19AIE113

INTRODUCTION TO ELECTRONICS

PROJECT REPORT

SEMESTER-2

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ACKNOWLEDGEMENT

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Contents

AIM

The aim of our project is Design an RC phase shift oscillator circuit/circuits to generate a set of sinusoidal signals and combine them to generate a clock pulse of arbitrary frequency which drives a sequential digital up counter.

working principle of RC phase shift oscillator (How transistors are used to generate sinusoidal signals wit ha specific frequency)

Making specific design for each oscillator circuit to generate corresponding sinusoids

Adding the sinusoids with an adder circuit to generate a square wave (You can simulate using Fourier analysis as well)

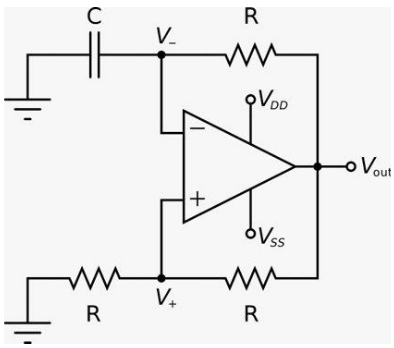
Using the generated square wave as a clock to a FF based counter (counts up to 15)

The FALSTAD is the major tool used to make the circuits

INTRODUCTION

OSCILLATOR:

An oscillator is a mechanical or electronic construction which produces oscillation depending on few variables. We all have devices which need oscillator, traditional clock that we all have in our home as a wall clock or wristwatch, various type of metal detectors, computers where microcontroller and microprocessors are involved all use oscillators, especially electronics oscillator which produces periodic signals. There are many types of Oscillators based on there configuration like Hartley Oscillator, Colpitts Oscillator, Wein Bridge Oscillator, Quartz Crystal Oscillator, Phase Shift Oscillator Circuit etc.



RC PHASE SHIFT OSCILLATOR

The phase-shift required by the feedback signal. They have excellent frequency stability and can yield a pure sine wave for a wide range of loads.

Ideally a simple RC network is expected to have an output which leads the input by 90^{o}.
However, in reality, the phase-difference will be less than this as the capacitor used in the circuit cannot be ideal. Mathematically the phase angle of the RC network is expressed as
RC phase-shift oscillators use resistor-capacitor (RC) network (Figure 1) to provide the phase-shift required by the feedback signal. They have excellent frequency

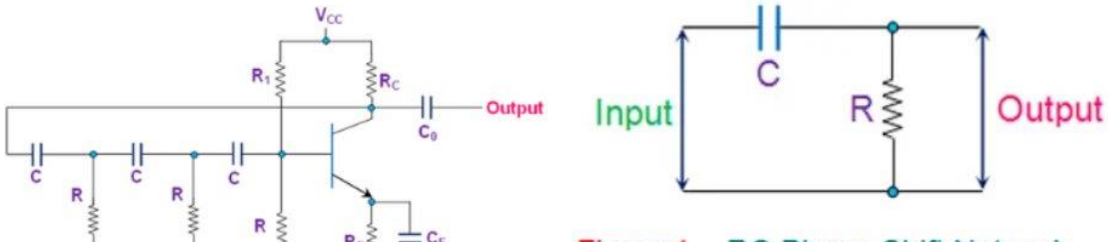
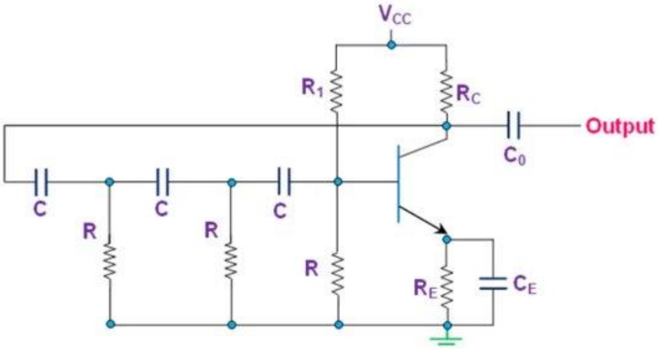


Figure 1 RC Phase-Shift Network

RC PHASE SHIFT OSCILLATRO USING BJT



In this case, RC phase-shift oscillator is formed by cascading three RC phase-shift networks, each offering a phase-shift of 60o

<u>SOFTWARE USED</u>:
FALSTAD SIMULATOR and MATLAB

THEORY
Here the collector resistor RC limits the collector current of the transistor, resistors R1 and R (nearest to the transistor) form the voltage divider network while the emitter resistor RE improves the stability. Next, the capacitors CE and Co are the emitter by-pass capacitor and the output DC decoupling capacitor, respectively. Further, the circuit also shows three RC networks employed in the feedback path.

