INTELLIGENT ELECTRICAL POWER GRIDS

MODELLING OF WIND FARMS IN MODELICA

1. OBJECTIVES AND PREPARATION

This tutorial delves deeper into power system modelling using OpenModelica. This tutorial builds on the last tutorial where we had a functional IEEE 9 bus system with controllers. This tutorial adds time varying renewable energy source (wind farm) to the existing network. The objective of this assignment is to explore more functionalities of OpenModelica to assist in power system modelling.

2. WIND POWER PARKS MODELING

Wind power parks are relatively easy to integrate into power systems in OpenModelica. Make a copy of the network file from last week. We will make additions to this new file now. The complete model will have the topology as shown in Figure 1.

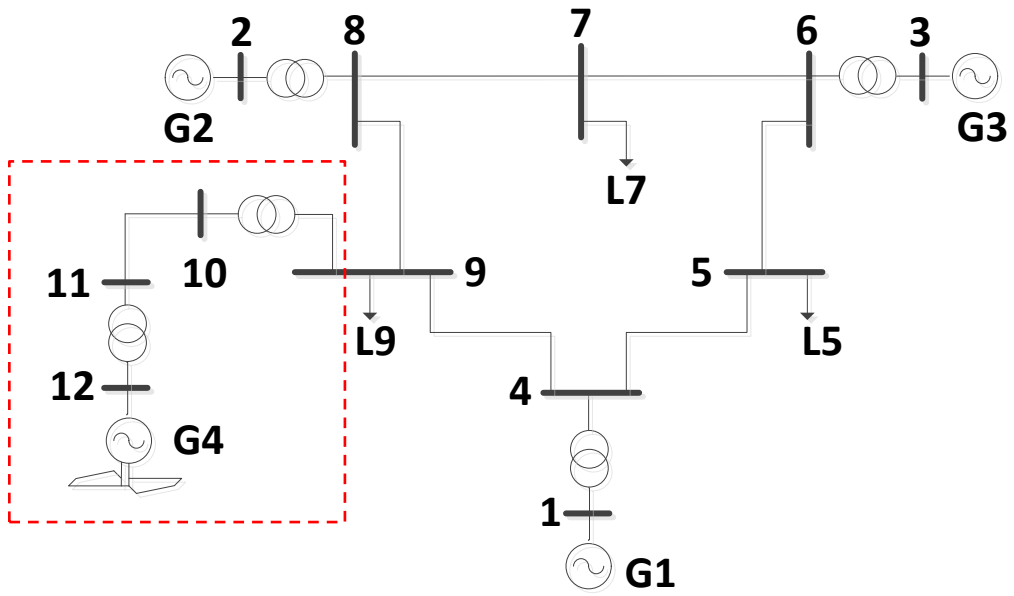

Figure 1: IEEE 9 bus with wind park

3. WORKFLOW

Follow the steps below to add the wind plant.

1. Set the load step 'height' to 0 on Load7.
2. Locate the windPlant model in DelMod library from ***DelMod*** → ***Generators*** → ***windPlant***. Drag it to the network model workspace and name it **gen12**.
3. Add the two transformers, and a line as shown and highlighted in Figure 1.

4. Make the new connections as shown in Figure 1.

gen12 has an input for wind speed. This can be either set to constant, random, or given a wind profile. For the particular case, the base wind speed is 19m/s. To check its working, drag a constant block to the network workspace, parameterize it to k=19 and connect it to gen12. This means the wind generator now has a constant wind speed input of 19m/s.

Once the model is created, the user needs to input parameter values for the components inside the model. The parameters for all the components are mentioned in tables 1-5. The power flow data is taken from MATPOWER LOAD FLOW RESULTS and is already filled in for convenience.

Table 1. Updated Transmission line data

Line Name	B (pu)	G (pu)	R (pu)	X (pu)
line_4_5	0.0790	0	0.0170	0.0920
line_5_6	0.1790	0	0.0390	0.1700
line_6_7	0.1045	0	0.0119	0.1008
line_7_8	0.0745	0	0.0085	0.0720
line_8_9	0.1530	0	0.0320	0.1610
Line_9_4	0.0880	0	0.0100	0.0850
Line_10_11	0.2179	0	0.0080	0.0347

Table 2. Transformer data (on equipment MVA base)

Name	LV Bus	HV Bus	V_b	V_n	Tap Ratio	R (pu)	X (pu)
XFR1	B1	B4	16.5	16.5	16.5/230.0	0	0.0576
XFR2	B2	B8	18	18	18/230.0	0	0.0625
XFR3	B3	B6	13.8	13.8	13.8/230	0	0.0586
XFR4	B12	B11	33	33	33/110	0.0016	0.0827
XFR5	B10	B9	110	110	110/230	0.0640	0.0016

Table 3. Load data

Name	Bus Connection	P_0	Q_0	S_n	V_b	V_0	angle_0
Load 5	Bus 5	90	30	100	230	1.016	-1.806
Load 7	Bus 7	100	35	100	230	1.019	3.53
Load 9	Bus 9	125	50	100	230	1.011	-0.392

