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(REVISION — 2015)

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DIPLOMA EXAMINATION IN ENGINEERING/TECHNOLOGY/ MANAGEMENT/COMMERCIAL PRACTICE — OCTOBER, 2019

ANALOG DEVICES & CIRCUITS

[*Time* : 3 hours

(Maximum marks : 100)

PART — A

(Maximum marks : 10)

Marks

I Answer *all* questions in one or two sentences. Each question carries 2 marks.

1. Define the term peak inverse voltage.
2. Name three schemes of amplifier coupling.
3. State Barkhausen's criteria for oscillation.
4. Draw the circuit of an op-amp integrator.
5. Define CMRR. (5×2 = 10)

PART — B

(Maximum marks : 30)

II Answer any *five* of the following questions. Each question carries 6 marks.

1. Explain a full wave bridge rectifier.
2. Explain a zener diode voltage regulator.
3. Explain a transformer coupled amplifier.
4. Explain class A, class B and class C amplifier.
5. Explain a RC phase shift oscillator circuit.
6. Explain the working of colpitts oscillator.
7. List the characteristics of an ideal op amp. (5×6 = 30)

Marks

PART — C

(Maximum marks : 60)

(Answer *one* full question from each unit. Each full question carries 15 marks.)

UNIT — I

III (a) Explain a center tapped full wave rectifier circuit with waveform. 8

(b) Explain a LC filter. 7

OR

IV (a) Explain the working of voltage regulator using IC7805. 7

(b) Explain a positive clipper using series diode. 8

UNIT — II

V (a) Explain a RC coupled amplifier and plot the frequency response. 8

(b) Distinguish between different coupling schemes used in multistage amplifiers. 7

OR

VI (a) Explain the working of a complementary symmetry pushpull amplifier. 8

(b) Compare voltage and power amplifier. 7

UNIT — III

VII (a) Explain an astable multivibrator using IC 555. 8

(b) Explain the working of crystal oscillator. 7

OR

VIII (a) Name the three multivibrators and give applications of each. 7

(b) Explain the working of Hartley oscillator. 8

UNIT — IV

IX (a) Explain a inverting amplifier using op-amp. 7

(b) Explain a summing amplifier using op-amp. 8

OR

X (a) Explain a comparator using op-amp. 8

(b) Explain a differentiator using op-amp. 7

Sub code: 3031 Register no:…….

Revision-2015 Signature: ……..…..

THIRD SEMESTER DIPLOMA EXAMINATION IN ELECTRICAL AND ELECTRONICS ENGINEERING

EXAMINATION –OCT-2019

ANALOG DEVICES AND CIRCUITS –ANSWER KEY

PART-A

(Maximum Marks: 100) **TIME: 3 Hours**

PART-A

(Maximum marks: 10)

I. Answer all questions. Each question carries 2 marks.

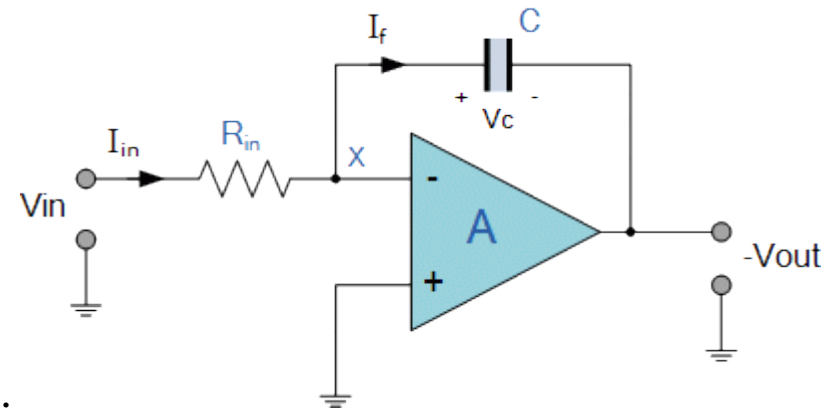
1. **. Peak Inverse Voltage (PIV)** Peak Inverse Voltage (PIV) rating of a diode is important in its design stages. It is the maximum voltage that the rectifying diode has to withstand, during the reverse biased period. When the diode is reverse biased, during the negative half cycle, there will be no current flow through the load resistor RL. Hence, there will be no voltage drop through the load resistance RL which causes the entire input voltage to appear across the diode. Thus V_{SMAX}, the peak secondary voltage, appears across the diode. Therefore, Peak Inverse Voltage (PIV) of half wave rectifier = V_{SMAX} Outline the concept of feedback.

2. Transformer **coupling**.
   Resister Capacitive **coupling**.
   Direct **coupling**.

3. According to Barkhausen criterion for sustained oscillation:

   1. **The magnitude of the product of open loop gain of the amplifier and the magnitude of the feedback factor is unity, i.e.,** $|\beta A|=1|\beta A|=1$ **where *A* is the gain of the amplifying element in the circuit and** $\beta(j\omega)\beta(j\omega)$ **is the transfer function of the feedback path.**
   2. **The total phase shift around the loop is** 0 **or integral multiples of** 2π**.**

4.



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5. Common-mode Rejection Ratio (CMRR)

A differential amplifier should have high differential voltage gain (ADM) and very low common mode voltage gain (ACM). The ratio ADM/ACM is called common-mode rejection ratio (CMRR) i.e.,

CMRR = ADM / ACM

(5x2=10)

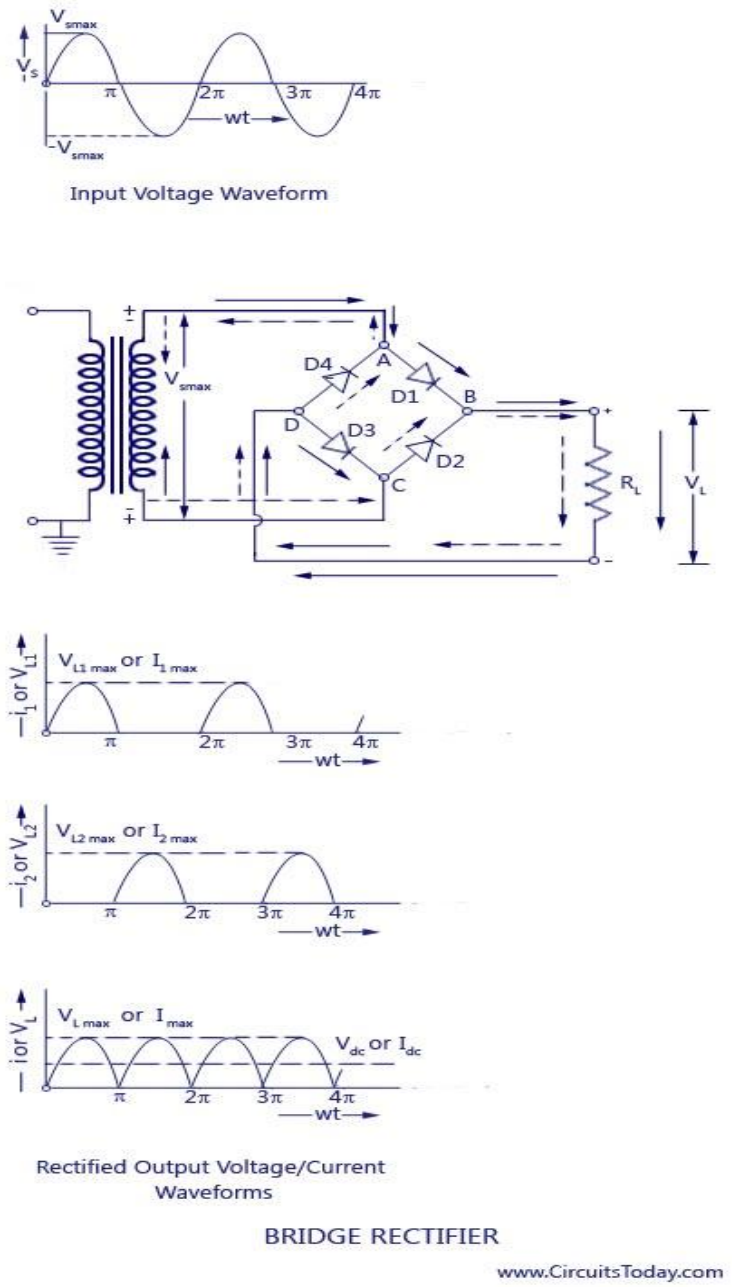
PART-B

(Maximum marks: 30)

II Answer any *five* questions. Each question carries 6 marks.

1 . Full Wave Bridge Rectifier.

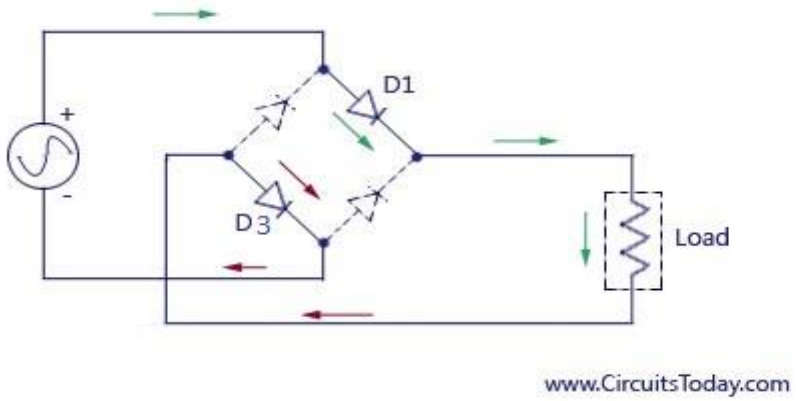
The working & operation of a full wave bridge rectifier is pretty simple. The circuit diagrams and wave forms we have given below will help you understand the operation of a bridge rectifier perfectly. In the circuit diagram, 4 diodes are arranged in the form of a bridge. The transformer secondary is connected to two diametrically opposite points of the bridge at points A & C. The load resistance R_L is connected to bridge through points B and D.