This arrangement causes the output waveform to shift by 180o during its course of travel from output terminal to the base of the transistor. Next, this signal will be shifted again by 180o by the transistor in the circuit due to the fact that the phase-difference between the input and the output will be 180o in the case of common emitter configuration. This makes the net phase-difference to be 360o, satisfying the phase-difference condition.

One more way of satisfying the phase-difference condition is to use four RC networks, each offering a phase-shift of 45o. Hence it can be concluded that the RC phase-shift oscillators can be designed in many ways as the number of RC networks in them is not fixed. However it is to be noted that, although an increase in the number of stages increases the frequency stability of the circuit, it also adversely affects the output frequency of the oscillator due to the loading effect.

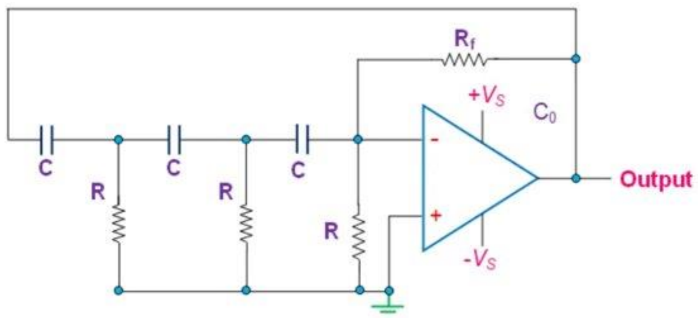
The generalized expression for the frequency of oscillations produced by a RC phase-shift oscillator is given by

$$f = \frac{1}{2\pi RC\sqrt{2N}}$$

Where, N is the number of RC stages formed by the resistors R and the capacitors C.

RC PHASE SHIFT OSCILLATOR USING OP-AMP

RC phase-shift oscillators can be designed using an Op-Amp as its part of the amplifier section (Figure 3). Nevertheless, the mode of working remains the same while it is to be noted that, here, the required phase-shift of 360o is offered collectively by the RC phase-shift networks and the Op-Amp working in inverted configuration.



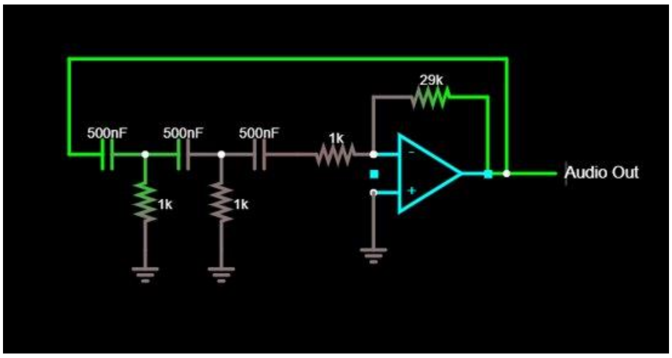
Further, it is to be noted that the frequency of the RC phase-shift oscillators can be varied by changing either the resistors or the capacitors. However, in general, the resistors are kept constant while the capacitors are gang-tuned. Next, by comparing the RC phase-shift oscillators with LC oscillators, one can note that, the former uses more number of circuit components than the latter one. Thus, the output frequency produced from the RC oscillators can deviate much from the calculated value rather than in the case of LC oscillators.

APPLICATIONS

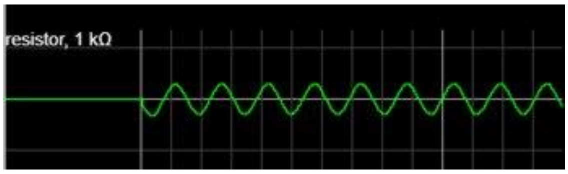
used as

1. local oscillators for synchronous receivers
2. musical instruments
3. low and/or audio-frequency generators.

