T.Y.B.Sc. SEM – V

Subject: Physics

Paper- 503

Unit -3

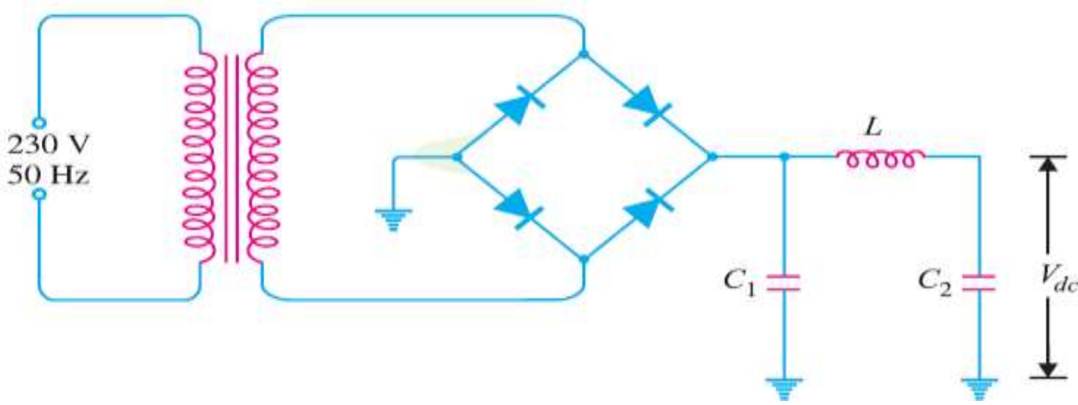
REGULATED D.C. POWER SUPPLY

- Introduction
- D.C. power supply
- Regulated power supply
- Zener diode as regulator
- Transistor voltage regulator
- Transistor series voltage regulator

INTRODUCTION:

ORDINARY D.C. POWER SUPPLY :

- An ordinary or unregulated d.c. power supply contains a rectifier and a filter circuit as shown in Fig. The output from the rectifier is pulsating d.c. These pulsations are due to the presence of a.c. component in the rectifier output. The filter circuit removes the a.c. component so that steady d.c. voltage is obtained across the load.



- **Limitations:** An ordinary d.c. power supply has the following drawbacks :

  (i) The d.c. output voltage changes directly with input a.c. voltage. For instance, a 5% increase in input a.c. voltage results in approximately 5% increase in d.c. output voltage.

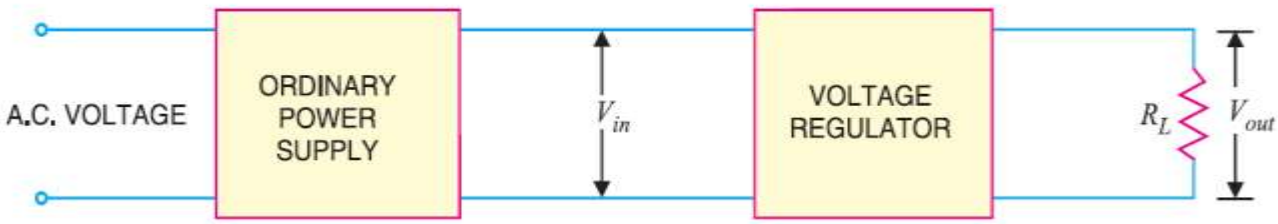
  (ii) The d.c. output voltage decreases as the load current increases. This is due to voltage drop in (*a*) transformer windings (*b*) rectifier and (*c*) filter circuit.

These variations in d.c. output voltage may cause inaccurate or erratic operation or even malfunctioning of many electronic circuits.

