EE 5308

POWER SYSTEMS ANALYSIS AND DESIGN

FINAL PROJECT REPORT

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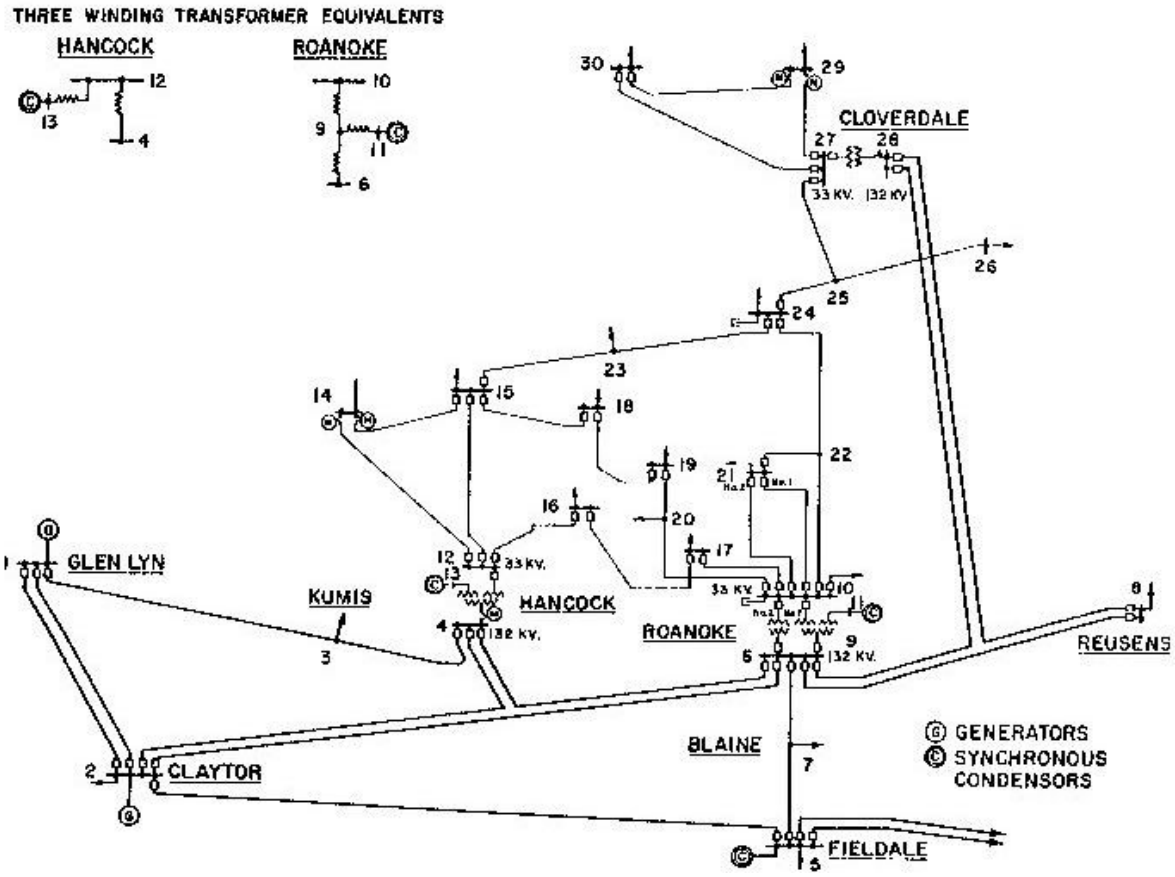
Power Flow Analysis and Fault Analysis on IEEE 30 Bus System

Abstract: This project requires designing an IEEE 30 bus system using PowerWorld and performing Power flow and Fault Analysis on the system. It is required to calculate the total generation, active and reactive power and the power losses of the system alongside performing fault analysis and for the different types of faults (Single phase to Ground, Line to Line, 3 Phase Balanced and Double Line to Ground faults). The results that would be displayed will be the total generation, active and reactive power and the power losses. A table would be displaying the various fault current magnitudes and angles with respect to the concerning bus.

