Sri Sai Vidya Vikas Shikshana Samithi ®

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DEPARTMENT OF ELECTRONICS & COMMUNICATION ENGINEERING

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Course Name: Introduction toElectronics Engineering	Course Code: 22ESC143	AY:2022-2023
Course Coordinator: Tejashree S	Scheme: 2022	Batch: 2022

Syllabus:

Power Supplies – Block diagram, Half-wave rectifier, Full-wave rectifiers and filters, Voltage regulators, Output resistance and voltage regulation, Voltage multipliers. **Amplifiers –** Types of amplifiers, Gain, Input and output resistance, Frequency response, Bandwidth, Phase shift, Negative feedback, multi-stage amplifiers

Learning Outcome:

CO1: Analyze the working of various electronic circuits such as Power supplies and Amplifiers.

1.1 Power supplies - Block diagram

A **regulated power supply** ensures that the output current remains constant, even if the input changes, by converting unregulated AC (alternating current) to a constant DC (direct current).

The block diagram of a D.C power supply is shown in Fig. 1.1.

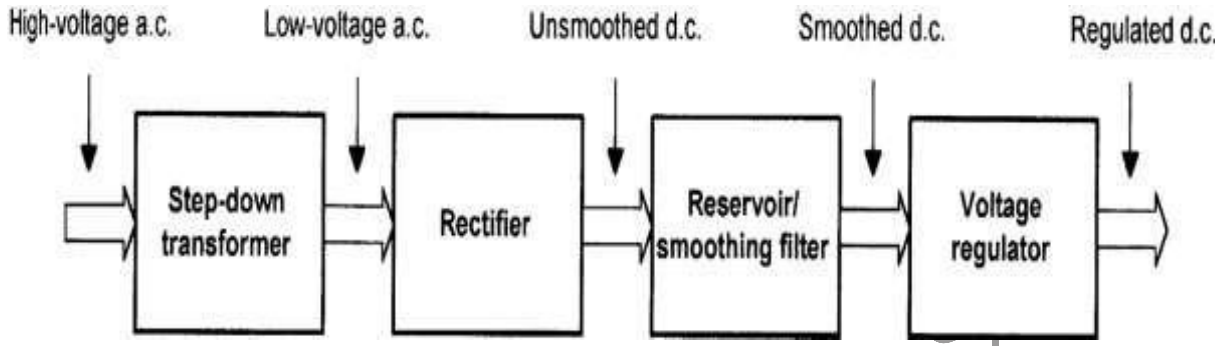


Figure 1.1 Block diagram of a D.C power supply

- The mains input is at a relatively high voltage; a step-down transformer of appropriate turns ratio is used to convert this to a low voltage.
- The a.c. output from the transformer secondary is then rectified using conventional silicon rectifier diodes to produce an unsmoothed (or pulsating d.c.) output.
- This is then smoothed and filtered before being applied to a circuit which will regulate (or stabilize) the output voltage so that it remains relatively constant in spite of variations in both load current and incoming mains voltage.
- Fig. 1.2 shows the realization of the block diagram of a D.C power supply using the electronic components in Fig. 1.1.

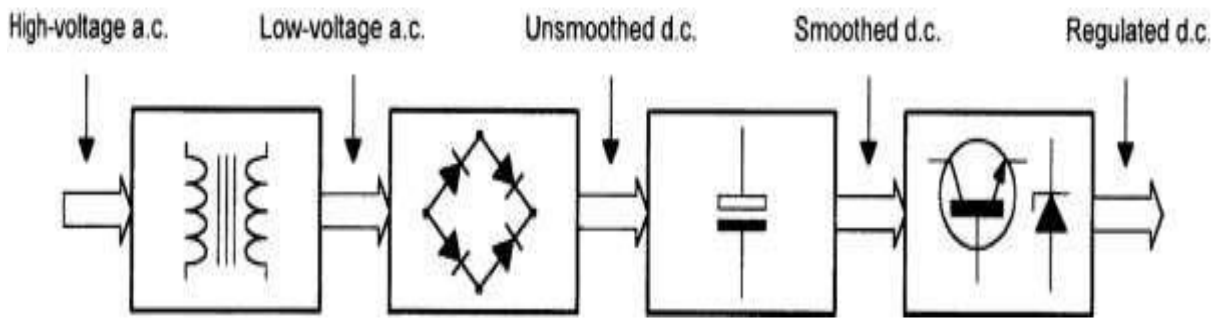


Figure 1. 2 Block diagram of a D.C power supply showing principal components

- The iron-cored step-down transformer feeds a rectifier arrangement.
- The output of the rectifier is then applied to a high-value reservoir capacitor. This capacitor stores a considerable amount of charge and is being constantly topped-up by the rectifier arrangement. The capacitor also helps to smooth out the voltage pulses produced by the rectifier.
- Finally, a stabilizing circuit (often based on a series transistor regulator and a Zener diode voltage reference) provides a constant output voltage.

1.2 Rectifiers:

- Rectifiers are the circuits which converts a.c voltage to pulsating d.c voltage.
- Rectifiers can be grouped into two types:

  i) Half-wave Rectifier

  ii) Full-wave Rectifier

1.2.1 Half-wave Rectifier

- The simplest form of rectifier circuit makes use of a single diode and, since it operates on only either positive or negative half-cycles of the supply, it is known as a **half-wave rectifier.** Fig. 1.3 shows a simple half-wave rectifier circuit.

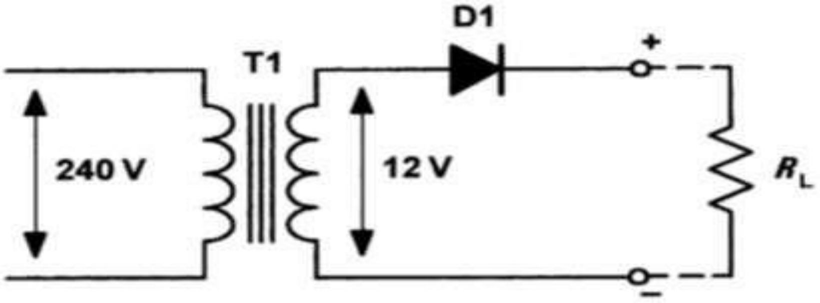


Figure 1.3 A simple half-wave rectifier circuit

- The mains voltage (220 to 240 V) is applied to the primary of a step- down transformer (T1).
- The secondary of T1 steps down the 240 V r.m.s. to 12 V r.m.s.
- During positive half cycle, the diode D1 is forward biased and acts as a closed switch as shown in figure 1.4, thus diode allows the current flows

through the load R_L and voltage is developed across it.

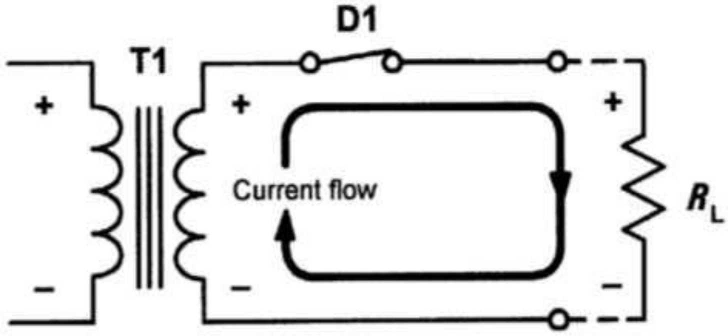


Figure 1.4 Half-wave rectifier circuit with D1 conducting (positive-half cycles of secondary voltage)

- During negative half cycle, the diode D1 is reverse biased and acts as an open switch as shown in figure 1.5, thus there will be no flow of current through the load R_L, thereby the output voltage is zero.

