National University of Singapore

Faculty of Engineering

EE2022 Electrical Energy Systems

Laboratory Manual

Experiment 3

Distributed Power System Modeling and Power Market Simulation

Academic Year 2012/2013

Objectives:

1. To learn interactive power system problem solving on a computer.
2. To understand PowerWorld simulator and its basic functions.
3. To carry out basic power system analyses, e.g. power flow.
4. To simulate simple scenarios for power market interactions.

Brief Features of the PowerWorld Simulator

PowerWorld Simulator is an interactive power systems simulation package designed to simulate power systems operation on a time frame ranging from several minutes to several days. The software contains a highly effective power flow analysis package capable of efficiently solving systems with up to 100,000 buses. The simulator runs in Windows and much of the interaction between the simulator and the user is accomplished using the mouse.

Clicking the left mouse button on objects is often used to achieve immediate results that may affect the power system. Conversely, clicking the right mouse button on an object will not immediately affect system operation.

Procedure

This simulation study consists of three case studies which are given as follows.

Case 1: A 3-bus system comprises three generators and two loads. All buses are interconnected each other by transmission lines. The system is illustrated in Fig.1.

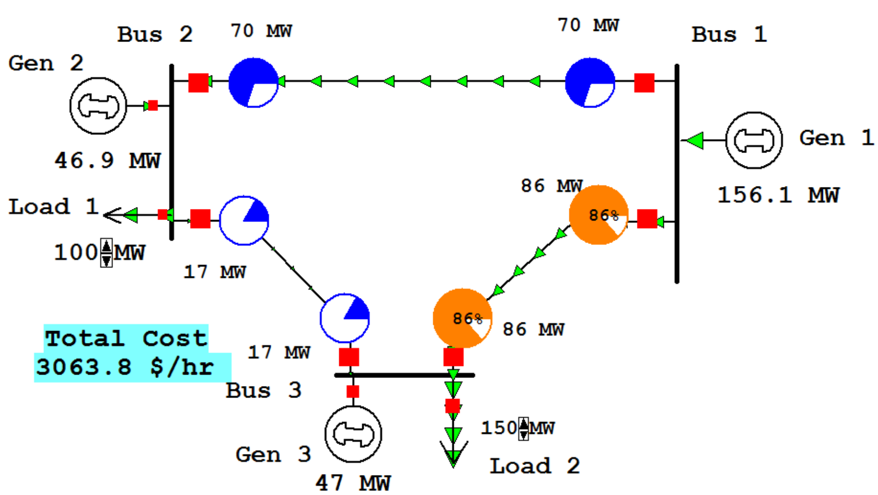

Fig.1. 3-bus system

You are requested to create such a system in your computer. System data are given below.

1. Generators:

Unit	Maximum Power (MW)	Minimum Power (MW)	Cost Function		
			A	B	C
Generator 1	400	0	0	10	0.00001
Generator 2	400	0	0	12	0.00001
Generator 3	400	0	0	20	0.00001

2. Transmission lines: R = 0.0, X = 0.20, B = 0, C = 0, Limit A = 100 MVA, Limit B = 1000 MVA and Limit C = 1000 MVA

3. Buses: Nominal Voltage: 66 kV

4. Load 1: 100 MW, 0 MVR and Load 2: 150 MW, 0 MVAR

Run the system and watch how the simulation runs.

Do the following simulation studies with different amounts of loads. Observe the simulation results such as operational cost of the system and power flow through the transmission lines. Note down the power settings of each generator.

Studies	Load 1		Load 2	
	Real Power (MW)	Reactive Power (MW)	Real Power (MW)	Reactive Power (MW)
1	150	0	150	0
2	175	0	150	0
3	200	0	150	0
4	225	0	150	0
5	150	0	175	0
6	150	0	200	0
7	150	0	225	0

Find out the maximum equal amounts of Load 1 and Load 2 such that the simulation does not violates any system constraints (transmission line limits).

Case 2: This is a 7-bus system which is illustrated in Fig.2.

