5.7 Interruption of capacitive current

- The cause of excessive voltage surges in the circuit breakers is the interruption of capacitive currents. Examples of such instances are opening of an unloaded long transmission line, disconnecting a capacitor bank used for power factor improvement etc.

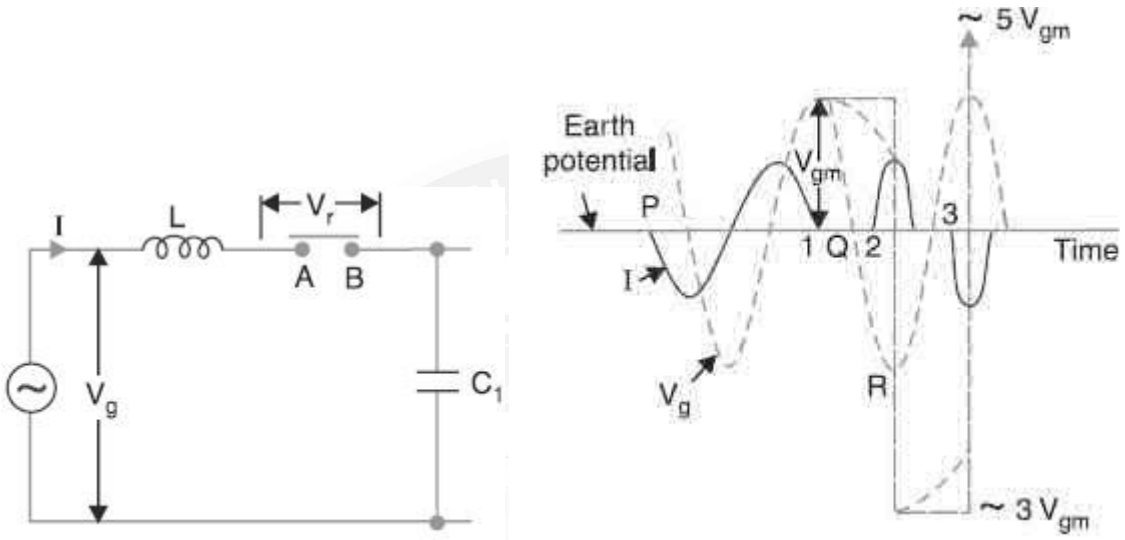

Figure 5.7.1 Equivalent circuit and Characteristic of unloaded transmission line

[Source: "Principles of Power System" by V.K Mehta, Page: 467]

- Such a line, although unloaded in the normal sense, will actually carry a capacitive current *I* on account of appreciable amount of capacitance *C* between the line and the earth. Let us suppose that the line is opened by the circuit breaker at the instant when line capacitive current is zero.
- At this instant, the generator voltage *Vg* will be maximum (*i.e., Vgm*) lagging behind the current by 90º. The opening of the line leaves a standing charge on it (*i.e.,* end *B* of the line) and the capacitor *C*1 is charged to *Vgm*.
- However, the generator end of the line (*i.e.,* end *A* of the line) continues its normal sinusoidal variations. The voltage *Vr* across the circuit breaker will be the difference between the voltages on the respective sides. Its initial value is zero (point 1) and increases slowly in the beginning. But half a cycle later, the potential of the circuit breaker contact *A*'becomes maximum negative which causes the voltage across the breaker (*Vr*)to become 2 *Vgm*.

- This voltage may be sufficient to restrike the arc. The two previously separated parts of the circuit will now be joined by an arc of very low resistance.
- The line capacitance discharges at once to reduce the voltage across the circuit breaker, thus setting up high frequency transient. The peak value of the initial transient will be twice the voltage at that instant i.e., − 4 Vgm. This will cause the transmission voltage to swing to − 4 Vgm to + Vgm i.e., −3Vgm.
- The re- strike arc current quickly reaches its first zero as it varies at natural frequency. The voltage on the line is now −3Vgm and once again the two halves of the circuit are separated and the line is isolated at this potential.
- After about half a cycle further, the aforesaid events are repeated even on more formidable scale and the line may be left with a potential of 5Vgm above earth potential. Theoretically, this phenomenon may proceed infinitely increasing the voltage by successive increment of2 times Vgm.
- While the above description relates to the worst possible conditions, it is obvious that if the gap break down strength does not increase rapidly enough, successive re-strikes can build up a dangerous voltage in the open circuit line. However, due to leakage and corona loss, the maximum voltage on the line in such cases is limited to 5 Vgm.