

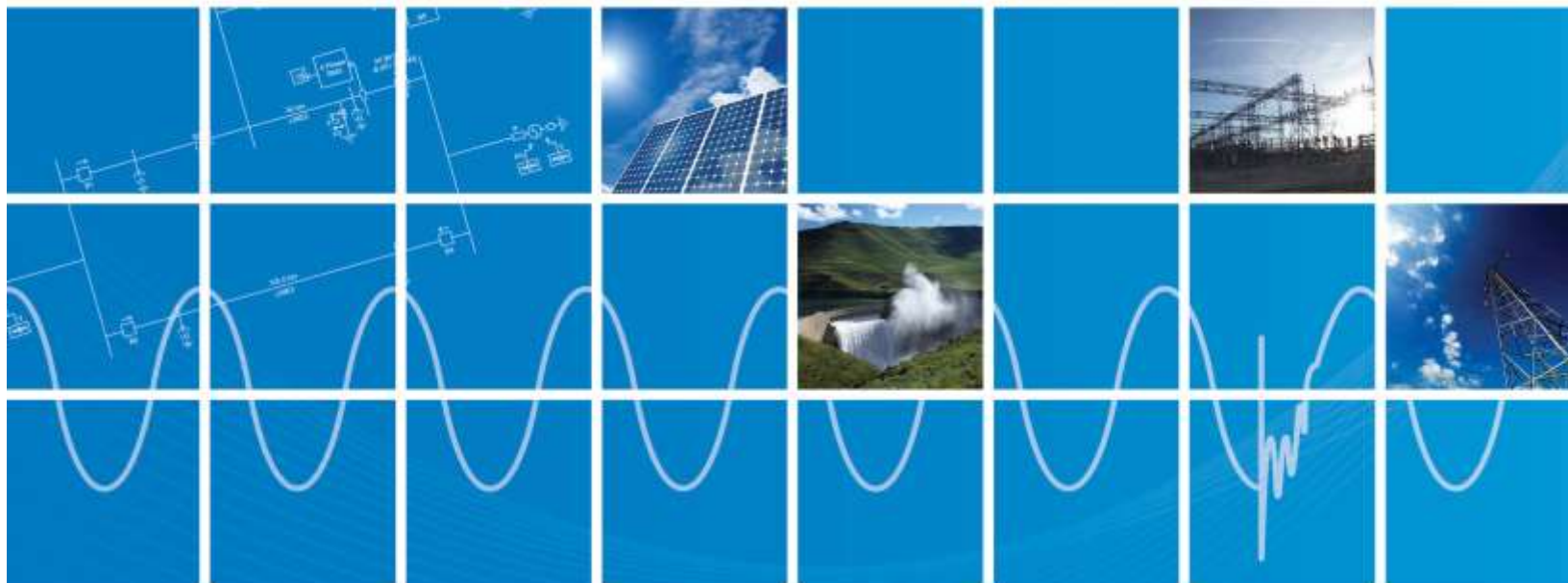


# FDNE Application Example 1

For PSCAD Version 5.0.0

May 6, 2020

Initial



Powered by Manitoba Hydro International Ltd.  
211 Commerce Drive  
Winnipeg, Manitoba  
R3P 1A3 Canada  
mhi.ca





## CONTENTS

1. OVERVIEW .....	2
2. IDENTIFICATION OF STUDY AREA .....	2
3. IMPEDANCE PARAMETERS USING THE HARMONIC IMPEDANCE SOLUTION COMPONENT. 2	
4. FDNE TO REPRESENT EXTERNAL AREA .....	3
5. CHECK LOG FILES.....	3
6. COMPENSATE FOR POWER SOURCES .....	4



## 1. OVERVIEW

Usually in electromagnetic transients studies, only a limited part of a large network system is required to be modeled in detail. The computation time saved can be significant by representing the remaining part of the system by a reduced network equivalent. In this example, the Frequency-Dependent Network Equivalent (FDNE) component can be used to model a reduced network equivalent circuit.

## 2. IDENTIFICATION OF STUDY AREA

In the IEEE example project called *Original\_network\_V5.pscx*, the network is divided in to two segments: The study area is the retained area for detailed transient studies, whereas the external area will be later replaced with an FDNE. The boundary buses are *WINNEBAGO3* and *KOSSUTH*.

## 3. IMPEDANCE PARAMETERS USING THE HARMONIC IMPEDANCE SOLUTION COMPONENT

In the example project called *Scan\_network\_V5.pscx*, the impedance of the external area is measured for frequencies ranging from 0 to 2,000 Hz, in 10 Hz increments. The **Impedance Output Type** parameter is set to **Phase Impedances**. In determining the frequency range, the following factors need to be considered:

- a. Frequencies that are of interest to the study
- b. FDNE curve-fitting accuracy

Some complicated networks may contain many resonance points when the impedance is plotted as a function of frequency. An accurate solution for this requires a very high order transfer function when curve-fitting the FDNE, leading to problems such as slow, and possibly unstable simulations. The upper bound of the frequency range can be reduced however, until the curve-fitting results are satisfactory. This is accepted as a valid trial and error approach.