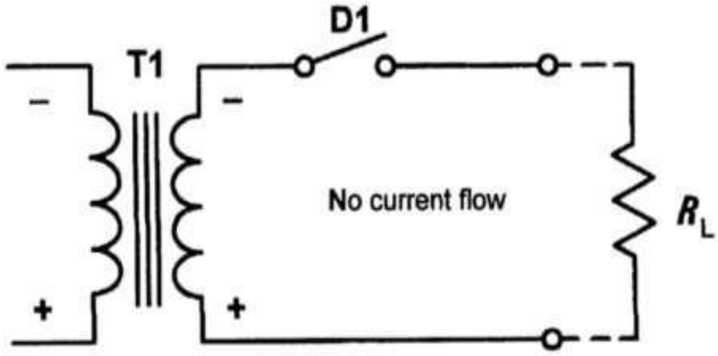


Figure 1.5 half-wave rectifier with D1 not conducting (negative- half cycles of secondary voltage)

- The input and output voltage waveform of a half-wave rectifier is shown in Fig. 1.6.

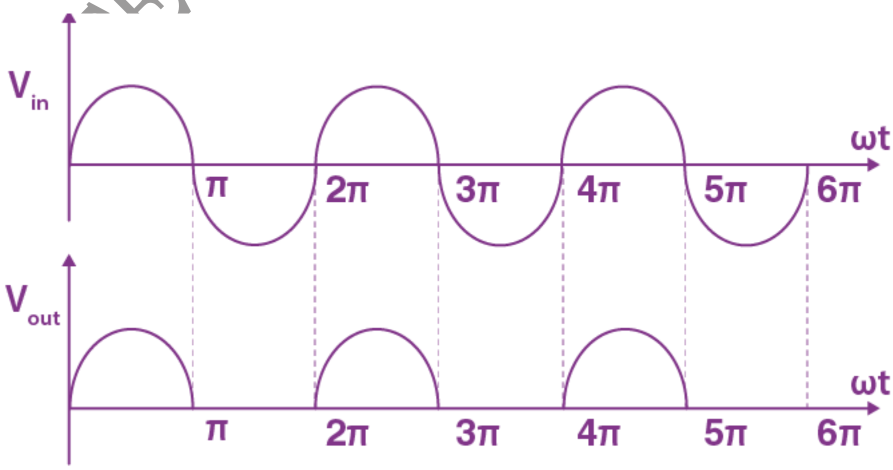


Figure 1.6 The input and output voltage waveform of a half-wave rectifier

- The relation between turns ratio and voltage of the primary and secondary of the transformer is given by:

$$\frac{N_1}{N_2} = \frac{V_{p(rms)}}{V_{s(rms)}}$$

- The peak voltage output from the transformer's secondary winding will be given by:

$$V_{pk} = 1.414\, V_{s(rms)}$$

Example:

A mains transformer having a turns ratio of 44:1 is connected to a 220 V r.m.s. mains supply. If the secondary output is applied to a half-wave rectifier, determine the peak voltage that will appear across a load.

Solution:

Given: $N_1 = 44$; $N_2 = 1$; $V_{p(rms)} = 220V$; $V_{s(rms)} = ?$

The r.m.s. secondary voltage will be given by:

$$\frac{N_1}{N_2} = \frac{V_{p(rms)}}{V_{s(rms)}}$$

$$V_{s(rms)} = \frac{V_{p(rms)}\, X\, N_2}{N_1} = \frac{220\, X\, 1}{44} = 5\text{V}.$$

The peak voltage developed after rectification will be given by:

$$V_{pk} = 1.414 \text{ X } V_{s(rms)} = 1.414 \text{ X } 5V = 7.07 \text{ V}.$$

Assuming that the diode is a silicon device with a forward voltage drop of V_γ =0.6V, the actual peak voltage dropped across the load will be:

$$V_L = V_{pk} - V_\gamma$$

$$V_L = 7.07 - 0.6$$

$$V_L = 6.47\, V$$

Half wave Rectifier with Filter:

- Fig. 1.7 shows a simple half-wave rectifier circuit with reservoir capacitor.

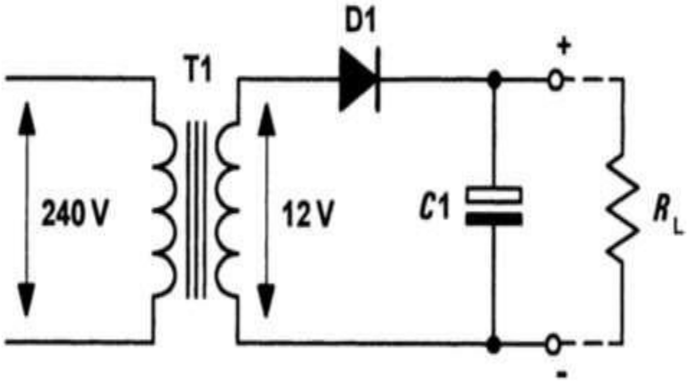


Figure 1.7 A simple half-wave rectifier circuit with reservoir capacitor

- The capacitor, C1, has been added to ensure that the output voltage remains at, or near, the peak voltage even when the diode is not conducting.
- When the primary voltage is first applied to T1, the first positive half-cycle output from the secondary will charge C1 to the peak value seen across R_L.
- Hence C1 charges to 16.3 V at the peak of the positive half-cycle. Because C1 and R_L are in parallel, the voltage across R_L will be the same as that across C1.

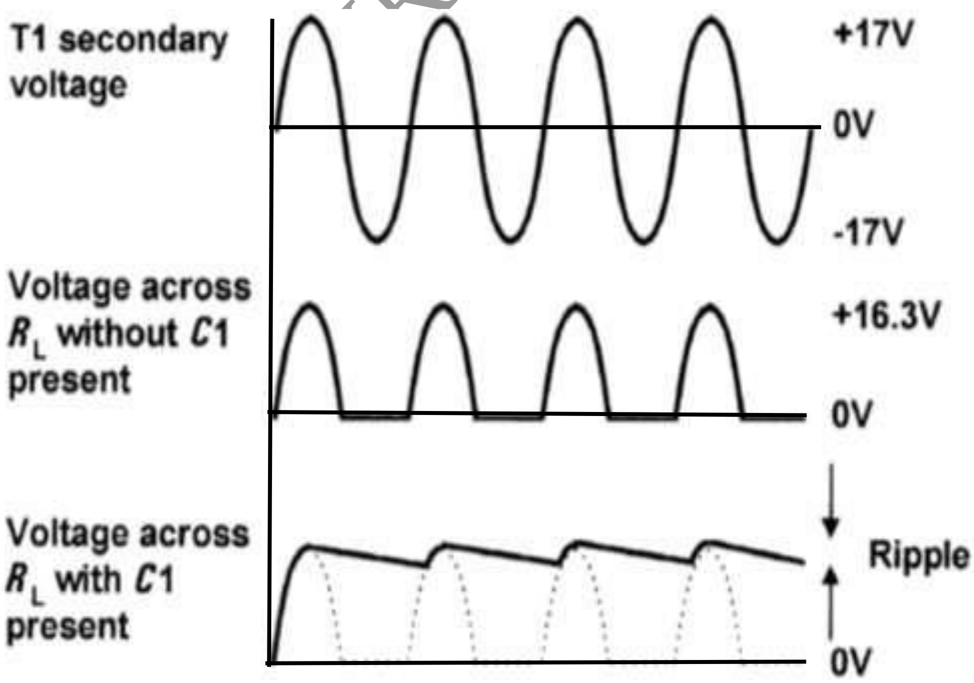


Figure 1.8 A simple half-wave rectifier circuit with reservoir capacitor

1.2.2 Full-wave rectifiers

- Unfortunately, the half-wave rectifier circuit is relatively inefficient as conduction takes place only on alternate half-cycles.
- A better rectifier arrangement would make use of both positive and negative half-cycles. These full-wave rectifier circuits offer a considerable improvement over their half-wave counterparts.
- They are not only more efficient but are significantly less demanding in terms of the reservoir and smoothing components.
- There are two basic forms of full wave rectifier:
  i) Bi-phase rectifier
  ii) Bridge rectifier

i) Bi-phase rectifier circuits

Fig. 1.9 shows a simple bi-phase rectifier circuit.

