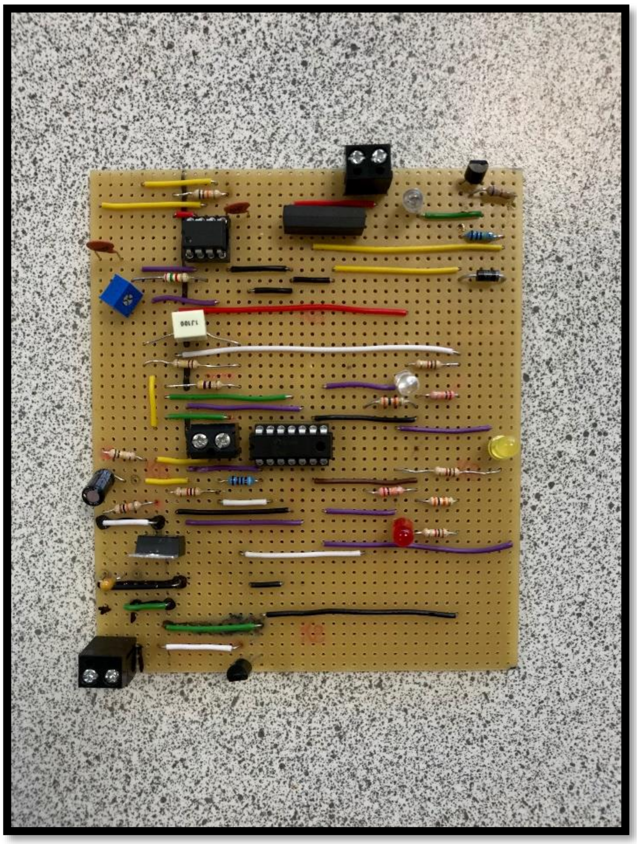
Waterford Institute of Technology



TEMPERATURE SENSOR WITH VCO OUTPUT RELAY DRIVER

Analogue Electronic Circuits– Mini Project

Supervisor: Martin Hayes

Brief Overview

This Report highlights the steps taken, along with explanations as to how this temperature sensor circuit was created.

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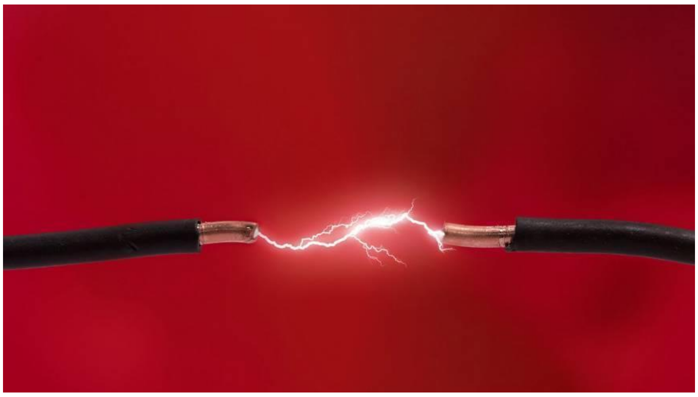
[20015453]

Abstract:

This is a report on the construction of a temperature sensor with a VCO output, which was created as part of a mini project in the Analogue Electronic Circuits module for semester two if the Internet of Things. The report will examine the approach I took, in order to construct this apparatus, further explanations as to what certain parts mean/do, some useful planning techniques used, testing and so forth.



(Google Images, 2018)

A much better understanding of how different components work, connections, and overall circuitry has been achieved from this project. I have also improved on some basics when it comes to creating circuits as such, with the likes of soldering, cutting tracks, preventing short circuits & much more. Tasks that were a bit shaky at first, coming from a computer science path, which now almost feel as second nature.

