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Measuring the Efficiency of a Geo-Thermal Heating System

A software solution to analyzing geothermal performance

TEAM GEOTHERMAL | CSIS 2810-402

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# A Word from Our Project Sponsor:

A person wearing a suit and tie smiling at the camera

Description generated with very high confidenceThe environment is the privilege of every responsible citizen. Electric cars to residential solar energy, reducing our carbon footprint has never been convenient, or more important.

Being able to visualize that footprint is critical to reducing it. To that end, our data visualization software will take you leaps and toward minimizing your footprint and taking your part in the world, in a cleaner, safer place for everyone.

# Project Overview

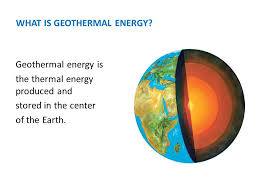
We aimed to create a system to monitor and log data from multiple sensor points. This data is then manipulated to give the user a complete picture of the efficiency of his/ hers geothermal heating and cooling system,

We aimed to Create a system to monitor and log data from multiple sensor points. This data is then manipulated to give the user a complete picture of the efficiency of his/hers geothermal heating and cooling system. This data is regularly uploaded from the local server to the cloud for ease of access and storage.

The five data points that are being measured am the ambient temperature, the temperature of the water as it enters the system, the temperature of the water as it leaves the system, the temperature of the water as it enters the tank, and the temperature of the water as it leaves the tank. These five temperature readings taken together make up a complete picture of the geothermal heating and cooling system's efficiency.

The data is read from the sensors and published to the cloud where it is than retrieved and visualized for consumption on demand. The graph has been optimized for visualizations of up to one year at a time, with the ability to pan, scale, and crop the visualization in real time.

# What is Geothermal?

**HARNESSING THE POWER OF THE SUN, BY TAPPING INTO THE EARTH.**

Geothermal heating works by taking advantage of the earth's insulating properties. Temperatures fluctuate greatly throughout the year, especially during the summer and winter months. Because of this great variance in temperature, traditional heating by air is at its least efficient when it is most required.

In contrast, the earth stays relatively warm throughout the year, with very little variance once past a certain depth. This is because the earth traps over BO% of the sun's heat Geothermal heating and cooling takes advantage of the earth's insulating properties by heating water in a series of pipes underground. These pipes sometimes called a loop, then feed the water into the home and use that water to heat the air.

This provides a remarkably efficient heating system during the summer, and by running the loop in reverse, heating the water in the home through ambient air, and expelling it into the cooler ground, we are able to Cool the home in the summer.

Mileage varies, but this system of heating and cooling tends to be several times more efficient than traditional heating and cooling solutions.