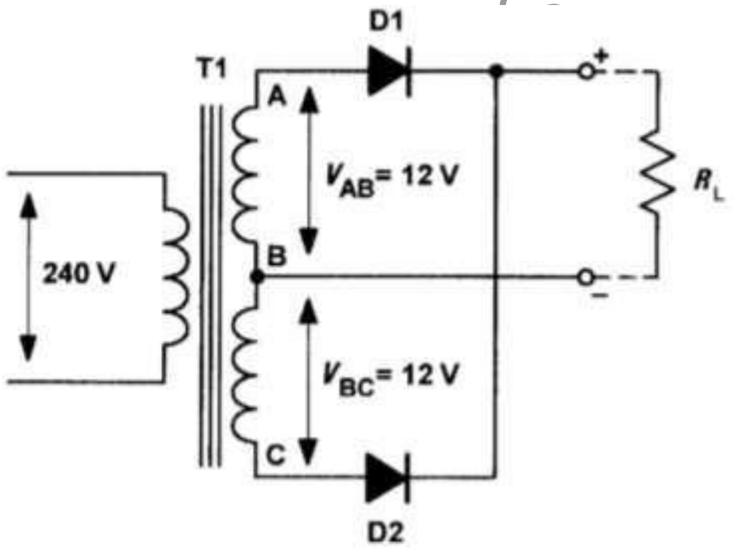


Figure 1.9 Bi-phase rectifier circuit

- Mains voltage (240 V) is applied to the primary of the step-down transformer (T1) which has two identical secondary windings, each providing 12 V r.m.s. (the turns ratio of T1 will thus be 240/12 or 20:1 for each secondary winding).
- On positive half-cycles, point A will be positive with respect to point B. Similarly, point B will be positive with respect to point C. In this condition D1 will allow conduction (its anode will be positive with respect

to its cathode) while D2 will not allow conduction (its anode will be negative with respect to its cathode). Thus D1 alone conducts on positive half-cycles.

- On negative half-cycles, point C will be positive with respect to point B. Similarly, point B will be positive with respect to point A. In this condition D2 will allow conduction (its anode will be positive with respect to its cathode) while D1 will not allow conduction (its anode will be negative with respect to its cathode). Thus D2 alone conducts on negative half-cycles.
- In Fig. 1.10 (a) D1 is shown conducting on a positive half- cycle while in Fig. 1.10 (b) D2 is shown conducting.

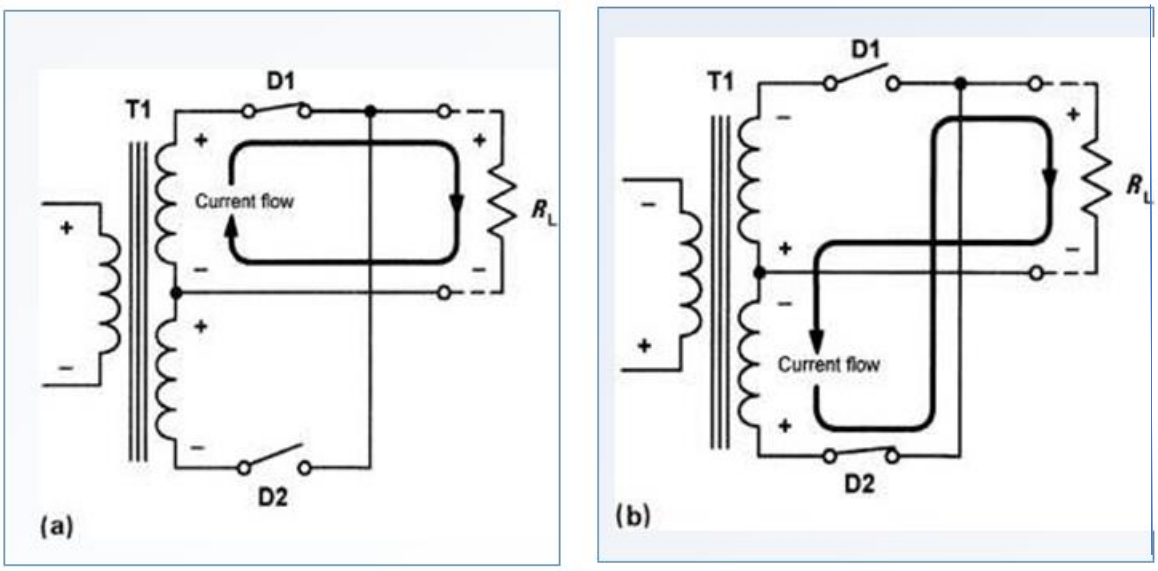


Figure 1.10 (a) Bi-phase rectifier with D1 conducting and D2 non-conducting
(b) bi-phase rectifier with D2 conducting and D1 non-conducting

Full wave Rectifier with Filter:

- This component operates in exactly the same way as for the half-wave circuit, i.e. it charges to approximately 16.3 V at the peak of the positive half-cycle and holds the voltage at this level when the diodes are in their non-conducting states.
- 1.11 shows voltage waveforms for the bi-phase rectifier, with and without C1 present.

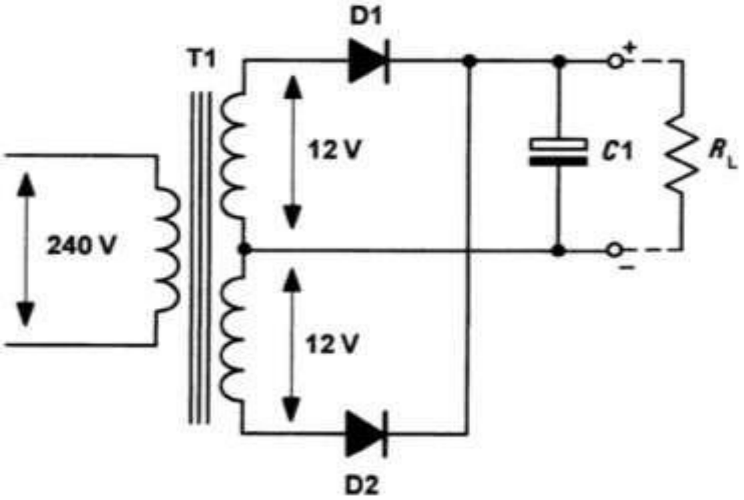


Figure 1.11 Waveforms for the bi-phase rectifier

ii) Bridge rectifier circuits

- An alternative to the use of the bi-phase circuit is that of using a four- diode bridge rectifier.
- A full-wave bridge rectifier arrangement is shown in Fig. 1.12.