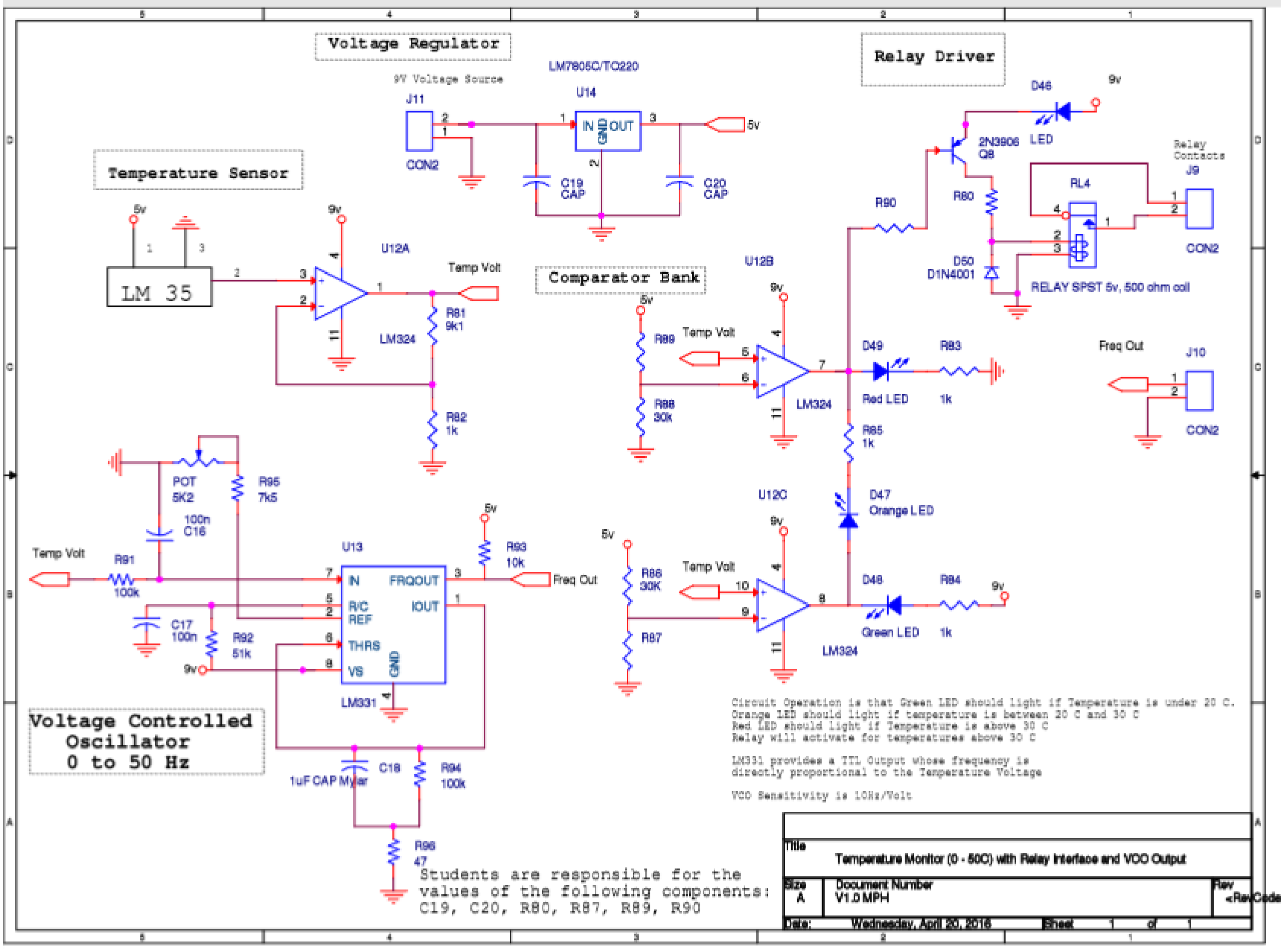
(skipprichard.com, n.d.)

Table of Contents

Introduction:

In this report I will discuss in detail as to how I went about creating this temperature sensor circuit board, which was created with reference to a circuit schematic – which our supervisor, Martin Hayes handed out.

Schematic:



As you can see the schematic was divided up into five different sections - Voltage Regulator, Temperature Sensor, Comparator Bank, Relay Driver, and the Voltage Controlled Oscillator.

This project consisted of a small temperature sensor display which was implemented using a different range of LED – its operation in this case it was set such that:

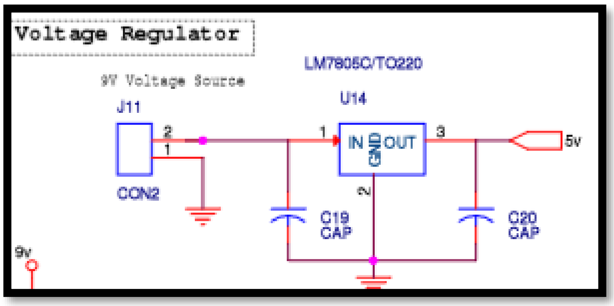
- If Temperature's under 20°C, Green LED should light (+ Relay light, which just indicates that the relay is not activated).
- If Temperature's between 20°C - 30°C, Orange LED should light (+ Relay light, which just indicates that the relay is not activated).
- If Temperature's over 30°C, RED LED should light only.