# Why Geothermal?

1. Geothermal Power is Reliable Power

2. Geothermal Power Creates Jobs and Spurs Economic Growth

3. Geothermal Energy Promotes National Security

4. Geothermal Energy is Environmentally Friendly

5. Geothermal is Increasing U.S. Exports Abroad

6. Geothermal Supports Local Economic Development

7. Geothermal is a Versatile Energy Resource

8. Geothermal Makes Good Economic Sense

9. Geothermal Uses Humanly Approachable Technology

10. Geothermal Energy is Widely Available

A picture containing screenshot

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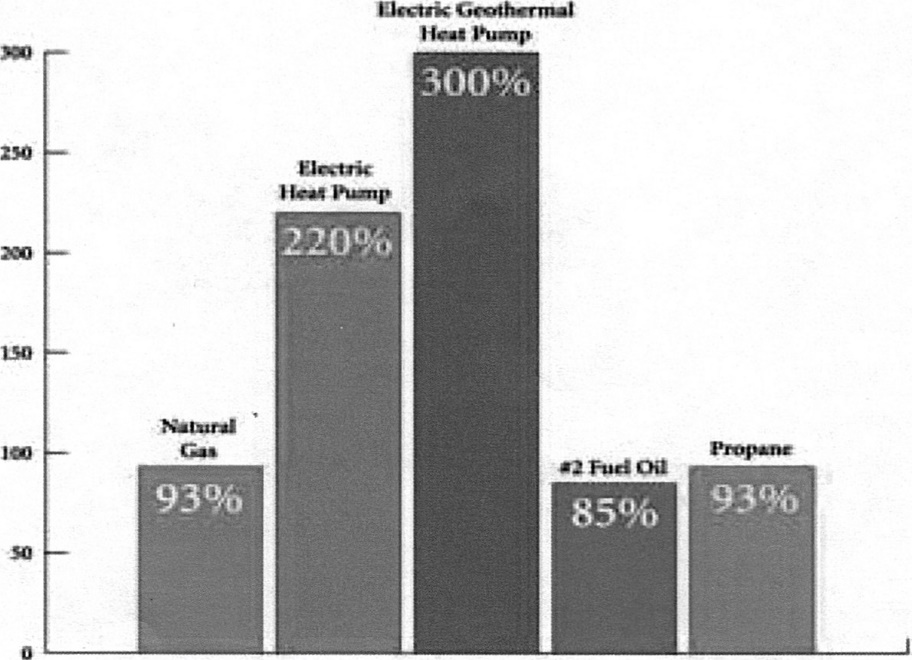
## Understanding the Problem

Estimated efficiency (left) shows the potential efficiency gains of a geothermal heat pump. Myeyewise.net graph (right) depicts a previously existing solution that is no longer maintained, but upon which this project was based.

BY COMPARING THE TEMPERATURES THROUGHOUT THE SYSTEM, AS WELL AS THE AMBIENT TEMPERATURES INSIDE AND OUT, WE CAN HAVE A CLEAR UNDERSTANDING OF HOW WELL THE SYSTEM IS FUNCTIONING.

There is a lot to consider when taking the plunge to invest in a geothermal heating system. How much will it cost, what will the savings be, when will the savings and costs balance out, and what impact is this having on my carbon footprint, just to name a few. Once you've considered these options and determined to move forward, determining whether the investment was worth is can be nearly impossible until the savings begin to catch up with your investment costs.

How can we determine whether the investment is truly living up to the promise of a cost saving, energy efficient, completely green energy powered heating solution? The key is data. By comparing the temperatures throughout the system, as well as the ambient temperature inside and outside, we can have a clear understanding of how well the system is functioning.



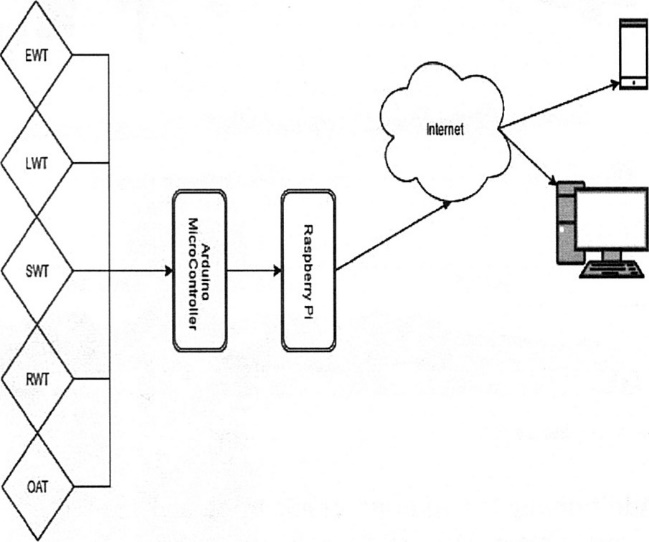
Getting the data is only half the problem. Once we have the data, we have to be able to consume it. Presenting the information in a way that is simple to comprehend and has impactful meaning requires being able to visualize the data in a graphical form. It also requires being able to visualize the various datasets individually, and together as a complete system.

What we require then is a solution for graphing the data and analyzing the graph once we have it. Since none of this data is static, we also need to be able to view the graph updates in real time without manual intervention.

# Solution:

# OUR SOLUTION IS DESIGNED TO BE PORTABLE, CLOUD READY, AND SIMPLY TO INSTALL.

Our solution is designed to be portable, cloud ready, and simple to install. The complete setup consists of an Arduino Nano, Raspberry Pi, and five DS18B20 temperature sensors. The sensors send the data to the Arduino, the Arduino interprets the data and sends it to the Pi, and the Pi sends the data to the cloud. It also serves a local web server for displaying data visualizations. On the backend we use a combination of MySQL, php, and a cloud based IOT platform called ThingSpeak.