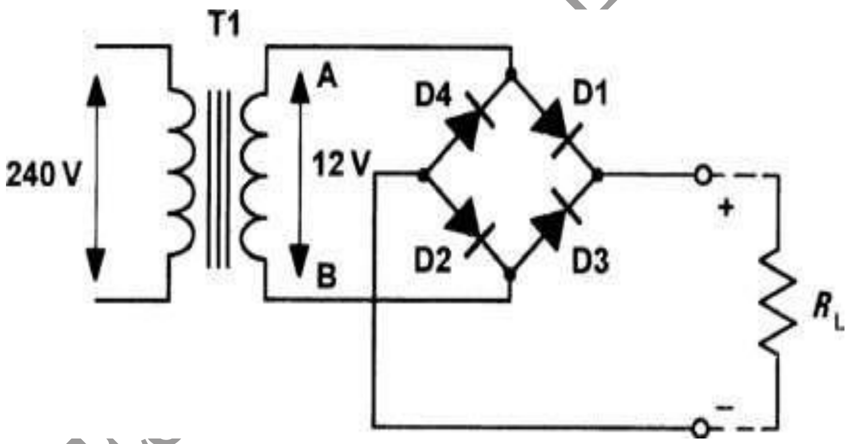


Figure 1.12 Full-wave bridge rectifier circuit

- Mains voltage (240 V) is applied to the primary of a step-down transformer (T1). The secondary winding provides 12 V r.m.s. (approximately 17 V peak) and has a turns ratio of 20:1, as before.
- On positive half-cycles, point A will be positive with respect to point B. In this condition D1 and D2 will allow conduction while D3 and D4 will not allow conduction.
- On negative half-cycles, point B will be positive with respect to point A. In this condition D3 and D4 will allow conduction while D1 and D2 will not allow conduction.

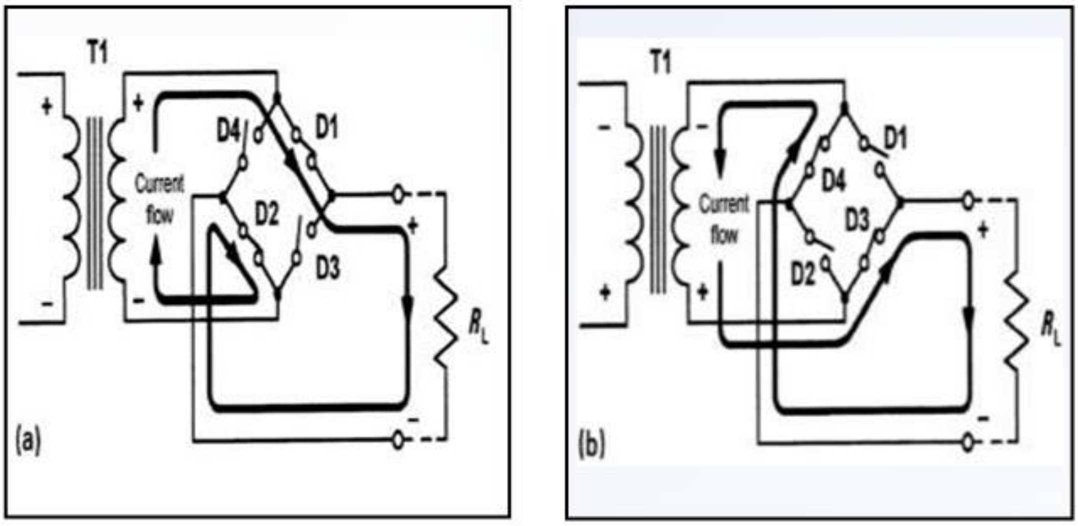


Figure 1.13 (a) Bridge rectifier with D1 and D2 conducting, D3 and D4 non- conducting (b) bridge rectifier with D1 and D2 non-conducting, D3 and D4 conducting

Bridge rectifier with filters:

- Fig. 1.14 shows how a reservoir capacitor (C1) can be added to maintain the output voltage when the diodes are not conducting.

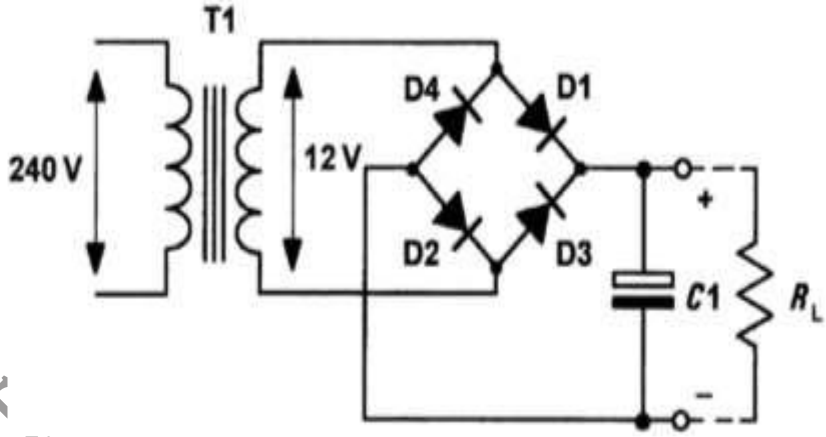


Figure 1.14 Bridge rectifier with reservoir

- This component operates in exactly the same way as for the bi-phase circuit, i.e. it charges to approximately 16.3 V at the peak of the positive half-cycle and holds the voltage at this level when the diodes are in their non-conducting states.
- The secondary and rectified output waveforms for the bridge rectifier are shown in Fig. 1.15.

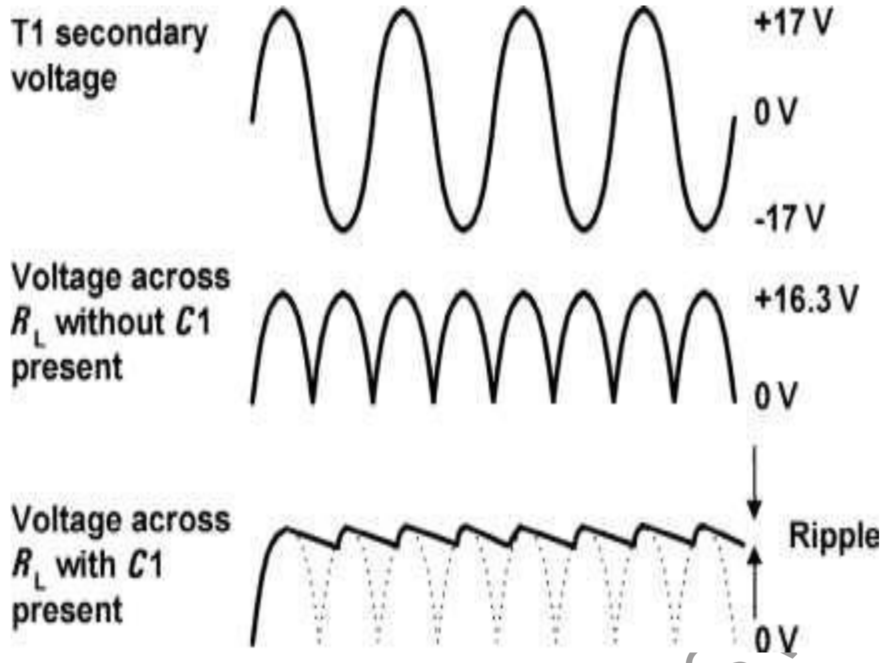


Figure 1.15 Waveforms for the bridge rectifier

1.3 Voltage regulators

- Voltage regulator is a circuit that maintains a constant d.c output voltage irrespective of variations in the input line voltage or in the load.
- Voltage regulator is one of the important application of a Zener diode.
- A simple voltage regulator is shown in Fig. 1.16.

