Voltage Collapse

An Overview

Voltage Collapse

Voltage collapse is a term used to identify a situation where the power flow problem does not have a solution, i.e. the scenario is unfeasible.

This means that the power flow equations cannot be satisfied and therefore there is no set of values for the voltages at the network nodes compatible with the given injections and with the given network parameters.

- This undesirable situation may arise in different ways that we shall review in the next slides.
- The power flow solution for the voltage at a given node can always be approximated, at this node, by a two-bus solution where the injections at one node are the real injections and where the rest of the network is represented by an equivalent swing node and an equivalent link to this swing. This allows us to use the formulas of the two-bus case to work out the examples.

Voltage Collapse Because of Active Power

- We know from the two-bus case that the problem has a solution only if

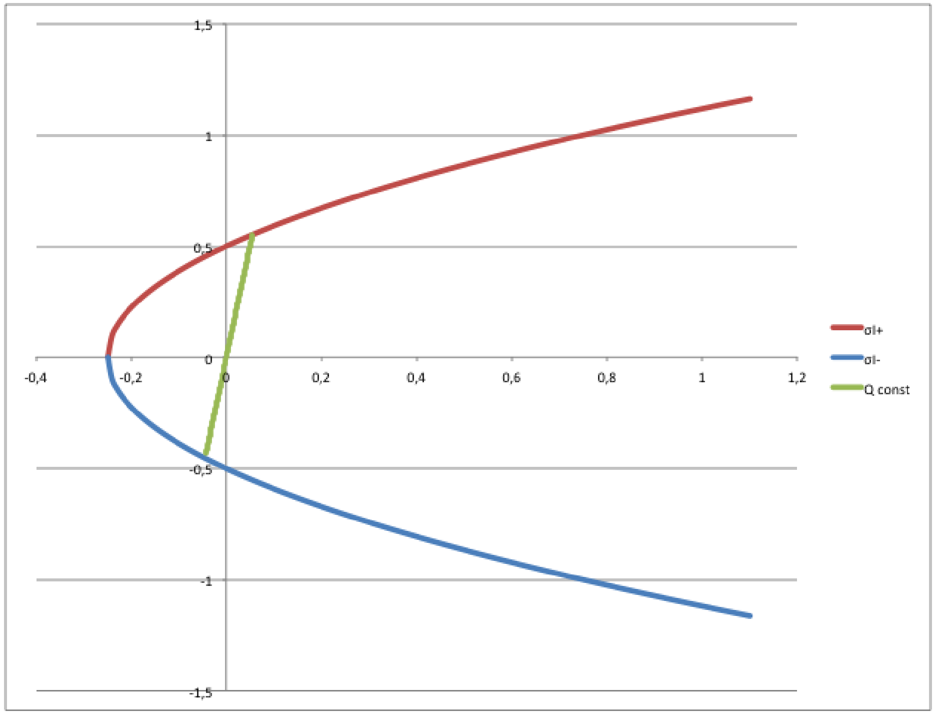
$$\frac{1}{4} + \sigma_R - \sigma_I^2 \geq 0 \qquad (1)$$

- Where

$$\sigma_R = \frac{RP + XQ}{|W|^2}; \sigma_I = \frac{XP - RQ}{|W|^2}$$

- Condition (1) defines a parabolic region on the σ plane.

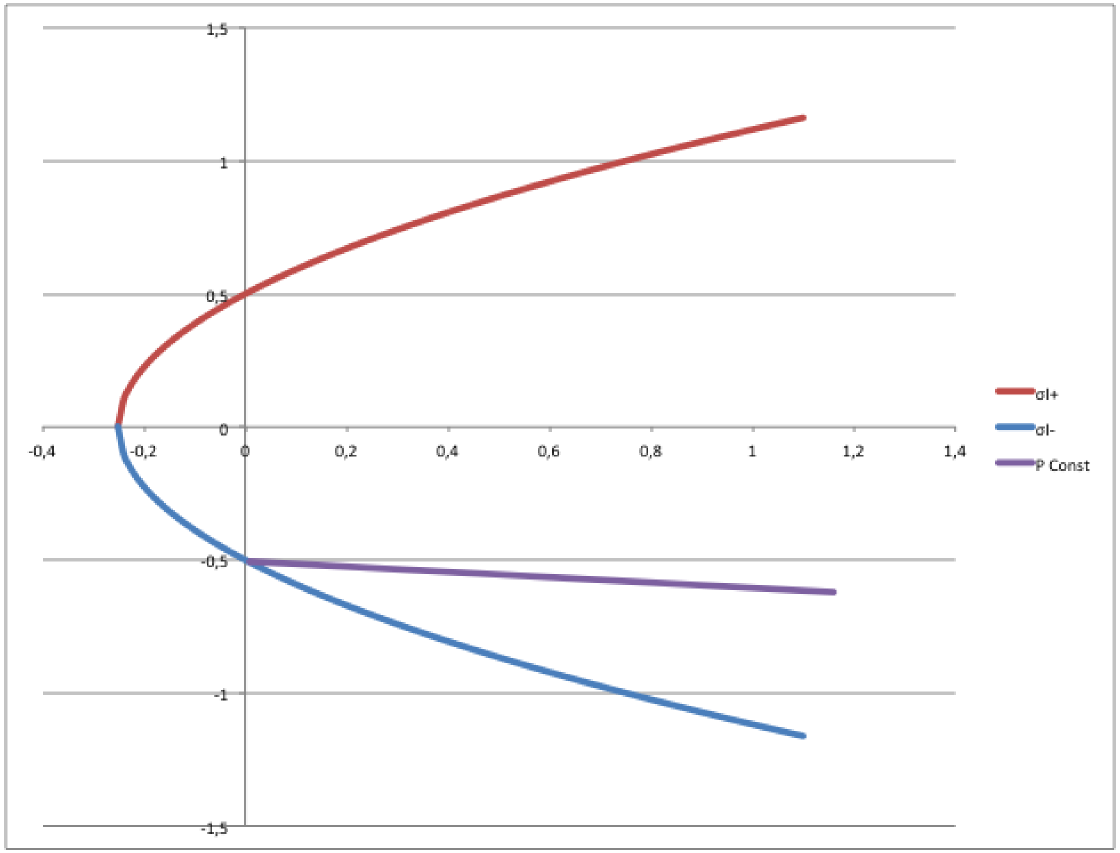
Using R=0.01 Ohms, X=0.1 Ohms we draw this parabola on the sigma plane Keeping Q= 0 MVAr we can see that as we vary P from -10 MW to 10 MW the path on the sigma plane crosses the boundary of the parabolic region at two points, so either injecting or absorbing too much active power at a node will cause Voltage collapse. Other values of Q will define parallel lines that will also intersect the boundary at two points.