Table 4: Generator data

Parameters	Gen1	Gen2	Gen3
Connected to bus	Bus1	Bus2	Bus3
D	0	0	0
M (kWs/kVA)	47.28	12.8	6.02
P_0 (MW)	21.65	163	85
Q_0 (MVar)	17.79	0.42	-13.38
Sn (MVA)	100	100	100
Td10 (s)	8.96	6	5.89
Tq10 (s)	0.310	0.5350	0.6
V_0 (pu)	1.04	1.025	1.025
V_b (kV)	16.5	18	13.8
Vn (kV)	16.5	18	13.8
angle_0 (deg)	0	12.281	7.127
ra (pu)	0	0	0
xd (pu)	0.1460	0.8958	1.3125
xd1 (pu)	0.0608	0.1198	0.1813
xq (pu)	0.0969	0.8645	1.2578
xq1 (pu)	0.0969	0.1969	0.25

Table 5. Wind plant data

Quantity	Value
V_b (kV)	33
V_0	1
Angle_0 (deg)	4.719
P_0 (MW)	-50
Q_0 (MVAr)	5.98

Note: please ignore the mention of entering negative values for the wind park P and Q from the video. Table 5 has already taken this into account!

We will now input wind speed from a text file into this model to give it more realistic representation.

1. Download the wind_speeds.txt file from modeling companion guide.
2. Delete the constant block.
3. Drag the component CombiTimeTable from ***Modelica*** → ***Blocks*** → ***Sources*** → ***CombiTimeTable*** into the network workspace near gen12.
4. Open the combiTimeTable element and fill the following information:
    a. tableOnFile: True
    b. tableName: “tab1” (Include the quotation marks “”)
    c. filename: Locate the *wind_speeds.txt* file by clicking on the button with three small dots next to this field.
    d. Your dialog box should look similar to Figure 2. Press OK

Subtask 1: Simulate the system by setting the stop time at 100s, interval = 0.1s. Run the simulation with constant wind speed (19m/s as described earlier) and variable wind speeds loaded from the text file. Observe the bus voltages, the generator active powers. Analyze and comment on the impact of variable wind on system frequency and voltage.

Subtask 2: Parameters *alphap* and *alphaq* are the voltage dependency of the wind turbine active and reactive power to the terminal voltage respectively. Default value 0 implies no influence, i.e. constant power supply. Typically, the values lie between [0,2]. Change the values of both parameters (keeping them same, e.g., 0,0 or 1,1) to observe the effect on voltages, powers, computational times. What conclusions can you draw?

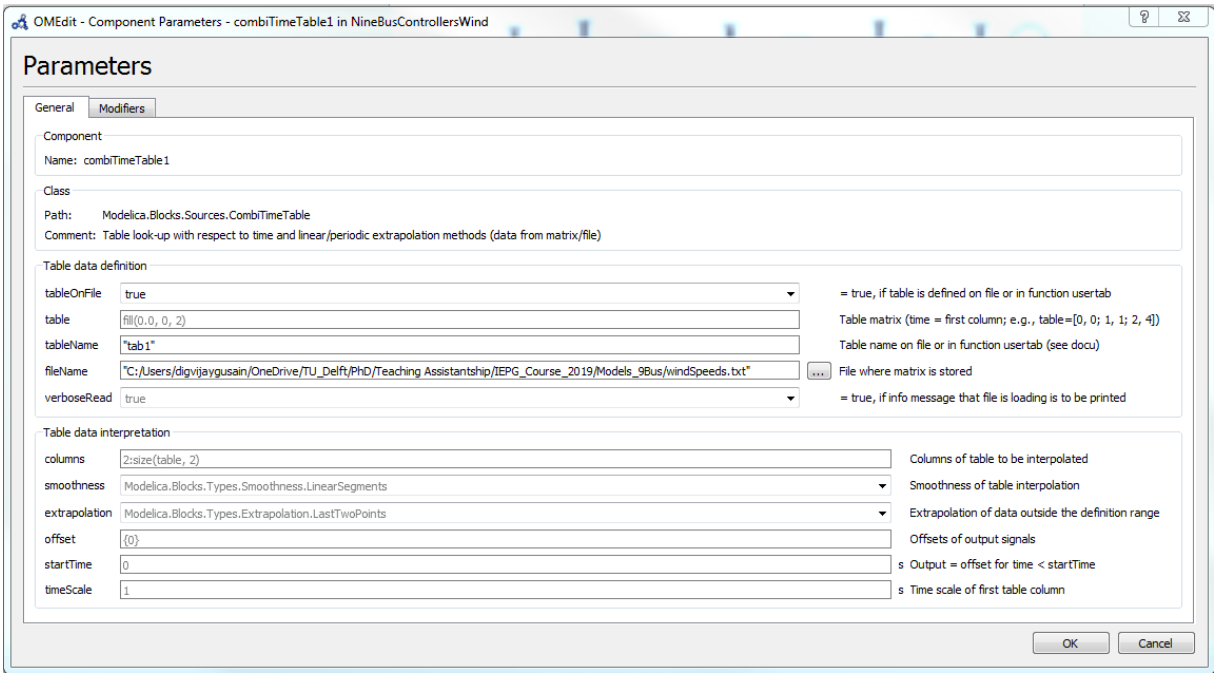

Figure 2: CombiTimeTable to import external data into Modelica.