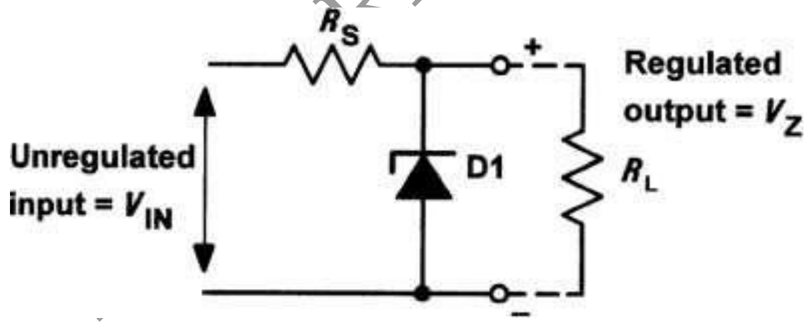


Figure 1.16 A simple shunt Zener voltage regulator

- R_S is included to limit the zener current to a safe value when the load is disconnected.
- When a load (R_L) is connected, the zener current (I_Z) will fall as current is diverted into the load resistance (it is usual to allow a minimum current of 2 mA to 5 mA in order to ensure that the diode regulates).
- The output voltage (V_Z) will remain at the Zener voltage until regulation fails at the point at which the potential divider formed by R_S and R_L

produces a lower output voltage that is less than V_Z.

- The ratio of R_S to R_L is thus important.
- Regulated output V_Z is given by:

$$V_Z = V_{IN} \times \frac{R_L}{R_L + R_S}$$

where V_{IN} is the unregulated input voltage.

- Thus the maximum value for R_S can be calculated from:

$$R_{S(max)} = R_L \times \left[\frac{V_{IN}}{V_Z} - 1\right]$$

- The power dissipated in the zener diode will be given by $\mathbf{P_Z = I_Z \times V_Z}$, hence the minimum value for R_S can be determined from the off-load condition when:

$$R_{S(min)} = \frac{V_{IN} - V_Z}{I_Z} = \frac{V_{IN} - V_Z}{\left(\frac{P_{Z\,max}}{V_Z}\right)} = \frac{(V_{IN} - V_Z) \times V_Z}{P_{Z\,max}}$$

where P_Z max. is the maximum rated power dissipation for the zener diode.

Example: A 5 V zener diode has a maximum rated power dissipation of 500 mW. If the diode is to be used in a simple regulator circuit to supply a regulated 5 V to a load having a resistance of 400 Ω, determine a suitable value of series resistor for operation in conjunction with a supply of 9 V.

Given

$V_Z = 5V$

$V_{IN} = 9V$

$R_L = 400\Omega$

$P_{Z\,max} = 500mW = 0.5W$

$$R_{S\,max} = R_L \times \left(\frac{V_{IN}}{V_Z} - 1\right)$$

$$= 400 \times \left(\frac{9}{5} - 1\right)$$

$$\boxed{R_{S\,max} = 320\,\Omega}$$

$$R_{S\,min} = \frac{V_{IN} V_Z - V_Z^2}{P_{Z\,max}}$$

$$= \frac{(9 \times 5) - 5^2}{0.5}$$

$$\boxed{R_{S\,min} = 40\,\Omega}$$

Hence suitable value for RS would be 150Ω (roughly midway between two extreams)

1.4 Output resistance and voltage regulation

- In a perfect power supply, the output voltage would remain constant regardless of the current taken by the load.
- Output resistance R_{out} is defined as the change in output voltage divided by the corresponding change in output current and hence is given by:

$$Rout = \frac{change\ in\ output\ voltage}{change\ in\ output\ current} = \frac{\triangle V_{out}}{\triangle I_{out}}$$

where $\triangle I_{out}$ represents a small change in output (load) current and $\triangle V_{out}$ represents a corresponding small change in output voltage.

- The regulation of a power supply is given by the relationship:

$$Regulation = \frac{change\ in\ output\ voltage}{change\ in\ line\ (input)\ voltage} X\ 100\%$$

- Ideally, the value of regulation should be very small.
- Simple shunt zener diode regulators of the type shown in Fig. 1.17 are capable of producing values of regulation of 5% to 10%.

- More sophisticated circuits based on discrete components produce values of between 1% and 5% and integrated circuit regulators often provide values of 1% or less.

Example: The following data were obtained during a test carried out on a d.c. power supply:

(i) Load test:

Output voltage (no-load) = 12 V

Output voltage (2 A load current) = 11.5 V

(ii) Regulation test:

Output voltage (mains input, 220 V) = 12 V

Output voltage (mains input, 200 V) = 11.9 V

Determine (a) the equivalent output resistance of the power supply and (b) the regulation of the power supply.

Solution:

The output resistance can be determined from the load test data:

$$R_{out} = \frac{\text{Change in output Voltage}}{\text{Change in output current}} = \frac{12 - 11.5}{2 - 0}$$

$$\boxed{R_{out} = 0.25\Omega}$$

The regulation can be determined from the regulation test data:

$$\text{Regulation} = \frac{\text{Change in output Voltage}}{\text{Change in line input Voltage}} \times 100\%$$

$$\text{Regulation} = \frac{12 - 11.9}{220 - 200} \times 100\% = \frac{0.1}{20} \times 100\%$$

$$\boxed{\text{Regulation} = 0.5\%}$$

1.5 Voltage multipliers

Voltage multiplier is a modified capacitor filter circuit that delivers a dc voltage twice or more times of the peak value (amplitude) of the input ac voltage.

Applications

1. Voltage multipliers are used for high-voltage and low-current devices such as cathode-ray tubes (the picture tubes in TV receivers, oscilloscopes and computer display).
2. Voltage multipliers can still be found in modern TVs, photocopiers, and bug zappers.
3. High voltage multipliers are used in spray painting equipment, most commonly found in automotive manufacturing facilities.
4. A voltage multiplier with an output of about 100kV is used in the nozzle of the paint sprayer to electrically charge the atomized paint particles which then get attracted to the oppositely charged metal surfaces to be painted. This helps reduce the volume of paint used and helps in spreading an even coat of paint.

- By adding a second diode and capacitor, the output of the simple half-wave rectifier can be increased. A voltage doubler using this technique is shown in Fig. 1.17.

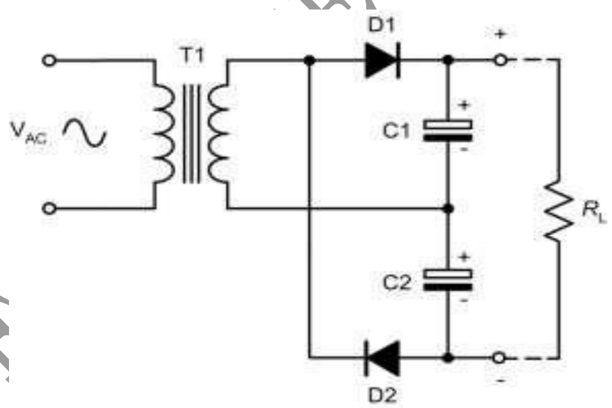


Figure 1.17 A voltage doubler

- In this arrangement C1 will charge to the positive peak secondary voltage while C2 will charge to the negative peak secondary voltage.
- Since the output is taken from C1 and C2 connected in series the resulting output voltage is twice that produced by one diode alone.
- The voltage doubler can be extended to produce higher voltages using the cascade arrangement shown in Fig. 1.18.

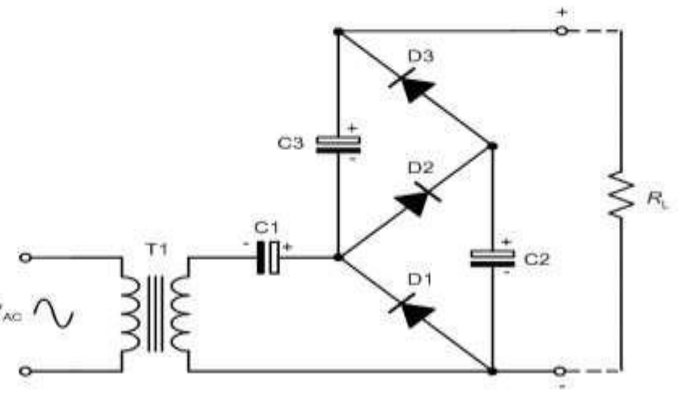


Figure 1.18 A voltage Tripler

- Here C1 charges to the positive peak secondary voltage, while C2 and C3 charge to twice the positive peak secondary voltage.
- The result is that the output voltage is the sum of the voltages across C1 and C3 which is three times the voltage that would be produced by a single diode.
- The ladder arrangement shown in Fig. 1.20 can be easily extended to provide even higher voltages but the efficiency of the circuit becomes increasingly impaired and high-order voltage multipliers of this type are only suitable for providing relatively small currents.

