STUDY OF SYMMETRICAL COMPONENTS AND NETWORKS USING MATLAB SIMULINK

Objective: Model a sequence network for the Single Line to Ground Fault in a given power system network and determine the waveforms of voltage and current.

Software used: MATLAB SIMULINK (Ver: 4.1)

Problem

Create a simulink model for the given power system under fault and determine current and voltage waveform. Model the same network using symmetrical components to reflect the type and location of the fault.

Data:

<table>
<thead>
<tr>
<th>Generator</th>
<th>Transmission line</th>
<th>Load</th>
</tr>
</thead>
<tbody>
<tr>
<td>3-ph Generator, 11kV, 50Hz</td>
<td>3-ph Transmission line</td>
<td>Impedance of load in ohms</td>
</tr>
<tr>
<td>Impedance of source in ohms</td>
<td>Length: 10km</td>
<td>Positive sequence: 3+j0.25</td>
</tr>
<tr>
<td>Positive sequence: 1+j0.25</td>
<td>Impedance of line in ohms</td>
<td>Zero sequence: 6+j0.754</td>
</tr>
<tr>
<td>Zero sequence: .001+j0.05</td>
<td>Positive sequence: 1+j0.1</td>
<td></td>
</tr>
<tr>
<td>Impedance of load in ohms</td>
<td>Zero sequence: 1+j0.30</td>
<td></td>
</tr>
</tbody>
</table>

Fig (1)

Matlab Simulink Diagram using “simPowersystem” toolbox
Procedure (1)

Simulation of Single Phase to Ground Fault using Matlab Simulink

1. Open Simulink library browser from Matlab
2. From simulink library browser, create a new model from the file menu.
3. Select the “simPowersystems” toolbox from simulink library browser
4. Place Three phase inductive source (generator), distributed parameter line, 3-ph RLC series branch and 3-phase fault in the workspace
5. Interconnect the Components to form the network as given in the fig (1)
6. Choose ground input and ground output appropriately.
7. Select “three-phase inductive source (generator)” and specify the parameters
   Source voltage: 11kV, Frequency : 50Hz,
   Source Impedance
   Positive sequence : 1.0 + j 0.25,
   Zero sequence : 0.001+j 0.05.
   *Convert reactance to Inductance
8. Select “Distributed parameters line” as transmission line and specify the parameters
   Length : 10km
   Impedance of line
   *Positive sequence : 1+j0.1
   Zero sequence : 1+j0.30
   * Convert impedance to Inductance/kilometer and resistance/ kilometer
   Apply a very minimal value for capacitance may be given, so that it can be neglected (approximately 0.00001)
9. Select “Series RLC Branch” as load and specify the parameters
   Positive sequence: 3+j0.25
   *Convert reactance to Inductance
10. Select “Three phase fault” block to form SLG fault and specify the parameters
    Select phase A to ground fault
    Fault time : 1 second.
    Fault resistance : 0.01ohms
    Ground resistance: 0.01ohms
    The fault transition time shall be 1s and 5s.
11. Measurements blocks are connected suitably to show the current and voltage waveforms
12. Setup the simulation time as 4seconds and obtain the waveforms of the fault current and the phase to ground voltages.
Procedure (2)

Modeling and simulating the sequence network

1. Form positive, negative and zero sequence networks separately with the given values of the positive, negative and zero sequence impedances of different components.
   *Neglect the capacitance values for the distributed parameter line, as it is very small
   * Network reduction should not be done
2. Place simple “series RLC branch” from Simulink library to form the sequence network
3. Interconnect the positive, negative and zero sequence networks at the fault point
   *Between transmission line and load
4. Use formula \( V_a = v_a0 + v_a1 + v_a2 \) and obtain fault voltage at phase A (=\( V_a \))
   (\( v_a0 \)-zero sequence voltage,\( v_a1 \)-positive sequence voltage,\( v_a2 \)-negative sequence voltage, at the fault point )
5. Obtain zero, positive and negative sequence voltages at fault point using voltage measurement block and name them \( v_a0 \), \( v_a1 \) and \( v_a2 \) accordingly.
6. Place “Sum” block from the Math library, connect the voltage signals \( v_a0 \), \( v_a1 \), \( v_a2 \) and place a “scope” to get the output waveform
7. To obtain phase voltage at B and C at fault, use appropriate formulae.
8. To apply phase shifts for the voltage signal, use “Transport delay” block from the Simulink library
   Calculate Delay time for 120° at 50Hz as \( \text{Delay time} = 20e-3 \times \frac{120}{360} \)
9. Fault current (Ia) will be thrice the sequence current (\( i_a0 = i_a1 = i_a2 \), for a single phase to ground fault); therefore, a gain of 3 should be used to obtain the actual current from sequence current (for a single phase to ground fault).
10. Obtain phase voltage at Phase A, B and C from the sequence network formed.
    Compare the results obtained from that of the three-phase system simulated using “simPowersystem”. Give your comments.
Questions: part A

1. Why sequence networks are needed to represent unsymmetrical faults? Compare symmetrical and unsymmetrical faults
2. Draw the sequence representation of generators, transmission lines, and transformers (for all types of winding connections)
3. Draw the interconnection of sequence networks for an LG, LL fault, and LLG fault.
4. Write down the expression for phase voltages in terms of sequence voltages.
5. What are distributed parameters and lumped parameters? When these are used in analysis?

Questions: Part B

1. What are the major components of power system tool box?
2. What is Powergui? Explain.
3. Discuss the major features and capabilities of the software used for the simulation. Can we use any other packages for the same experiment?
4. Develop a programme (codes) by yourself for the problem with a suitable front end