Taking this operation into account along with the schematic, it was time to begin the design process!

Project Description:

I will go through the project itself now in detail, explaining the process, what it does / how it works (which I previously briefly mentioned), and outputs with relevant images.

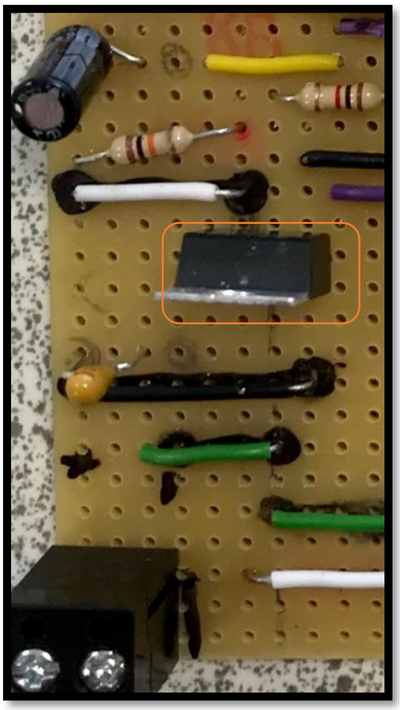
Voltage Regulator:



(Section from Schematic)

This component section shows an LM7805C taking in a 9V supply and giving an output of 5V. From this diagram we have two capacitors without a given value, C19 & C20. The values of 0.33uF (C19) & 0.1uF(C20) had to be looked up in a datasheet for the LM7805 - (sparkfun).

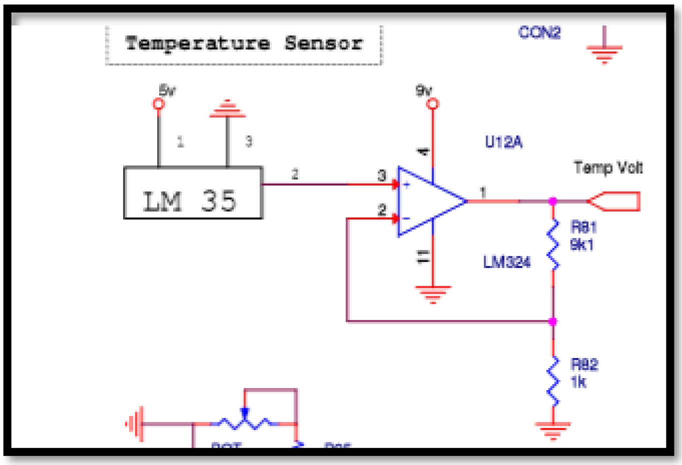
Part location on physical board:



- Black wire here – 9V power supply.
- Green wire – Ground (GND)
- White wire – 5V output.
- C20 is the capacitor top left.
- C19 is the capacitor in the centre left.
- LM7805 is highlighted with an orange box.
- Capacitors in this section were both polarised.

This circuit section will next proceed into the Temperature Sensor section as highlighted in the next page – the 5V output becomes the input of the temp. sensor.

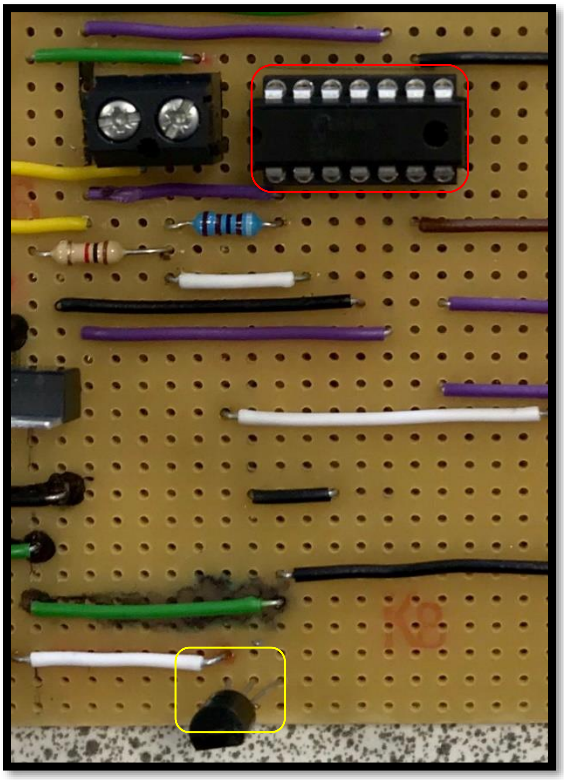
Temperature Sensor:



(Section from Schematic)

This component section shows an LM35 temperature sensor taking in the 5V's as and sending an output to the LM324 amplifier (pin3). The LM324 is the centre of many components in this project as it helps distinguish the different voltages with respect to the temperature of the LM35. This section of the circuit then forwards a new output – temperature voltage.

Physical location on board:

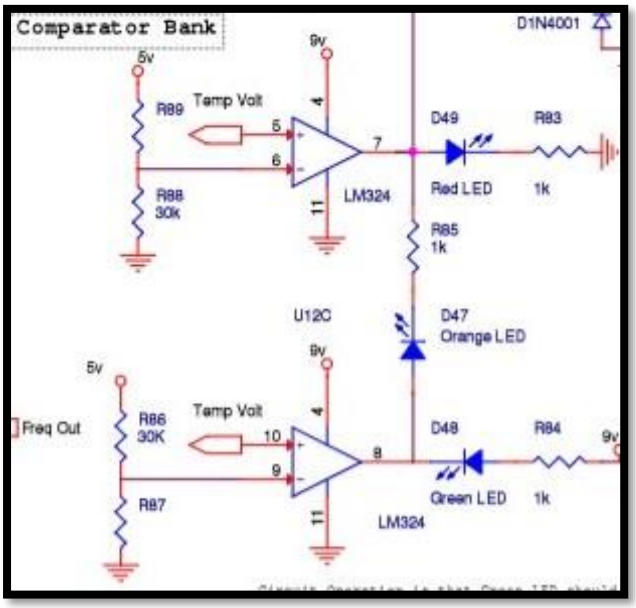


- White wire – 5V input into LM35 pin 1 (yellow).
- LM35 output going to pin 3 of LM324 Amplifier (red), via the short black wire.
- New Temp. volt track output created via short purple line from pin 1 of LM324.
- Pin 3 of temperature sensor is going to GND, as indicated by the longer green wire.

The next section of the board is the Comparator bank, which will show how the various temp volt inputs are affecting the corresponding LED lights.

Comparator Bank:

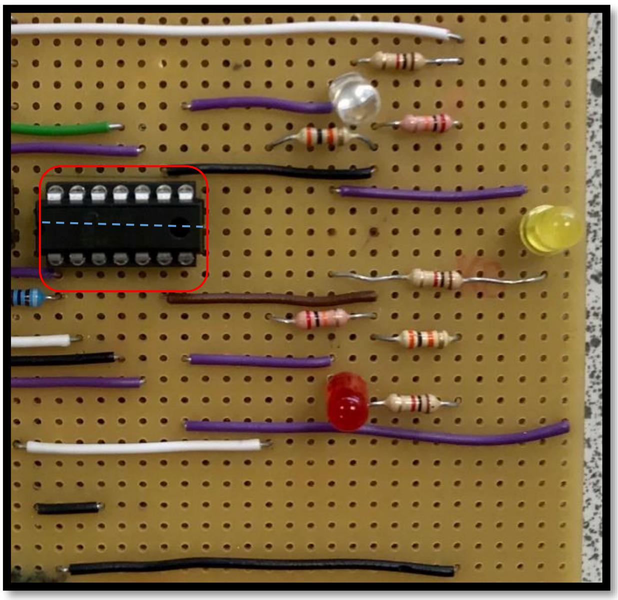
This is a continuation of the LM324 amplifier and its various inputs/outputs.



From this schematic there were two resistors missing, R89 & R87. These were calculated to be 20k for R89:

5V supply, with two resistors in series, one being 30k ohms = roughly 3V across it, therefore the other would have roughly 2V across it, i.e. 20k ohms.

Physical location on board:



If voltage exiting pin 8 is less than that across the Green LED, the Green LED will light.