The sensors connect to the Arduino in the OneWire configuration and send the signal to the Arduino on its digital 10 pin number 2. The data is then interpreted by the Arduino using the purpose built, and open source Dallas OneWire library. The data is then sent to the raspberry pi where a python script runs as a daemon. This script formats the data for consumption by the ThingSpeak API and attempts to submit the data to the API. It also submits the same dataset to a locally running MySQL server for local storage in the event of a network outage.

The raspberry pi hosts a local Apache server serving the MySQL/PHP stack. The server hosts a local copy of the webapp that displays the data visualizations. The application is reactive, responding to new data in real time without the requirement of a browser refresh. It is designed to run without the aid of a keyboard or mouse, and to be accessed from a monitor local to the server, or from a phone or tablet on the WIFI. The web app polls for new data on an interval set during install, in accordance to the frequency that new data is submitted to the database.

# Improvements to come

A static solution is a useless KEY TO A PRODUCT CONTINUOUS. It is not enough to leave provide a solution and let it become static and unmaintained. Our shortlist of improvements includes some of the following:

1. Provide a scaling option to change the dataset from I year to some other scale.

2. provide the ability to use more sensors, and automatically graph the data from these sensors as

well.

3. Create a mobile app. With notifications when temperatures reach a specified threshold.

4. Provide the ability to update the data of other various sensors.

![A screenshot of a social media post

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confidence](data:image/jpeg;base64,/9j/4AAQSkZJRgABAQEAYABgAAD/4RD+RXhpZgAATU0AKgAAAAgABAE7AAIAAAARAAAISodpAAQAAAABAAAIXJydAAEAAAAiAAAQ1OocAAcAAAgMAAAAPgAAAAAc6gAAAAgAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAEJyYW5kb24gUm9iaW5zb24AAAAFkAMAAgAAABQAABCqkAQAAgAAABQAABC+kpEAAgAAAAMxOQAAkpIAAgAAAAMxOQAA6hwABwAACAwAAAieAAAAABzqAAAACAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAA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8Tv+iR/+XLbf/E0f8Jt8Tv+iR/+XLbf/E0Aek0V5t/wm3xO/wCiR/8Aly23/wATWJ/bXxc/4T7+3/8AhXtx/Z/9mfYv7I/4SW38rzfN3+f6btvy/dzjv2oA9korzb/hNvid/wBEj/8ALltv/iaP+E2+J3/RI/8Ay5bb/wCJoA9Jrzb4yf8AMhf9jnp3/tSj/hNvid/0SP8A8uW2/wDiaxPEB+IvjfVfC0GofDz+xrTTPEFpqU91/bdvcYSNiGGwYPRieMnjGOaAPZKKKKAM6iiigCxp3/INg/3BVmq2nf8AINg/3BVmgAooooAKKKKAI7a2gs7WK1s4Y4LeFBHFFEgVI1AwFUDgAAYAFSUUUAFFFFABRRRQAUUUUAFFFFABRRRQAVHc3CWtrLcSiRkhQuwijaRyAMnaigsx9AASegFSVHctOtrK1nHHLcBCYo5ZCiM2OAzAMVBPUgHHoelAHNWfjN73w7bXq6VJDqN7qFzp1pp00y5M0MkykPIuVUBYHdiN2ApC+YdoaOX4hWItpLm3s7h4bGFrnVy5VW06JZJInyMkSMskM2QhI2wyEFiY1ko6T4a8Rx6ZH9vg0uC+03VrnVrAQXsk0U7TvcF4pcwoUAS5ZQ67vmw5UgbGJPh3OllfWlvqEbprtrJaaxI8ZUhZJp5ne3UE7TuupkCuWwGjYlvLZZQDu6KKKACiiigAooooAKKKKACiiigAooooAKKKKACsTxL4k/4R5bDbp9xeNeXtvbExjbHAss8cJkdzwMGVcKMsx6DaHZduub8a6frmq6daWug2unzbL22u5Wvbx4NvkXEUwVQsT53eWVJONuQfm6UAVh4wvpfGtxocFpo6RQ3otFa71dorm4xBDPI0UAhbfsSYcbx052g5q7ofiyDW7qCNbaSCK/tTfaZKzA/bLYFAZMDmM5kjO1udsiH73mJHm33hzVdR1DL6bodml5dWF7fX1tI32gNbSRyCEjyx543RlVkZo8LJ9z5fns+G/Cc+jXWn/abmOW30XT20vTRGpDvAxiJebPG/EMS4XA+V3/5aBIwDqaKKKACiiigAooooAKKKKACiiigAooooAKKKKACuSvfG8mkXJudd0z+z9Eea5giu3ldpwYI5ZHd4PL4jKW8rKyu5YGM7RuO3ra4mfw3rmtX+s23iO00+Sx1OG5sFvrbUX8+1s5AQqRQtBtVj8hclzuYZyVSNFALp8ZvHIdOuNKkt9eleNbXTpJlIkEqyvGzSrlVAWCYv1KmFwokzGZNvR9Vg1rTEvbZJIwXkikilADxSRu0ciNgkEq6spKkqcZBIwTzcvhPVbnU18RXdzZvr1q8Jt4olZLWRYUuIwHzudTILuY5GfLLRjEnlsZeg0DSP7D0hbRp/tErTTXM0oTYrSzSvLJtXJ2rvkbAJJAwCWPJANKiiigAooooAKKKKACiiigAooooAKKKKACiiigCjrF9Pp2mPPZ2Ul9cF44ooEyMs7qgLEAlUBbczAHaoY4OMHjb34j31jftp9xpuj2l3aef9vmv9ZaC0g2C1ZdsxgJbcL2IfMiYYMOeCeu8QprEug3CeG3t49RbaInuH2KoLDeQ2x8Ns3bSUYBtuVYZB5+30bWbS102e38M+G/tmnPMsEcuoSyugkALTLdNAXDsd+8FCX3BjJkEMAXj4u8i/W3vLLbFBNBZahcwy747a8mEZjiUFVaRf3sYL7Rgyx8EeYYukrhNI+Hc+kafZaOmoRzaYr2F1dSGMrM09nHAiBBkqEf7NExzkrtcDd5gaLu6ACiiigAooooAzqKKKALGnf8g2D/cFWarad/yDYP8AcFWaACiiigAooooAKKKKACiiigAooooAKKKKACiiigAooooAKKKKACiiigAooooAKKKKACiiigAooooAKKKKACiiigAooooAKKKKAK2oX8OmWEl3cpcPFHjcttbSXEhyQOI41Zj17A4HPQVR0jxRpOt6NHq1lcSJYzOiRTXdvJaiUvtEezzVUsGLqFIyGJwCTWvXmzC80j4N+Cw1vrEN9Z/2QJILGC4aVAhi89ZI4gWKiIShlcYzgY3baAPSaK8y1KDxZF49v7+wOqHT11a2QL5jtF5Z/s5PliJwU2S6gWKjbuBZjujQrJ8NoPEiaqZPEGo6hPM1l/xMoJ7C5iiju9yfdkmmZGwfNA+yosRHJwPKFAHd6xqsGi6Y97cpJIA8cUcUQBeWSR1jjRckAFnZVBYhRnJIGSK0/ijSbbWRpc1xILjekTOLeRoYpHxsjeYL5aO25MIzBjvTAO9c0vGP+itoWsy/8emkamLi7I6pE8E1uZPQKhnV3JICojt2wc3UTdad4yc6CusRXd7e28lzaGzElheIRHHLOZ9h8tlhQgIZYyWhX5G3jzADtqo6pqsGkR20t2knkz3UVqZEAIjaRtkZYZzguyJwDguCcKGYeU6NB4yTTp5L7UdYnuWhg/tmBLC7i8tvtEP2jypJJmDMIvtQX7Eiqeq4Pkiuk1bybj4ZatpOnf2ww1rzNM0xNX8wzM88ezIEv7/y0JkkYyAuESRlBjVKAPQKKKKACiiigAooooAKKKKACiiigAooooAKKKKACiiigAooooAKKKKACiiigAooooAKKKKACiiigAooooAKKKKACiiigDOooooAkt5fs9tHFjdsXGc4zUv2v/Y/WiigA+1/7H60fa/9j9aKKAD7X/sfrR9r/wBj9aKKAD7X/sfrR9r/ANj9aKKAD7X/ALH60fa/9j9aKKAD7X/sfrR9r/2P1oooAPtf+x+tH2v/AGP1oooAPtf+x+tH2v8A2P1oooAPtf8AsfrR9r/2P1oooAPtf+x+tH2v/Y/WiigA+1/7H60fa/8AY/WiigA+1/7H60fa/wDY/WiigA+1/wCx+tH2v/Y/WiigA+1/7H60fa/9j9aKKAD7X/sfrR9r/wBj9aKKAD7X/sfrR9r/ANj9aKKAD7X/ALH60fa/9j9aKKAD7X/sfrR9r/2P1oooAPtf+x+tH2v/AGP1oooAPtf+x+tH2v8A2P1oooAPtf8AsfrR9r/2P1oooAPtf+x+tH2v/Y/WiigA+1/7H60fa/8AY/WiigA+1/7H60fa/wDY/WiigA+1/wCx+tH2v/Y/WiigA+1/7H60fa/9j9aKKAD7X/sfrR9r/wBj9aKKAD7X/sfrR9r/ANj9aKKAD7X/ALH60fa/9j9aKKAD7X/sfrR9r/2P1oooAPtf+x+tH2v/AGP1oooAPtf+x+tH2v8A2P1oooAPtf8AsfrR9r/2P1oooAPtf+x+tH2v/Y/WiigA+1/7H60fa/8AY/WiigA+1/7H60fa/wDY/WiigA+1/wCx+tH2v/Y/WiigA+1/7H60fa/9j9aKKAD7X/sfrR9r/wBj9aKKAD7X/sfrR9r/ANj9aKKAK1FFFAH/2Q==)

