

Load Flow Analysis of IEEE-14 Bus using E-TAP software Chirag A. Patel¹, Kishan R. Karangiya², Vikesh M. Patel³, Meru D. Shah⁴

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Abstract—Our project is based on power system analysis of IEEE-14 bus system on this system we are going to study load flow analysis, using E-TAP software. Various power system component like Generator, Transformer, Transmission line load are modeled and simulated. Then after results and reports generated and discussion that result. According to single line diagram of the IEEE-14 bus standard system. It consists of five synchronous machines with IEEE type-1 exciters, three of which are synchronous compensators used only for reactive power support. There are 11 loads in the system totaling 259 MW and 81.3 Mvar. The dynamic data for the generators exciters was selected from given Data sheet.

Keywords: Load flow analysis, E-TAP software, IEEE-14 Bus.

I. INTRODUCTION

Electric power system stability is one of challenging problem to protect the system operation. So it is of vital importance to examine and protect the power system equipments. To determine the stability of the power system for every fault that occurs in the power system studies like load flow, short circuit and transient stability study plays an important role. In our paper to perform load flow, short circuit and transient stability analysis we have considered IEEE-14 bus system. Here load flow studies determine if the system voltage remain within specified limit under normal or emergency operation conditions or whether the equipments like transformers and conductors are overloaded. A short circuit study determines the magnitude of the current during an electrical fault. The ability of the system to return back to stable condition and maintain its synchronism is called transient stability.

II. RELATED WORK

In [1] Manoj kumar & Ganga agnihotri described the stability study as the important parameter of economic, reliable and secure power system planning and operation. Here they had described the power system stability analysis of IEEE-9 bus system. The system is simulated and stability is analysed on E-TAP software.

In [2] someh kamel, meena kods and clowdio a. canizars described the modeling of IEEE-14 bus system using power system toolbox (PST). Here the system was tested under different disturbances and an analysis of the dynamic behavior of the system was checked. They had described the solution to increase the margins of the stability analysis. To increase the stability margin they had added controllers and a test was conducted to show the effect of those controllers different stability margins under different faults.

In [3] Renuka kamder, Mukesh kumar kirar, Manoj kumar & Ganga agnihotri had performed a study to determine the performance of the system at both stationary and running condition of the power system. They had performed the short circuit analysis of an industrial electrical power distribution system. Short circuit analysis can be performed at both the stationary and the running condition of the power system to make the final layout of the system, calculate the voltage levels, cable size and reading of transformers and generators. They used E-TAP software for the simulation of short circuit under different faulty condition.

In [4] Depender kaur mander, Supreet kaur saint had described the load flow analysis and as well as performed the research work for the power system design purpose. They had described that load flow analysis is really essential for planning, operation and interchanged of power between the power system utilities. The load flow study is carried out to determine the magnitude and phase angle of the voltage and real and active power in each line in the power system. They had also given an overview of various techniques which were useful for load flow study under faulty condition in the electric power system.

