SNS COLLEGE OF ENGINEERING

Kurumbapalayam (Po), Coimbatore – 641 107

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DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING

COURSE NAME : 23EET206 CONTROL SYSTEMS AND INSTRUMENTATION

II YEAR ECE /III SEMESTER

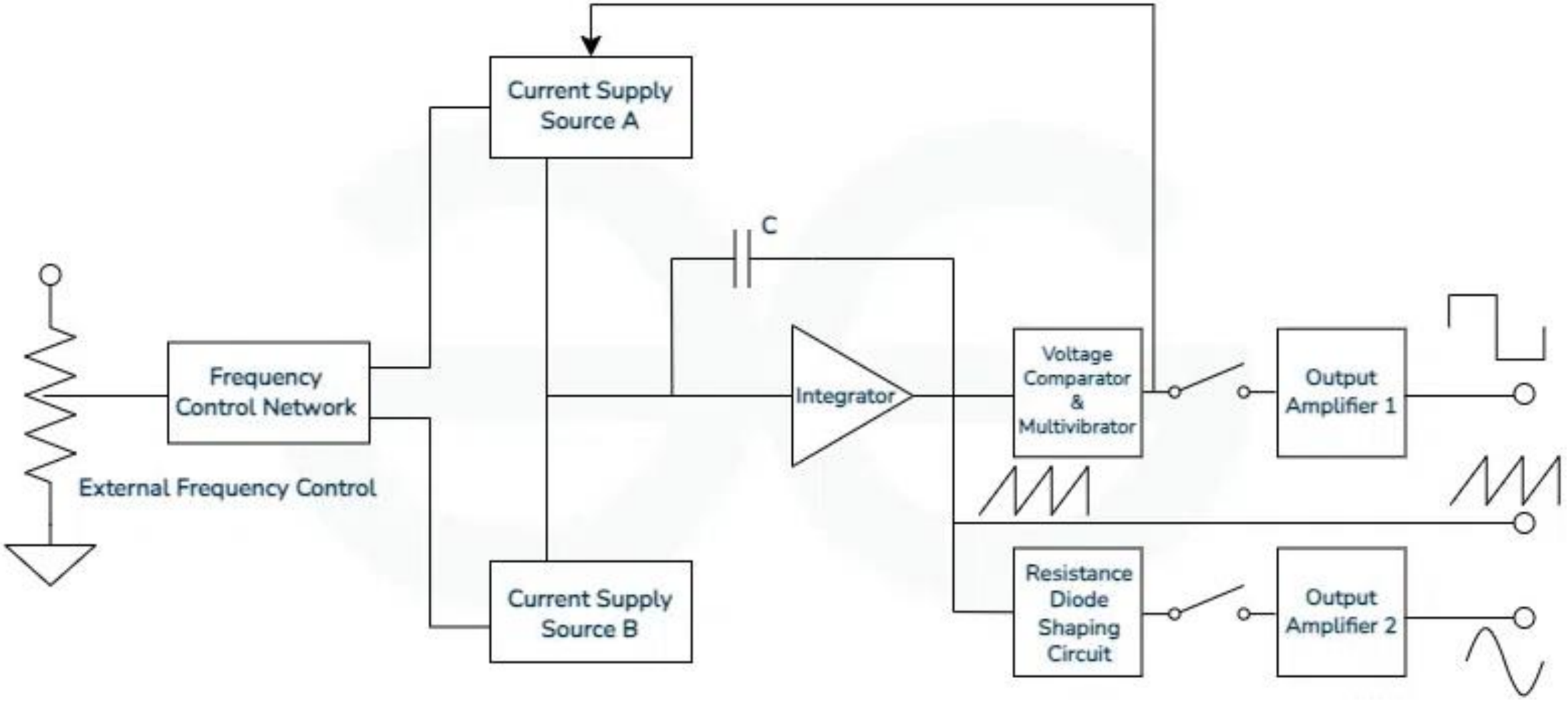
Unit 5-Oscilloscope, Signal Generator, Analyzer and Data Acquisition System

Topic 2 : Function Generator

FUNCTION GENERATOR

- A Function Generator is a scientific device that can generate a variety of different waveforms with a wide range of frequencies.
- Function Generator is an electronic equipment that allows us to generate waveforms corresponding to different functions and also gives us the control over the properties of this function generated by it. Once a functional waveform has been generated, we can control how much is its amplitude, what is the frequency after which it repeats . Depending on the trigger given the signal generated can be repetitive or not. Function Generator is known to be versatile because of its ability to produce various waveforms with wide frequency range.

