Abu Dhabi University

EEN 360 - Electronic Devices and Circuits II

Project Report
Designing Wein-Bridge Oscillator

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Section 1

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Abstract

This project report explains in great detail how to design and manufacture a stable Wien Bridge Oscillator and how to improve the design by using amplitude controlling non-linear circuit.

1 Specifications

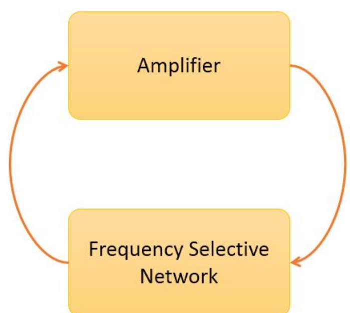
We had to design, simulate, improve and implement on PCB the Wien Bridge oscillator for the given specifications:-

- The oscillator should output 18KHz frequency.
- Use diodes 1N4007 for amplitude stabilization.
- Use amplifier 741.

2 Introduction

Oscillator is an electronic device which provides single frequency oscillating signal at the output at a time. A basic oscillator comprises of an amplifier with a frequency selective positive feedback loop. As we all know, any electronic circuit contains different types of noises (Thermal noise, White noise, shot noise, etc.) and when these noises pass through an amplifier, its magnitude increases.

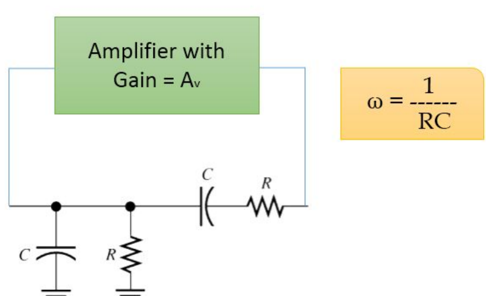
This amplified-frequency-mixed signal passes through a frequency selective network and all other frequency components except one frequency component are canceled out. This leaves us with one frequency component only, which proceeds into the cycle and gets amplified again by the amplifier. This process repeats on many times a second and we get a single frequency wave at the output.



The amplifier we are going to use in this project is an op-amp 741. The advantage of using an op-amp is that we can put the gain control circuit on the negative feedback and the frequency selective circuit on the positive feedback. Thus, making it easy to control the gain of the amplifier without disturbing the frequency selective network. There are no inputs to the circuit, only supply voltages are provided to the amplifier for it to operate. [3]

The frequency selective network we are going to use is a typical RC circuit which resonates at the frequency given by

$$f_{oscillation} = \frac{1}{2\pi RC} \tag{1}$$



The idea of a frequency selective network is to cut-out all the frequency components except one particular. Resonating circuits exactly do this by always oscillating at the resonance frequency given a range of frequencies at the input.

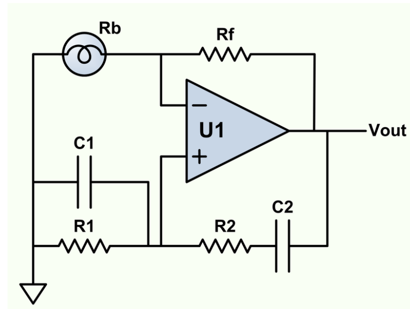


Figure 1: Original Wien Bridge Oscillator Circuit[1]

The modern Wien Bridge Oscillator is consequence of the circuit originally designed by William Hewlett in 1939. In this circuit he uses a frequency selective network as a positive feedback to the Op-Amp and uses a electric lamp for amplitude stabilization. When the voltage across the lamp increases, the lamp heats up and its resistance increases resulting in decreased loop gain and when the voltage across the lamp is less, the resistance of the lamp is less due to less heating of the filament and the loop gain increases. [2]

3 Designing

In order to design a stable oscillator we should follow a number of steps and tackle numerous problems in the following manner

3.1 Choosing the Right Capacitor for Frequency selective Network

Since we are assigned with the frequency of 18 KHz, it will be wise for us to go with the capacitor meeting the following criteria:-

- It should be very cheap.
- Readily Available in the market.
- Small in size.
- Ceramic capacitor.
- For the given frequency, the value of the resistors should be in KΩ range.

The capacitor of 1.5nF met all the requirements.