III. SYSTEM BLOCK DIAGRAM

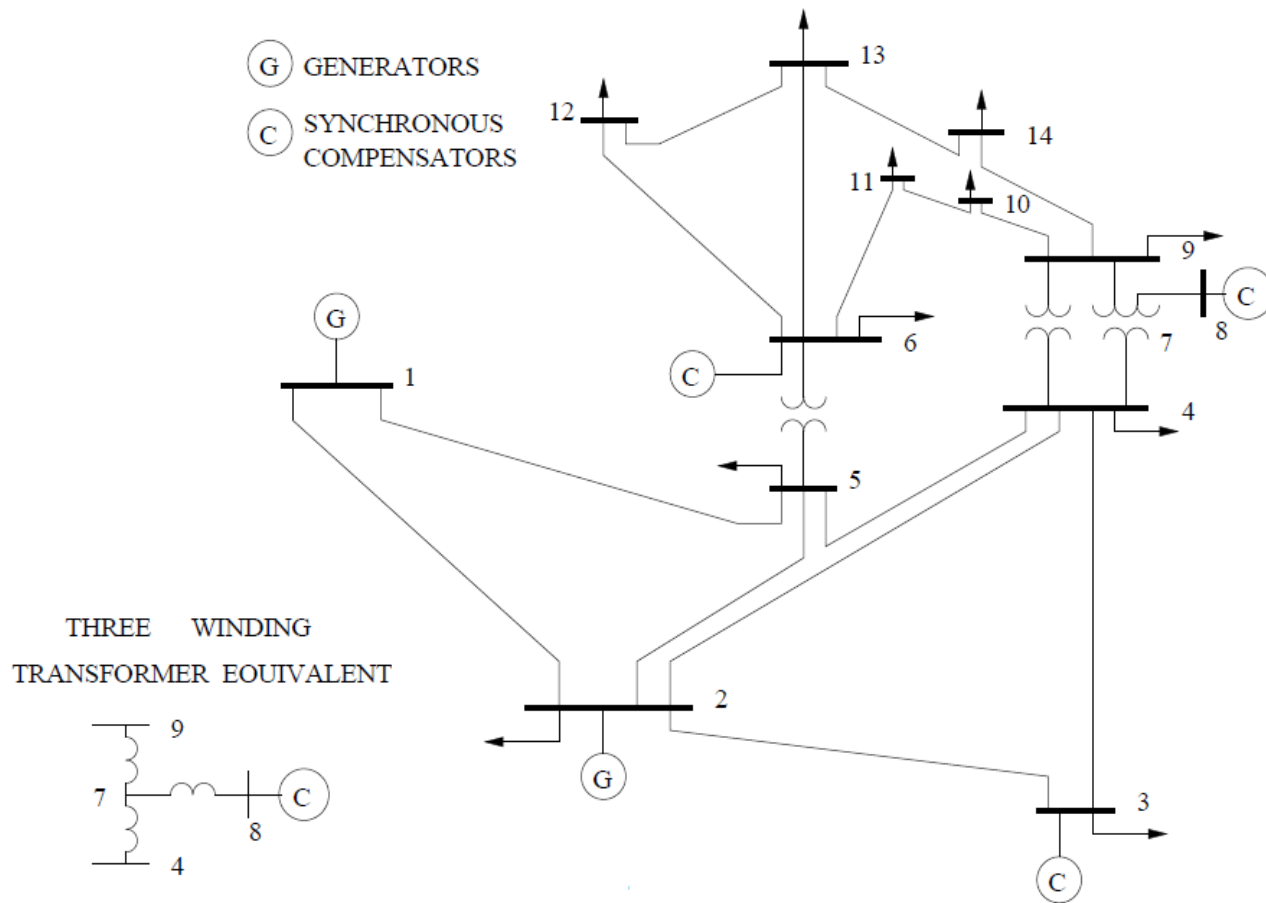


Figure 1: System Block Diagram

In the Machine 14 Bus systems is taken as case study which is shown in Figure. Bus-1 and bus-2 are generator buses which are rated 69kv with 100MVA base, Synchronous Compensators are connected at buses 3 and 8. Load is connected to all bus except bus-1,7and 8. Parameters given here are in per unit (p.u) format on 100MVA base. There are four transformers connected in the system; in which one is three-winding and others are two winding transformers.

