# Computer Applications in Electric Power Systems- Assignment 2

By

Pratik Sonthalia, Radhakrishnan Natarajan

Labeling of the operational states of the system:

1. High Load Rate during peak hours
2. Shut down for maintenance
3. Low load rate during night
4. Disconnection of a line for maintenance.

Upon forming the clusters, following information was about the clusters:

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Cluster Type** | **Clusters:** | **Sub1** | **Sub2** | **Sub3** | **Sub4** | **Sub5** | **Sub6** | **Sub7** | **Sub8** | **Sub9** |
| Generator on maintenance | Voltage | 1 | 1 | 1 | 0.8967 | 0.8521 | 0.9547 | 0.9042 | 0.9385 | 0.8112 |
| Angle | 0 | -20.5763 | -24.8788 | -15.1606 | -27.3207 | -27.8696 | -32.6833 | -26.8079 | -29.8026 |
| Night-time lower load | Voltage | 1 | 1 | 1 | 0.9906 | 0.9943 | 1.0144 | 1.0112 | 1.01 | 0.9829 |
| Angle | 0 | 24.6314 | 19.3979 | 4.2256 | 7.492 | 16.5832 | 17.0778 | 18.8426 | 7.7082 |
| Day-time higher load | Voltage | 1 | 1 | 1 | 0.986 | 0.9751 | 0.9996 | 0.9803 | 0.9909 | 0.9579 |
| Angle | 0 | -17.4337 | -10.3298 | -7.9622 | -12.9478 | -13.1861 | -18.0618 | -17.4337 | -15.3871 |
| Line on maintenance | Voltage | 1 | 1 | 1 | 1.0045 | 0.9867 | 0.9963 | 0.9606 | 0.9599 | 0.8103 |
| Angle | 0 | -2.6246 | -2.8446 | -2.6235 | -6.7855 | -5.7104 | -9.9391 | -8.7167 | -23.197 |

**Clarity About night-time lower load-** Night-time lower load can be easily determines by expecting the voltages at the buses to be higher than the 1 pu since the power generated will be higher than the power consumed. It is observed in the second case where the voltages at the substations 6, 7 and 8 are observed to be higher than 1. The average voltage of the system is also higher than 1 pu and can be confidently classified as Night-time lower load.

**Confusion about day-time higher load, line on maintenance and generator on maintenance-** Day-time higher load, line on maintenance and generator on maintenance will result in lower voltages at certain buses but the location can be arbitrary based on the load location, location of the line or the generator that is being put out of service for maintenance.

It should be noted that during higher loads, the voltages at the load buses will be low. A lower voltage will be across the system. However, the extent of lowering of the voltages cannot be determined.

**Interesting observation about angles-** Putting a line on maintenance can put a substation completely isolated from the system, thus, virtually zero voltage at that particular substation. A higher load shall not make a substation voltage to be zero. All the above information is not sufficient to derive anything from the obtained cluster since the fall in the voltage due to any of the above operation cannot be estimated with certainty. However, an interesting observation it was found for one of the cluster that voltage angles of Bus 2 and Bus 8 are same in the third case. It would mean very low power is flowing in the line since real power flowing between two buses is primarily dependent on the angle difference between the buses. Same was observed for all the instants belonging to the cluster. It can be safe to observe that generator at bus 2 was on maintenance on these cases. The average voltage is slightly lower than 1 pu in this cluster.

**Clarity about day-time higher load-** From the two cases of high load and line on maintenance, it cannot with certainty be said that keeping a line for maintenance will lead to lowering of voltage or even congestion of lines. However, in the case of high load it can be said, there will be lowering of voltages. Hence, the cluster with the lowest average voltage has been labeled as High-Load during day-time.

**Alternate justification and reason for rejection-** Another line of reasoning can be that during peak load or light load, the system is operating within is capacity and the average voltage hovers around 1 pu; slightly higher than 1 pu for light load and less than 1 pu for heavy load. However, during line congestion or generator on maintenance, due to system constraints, the voltage may drop at certain voltage more so in cases of generator out on maintenance. Hence, the order will be different in this case. However, in such interconnected system, the effect of maintenance cannot be said with certainty. The observation of same angle at Bus 2 and Bus 8 holds more importance and should be given preference.

**Logic for labeling in the code -** The labeling cannot be generalized, particularly, considering the assumption that all the observation belong to a particular generator/ line being taken out for service. However, the classification in the code has been done on the basis of average voltage in congruence with the observations above.