Full Wave Bridge Rectifier – Circuit Diagram with Input and Output Wave Forms

During the first half cycle

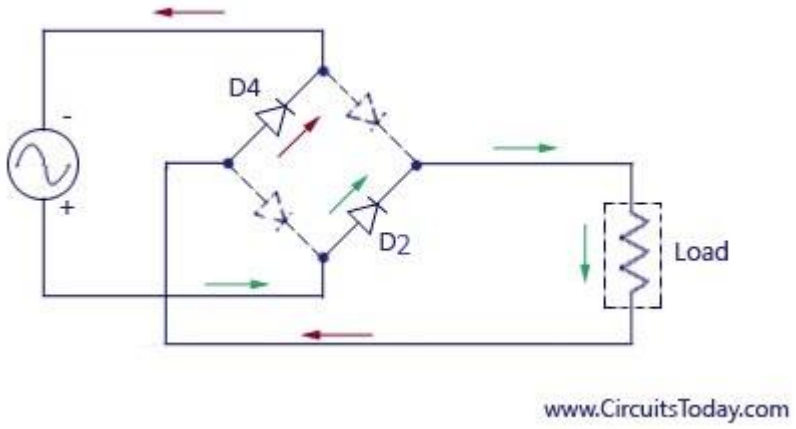
During first half cycle of the input voltage, the upper end of the transformer secondary winding is positive with respect to the lower end. Thus during the first half cycle diodes D1 and D_3 are forward biased and current flows through arm AB, enters the load resistance R_L, and returns back flowing through arm DC. During this half of each input cycle, the diodes D_2 and D_4 are reverse biased and current is not allowed to flow in arms AD and BC. The flow of current is indicated by solid arrows in the figure above. We have developed another diagram below to help you understand the current flow quickly. See the diagram below – the green arrows indicate beginning of current flow from source (transformer secondary) to the load resistance. The red arrows indicate return path of current from load resistance to the source, thus completing the circuit.



Flow of current in Bridge Rectifier

During the second half cycle

During second half cycle of the input voltage, the lower end of the transformer secondary winding is positive with respect to the upper end. Thus diodes D_2 and D_4 become forward biased and current flows through arm CB, enters the load resistance R_L, and returns back to the source flowing through arm DA. Flow of current has been shown by dotted arrows in the figure. Thus the direction of flow of current through the load resistance R_L remains the same during both half cycles of the input supply voltage. See the diagram below – the green arrows indicate beginning of current flow from source (transformer secondary) to the load resistance. The red arrows indicate return path of current from load resistance to the source, thus completing the circuit.



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2. Zener Diode Voltage Regulator

when the reverse bias on a crystal diode is increased, a critical voltage, called breakdown voltage is reached where the reverse current increases sharply to a high value. The breakdown region is the knee of the reverse characteristic as shown in Fig.1the breakdown voltage is sometimes called zener voltage and the sudden increase in current is known as zener current.

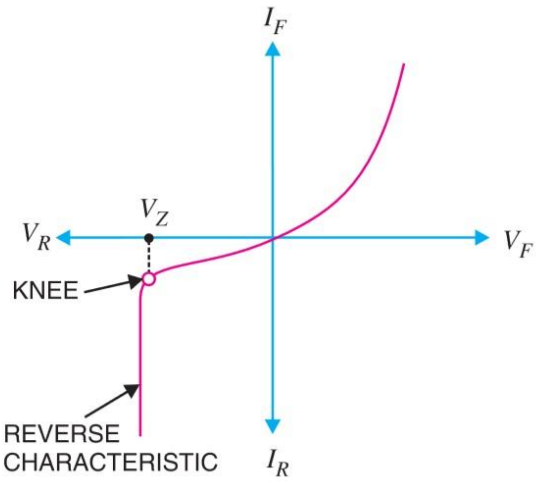

Fig 1

when the zener diode is operated in the breakdown or zener region, the voltage across it is substantially constant for a large change of current through it. This characteristic permits it to be used as a voltage regulator. Fig.2 shows the circuit of a zener diode regulator. As long as input voltage Vin is greater than zener voltage VZ , the zener operates in the breakdown region and maintains constant voltage across the load. The series limiting resistance RS limits the input current.

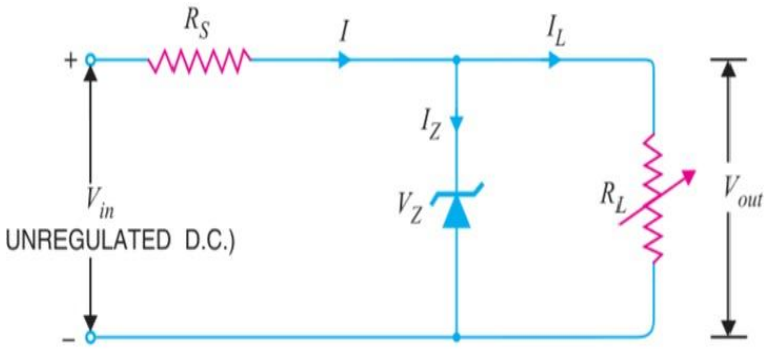

Fig.2

Voltage Regulator

Operation.

The zener will maintain constant voltage across the load inspite of changes in load current or input voltage. As the load current increases, the zener current decreases so that current through resistance RS is constant. As output voltage = Vin – IRS, and I is constant, therefore, output voltage remains unchanged. The reverse would be true should the load current decrease. The circuit will also correct for the changes in input voltages. Should the input voltage Vin increase, more current will flow through the zener, the voltage drop across RS will increase but load voltage would remain constant. The reverse would be true should the input voltage decrease.

Limitations. A zener diode regulator has the following drawbacks :

(i) It has low efficiency for heavy load currents. It is because if the load current is large, there will be considerable power loss in the series limiting resistance.

(ii) The output voltage slightly changes due to zener impedance as Vout = VZ + IZ ZZ. Changes in load current produce changes in zener current. Consequently, the output voltage also changes. Therefore, the use of this circuit is limited to only such applications where variations in load current and input voltage are small.

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3. Transformer-Coupled Amplifier

The main reason for low voltage and power gain of RC coupled amplifier is that the effective load (RAC) of each stage is *decreased due to the low resistance presented by the input of each stage to the preceding stage. If the effective load resistance of each stage could be increased, the voltage and power gain could be increased. This can be achieved by transformer coupling. By the use of impedance-changing properties of transformer, the low resistance of a stage (or load) can be reflected as a high load resistance to the previous stage.

Transformer coupling is generally employed when the load is small. It is mostly used for power amplification. Fig. 11.15 shows two stages of transformer coupled amplifier. A coupling transformer is used to feed the output of one stage to the input of the next stage. The primary P of this transformer is made the collector load and its secondary S gives input to the next stage.

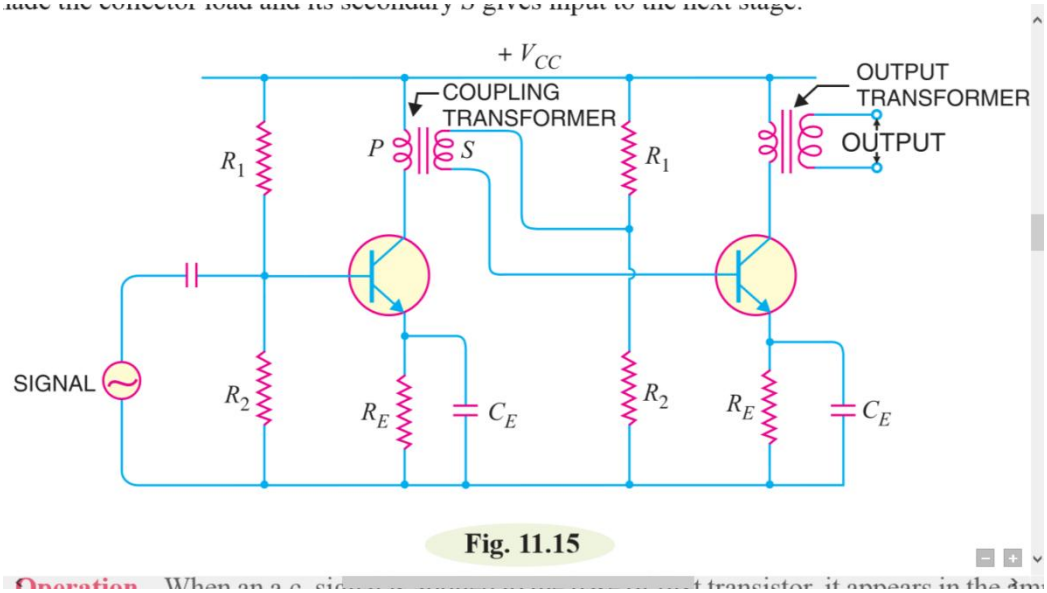
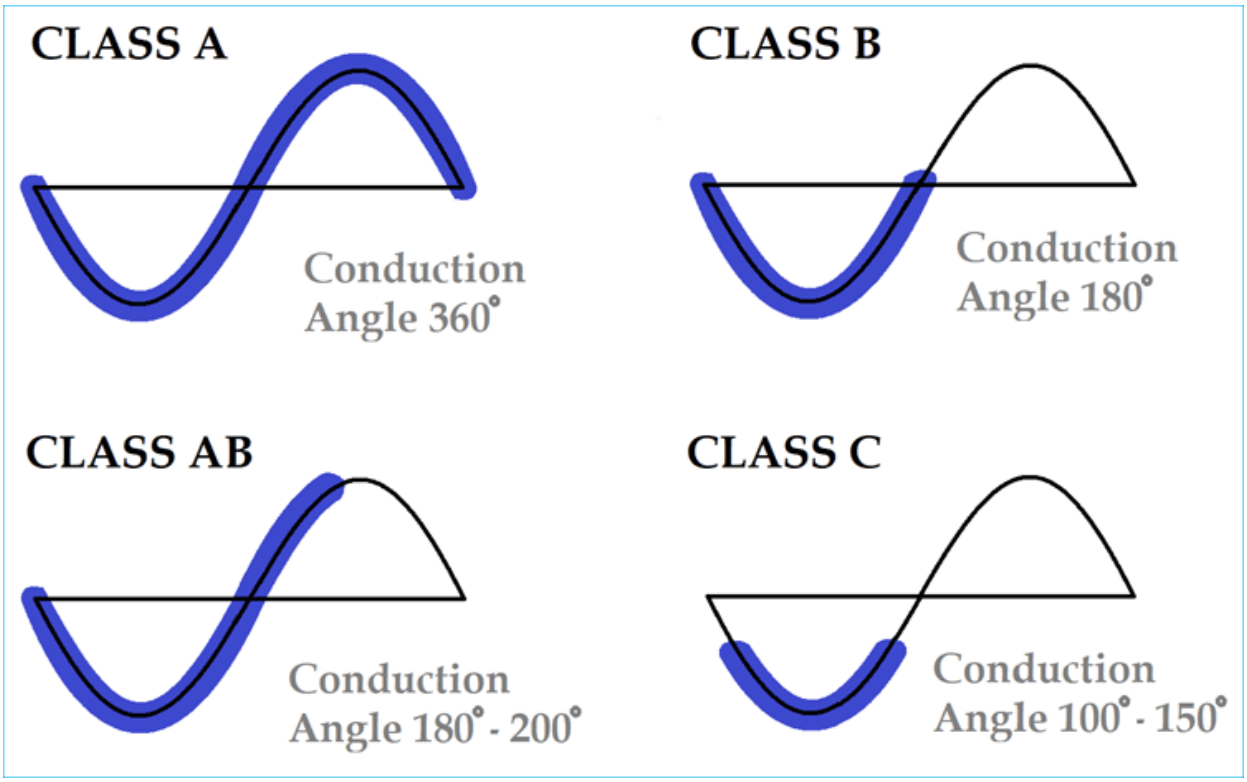