IV. FLOW CHART

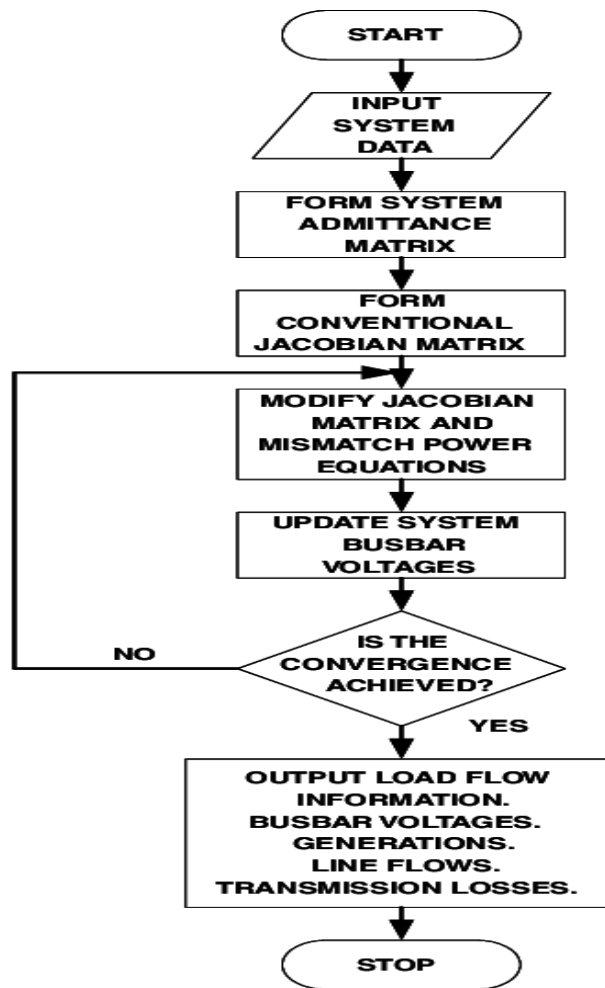


Figure 2: Flowchart

Step 1: Start the E-TAP software and design IEEE-14 bus in it.

Step 2: Then input the data to the component of IEEE-14 bus in the software.

Step 3: Then from the necessary admittance matrix and jacobian matrix to perform the load flow by newton raphson's method.

Step 4: If required change the voltage at each component.

Step 5: Check the convergence. If convergence exists go for the final step of the load flow to find bus voltage and losses. If convergence do not exists go to step 3 again and make the changes required.

Step 6: Stop the load flow and note the reading.

V. IEEE-14 BUS DATA

Data required for bus is given in below table.

BUS DATA

DRAWING OF TRANSFORMER

Bus Number	Voltage Base(kV)	Vo(pu)	θ_0 (rad)
1	69	1	0
2	69	1	0
3	69	1	0
4	69	1	0
5	69	1	0
6	13.8	1	0
7	13.8	1	0
8	18	1	0
9	13.8	1	0
10	13.8	1	0
11	13.8	1	0
12	13.8	1	0
13	13.8	1	0
14	13.8	1	0

From Bus	To bus	Power Rating (MVA)	Voltage Rating (kv)	Frequency Rating (Hz)	Voltage Ratio (Kv/Kv)	R (Pu)	X (Pu)	Fix Tap Ratio (Pu/Pu)
5	6	100	69	60	5	0	0.25202	0.932
4	9	100	69	60	5	0	0.55618	0.969
4	7	100	69	60	5	0	0.20912	0.978
8	7	100	18	60	1.304348	0	0.17615	0

GENERATOR DATA

Bus Number	Power Rating (MVA)	Voltage Rating (KV)	Active Power (Pu)	Vo (Pu)	Q max (Pu)	Q min (Pu)	V max (Pu)	V min (Pu)
2	100	69	0.4	1.045	0.5	-0.4	1.0451	0.8
6	100	13.8	0	1.07	0.24	-0.06	1.0701	0.6
3	100	69	0	1.01	0.4	0	1.0101	0.6
8	100	18	0	1.09	0.2517	-0.06	1.0901	0.6

LOAD DATA

Bus Number	Power Rating (MVA)	Voltage Rating (kv)	Active power (pu)	Reactive power (pu)	V max (pu)	V min (pu)
11	100	13.8	0.035	0.018	1.2	0.6
13	100	13.8	0.135	0.058	1.2	0.6
3	100	69	0.942	0.19	1.5	0.8
5	100	69	0.076	0.016	1.2	0.6
2	100	69	0.217	0.127	1.2	0.8
6	100	13.8	0.112	0.075	1.5	0.6
4	100	69	0.478	0.04	1.2	0.6
14	100	13.8	0.149	0.05	1.2	0.5
12	100	13.8	0.061	0.016	1.2	0.6
10	100	13.8	0.09	0.058	1.2	0.6
9	100	13.8	0.295	0.166	1.2	0.6