FUNCTION GENERATOR



FUNCTION GENERATOR

- It consists of a Frequency Control Network which controls the frequency of circuit depending on the current levels in circuit. Frequency can be varied by increasing or decreasing current levels.
- The current sources are controlled by Frequency control network and the current sources then drive the integrator as shown in the block diagram. Here there are two current sources, namely current source ‘A’ and current source ‘B’.
- Integrator receives a constant supply if current from source A and performs integration on it with time. The linear increase in output of integrator over time can calculated. So the output of integrator will be

$$V_{out}=(-1/C)\int i.dt$$

- Any variation in current, high or low will directly affect the output voltage which helps in voltage regulation.

FUNCTION GENERATOR

- we observe a voltage comparator and multi-vibrator device which performs the task of triggering a change in the phase of the output voltage corresponding to the last peak level.
- Any change in phase makes the current supply from Source A to stop and Source B begins to supply power to the integrator. As the current source changes, the direction of current also changes resulting in reverse current. Now the reverse current lowers the output of integrator with time (in proportion) .
- When current reaches maximum value, the comparator switches the current source beginning to take supply from Source A.

FUNCTION GENERATOR

- The output of an integrator therefore is a triangular waveform whose frequency is based on current supply from current sources.
- The output of comparator is a square waveform.
- The resistance diode in the circuit helps to vary the triangular wave slope with minimal distortion.
- At the end, the amplifiers help in providing two waveforms which are then observed using oscilloscope.

SPECIFICATION

Waveforms can be of different type like

•**Sine wave:** This is generated from triangular wave by adding a pair of back to back diodes. Some specifications of this waveform is higher distortion as compared to sine waves produced by other test instruments

•**Triangular wave:** The line obtained in this signal will not particularly be a straight line. This means there will be a departure from straight line. If levels are around 90% of waveform amplitude then 99% linearity can be achieved.

•**Square wave:** It categorizes one important specification which is edge rise and fall time which is significant in logic chips. Synchronous chips needing clock require an edge of specific speed. A function generator can produce rise time and fall time of 100ns between 10 and 90% of the waveform.

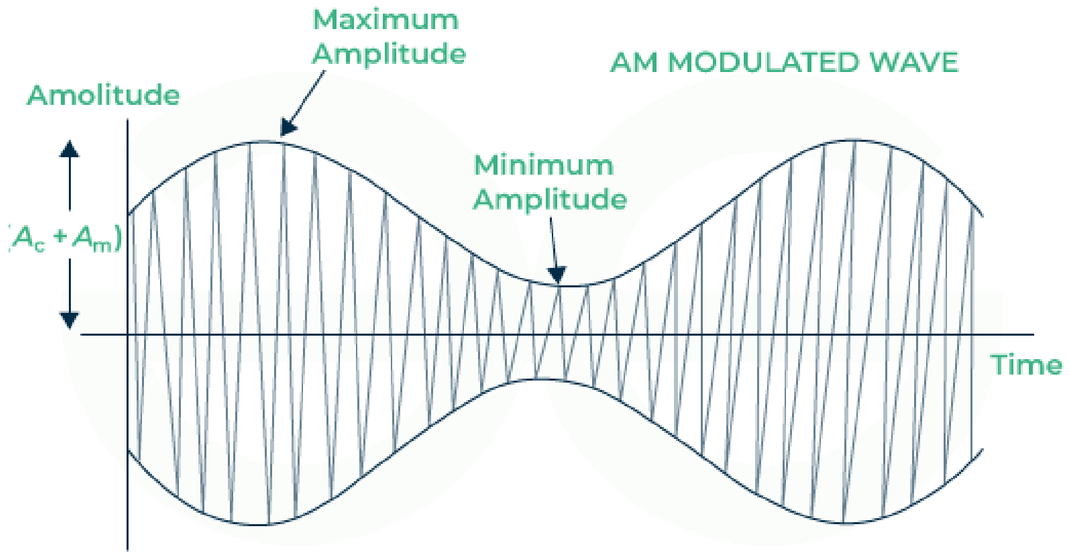
SPECIFICATION

Output symmetry: Output symmetry is another important specification. Function generator provides a range over which we can control the symmetry of our output waveform. The average range is 20% - 80% with positive or negative 10% error.