3.2 Finding the Resistor Values for Frequency Selective Network

Now that we have chosen the right capacitor, we can calculate the resistors required for the frequency network in order for it to resonate at the required frequency

$$f_{oscillation} = \frac{1}{2\pi RC} \tag{2}$$

$$R = \frac{1}{2\pi f_{oscillation} C} \tag{3}$$

$$R = \frac{1}{2\pi \times 18 \times 10^3 \times 1.5 \times 10^{-9}} = 5.9k\Omega \tag{4}$$

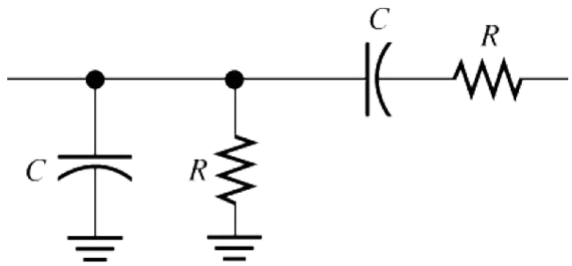


Figure 2: Frequency Selective Network

3.3 Finding the Resistor Values for Appropriate Gain

For this we need to consider the fact that the open loop gain should be more than 3 for the oscillation to start.

$$A_v = \frac{R_4 + R_1}{R_1} > 3 \tag{5}$$

S.No.	R1	R4	Gain	Oscillation
1	5K	5K	2	No Oscillation
2	5K	10K	3	No Oscillation
3	5K	15K	4	Oscillation Present
4	5K	20K	5	Oscillation Present

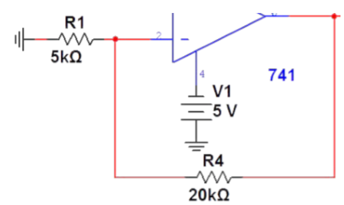
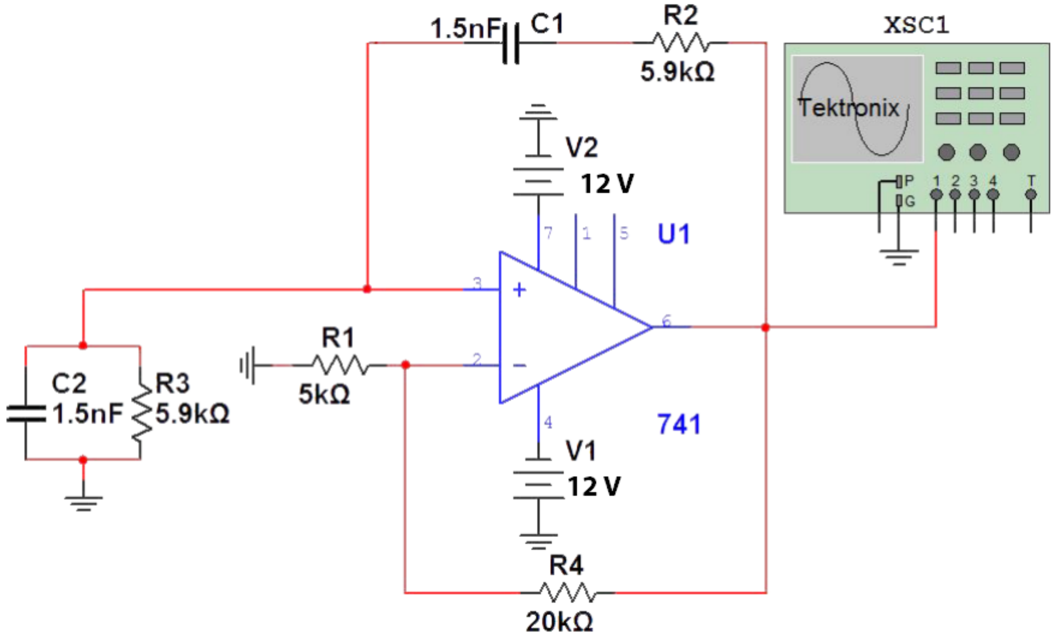


