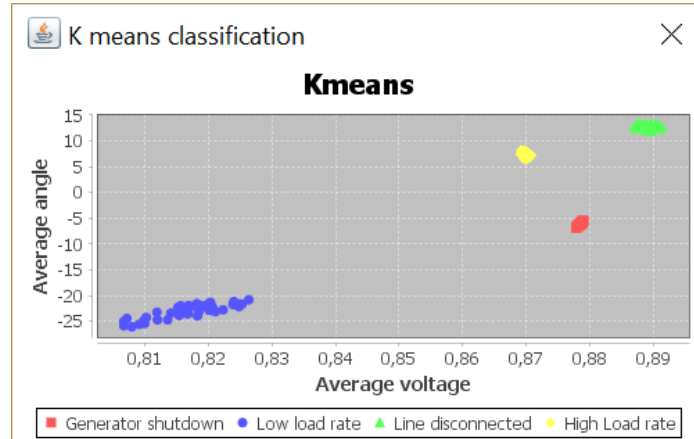


Labelling the power system states

There are 4 possible states for the system under analysis. The next figure shows the plot of medium voltage and medium angles for each one of the points of the system. A point represents a state of the system for a specific time, hence, it has 18 attributes that define it (9 voltage values and 9 angle values for each bus). In the figure there can be seen four main clusters. The labelling for each cluster can be seen in the legend below.



It can be seen that the green cluster has positive angle values for most of the buses where the other clusters have not. This is because the reactive power flow for the states (points) gathered in this cluster is different from the other clusters. Since the generators do not produce reactive power, it has to be produced by the lines. Therefore, disconnection of a line for maintenance is the state associated to the green cluster.

Low load rate has as consequence the increase of the bus voltages, therefore, cluster with the blue colour is the one associated to that state since the voltage of all the buses is always higher in that cluster.

Concerning the two remaining states, they have similar consequences regarding the voltage levels (both states tend to drop the voltage down), hence, voltage will not be a good indicator to label the two remaining clusters. The good indicator here will be the power flow. High load rate implies higher power flows than the case in where a generator is shut down. The power flow over one line can approximately be calculated as follows.

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

Where E and V are the absolute voltage values of each terminal of the line, X is the line impedance and δ is the angular difference between the two so-mentioned voltages. Assuming the lines to have similar impedance, an estimation of the power flow for each line can be done considering the voltage values of the centroids. The calculations show that for almost every line the power flow through the lines in the yellow cluster is higher than in cluster with the red colour, therefore, high load rate corresponds to the yellow cluster and shut down of generator corresponds to cluster the cluster with red colour.