voltage is below certain level. While sudden drips or rapid fluctuations of less that 1 or 1.5% produce annoying eight fluctuations, they are called as eight flickers.

The methods for controlling voltage are tap changing transformers. Regulating transformers etc synchronous condenser. Static shunt capacitors, shunt reactors are common source of reactive power.

5.8 REQUIREMENTS OF VOLTAGE & REACTIVE POWER CONTROL

For efficient & reliable operation of power system should have the following:

a) All the machines and equipments are designed to operate at a certain voltage. Operation above or below the allowable range could damage them.
b) System stability in increase to maximize utilization of the transmission system. Voltage and reactive power control have a significant impact on system stability.
c) The reactive power flow is minimized so as to reduce I^2R and I^2X losses and to operate the transmission system efficiently (IP) mainly for active power transfer.

The reactive power cannot be transmitted over long distance; voltage control has to be affected by using special devices dispersed throughout the system. This is in contrast to the control of frequency which depends on the overall system active power balance. The problem of maintain voltage constant is that the loads keep on changing over a wide range, when the load varies, the power requirement also varies.

5.9 IMPORTANCE OF VOLTAGE CONTROL

The variations of Voltage at load will affect the consumer terminals. So , we should maintain the voltage within prescribed limits for the following reasons.

1. In lighting load, the lamp characteristics are very sensitive to change of voltage.
   If the supply voltage decrease, then the illumes acting power may decrease.
   If the supply voltage increase, the of the lamp reduces.
2. In induction motors, the voltage variations may cause erratic operation. If the supply voltage increase, the motor may operate with a saturated magnetic circuit and produce heating, thereby low power factor. If the voltage decrease. The starting torque of the motor may reduce.
3. In distribution transformers, the voltage variations may cause excessive heating and thereby rating of transformer.

   Location of voltage control equipment.

The voltage control equipments are connected between the generating station and the consumers. It is used at more than one point in any part of power system because, the power network is very large and there is a considerable voltage drop in transmission distribution load characteristics.

Voltage control equipment is located at .

1. Generating stations
2. Transformer stations
3. Feeders

5.10 GENERATION AND ABSORPTION OF REACTIVE POWER

1. Synchronous generators

It can generate or absorb reactive power. Reactive power (q) is supplied by synchronous generators depending upon the short circuit ratio (SCR).

$SCR = 1/X_S$

Where X_s = synchronous reactance.

An over excited synchronous machine operating on no load condition, generates reactive power. An under excited synchronous machine absorbs reactive power. It is undesirable to transmit large amount of KVAR over transmission lines as this produces excessive voltage droop.

2. Shunt capacitors:

It offers the cheapest means of reactive power supply.

3. Shunt reactors:

It offers the cheapest means of reactive power absorption and these are connected in the transmission line during light load conditions.

4. Transformers:

It always absorb reactive power regardless of their loading.

At no load – shunt magnetizing reactance effect is predominant.

At full load – series leakage inductance effect is pre-dominant.

$$P.U\ reactance, X_T = \frac{Actual\ X}{Base\ value} = \frac{Actual\ X}{\frac{V}{I}}$$

$$Actual\ X = X_T \frac{V}{I} = X_T\ \frac{KV}{I} \times 1000$$

$$I_{ph} = \frac{KVA}{\sqrt{3}\ KV}$$

$$X = \frac{X_T}{KVA} \times \sqrt{3} \times KV^2 \times 1000$$

$$Reactive\ power\ absorbed\ or\ loss[Q_T] = 3 \times |I^2| \times VAR$$

$$= 3 \times |I^2| \times \frac{X_T}{KVA} \times \frac{X_T}{KVA} \times 1000$$

$$= \frac{3KVA^2}{3KV^2} \times \frac{X_T}{KVA} \times \sqrt{3} \times KV^2 \times 1000$$

$$= \sqrt{3} \times KVA \times X_T \times KVAR$$

Where,

$I = Current\ in\ amps\ flowing\ through\ the\ transformer.$

$X = Transformer\ reactance/phase$

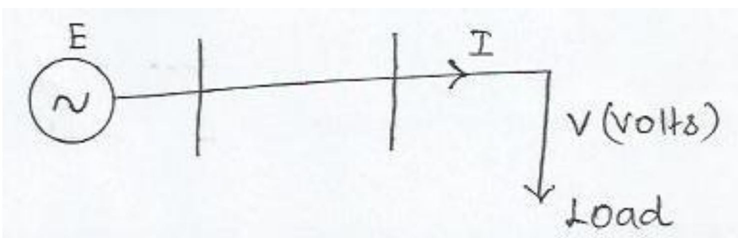
5. Cables:

Cables generate more reactive power than transmission lines because the cables have high capacitance.