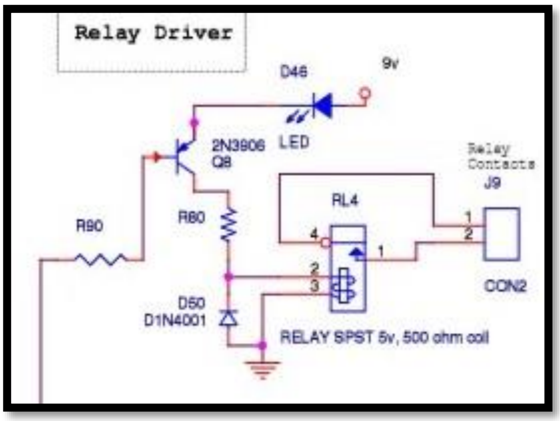
If voltage is > than that across green LED it will pass up through and light the orange.

Else if that voltage is now less than the output voltage across pin 7 orange will go off, and red will remain on.

(Short notice: the tracks on this board - from this view are going vertically) i.e. anything in line vertically is connected, unless the track is broken in between.)

The tracks in between the pins of the LM324 are all broken. (blue dotted line would be indication of the broken track beneath).

Relay Driver:



This section of the schematic is basically taking the output voltage going through the Base leg of the 2N3906 transistor and determining whether or not the Relay LED will light or not. The value for resistors R90 & R80 had to be calculated as follows:

9V supply -> through LED (-2V) = 7V, which is going in through the collector.

The voltage at the base would therefore = 7 – 0.7 = 6.3V.

We know the relay takes in 5V at the coil, which is a 500Ω coil.

Current at pin 2 would therefore be I = V/R = 5/500 = 10mA.

Voltage across R80 = 7-5 = 2V.

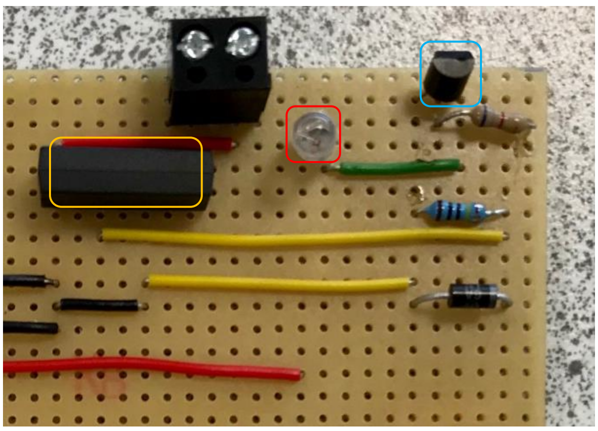
- Therefore R80 = V/I = 2/10mA = 200 Ω. | $I_C = I_E$

Current at Base (I_B) = IC/10 = 1mA.

- R90 = V/I = 6.3/1mA = 6300Ω.

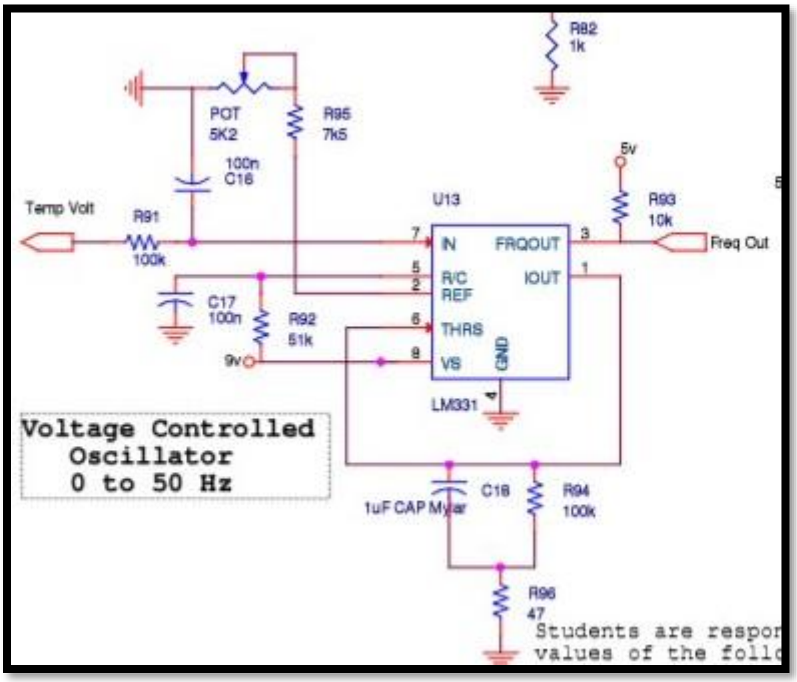
If the voltage entering the base is not big enough to activate the switch, the voltage across the collector will pass down and around and light up the LED. Otherwise the LED will not light if the base voltage is higher. This is the case when the temperature is > 30°C, where the red LED lights, Relay turns off.

