Self Adaptive Colpitts Oscillator using ML Techniques

Report

EC2.202a. Electronics Workshop II

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Aim of the Project:

The aim of the project is to make a colpitts oscillator self adaptive to the environment in case of temperature changes.

Introduction:

What is a Colpitts Oscillator ?

A Colpitts oscillator is a type of electronic oscillator circuit that is used to generate high-frequency signals in the radio frequency (RF) range.

The Colpitts oscillator consists of an LC resonant circuit, usually made up of two capacitors and an inductor, and a transistor or vacuum tube amplifier. The LC circuit provides the feedback necessary for oscillation, while the amplifier provides the gain required to sustain the oscillation.

Applications

The Colpitts oscillator is commonly used in applications such as radio receivers and transmitters, frequency synthesizers, and signal generators. It is known for its high frequency stability and low phase noise.

Self-Adaptive

Temperature can have a significant effect on the operation of a Colpitts oscillator. The capacitance and inductance values of the tank can change with temperature, which can alter the oscillation frequency of the oscillator. This can lead to frequency drift or instability, which can be a problem in applications that require precise frequency control.

To avoid this, the circuit can be made self-adaptive by reading in the temperature and adjusting the components to stabilise the circuit. An ML model is prepared based on the simulation of the circuit while changing the temperatures and that is fed into a neural network on the arduino that is used to adjust the frequency of the oscillator.

Components

1. Heat sensor
2. Inductor
3. Capacitor
4. Resistor
5. Arduino
6. Connecting Wires
7. Breadboard
8. Function Generator
9. DC Power Supply
10. Oscilloscope

Stages:

1. Simulation of colpitts circuit
2. ML Model to make it self adaptive
3. Hardware of colpitts
4. Hardware of self Adaptive circuit

Colpitts Oscillator Circuit: Simulation

The basic operation of a Colpitts oscillator involves the charging and discharging of the capacitors in the LC circuit, which causes the voltage across the circuit to oscillate at a particular frequency determined by the values of the inductor and capacitors. The amplifier provides the necessary power to overcome the losses in the circuit and maintain the oscillation.

The circuit is made in MicroCap Simulator.

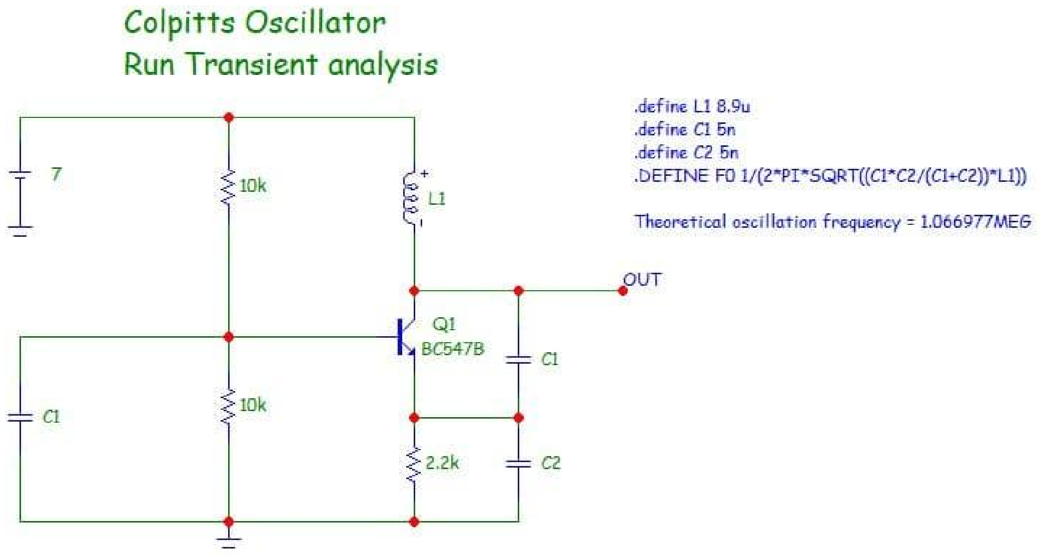
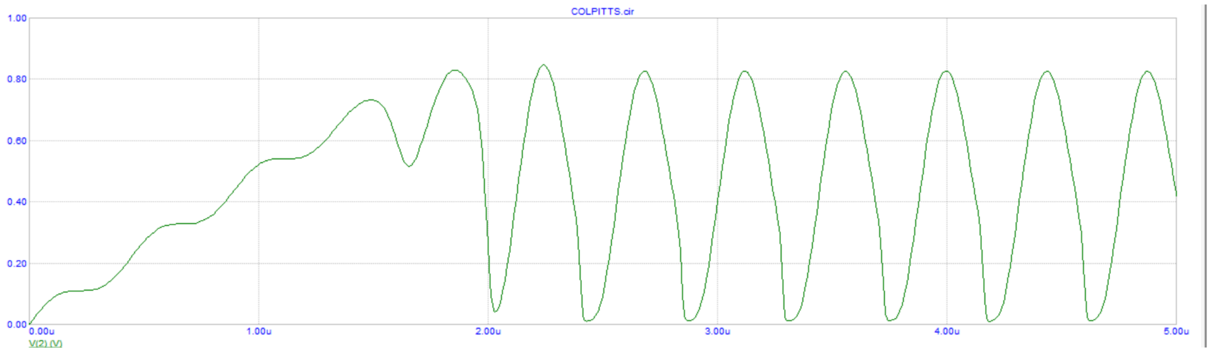