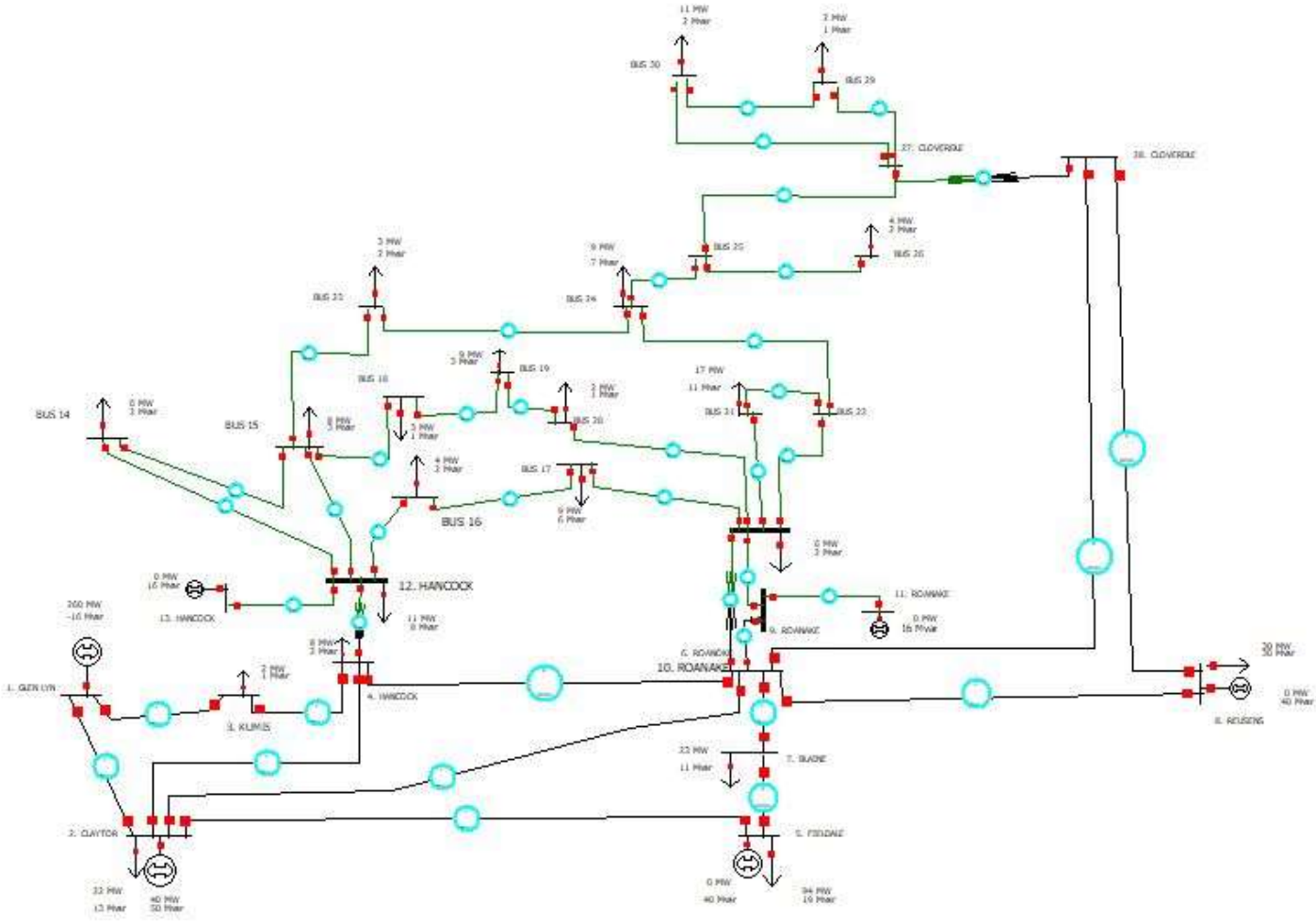
Procedure: The data required to design the IEEE 30 bus system is acquired from the *University of Washington* website. The IEEE 30 bus system model is designed using PowerWorld Simulator. Th following model needs to be designed using PowerWorld Simulator.