6. Overhead lines:

Transmission lines are considered as generating KVAR in their shunt capacitance and consuming KVAR in their series inductance. The inductive KVAR Vary with the line current, where as the capacitive KVAR vary with the system potential.

Consider transmission line be loaded such that load current be 'I' amperes and load voltage 'V' volts as shown in figure.



If we assume the transmission line to be lossless, the reactive power absorbed by the line will be

$$\Delta Q_L = |I|^2 \times X_L$$

$$= |I|^2 \omega L$$

Due to the capacitance of the line, the reactive power generated by the line will be

$$\Delta Q_c = \frac{|V|^2}{X_c} = |V|^2 \omega C$$

Suppose $\Delta Q_L = \Delta Q_c$

$$|V|^2 \omega C = |I|^2 \omega L$$

$$= \left|\frac{V}{I}\right|^2 = \frac{\omega L}{\omega C} = \frac{L}{C}$$

$$Z_n = \frac{V}{I} = \sqrt{\frac{L}{C}}$$

Where Z_n is called surge impedance of the line.\

A line is said to be operating as its surge impedance loading when it is terminated by a resistance equal to its surge impedance. The power transmitted under to its impedance. The power transmitted under this condition is called natural or surge power.
In general,

$$P = \frac{|E||V|}{X} \sin\delta$$

$\delta = 90°$, max $power\ can\ be\ transfered.$

$$P = \frac{|E||V|}{X} MW$$

By varying X, δ , $|V|$, we can get the control power.

Case (i)

$\Delta Q_L > \Delta Q_c$

$|V|^2 \omega C < |I|^2 \omega L$

The voltage sags if the voltage at the two ends are maintained constant. The variation of voltage along the line is as shown in fig 2.

Here the line is loaded below Zn (ie) light load condition. The net effect of the line will be absorbed reactive power.
Case (ii)

$\Delta Q_L < \Delta Q_c$

$|V|^2 \omega C > |I|^2 \omega L$

The variation of voltage along the line is as shown in fig 5.2 and we find that the voltage rises and maintains constant voltage at the ends. Under light load conditions the effect of shunt capacitors is predominating and the line will generate reactive power.

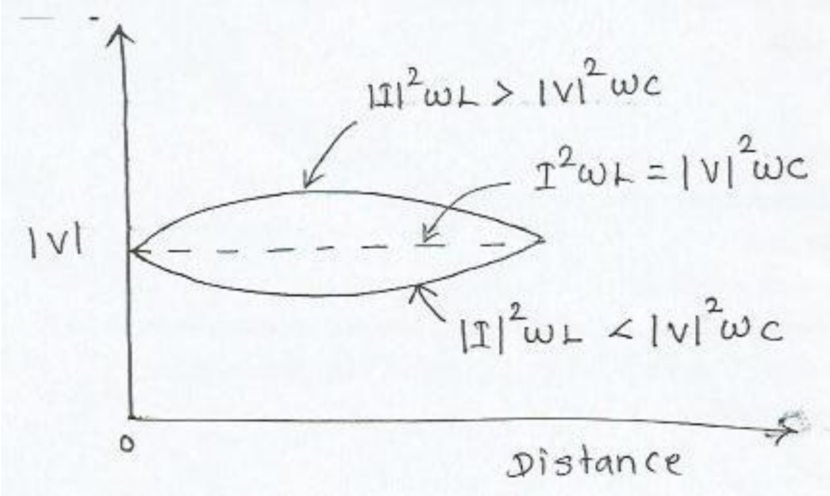


Figure 5.2 The variation of voltage along the line