DC offset: This specification is provided by some Function Generators. This allows to control the base voltage level of signal over a given range. Sample range can be around +5V or -5V.

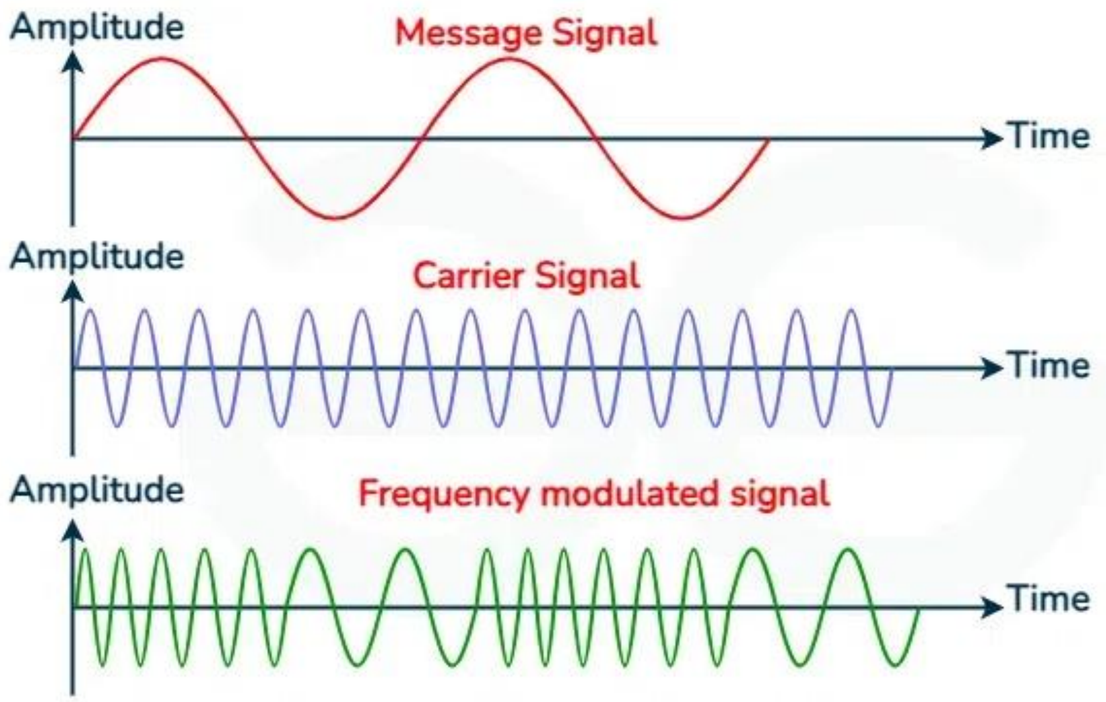
AMPLITUDE MODULATION

This is the most common type of modulation performed. In the given figure, we have tried to show the setup for performing amplitude modulation and see the waveform generated after amplitude modulation. Observe that in this modulation, the amplitude of the wave is varied in proportion to that of the message signal, which is being transmitted. Function Generator allows us to choose the source of modulation from some other channel without extra circuitry.