Fig. MicroCap Schematic of the circuit

Simulation Result:

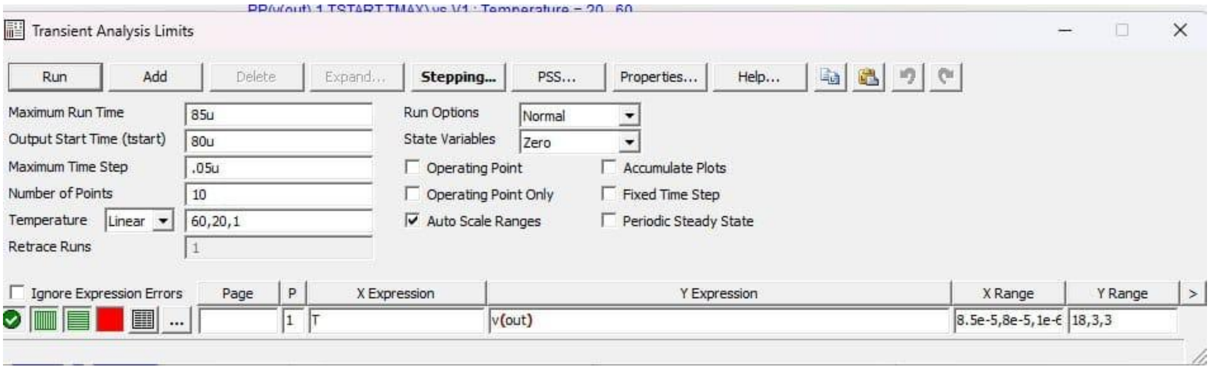
For 5 micro seconds:



Making the Circuit Self Adaptive

The dominant component in this circuit is the capacitor.

These are the simulations that were applied to the circuit.



The circuit was simulated for the frequency and power output values against various temperatures ranging from 20 - 60 degrees. The following graphs were observed:

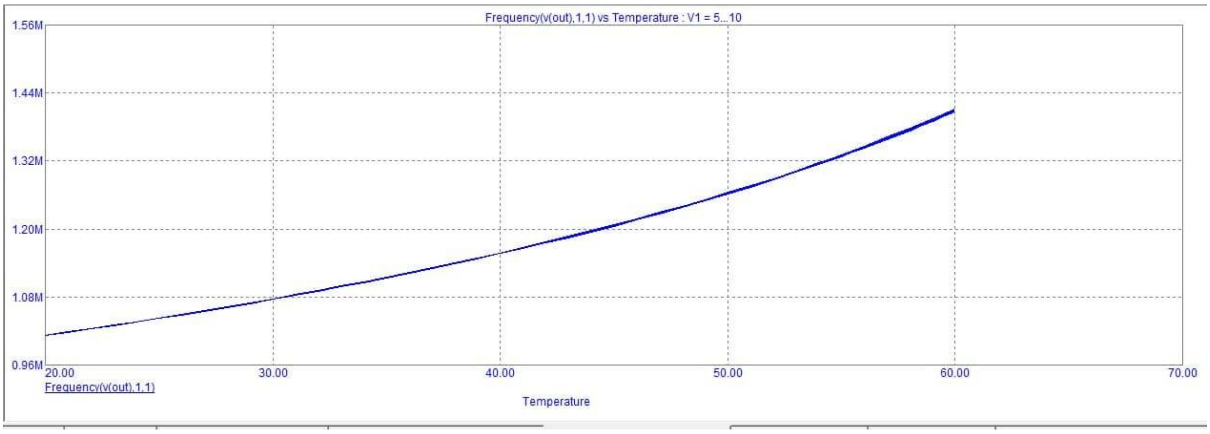


Fig. Frequency vs Temperature

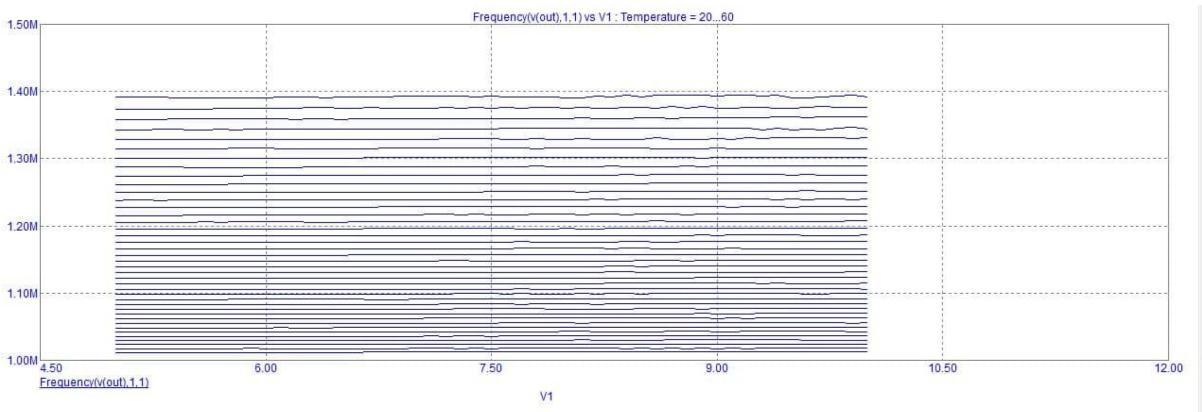


Fig. Frequency vs Temperature

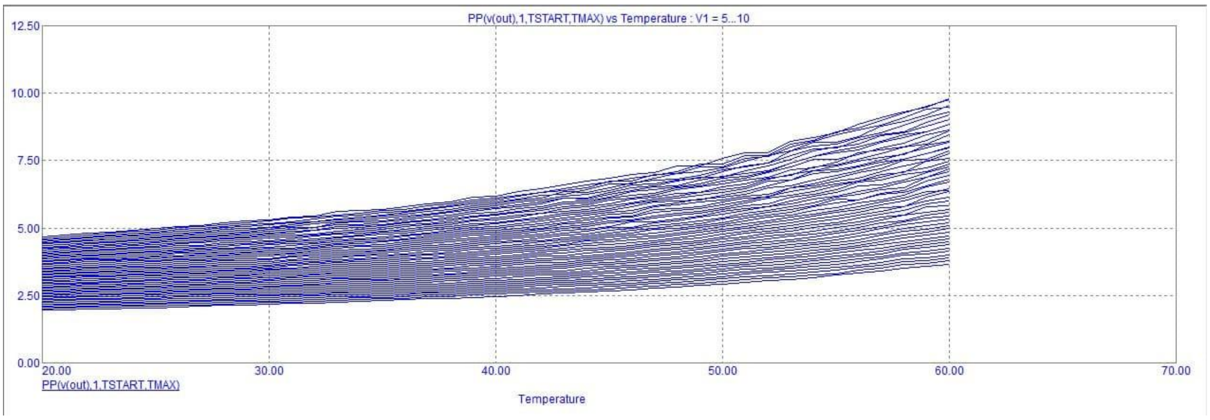


Fig. Power vs Temperature

