Engineering Notebook

Automated Irrigation System

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Circuits Review

Capacitors - Store energy in a way

$C = \frac{Q}{\Delta V}$ → amount of charge on one side of struct

ΔV → change of electric potential across the structure

Electric Potential

$\Delta U_E = -W_E$

$\Delta U_E = -\int_a^b F_E \cdot dl$

F_E ↳ qE

$\Delta U_E = q\left(-\int_a^b E \cdot dl\right)$

$\Delta U_E = q\,\Delta V$

↳ change in electric potential

ΔV is change in electric potential hold info about all possible electrical interactions along a path from a to b

Capacitors Series vs parallel

$C_{eff\ (series)} = \frac{1}{\frac{1}{C_1} + \frac{1}{C_2} + \dots}$

$C_{eff\ (parallel)} = C_1 + C_2$

Electric Current

det: amount of charge passing a boundary (gate) per time

$$I = \frac{dq}{dt}$$

$$I_{avg} = \frac{\Delta q}{\Delta t} = \frac{1C}{1s} = 1\ Amp \rightarrow \frac{C}{s}$$

Current density:

det: $\frac{\text{current measured}}{\text{gate size}}$

Linear, Surface, Vol charge density

$$\lambda = \frac{dq}{dl}$$

$$\sigma = \frac{dq}{dA}$$

$$\rho = \frac{dq}{dV}$$

Linear current density

$$\boxed{I = \lambda v = \frac{I}{1\text{point}}}$$

Surface current density

$$\boxed{K = \frac{I}{\text{gatesize}} = \frac{I}{l}}$$

$$I = \frac{dq}{dt} \rightarrow \frac{\sigma\, dA}{dt} = \sigma \frac{l\, dx}{dt} \rightarrow \sigma l v$$

$$\frac{I}{l} = \sigma v$$

$$\boxed{K = \sigma v}$$

Volume current density

$$\boxed{J = \rho v = \frac{I}{A}}$$

Conductivity: How easy for charge to move through

$$\sigma_{con} = \frac{1}{\rho_{res}}$$

Ohm's Law

$V = IR$ $\qquad$ $R = \frac{\rho_{res} L}{A}$

Basic Circuits

Batteries are a 2 sided structure w/ ⊕/⊖ sides - keeps a constant change of electric potential between the 2 sides

EMF = Electro motive force
($\mathcal{E}$ = voltage across battery)

- **Resistors**: limit current, loses energy in circuit

$$P_{loss} = \frac{dW_{lost}}{dt} = \frac{dq\,V}{dt}$$

charge crossing resistor
change of electric pot. across resistor

$P_{loss} = IV$

Circuit Analysis

- 3 tools
  - kirchoffs loop rule
    - ↳ ΔV is path independent
  - Junction rule
    - ↳ current in = current out
  - Ohm's Law $V_r = IR$

also
$P = IV$

where P = power in Watts

Setting up Plant Waterer

materials needed:

- a water sensor
- a pump, voltage?
- power supply 12V
  - can't be plugged into my computer all the time, how much A (current is needed)
- Relay
  - need to research more
- terminal block (chocolate)
  - used to connect wires
- multimeter,

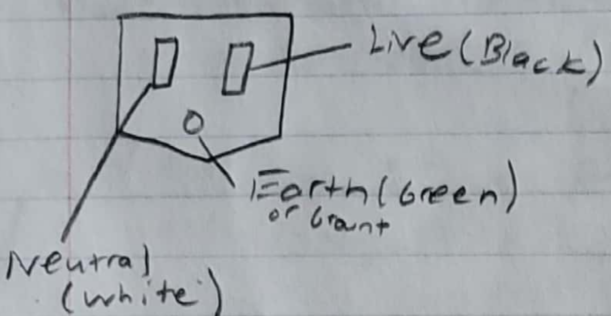
Game Plan:

1) research which components to buy
   - correct power supply → 12 V A?
   - what's a relay?
   - V and amp diagram?
2) connect all the wires and stuff
3) code arduino
4) watch plant grow

Notes:

the Arduino can handle up to 20 V but 12 V recommended

Power Supply Research:



- will need a computer power supply cable.
- will need a wire cutter
- also a multimeter

whats a relay (Research):

Relay: an electrically operated switch that open's and closes circuits by receiving electrical signals from outside sources.

