EE 5200: Journal Paper Analysis

Analysis of Voltage Sag on Transmission System under Fault Conditions

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BASE PAPER: Factor Affecting Characteristics of Voltage sag due to Fault in the Power System

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LINK: http://www.journal.ftn.kg.ac.rs/Vol_5-1/16-Patne-Thakre.pdf

BACKGROUND

The authors start the journal paper with introduction about faults in the power system which is the most common reason for occurrence of power quality problems. Out of many different power quality problems such as transients, voltage fluctuations, harmonics, inter-harmonics, voltage imbalance, voltage distortion, DC offset, noise and notches, voltage sag is the most important power quality problem. They have defined with is voltage sag according to the IEEE standard 1159-1995. Voltage sag is characterized by magnitude of voltage, three phase balance, duration of sag and phase-angle jump.

Voltage divider model is used by the authors to determine the voltage sag. A three 150 kV transmission lines which is relatively around 800 kms in length is considered in order to study the effects of factors affecting the sag characteristics. The simulation is carried out using PSCAD/EMTDC software package with fault position method. Using this method results for different types of faults as well as effects of magnitude of sag due to change in X/R ratio of transmission lines, type of transmission as single or double circuit transmission and point of wave of initiation are explained by the authors.

DETERMINATION OF VOLTAGE SAG

The authors have performed fault analysis on a radial system using voltage divider model in order to determine the voltage sag which is shown in Fig. 1.The voltage sag characteristics at any node can be simulated using information of all impedances such as positive, negative and zero sequence resistances and reactance's of the power components and fault impedances. Z_s which is the sum of the R_s + j X_s is the source impedance at the point of common coupling (PCC). The voltage at the sensitive load terminal is given by

$$\bar{V}_{sag} = \bar{E}\,\frac{\bar{Z}_f}{\bar{Z}_f + \bar{Z}_s} \qquad (1)$$

Assume that the prefault voltage is 1 pu., therefore E = 1. So, equation (1) becomes,

$$\bar{V}_{sag} = \frac{\bar{Z}_f}{\bar{Z}_f + \bar{Z}_s} \quad (2)$$

Feeder Impedance Z_f consists of fault impedance.

Consider $Z_f = zl$, where z is the impedance of the feeder per unit length and l is the distance between the PCC and the fault. Calculation of sag as a function of the distance can be performed using equation (2).

$$\bar{V}_{sag} = \frac{\bar{z}\bar{l}}{\bar{z}\bar{l} + \bar{Z}_s} \quad (3)$$

In equation (3) V_{sag}, Z_f, Z_s and zl are complex quantities.

From equation (3), magnitude of the voltage at the PCC terminal will be

$$|V_{sag}| = \frac{|zl|}{|zl| + |Z_s|} \quad (4)$$

Phase – angle jump with voltage sag at PCC is given by

$$\Delta\emptyset = arctan\frac{X_f}{R_f} - arctan\frac{X_s + X_f}{R_s + R_f} \quad (5)$$

where $Z_f = X_f + j\,R_f$ and $Z_s = R_s + j\,X_s$

If the X/R ratio of the source and the feeder are different then the phase-angle jump will be present.

SYSTEM UNDER STUDY

In order to investigate the performance of the method of fault positions for voltage sag assessment in a large transmission system, a model in Fig. 1 is used. The transmission network having a geographical extension of around 760 kms is connected to six critical industrial customers through a solidly ground delta wye transformer. The transmission network consists of three 150kV lines and distribution network is considered at 20kV. The fact that a severe sag occurs if the fault location is at 100 kms away from the industrial customers.

In the simulation studies the required values of positive, negative and zero sequence impedances for each line is shown in Table I. The fault is created on the line 7-8 and the voltage is measured at the node 1 where the sensitive load is assumed to be connected.

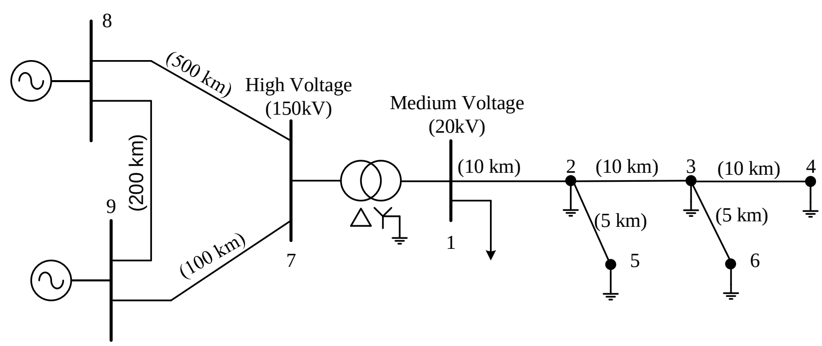

Fig. 1 System Under Study

The system is simulated for both balanced and unbalanced faults and the simulation results are obtained for 3 phases to ground fault (ABC-G) and the unsymmetrical faults like A-G, B-C, BC-G. Also, the authors have performed critical analysis on location of fault, X/R ratio of the lines, point of initiation and single/double circuit transmission.

CRITICAL ANALYSIS

1. Analysis of the unbalanced voltage sag needs to be provided.
2. The detail mathematical analysis of unbalanced in terms of sequence components, sequence voltage and current needs to be provided.
3. Phase angle jump analysis and the impact of various power system parameters should be emphasized.
4. The effect of source strength and at different locations the fault behind the transformer on voltage sag should explained and demonstrated through simulation studies.
5. The different types of voltage sag need to be discussed and elaborate in terms of classification parameters, mathematical analysis and in terms of results.
6. Analysis of voltage sag in source impedance and feeder impedance with respect to short circuit capacity is not provided in the paper.
7. Authors should provide the other points namely point on wave of sag recovery, missing voltage and effect of voltage sag on various related power quality issues.

CONCLUSION

The authors have provided analysis of system characteristics of sag in the system with the type of the fault and location of the fault. Also, the sag characteristics depends on circuit configuration, X/R ratio of lines, point of wave of sag initiation and single or double circuit transmission.

PROPOSED CONCEPT

Simulation of different types of voltage sag can be performed along with analysis of current of each phase during symmetrical and unsymmetrical faults. Also, the simulation can be remodeled by considering the transformer connections and analysis of fault at different locations behind the transformer.