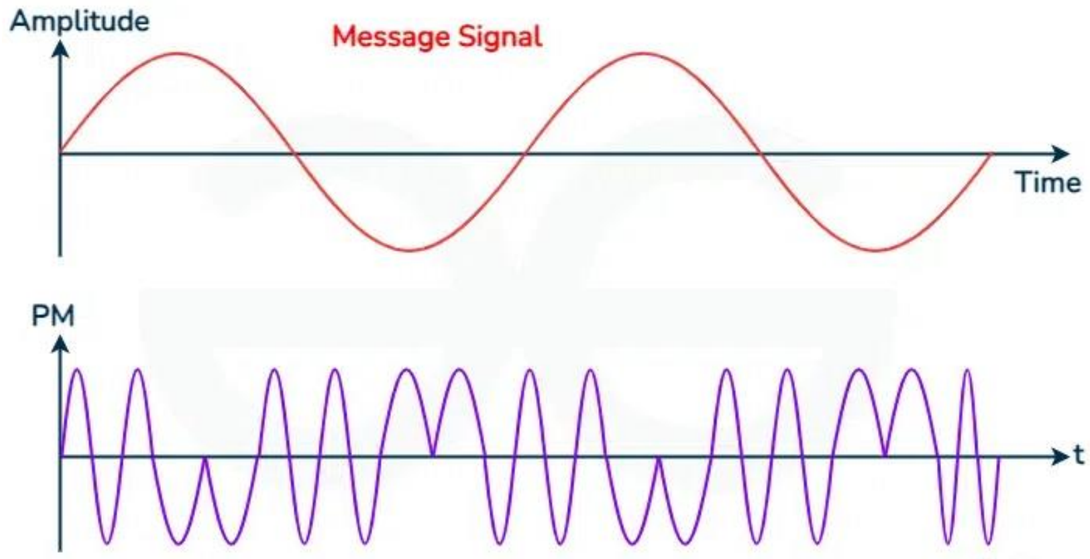
FREQUENCY MODULATION

This method comes into mind when we talk about broadcasting because frequency modulation helps in broadcasting multiple frequencies together .It is widely used for video broadcasting, medical monitoring systems, radar and more. Look at the figure below which shows the 1 kHz sine wave that was frequency modulated using sine wave of 10 Hz.



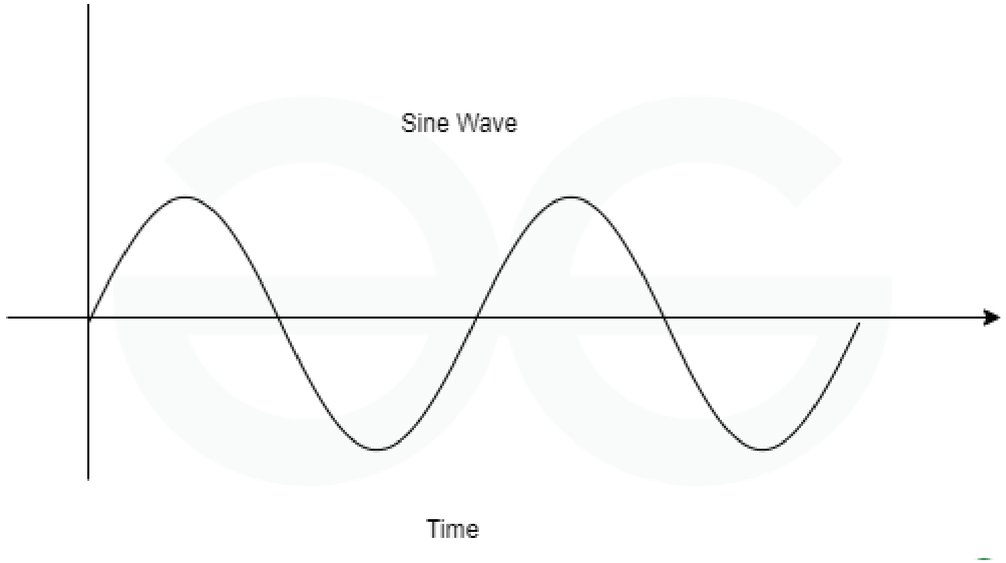
PHASE MODULATION

This modulation helps to change the phase of original wave by modulating it with the phase of carrier wave. We can see phase modulation being performed in Wi-Fi, GSM, and satellite broadcasting transmissions. It can performed using different techniques mainly PSK (Phase-shift keying), BPSK (Binary phase-shift keying), QPSK (Quadrature phase-shift keying) and more. Look at a sample phase modulation given below with deviation of 180^0



