1 Problem Statement

1. The problem is that MNC_OEM [EMS Product Provider to the concerned utility] do not want to create fictitious bus and fictitious line as needed for simulation of single pole open/close event in transient stability in PowerApps.

2. PowerApps validation is done with respect to the reference "Power System Stability And Control", by Prabha Kundur. Relevant portion of Kundur text book is reproduced in the following

Example 13.5

The system shown in Figure E13.11 (Example 13.4) is subjected to a single line-to-ground fault at point F on circuit 2. The fault is cleared by single-phase switching which disconnects the faulted conductor at both ends simultaneously. Show how the network may be represented in stability studies during the period when one conductor of circuit 2 is switched out.

--- Continued in Page 2….

Solution

This situation differs slightly from that depicted in Figure 13.26. As shown in Figure E13.19, the impedances of conductors of phases b and c need to be accounted for. This is achieved by including the impedances associated with circuit 2 in the sequence networks.

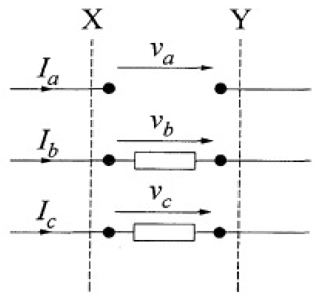


Figure E13.19

Figure E13.20 shows the sequence networks of the system of Figure E13.11 and their interconnection to represent the condition with one phase of circuit 2 open at both ends.

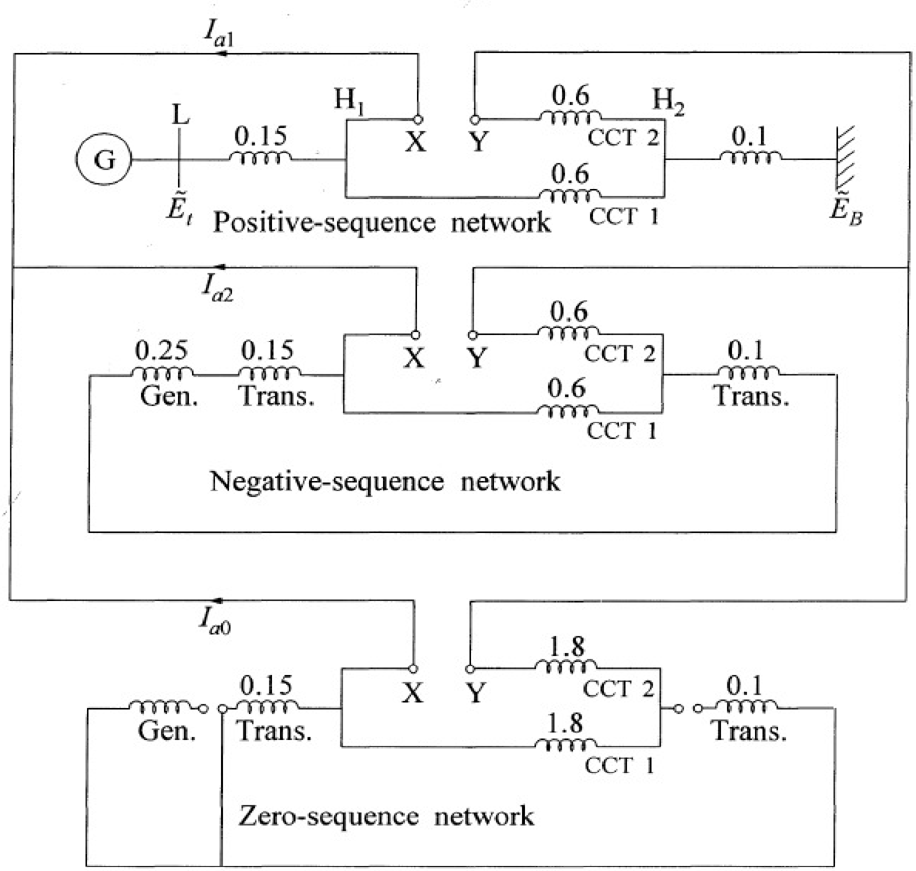
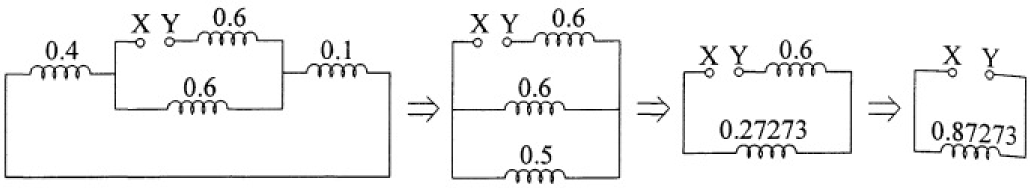
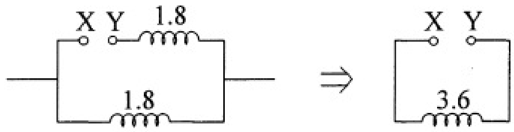