Figure 3: Calculating open loop gain

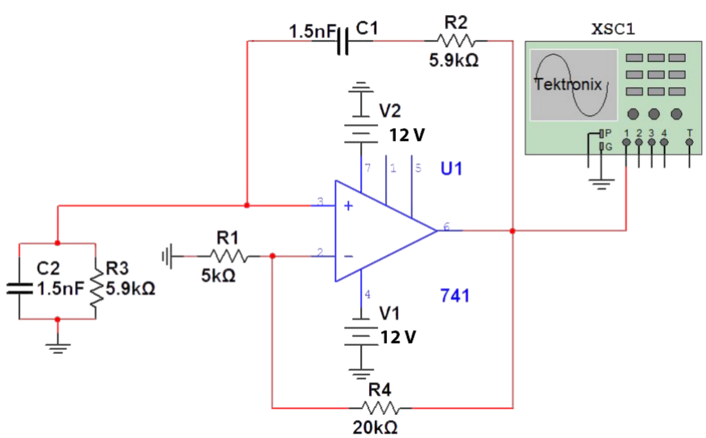
3.4 Design

So finally after calculating all the resistor and capacitor values, we are left with the following circuit



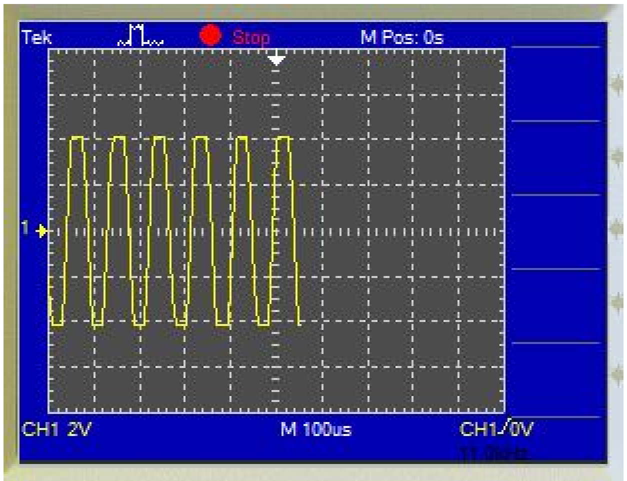
4 Simulation

After designing the circuit, we simulated it in Multi-Sim software before implementing the design. This is a good practice as Multi-Sim simulates close to real components and it takes into account some tolerance of components and adds some noise into the circuit for better realistic simulation. The simulation was setup as shown below:-