FALSTAD SIMULATION



Output

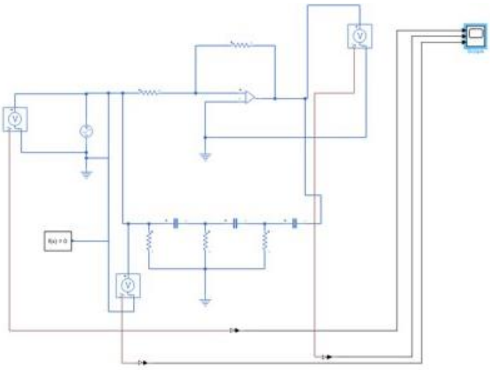


MATLAB SIMULATION

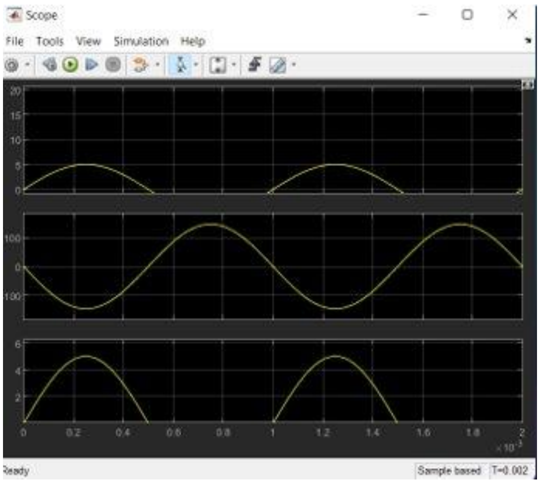
Components used

1. Voltage sensor
2. Solver Configuration
3. Resistor
4. Ground
5. A/c Voltage Source
6. Op – AMP
7. Capacitor
8. Ps Simulink Converter

CIRCUIT



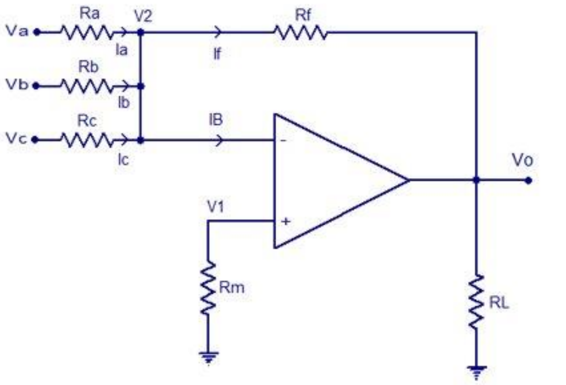
OUTPUT



ADDER CIRCUIT

SUMMING AMPLIFIER USING OP-AMP

Summing amplifier is a type operational amplifier circuit which can be used to sum signals. The sum of the input signal is amplified by a certain factor and made available at the output. Many number of input signal can be summed using an op-amp. The circuit shown below is a three-input summing amplifier in the inverting mode.



In the circuit, the input signals Va, Vb, Vc are applied to the inverting input of the op-amp through input resistors Ra, Rb, Rc. Any number of input signals can be applied to the inverting input in the above manner. Rf is the feedback resistor. Non-inverting input of the op-amp is grounded using resistor Rm. RL is the load resistor. By applying Kirchhoff's current law at not V2 we get,

$$Ia + Ib + Ic = If + Ib$$

Since the input resistance of an ideal op-amp is close to infinity and has infinite gain. We can neglect Ib & V2

There for

Equation (1) can be rewritten as

$$(Va/Ra) + (Vb/Rb) + (Vc/Rc) = (V2-Vo)/Rf$$

Neglecting Vo,we get

$$Va/Ra + Vb/Rb + Vc/Rc = -Vo/Rf$$

$$Vo = -Rf\ ((Va/Ra)+(Vb/Rb)+(Vc/Rc))$$

$$Vo = -((Rf/Ra\ )Va + (Rf/Rb)\ Vb + (Rf/Rc)\ Vc)\ldots\ldots..(2)$$

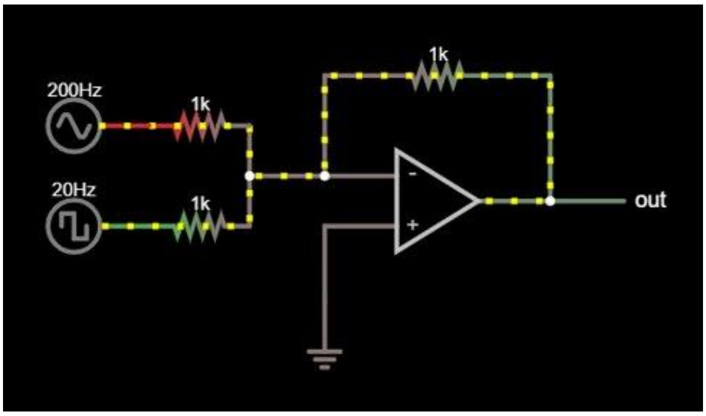
If resistor Ra, Rb, Rc has same value ie; Ra=Rb=Rc=R, then equation (2) can be written as