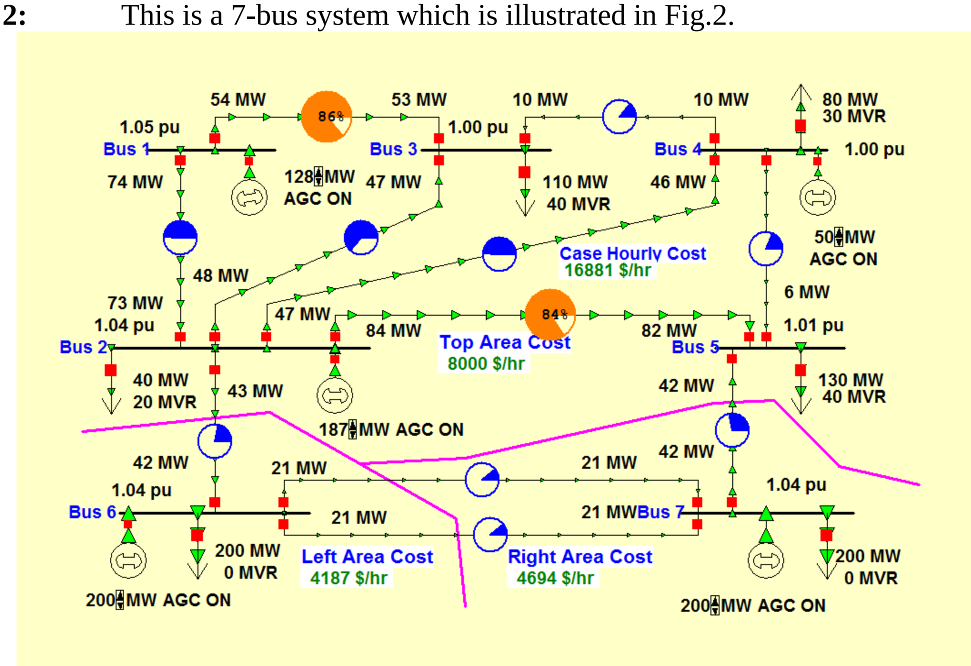

Fig.2. 7-bus system

You are requested to open the 7-bus system, and make a copy in your folder. Play with the system by changing the generation and loads. Observe the simulation results such as operational cost of each area and power flow through the transmission lines.

Case 3: This is a grid-connected microgrid with several distributed energy resources which is illustrated in Fig.3.