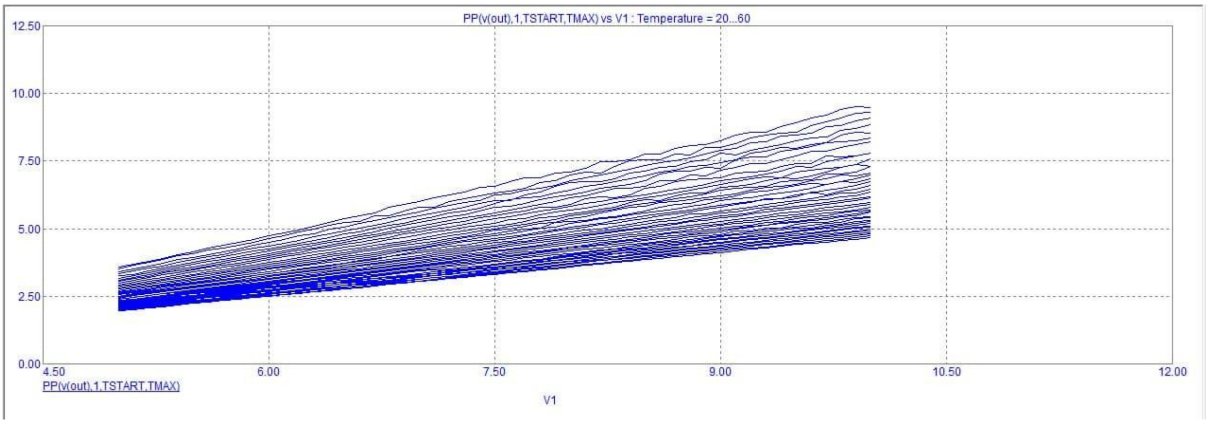


Fig. Power vs Temperature

These values were collected into a csv and used to train a model. The dominant component in this circuit is the capacitor

Results:

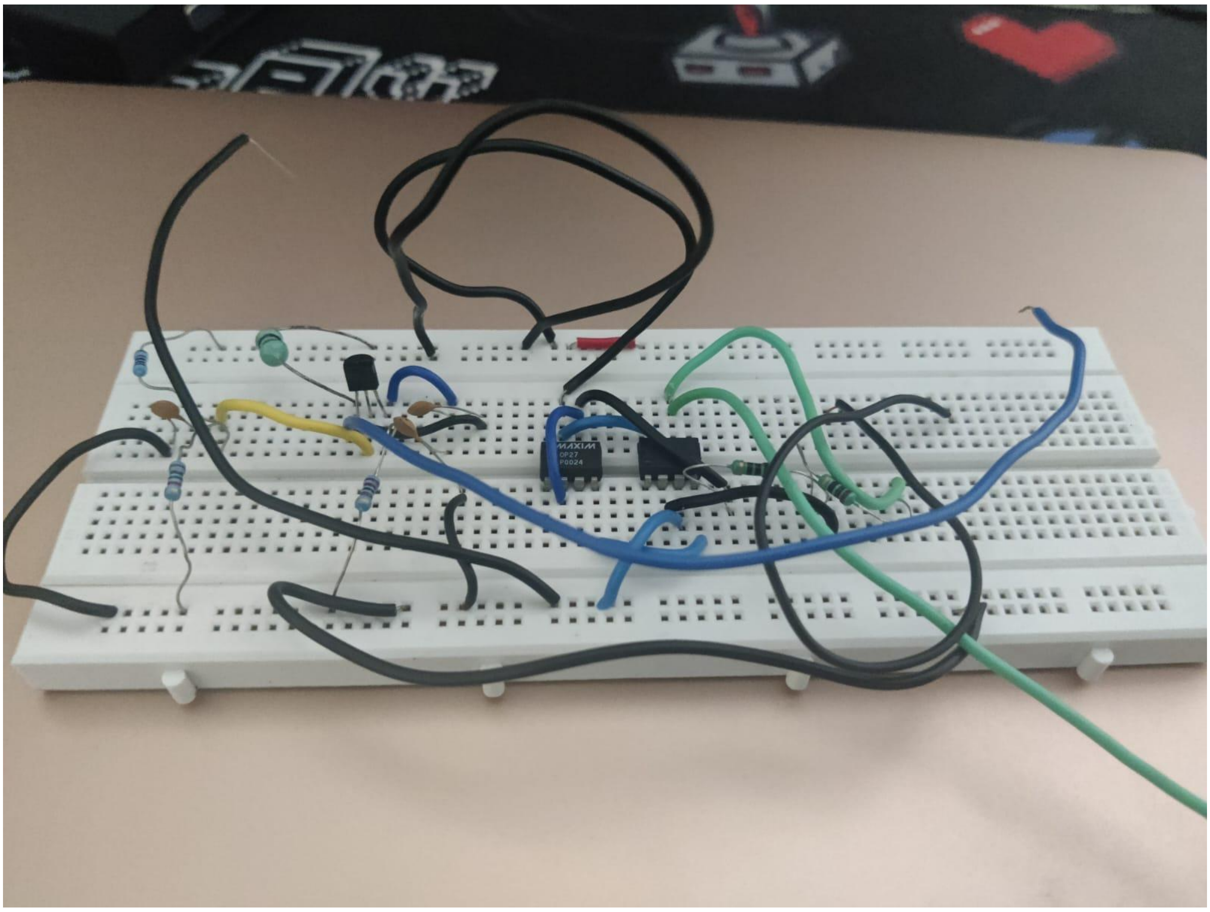
```
14/14 [==============================] - 0s 2ms/step
Mean squared error     : 2.0523059452064487e-05
Root Mean squared error: 0.004530238343847318
Mean Absolute error    : 0.004078817776201271
R2 score    : 0.9983679209024234
```

```
Weights and biases of the layers after training the model:

dense_6
Weights
Shape:  (2, 4)
 [[ 8.4985942e-03 -4.8610666e-03  2.1839321e-03  5.8259163e-04]
 [ 6.2884718e-01  3.7706763e-01 -2.3587153e-04 -4.5336583e-01]]
Bias
Shape:  (4,)
 [-0.46556187  0.6006878  -0.00643603 -0.17260675]

dense_7
Weights
Shape:  (4, 2)
 [[ 0.07293656 -0.74979895]
 [ 0.5258293   0.56097907]
 [-0.00783858 -0.06836054]
 [ 0.15467049  0.2779006 ]]
Bias
Shape:  (2,)
 [ 0.5245291  -0.52947783]

dense_8
Weights
Shape:  (2, 1)
 [[ 0.62905735]
 [-0.7078987 ]]
Bias
Shape:  (1,)
 [0.6156947]
```