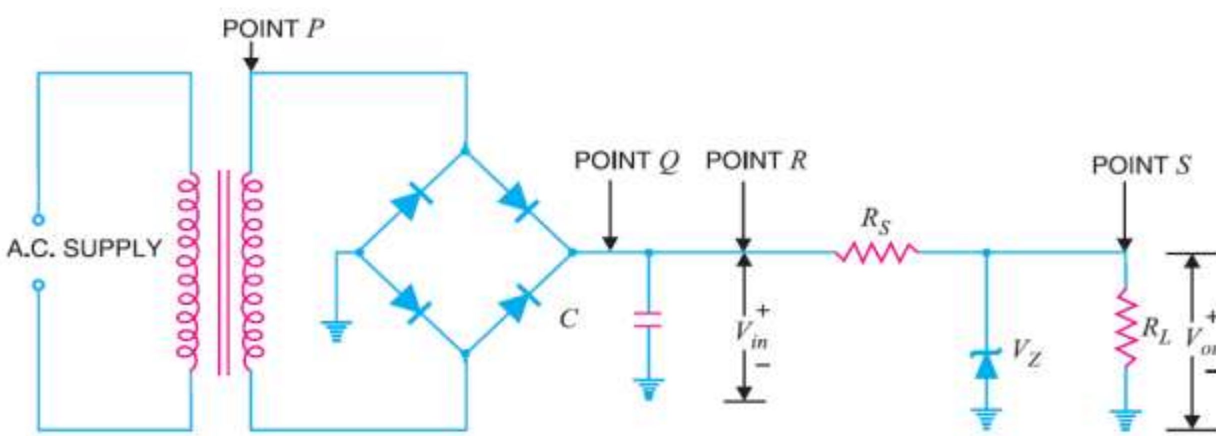
For example, in an oscillator, the frequency will shift and in transmitters, distorted output will result. Therefore, ordinary power supply is unsuited for many electronic applications and is being replaced by regulated power supply.

REGULATED POWER SUPPLY :

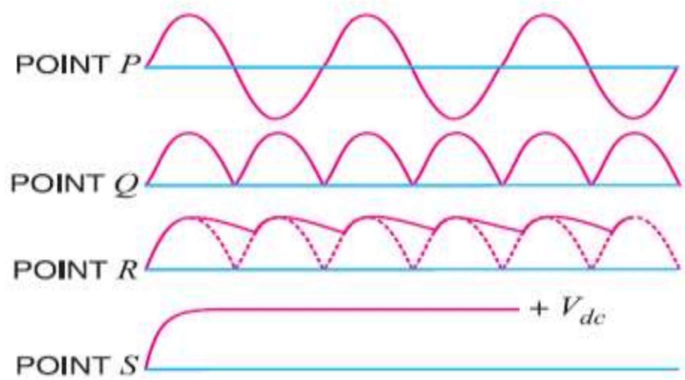
- *"A d.c. power supply which maintains the output voltage constant irrespective of a.c. mains fluctuations or load variations is known as* **regulated d.c. power supply."**



- Fig. shows the complete circuit of a regulated power supply using zener diode as a voltage regulating device. As you can see, the regulated power supply is a combination of three circuits *viz.,* (*i*) bridge rectifier (*ii*) a capacitor filter *C* and (*iii*) zener voltage regulator.
- The bridge rectifier converts the transformer secondary a.c. voltage (point *P*) into pulsating voltage (point *Q*). The pulsating d.c. voltage is applied to the capacitor filter. This filter reduces the pulsations in the rectifier d.c. output voltage (point *R*). Finally, the zener voltage regulator performs two functions.
- Firstly, it reduces the variations in the filtered output voltage. Secondly, it keeps the output voltage (*Vout*) nearly constant whether the load current changes or there is change in input a.c. voltage. Fig. shows the waveforms at various stages of regulated power supply.