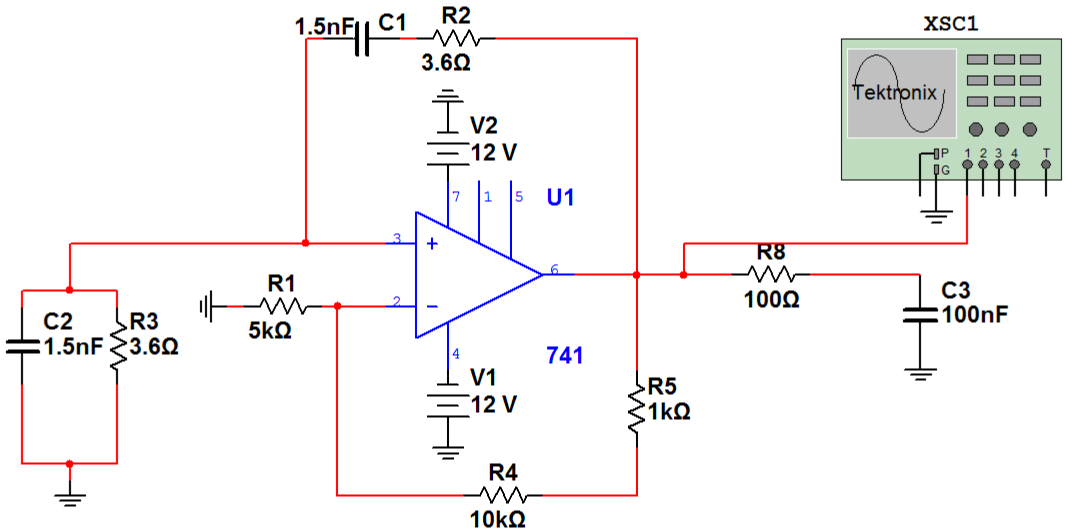
4.1 Frequency Problem

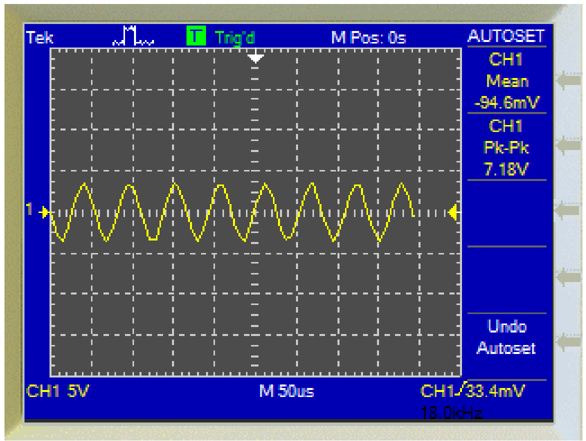
After running the simulation, we got the sinusoidal wave but it was of 13.5 KHz.



To solve this problem, we decreased the resistor values of frequency selective network to get to the appropriate frequency.

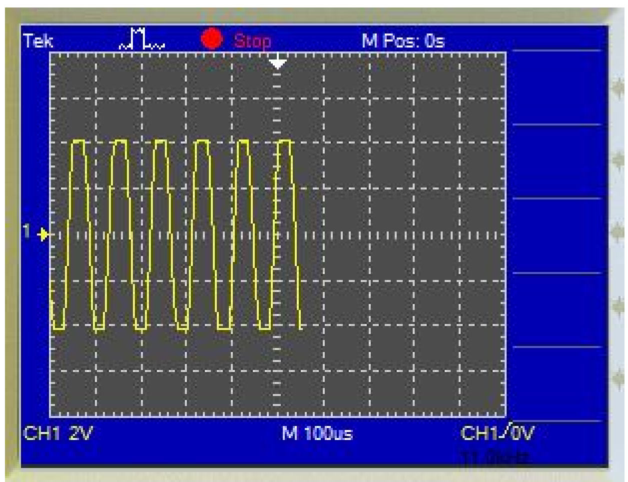
$$f_{oscillation} \propto \frac{1}{R} \tag{6}$$



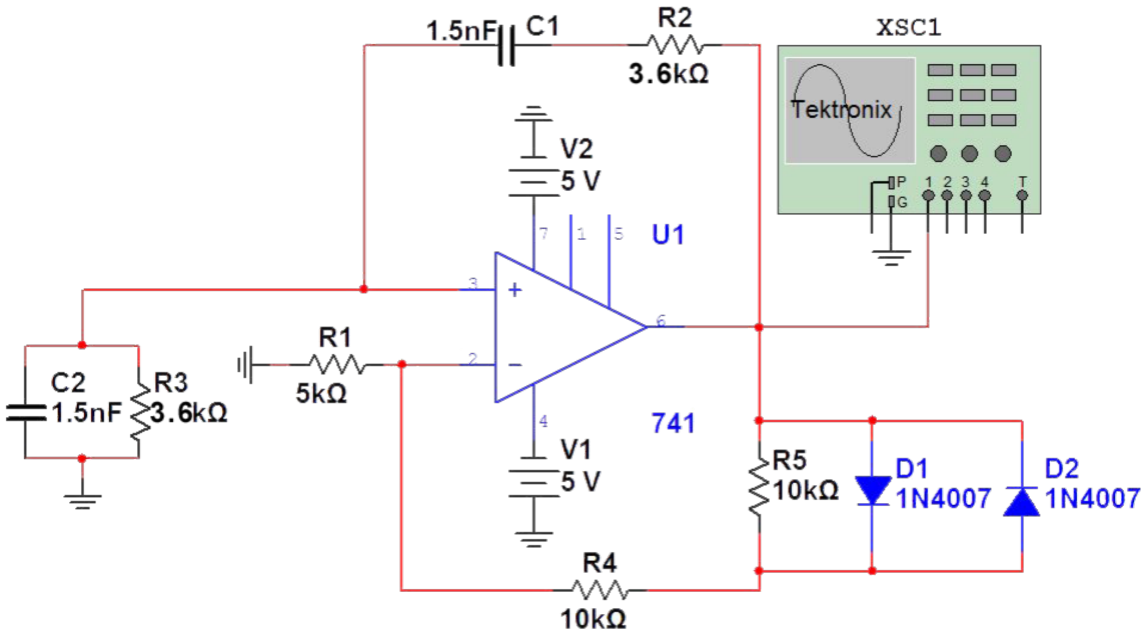


4.2 Amplitude Problem

As we can see that our signal is chopped-off from peaks and is distorted.