Line Detail

From Bus	To Bus	Power Rating (MVA)	Voltage Rating (kV)	Frequency Rating (Hz)	R (Pu)	X (Pu)	B(Pu)
2	5	100	69	60	0.05695	0.17388	0.03400
6	12	100	13.8	60	0.12291	0.25581	0.00000
12	13	100	13.8	60	0.22092	0.19988	0.00000
6	13	100	13.8	60	0.06615	0.13027	0.00000
6	11	100	13.8	60	0.09498	0.19890	0.00000
11	10	100	13.8	60	0.08205	0.19207	0.00000
9	10	100	13.8	60	0.03181	0.08450	0.00000
9	14	100	13.8	60	0.12711	0.27038	0.00000
14	13	100	13.8	60	0.17093	0.34802	0.00000
7	9	100	13.8	60	0.0000	0.11001	0.00000
1	2	100	69	60	0.01938	0.05917	0.05280
3	2	100	69	60	0.04699	0.19757	0.04380
3	4	100	69	60	0.06701	0.17103	0.03460
1	5	100	69	60	0.05403	0.22304	0.04920
5	4	100	69	60	0.01335	0.04211	0.01280
2	4	100	69	60	0.05811	0.17632	0.03740
5	6	100	69	60	0.0000	0.25202	0.00000
4	9	100	69	60	0.0000	0.55618	0.00000
4	7	100	69	60	0.0000	0.20912	0.00000
8	7	100	18	60	0.0000	0.17615	0.00000

VI . LOAD FLOW RESULT

Project: IEEE 14 BUS

ETAP

Date: 03-23-2017

Contract:

Revision: Base

Config: Normal

Bus Loading Summary Report

Bus			Directly Connected Load								Total Bus Load			
			Constant KVA		Constant Z		Constant I		Generic		MVA	% PF	Amp	Percent Loading
ID	KV	Rated Amp	MW	Mvar	MW	Mvar	MW	Mvar	MW	Mvar				
Bus 1 H_1	1.000		0	0	0	0	0	0	0	0	222.298	99.6	127070.2	
Bus 2 H_2	1.000		21.700	12.700	0	0	0	0	0	0	197.799	97.4	109281.6	
Bus 3 H_3	1.000		94.200	19.000	0	0	0	0	0	0	97.477	94.6	55721.2	
Bus 4 H_4	1.000		47.800	-2.900	0	0	0	0	0	0	117.128	98.7	66454.1	
Bus 5 H_5	1.000		7.600	1.600	0	0	0	0	0	0	114.521	99.0	64857.4	
Bus 6 L_6	1.000		11.200	7.500	0	0	0	0	0	0	48.748	90.5	26202.4	
Bus 7 Z_7	1.000		0	0	0	0	0	0	0	0	22.907	85.2	17898.0	
Bus 8 T_8	1.000		0	0	0	0	0	0	0	0	17.425	0.0	9241.1	
Bus 9 L_9	1.000		29.500	14.600	0.002	-21.184	0	0	0	0	51.220	86.0	28060.7	
Bus 10 L_10	1.000		9.000	5.800	0	0	0	0	0	0	10.707	84.1	5881.9	
Bus 11 L_11	1.000		2.500	1.500	0	0	0	0	0	0	8.075	90.4	4411.1	
Bus 12 L_12	1.000		6.100	1.600	0	0	0	0	0	0	8.066	95.6	4412.4	
Bus 13 L_13	1.000		12.500	5.800	0	0	0	0	0	0	20.581	92.0	11212.6	
Bus 14 L_14	1.000		14.900	5.000	0	0	0	0	0	0	15.717	94.8	8762.7	

* Indicates operating load of a bus exceeds the bus critical limit (100.0% of the Continuous Ampere rating).

+ Indicates operating load of a bus exceeds the bus marginal limit (95.0% of the Continuous Ampere rating).

Figure 3: bus loading summary report

In the above figure the active power and reactive power flowing and consuming along with the mutual buses is calculated by substituting the standard value of IEEE-14 bus system and the result if calculated in E-TAP software.