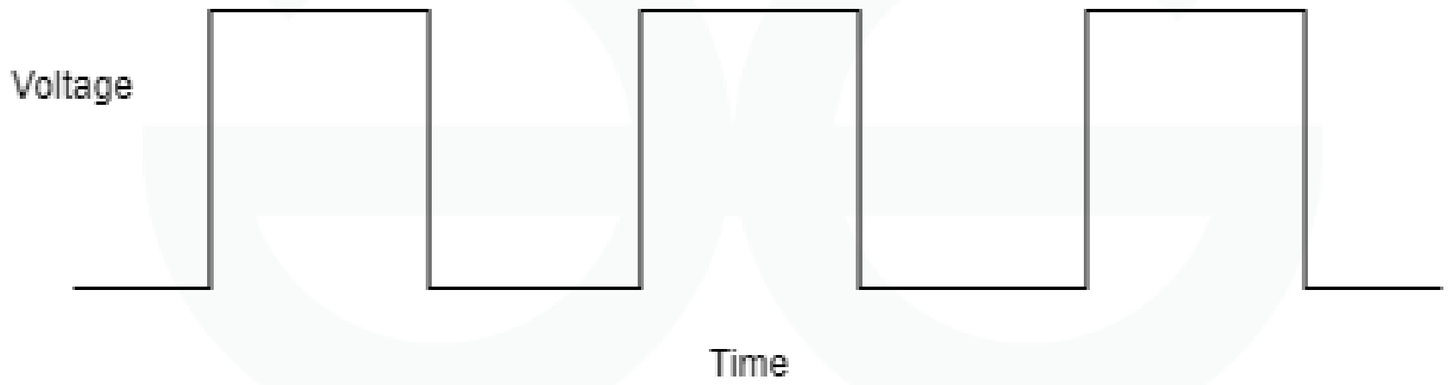
WAVEFORMS

Sine wave is a significant periodic wave which is a common choice for input signal is communication systems. It is denoted by y=sin(x) and can be used for generating other waveforms. It is a smooth wave that oscillates from 0 to 1 and then from maximum value of 1 to a minimum value of -1 until it begins to repeat itself. It can be generated using an RC network and It is mainly used as current and voltage signal for various generators.



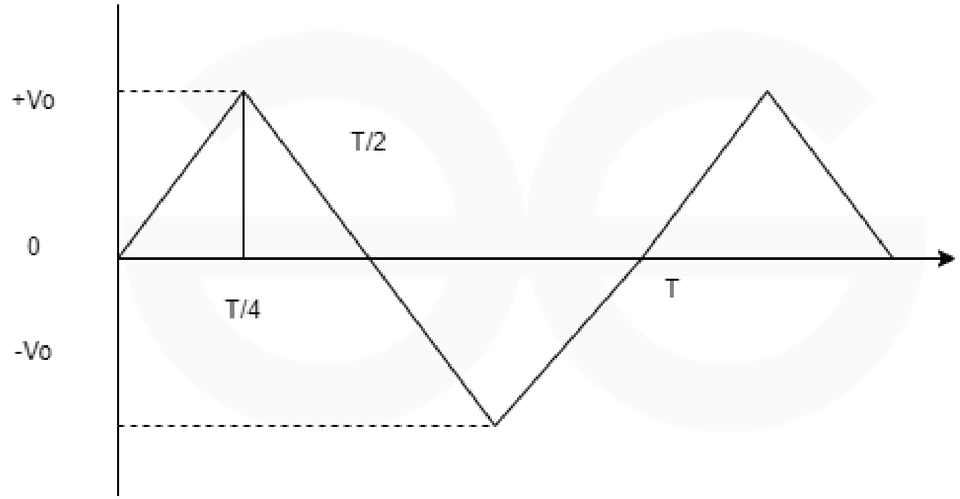
WAVEFORM

Square Wave is a a non-sinusoidal waveform which is periodic and whose amplitude oscillates from maximum to minimum with a constant frequency. There are instantaneous transitions rather than gradual transition. This makes square wave suitable choice for digital data transmission. This wave has a duty cycle of 50% due to which its second harmonic is absent.



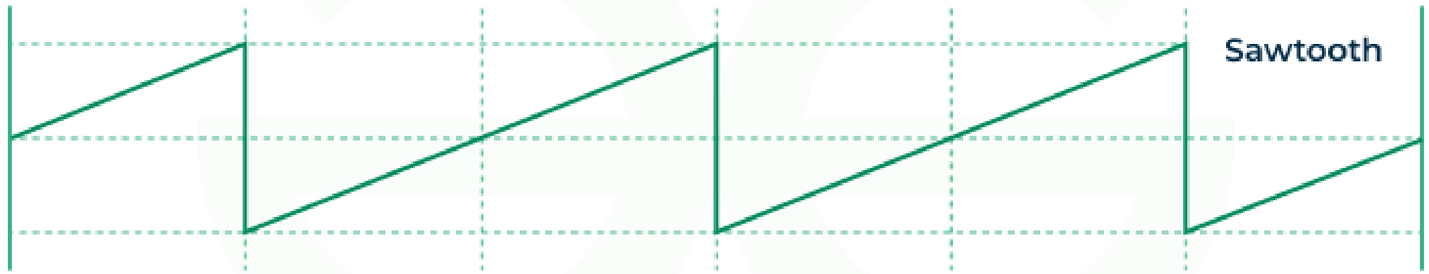
WAVEFORM

In a triangular waveform, signal moves up and down i.e. linearly varies with time. This output is usually generated by an operational amplifier when it works as an integrator. This is a fundamental kind of waveform generated by Function Generator and can be used to generate square pulse as well. The main use of such waveform comes in testing of amplifiers since triangular waveform shows any kind of distortion which other waveforms fail to show. Due to rich harmonics of this kind of pulse, it is used widely in musical instruments. It is used in sound synthesis as it has comparatively less harsh harmonics than other signals which makes it sound good. They are also used in sweep circuits and for testing purposes.