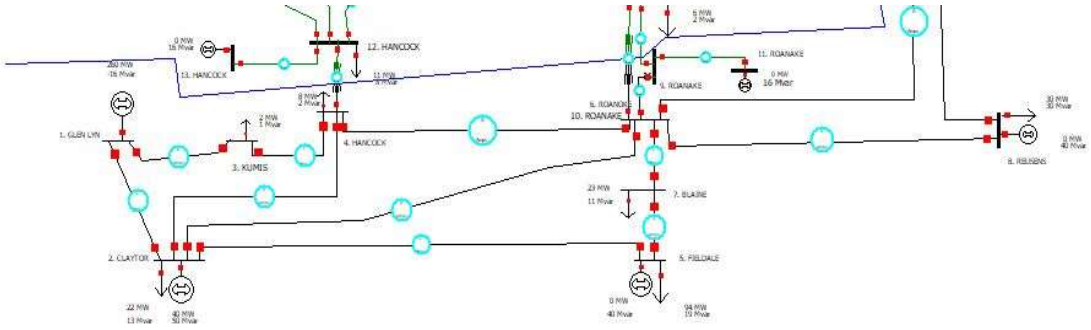
The following data is collected from the model.

S.No	COMPONENT	Total Number
1	Buses	30
2	Generators	6
3	Transmission Lines	37
4	Transformers	4
5	Loads	21

Using the bus data sheet and the branch data sheet as acquired from the *University of Washington* website. The PowerWorld model is designed as below.



The Bus 1 is selected as Slack bus. We observe that we have five Generator bus and the rest are Load buses. We observe that the system within the blue line in the image below is inherently 33kV which is stepped down from 132kV by the transformers in the system. The nominal voltage levels at buses 1,2,3,4,5,6,7,8 and 28 is at 132kV. At buses 11 and 13 the nominal voltage is 11kV while 1kV at bus 9. The rest of the buses have a nominal voltage of 33kV.