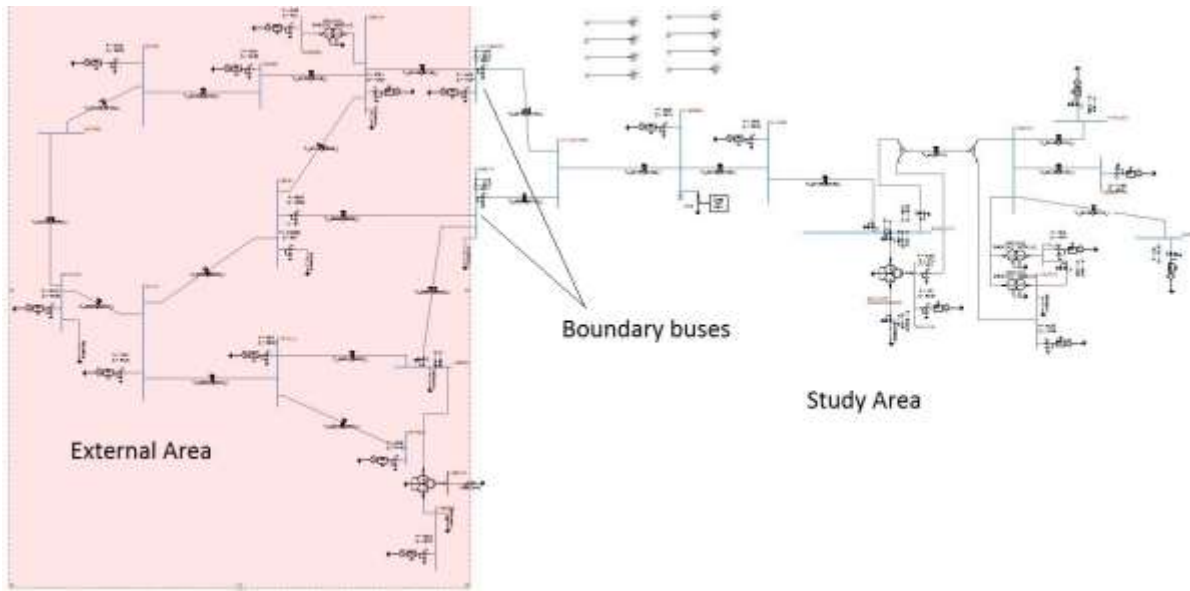


Figure 1: Original Network

## 4. FDNE TO REPRESENT EXTERNAL AREA

In the example project called *FDNE\_network\_V5.pscx*, the external area is replaced with an FDNE. The **Data Format** parameter is set to **From Harmonic Impedance Component**. The total number of ports is 6 (the dimension of the external network is 6, as seen from boundary buses *WINNEBAGO3* and *KOSSUTH*).

## 5. CHECK LOG FILES

The **Detailed log file** parameter is set to **Create**. Run the simulation and go to the PSCAD project temporary directory. Open the FDNE log (*FDNE\*.log*) file: This file contains information on any errors and also the curve-fitting results.

Maximum Fitting Error Requested:	0.1000 %
Maximum Number of Poles:	30
<b>Maximum Fitting Error:</b>	<b>0.0923%</b>
<b>Number of Poles:</b>	<b>21</b>

The order of the transfer function is 21 and the fitting error is less than 0.1% (0.0923%). You can also plot the actual and fitted frequency dependent admittance and see if the results are satisfactory (see output files *FDNE\*\_Y\_MAG.out* and *FDNE\*\_Y\_ANG.out*)



## 6. COMPENSATE FOR POWER SOURCES

The FDNE by default represents only the passive equivalent network of the external area. To maintain the correct power flow, the effect of active power sources in the external area is approximated by defining the terminal conditions at the boundary buses. In the example project *Original\_network\_V5.pscx*, a multi-meter is inserted (note the direction is away from external area) to measure P, Q, V and angle. At steady-state, the terminal values (per phase) can be measured as:

For boundary bus WINNEBAGO3 (nodes 1 to 3):

Active Power, P = -132.5/3  
Reactive Power, Q = -39.21/3  
Voltage, V = 356.3/sqrt(3)  
Angle of Voltage, A = -37.77 deg

For boundary bus KOSSUTH (nodes 4 to 6):

Active Power, P = -117.5/3  
Reactive Power, Q = -23.47/3  
Voltage, V = 357.4/sqrt(3)  
Angle of Voltage, A = -36.47 deg

Hence the power injection data file is (*PQVD\_60.txt*):

```
! Voltage, angle P and Q at terminals of FDNE
6 ! 6 ports/nodes
1 ! only one frequency
0.1 ! ramp time in seconds for current injections
60.0 ! frequency
205.7099 -37.7700 -44.1667 -13.0667 ! V, angle, P,Q respectively for node 1
205.7099 -157.7700 -44.1667 -13.0667 ! V, angle, P,Q respectively for node 2
205.7099 82.2300 -44.1667 -13.0667
206.1776 -36.4700 39.2000 -7.8233
206.1776 -156.4700 39.2000 -7.8233
206.1776 83.5300 39.2000 -7.8233
```



DOCUMENT TRACKING

Rev.	Description	Date
0	Initial	6/May/2020