- I think this will be used to control when the pump will be allowed to draw water and pump it to the system
- will a 5v Relay work?
  - Yes but need to order a module, this kit does not come with a relay module for the relay to attach to

Power Supply Research continued:

So I still don't understand what the diff. is between a live wire and a neutral and and an earth/ground wire.

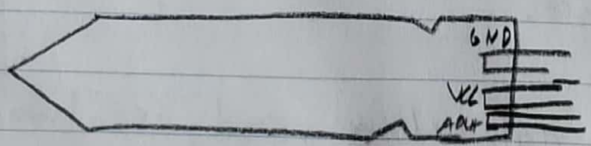
- **Live wire**: carries a high voltage, and is always carrying an electrical current while connected to a power source
- **Neutral wire**: allows any excess current to be fed to ground and also completes the circuit

• ground wire: not needed for the ~~wire~~ circuit to function but it allows for protection in case of a short circuit, protects circuit.

DC power Supply Research:

- Questions
  - if a component has 12 v going in (Arduino uno R3) then has a 5v wire going out how does this affect the power needed to run the Arduino?
    - So it looks like the soil moisture sensor only needs 3.3V to 5v of power which
    - Each of the 14 digital pins on the UNO can be used as input or output they operate at 5 volts, each pin can provide or receive 20mA Max is 40mA cannot exceed
  - Resistance of a wire? 16cm?
  - Voltage drop of components in series?
  - Do I treat components like a capacitor?
    - Soil Moisture Sensor is kinda like a capacitor

Soil Moisture Sensor:



- VCC: is the Power Supply Pin
- GND: Ground
- Aout: Analog voltage output, As Moisture level increases, the output voltage decreases and vice versa

12V water pump:
- has 8mm inlet outlet holes for tubing to connect to (diameter)

Resistance of wire:
- assuming #22 gauge solid wire
  - 2 inch jumper → ~3 mohm (milliohm)
  - 6 inch jumper → ~9 mohm

$R = \frac{\rho L}{A}$

ρ = resistivity
L = length
A = cross sectional Area

Copper resistivity = 1.68×10^{-8} ohm
Cross sec Area = 0.33 mm^2 or $0.33 \times 10^{-6} \text{ m}^2$