Physical location on circuit board:

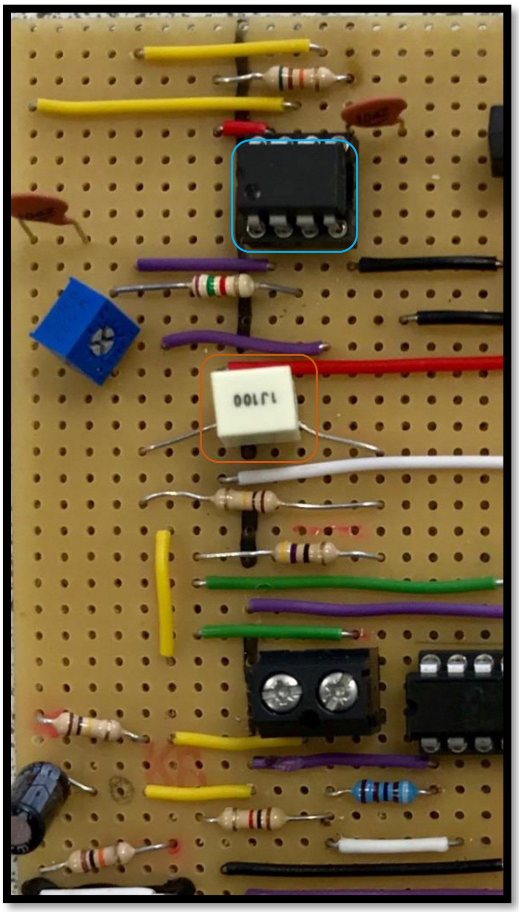


- 2N3906 transistor (cyan box indicator).
- RELAY (yellow box indicator).
- RELAY LED (red box).

Voltage to Frequency converter:



Physical board part location:

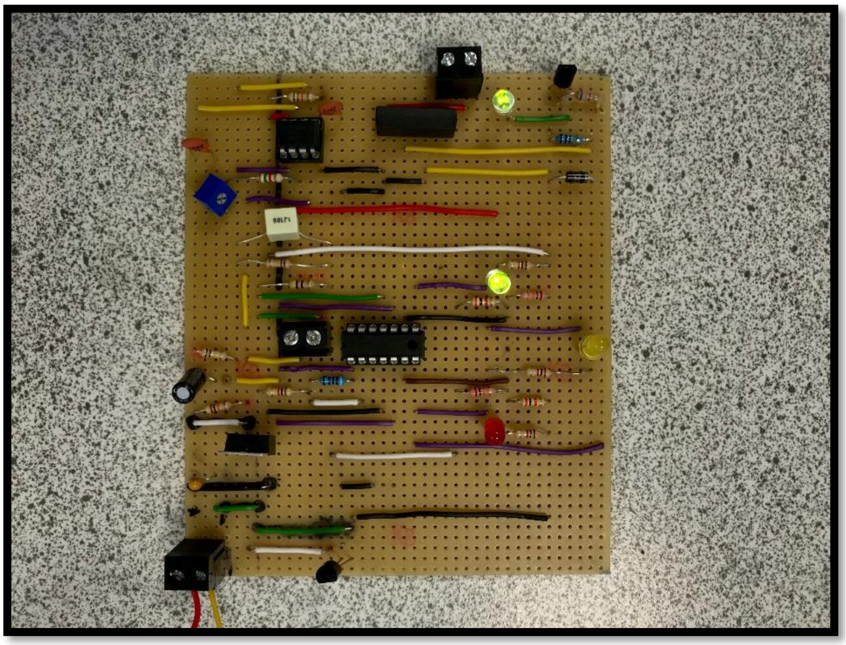


- LM331 (indicated with cyan box) [bottom pins left to right 1-4] [top pins right to left 5-8]
- Myler capacitor (orange box)
- POT (blue)

I have set up and created the frequency converter in the project design correctly, but unfortunately, I do not have the relevant screenshots of the voltage to frequency curve mapping.