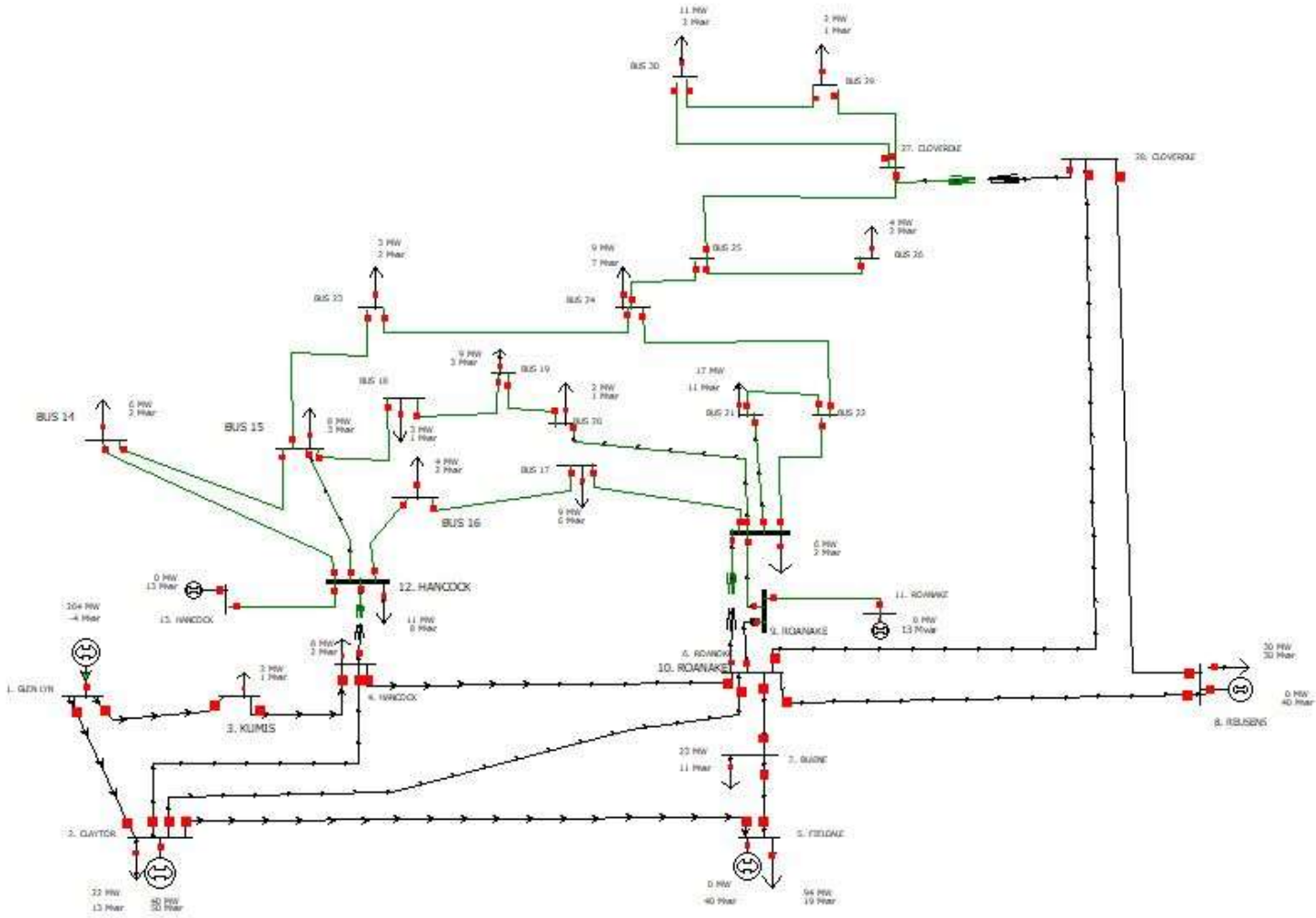
The transformer connections are described in the table below.

S.No	From Bus	To Bus	Voltage	Off-nominal Turns Ratio
1	4. HANCOCK	12. HANCOCK	132-33 kV	0.932
2	6. ROANAKE	9. ROANAKE	132-1 kV	0.978
3	6. ROANAKE	9. ROANAKE	132-33 kV	0.969
4	28. CLOVERDLE	27. CLOVERDLE	132-33 kV	0.968

We have a total of six generators in the system. The Generator connections are described in the table below. It is to be noted that the Synchronous Condensors are connected to the buses 5,8,11 and 13.

S.No	Name of the Bus	Generator MW	Generator MVar
1	1.GLEN LYN	260.20	-16.10
2	2.CLAYTOR	40.00	50.00
3	5.FIELDALE	0.00	37.00
4	8.REUSENS	0.00	37.30
5	11.ROANAKE	0.00	16.20
6	13.HANCOCK	0.00	10.60

Power Flow Analysis: The Power flow analysis is then applied on the system where we observe the following model.



The following characteristics are observed.