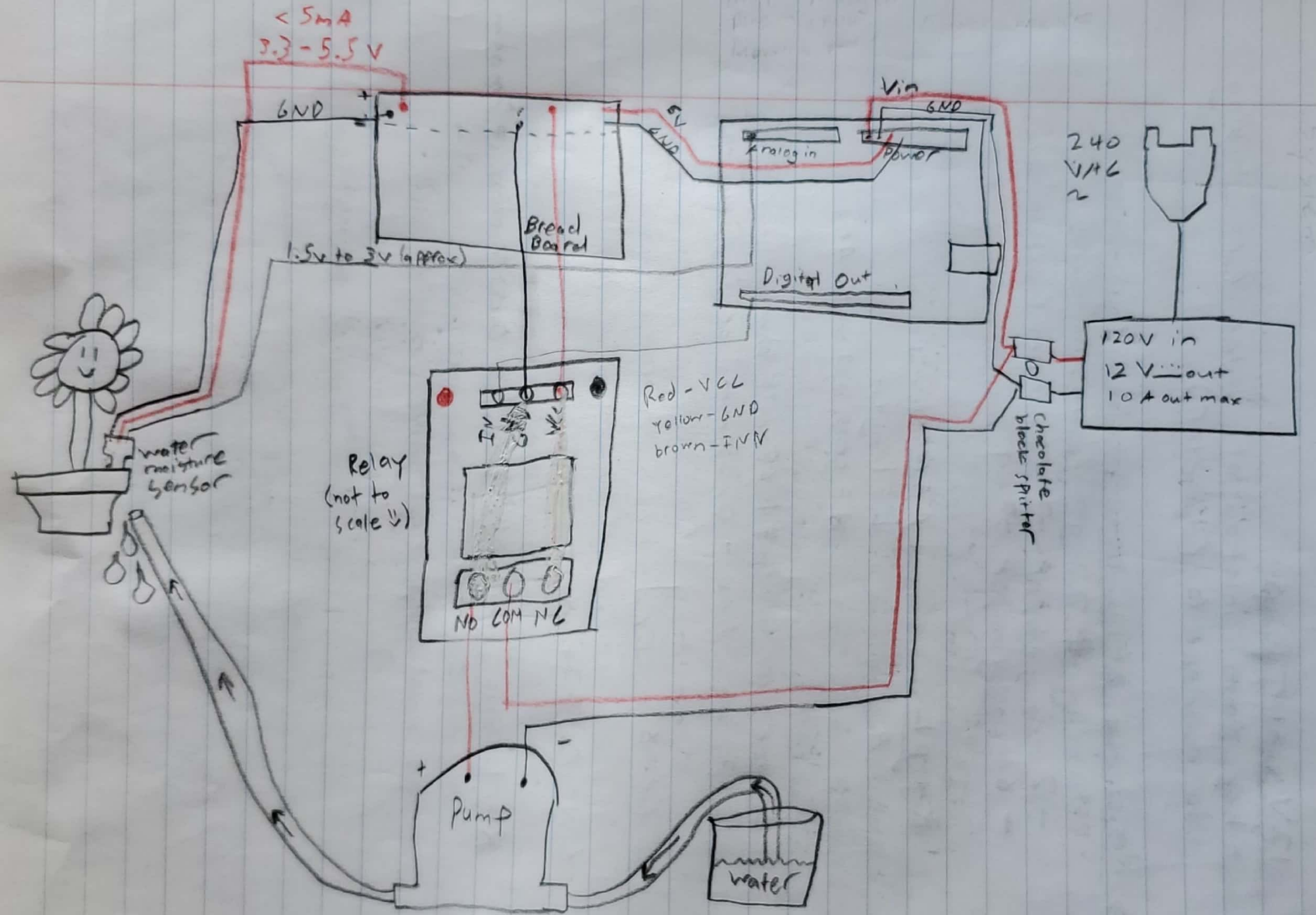
so for 6 in ex

6 in = 0.1524 m

$R = \frac{1.68 \times 10^{-8} \text{ ohm} (0.1524 \text{ m})}{0.33 \times 10^{-6}} = 0.007 \text{ ohms} = 7 \text{ mohm}$

so basically negligable

Irrigation System Circuit Diagram



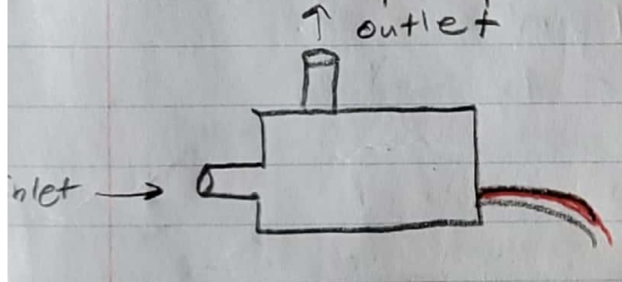
- 12V in, 10A → this might blow up my Arduino
  - So it looks like my arduino shouldn't blow up cause it should only draw the current it needs

- Normally the Arduino recieves 5V DC from USB, but the Uno will be doing other functions so this is good

Things to do / Questions

- figure out how pump works?
- test Arduino board
- test Soil moisture Sensor
- how to trigger relay?