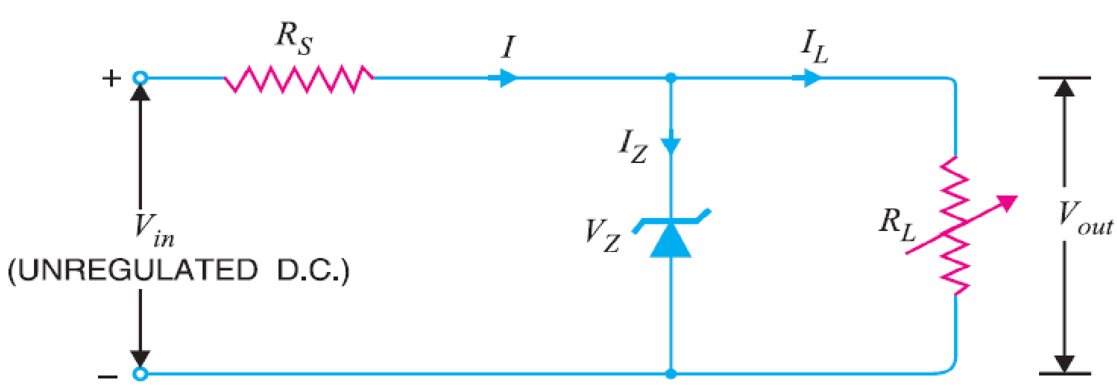


- capacitor filter constitute an ordinary power supply. However, when voltage regulating device is added to this ordinary power supply, it turns into a regulated power supply.



ZENER DIODE AS VOLTAGE REGULATOR :

- 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. 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.



☸ 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.

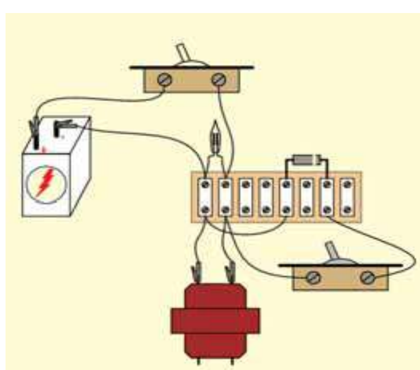
☸ As output voltage = *Vin* – *IRS*, and *I* is constant, therefore, output voltage remains unchanged. The reverse would be true should the load current decrease. The circuit will also correct for the changes in input voltages.

☸ 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.



TRANSISTOR SERIES VOLTAGE REGULATOR

- Figure shows a simple series voltage regulator using a transistor and zener diode. The circuit is called a series voltage regulator because the load current passes through the series transistor $Q1$ as shown in Fig. The unregulated d.c. supply is fed to the input terminals and the regulated output is obtained across the load. The zener diode provides the reference voltage.

- **Operation.** The base voltage of transistor $Q1$ is held to a relatively constant voltage across the Zener diode. For example, if 8V zener (*i.e.*, VZ = 8V) is used, the base voltage of $Q1$ will remain approximately 8V. Referring to Fig. ,

$$Vout = VZ - VBE$$

(i) If the output voltage decreases, the increased base-emitter voltage causes transistor $Q1$ to conduct more, thereby raising the output voltage. As a result, the output voltage is maintained at a constant level.

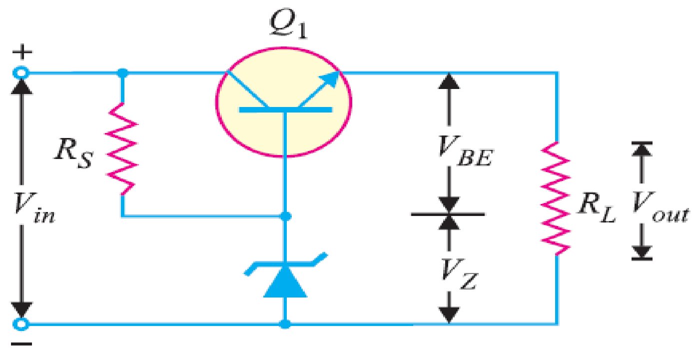
(ii) If the output voltage increases, the decreased base-emitter voltage causes transistor $Q1$ to conduct less, thereby reducing the output voltage. Consequently, the output voltage is maintained at a constant level.

(iii) The advantage of this circuit is that the changes in zener current are reduced by a factor β. Therefore, the effect of zener impedance is greatly reduced and much more stabilised output is obtained

Limitations:

(i) Although the changes in zener current are much reduced, yet the output is not absolutely constant. It is because both VBE and VZ decrease with the increase in room temperature.