Fig. 11.15

Operation.

When an a.c. signal is applied to the base of first transistor, it appears in the amplified form across primary P of the coupling transformer. The voltage developed across primary is transferred to the input of the next stage by the transformer secondary as shown in Fig.11.15. The second stage renders amplification in an exactly similar manner4. List out the various types of couplings in amplifier and write their applications.

4. Class A: Single-ended; the amplifier device is biased about the center of the input signal swing. • Class B: Push-pull; each device conducts over half the input signal swing. • Class AB: Push-pull; each device conducts over slightly more than half the input signal swing to simplify crossover



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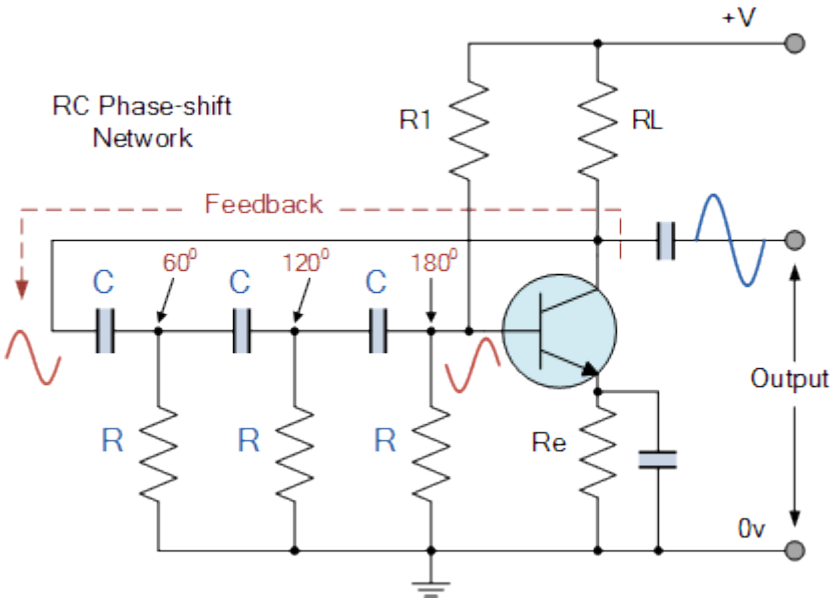
5. RC Phase-Shift Oscillator.

For an oscillator to sustain oscillations indefinitely, sufficient feedback of the correct phase, that is "Positive Feedback" must be provided along with the transistor amplifier being used acting as an inverting stage to achieve this.

In an **RC Oscillator** circuit the input is shifted 180^o through the amplifier stage and 180^oagain through a second inverting stage giving us "$180^o + 180^o = 360^o$" of phase shift which is effectively the same as 0^o thereby giving us the required positive feedback. In other words, the phase shift of the feedback loop should be "0".

In a **Resistance-Capacitance Oscillator** or simply an **RC Oscillator**, we make use of the fact that a phase shift occurs between the input to a RC network and the output from the same network by using RC elements in the feedback branch, for example

Basic RC Oscillator Circuit



The basic **RC Oscillator** which is also known as a **Phase-shift Oscillator**, produces a sine wave output signal using regenerative feedback obtained from the resistor-capacitor combination. This regenerative feedback from the RC network is due to the ability of the capacitor to store an electric charge, (similar to the LC tank circuit).

This resistor-capacitor feedback network can be connected as shown above to produce a leading phase shift (phase advance network) or interchanged to produce a lagging phase shift (phase retard network) the outcome is still the same as the sine wave oscillations only occur at the frequency at which the overall phase-shift is 360^{o}.

By varying one or more of the resistors or capacitors in the phase-shift network, the frequency can be varied and generally this is done by keeping the resistors the same and using a 3-ganged variable capacitor.

If all the resistors, R and the capacitors, C in the phase shift network are equal in value, then the frequency of oscillations produced by the RC oscillator is given as:

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

Where:

- f_r is the Output Frequency in Hertz
- R is the Resistance in Ohms
- C is the Capacitance in Farads
- N is the number of RC stages. (N = 3)

6. Colpitts Oscillator

Colpitts Oscillator is a type of LC oscillator which falls under the category of Harmonic Oscillator and was invented by Edwin Colpitts in 1918. Figure 1 shows a typical Colpitts

oscillator with a tank circuit in which an inductor L is connected in parallel to the serial combination of capacitors C_1 and C_2 (shown by the red enclosure).

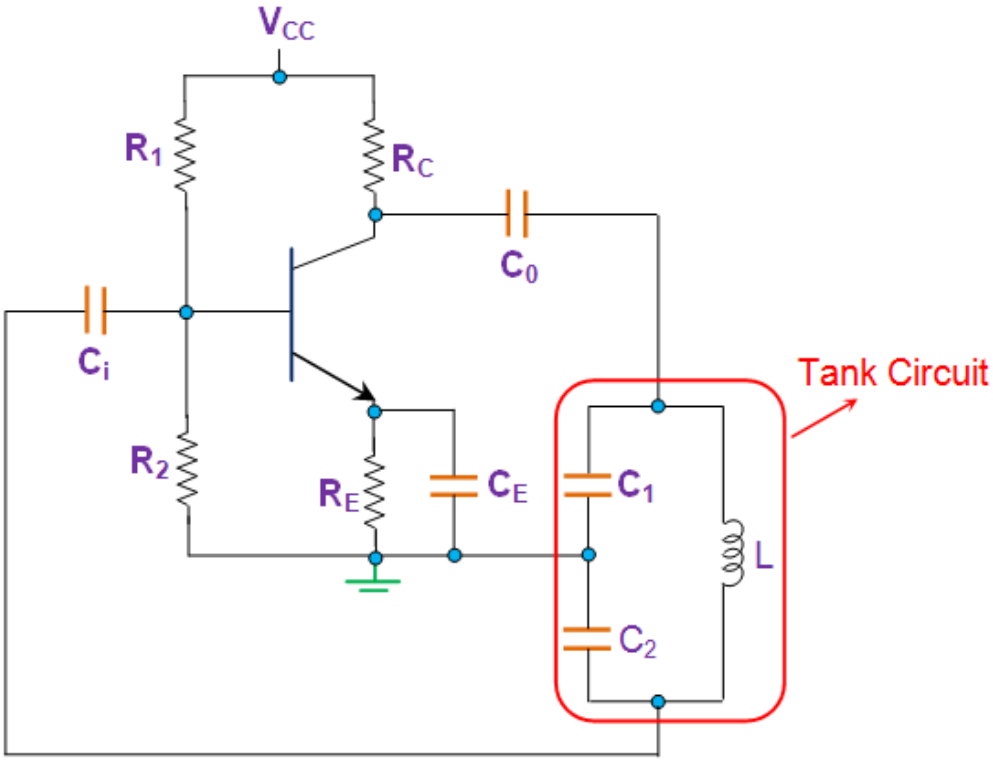


Figure 1 Colpitts Oscillator

Other components in the circuit are the same as that found in the case of common-emitter amplifier which is biased using a voltage divider network i.e. R_C is the collector resistor, R_E is the emitter resistor which is used to stabilize the circuit and the resistors R_1 and R_2 form the voltage divider bias network. Further, the capacitors C_i and C_o are the input and output decoupling capacitors while the emitter capacitor C_E is the bypass capacitor used to bypass the amplified AC signals.

Here, as the power supply is switched ON, the transistor starts to conduct, increasing the collector current IC due to which the capacitors C_1 and C_2 get charged. On acquiring the maximum charge feasible, they start to discharge via the inductor L. During this process, the electrostatic energy stored in the capacitor gets converted into magnetic flux which inturn is stored within the inductor in the form of electromagnetic energy. Next, the inductor starts to discharge which charges the capacitors once again. Likewise, the cycle continues which gives rise to the oscillations in the tank circuit.

Further the figure shows that the output of the amplifier appears across C_1 and thus is in-phase with the tank circuit's voltage and makes-up for the energy lost by re-supplying it. On the other hand, the voltage feedback to the transistor is the one obtained across the capacitor C_2, which means the feedback signal is out-of-phase with the voltage at the transistor by 180^o. This is due to the fact that the voltages developed across the capacitors C_1 and C_2 are opposite in polarity as the point where they join is grounded. Further, this signal is provided with an additional phase-shift of 180^o by the transistor which results in a net phase-shift of 360^o around the loop, satisfying the phase-shift criterion of Barkhausen principle.