$$Vo = -(Rf/R)\ x\ (Va + Vb + Vc)\ldots\ldots\ldots\ldots\ldots.(3)$$

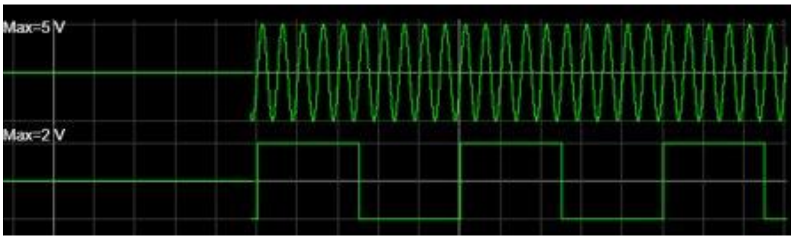
If the values of Rf and R are made equal , then the equation becomes,

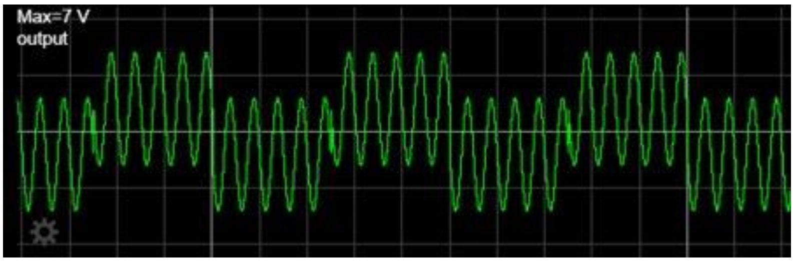
$$Vo = -(Va + Vb + Vc)$$

FALSTAD SIMULATION FOR ADDER CIRCUIT



Output





<u>FF BASED COUNTER</u>
WHAT IS A COUNTER?

A counter is a device which it can count any particular event on the basis of how many times that the particular event is occurred.

In digital circuits, the counter can count and store the number of time any particular event or process have occurred, depending on a clock signal.

Types of Counter:

1. Asynchronous counter.
2. Synchronous counter.

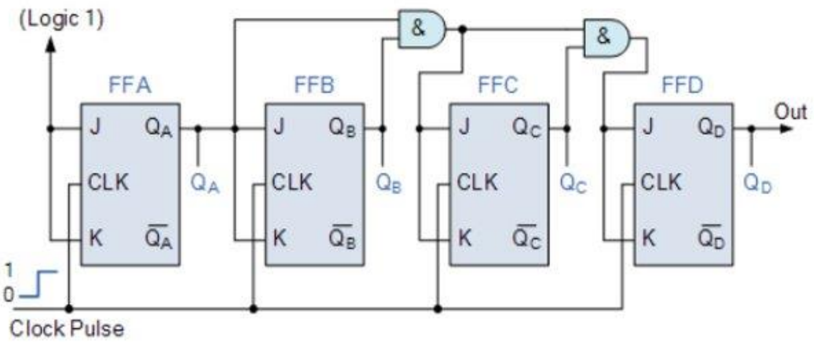
For our project we will be using Synchronous counter, and in synchronous counter there are *two types:*

1. Synchronous up counter.
2. Synchronous down counter.

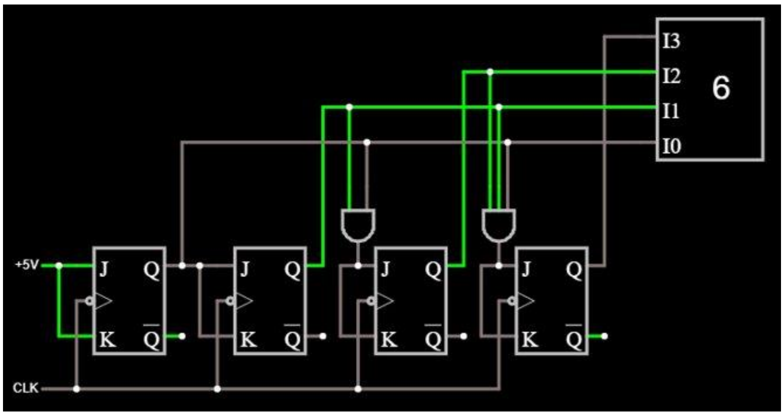
We will be using synchronous up counter for this project.

4-BIT SYNCHRONOUS UP COUNTER

In Synchronous Counter, the external clock signal is connected to the clock input of every individual JK flip-flop within the counter so that all the flip-flops are clocked together simultaneously (in parallel) at the same time with results in no propagation delay.