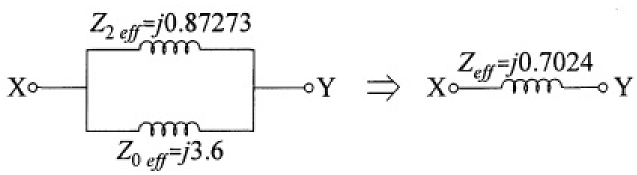
Figure E13.20



(a) Reduction of negative-sequence network



(b) Reduction of zero-sequence network



(c) Total effective series impedance

Figure E13.21 Reduction of negative- and zero-sequence networks

As shown in Figure E13.21, the effective negative- and zero-sequence impedances as viewed from points X and Y are

$$Z_{2eff} = j0.87273 \quad \text{pu}$$

$$Z_{0eff} = j3.6 \quad \text{pu}$$

and the net effective impedance that has to be inserted between points X and Y of the positive sequence network is

$$Z_{eff} = j0.7024 \quad \text{pu}$$

Thus, from the viewpoint of power transfer between the generator and the infinite bus, the effect of opening one phase of circuit 2 is the same as increasing the reactance of the circuit by 0.7024 pu. ■

2 Solution

2.1 Preliminary Steps

1. Refer figure E13.20 of Kundur Text book.
2. Our input data will have a line data between H1 and H2 and nodes X and Y will be absent in our input data
3. The Node X is same as H1 and need not be created.
4. Before reading the data from mdb file, the first data to be read is from Event data for any SPOPEN event …….. If any SPOPEN event is specified, we need to create internally a fictitious station and a fictitious node with unique name to represent Node Y of figure E13.20. Further we need to create a fictitious line between nodes H1 and Y with very small impedance, so that the quality of solution remains unchanged. Further the "from" and "to" node information of the line impedance between H1 and H2 must be changed internally. Note the database will change accordingly. This is the first step.

2.2 Computation Steps for SPOPEN[single pole open event]

- User will specify the line between H1 and H2 as SPOPEN. However this must be implemented as fictitious line between H1 and fictitious bus Y as open. Refer figure E13.20
- After opening the fictitious line between H1(X)-Y , the effective negative sequence and zero sequence impedance between nodes H1[X]-Y must be computed and inserted in the positive sequence network model. The calculation procedures are implemented in PowerApps , Transient stability in function CheckToAddSPOPENConductorToPositiveSequenceNW()
- THE ORIGINAL BRANCH MODEL BETWEEN H1 AND H2 , WHICH IS NOW CHANGED TO FICTITIOUS BUS Y AND H2 WILL REMAIN UNCHANGED

2.3 PowerApps Simulation Values for the Kundur Example

The fictitious line is represented between H1-X and the actual line between X-H2 in the data file. This now needs to be done internally by PowerApps as MNCOEM will not create this fictitious line and nodes

The output calculations in zppfile.txt file is as follows

Zpp2 =	0.00000	0.25455
Zpq2 =	0.00000	0.03636
Zpp0 =	0.00000	0.15000
Zpq0 =	0.00000	0.15000
Zqq2 =	0.00000	0.69091
Zqp2 =	0.00000	0.03636
Zqq0 =	0.00000	3.75000
Zqp0 =	0.00000	0.15000

zopen2 = 0.00000 0.87273 [Note this matches with Kundur Example negative sequence impedance between X and Y nodes]

zopen0 = 0.00000 3.60000 [Note this matches with Kundur Example 0 sequence impedance between X and Y nodes]

zeff = 0.00000 0.70244 [Note this matches with the effective impedance between X and Y of Kundur Example]

yopn = 0.00000 -1.42361 [This is the admittance to be inserted between nodes X and Y of Y bus]

2.3.1 Y bus model verification in PowerApps simulation

In the example prepared the fictitious line is connected between the nodes H1 and X, thus we need to examine the Y bus formulation of these nodes in sequence domains.