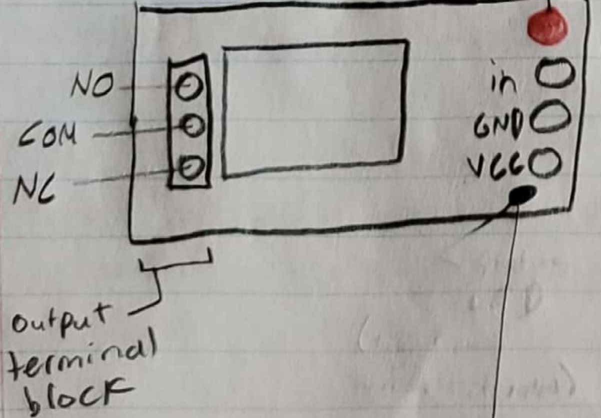
Water pump

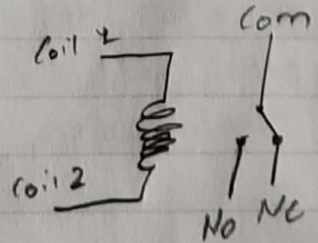


Relay

Power LED (red when powered on)

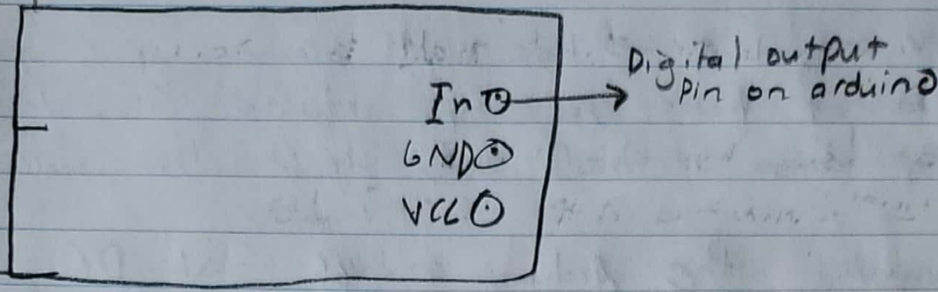
terminology
COM: common terminal
NC: normally closed
NO: normally open





status LED (lights when activated)

Relay cont.



<u>Control Pin</u>: also known as In
- this will connect to the Arduino
- The input pin is active low meaning that logic LOW activates the relay and a logic HIGH deactivates it.

This module operates on 5 volts and draws approximately 70mA (.07A) when activated

<u>GND Pin</u>: common ground pin
<u>VCC Pin</u>: provides power to module

Testing Water/Moisture Sensor

- Bone Dry Soil is ~512
- Water (submerged is ~220
-

- Im going to go with meas. >450 for needs to be watered

- after watering measurement is at 263 but just to be safe I will go with 300 so I don't flood my plant.

Final values:
<300 is too wet
300 - 400 is ideal range
>400 is too dry

Component tests
- Relay works, I uploaded a simple program that switches the relay every 3 sec.

- Water pump works, found out that it has to be Submerged in water. Initially, I tried to use a tube to draw water out of the water bowl, but the pump doesn't have enough suction power to draw water.

First System Test

• System worked but had trouble with the soil moisture sensor.
  - Could not get relay to activate and provide power to pump when I removed the soil moisture sensor from the pot. Ideally when I took out the sensor from the soil it should have provided a reading that was "too dry" and let the arduino know that it was time to activate the relay
  - I eventually got it to work. I had to readjust the values that determined if the soil was too dry or too wet. For some reason the output value decrease greatly so the system always thought the moisture was too wet or under ideal conditions even if the sensor was in dry air.