1.6 Amplifiers

An **amplifier** is an electronic device that increases the voltage, current, or power of a signal. Amplifiers are used in wireless communications and broadcasting, and in audio equipment of all kinds.

Types of Amplifiers:

The following are the types of amplifiers:

1. A.C. coupled amplifiers

In a.c. coupled amplifiers, stages are coupled together in such a way that d.c. levels are isolated and only the a.c. components of a signal are transferred from stage to stage.

2. D.C. coupled amplifiers

In d.c. (or direct) coupled amplifiers, stages are coupled together in such a way that stages are not isolated to d.c. potentials. Both a.c.

and d.c. signal components are transferred from stage to stage.

3. Large-signal amplifiers

Large-signal amplifiers are designed to cater for appreciable voltage and/or current levels (typically from 1 V to 100 V or more).

4. Small-signal amplifiers

Small-signal amplifiers are designed to cater for low-level signals (normally less than 1 V and often much smaller). Small-signal amplifiers have to be specially designed to combat the effects of noise.

5. Audio frequency amplifiers

Audio frequency amplifiers operate in the band of frequencies that is normally associated with audio signals (e.g. 20 Hz to 20 kHz).

6. Wideband amplifiers

Wideband amplifiers are capable of amplifying a very wide range of frequencies, typically from a few tens of hertz to several megahertz.

7. Radio frequency amplifiers

Radio frequency amplifiers operate in the band of frequencies that is normally associated with radio signals (e.g. from 100 kHz to over 1 GHz).

8. Low-noise amplifiers

Low-noise amplifiers are designed so that they contribute negligible noise (signal disturbance) to the signal being amplified.
These amplifiers are usually designed for use with very small signal levels (usually less than 10 mV or so).

1.7 Gain

- One of the most important parameters of an amplifier is the amount of amplification or gain that it provides.

- Gain is simply the ratio of output voltage to input voltage, output current to input current, or output power to input power.

- These three ratios give, respectively the voltage gain, current gain and power gain. Thus,

$$\text{Voltage gain, } A_v = \frac{V_{out}}{V_{in}}$$

$$\text{Current gain, } A_i = \frac{I_{out}}{I_{in}}$$

$$\text{Power gain, } A_p = \frac{P_{out}}{P_{in}}$$

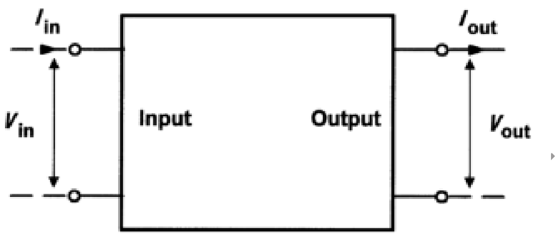


Figure 1.19: Block diagram for an amplifier showing input and output voltages and currents

Note that, since power is the product of current and voltage (P = I V), we can infer that:

$$A_p = \frac{P_{out}}{P_{in}} = \frac{I_{out} \times V_{out}}{I_{in} \times V_{in}} = \frac{I_{out}}{I_{in}} \times \frac{V_{out}}{V_{in}} = A_i \times A_v$$

Example: An amplifier produces an output voltage of 2 V for an input of 50 mV. If the input and output currents in this condition are, respectively, 4 mA and 200 mA, determine:

(a) the voltage gain; (b) the current gain;(c) the power gain.

Solution

(a) The voltage gain is calculated from:

$$A_v = \frac{V_{out}}{V_{in}} = \frac{2\text{ V}}{50\text{ mV}} = 40$$

(b) The current gain is calculated from:

$$A_i = \frac{I_{out}}{I_{in}} = \frac{200\text{ mA}}{4\text{ mA}} = 50$$

(c) The power gain is calculated from:

$$A_p = \frac{I_{out} \times V_{out}}{I_{in} \times V_{in}} = \frac{200\text{ mA} \times 2\text{ V}}{4\text{ mA} \times 50\text{ mV}} = \frac{0.4\text{ W}}{200\ \mu\text{W}} = 2{,}000$$

Note that the same result is obtained from:

$$A_p = A_i \times A_v = 50 \times 40 = 2,000$$

1.8 Input and output resistance

- Input resistance is the ratio of input voltage to input current and it is expressed in ohms.
- The input of an amplifier is normally purely resistive (i.e. any reactive component is negligible) in the middle of its working frequency range (i.e. the mid-band).
- Output resistance is the ratio of open-circuit output voltage to short-circuit output current and is measured in ohms.
- Fig. 1.20 shows how the input and output resistances are 'seen' looking into the input and output terminals, respectively.

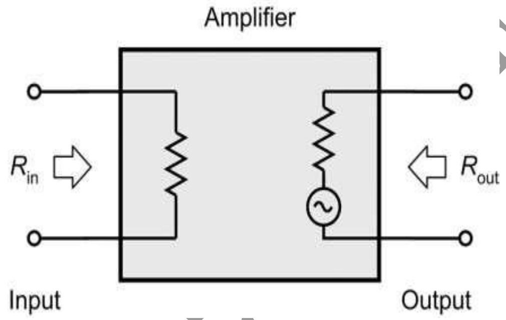


Figure 1.20 The Input and output resistance, with the input and output terminals, respectively.

1.9 Frequency response

- The frequency response characteristics for various types of amplifier are shown in Fig. 1.21.

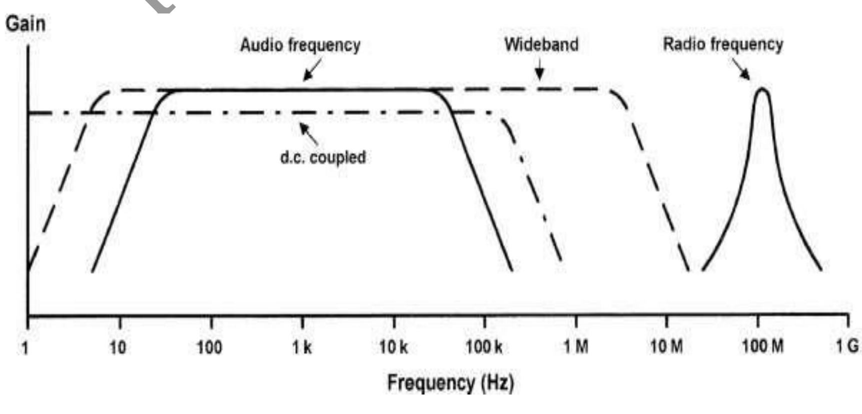


Figure 1.21 Frequency response and bandwidth (output power plotted against frequency)

- The frequency response of an amplifier is usually specified in terms of the upper and lower cut-off frequencies of the amplifier.
- These frequencies are those at which the output power has dropped to 50% (otherwise known as the −3 dB points) or where the voltage gain has dropped to 70.7% of its mid-band value.
- Figs 1.22 and 1.23, respectively, show how the bandwidth can be expressed in terms of either power or voltage (the cut- off frequencies, f1 and f2, and bandwidth are identical).