(ii) The output voltage cannot be changed easily as no such means is provided.



TRANSISTOR SHUNT VOLTAGE REGULATOR :

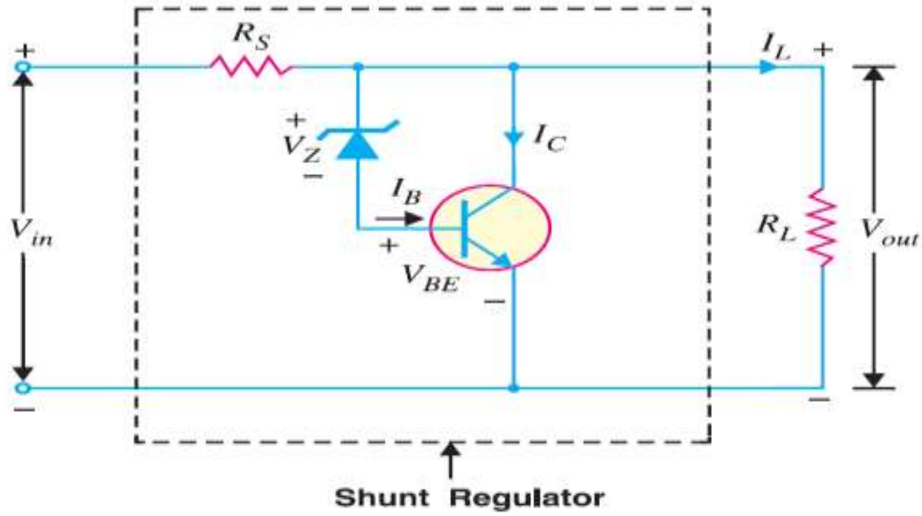
- A shunt voltage regulator provides regulation by shunting current away from the load to regulate the output voltage. Fig. shows the circuit of shunt voltage regulator. The voltage drop across series resistance depends upon the current supplied to the load *RL*. The output voltage is equal to the sum of zener voltage (*VZ*) and transistor base-emitter voltage (*VBE*) *i.e.*, $Vout = VZ + VBE$
- If the load resistance decreases, the current through base of transistor decreases. As a result, less collector current is shunted. Therefore, the load current becomes larger, thereby maintaining the regulated voltage across the load. Reverse happens should the load resistance increase.
- **Drawbacks.** A shunt voltage regulator has the following drawbacks :

(*i*) A large portion of the total current through *RS* flows through transistor rather than to the load.

(*ii*) There is considerable power loss in *RS*.

(*iii*) There are problems of overvoltage protection in this circuit.

For these reasons, a series voltage regulator is preferred over the shunt voltage regulator.



Chapter Review Topics

1. What do you understand by unregulated power supply ? Draw the circuit of such a supply.
2. What are the limitations of unregulated power supply ?
3. What do you understand by regulated power supply ? Draw the block diagram of such a supply.
4. Write a short note on the need for regulated power supply.
5. Explain the action of a zener voltage regulator with a neat diagram.
6. Write short notes on the following :
   (*i*) Transistor series voltage regulator
   (*ii*) Negative feedback voltage regulator
   (*iii*) Glow tube voltage regulator
7. What are the limitations of transistorised power supplies ?
8. Draw the circuit of the most practical valve operated power supply and explain its working.

Problems

1. A voltage regulator is rated at an output current of I_L = 0 to 40 mA. Under no-load conditions, the ouput voltage from the circuit is 8V. Under full-load conditions, the output voltage from the circuit is 7.996 V. Determine the value of load-regulation for the circuit. **[100 μV/mA]**
2. The zener diode in Fig. 17.32 has values of $I_{Z(min)}$ = 3 mA and $I_{Z(max)}$ = 100 mA. What is the minimum allowable value of R_L ? **[241 Ω]**