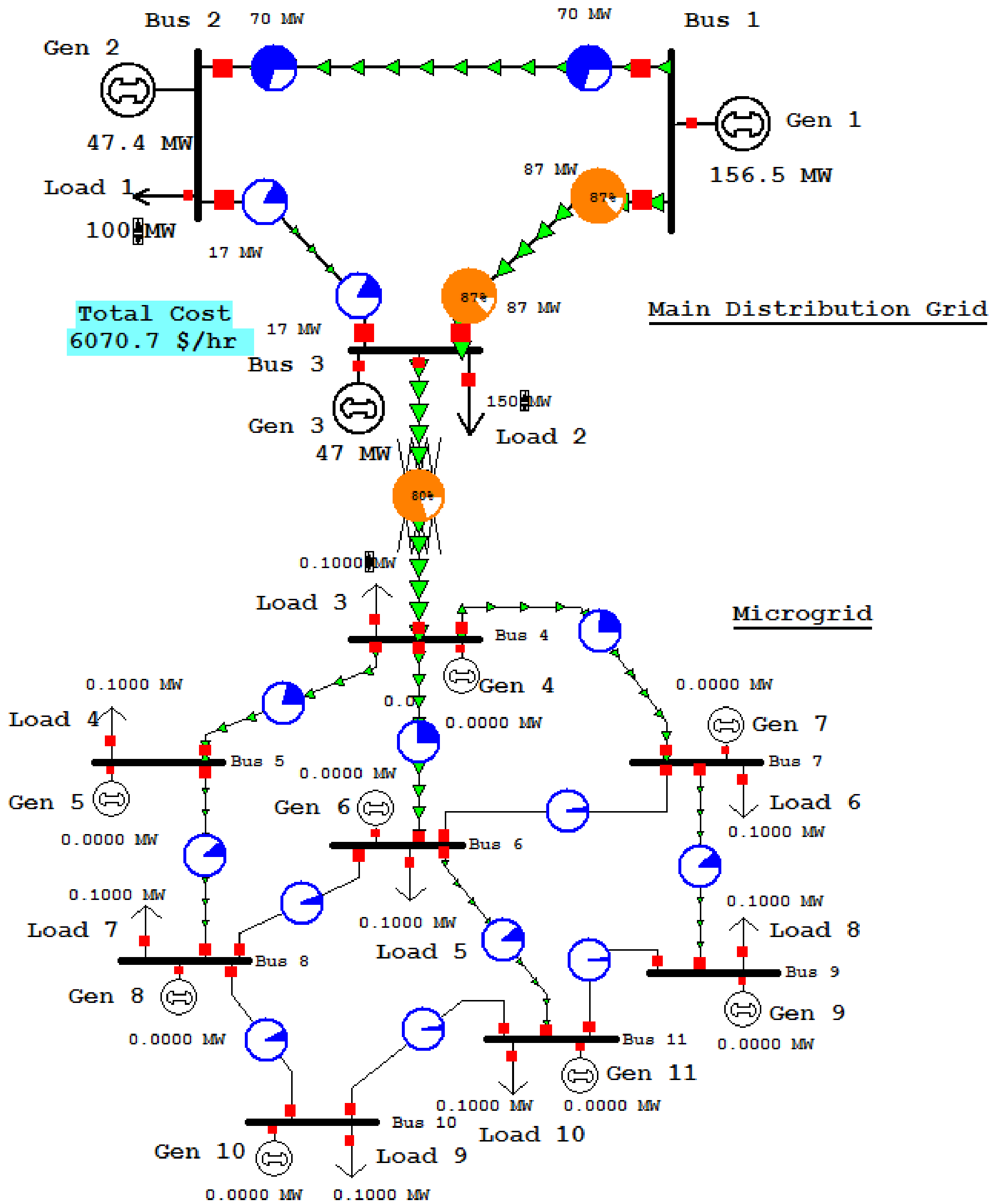

Fig.3. A Microgrid

You are requested to create such a system in your computer. Data for the microgrid are given below. Data of the main distribution grid is same as the system data in Case 1.

1. Transmission lines including the transformer: R = 0.0, X = 0.10, B = 0, C = 0, Limit A = 1 MVA, Limit B = 10 MVA and Limit C = 10 MVA

2. Buses: Nominal Voltage: 400 V

3. Loads: 100 kW and 0 kVR

4. Generators:

Unit	Fuel Type	Maximum Power (kW)	Minimum Power (kW)	Cost Function		
				A	B	C
Gen 4	Coal	800	0	219.8	7.03	0.0044
Gen 5	Gas	600	150	239.4	7.78	0.0016
Gen 6	Coal	700	100	414.0	7.94	0.0007
Gen 7	Wind	500	0	218.0	2.1	0.0002
Gen 8	Solar	300	0	705.0	2.0	0.0001
Gen 9	Diesel	100	10	301.2	10.1	0.0089
Gen 10	Gas	600	150	249.2	7.81	0.0014
Gen 11	Solar	200	0	652.0	2.1	0.0002

Run the system, and watch how the simulation runs.

Simulate the microgrid in islanded mode. Make sure that there is a slack bus in the microgrid. Observe the simulation results.

<u>Discussion</u>
Study and discuss the control actions such as ED (Economic Dispatch), AGC (Automatic Generation Control) and OPF (Optimum Power Flow). How will these control actions affect the power settings of generators in distributed power systems.

<u>Reference</u>
User manual of PowerWorld Simulator, Available at: http://www.powerworld.com/