To solve this problem, we introduce a non-linear amplitude control by using diodes to control the gain of the amplifier. The diodes turn "ON"(forward biased) when the output voltage is greater than 0.7V and allow the current to pass through themselves. When this happens, the gain of the amplifier is 3. On the other hand, if the output voltage is less than 0.7V, the diodes are "OFF"(reverse biased) and they do not allow the current to pass through them. Rather the current passes through the 10K resistor and the amplifier gain is about 5. Thus in this way, gain is more for less voltage and less for more voltage making a non-linear amplifier and the output amplitude is stabilized.



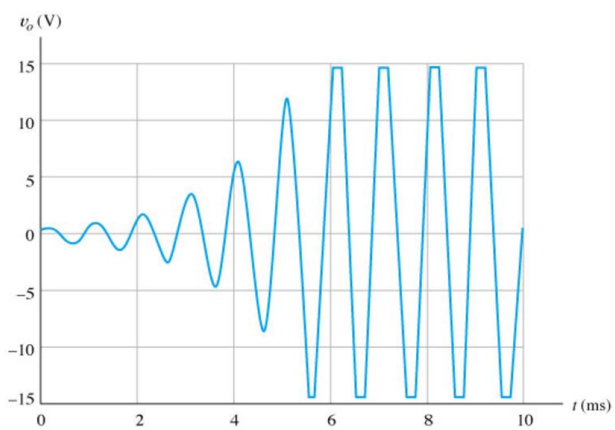


Figure 4: Before Amplitude Stabilization

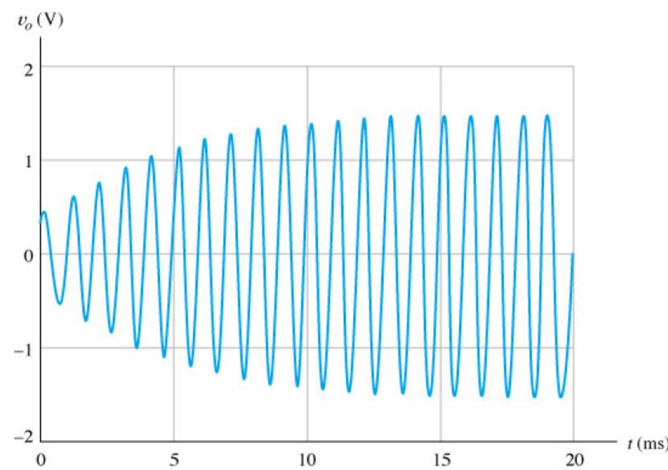


Figure 5: After Amplitude Stabilization

5 List of Equipment Used

- Breadboard.
- Oscilloscope.
- Wires.
- Resistors and Capacitors.
- Function Generator.
- Function generator cables.
- Crocodile Clip Cables.
- 741 OP-AMP IC.
- Soldering Iron.
- Soldering Wire.
- Solder sucker.
- Vera-board.
- 8 pin IC bracket.
- Variable resistors.