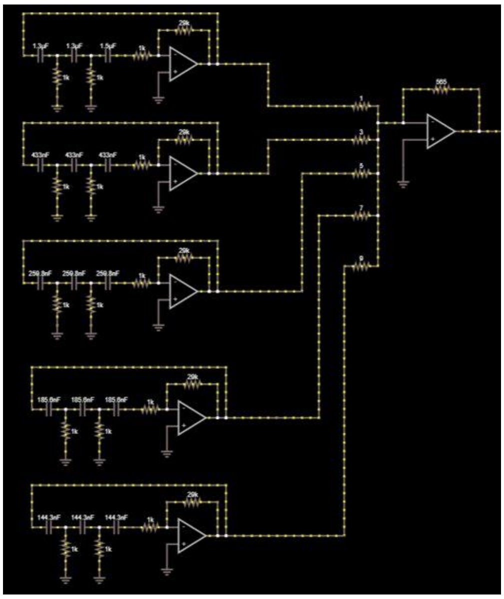
FALSTAD SIMULATION



PROCEDURE:

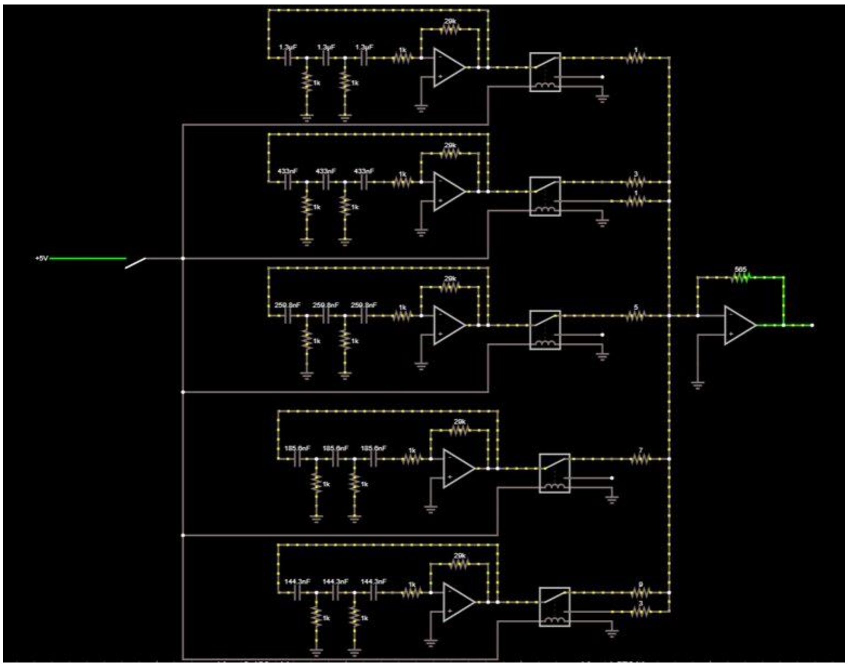
1. Connect the individual RC Phase Shift Oscillator to summing amplifier
2. Connect the summing amplifier to the FF based counter which was seen before

FINAL CIRCUIT:



Producing 50 Hz Square wave using Fourier Series

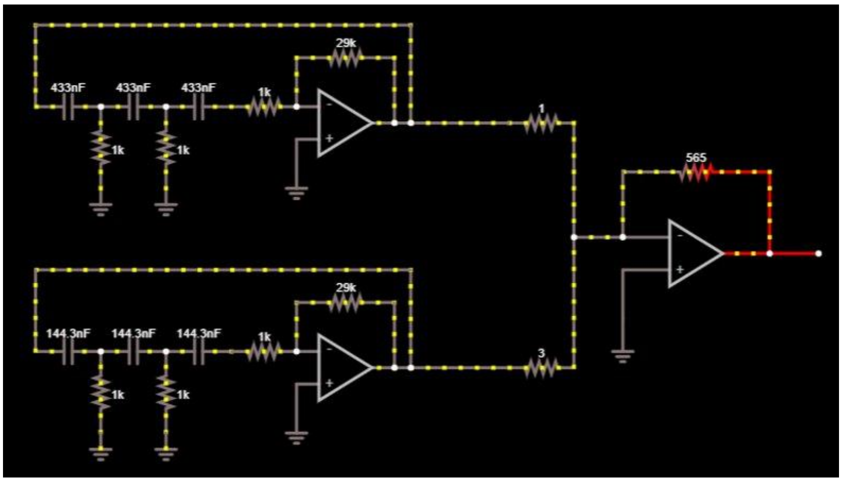
1. We Generate a Square wave by adding odd harmonics of sinusoidal wave.
2. This produces a square of fundamental frequency.
3. Here we are taking first 5 odd harmonics of sine wave with fundamental frequency 50Hz.
4. On adding them it produces a 50 Hz square wave



Producing 150 Hz Square wave using Fourier Series

Here we are taking first 2 odd harmonics of sine wave with fundamental frequency 150Hz.