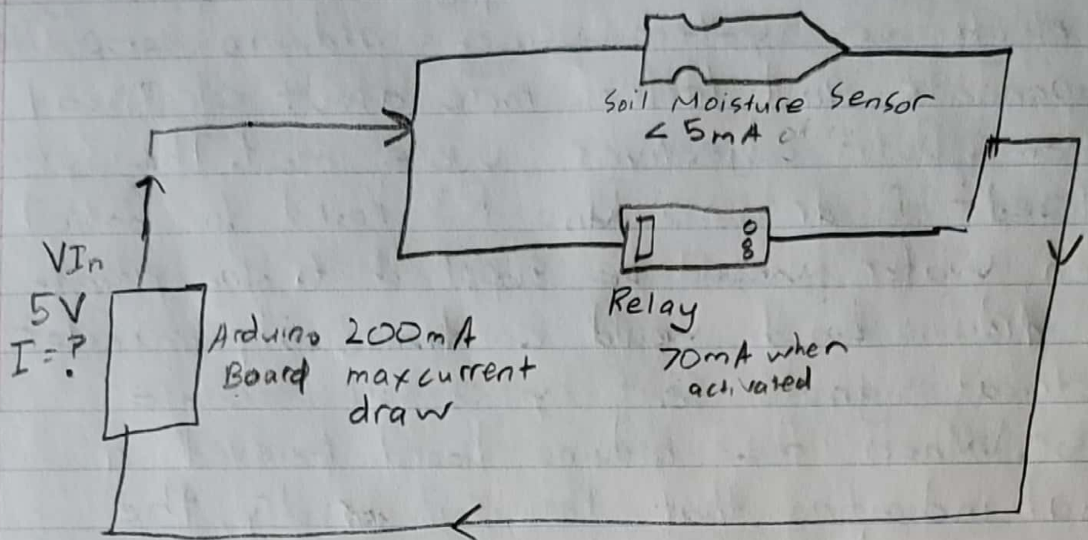
Problem: Arduino board got too hot
• Based off quick research, the most likely reason that the board is overheating is because of too much current draw.
  - The arduino board is powering the moisture sensor and the Relay.

  • Power Requirements for Relay:
    - operates on 5V and draws approximately 70mA when the relay is activated

  • Power Requirements for Soil Moisture Sensor:
    - operates on either 5V or 3.3V, and draws <5mA of current

System Test cont.

• Diagram of Arduino Board Circuit Redrawn



• Recorded a current of .03 A (30mA)
  - this is most likely when the Relay is not activated,
  - far from 200mA recommended max current draw

• <u>observation</u>: the arduino Uno was getting warm when it was just the Uno being powered 12v through VIN. It was not powering any other components. Upon further research it is recommended that the Uno is not supplied 12v of power as their is a tiny heat sink that does not do a good job of dissipating heat
  - there is a component called a buck dc to dc converter that can supposedly lower voltage. I will need to do more research. This would be ideal because I don't want to lower the voltage provided by the power supply since the pump requires 12V
  - <u>Arduino Uno Power Specification (VIN)</u>:
    • Recomended 7-12v although 12 will likely cause it to overheat.

Conclusion

The objectives of this project were to design an irrigation system using arduino compatible components and to learn more about electrical systems. Both objectives were met. The system utilized an arduino uno R3 board to control when water would be supplied to the plant. The arduino board would continuously monitor electrical signals sent by a soil moisture sensor. When the arduino board recieved a signal indicating that the soil was dry, the arduino would activate a relay which would then provide power to the water pump.

This project gave me a better understanding of how electrical components in a system interact/communicate with each other through electrical signals. There were two main concerns once the system was assembled. One was that the soil moisture sensor would send inconsistent signals. This was most likely due to different moisture levels in different parts of my room. The other concern was that the arduino board became hot after a short amount of time. Based off testing and research, the most probable reason that the board overheated was because of a high voltage being supplied to the board for power.

Conclusion Cont.

For future projects I will try and keep a log of power requirements for the components in a system. This will ensure that components are not damaged. To prevent the the board from overheating I would try and use a buck Converter and resistors to decrease the voltage supplied to just the arduino board.