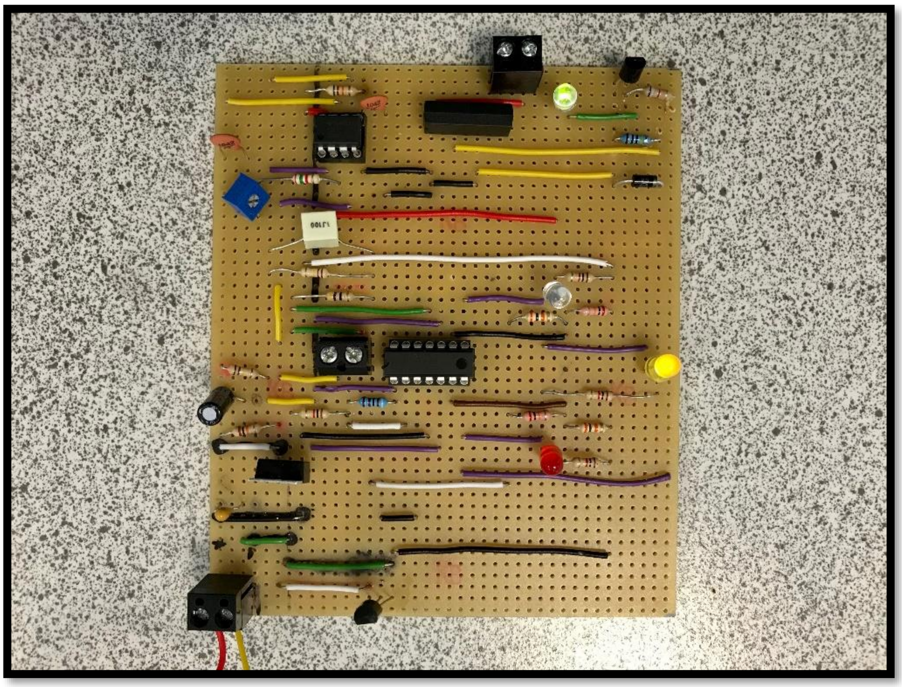
Preview of Temperature Voltage Project in action:

- Below 20°C.



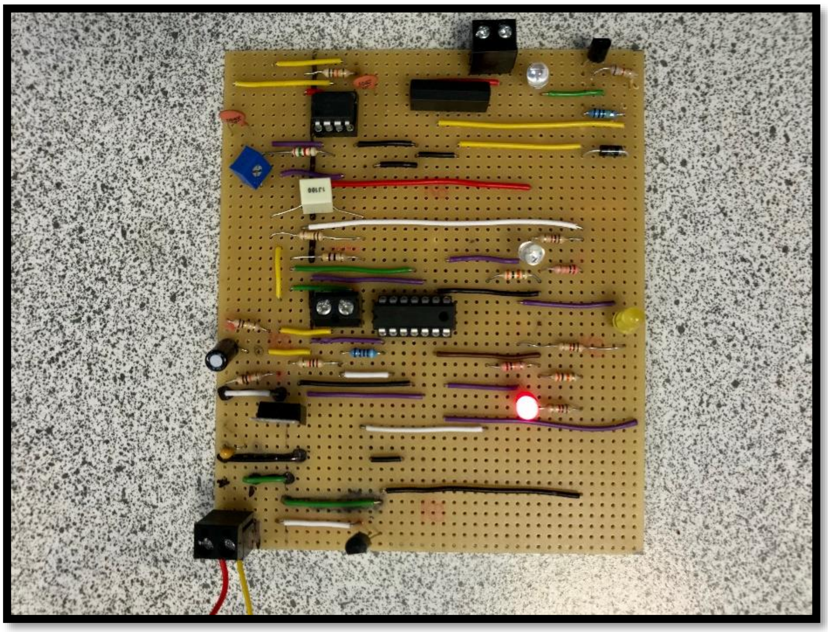
Temperature's under 20°C, Green LED lights (+ Relay light, which just indicates that the relay is not activated).

- Between 20°C - 30°C



Temperature between 20°C - 30°C, Orange LED will light (+ Relay light, which just indicates that the relay is not activated).

