tion is ....

(i) $\frac{1}{A_v} - \frac{1}{A_{fb}}$ (ii) $\frac{1}{A_v} + \frac{1}{A_{fb}}$

(iii) $\frac{A_v}{A_{fb}} + \frac{1}{A_v}$ (iv) $\frac{1}{A_{fb}} - \frac{1}{A_v}$

22. In the expression for voltage gain with negative voltage feedback, the term $1 + A_m\, m_v$ is known as ....

(i) gain factor (ii) feedback factor
(iii) sacrifice factor (iv) none of the above

23. If the output impedance of an amplifier is Z_{out} without feedback, then with negative voltage feedback, its value will be ....

(i) $\frac{Z_{out}}{1 + A_v\, m_v}$ (ii) $Z_{out}\,(1 + A_v\, m_v)$

(iii) $\frac{1 + A_v\, m_v}{Z_{out}}$ (iv) $Z_{out}\,(1 - A_v\, m_v)$

24. If the input impedance of an amplifier is Z_{in} without feedback, then with negative voltage feedback, its value will be ....

(i) $\frac{Z_{in}}{1 + A_v\, m_v}$ (ii) $Z_{in}\,(1 + A_v\, m_v)$

(iii) $\frac{1 + A_v\, m_v}{Z_{in}}$ (iv) $Z_{in}\,(1 - A_v\, m_v)$

25. Feedback circuit .... frequency.

(i) is independent of
(ii) is strongly dependent on
(iii) is moderately dependent on
(iv) none of the above

26. The basic purpose of applying negative voltage feedback is to ....

(i) increase voltage gain
(ii) reduce distortion
(iii) keep the temperature within limits
(iv) none of the above

27. If the voltage gain of an amplifier without feedback is 20 and with negative voltage feedback it is 12, then feedback fraction is ....

(i) 5/3 (ii) 3/5
(iii) 1/5 (iv) 0.033

28. In an emitter follower, we employ ...... negative current feedback.

(i) 50% (ii) 25%
(iii) 100% (iv) 75%

29. An amplifier has an open loop voltage gain of 1,00,000. With negative voltage feedback, the voltage gain is reduced to 100. What is the sacrifice factor ?

(i) 1000 (ii) 100
(iii) 5000 (iv) none of the above

30. In the above question, what will happen to circuit performance ?

(i) distortion is increased 1000 times
(ii) input impedance is increased 1000 times
(iii) output impedance is increased 1000 times
(iv) none of the above

31. The non-linear distortion of an amplifier is D without feedback. The amplifier has an open-loop voltage gain of A_v and feedback fraction is m_v. With negative voltage feedback, the non-linear distortion will be ....

(i) $D\,(1 + A_v\, m_v)$ (ii) $D\,(1 - A_v\, m_v)$

(iii) $\frac{1 + A_v\, m_v}{D}$ (iv) $\frac{D}{1 + A_v\, m_v}$

32. The output and input voltages of an emitter follower have a phase difference of ....

(i) 180º (ii) 90º
(iii) 0º (iv) 270º

33. It is most necessary to control signal-to-noise ratio at ....

(i) initial stage (ii) driver stage
(iii) output stage (iv) detector stage

34. In order to obtain good gain stability in a negative voltage feedback amplifier (A_v = voltage gain without feedback ; m_v = feedback fraction), ...

(i) $A_v\, m_v = 1$ (ii) $A_v\, m_v >> 1$
(iii) $A_v\, m_v < 1$ (iv) none of the above

35. Emitter follower is also known as ....

(i) grounded emitter circuit
(ii) grounded base circuit
(iii) grounded collector circuit
(iv) none of the above