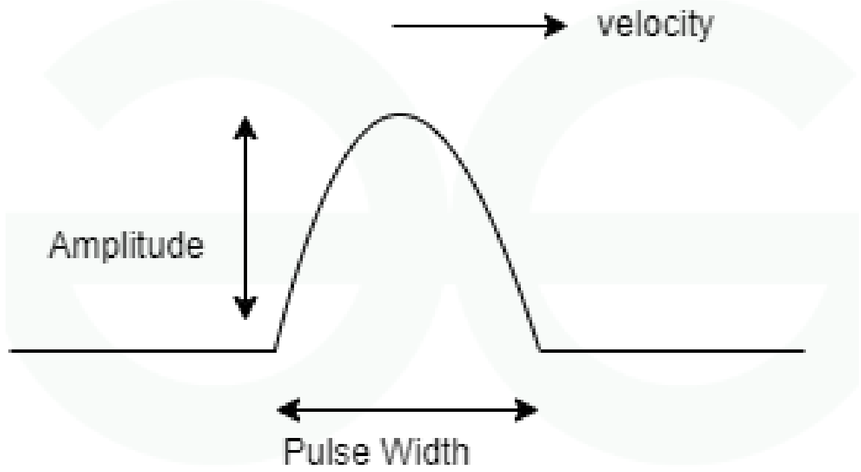
WAVEFORM

Sawtooth wave can be categorized as some kind of triangular wave in which the rising edges are very sharp as compared to the falling edges which are gradual. The name comes from the shape of the waveform which appears to be a sawtooth. We can generate this waveform by the same method followed for triangular pulse, the only thing to keep in mind is that difference in falling and rising times should be maintained and this can be done by controlling the rate of charge for each element. Similar to triangular wave, sawtooth wave is also used for sound generation. It helps to create sounds with subtractive analog music synthesizers. It is also used in electroencephalogram (EEG) because alpha oscillations of this wave are easier to remove than sine wave.