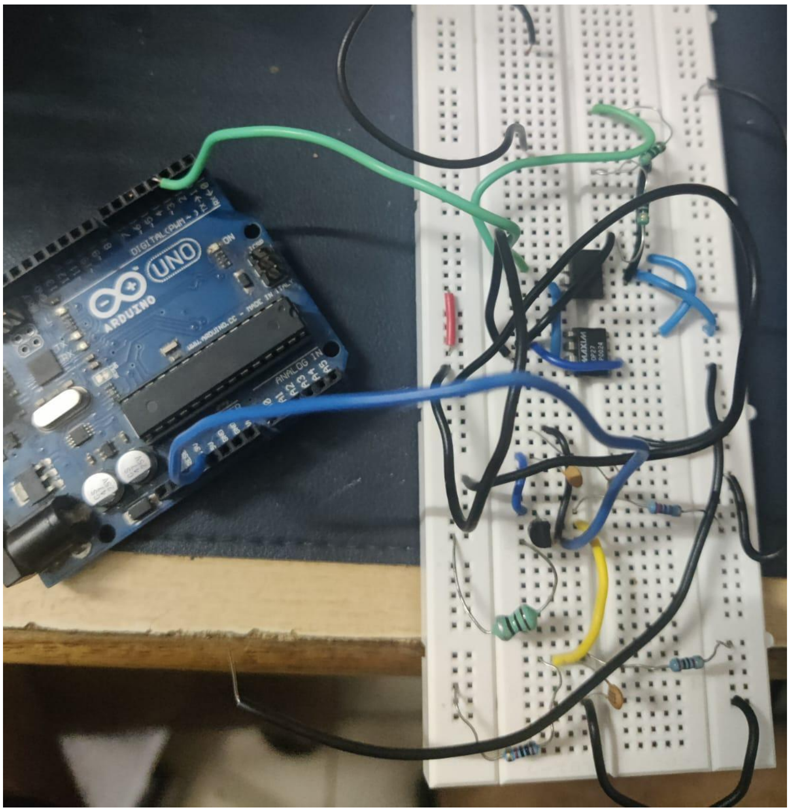
The dominant component in this circuit is the capacitor.

Hardware:

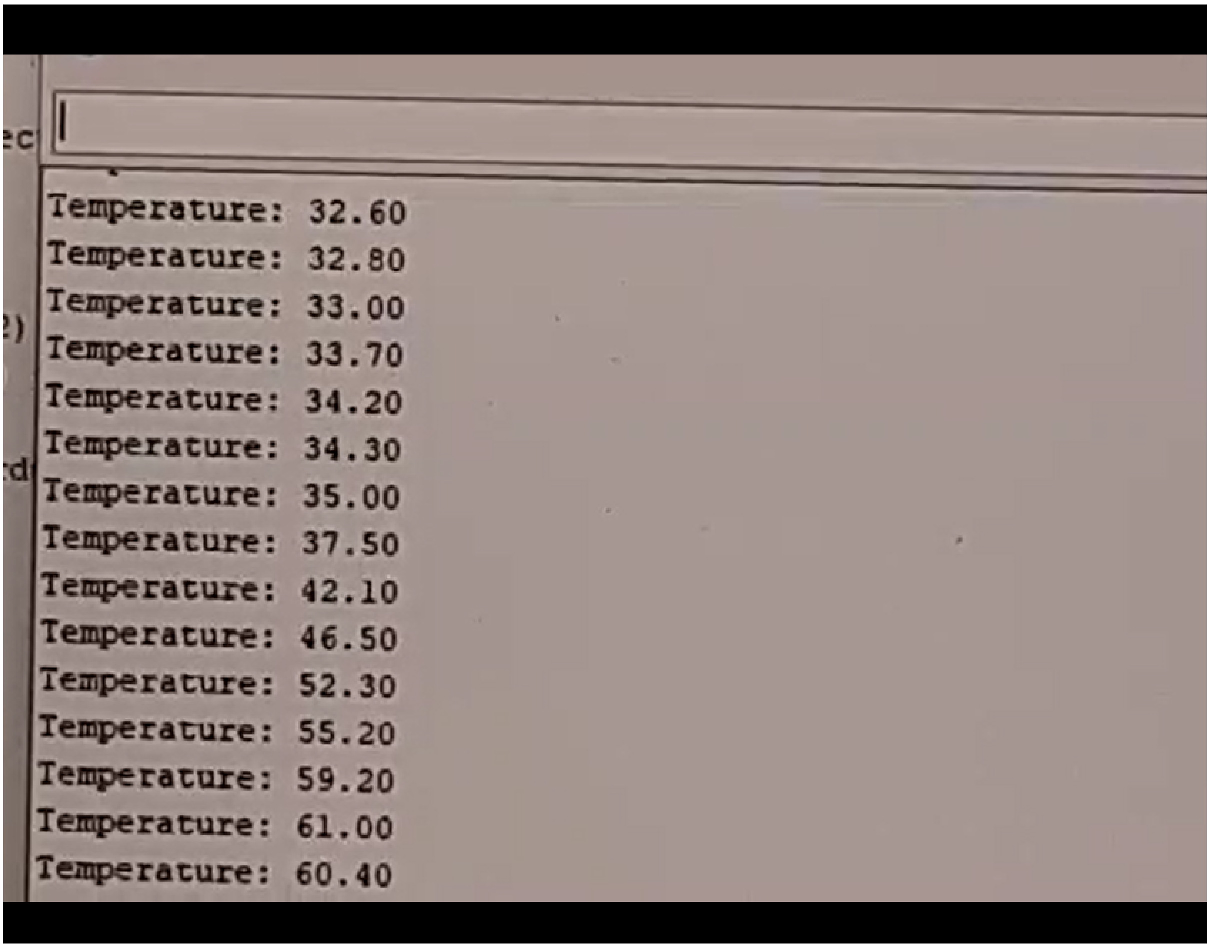
Circuit:



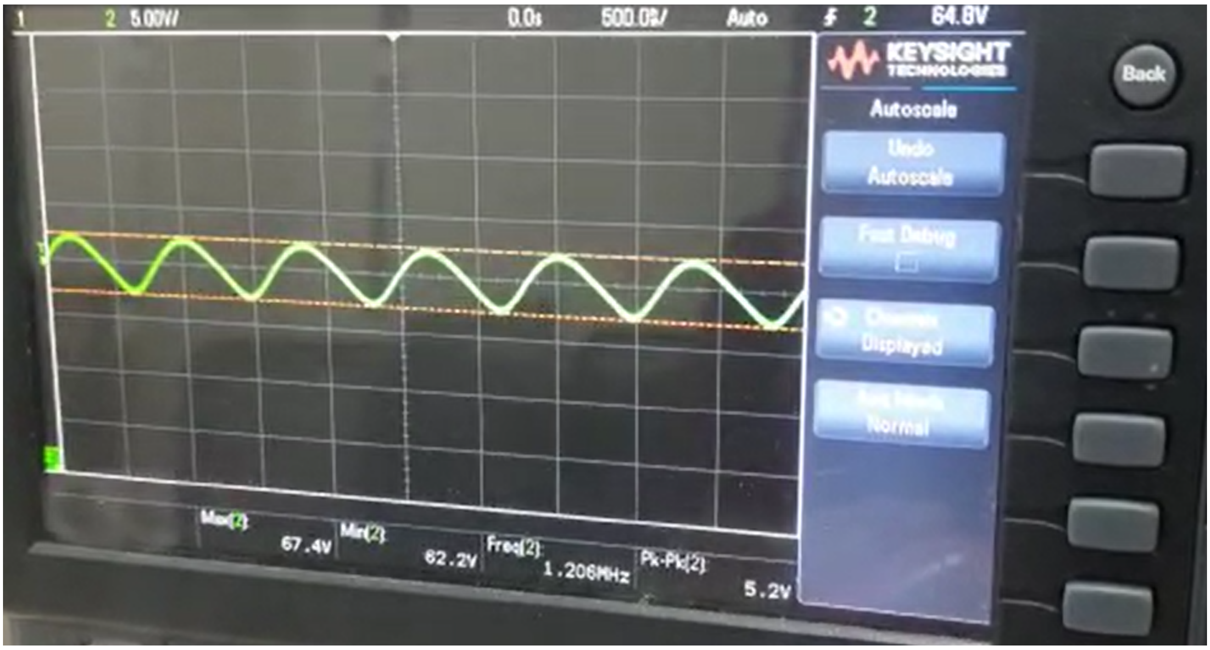
After using the Arduino to get a feedback from the temperature sensor:



Serial monitor:



Results:



Link to working circuit:
https://drive.google.com/file/d/1tSbl-m_WLQWm0Rmu_JZYhxrFCjkvr9XF/view?usp=sharing

Conclusion

Thus we have successfully implemented a self-adaptive Colpitts oscillator that can adjust to temperature changes to give a stable frequency.