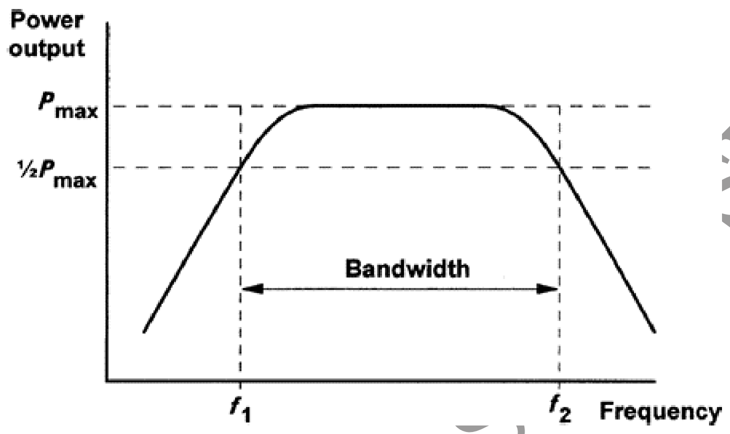


Figure 1.22 Frequency response and bandwidth (output powerplotted against frequency)

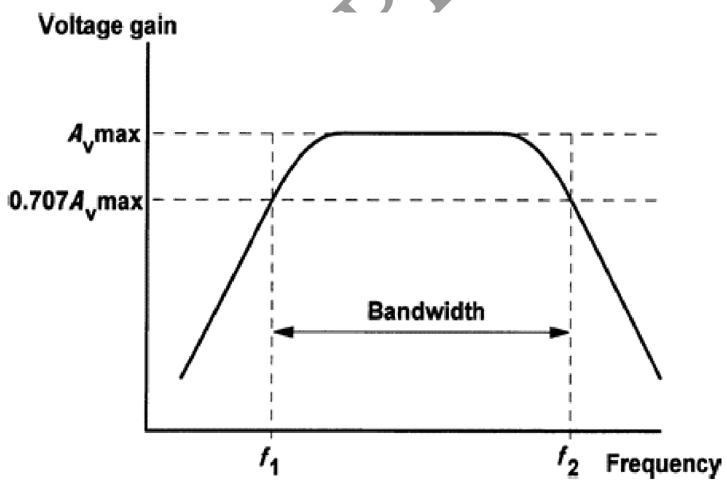
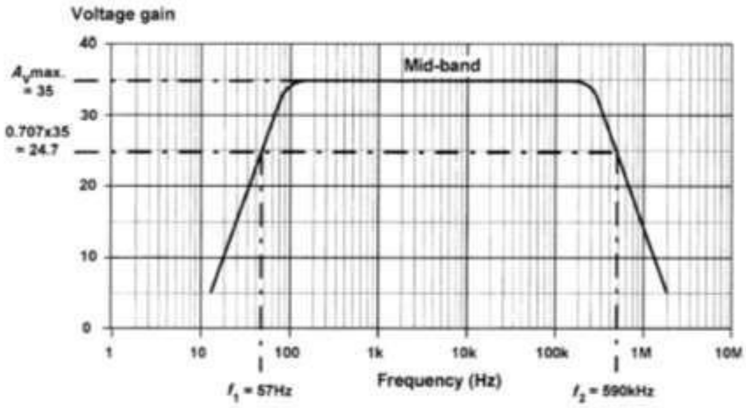


Figure 1.23 Frequency response and bandwidth (output voltage plotted against frequency)

Example: Determine the mid-band voltage gain and upper and lower cut-off frequencies for the amplifier whose frequency response is shown in figure below.



Solution: The mid-band voltage gain corresponds with the flat part of the frequency response characteristic. At that point the voltage gain reaches a maximum of 35.

The voltage gain at the two cut-off frequencies can be calculated from:

$$Av\ cut\text{-}off = 0.707 \times Av\ max = 0.707 \times 35 = 24.7$$

This value of gain intercepts the frequency response graph at f1 =57 Hz and f2 = 590 kHz.

1.10 Bandwidth

- The bandwidth of an amplifier is usually taken as the difference between the upper and lower cut-off frequencies

  Bandwidth = f2 – f1
- The bandwidth of an amplifier must be sufficient to accommodate the range of frequencies present within the signals that it is to be presented with.
- Many signals contain harmonic components (i.e. signals at2f, 3f, 4f, etc. where f is the frequency of the fundamental signal).
- To reproduce a square wave, for example, requires an amplifier with a very wide bandwidth (note that a square wave comprises an infinite series of harmonics).

1.11 Phase Shift

- Phase shift is the phase angle between the input and output signal voltages measured in degrees.

- The measurement is usually carried out in the mid-band where, for most amplifiers, the phase shift remains relatively constant.
- The conventional single-stage transistor amplifiers provide phase shifts of either 180° or 360°.

1.20 Negative feedback

- Many practical amplifiers use negative feedback in order to precisely control the gain, reduce distortion and improve bandwidth.
- The gain can be reduced to a manageable value by feeding back a small proportion of the output.
- The amount of feedback determines the overall (or closed- loop) gain. Because this form of feedback has the effect of reducing the overall gain of the circuit, this form of feedback is known as negative feedback.
- An alternative form of feedback, where the output is fed back in such a way as to reinforce the input (rather than to subtract from it) is known as positive feedback. This form of feedback is used in oscillator circuits. Fig. 1.24 shows the block diagram of an amplifier stage with negative feedback applied.
- In this circuit, the proportion of the output voltage fed back to the input is given by β and the overall voltage gain will be given by:

$$\boxed{\text{Overall gain, } G = \frac{V_{out}}{V_{in}}}$$

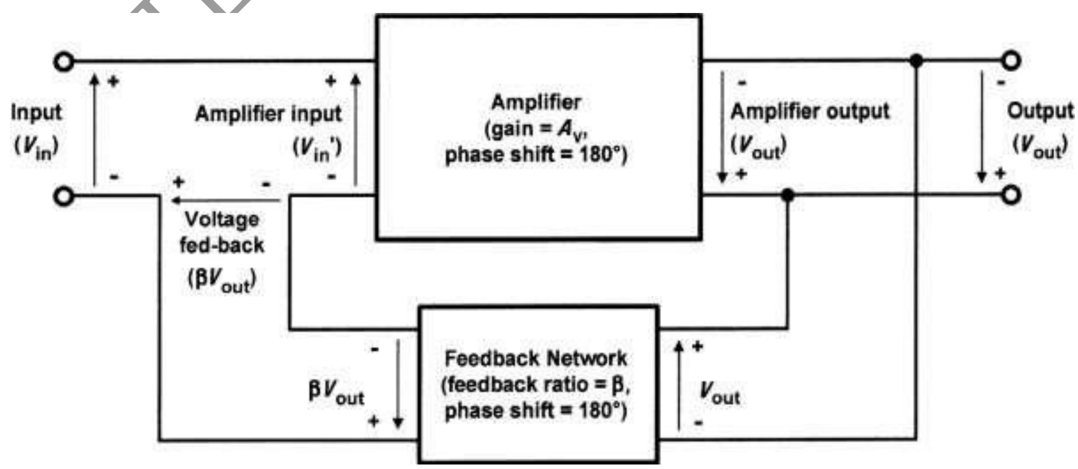


Figure 1.24 Amplifier with negative feedback applied

Now, $V_{in}' = V_{in} - \beta V_{out}$ (Apply KVL)

$$V_{in} = V_{in}' + \beta V_{out} \rightarrow (1)$$

and

$$V_{out} = A_V \times V_{in}' \rightarrow (2)$$ {Av – internal gain}

Hence, overall gain is given by

$$G = \frac{V_{out}}{V_{in}} = \frac{A_V \cdot V_{in}'}{V_{in}' + \beta V_{out}}$$ {Sub V_{out}}

$$G = \frac{A_V \cdot V_{in}'}{V_{in}' + \beta (V_{in}' A_V)}$$

$$G = \frac{A_V \cdot V_{in}'}{V_{in}' + \beta V_{in}'} = \frac{A_V \cdot \cancel{V_{in}'}}{\cancel{V_{in}'}(1+\beta A_V)}$$

$$\boxed{G = \frac{A_V}{1+\beta A_V}}$$

- Hence, the overall gain with negative feedback applied will be less than the gain without feedback.
- Furthermore, if Av is very large (as is the case with an operational amplifier) the overall gain with negative feedback applied will be given by:
  G = 1/β (when Av is very large)
- The loop gain of a feedback amplifier is defined as the product of β and Av.