Answers to Multiple-Choice Questions

1. (*ii*)	**2.** (*i*)	**3.** (*iii*)	**4.** (*iv*)	**5.** (*ii*)
6. (*i*)	**7.** (*iii*)	**8.** (*ii*)	**9.** (*i*)	**10.** (*iii*)
11. (*ii*)	**12.** (*ii*)	**13.** (*i*)	**14.** (*ii*)	**15.** (*iii*)
16. (*i*)	**17.** (*iii*)	**18.** (*ii*)	**19.** (*iv*)	**20.** (*i*)
21. (*iv*)	**22.** (*iii*)	**23.** (*i*)	**24.** (*ii*)	**25.** (*i*)
26. (*ii*)	**27.** (*iv*)	**28.** (*iii*)	**29.** (*i*)	**30.** (*ii*)
31. (*iv*)	**32.** (*iii*)	**33.** (*i*)	**34.** (*ii*)	**35.** (*iii*)

Chapter Review Topics

1. What do you understand by feedback ? Why is negative feedback applied in high gain amplifiers ?
2. Discuss the principles of negative voltage feedback in amplifiers with a neat diagram.
3. Derive an expression for the gain of negative voltage feedback amplifier.
4. What is a feedback circuit ? Explain how it provides feedback in amplifiers.
5. Describe the action of emitter follower with a neat diagram.
6. Derive the expressions for (*i*) voltage gain (*ii*) input impedance and (*iii*) output impedance of an emitter follower.

Problems

1. An amplifier has a gain of 2×10^5 without feedback. Determine the gain if negative voltage feedback is applied. Take feedback fraction $m_v = 0.02$. **[50]**
2. An amplifier has a gain of 10,000 without feedback. With negative voltage feedback, the gain is reduced to 50. Find the feedback fraction. **[$m_v = 0.02$]**
3. A feedback amplifier has an internal gain $A_v = 40db$ and feedback fraction $m_v = 0.05$. If the input impedance of this circuit is 12 kΩ, what would have been the input impedance if feedback were not present ? **[2kΩ]**
4. Calculate the gain of a negative voltage feedback amplifier with an internal gain $A_v = 75$ and feedback fraction $m_v = 1/15$. What will be the gain if A_v doubles ? **[12.5 ; 13.64]**
5. An amplifier with negative feedback has a voltage gain of 100. It is found that without feedback, an input signal of 50 mV is required to produce a given output, whereas with feedback, the input signal must be 0.6 V for the same output. Calculate (*i*) gain without feedback (*ii*) feedback fraction. **[(i) 1200 (ii) 0.009]**

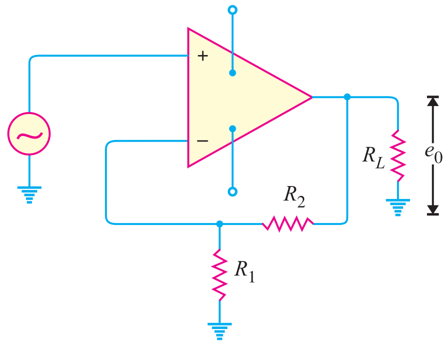

Fig. 13.30

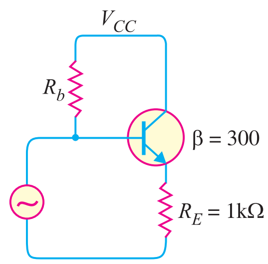

Fig. 13.31

6. Fig. 13.30 shows the negative feedback amplifier. If the gain of the amplifier without feedback is 10^5 and $R_1 = 100\ \Omega$, $R_2 = 100\ \text{k}\Omega$, find (*i*) feedback fraction (*ii*) gain with feedback. **[(i) 0.001(ii) 1000]**

7. In Fig. 13.31, if input and output impedances without feedback are 2 MΩ and 500 Ω respectively, find their values after negative voltage feedback. **[302MΩ; 1.6Ω]**
8. An amplifier has a current gain of 240 without feedback. When negative current feedback is applied, determine the effective current gain of the amplifier. Given that current attenuation $m_i = 0.015$. **[52.7]**
9. An amplifier has an open-loop gain and input impedance of 200 and 15 kΩ respectively. If negative current feedback is applied, what is the effective input impedance of the amplifier? Given that current attenuation $m_i = 0.012$. **[4.41 kΩ]**
10. An amplifier has $A_i = 200$ and $m_i = 0.012$. The open-loop output impedance of the amplifier is 2kΩ. If negative current feedback is applied, what is the effective output impedance of the amplifier ? **[6.8 kΩ]**

