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Evaluation of voltage stability on IEEE 14 bus distribution system with and without STATCOM

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ABSTRACT

Many radial distribution systems are part of rural electrification, leading to many faults and disturbance in the lines due to human caused effects or environmental effects. In this paper we consider a IEEE 14 bus distribution system with several loads and with two generators. Voltage analysis is carried out with respect to the distribution parameters of the buses and the line. The calculation of voltage pu parameters are carried out to obtain load flow indices for the IEEE 14 bus system with STATCOM and without STATCOM. The complete design and analysis is carried out in MATLAB software with comparison of voltage pu values with and without STATCOM in a table given in last section.

Keywords: Radial Distribution ,STATCOM, IEEE 14BUS

I. INTRODUCTION

With the increase in power demand of loads also in the rural areas, the distribution systems are more affected with power quality issues. The interconnection of small industrial loads to the line may also lead to voltage fluctuations and drop in power factor. The high consumption of reactive power from the power grid may also lead to harmonic injection in the distribution lines affecting other loads. To overcome these power quality issues, distribution generation concept is introduced creating remarkable reduction in the problems of the distribution system. These distribution generators [1] [2] are placed at several locations with certain power generation capacities, supporting the radial system connected loads. The loads nearer to the distribution generators consume most of the power from these sources leading to reduction of power consumption form the power grid source.

As the power consumption from the power grid source is reduced the reactive power consumption is also reduced simultaneously, which increases the power factor of the line and also helps in reduction of voltages drops and harmonic distortions. The power outage [3] of the power grid will also be not affective on most of the buses which are connected to DGs. The buses connected to DGs have a continuous supply as compared to other buses reducing interruptions per years [4] and time outage of power to a certain bus. We consider a IEEE 14 bus system with loads connected to each bus. The one line diagram of IEEE 14 bus system can be seen below in fig. 1.

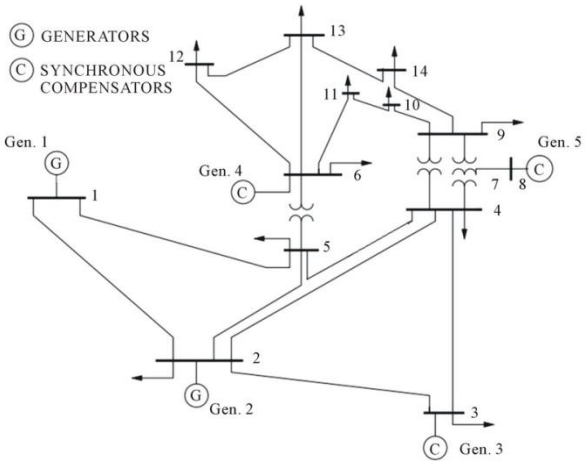

Figure 1. IEEE 14 bus system one line diagram.

II. METHODS AND MATERIAL

The IEEE 14 bus system has two generators with three synchronous compensators which can be over excited synchronous machines. All the 14 buses have load points connected with active and reactive power consumption. Assuming that these loads are linear balanced loads the supply is provided with a single source at bus 1, by a tapping from the main power grid. The supply capacity of the power grid is limited to a certain value with complete power divided to all the buses. The complete load and generator data [6] of the 14 bus system can be seen below in table I.