At this state, the circuit can effectively act as an oscillator producing sustained oscillations by carefully monitoring the feedback ratio given by (C_1 / C_2). The frequency of such a **Colpitts Oscillator** depends on the components in its tank circuit and is given by

$$F = \frac{1}{2\pi\sqrt{LC_{eff}}}$$

Where, the C_{eff} is the effective capacitance of the capacitors expressed as

$$\frac{C_1 C_2}{C_1 + C_2}$$

7. Characteristics of an Ideal Op-Amp

• Infinite input impedance

• Zero output impedance

• Zero common-mode gain, or, infinite common-mode rejection

• Infinite open-loop gain A

• Infinite bandwidth.

(5x6=30)

PART-C

(Maximum marks: 60)

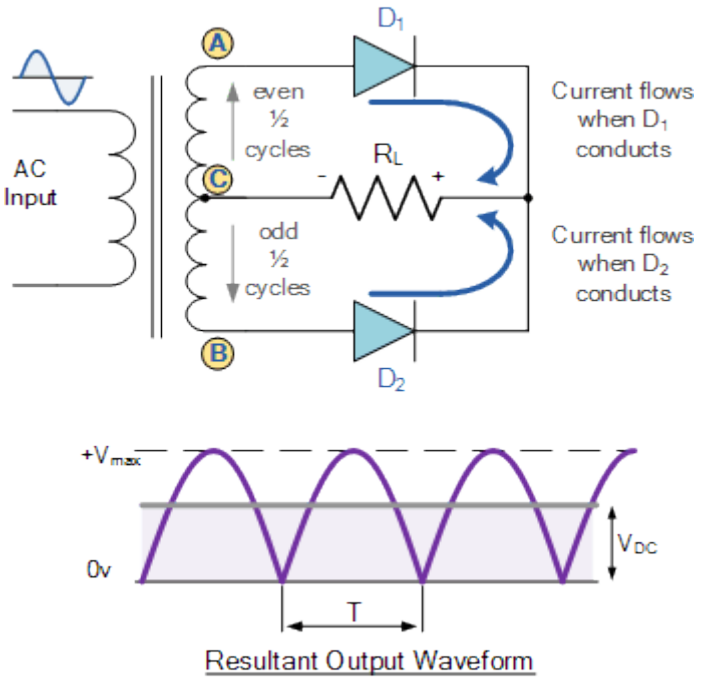
(Answer any one full question from each unit. Each question carries 15 marks.)

UNIT-I

III. a) Center Tapped Full Wave Rectifier

In a **Full Wave Rectifier** circuit two diodes are now used, one for each half of the cycle. A multiple winding transformer is used whose secondary winding is split equally into two halves with a common centre tapped connection, (C). This configuration results in each diode conducting in turn when its anode terminal is positive with respect to the transformer centre point C producing an output during both half-cycles, twice that for the half wave rectifier so it is 100% efficient as shown below.

Circuit



The full wave rectifier circuit consists of two *power diodes* connected to a single load resistance (R_L) with each diode taking it in turn to supply current to the load. When point A of the transformer is positive with respect to point C, diode D_1 conducts in the forward direction as indicated by the arrows.

When point B is positive (in the negative half of the cycle) with respect to point C, diode D_2 conducts in the forward direction and the current flowing through resistor R is in the same direction for both half-cycles. As the output voltage across the resistor R is the phasor sum of the two waveforms combined.

As the spaces between each half-wave developed by each diode is now being filled in by the other diode the average DC output voltage across the load resistor is now double that of the single half-wave rectifier circuit and is about $0.637V_{max}$ of the peak voltage, assuming no losses.

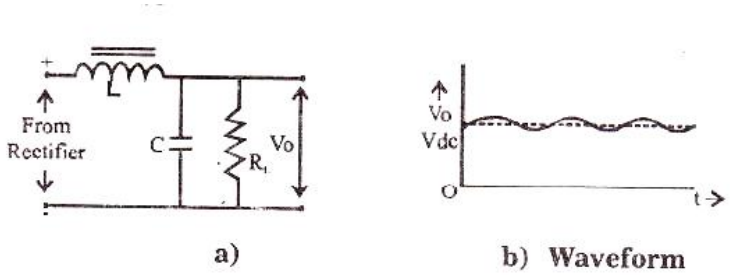
$$V_{d.c.} = \frac{2V_{max}}{\pi} = 0.637V_{max} = 0.9V_{RMS}$$

Where: V_{MAX} is the maximum peak value in one half of the secondary winding and $V_{RMS}$is the rms value.

The peak voltage of the output waveform is the same as before for the half-wave rectifier provided each half of the transformer windings have the same rms voltage value. To obtain a different DC voltage output different transformer ratios can be used. The main disadvantage of this type of full wave rectifier circuit is that a larger transformer for a given power output is required with two separate but identical secondary windings making this type of full wave rectifying circuit costly compared to the “Full Wave Bridge Rectifier” circuit equivalent.

b) LC Filter

In the above two filters the reactive components are singly connected, however no element will be perfect in doing the job i.e. inductor in series may pass small quantity of AC and Capacitor in parallel may not block all the AC component. So for better filtering two components are connected as filter which provides less ripple factor at the output compared to the above filter.

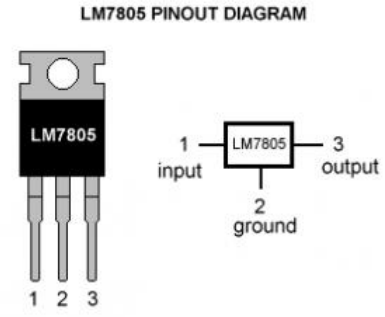


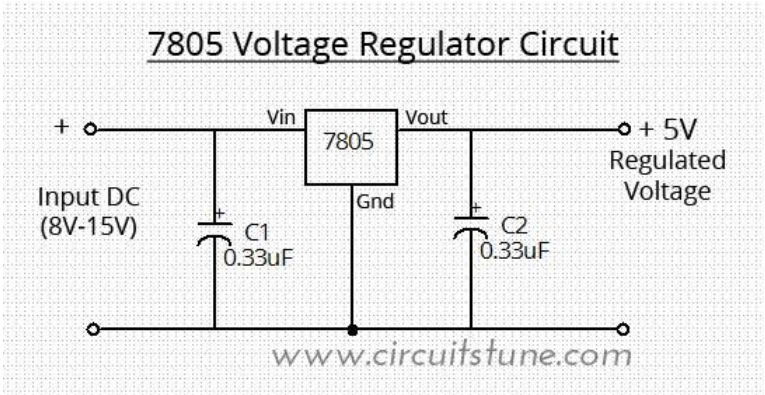
OR

IV a) 7805 IC voltage regulator

The main advantage of IC voltage regulators is that properties like thermal compensation, short circuit protection and surge protection can be built into the device. Most of the commonly used IC voltage regulators are three-terminal devices.

Voltage sources in a circuit may have fluctuations resulting in not giving fixed voltage outputs. Voltage regulator IC maintains the output voltage at a constant value. 7805 IC, a voltage regulator integrated circuit (IC) is a member of 78xx series of fixed linear voltage regulator ICs used to maintain such fluctuations. The xx in 78xx indicates the fixed output voltage it provides. 7805 IC provides +5 volts regulated power supply with provisions to add heat sink as well.





The 7805 IC is connected to provide a fixed d.c. output of + 5V. The unregulated input voltage Vi is connected to the IC's IN terminal and the IC's OUT terminal provides + 5V. Capacitors, although not always necessary, are sometimes used on the input and output as shown in Fig. 17.26. The output capacitor (C2) acts basically as a line filter to improve transient response. The input capacitor (C1) is used to prevent unwanted oscillations.

b) SERIES POSITIVE CLIPPER

In a series positive clipper, a diode is connected in series with the output, as shown in Fig 1(a). Duringthe positive half of the input voltage, the terminal A is positive with respect to B. This re verse biasesthe diode and it acts as an open switch Therefore all the applied voltage drops across the diode and

none across the resistor As a result of this there is no output voltage during the positive half cycl e of the input voltage.

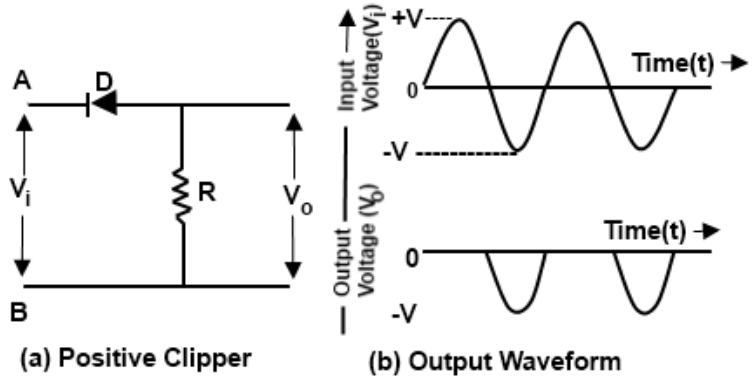


Figure 1:Series Positive Clipper

During the negative half cycle of the input voltage the terminal B is positive with respect to A.Thereforeitforwardbiasesthediodeanditactsasaclosedswitch.Thusthereisonvolt agedropacross diode during the negative half cycle of the input voltage. All the input voltage is dropped across the resistor as shown in the output waveform.

Clippers prevent either or both polarities of a wave form exceeding a specific amplitude level. However appositive Clipper is that which removesorclipsthepositivehalfcompletely.HencethecircuitoftheFig2.1iscalledapo sitiveClipperHereitmayhenotedthediodeactsaseriesswitchbetweenthesource and

load. Due to this reason the circuit is called series positive clipper.

UNIT-II

V. a) RC Coupled Transistor Amplifier

This is the most popular type of coupling because it is cheap and provides excellent audio fidelity over a wide range of frequency. It is usually employed for voltage amplification. Fig. 11.9 shows two stages of an RC coupled amplifier. A coupling capacitor CC is used to connect the output of first stage to the base (i.e. input) of the second stage and so on. As the coupling from one stage to next is achieved by a coupling capacitor followed by a connection to a shunt resistor, therefore, such amplifiers are called resistance - capacitance coupled amplifiers.

