EXPERIMENT P9: UNSYMMETRICAL FAULT (OPEN-ENDED)

Related course: KIE4004 (Power System)

OBJECTIVES:
1. To model a 10-bus power system network using PowerWorld Simulator software
2. To analyse the power system under unsymmetrical fault conditions

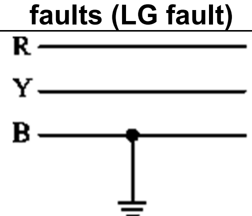
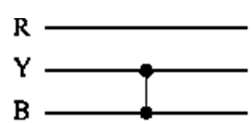
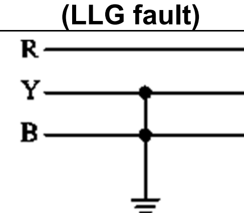
EQUIPMENT:
PC with PowerWorld software

INSTRUCTIONS:
1. Save all your results in a pendrive
2. Follow the demonstrator's instructions throughout the experiment

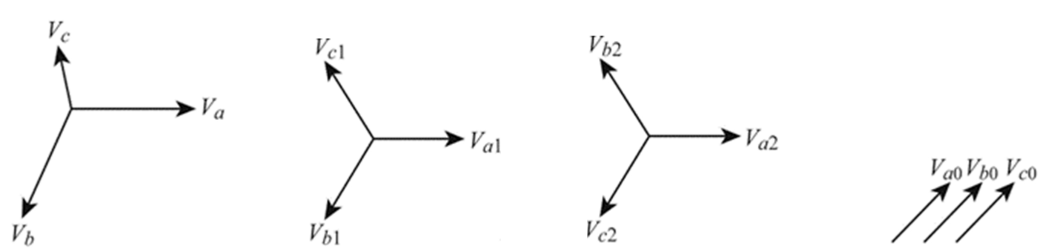
REFERENCE(S):
Refer to the main references of KIE4004

INTRODUCTION:

Unsymmetrical faults are faults that cause unequal current with unequal phase shift in a three-phase system. They occur due to open or short circuit in a power system by natural disturbances or manual errors. Natural disturbances are heavy wind, ice on the lines, tree branches falling on lines, lightning strokes and natural disasters. These faults are classified as:

Single-line-to-ground faults (LG fault)	**Double-line fault (LL fault)**	**Double-line-to-ground fault (LLG fault)**
		
• Occur when any one line is in contact with the ground • Most frequently occurring fault (60 to 75%)	• Occur when two lines are short-circuited. • Fault occurrence of 5 to 15%	• Occurs when two lines are short-circuited and is in contact with the ground. • Fault occurrence of 15 to 25%

Symmetrical components are derived from an unsymmetrical network to analyze unsymmetrical faults. The unsymmetrical network can be expressed in terms of three linear symmetrical components: positive, negative and zero sequence components.



Unsymmetrical network | Positive sequence network | Negative sequence network | Zero sequence network

Where: V_{a0}, V_{b0}, V_{c0} = zero sequence component of 3 phases
V_{a1}, V_{b1}, V_{c1} = positive sequence component of 3 phases
V_{a2}, V_{b2}, V_{c2} = negative sequence component of 3 phases

Unsymmetrical three-phase voltages (V_a, V_b, V_c):

$$\begin{bmatrix} V_a \\ V_b \\ V_c \end{bmatrix} = \begin{bmatrix} V_{a0} \\ V_{b0} \\ V_{c0} \end{bmatrix} + \begin{bmatrix} V_{a1} \\ V_{b1} \\ V_{c1} \end{bmatrix} + \begin{bmatrix} V_{a2} \\ V_{b2} \\ V_{c2} \end{bmatrix} = \begin{bmatrix} 1 & 1 & 1 \\ 1 & a^2 & a \\ 1 & a & a^2 \end{bmatrix} \begin{bmatrix} V_0 \\ V_1 \\ V_2 \end{bmatrix}$$

Symmetrical component voltages:

$$\begin{bmatrix} V_0 \\ V_1 \\ V_2 \end{bmatrix} = \frac{1}{3} \begin{bmatrix} 1 & 1 & 1 \\ 1 & a & a^2 \\ 1 & a^2 & a \end{bmatrix} \begin{bmatrix} V_a \\ V_b \\ V_c \end{bmatrix}$$

$a = 1\angle 120^o$
V_0 = zero sequence component voltage
V_1 = positive sequence component voltage
V_2 = negative sequence component voltage

PROCEDURES:

A three-phase power system network consisting of 10 buses on the same base power is as shown in Figure 1.

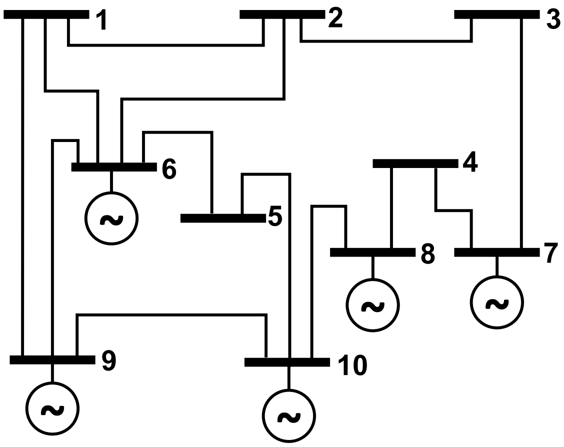


Figure 1

The reactance (in p.u.) of the lines in the network shown in Figure 1 is:

Bus-Bus	$X^1=X^2$	X^0
1-2	0.075	0.25
1-6	0.225	0.52
1-9	0.155	0.32
2-3	0.235	0.51
2-6	0.235	0.51
3-7	0.235	0.50
4-7	0.155	0.30

Bus-Bus	$X^1=X^2$	X^0
4-8	0.235	0.50
5-6	0.155	0.20
5-10	0.225	0.50
6-9	0.035	0.10
8-10	0.150	0.32
9-10	0.310	0.70

All generators have a reactance $X^1=X^2=0.05$ p.u. and $X^0=0.025$ p.u. A load is connected to Bus 1 to 5.

1. Using PowerWorld software, construct the 10-bus power system as shown in Figure 1 using the data given in the Table. Set Bus 10 as the ‘slack bus’ (reference bus). Use ‘MVA Base’ as 100 MVA and nominal voltage at every bus as 132 kV. Set all load at the buses to 100 MW each. Set the maximum limit of every generator and lines to 10000 MW and 10000 MVAR. Simulate the system.
2. When a bolted fault occurs at bus 2, simulate the system and find the fault current, voltage at every bus and current in every line for each of the following faults:
   a) single-line-to-ground fault
   b) line-to-line fault
   c) double-line-to-ground fault

   Note: When simulating the fault, change the power of all loads and generators to 0.
3. Manually (hand or type-written), calculate the fault current for every case in step 2. Use bus admittance matrix method.
4. Compare the simulation results in step 2 with the manual calculation in step 3. If there is any difference between both of them, identify the source of the difference.

OPEN-ENDED TASKS (do these tasks during the lab session):

One technique for limiting fault current is to place a reactance in series with generators. Such reactance can be modelled in PowerWorld by increasing the generator’s positive sequence internal impedance. Continued from the same system, at which generator that a reactance should be placed in series so that the single-line-to-ground fault current of the whole system is limited to 40% of the value obtained in step 2a? What is the value of that series reactance?

END OF EXPERIMENT