Assignment 1: Short-Circuit Fault Current Calculations

The three-phase power transmission circuit represented by its one-line diagram in Fig. 1, undergoes different kinds of short-circuit faults at the receiving end of the transmission line, where a resistive load of 500 Ohms connects. The load is fed from an equivalent synchronous generator through a transmission line and transformer, with the equivalent generator assumed to behave like a voltage source (constant voltage and frequency). The three-phase transformer is delta-star connected with its star point solidly grounded. The positive, negative and zero sequence impedances of the transmission line require calculation – the transmission line configuration and basic data are given in Fig. 2 and in table I.

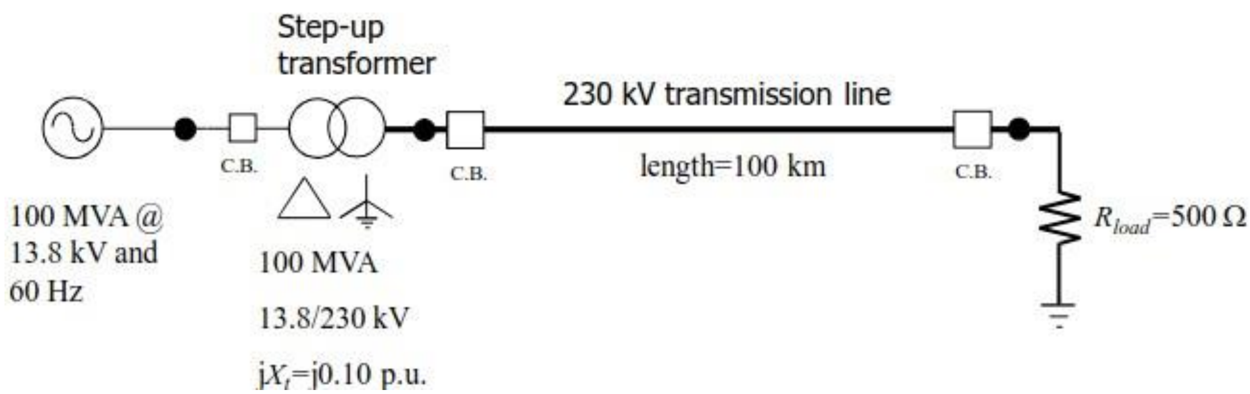

Fig. 1. The studied transmission circuit

The assignment has two main aspects to it:

1. To carry out the short-circuit fault currents calculations when various kinds of faults take place at the receiving end of the transmission line. The following types of faults are considered: i) three-phase-to-ground; ii) one-phase-to-ground; iii) two-phase; iv) two-phase-to-ground

2. For the same short-circuit fault conditions as in point 1 above, carry out time-domain simulations using the PSCAD computer package. These two points are elaborated further in the next viewgraph

a. Get acquainted with the use and basic functions of PSCAD. The tutorial session carried out by Nida Riaz would have given you a strong head-start on the use of PSCAD but in case you missed the tutorial, you may find the following link of some assistance: http://www.youtube.com/watch?v=tUKCos3wdpY, describing how to create a simple circuit.

b. Once you feel that you have got a hand on the use of its basic functionality, open the Tutorial Session. This is done by clicking in PSCAD button (most upper left-hand-side corner of the screen) and selecting load, examples, tutorial and simpleac. Notice that the one-line diagram of the circuit corresponds (almost) to the one-line diagram in Fig. 1.

c. Double click in each one of the components and get acquainted with all the data options of each one of them and make careful notes. Change the type of voltage source to be inductive as opposed to the initial type R-R/L (These are found from the configuration sheet, which you can access by double clicking the voltage source component). Now, change the "Impedance Data Format" to "RRL values". After this, proceed to the "Positive Sequence Rrl" sheet of the voltage source and set the value of the "Inductance" parameter in [H] so that the reactance of the voltage source corresponds to 0.5 Ohms (i.e. calculate the value of the inductance). Have a good look at the data fields of the C.B. Timed Breaker Logic and the Timed Fault Logic control boxes. A double click on the fault impedance icon allows you to go into Configuration where you can change among other things: fault resistance and fault type. Disconnect the resistive load of 500 Ohms. You may leave the fault resistance ON at 0.01 Ohms but change all three phases: A, B and C, to be on fault. This ensures that the setting corresponds to a three-phase-to-ground short-circuit fault.