The resistances R1, R2 and RE form the biasing and stabilisation network. The emitter bypass capacitor offers low reactance path to the signal. Without it, the voltage gain of each stage would be lost. The coupling capacitor CC transmits a.c. signal but blocks d.c. This prevents d.c. interference between various stages and the shifting of operating point.

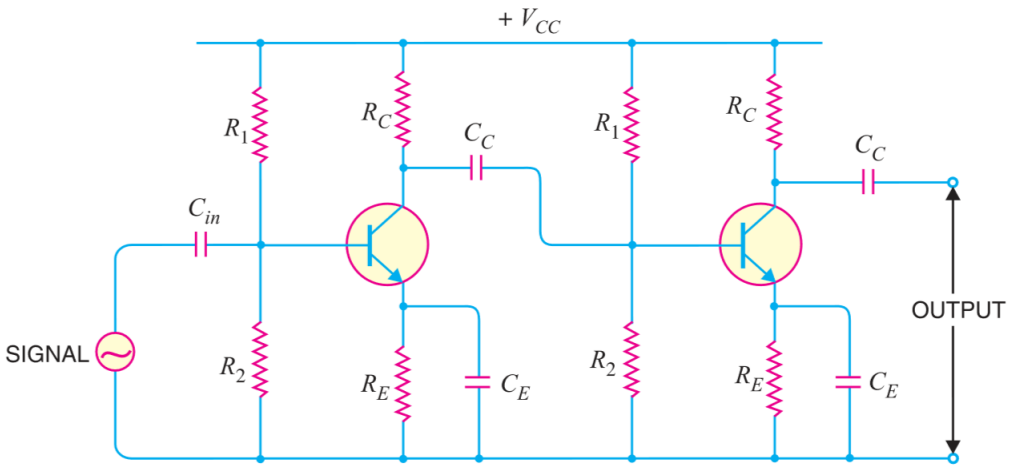


Fig. 11.9

Operation.

When a.c. signal is applied to the base of the first transistor, it appears in the amplified form across its collector load RC. The amplified signal developed across RC is given to base of next stage through coupling capacitor CC. The second stage does further amplification of the signal. In this way, the cascaded (one after another) stages amplify the signal and the overall gain is considerably increased.

It may be mentioned here that total gain is less than the product of the gains of individual stages. It is because when a second stage is made to follow the first stage, the effective load resistance of first stage is reduced due to the shunting effect of the input resistance of second stage. This reduces the gain of the stage which is loaded by the next stage. For instance, in a 3-

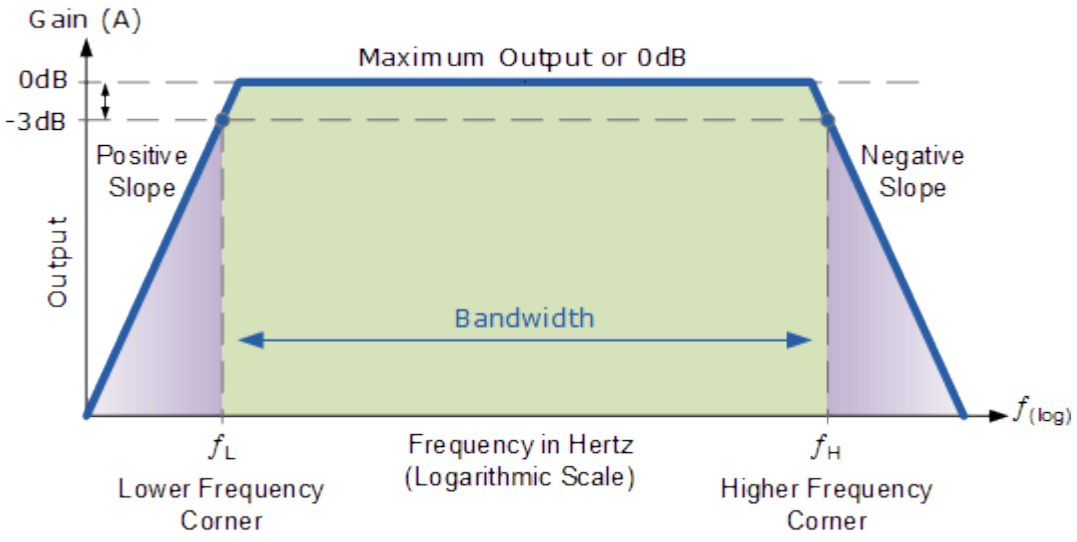
stage amplifier, the gain of first and second stages will be reduced due to loading effect of next stage. However, the gain of the third stage which has no loading effect of subsequent stage, remains unchanged. The overall gain shall be equal to the product of the gains of three stages.

Advantages

(i) It has excellent frequency response. The gain is constant over the audio frequency range which is the region of most importance for speech, music etc.
(ii) It has lower cost since it employs resistors and capacitors which are cheap.
(iii) The circuit is very compact as the modern resistors and capacitors are small and extremely light.

Disadvantages

(i) The RC coupled amplifiers have low voltage and power gain. It is because the low resistance presented by the input of each stage to the preceding stage decreases the effective load resistance (RAC) and hence the gain.
(ii) They have the tendency to become noisy with age, particularly in moist climates.
(iii) Impedance matching is poor. It is because the output impedance of RC coupled amplifier isseveral hundred ohms whereas the input impedance of a speaker is only a few ohms. Hence, little power will be transferred to the speaker

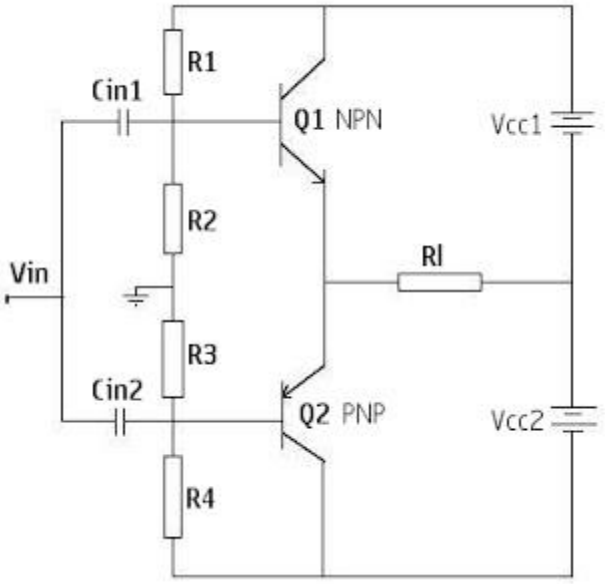


b)

S. No	Particular	*RC* coupling	Transformer coupling	Direct coupling
1.	*Frequency response*	Excellent in the audio frequency range	Poor	Best
2.	*Cost*	Less	More	Least
3.	*Space and weight*	Less	More	Least
4.	*Impedance matching*	Not good	Excellent	Good
5.	*Use*	For voltage amplification	For power amplification	For amplifiying extremely low frequencies

OR

VI **a) CIRCUIT DIAGRAM OF COMPLEMENTARY SYMMETRY PUSH-PULL AMPLIFIER**



CIRCUIT EXPLANATION OF COMPLEMENTARY SYMMETRY PUSH PULL AMPLIFIER

This arrangement uses two transistors having complementary symmetry (one transistor is PNP and the other is NPN).
The term complementary arises from the fact that one transistor is N-P-N type and the other is P-N-P type. They have symmetry as they are made with the same material and technology and are of same maximum rating.

The resistors R1 and R2 provide the voltage divider bias to forward bias the Emitter-Base Junction of transistor Q1 and Similarly Resistors R3 and R4 provide the voltage divider bias for

Emitter junction of transistor Q2. The Resistors are so selected that under zero signal condition, the operating point is cutoff and so no collector current flows.

WORKING

The signal applied at the input goes to the base of both the transistors. The two transistors conduct in the opposite half cycle of input signal, the NPN transistor Q1 is forward biased and conducts while the PNP transistor Q2 is reverse biased and so doesnot conduct. This results in a half cycle of output voltage across the load, resistor Rl. Similarly during the negative half cycle only the PNP transistor Q2 is forward biased and conducts which develops second half cycle of the output voltage across the Load Resistor Rl. Transistor Q1 being reverse biased and doesnot conduct during the negative half cycle of the input signal. Thus during a complete cycle of input, a complete cycle of output will developed.

Advantages (i) This circuit does not require transformer. This saves on weight and cost.

(ii) Equal and opposite input signal voltages are not required.

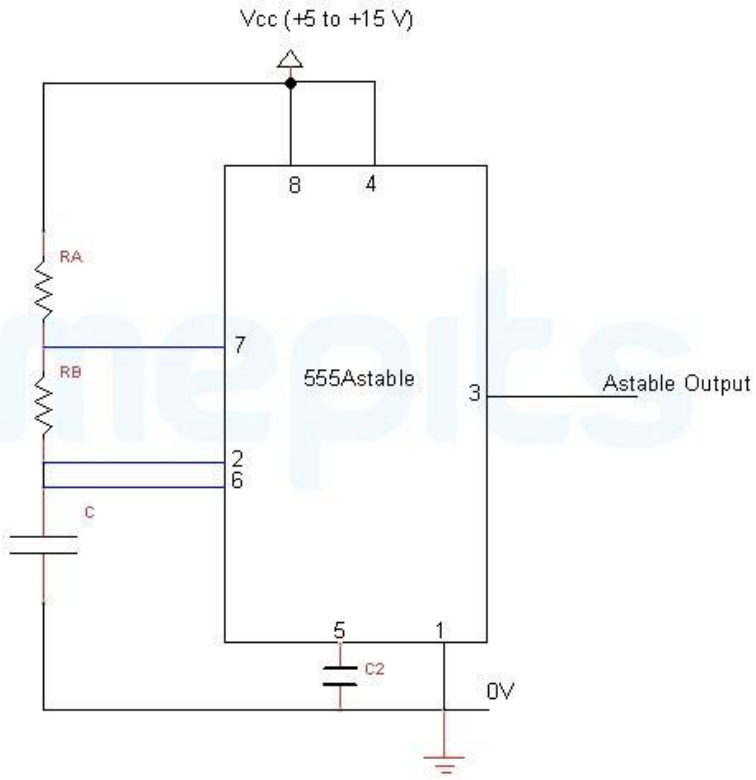
Disadvantages (i) It is difficult to get a pair of transistors (npn and pnp) that have similar characteristics. (ii) We require both positive and negative supply voltages.

b) Generally, the voltage amplifier is used for the amplification of very low voltage signal in a circuit, whereas the power amplifiers are used for drive the loudspeaker. A voltage amplifier increases the voltage level of a signal whereas the power amplifier increases the power of the signal.