Discussion Questions

1. Why is negative voltage feedback employed in high gain amplifiers ?
2. How does negative voltage feedback increase bandwidth of an amplifier ?
3. Feedback for more than three stages is seldom employed. Explain why ?
4. Why is emitter follower preferred to transformer for impedance matching ?
5. Where is emitter follower employed practically and why ?
6. What are the practical applications of emitter follower ?

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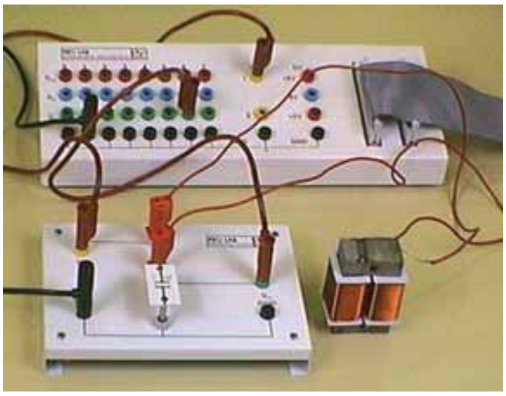
Contents

14

Sinusoidal Oscillators



INTRODUCTION

Many electronic devices require a source of energy at a specific frequency which may range from a few Hz to several MHz. This is achieved by an electronic device called an *oscillator*. Oscillators are extensively used in electronic equipment. For example, in radio and television receivers, oscillators are used to generate high frequency wave (called *carrier wave*) in the tuning stages. Audio frequency and radio-frequency signals are required for the repair of radio, television and other electronic equipment. Oscillators are also widely used in radar, electronic computers and other electronic devices.

Oscillators can produce sinusoidal or non-sinusoidal (*e.g.* square wave) waves. In this chapter, we shall confine our attention to sinusoidal oscillators *i.e.* those which produce sine-wave signals.

14.1 Sinusoidal Oscillator

An electronic device that generates sinusoidal oscillations of desired frequency is known as a ***sinusoidal oscillator.**

Although we speak of an oscillator as "generating" a frequency, it should be noted that it does not create energy, but merely acts as an energy converter. It receives d.c. energy and changes it into a.c. energy of desired frequency. The frequency of oscillations depends upon the constants of the device.

It may be mentioned here that although an alternator produces sinusoidal oscillations of 50Hz, it cannot be called an oscillator. Firstly, an alternator is a mechanical device having rotating parts whereas an oscillator is a non-rotating electronic device. Secondly, an alternator converts mechanical energy into a.c. energy while an oscillator converts d.c. energy into a.c. energy. Thirdly, an alternator cannot produce high frequency oscillations whereas an oscillator can produce oscillations ranging from a few Hz to several MHz.

Advantages

Although oscillations can be produced by mechanical devices (*e.g.* alternators), but electronic oscillators have the following advantages :

(*i*) An oscillator is a non-rotating device. Consequently, there is little wear and tear and hence longer life.

(*ii*) Due to the absence of moving parts, the operation of an oscillator is quite silent.

(*iii*) An oscillator can produce waves from small (20 Hz) to extremely high frequencies (> 100 MHz).

(*iv*) The frequency of oscillations can be easily changed when desired.

(*v*) It has good frequency stability *i.e.* frequency once set remains constant for a considerable period of time.

(*vi*) It has very high efficiency.

14.2 Types of Sinusoidal Oscillations

Sinusoidal electrical oscillations can be of two types *viz* *damped oscillations* and *undamped oscillations*.

