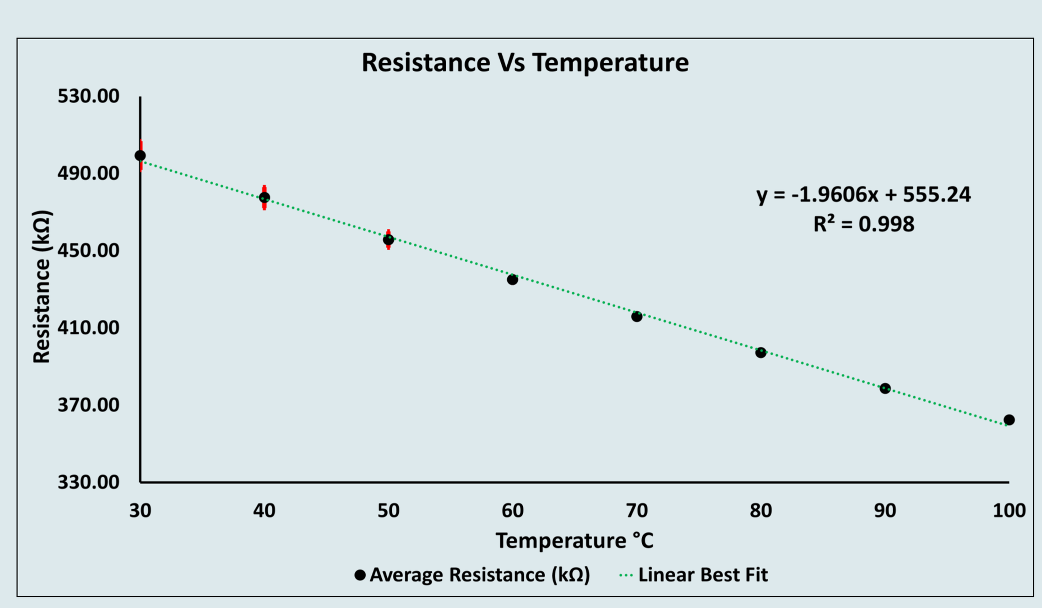


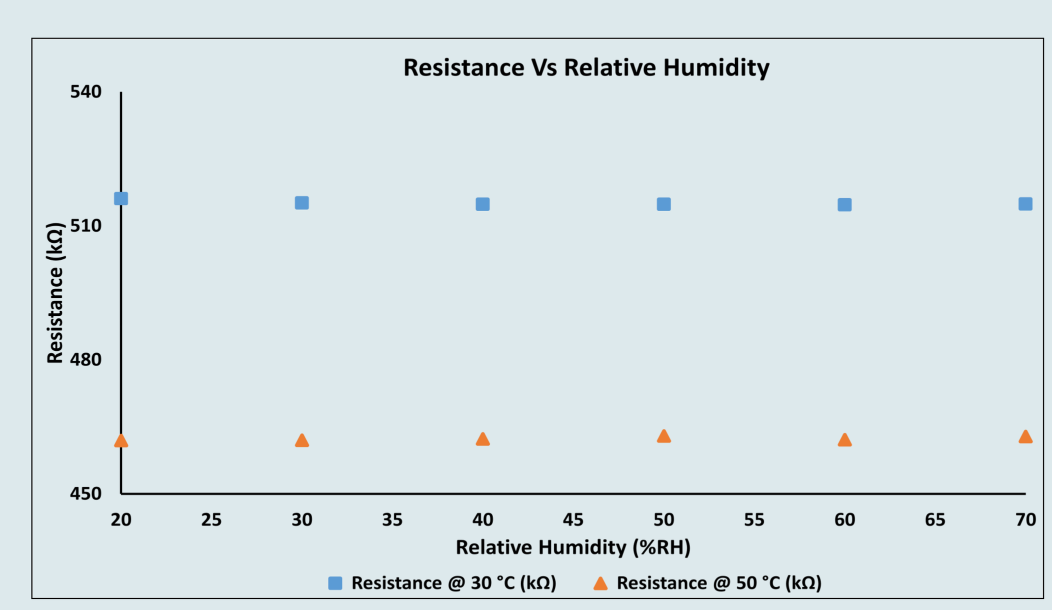
(a) Resistance Vs Temperature



(b) Resistance Vs Relative Humidity

RESULTS AND DISCUSSION





Thermistor resistance response towards varying temperatures: Average resistance change of 4.36%, 8.71%, 12.86%, 16.69%, 20.43%, 24.14% and 27.42% was obtained at 40°C, 50°C, 60°C, 70°C, 80°C, 90°C and 100°C, respectively when compared to the average base resistance value at 30°C.

Thermistor resistance response towards varying relative humidity: Maximum change of 0.19%, 0.25%, 0.25%, 0.27% and 0.24% at 30°C; 0.01%, 0.08%, 0.21%, 0.03% and 0.19% at 50°C was obtained for 30% RH , 40% RH, 50% RH, 60% RH and 70% RH, when compared to the average base resistance of the thermistor at 20% RH.

CONCLUSION AND FUTURE GOALS

- A fully printed thermistor was successfully fabricated using screen and gravure printing processes.
- The resistive response of the thermistor towards temperatures ranging from 30°C to 100°C, in steps of 10°C was investigated.
- The resistive response demonstrated a maximum resistance change of 27.42% at 100°C, when compared to the base resistance at 30°C with an average sensitivity of 2 kΩ/°C and a correlation coefficient of 0.99.
- In addition, Maximum change of 0.27% and 0.21% at 60 and 50 %RH for temperatures at 30 °C and 50 °C, respectively when compared to the base resistance at 20% RH was obtained for humidity varying from 20% RH to 70% RH in steps of 10% RH.
- Further research is underway to better understand the response of the thermistor by investigating its response for temperatures below room temperature until -20°C and to implement it into a field deployable sensing system.

ACKNOWLEDGEMENTS

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