S.NO	Voltage amplifier	Power amplifier
1	Transistor chosen should have high value of β about 100	Transistor should have small value of β about 20 to 50.
2	Load resistance Rc has high value about 10KΩ	Load has small value 10Ω to 20Ω
3	Input voltage is low approx few mV	Input voltage is high about few volt
4	It has low power output & high voltage output.	It has high power output and low voltage output .
5	Collector current has low value 100mA.	Collector current has high value.
6	Output impedance of voltage amplifier has high value.	Output impedance has low value.
7	Usually R-C coupling is used.	Transformer or tuned circuit is always used

UNIT-III

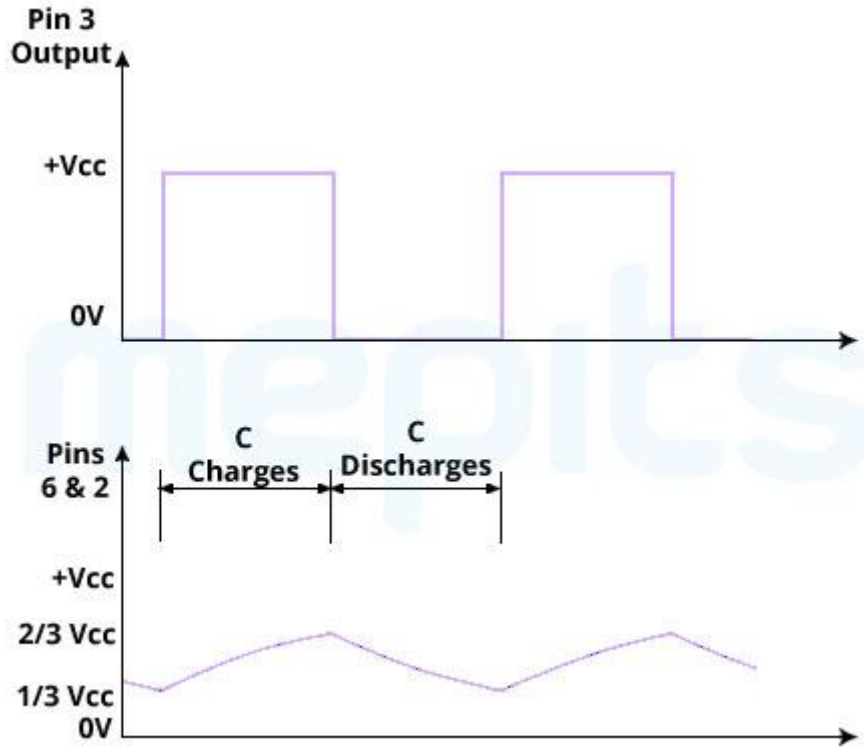
VII **a)** Astable mode of the 555 IC is achieved by connecting the resistors R1, R2 and the capacitor C1 to the timer IC as shown in the figure. R1 is connected between pin4 and pin7.While R2 is connected between pin7 and pin6 with the pin2 as a common node. Connection of the capacitor C1 is between pin1 and pin6.The output produced by the astable circuit is not stable in both the HIGH and the LOW states and it continuously switches from one state to the other. The timing (time period) during which the output is either high or low is determined by R1, R2 and C1.



Astable Multivibrator Operation

An astable 555 timer circuit usually contains an SR flip flop, two comparators, a **NPN transistor** and few discrete components like*resistors* and *capacitors* for its operation. Initially, when the power supply is switched ON, consider that the SR flip flop is cleared with Q=0. At this stage, the discharging transistor will remain OFF since Q (Q=0) is connected to the base of the transistor. The capacitor, C will now charge through R_A and R_B to Vcc. Hence we can say that, the time constant required for charging is equal to (R_A + R_B) C. As the threshold voltage (capacitor voltage) becomes greater than 2/3 Vcc, comparator 1 will be HIGH. The comparator output is HIGH because the voltage at the non-inverting terminal is greater than the inverting terminal. Now S=1, R=0, Q=1 and Vout=0 for the flip flop.

This change in Q will turn the discharging transistor to ON condition. Capacitor C will now turn over to the discharging mode. The discharging takes place through the resistor R_B. Hence the discharge time constant will be R_BC. When the capacitor voltage becomes lower than 1/3 Vcc, comparator 2 will be HIGH.As a result, S=0, R=1, Q=0 and Vout=1.Discharging transistor will now turn ON and the next cycle of operation will begin.



$$t1 = 0.693(R_A + R_B)$$

$$t2 = 0.693\ R_B C$$

$$T = t1 + t2 = 0.693(R_A + 2R_B)\ C$$

b) Crystal Oscillator

Crystal oscillators operate on the principle of inverse piezoelectric effect in which an alternating voltage applied across the crystal surfaces causes it to vibrate at its natural frequency. It is these vibrations which eventually get converted into oscillations. These oscillators are usually made of Quartz crystal, eventhough other substances like Rochelle salt and Tourmaline exhibit the piezoelectric effect because, quartz is inexpensive, naturally-available and mechanically-strong when compared to others.

In crystal oscillators, the crystal is suitably cut and mounted between two metallic plates as shown by Figure 1a whose electrical equivalent is shown by Figure 1b. In reality, the crystal behaves like a series RLC circuit, formed by the components

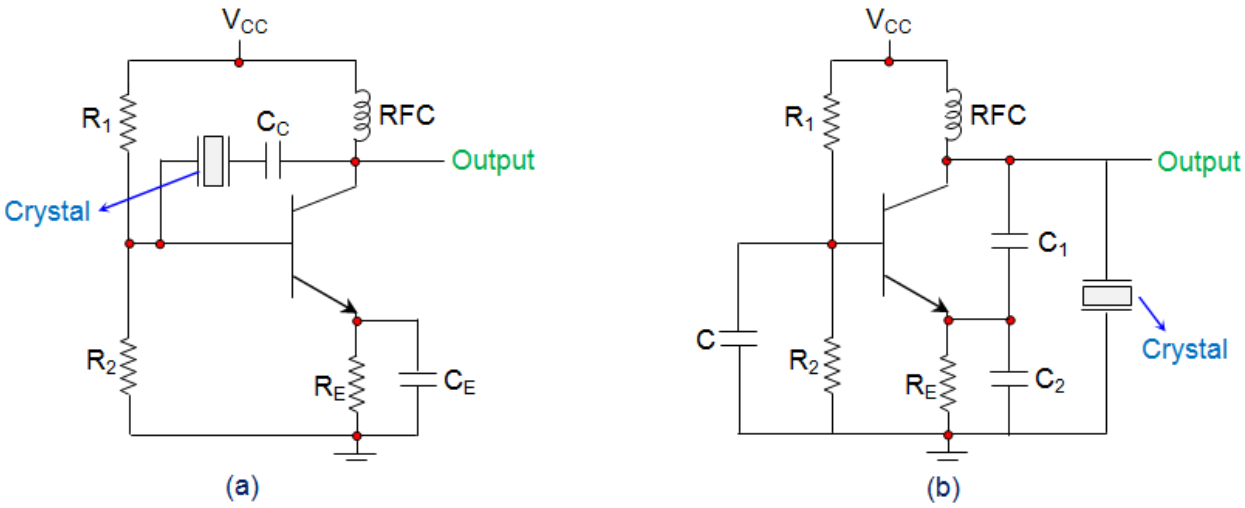


Figure 2 Crystal Oscillator Operating in (a) Series Resonance (b) Parallel Resonance

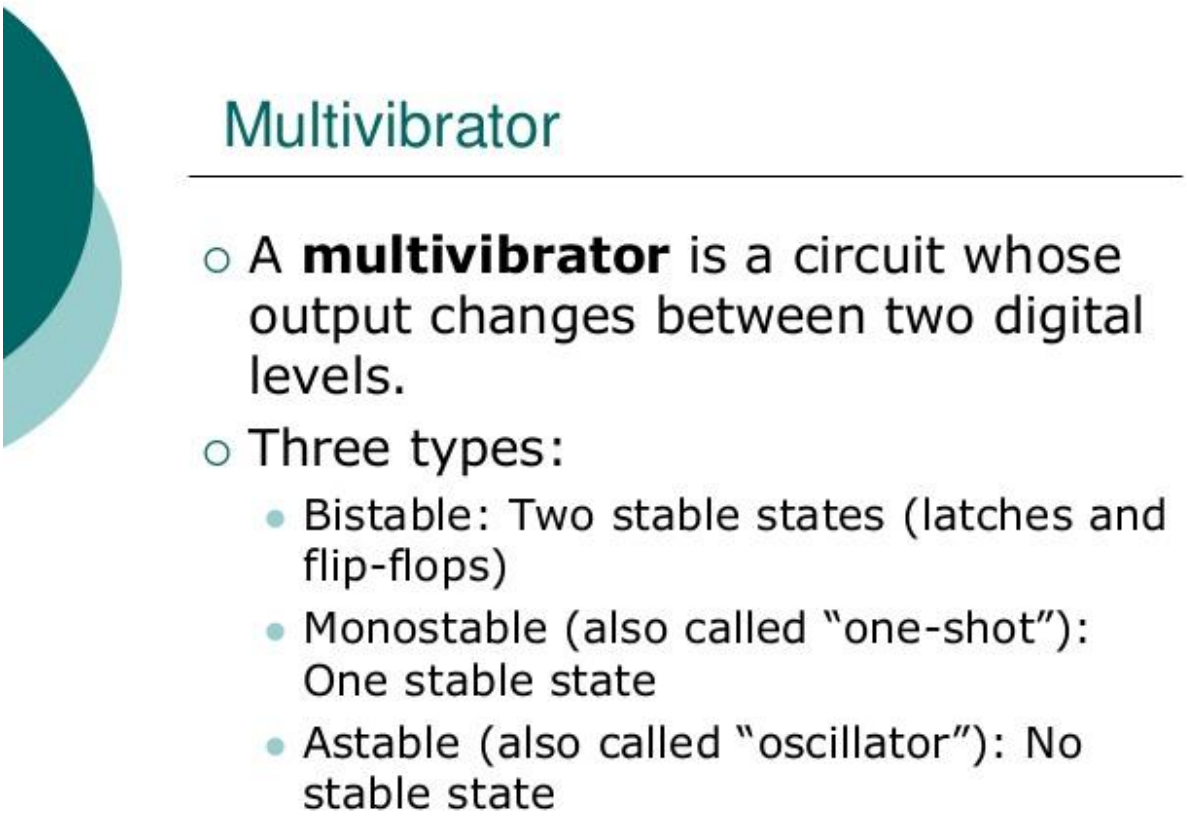
stabilizes the circuit. Further, C_E (Figure 2a) acts as an AC bypass capacitor while the coupling capacitor C_C (Figure 2a) is used to block DC signal propagation between the collector and the base terminals. Next, the capacitors C_1 and C_2 form the capacitive voltage divider network in the case of Figure 2b. In addition, there is also a Radio Frequency Coil (RFC) in the circuits (both in Figure 2a and 2b) which offers dual advantage as it provides even the DC bias as well as frees the circuit-output from being affected by the AC signal on the power lines.