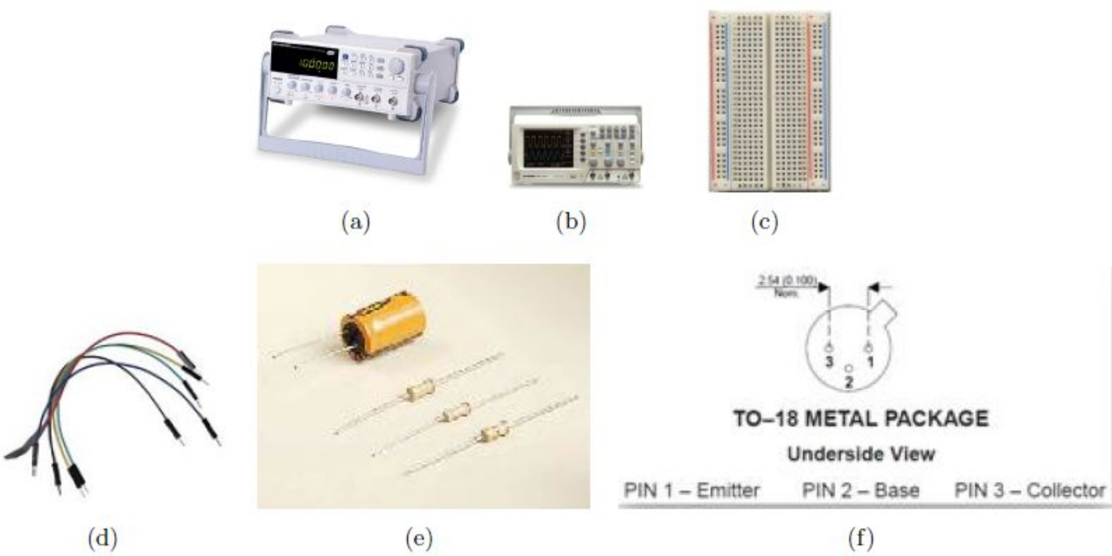


Figure 1: List of equipment

Figure 6: These are some of the things that are needed for testing of the circuit

6 Results and Discussions

6.1 Project Testing Set-up

In order for us to test the circuit with slightly different values of resistors and to allow us to gain control over the output frequency we tweaked the final circuit in the following manner:

- We added a low pass filter at the end of the circuit to further smooth out the wave.
- We added 1K potentiometers in series with the existing ones in frequency selective network for gaining control over the output frequency frequency.

A project Test was setup by connecting the +V and -V to variable +V supply and variable -V supply respectively. As we increased or decreased +V, keeping the -V constant, the positive slope of the output increased or decreased respectively. On the other hand, as we increased or decreased -V, keeping the +V constant, the negative slope of the output increased or decreased respectively. The result we concluded was, as we change the supply voltage of the op-amp, the frequency changes. And as the difference between $|+V|$ and $|-V|$ increased, distortion became more prominent.

6.2 Effect of Low-Pass Filter

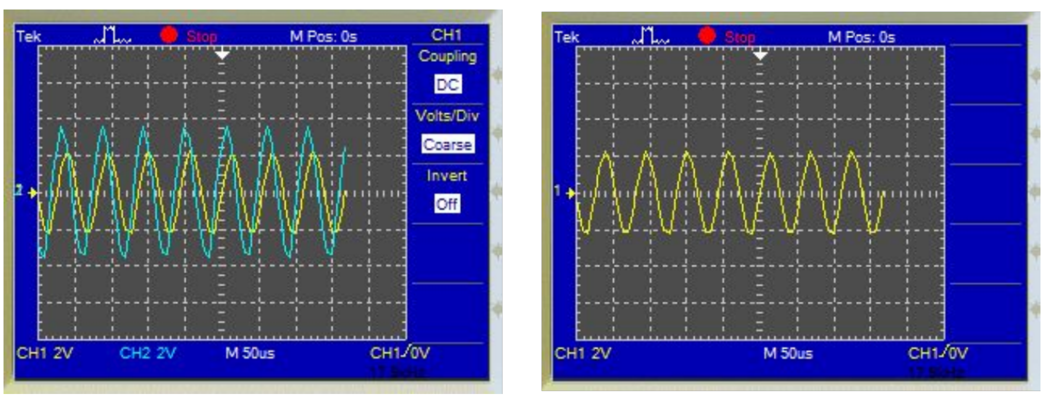


Figure 7: The blue wave is the output voltage without low-pass filter and yellow output is with low-pass filter. As we can see, this smooths the output but there is a voltage drop to compromise for this.