S.No		
1	TOTAL GENERATION	300.2 + j145.7 MVA
2	ACTIVE POWER	283.4 MW
3	REACTIVE POWER	126.2 MVar

4	POWER LOSSES	19.8 MW

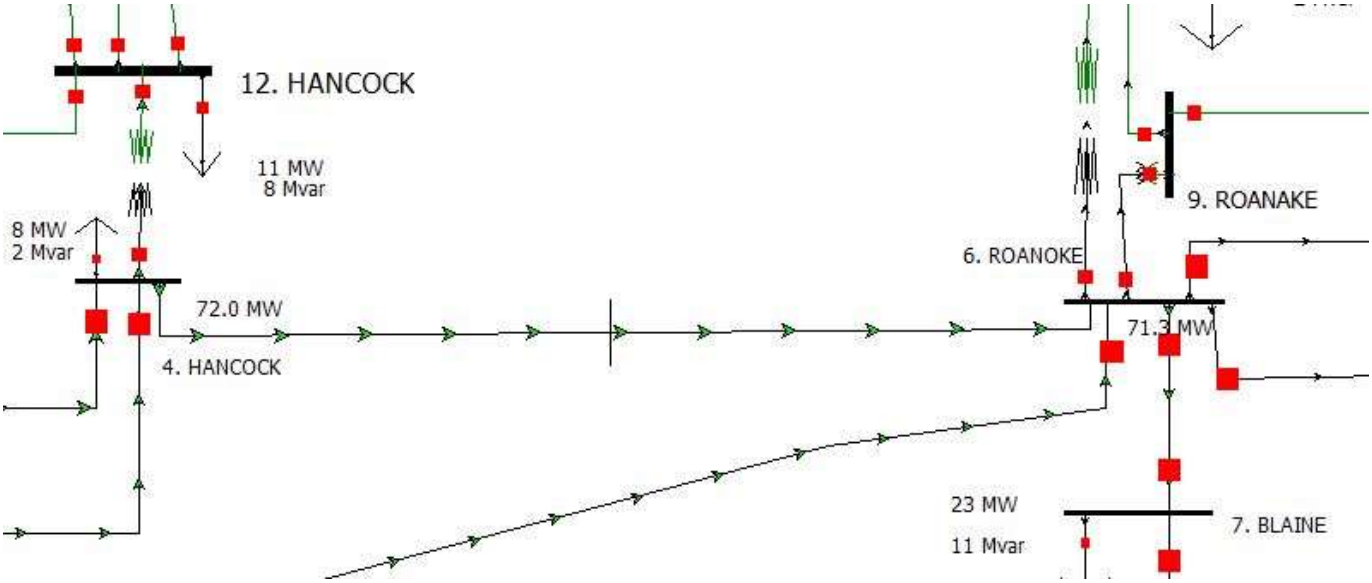
Fault Analysis: Now, the Fault Analysis is to be performed. The following tests need to be executed. The tests are executed by using the Fault Analysis tab. The Line-Line, Single phase to Ground, 3 Phase Balanced and Double Line to Ground faults. The fault analysis is performed at the bus numbers 5, 20 and 28. The following values are obtained.

Bus No	Single Line to Ground Fault		Line – Line Fault		3 Phase Balanced Faults		Double Line to Ground Faults	
	Fault Current Magnitude	Fault Current Angle	Fault Current Magnitude	Fault Current Angle	Fault Current Magnitude	Fault Current Angle	Fault Current Magnitude	Fault Current Angle
5. FIELDALE	3.602 pu	-90.90	4.098 pu	-169.98	4.733 pu	-79.98	2.857 pu	82.53
20. BUS 20	1.487 pu	-93.74	2.262 pu	-173.82	2.612 pu	-83.82	1.031 pu	82.36
28. CLOVERDLE	3.263 pu	-89.13	4.085 pu	-170.71	4.717 pu	-80.71	2.473 pu	86.47

Now, the Fault Analysis is applied at an in-line fault occurring in the middle of transmission line between buses 4 and 6. We are considering Line-Line and Double Line to Ground Faults.

Bus No	Line – Line Fault		Double Line to Ground Faults	
	Fault Current Magnitude	Fault Current Angle	Fault Current Magnitude	Fault Current Angle
Between Bus 4 and Bus 6	4.939 pu (or) 2160.250 A	-168.70	3.088 pu (or) 1350.550 A	86.50

The Fault Location is at 50% to the Bus 4 and Bus 6. It is depicted as follows.



The following parameters are observed between the Fault location and the two buses.