Example An amplifier with negative feedback applied has an open-loop voltage gain of 50, and one-tenth of its output is fed back to the input (i.e. β = 0.1). Determine the overall voltage gain with negative feedback applied.

Solution: With negative feedback applied, the overall voltage gain is:

$$G = \frac{A_v}{1+\beta A_v} = \frac{50}{1+(0.1\times 50)} = \frac{50}{6} = 8.33$$

Example If, in Example 7.3, the amplifier's open-loop voltage gains increases by 20%, determine the percentage increase in overall voltage gain.

Solution The new value of voltage gain will be given by:

$$A_V = A_V + 0.2A_V$$
$$= 50 + (0.2 \times 50)$$
$$\boxed{A_V = 60}$$

overall gain $G = \frac{A_V}{1+\beta A_V} = \frac{60}{1+(0.1 \times 60)} = \frac{60}{7}$

$$\boxed{G = 7.14}$$

The increase in overall voltage gain, expressed as a percentage will thus be,

$$\frac{8.57 - 8.33}{8.33} \times 100\% = 2.88\%$$

Example An integrated circuit that produces an open loop gain of 100 is to be used as the basis of an amplifier stage having a precise voltage gain of 20. Determine the amount of feedback required.

Solution: Re-arranging the formula,

$$G = \frac{A_V}{1+\beta A_V}$$

Re-arranging the formula for β

$$\beta = \frac{1}{G} - \frac{1}{A_V}$$
$$\beta = \frac{1}{20} - \frac{1}{100}$$
$$\beta = 0.05 - 0.01$$
$$\boxed{\beta = 0.04}$$

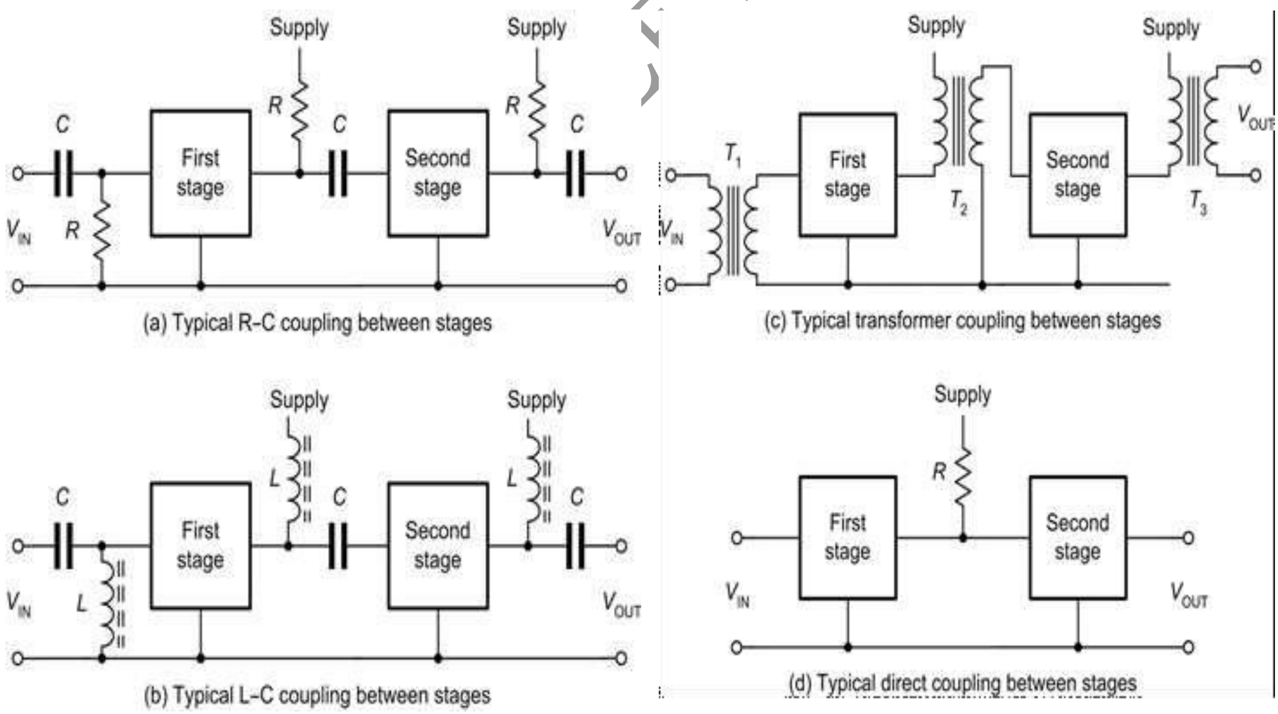
1.21 Multi-stage amplifiers

- A **Multistage Amplifier** is obtained by connecting several single-stage amplifiers in series or cascaded form. Whenever we are unable to get the required amplification factor, input, and output resistance values by using a single-stage amplifier, that time we will use Multistage amplifiers. Based on the requirement, we will connect the number of transistors to the output of a single-stage amplifier.

- To provide sufficiently large values of gain, it is frequently necessary to use a number of interconnected stages within an amplifier.
- The overall gain of an amplifier with several stages (i.e. a multi-stage amplifier) is simply the product of the individual voltage gains. Hence:

$$AV = AV1 \times AV2 \times AV3, \text{ etc.}$$

- The bandwidth of a multistage amplifier will be less than the bandwidth of each individual stage.
- An increase in gain can only be achieved at the expense of a reduction in bandwidth.
- Signals can be coupled between the individual stages of a multi-stage amplifier using one of a number of different methods shown in Fig. 1.25.



(a) Typical R–C coupling between stages

(c) Typical transformer coupling between stages

(b) Typical L–C coupling between stages

(d) Typical direct coupling between stages

Figure 1.25 Different methods used for inter-stage coupling

MODULE-1

QUETSION BANK

1. What is a regulated power supply? With neat block diagram Summarize the working of DC power supply. Also mention the principal components used in each block.
2. With circuit diagram and waveforms brief out the operation of Half wave rectifiers with filters.
3. Discuss the need of filter circuit. With circuit diagram and waveforms brief out the operation of smoothing filter for full wave rectifiers.
4. Explain the working of Bridge rectifier circuit without filter with neat diagram and waveforms.
5. A 5V zener diode has a maximum rated power dissipation of 500 mW. If the diode is to be used in a simple regulator circuit to supply a regulated 5V to a load having a resistance of 500 Ω, determine a suitable value of series resistor for operation in conjunction with a supply of 9V.
6. What is voltage multiplier and mention its applications? With circuit diagram brief out the operation of voltage Tripler circuit.
7. Mention the advantages of Negative Feedback in amplifiers circuits. With relevant equations and diagram, explain the concept of negative feedback.
8. What is an amplifier? Explain the types of amplifiers?
9. Explain the following terms
   i) Gain ii) Bandwidth iii) Frequency response iv) Phase shift
   v) Input & output resistance
10. An integrated circuit that produces an open loop gain of 50 is to be used as the basis of an amplifier stage having a precise voltage gain of 10. Determine the amount of feedback required.

Course Coordinator **Module Coordinator** **HOD**