On adding them it produces a 150 Hz square wave.



Selecting the appropriate values for each element

Selecting R and C values of RC phase shift oscillator to generate a specific frequency.

For an RC phase shift oscillator, WKT the output frequency is

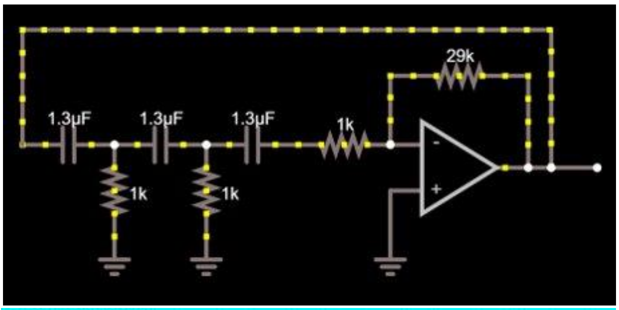
Here, we are using 3 RC stages(N=3).

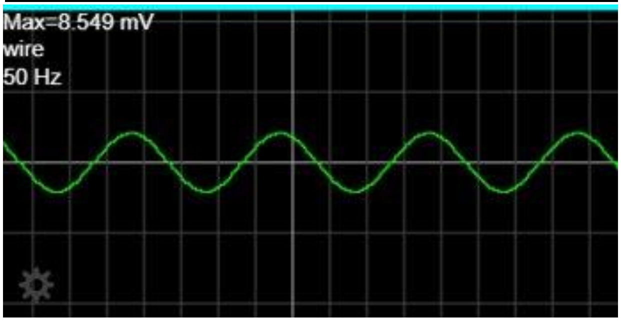
Fixing the value of R as 1kΩ.

By selecting the required frequency, we can calculate the value of the Capacitor.

For 50Hz sine wave the value of capacitor required is 1.3μF.

$$f = \frac{1}{2\pi RC\sqrt{2N}}$$

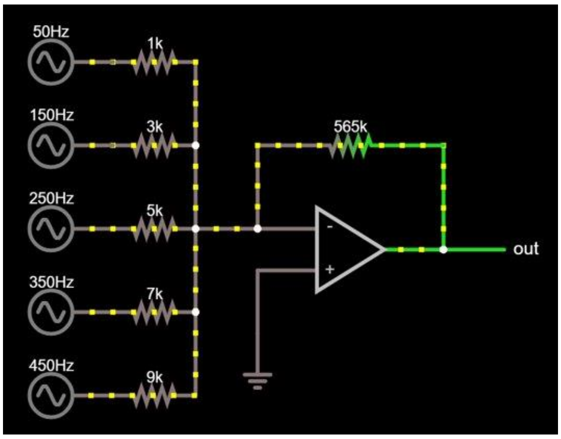




Resistance values for summing amplifier

To get a square wave, we have to multiply the odd harmonics of the sine wave with its respective coefficients and add them.

Selected Feedback resistance, So the output is nearly 5V.



1 V (peak) repeating square wave at 50 Hz is equivalent to:

$\left(\frac{4}{\pi}\right)$(1 V peak sine wave at 50 Hz)

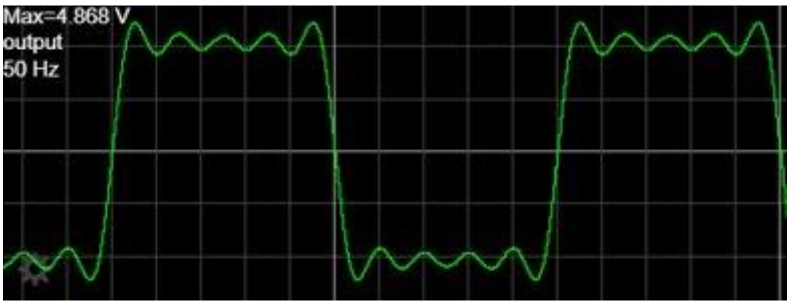
+ $\left(\frac{4}{\pi}\right)$(1/3 V peak sine wave at 150 Hz)