(*i*) Damped oscillations. The electrical oscillations whose amplitude goes on decreasing with time are called *damped oscillations*. Fig. 14.1 (*i*) shows waveform of damped electrical oscillations. Obviously, the electrical system in which these oscillations are generated has losses and some energy is lost during each oscillation. Further, no means are provided to compensate for the losses and consequently the amplitude of the generated wave decreases gradually. It may be noted that frequency of oscillations remains unchanged since it depends upon the constants of the electrical system.

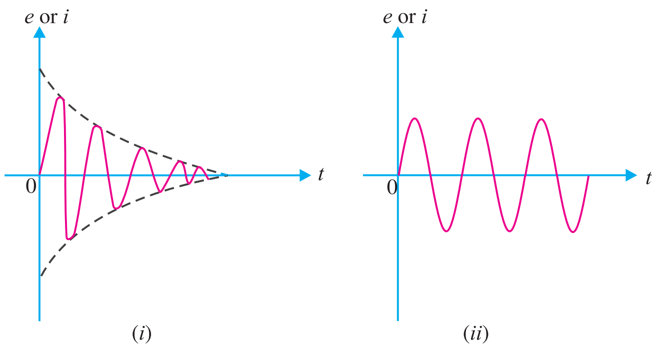


Fig. 14.1

* Note that oscillations are produced without any external signal source. The only input power to an oscillator is the d.c. power supply.

***(ii)* Undamped oscillations.** The electrical oscillations whose amplitude remains constant with time are called *undamped oscillations*. Fig. 14.1 (*ii*) shows waveform of undamped electrical oscillations. Although the electrical system in which these oscillations are being generated has also losses, but now right amount of energy is being supplied to overcome the losses. Consequently, the amplitude of the generated wave remains constant. It should be emphasised that an oscillator is required to produce undamped electrical oscillations for utilising in various electronics equipment.

14.3 Oscillatory Circuit

A circuit which produces electrical oscillations of any desired frequency is known as an **oscillatory circuit** *or* **tank circuit.**

A simple oscillatory circuit consists of a capacitor (*C*) and inductance coil (*L*) in parallel as shown in Fig. 14.2. This electrical system can produce electrical oscillations of frequency determined by the values of *L* and *C*. To understand how this comes about, suppose the capacitor is charged from a d.c. source with a polarity as shown in Fig. 14.2 (*i*).

(*i*) In the position shown in Fig. 14.2 (*i*), the upper plate of capacitor has deficit of electrons and the lower plate has excess of electrons. Therefore, there is a voltage across the capacitor and the capacitor has electrostatic energy.

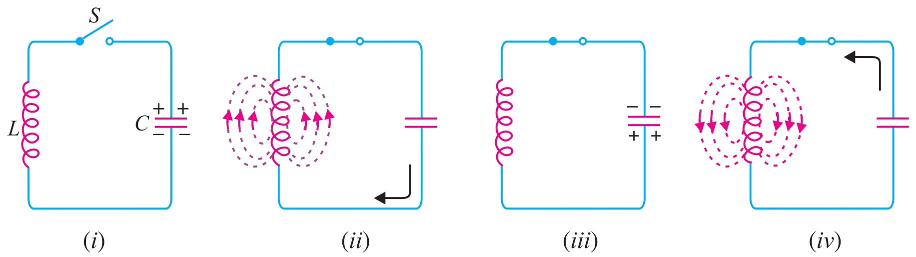


Fig. 14.2

(*ii*) When switch *S* is closed as shown in Fig. 14.2 (*ii*) , the capacitor will discharge through inductance and the electron flow will be in the direction indicated by the arrow. This current flow sets up magnetic field around the coil. Due to the inductive effect, the current builds up slowly towards a maximum value. The circuit current will be maximum when the capacitor is fully discharged. At this instant, electrostatic energy is zero but because electron motion is greatest (*i.e.* maximum current), the magnetic field energy around the coil is maximum. This is shown in Fig. 14.2 (*ii*). Obviously, the electrostatic energy across the capacitor is completely converted into magnetic field energy around the coil.

