ASSIGNMENT No. 2
Due Date: 7 February 2020

Transient Recovery Voltage (TRV) in Circuit Breakers using a Lumped-Circuit Line Model

The case below is typical of a short circuit in a transmission line at some distance from the source.

We want to study the voltage across the circuit breaker contacts after interrupting a short-circuit (Transient Recovery Voltage TRV). The circuit breaker is connecting two subcircuits with different natural frequencies of oscillation. The system is represented using the equivalent circuit below. On the left hand side of the breaker, we have the source voltage and a resistance and inductance that represent the impedance of the system supplying the transformer plus the impedance of the transformer. The capacitor at node two on the left of the breaker represents the combined substation capacitance due to the substation busbars. On the right of the breaker we have the transmission line parameters: total resistance, inductance and capacitance represented as simple lumped parameters.

In this assignment you will write your own computer program using nodal analysis to solve the system and will compare the results of your program with those obtained using MicroTran.
1. Assume the system is operating with zero initial conditions and that switch \( S_1 \) is initially closed.

2. The short circuit occurs at \( t = 0 \).

3. Suppose switch \( S_1 \) is instructed to open 4 cycles (66.67 ms) after the fault occurs. However, because the breaker cannot chop current, it will not actually open until the current passes through zero.

4. The simulation will span from \( t = 0 \) to \( t = 200 \) ms.

5. Choose an appropriate \( \Delta t \) according to the time constants of the circuit. For this purpose, evaluate the approximate resonant frequencies (you can neglect the resistances) of the circuits on the left and right side of the breaker before opening the switch and of the combined circuit after closing the switch.

Plot the following graphs. Magnify the region around some ms before opening the breaker and the transients created by this operation.

1. Plot \( v(one) \), \( v(two) \), \( v(three) \) on the same graph for your program and for MicroTran.

2. Plot \( i(four, ground) \) on the same graph for your program and for MicroTran.

3. Plot \( v(two, three) \) on the same graph for your program and for MicroTran.

4. Analyze the results and make relevant comments.