On supplying the power to the oscillator, the amplitude of the oscillations in the circuit increases until a point is reached wherein the nonlinearities in the amplifier reduce the loop gain to unity. Next, on reaching the steady-state, the crystal in the feedback loop highly influences the frequency of the operating circuit. Further, here, the frequency will self-adjust so as to facilitate the crystal to present a reactance to the circuit such that the Barkhausen phase requirement is fulfilled.

$$f_s = \frac{1}{2\pi\sqrt{L_s C_s}}$$

OR

VIII a)



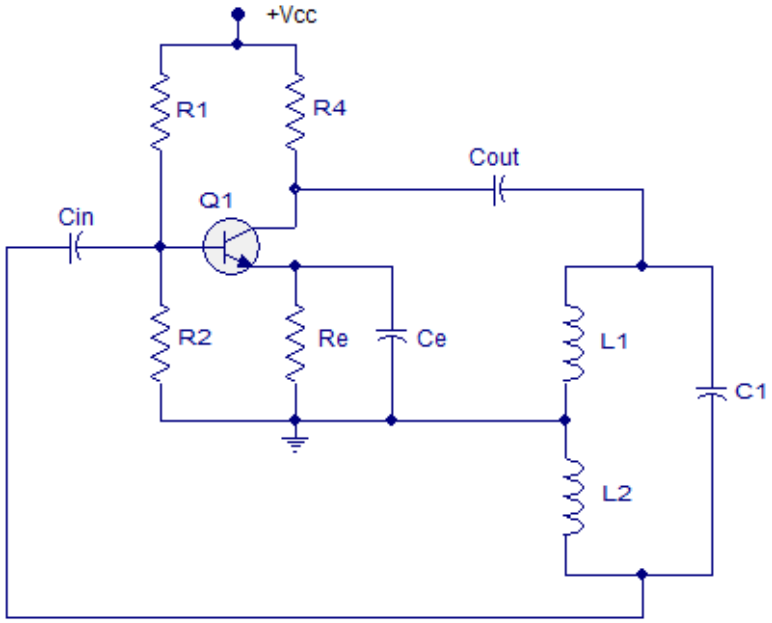
Bistable Multivibrators have several applications like frequency dividers, as a storage device in computer memories or counters but they are most excellent used in circuits like Latches and Counter.

The monostable multivibrator is used as delay and timing circuits. It is often used to trigger another pulse generator. It is used for regenerating old and worn out pulses.

The applications of Astable multivibrators involve in radio gears to transmit and receive radio signals and also in time, morse code generators and some systems which require a square wave like analog integrated circuits and TV broadcasts

b) Hartley oscillator circuit.

In a Hartley oscillator the oscillation frequency is determined by a tank circuit comprising of two inductors and one capacitor. The inductors are connected in series and the capacitor is connected across them in parallel. Hartley oscillators are commonly used in radio frequency (RF) oscillator applications and the recommended frequency range is from 20KHz to 30MHz. Hartley oscillators can be operated at frequencies lower than 20KHz, but for lower frequencies the inductor value need to be high and it has a practical limit. The circuit diagram of a typical Hartley oscillator is shown in the figure below.



In the circuit diagram resistors R1 and R2 give a potential divider bias for the transistor Q1. Re is the emitter resistor, whose job is to provide thermal stability for the transistor. Ce is the emitter by pass capacitors, which by-passes the amplified AC signals. If the emitter by-pass capacitor not there, the amplified ac voltages will drop across Re and it will get added on to the base-emitter voltage of Q1 and will disrupt the biasing conditions. Cin is the input DC decoupling capacitor while Cout is the output DC decoupling capacitor. The task of a DC decoupling capacitor is to prevent DC voltages from reaching the succeeding stage. Inductor L1, L2 and capacitor C1 forms the tank circuit.

When the power supply is switched ON the transistor starts conducting and the collector current increases. As a result the capcitor C1 starts charging and when the capacitor C1 is fully charged it starts discharging through coil L1. This charging and discharging creates a series of damped oscillations in the tank circuit and it is the key.

The oscillations produced in the tank circuit is coupled (fed back) to the base of Q1 and it appears in the amplified form across the collector and emitter of the transistor. The output voltage of the transistor (voltage across collector and emitter) will be in phase with the voltage across inductor L1. Since the junction of two inductors is grounded, the voltage across L2 will be 180° out of phase to that of the voltage across L1. The voltage across L2 is actually fed back to the base of Q1. From this we can see that, the feed back voltage is 180° out of phase with the transistor and also the transistor itself will create another 180° phase difference. So the total phase difference between input and output is 360° and it is very important condition for creating sustained oscillations.

Barkhausen Criterion: *A linear system will produce sustained oscillations only at frequencies for which the gain around the feedback loop is 1 and the phase shift around the feedback loop is ZERO or an integral multiple of 2*$\prod$.

Frequency of the Hartley oscillator.

The frequency “F” of a Hartley oscillator can be expressed using the equation;

$$F = \frac{1}{2\pi\sqrt{LC}}$$

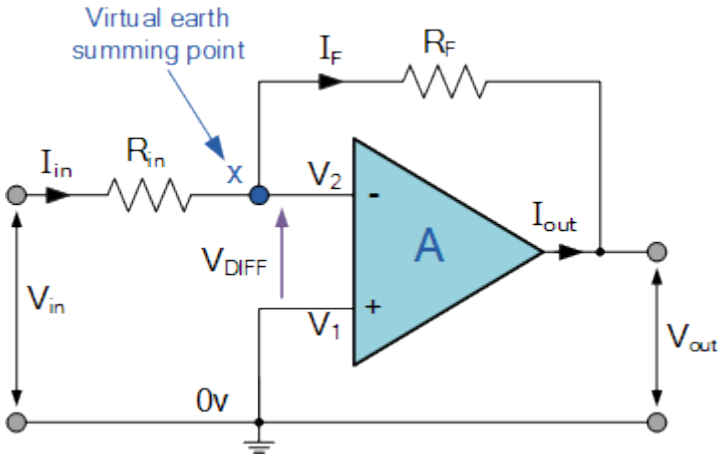
C is the capacitance of the capacitor C1 in the tank circuit.

L = L1+L2, the effective series inductance of the inductors L1 and L2 in the tank circuit.

Here the coils L1 and L2 are assumed to be winded on different cores. If they are winded on a single core then L=L1+L2+2M where M is the mutual inductance between the two coils.

UNIT IV

IX a) Inverting Operational Amplifier Configuration



In this **Inverting Amplifier** circuit the operational amplifier is connected with feedback to produce a closed loop operation. When dealing with operational amplifiers there are two very important rules to remember about inverting amplifiers, these are: "No current flows into the input terminal" and that "V1 always equals V2". However, in real world op-amp circuits both of these rules are slightly broken.

This is because the junction of the input and feedback signal (X) is at the same potential as the positive (+) input which is at zero volts or ground then, the junction is a **"Virtual Earth"**. Because of this virtual earth node the input resistance of the amplifier is equal to the value of the input resistor, Rin and the closed loop gain of the inverting amplifier can be set by the ratio of the two external resistors.

We said above that there are two very important rules to remember about **Inverting Amplifiers** or any operational amplifier for that matter and these are.

- No Current Flows into the Input Terminals
- The Differential Input Voltage is Zero as V1 = V2 = 0 (Virtual Earth)

Then by using these two rules we can derive the equation for calculating the closed-loop gain of an inverting amplifier, using first principles.

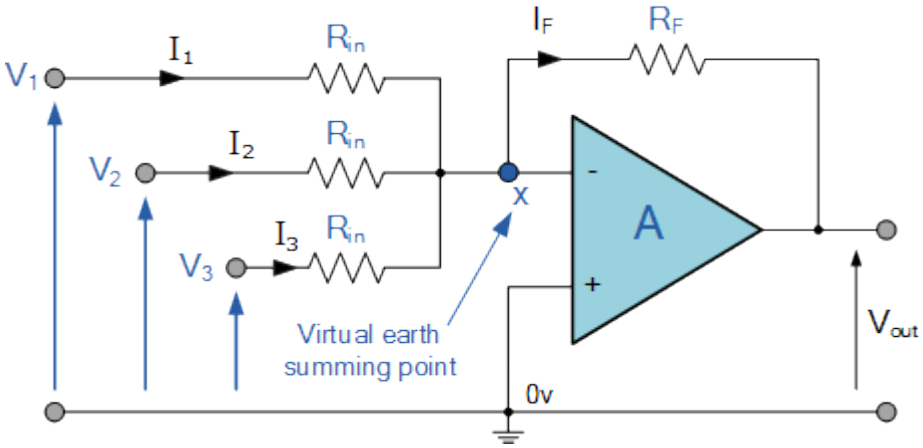
Current (i) flows through the resistor network as shown.

$$\text{Gain (Av)} = \frac{V_{out}}{V_{in}} = -\frac{R_f}{R_{in}}$$

b) The Summing Amplifier

The **Summing Amplifier** is another type of operational amplifier circuit configuration that is used to combine the voltages present on two or more inputs into a single output voltage.
We saw previously in the inverting operational amplifier that the inverting amplifier has a single input voltage, (Vin) applied to the inverting input terminal. If we add more input resistors to the input, each equal in value to the original input resistor, (Rin) we end up with another operational amplifier circuit called a **Summing Amplifier**, "*summing inverter*" or even a "*voltage adder*" circuit as shown below.

