

Module 2 : Equipment and Stability Constraints in System Operation

Lecture 9 : Voltage Instability

Objectives

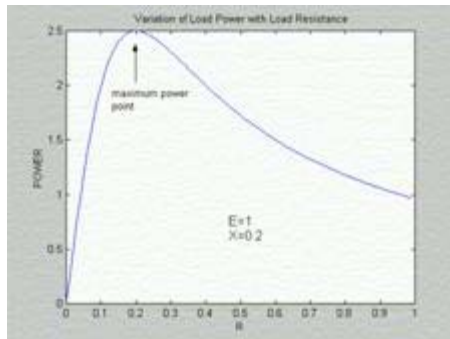
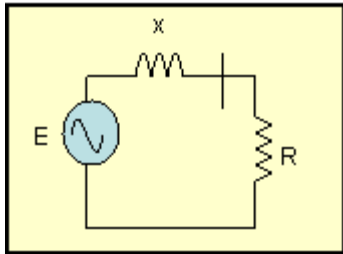
In this lecture you will learn the following

- What is voltage instability ?

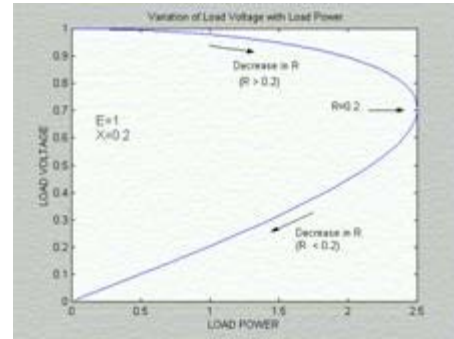
Voltage Instability

Voltage Instability is another stability problem that may manifest under heavy loading conditions. This problem causes extremely low voltages. It stems due to the actions of loads to demand power which is beyond the capability of the generators and the transmission network.

To understand this, consider a system shown below. As the load resistance decreases, the voltage at the load bus falls while power is expected to increase. However, a point comes beyond which the load power *decreases* as resistance falls. This occurs at $R=X$ (the maximum power point) --- show this!



(click to enlarge)

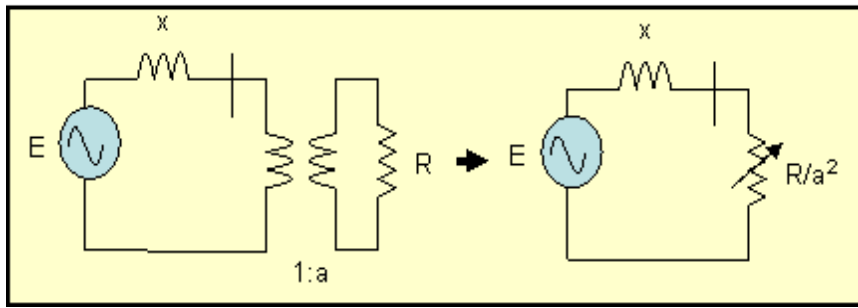


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Now, suppose the load is not a constant resistance, but is a *controlled* resistance which tries to keep load power constant by *decreasing* resistance if power is less than the desired value. This is all fine if the desired power is less than the maximum power point. If the desired power is greater than the maximum power point, the system will never reach an equilibrium because beyond the maximum power point, the controller action reduces the resistance, which *reduces* power and further pulls down the voltage. Usually any controller will have limits because of which controller action will cease beyond a point. However, the "damage has been done", in the sense that load voltage will be very low.

Voltage Instability (Con td..)

A *controlled* resistance which maintains constant power can be implemented using a tap changing transformer feeding a constant resistance. The tap value is changed if voltage at load is not equal to the desired value. Therefore the reflected resistance on the system side is controlled.



Normally, a power system has connected loads which are lesser than the maximum power transfer capability of the generation and transmission network. However, loss of lines may significantly increase transmission reactance. Generators may also hit their reactive capability limits resulting in inability to maintain voltage at key points in the network. This results in decrease of effective "E" and increase of effective "X" seen by loads.

We illustrate this with an [example](#).

A stronger transmission network and adequate reactive power reserves, to maintain voltages at key points in the network, are needed to avoid voltage instability.

Recap

In this lecture you have learnt the following

- Voltage stability is triggered by having loads which attempt to draw power which is beyond the maximum capability of generation and transmission.
- Limited power transfer capability occurs due to a weak network aggravated by generators hitting their reactive power capability limits

Congratulations, you have finished Lecture 9. Please view the next slide for concluding remarks for this module.