Voltage Collapse Because of Reactive Power

- Using the same parameter values we can draw now on the sigma plane the points representing injections with constant P and changing Q. This is again a straight line on the sigma plane, but in this case there is only one intersection point with the boundary.
- This indicates that the reactive power produces collapse only if its value is below a given threshold.

(Q=0,5 MVAr in this example).



Voltage Collapse Because of 'Wrong' Solution

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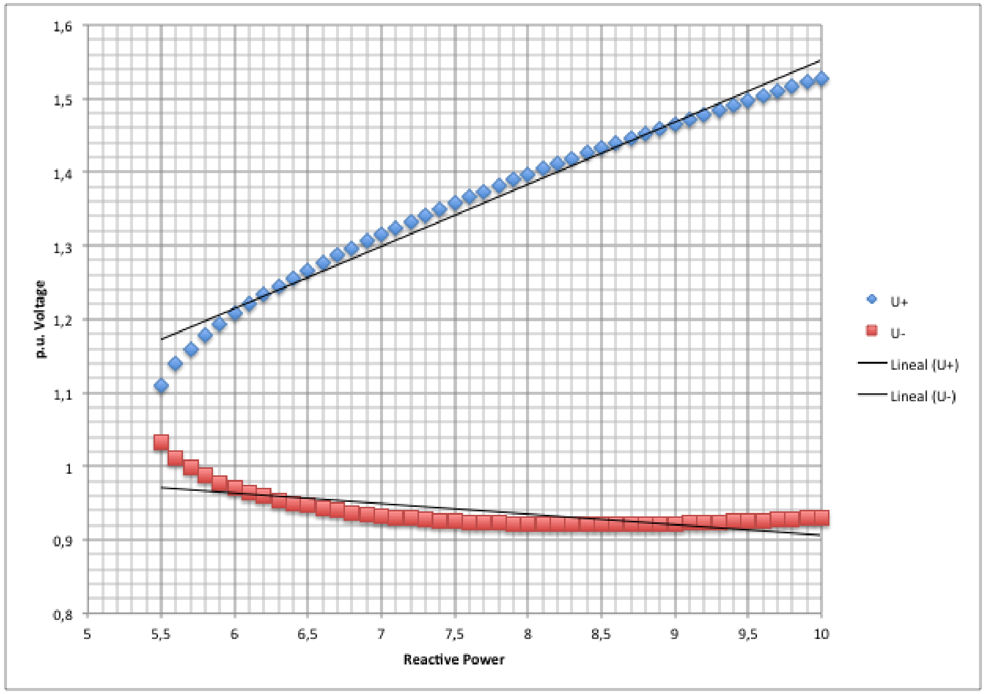
- If a non-operational solution were instantiated at a given node, then the voltage control devices would bring the system to the voltage collapse point.
- The voltage control devices inject more or less reactive power at the controlled bus in order to keep the voltage at its set point. They assume that the dV/dQ sensitivity is positive.
- In a non-operational solution, this sensitivity is reversed: on the lower branch of the QV diagram, increasing the reactive power injection lowers the voltage!.
- Therefore the voltage control devices would destabilize the system until it collapses (protections will trip).



Voltage Collapse and Iterative Algorithms

- When presented with an unfeasible case, an iterative algorithm will usually blow up, but occasionally it can also spuriously converge to a false solution.
- Even in the case that the iteration is not convergent, the method does not provide any clue about the problem: is it due to a wrong choice of the seed? or is there really no solution?
- This is a rather disappointing situation.

Voltage Collapse and HELM

- HELM is a constructive method. If the solution exists, it will find it.
- If the solution does not exist, the method will not construct a solution (non-equivocal results).
- Furthermore HELM is able to provide information about the problems that caused the voltage collapse (Sigma plots).

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