# Wiring Diagram

A circuit board

Description generated with high confidence

*Power Supply Excluded. Diagram made with Fritzing.*

# Source Code

### ARDUINO CODE:

// credit to Miles Burton for the libraries in use

#include <OneWire.h>

#include <DallasTemperature.h>

// pin2

#define ONE\_WIRE\_BUS 2

//OneWire reading all pins

OneWire oneWire(ONE\_WIRE\_BUS);

// tell Dallas Temperature to read pins

DallasTemperature sensors(&oneWire);

void setup(void)

{

// start serial port

Serial.begin(9600);

// Start sensors

sensors.begin();

}

void loop(void)

{

String temps;

//get temperature readings

sensors.requestTemperatures();

for (int i=0; i <= sensors.getDeviceCount()-1; i++){

temps.concat((String)sensors.getTempFByIndex(i) + " ");

}

Serial.println(temps);

delay(1000);

}

### PYTHON CODE:

**import** serial  
**import** subprocess  
  
*#opens port for comunication with arduino*ser = serial.Serial(**'/dev/ttyACM0'**,9600)  
s = [0,1]  
  
counter = 0  
  
*#opens a process allowing me to use the command line to open gnuplot*proc = subprocess.Popen([**'gnuplot'**],  
 stdin=subprocess.PIPE,  
 )  
**while True**:  
 *#saves data to file* f=open(**'data.dat'**,**'a+'**)  
 s[0] = str(ser.readline())  
 print s[0]   
 f.write(str(counter)+**" "** + s[0])  
 f.close  
 counter = counter + 1  
 *#uses command line to plot with gnuplot* proc.stdin.write(**'set xrange [%d:%d]\n'** % (counter-100, counter+100))  
 proc.stdin.write(**'set yrange [0:100]\n'**)  
 proc.stdin.write(**'set xlabel "Time (Sec)"\n'**)  
 proc.stdin.write(**'set ylabel "Temperature (Degrees)"\n'**)  
 proc.stdin.write(**'plot "data.dat" u 1:2 t "One" with line lw 2, "data.dat" u 1:3 t "Two" with line lw 2, "data.dat" u 1:4 t "Three" with line lw 2\n'**)

# 

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