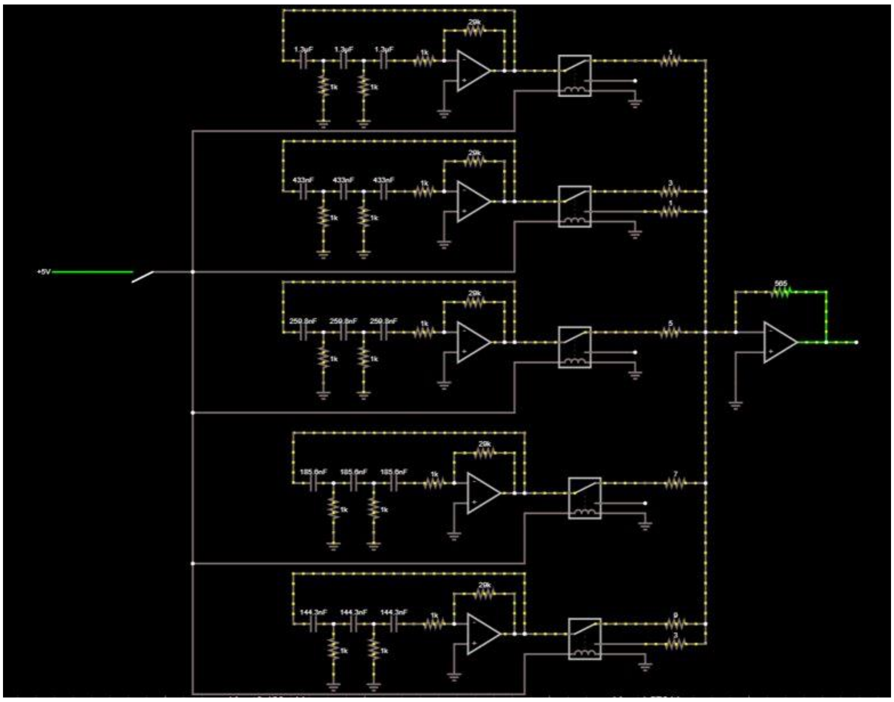
+ $\left(\frac{4}{\pi}\right)$(1/5 V peak sine wave at 250 Hz)

+ $\left(\frac{4}{\pi}\right)$(1/7 V peak sine wave at 350 Hz)

+ $\left(\frac{4}{\pi}\right)$(1/9 V peak sine wave at 450 Hz)

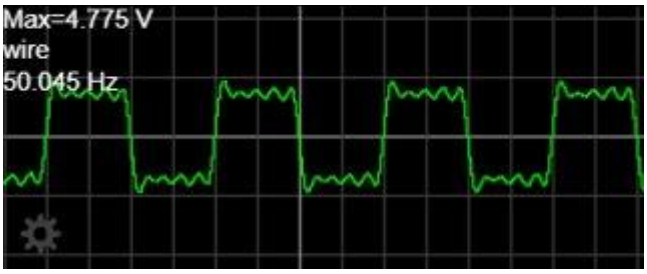
+ . . . *ad infinitum* . . .