d. Notice that the C.B. has been set to open the faulted phase(s) 10 ms after the occurrence of the fault (at 60 Hz, one full cycle of the current takes 16.67 ms). So, the C.B. opens just after half a cycle. You may change that in your simulation for the purpose of appreciating fully the amplitude of the fault currents. Once you are happy with your changes, run the simulation and take a note of the maximum amplitudes of the three-phase-short-circuit fault currents.

e. Carry out simulations for the other three types of classical short-circuit faults, namely, one-phaseto-ground, two-phase and two-phase-to-ground.

f. Using the transmission line impedance matrix calculated by PSCAD (table I), given in [mΩ/meter], calculate the transmission line's positive, negative and zero sequence impedances in Ohms. Assume that the transmission line is fully transposed.

g. Select a suitable base voltage and base power to express the transmission line sequence parameters and the resistive load in the power transmission circuit in Fig.1, on a per-unit basis.

h. Carry out a power flow solution for the power transmission circuit in Fig. 1 (using the power flow computer program provided).

i. Determine the short-circuit fault currents in phase quantities in kA. Carry out these calculations for the four types of short-circuit faults listed above, for the case when they occur, at different times, at the receiving end of the transmission line. In all these calculations, assume that the fault impedance (Zf) takes a resistive value of 0.01 Ohms. Do not forget to include the impedance of the equivalent voltage source in your calculations (0.5 Ohms) but neglect the impedance of the load (500 Ohms).

j. Determine 10% fixed series compensation for the transmission line as shown in the figure 2. The percentage series compensation means the percentage reactance compensated by the series capacitor bank from the total line reactance.

What To Report:

a. Report on the assumptions made on the calculation of the sequence impedances expressed in ohms and in per-unit.
b. Report on the main stages of your power flow solution and provide the nodal voltages as furnished by a convergent power flow solution using a power mismatch tolerance of at least 10^{-6}.
c. Report on your short-circuit fault current calculations, using as much detail as possible. This would cover calculations for all four kinds of faults addressed in this assignment. Final fault current values will be reported in kA and in phase values (A,B,C).
d. For each type of fault simulated with PSCAD, report on its maximum value and contrast this with the corresponding value obtained in c). Elaborate on the main reasons for any possible discrepancy. Notice that PSCAD provides results in waveform and instantaneous values whereas your calculations are carried out using RMS phasors.

The transmission line configuration and basic data for the 230 kV transmission line is given below: Each phase (a,b,c) is made up of two identical conductors (bundled) of the type Chukar and separated by a distance of 45.72 cm. The transmission line has two over-head ground wires of ordinary steel ½ inch in diameter. They are placed in the tower on top of the phase conductors, as illustrated in Fig. 2. The transmission line is 100 km long and operating at 60 Hz. The ground under the conductors is assumed to have constant conductivity of 0.01 S/m throughout the entire length of the line.

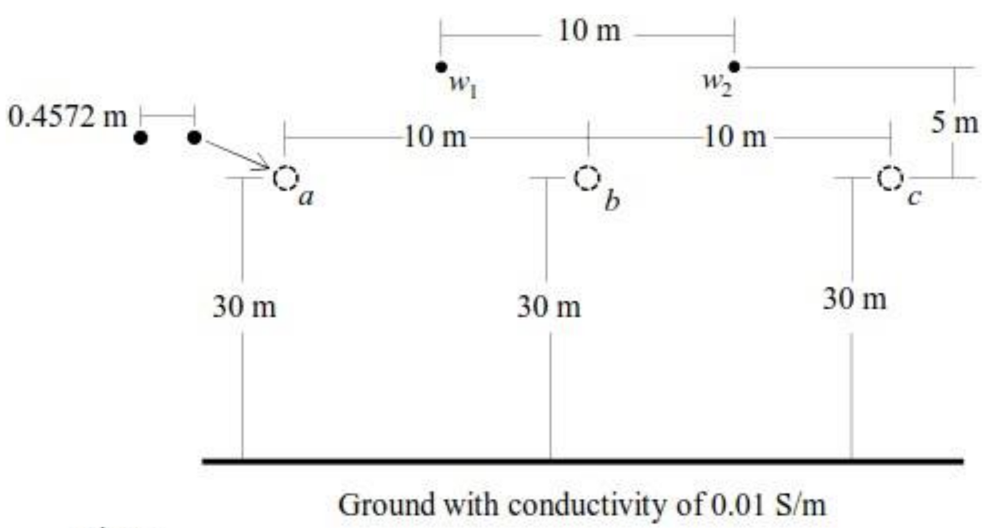

Fig. 2