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Contract:		SN:
Engineer:	Study Case: LF	Revision: Base
Filename: IEEE14BUS		Config: Normal

Branch Loading Summary Report

CKT / Branch		Cable & Reactor			Transformer				
ID	Type	Capacity (Amp)	Loading Amp	%	Capacity (MVA)	Loading (input)		Loading (output)	
						MVA	%	MVA	%
4,7	Transformer				100.000	20.292	20.2	29.696	29.7
4,9	Transformer				100.000	16.176	16.2	16.087	16.1
4,6	Transformer				100.000	65.819	65.8	66.817	66.8

* Indicates a branch with operating load exceeding the branch capability.

Figure 4: branch loading summary report

In the above figure there is shown the calculation of branch loading summary report in the E-TAP software.

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Filename: IEEE14BUS		Config: Normal

Marginal Report

Device ID	Type	Condition	Rating Limit	Unit	Operating	% Operating	Phase Type
Bus 14 L_14	Bus	Over Voltage	1.000	kV	1.026	102.6	3-Phase
Bus 2 H_2	Bus	Over Voltage	1.000	kV	1.065	106.5	3-Phase

figure 5: marginal report

In the above figure there is shown that how much margin is *negotiable* while in the calculation of the ieee-14 bus load flow.

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Revision: Base
Config: Normal

Branch Losses Summary Report

Ckt / Branch ID	From-To Bus Flow		To-From Bus Flow		Losses		% Bus Voltage		% Drop in Vmag
	MW	Mvar	MW	Mvar	kW	kvar	From	To	
1_2	156.838	-20.605	-152.590	27.678	4297.9	7272.8	106.0	106.5	1.50
1_5	75.516	2.566	-72.753	2.261	2762.2	6085.6	106.0	102.0	4.05
2_3	72.227	2.560	-70.916	1.602	2222.2	5162.6	106.5	101.0	2.50
2_6	56.122	-1.562	-56.656	2.022	1676.8	1670.6	106.5	101.8	2.72
2_5	61.519	1.157	-60.615	-2.085	903.8	-927.9	106.5	102.0	2.55
3_6	-22.286	6.661	22.689	-6.826	272.6	-262.7	101.0	101.8	0.77
6_5	-61.155	1.516	61.670	-16.196	516.2	1622.2	101.8	102.0	0.18
6_7	28.071	-9.689	-28.070	11.292	1.7	1702.1	101.8	106.2	4.28
6_9	16.081	-0.625	-16.080	1.760	1.2	1206.9	101.8	105.6	2.82
5_6	66.099	12.627	-66.096	-8.016	6.6	6621.2	102.0	107.0	5.05
6_11	72.27	2.566	-72.202	-2.668	55.6	116.1	107.0	105.7	1.21
6_12	72.27	2.566	-72.215	-2.256	71.8	169.5	107.0	105.5	1.68
6_13	17.750	7.218	-17.528	-6.801	212.1	617.8	107.0	105.0	1.96
7_8	0.000	-17.176	0.000	17.625	0.0	661.1	106.2	109.0	2.85
7_9	28.070	5.782	-28.070	-6.980	0.0	801.9	106.2	105.6	0.56
9_10	52.26	6.216	-52.211	-6.182	12.9	26.1	105.6	105.1	0.49
9_16	94.26	2.608	-92.208	-2.261	116.1	266.9	105.6	102.6	2.06
10_11	-2.789	-1.618	2.802	1.668	12.6	29.5	105.1	105.7	0.59
12_13	1.615	0.756	-1.609	-0.769	6.2	5.7	105.5	105.0	0.48
12_16	56.67	1.769	-55.592	-1.629	56.1	110.2	105.0	102.6	1.69
					12601.5	20125.2			

figure 6: branch losses summary report

In the above figure the standard ieee-14 bus system gives that how much losses will occur during the load flow analysis in the mutual branches using E-TAP software.

VIII. CONCLUSION

Load flow analysis, Short circuit analysis and transient stability analysis of IEEE-14 bus has been performed on ETAP software. The Critical Clearing time i.e. the maximum allowable value of the clearing time for which the system remains to be stable is calculated for a given fault. System frequency and voltage is analyzed for different loading conditions and faults on busses. The excess amount of load has to be shedded to maintain system stability.

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