10. Waterproof Sensor

Purpose: Fabricate an Effective Waterproof Capacitance Sensor.

Goal: Make a sensor that has adequate sensitivity and range, and is waterproof..

Key References --

Sensor Design Article: This is interesting for sure. Notice how this sensor is made from two rings of copper, wrapped around PVC tubing. And they are then inserting the sensor down into another (wider) PVC tube and it is sensing (forming) capacitance through the insulating PVC tubing. I do note here, however, that they are sensing capacitance via the high-frequency pulsing/waveform method. So now I wonder if that approach does yield greater sensitivity and dynamic range. I may have to test this out.

A Portable Pull-Out Soil Profile Moisture Sensor Based on High-Frequency Capacitance @ https://www.mdpi.com/1424-8220/23/8/3806

Esp this photo: @ https://www.mdpi.com/sensors/sensors-23-03806/article_deploy/html/images/sensors-23-03806-g006.png

To Modify RPi side .cpp code --

Use Kate on my desktop.

Then copy to the RPi using below command:

```
scp /home/jroc/Dropbox/projects/MoistureSensor/CapSensor/RPi/RPi_CapDataReceive.cpp pi@192.168.1.118:/home/rf24libs/RF24/examples_linux/
```

Then on the RPi, cd into the build directory and execute 'make'

BUT if this is the first iteration of the program, you need to first add it to CMakeLists.txt in the examples_linux directory (above the build directory).

NOTE: All the code is under git version control. So the executables for both the ATTiny and RPi are on my desktop.

Raspberry Pi Login --

Pi user is: pi. So SSH login is:

`ssh pi@192.168.1.118`
password: `pi9012`

And then once in, get into the working directory for the nRF24 utilities and programs:

```
cd /home/rf24libs/RF24/examples_linux/build
```

The run the RPi receiving program:

```
./RPi_CapDataReceive
```

Next Step: Assemble the sensor circut onto a perf-board, then use it in a real plant pot, indoors, while using a normal, store-bought, plant water moisture meter to gauge if this sensor would be able to discern Dry - Moist - Soaked.

6/16/2023 --

Results: **Partial Success**. I am getting stronger readings with the more robust sensor, and good solid readings through the membrane of a waterproofing baggy. But the dynamic range across dry - moist - soaked may not be sufficient.

Design: Fabricated a beefy sensor from sheet aluminium. Using the Dremel I cut a strip in two with an interlocking zig-zag pattern. Then I put the whole sensor into a baggy. See photo.

Open Air: 0 pF

Placing thumb On Sensor: 4 pF.

In Dryish Soil: 25-27 pF

Watered Soil: 29-33 pF

Fully Drenched Soil: 30-33 pF

Discussion:

06/10/2023b --

Results: **Failure**. Wrapped sensor stick in Glad Cling-Wrap (LDPE). I did wrap about 10 layers (to make it waterproof). Measurements:

Open Air: 9-10 pF in open air

Placing Thumb On Sensor: No real change

In Dry Soil: NA, didn't have any dry soil to test.

"Watered" Soil: NA, didn't have any to test.

Fully Drenched Soil: 9-10pF.

Discussion: So, the Cling-Wrap is not at all effective.

06/10/2023a --

Results: Partial Success. Took my existing popsicle stick sensor and stuck it into a baggy. Measurements:

> **Open Air**: 9-8 pF in open air
>
> **Placing Thumb On Sensor**: 11-12 pF range
>
> **In Dry Soil**: 12-12.5 pF.
>
> **"Watered" Soil**: 15-16pF.
>
> **Fully Drenched Soil**: 15-16pF.

Discussion: So, ok, inside plastic kinda works; but the range of sensitivity isn't very good. I will note, tho, that the pot I used only allowed half of the popsicle stick to be submerged. would the sensitivity be better if it was fully underground?

Prep --

> Just stuck the sensor stick into a baggy. Then worked the bagged stick into a pot with soil in it. Note, tho, that the pot I used only allowed half of the popsicle stick to be submerged. See photo.

Software --

> **RPi**: No change.
>
> **ATTiny**: No change from MS09 sketch.
>
> **Git Commit**: No commit made as yet.

Hardware --

> No change other than placing the sensor stick into a plastic bag.

Next Step: Unsure.

> **Gorilla Waterproof Patch and Seal Clear Spray Paint**: This is probably the best answer. Available at Lowes/Home-Depot. $15 for a spray bottle. Not cheap. And I wonder if it would be good for my bird-bath bowel??
>
> **Polyurethane**: As a finishing product - the spray I used, likely any can of liquid poly I might be able to buy at Lowes and such - these are not waterproof. But "...thermoset polyurethanes can practically have zero water absorption compared to other known materials."
>
> **~~Low-Density Polyethylene~~**: Cling-Wrap. See 06/10/2023b test. A fail.
>
> > "It has a melting point of 239 degrees Fahrenheit (115 degrees Celsius), is waterproof, provides electrical insulation, and is resistant to both acids and bases." [https://www.edlpackaging.com/blog/understanding-the-differences-between-polyolefin-packaging-films/]
> >
> > And as I was researching all this I see many posts saying that "In response to consumer concerns over chemicals in plastics, SC Johnson changed the forumla for Saran Wrap, substituting LDPE (low-density polyethylene) for the PVDC, which eliminated DEHA in the product. || Other major brands of cling wrap, **including Glad Wrap, have also changed to LDPE**, but a few, like Reynolds Foodservice Film (sold at Wal-Mart and on Amazon) continue to use PVDC."

High-Density Polyethylene: High-density polyethylene (HDPE) has a crystalline structure with tightly packed molecules. This material's polymer structure makes it durable and a popular choice for rigid packaging containers. It also has greater resistance to chemicals and extreme temperature conditions, with a melting point of 275 degrees Fahrenheit (135 degrees Celsius). Like LDPE, HDPE is waterproof, low cost, and lightweight. [https://www.edlpackaging.com/blog/understanding-the-differences-between-polyolefin-packaging-films/]