Summing Amplifier Circuit



In this simple summing amplifier circuit, the output voltage, (Vout) now becomes proportional to the sum of the input voltages, V1, V2, V3, etc. Then we can modify the original equation for the inverting amplifier to take account of these new inputs thus:

$$-\text{Vout} = \frac{R_F}{R_{IN}}\left(\text{V1} + \text{V2} + \text{V3}\ldots\text{etc}\right)$$

OR

X a) Op-amp Comparator

A comparator finds its importance in circuits where two voltage signals are to be compared and to be distinguished on which is stronger. A comparator is also an important circuit in the design of non-sinusoidal waveform generators as relaxation oscillators.

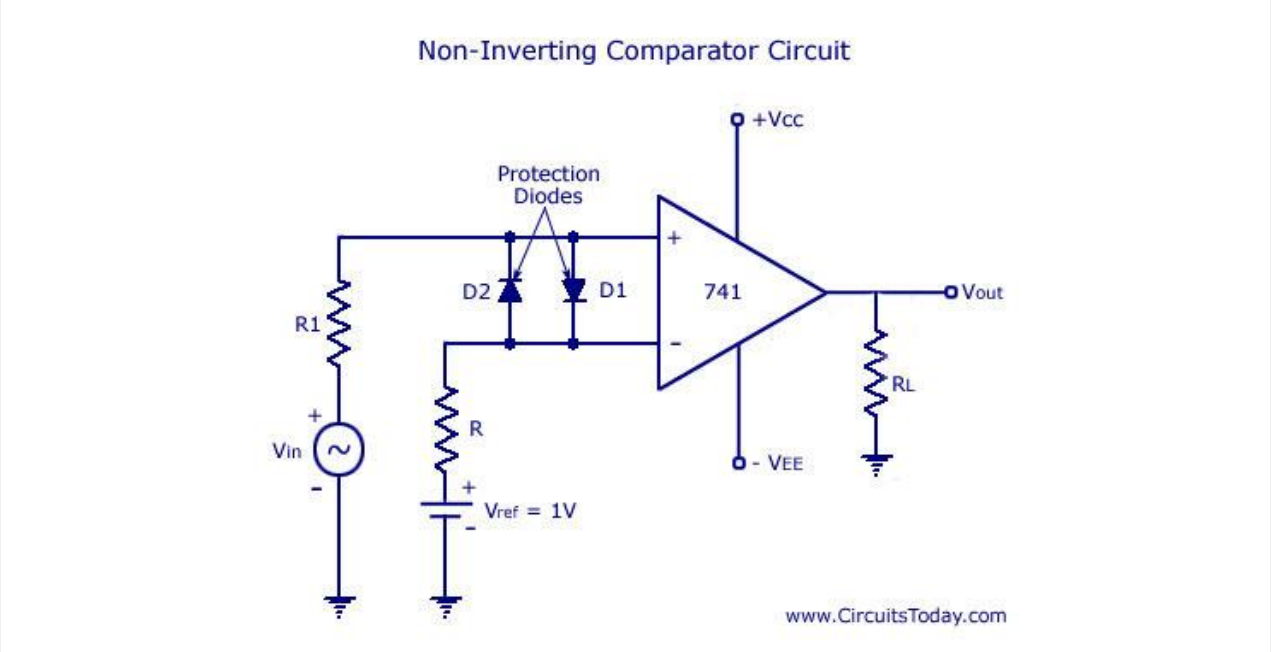
In an op-amp with an open loop configuration with a differential or single input signal has a value greater than 0, the high gain which goes to infinity drives the output of the op-amp into saturation. Thus, an op-amp operating in open loop configuration will have an output that goes to positive saturation or negative saturation level or switch between positive and negative saturation levels and thus clips the output above these levels. This principle is used in a comparator circuit with two inputs and an output. The 2 inputs, out of which one is a reference voltage (Vref) is compared with each other.

Working

Non-inverting 741 IC Op-amp Comparator Circuit

A non-inverting 741 IC op-amp comparator circuit is shown in the figure below. It is called a non-inverting comparator circuit as the sinusoidal input signal Vin is applied to the non-inverting terminal. The fixed reference voltage Vref is give to the inverting terminal (-) of the op-amp.

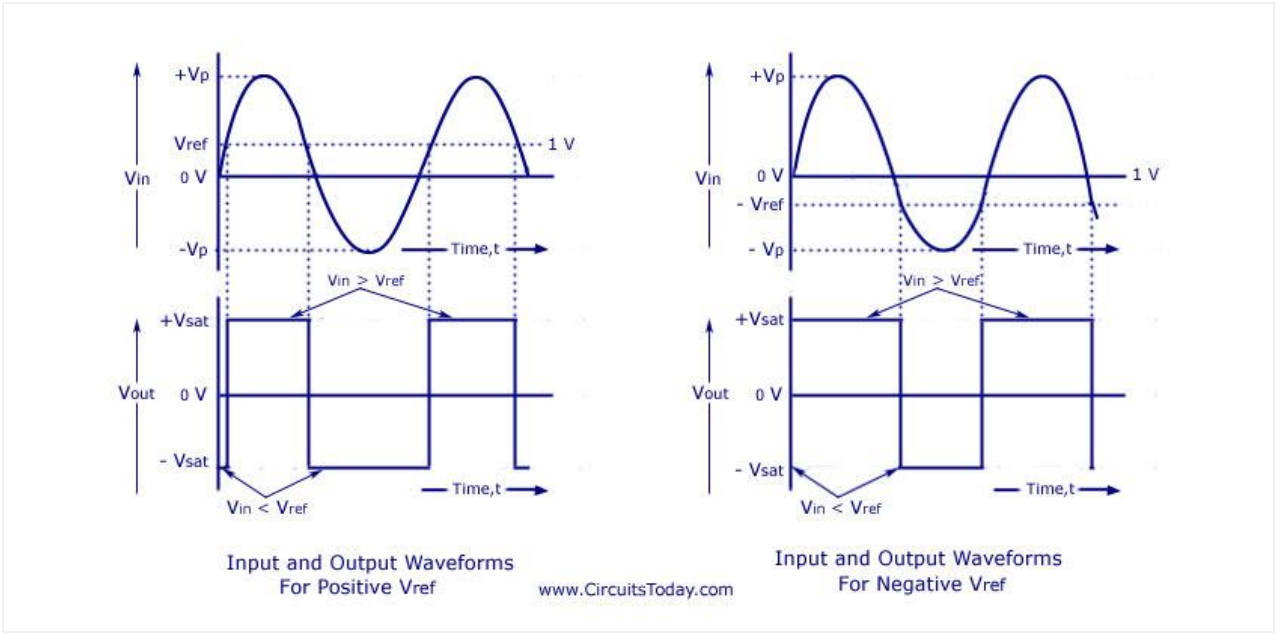
When the value of the input voltage Vin is greater than the reference voltage Vref the output voltage Vo goes to positive saturation. This is because the voltage at the non-inverting input is greater than the voltage at the inverting input.



741 IC Non-Inverting Comparator Circuit

When the value of the input voltage Vin is lesser than the reference voltage Vref, the output voltage Vo goes to negative saturation. This is because the voltage at the non-inverting input is smaller than the voltage at the inverting input. Thus, output voltage Vo changes from positive saturation point to negative saturation point whenever the difference between Vin and Vref changes. This is shown in the waveform below. The comparator can be called a voltage level detector, as for a fixed value of Vref, the voltage level of Vin can be detected.

The circuit diagram shows the diodes D1and D2. These two diodes are used to protect the op-amp from damage due to increase in input voltage. Thes diodes are called clamp diodes as they clamp the differential input voltages to either 0.7V or -0.7V. Most op-amps do not need clamp diodes as most of them already have built in protection. Resistance R1 is connected in series with input voltage Vin and R is connected between the inverting input and reference voltage Vref. R1 limits the current through the clamp diodes and R reduces the offset problem.



741 IC Op-Amp Non-Inverting Comparator Waveform

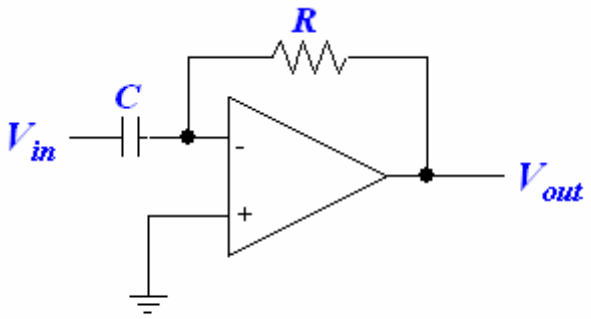
b) Opamp differentiator circuit

Definition

Opamp Differentiator is a circuit which provides output proportional to the differential of input signal. If V_i is the input signal applied to a differentiator then the output is $V_o = K*dV_o/dt$ where K is proportionality constant.

Opamp differentiator operation

The opamp differentiator is as shown below



Opamp differentiator

It is obvious from the circuit shown above that negative feedback is provided from output to inverting terminal.Using the concept of virtual ground the inverting terminal will be at zero potential(Since the non inverting terminal of opamp is at ground potential). the differentiator circuit can be redrawn as follows

Applying KCL at inverting node of opamp, we get

$$(0-V_{out})/R + I_c = 0$$

$$I_c = V_{out}/R$$

where$I_c = C*d(0-V_{in})/dt$. Hence we get $V_{out} = -R*C*dV_{in}/dt$.

If we apply a periodic triangular signal to opamp differentiator the output will be a periodic square wave.