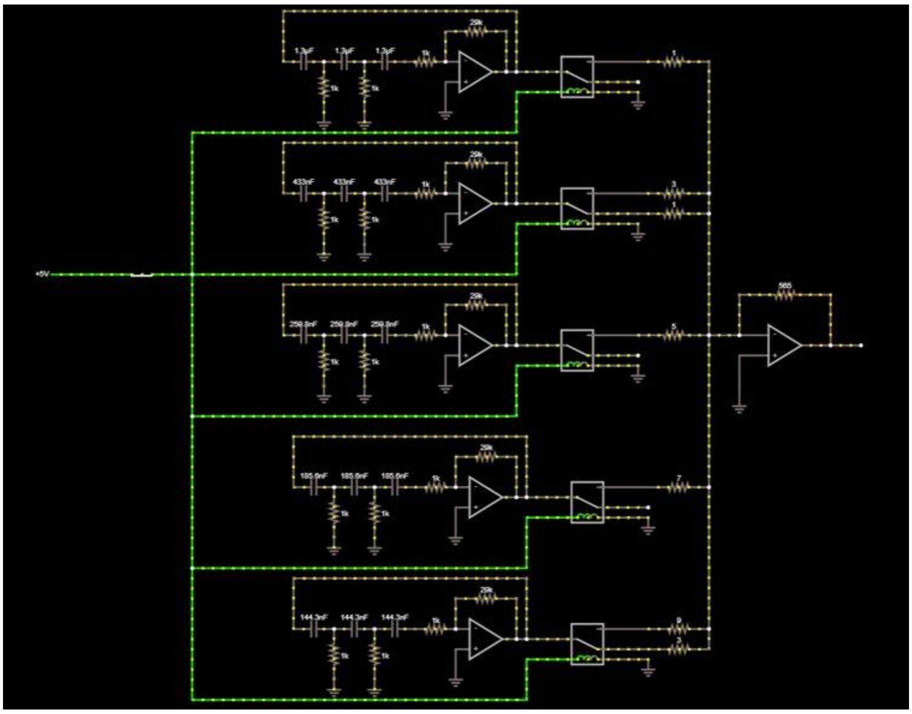




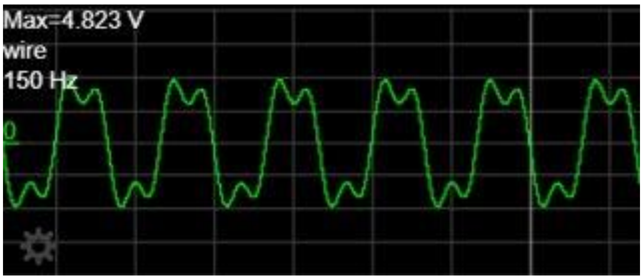
We are using Relays to produce multiple frequencies in a single circuit.

When the switch is in "OFF" state, we are generating 50HZ square wave.

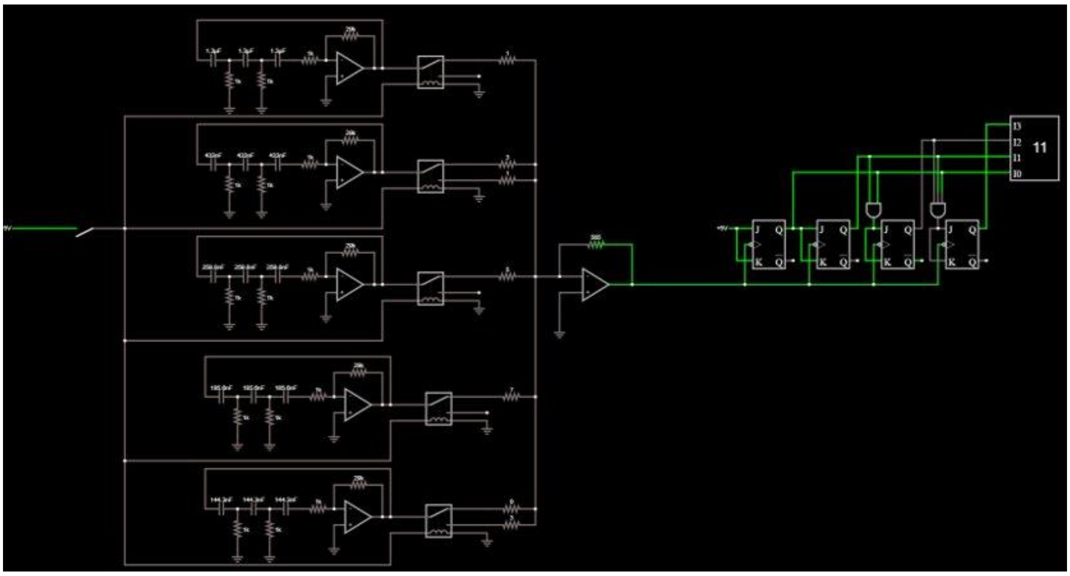




When the switch is in "ON" state, we are generating 150HZ square wave.



FINAL CIRCUIT



LINKS TO ACCESS CIRCUITS
RC Phase Shift Oscillator
summing amplifier
ff based counter
final circuit

INFERENCE

1. The waves produced from the RC Phase Shift Oscillators of different frequencies are combined to the summing amplifier.
2. From the summing amplifier, we can see that it produced a pulse of square wave
3. Finally, this square wave pulse is connected to the ff based counter

CONCLUSION
We have successfully built the RC phase shift oscillator and produced the various sinusoids. Then we connected RC phase shift oscillator with different frequencies and connected it to the summing amplifier. Then, the total circuit including the summing amplifier is connected to the ff based counter and we observe results in Falstad circuit simulator.

REFERENCES:

- Class Slides
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- https://www.electronics-tutorials.ws/opamp/opamp_4.html
- https://www.electronics-tutorials.ws/counter/count_3.html

Individual Contributions

(Including FALSTAD and MATLAB simulation)

RC Phase Shift Oscillator using BJT – Divith Phoghat

RC Phase Shift Oscillator using Op-Amp – Karnati Sai Prashanth

Adder Circuit – Rachure Charith Sai

FF Based Counter – Jayanth M

Final Circuit – Srikakolapu Venkata Sai Dhanush