WAVEFORM

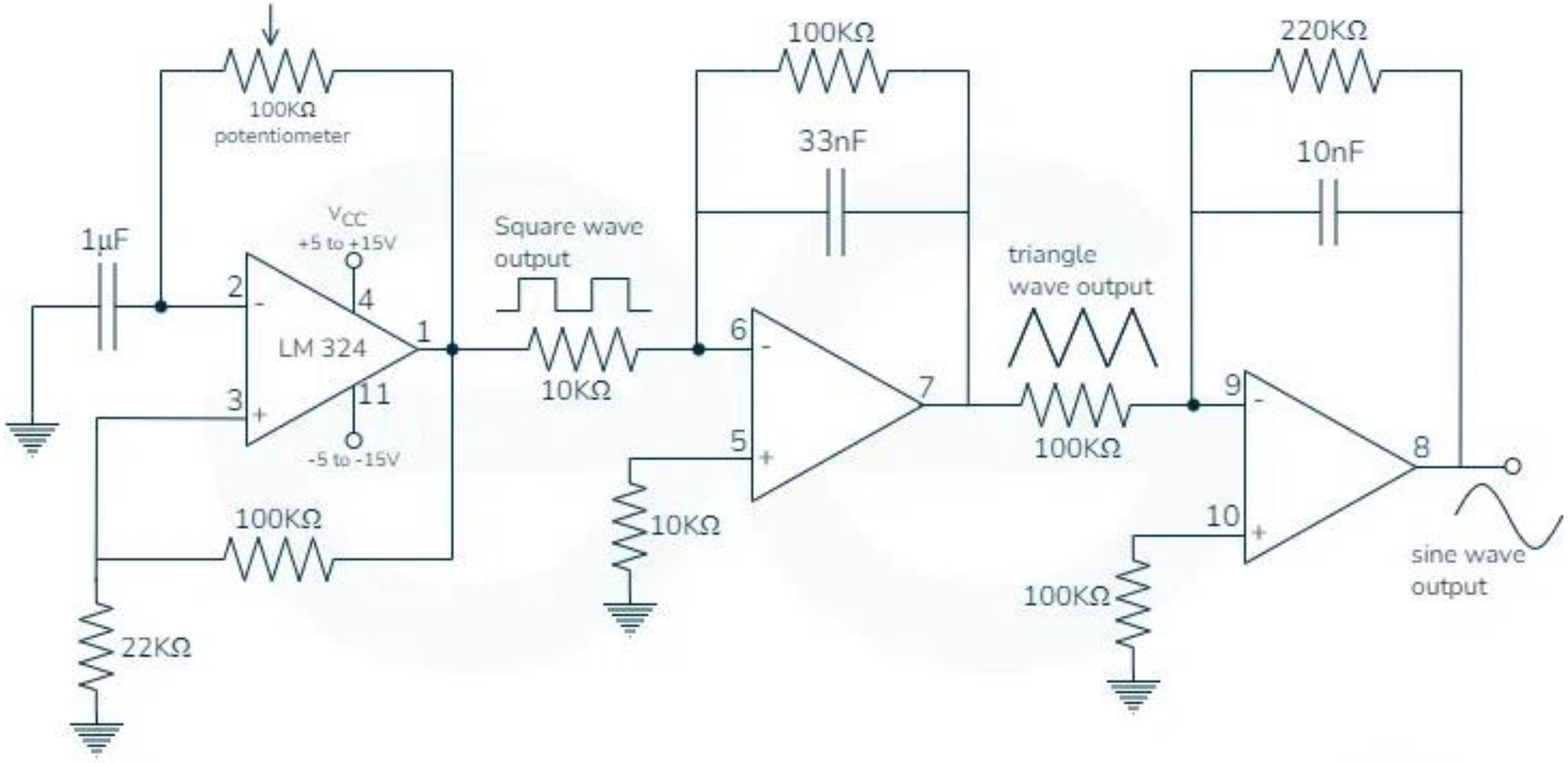
Pulse waveform is a special kind of waveform used for dealing with digital data. It is a non-sinusoidal waveform that resembles square wave .The only difference is that it has an offset duty cycle which means that the space ratio is 1:1 . Digital data which consists of bits of 0s and 1s is transmitted through these waves. One most wide-spread application of pulse wave is for analyzation of cardiac output during any major surgery or fluid transport. It is widely used in epidemiological and physiological studies to study the stiffness of arteries and calculate any possible risk.



ANALOG FUNCTION GENERATOR

As the name suggests analog function generators are specifically used for generating analog signals. Analog signals are continuous function signal in the time domain which can take infinite number of values in a given range. An Analog function generator generates simple waveforms of varying magnitudes and frequencies that repeat over a period of time. These generators use signal generator circuit and an electronic oscillator for generation of signal. Let us see how it works to generate output waveform