Line Flow at From Bus				Line Flow at To Bus			Line Losses	
4. HANCOCK (4)				FaultPt (31)				
Sign Convention: From --> To		72.04	MW	-71.68	Sign Convention: To --> From		0.360	MW
		-13.83	Mvar	14.68			0.855	Mvar
% MVA	0.00	73.35	MVA	73.16	0.00	% MVA		
% Amps		340.60	Amps	340.24		% Amps		

Line Flow at From Bus				Line Flow at To Bus			Line Losses	
FaultPt (31)				6. ROANOKE (6)				
Sign Convention: From --> To		71.68	MW	-71.32	Sign Convention: To --> From		0.360	MW
		-14.68	Mvar	15.53			0.854	Mvar
% MVA	0.00	73.16	MVA	72.99	0.00	% MVA		
% Amps		340.24	Amps	339.85		% Amps		

When the Fault occurs, the relays at the beginning of Bus 4 (Hancock) and Bus 6 (Roanake) open the circuit for protection. The Buses 2 and 3 feed the Bus 4 while Bus 2 feeds the Bus 6 as well.

We observe the following characteristics.

1	1. GLEN LYN	2	2. CLAYTOR	1	Closed	Line	NO	175.3	-13.2	175.8	0.0	0
1	1. GLEN LYN	3	3. KUMIS	1	Closed	Line	NO	88.4	9.0	88.8	0.0	0
2	2. CLAYTOR	4	4. HANCOCK	1	Closed	Line	NO	43.9	5.6	44.3	0.0	0
2	2. CLAYTOR	5	5. FIELDALE	1	Closed	Line	NO	83.1	3.0	83.1	0.0	0
2	2. CLAYTOR	6	6. ROANOKE	1	Closed	Line	NO	60.7	2.9	60.8	0.0	0
3	3. KUMIS	4	4. HANCOCK	1	Closed	Line	NO	82.4	-1.5	82.4	0.0	0
4	4. HANCOCK	6	6. ROANOKE	1	Open	Line	NO	0.0	0.0	0.0	0.0	0
4	4. HANCOCK	12	12. HANCOCK	1	Closed	Transforme	YES	44.5	14.1	46.7	0.0	0
4	4. HANCOCK	31	FaultPt	1	Closed	Line	NO	72.0	-13.8	73.4	0.0	0
5	5. FIELDALE	7	7. BLAINE	1	Closed	Line	NO	-14.5	13.5	19.8	0.0	0
6	6. ROANOKE	7	7. BLAINE	1	Closed	Line	NO	38.0	-4.0	38.2	0.0	0
6	6. ROANOKE	8	8. REUSENS	1	Closed	Line	NO	29.6	-9.9	31.2	0.0	0
6	6. ROANOKE	9	9. ROANAKE	1	Closed	Transforme	YES	27.6	-4.5	27.9	0.0	0
6	6. ROANOKE	10	10. ROANAKE	1	Closed	Transforme	YES	15.8	1.5	15.8	0.0	0
6	6. ROANOKE	28	28. CLOVERDLE	1	Closed	Line	NO	18.8	0.8	18.8	0.0	0
31	FaultPt	6	6. ROANOKE	1	Closed	Line	NO	71.7	-14.7	73.2	0.0	0
8	8. REUSENS	28	28. CLOVERDLE	1	Closed	Line	NO	-0.5	0.5	0.7	0.0	0
9	9. ROANAKE	10	10. ROANAKE	1	Closed	Line	NO	27.6	6.8	28.4	0.0	0

Conclusion: The IEEE 30 Bus system was designed using PowerWorld and its network described. The Total Generation, Active and Reactive power and Power losses of the system have been determined before and after Load Flow Analysis. The Fault Analysis was performed at bus 5, 20 and 28 and at an in-line fault occurring between bus 4 and bus 6. The faults were described and the location of the in line fault was depicted.

References:

1) *https://www.powerworld.com*
2) *http://labs.ece.uw.edu/pstca/pf30/pg_tca30bus.htm*
3) *Dr. Wei-Jen Lee, "Network Equation and Power Flow"*