- Above 30°C



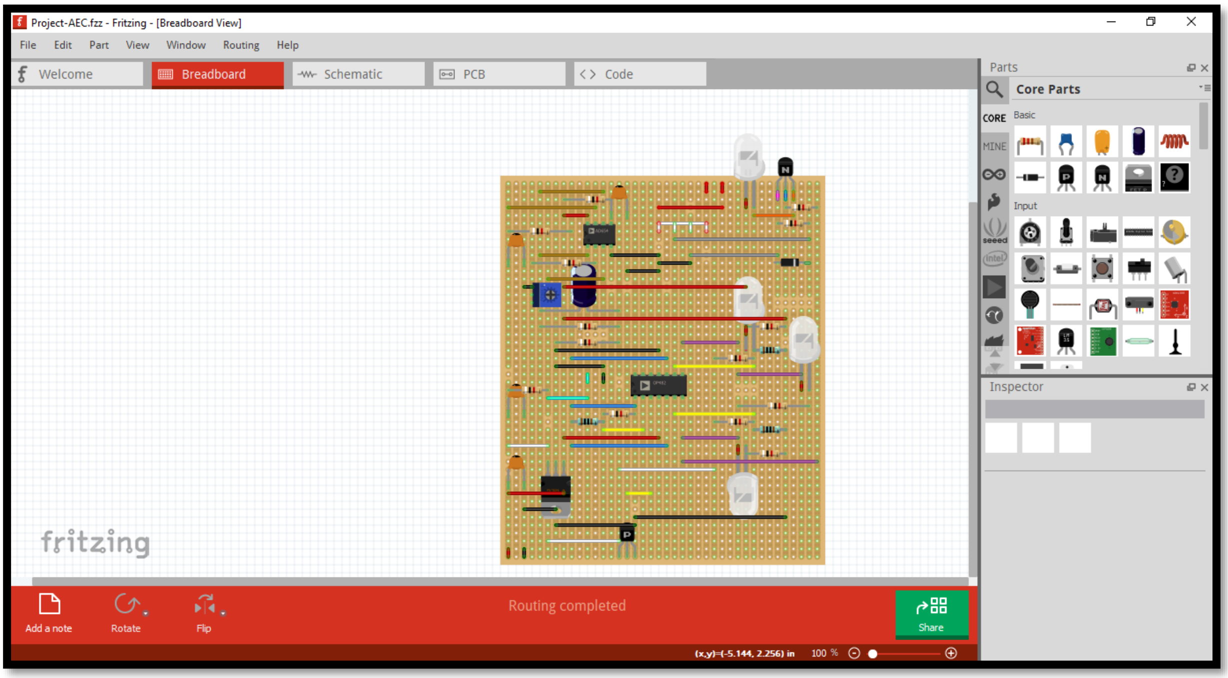
For temperature over 30°C, RED LED will only light.

Hardware Construction:

In order to create this circuit board, I felt it was necessary for me to firstly make a plan of the board itself, along with all the components and where tracks should be broken etc.

This was all down to an software app called Fritzing - http://fritzing.org/home/

I used this to create my design, which simply meant that all I had to do was physically recreate that design template. Fritzing design below.



(Frizting, n.d.)

During debugging some parts were rotated/relocated, and an additional track was cut, which had been shortening the circuit to the transistor. This caused problems for some time and it was quite challenging to overcome. Before these changes were made the red LED would remain constantly on – as a result of that shorted track.

Some additional help was needed, and after some long analysis the problem was discovered – with some debugging help from our supervisor, who so kindly helped. It's always the smallest things that can cause the biggest problems!

Below are the main tools used in the creation of this board & their uses:

- Soldering Iron: used to solder components to the circuit board.
- Solder: wire heated by Iron in order to stick the components.
- Wire-cutter: used to break tracks & trim wires.
- Plier: used to grip smaller items/bend wires etc.
- A Digital-Multimeter: used for testing connections.
- Power source: used to power up the circuit board and test connections.

Conclusion:

In conclusion, this project has been a great experience to work on. I've mentioned this briefly before but, I've now got much better understanding of how different components work, connections, and overall circuitry has been achieved from this project.

I have also improved on some basics when it comes to creating circuits as such, with the likes of soldering, cutting tracks, preventing short circuits & much more. It's been difficult at times but now that I have had the chance do create such an apparatus it really has opened my eyes to how all this works & also why this and that behaves as it does.

A lot of questions have been answered through the progress on this mini project and it truly has been an interesting experience/learning curve in my studies.

References

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