6.3 Final Circuit Diagram

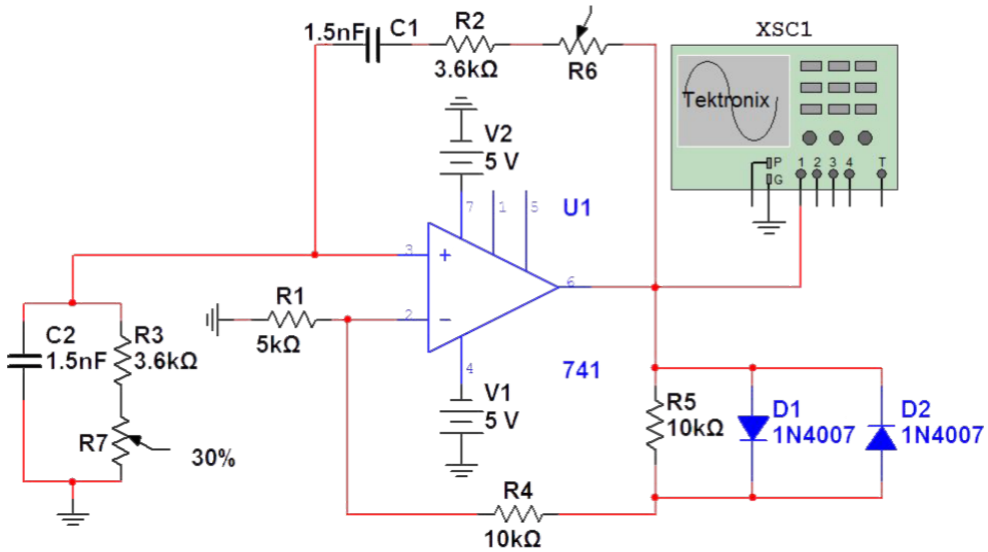


Figure 8: This is the final circuit diagram before building the PCB

6.4 Oscilloscope output

After we built the PCB, and connected to the oscilloscope it was giving us output frequency of around 17 KHz. We tweaked with the 1K potentiometers until we got exactly 18KHz on the oscilloscope. We got the following result.

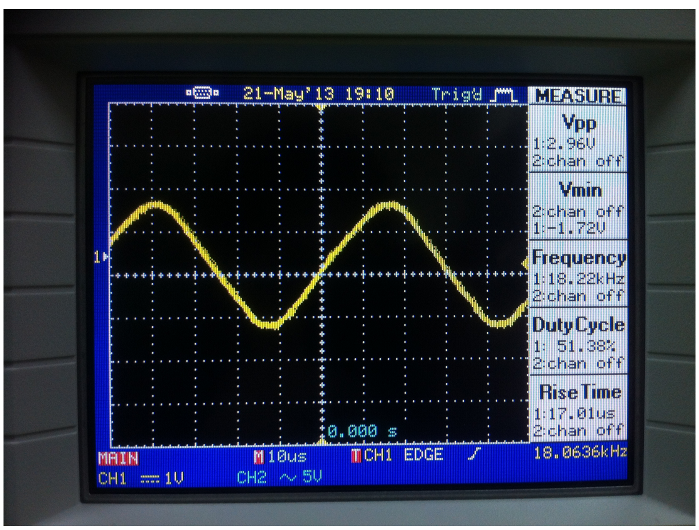


Figure 9: This is the output from the oscilloscope directly from the PCB output terminal. Here we can see that the output frequency is 18.0 KHz. The wave is appearing somehow triangular because the time divisions are too large.