(*iii*) Once the capacitor is discharged, the magnetic field will begin to collapse and produce a counter e.m.f. According to Lenz's law, the counter e.m.f. will keep the current flowing in the same direction. The result is that the capacitor is now charged with opposite polarity, making upper plate of capacitor negative and lower plate positive as shown in Fig. 14.2 (*iii*).

(*iv*) After the collapsing field has recharged the capacitor, the capacitor now begins to discharge; current now flowing in the opposite direction. Fig. 14.2 (*iv*) shows capacitor fully discharged and maximum current flowing.

The sequence of charge and discharge results in alternating motion of electrons or an oscillating current. The energy is alternately stored in the electric field of the capacitor (*C*) and the magnetic field of the inductance coil (*L*). This interchange of energy between *L* and *C* is repeated over and again resulting in the production of oscillations.

Waveform. If there were no losses in the tank circuit to consume the energy, the interchange of energy between L and C would continue indefinitely. In a practical tank circuit, there are resistive and radiation losses in the coil and dielectric losses in the capacitor. During each cycle, a small part of the originally imparted energy is used up to overcome these losses. The result is that the amplitude of oscillating current decreases gradually and eventually it becomes zero when all the energy is consumed as losses. Therefore, the tank circuit by itself will produce *damped oscillations* as shown in Fig. 14.3.

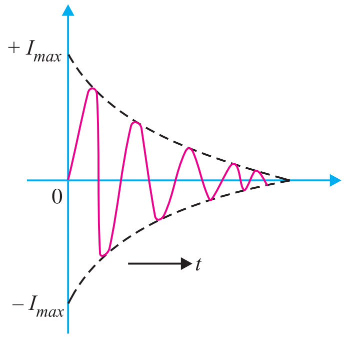


Fig. 14.3

Frequency of oscillations. The frequency of oscillations in the tank circuit is determined by the constants of the circuit *viz* L and C. The actual frequency of oscillations is the resonant frequency (or natural frequency) of the tank circuit given by :

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

It is clear that frequency of oscillations in the tank circuit is inversely proportional to L and C. This can be easily explained. If a large value of capacitor is used, it will take longer for the capacitor to charge fully and also longer to discharge. This will lengthen the period of oscillations in the tank circuit, or equivalently lower its frequency. With a large value of inductance, the opposition to change in current flow is greater and hence the time required to complete each cycle will be longer. Therefore, the greater the value of inductance, the longer is the period or the lower is the frequency of oscillations in the tank circuit.

14.4. Undamped Oscillations from Tank Circuit

As discussed before, a tank circuit produces damped oscillations. However, in practice, we need continuous undamped oscillations for the successful operation of electronics equipment. In order to make the oscillations in the tank circuit undamped, it is necessary to supply correct amount of energy to the tank circuit at the proper time intervals to meet the losses. Thus referring back to Fig. 14.2, any energy which would be applied to the circuit must have a polarity conforming to the existing polarity at the instant of application of energy. If the applied energy is of opposite polarity, it would oppose the energy in the tank circuit, causing stoppage of oscillations. Therefore, in order to make the oscillations in the tank circuit undamped, the following conditions must be fulfilled :

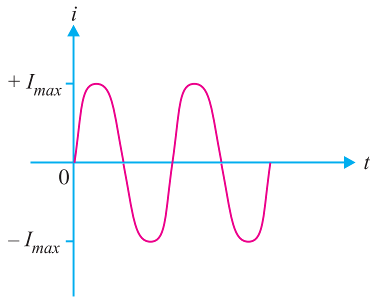


Fig. 14.4

(*i*) The amount of energy supplied should be such so as to meet the losses in the tank circuit and the a.c. energy removed from the circuit by the load. For instance, if losses in LC circuit amount to 5 mW and a.c. output being taken is 100 mW, then power of 105 mW should be continuously supplied to the circuit.

(*ii*) The applied energy should have the same frequency as that of the oscillations in the tank circuit.

(*iii*) The applied energy should be in phase with the oscillations set up in the tank circuit *i.e.* it should aid the tank circuit oscillations.