The relevant Y bus elements are reproduced in the following. [1000 corresponds to low resistance fictitious line]

H1		10000.00000	-8.33433	10000.00000	-8.33433	10000.00000	-7.22222	-- diagonal
X		10000.00000	-1.66767	10000.00000	-1.66767	10000.00000	-0.55556	-- diagonal
H1	X	-10000.00000	0.00100	-10000.00000	0.00100	-10000.00000	0.00000	– off – diagonal

At time t=0.0;; The following is matching with the above at the beginning of the TS simulation

H1		10000.00000	-8.33433	10000.00000	-8.33433	10000.00000	-7.22222	
X		10000.00000	-1.66767	10000.00000	-1.66767	10000.00000	-0.55556	
H1	X	-10000.00000	0.00100	-10000.00000	0.00100	-10000.00000	0.00000	Lower Half
H1	X	-10000.00000	0.00100	-10000.00000	0.00100	-10000.00000	0.00000	Upper Half

Line FICT Opened at 0.080000
Diagonals are 0.000000 -8.333333 0.000000 -1.666667 // this is H1 and X imaginary parts as Fict is mainly real part.
Off Diagonal are 0.000000 0.000000 0.000000 0.000000 // this is correct as this represent fict line.
Network Y Bus in Transient Stability t = 0.080000

H1		0.00000	-8.33333	0.00000	-8.33333	0.00000	-7.22222	// verified correct 10000.0 is removed
X		0.00000	-1.66667	0.00000	-1.66667	0.00000	-0.55556	// found correct after line open.
H1	X	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	Lower Half // correct
H1	X	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	Upper Half //correct

NOW EFFECTIVE 0 AND –VE SEQU IMP MUST BE IMPLEMENTED AT THE SAME TIME T = 0.08 SECONDS

zopen2 = 0.00000 0.87273 // MATCHES WITH KUNDUR EXAMPLE
zopen0 = 0.00000 3.60000 // MATCHES WITH KUNDUR EXAMPLE
zeff = 0.00000 0.70244 //MATCHES WITH KUNDUR EXAMPLE

yopn = 0.00000 -1.42361 // INVERSE OF ZEFF....This value is added to +ve seq network only.. in place of original fictitious value.

After Single Open Conductor Impedance is Added to Y bus [Results are OK]

Network Y Bus in Transient Stability t = 0.080000

H1		0.00020	-9.75694	0.00000	-8.33333	0.00000	-7.22222	//diag increases by yopn
X		0.00020	-3.09028	0.00000	-1.66667	0.00000	-0.55556	// diag increases by yopn
H1	X	-0.00020	1.42361	0.00000	0.00000	0.00000	0.00000	Lower Half // off diag by yopn
H1	X	-0.00020	1.42361	0.00000	0.00000	0.00000	0.00000	Upper Half // off diag by yopn

Line FICT Closed at 0.120000 // we should get back original matrix.[RESULTS FOUND OK]
Diagonals are 10000.000203 -9.757944 10000.000203 -3.091278
Removed Open conductor Effective impedance

Network Y Bus in Transient Stability t = 0.120000—should be same as t=0.0…

H1		10000.00000	-8.33433	10000.00000	-8.33433	10000.00000	-7.22222	
X		10000.00000	-1.66767	10000.00000	-1.66767	10000.00000	-0.55556	
H1	X	-10000.00000	0.00100	-10000.00000	0.00100	-10000.00000	0.00000	Lower Half
H1	X	-10000.00000	0.00100	-10000.00000	0.00100	-10000.00000	0.00000	Upper Half

Conclusion: The results from PowerApps simulation matches with the text book example for the case of the single pole open/close condition