6.5 PCB

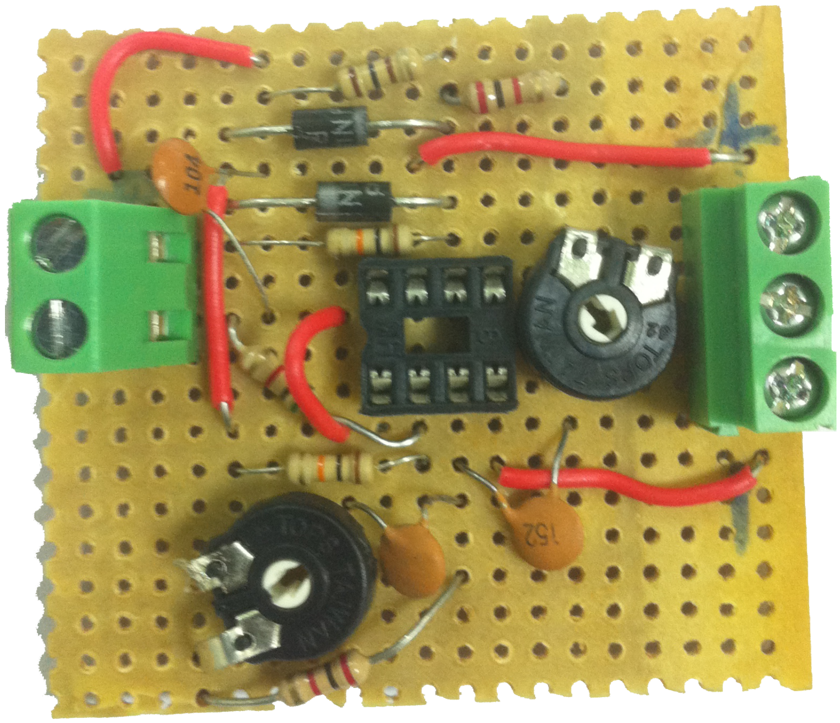


Figure 10: This is the final PCB, the input to the circuit is from the right terminal block where the center input is ground and the other are positive and negative supply for the op-amp. The output is from the left terminal block bottom one being the ground and the top one being the signal.

7 Cost of Equipment

S.No.	Item	No. of Items	Cost
1	Single Core Wire	1 meter	2 Dhs
2	8 pin IC mounting bracket	1	1 Dhs
3	3K Resistors	2	1 Dhs
4	1.5 nF Capacitors	2	1 Dhs
5	100 nF Capacitor	1	0.5 Dhs
6	100 ohm Resistor	1	0.5 Dhs
7	1N4007 Diodes	2	2 Dhs
8	10K Resitor	2	1 Dhs
8	OP-AMP 741 IC	1	4 Dhs
9	1K Potentiometer	2	4 Dhs
10	3-Terminal Block	1	2 Dhs
11	2-Terminal Block	1	2 Dhs
13	Copper Veraboard	1	8 Dhs
Total		18	29 Dhs

8 Conclusion

- Electronic resonating circuits have low accuracy than the crystal oscillators which are readily available in the market. For generating highly accurate and precise frequency, we can replace the feed back frequency selective network with a crystal oscillator. Crystal oscillator contains a crystal which has piezo-electric properties and can resonate to one particular frequency.
- Oscillators made up of Op Amp are usually limited to the lesser end of the frequency spectrum, mainly due to the reason that they do not possess the required bandwidth to attain low phase shift on higher frequencies. The Op Amps with current feedback have larger bandwidth in comparison to the voltage feedback Op Amps. However there remains a difficulty in practical usage of these due to their sensitivity of the feedback capacitance.
- Low pass filter can remove the harsh edges but it consumes power from the signal.
- Wien bridge oscillator frequency depends on the supply voltage.
- MULTISIM simulates close to real components and takes into account some probabilities.
- Amplifier gain should be above 3 for an oscillation to happen.
- Distortion happens if the input voltages (-V and +V) are not equal.
- Op Amps with voltage feedback are restricted to a few hundred kHz as a maximum, due to their low frequency roll off. While cascading the bandwidth is reduced because of the multiple contribution of phase shift.
- The Wien-bridge oscillator has a small number of parts and fine frequency stability, nevertheless the fundamental circuit has high output deformation.
- Wein bridge oscillator as a solution the problems we face. AGC improves the deformation significantly, predominantly in the lesser frequency range. Nonlinear feedback offers the paramount presentation over the mid- and upper-frequency ranges.

9 Presentation

You can access our presentation from the following link:
`https://www.dropbox.com/s/s7klodc27t4j9ss/Electronic%20Circuits.ppt`

10 Team Dynamics

Part and Member	Weight Grade	Muhammad Obaidullah	Bilal Arshad
Abstract	10%	50%	50%
Introduction	15%	50%	50%
Procedure Part 1	15%	50%	50%
Procedure Part 2	15%	50%	50%
Results Part 1	15%	50%	50%
Results Part 2	15%	50%	50%
Conclusion	15%	50%	50%
Total	100%	50%	50%

References

[1] Wikipedia.org "*A simplified schematic of a Wien bridge oscillator with labels on each component.*", Internet:http://en.wikipedia.org/wiki/File:Wein_Bridge_Oscillator.png, 7 August 2011 [2 June 2013].

[2] Wikipedia.org "*Wien bridge oscillator*", Internet:http://en.wikipedia.org/wiki/Wien_bridge_oscillator, 1 May 2013 [2 June 2013].

[3] Kumar, Umesh. (2010). Fractional Wien Bridge Oscillator Journal of Active and Passive Electronic Devices. [Electronic]. Vol. 5 (issue 1/2), pages 3-5. Available: http://search.ebscohost.com [2 June 2013].