ANALOG FUNCTION GENERATOR



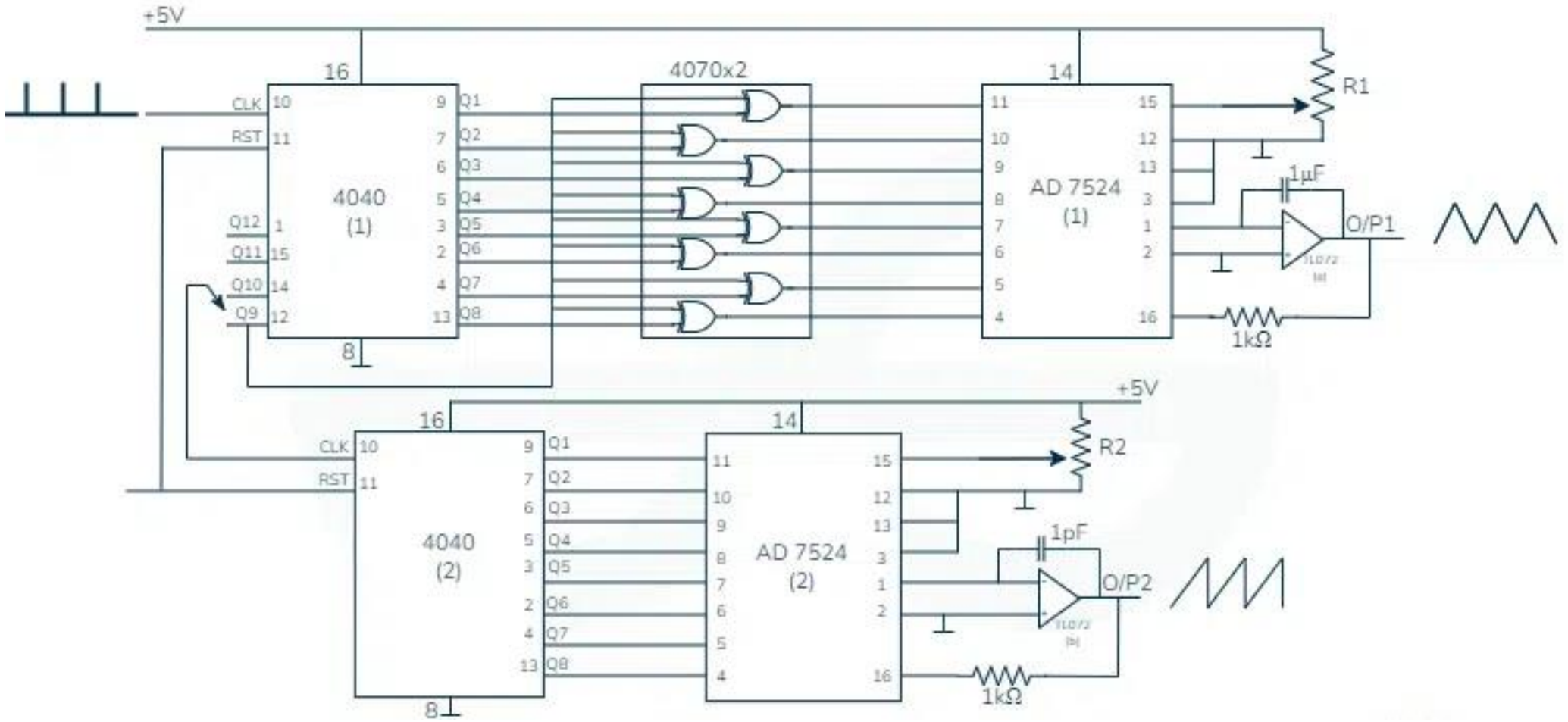
ANALOG FUNCTION GENERATOR

- It mainly consists of an oscillatory circuit which generates fundamental waveforms like sine wave. Operational amplifiers or PLL can be used for implementing this circuit.
- The next part involves waveform shaping which is done using a comparator circuit and a reference voltage for comparison.
- Now a frequency control knob is used in the function generator to control the frequency of signals being generated. This can also be done by using capacitor or resistances. Then ,we change the gain to modify the amplitude of wave.
- Now function selector switch helps us to select the type of waveform we need and then signal goes through a final amplifier for matching. The output is shown

DIGITAL FUNCTION GENERATOR

Digital function generators are specifically used for generating digital signals. Digital signals are signals which have discrete values in a certain given range this means they can only take finite number of values. A Digital function generator generates simple waveforms of certain magnitude. These generators use digital technology for generation of signal. They mostly use direct digital synthesis, DDS for this.

DIGITAL FUNCTION GENERATOR



DIGITAL FUNCTION GENERATOR

- The primary step involved is generation of a digital waveform which is converted to analog format using a digital-to-analog converter (DAC). The quantized values are converted to continuous values.
- The DAC controls the quality of signal by determining the sampling rate and resolution. This is directly linked to the accuracy of waveform.
- The generator allows users to control the properties of wave by allowing them to set them using buttons, knobs, a touchscreen, or software control via a computer.
- Then the random pulse is modulated by Digital function generator by managing frequency/phase of the generated waveform. Frequency sweeping is also performed.
- Synchronization of waveform is done and triggering options can be provided for initiating waveform at certain time instants. Then generated signal is passed through amplifier and shown using screen.

References

1. Albert D. Helfrick, William D. Cooper, “Modern Electronic Instrumentation and Measurement Techniques”, Pearson, 1st Edition, 2016 (Unit IV-V).
2. Sawhney A K., “Course in Electrical, Electronic Measurements and Instrumentation”, Shree Hari Publications, 2021(Unit IV-V).
3. Patranabis D, “Principles of Industrial Instrumentation”, Mc-Graw Hill Education, 3rd Edition, 2017 (Unit IV-V).

Thank You