TABLE I

LOAD FLOW REPORT

Bus ID	kV	Voltage % Mag.	Voltage Ang.	Generation MW	Generation Mvar	Load MW	Load Mvar	Load Flow ID	Load Flow MW	Load Flow Mvar	Load Flow Amp	Load Flow % PF	XFMR % Tap
*Bus 1 H_1	1.000	106.000	0.0	232.404	-16.561	0	0	Bus 2 H_2	156.888	-20.405	8617.8	-99.2	
								Bus 5 H_5	75.516	3.844	4184.5	99.9	
*Bus 2 H_2	1.000	104.500	-5.0	40.000	43.333	21.700	12.700	Bus 1 H_1	-152.590	27.678	8567.9	-98.4	
								Bus 3 H_3	73.237	3.560	4051.5	99.9	
								Bus 4 H_4	56.133	-1.562	3102.5	-100.0	
								Bus 5 H_5	41.319	1.157	2294.8	100.0	
*Bus 3 H_3	1.000	101.000	-12.7	0.000	25.063	94.200	19.000	Bus 2 H_2	-70.914	1.602	4054.7	-100.0	
								Bus 4 H_4	-23.286	4.461	1353.1	-98.2	
Bus 4 H_4	1.000	101.769	-10.3	0	0	47.800	-3.900	Bus 2 H_2	-54.456	3.033	3094.1	-99.8	
								Bus 3 H_3	23.659	-4.824	1369.8	-98.0	
								Bus 5 H_5	-61.155	15.816	3583.7	-96.8	
								Bus 7 Z_7	28.071	-9.689	1684.7	-94.5	-2.200
								Bus 9 L_9	16.081	-9.435	912.6.4	-100.0	-3.100
Bus 5 H_5	1.000	101.954	-8.8	0	0	7.600	1.600	Bus 1 H_1	-72.753	2.241	4121.8.5	-100.0	
								Bus 2 H_2	-40.615	-2.085	2303.0.2	99.9	
								Bus 4 H_4	61.670	-14.194	3583.5.7	-97.5	
								Bus 6 L_6	44.099	12.437	2594.6.6	96.2	-6.800
*Bus 6 L_6	1.000	107.000	-14.2	0.000	12.770	11.200	7.500	Bus 11 L_11	7.357	3.564	4411.1	90.0	
								Bus 12 L_12	7.787	2.504	4413.4	95.2	
								Bus 13 L_13	17.750	7.218	10339.3	92.6	
								Bus 5 H_5	-44.094	-8.016	24182.2	98.4	
Bus 7 Z_7	1.000	106.150	-13.4	0	0	0	0	Bus 8 T_8	0.000	-17.174	9541.1	0.0	
								Bus 9 L_9	28.070	5.782	15587.6	97.9	
								Bus 4 H_4	-28.070	11.392	16476.6	-92.7	
*Bus 8 T_8	1.000	109.000	-13.4	0.000	17.635	0	0	Bus 7 Z_7	0.000	17.635	9541.1	0.0	
Bus 9 L_9	1.000	103.591	-14.9	0	0	29.502	-4.584	Bus 7 Z_7	-28.070	-4.930	15587.6	98.5	
								Bus 10 L_10	5.224	4.216	3670.3	77.8	
								Bus 14 L_14	9.424	3.608	5517.4	93.4	
								Bus 4 H_4	-16.080	1.740	8843.5	-99.4	
Bus 10 L_10	1.000	105.096	-15.1	0	0	9.000	5.800	Bus 9 L_9	-5.211	-4.182	3670.3	78.0	
								Bus 11 L_11	-3.789	-1.618	2263.5	92.0	
Bus 11 L_11	1.000	105.690	-14.8	0	0	3.500	1.800	Bus 6 L_6	-7.302	-3.448	4411.1	90.4	
								Bus 10 L_10	3.802	1.648	2263.5	91.8	
Bus 12 L_12	1.000	105.519	-15.1	0	0	6.100	1.600	Bus 6 L_6	-7.715	-2.324	4413.4	95.6	
								Bus 13 L_13	1.615	0.724	975.2	90.6	
Bus 13 L_13	1.000	105.038	-15.2			13.500	5.800	Bus 6 L_6	-17.538	-6.801	10339.3		

The branch connection data from each bus to another is given below in TABLE II with its resistance, Reactance and Impedance of the line from bus to bus.

TABLE II

Branch Connections

CKT/Branch ID	Type	Connected Bus ID From Bus	Connected Bus ID To Bus	% Impedance, Pos. Seq., 100 MVA Base R	X	Z	Y
4_7	2W XFMR	Bus 4 H_4	Bus 7 Z_7	0.02	20.45	20.45	
4_9	2W XFMR	Bus 4 H_4	Bus 9 L_9	0.05	53.89	53.89	
5_6	2W XFMR	Bus 5 H_5	Bus 6 L_6	0.02	23.49	23.49	
1_2	Impedance	Bus 1 H_1	Bus 2 H_2	1.94	5.92	6.23	5.2800000
1_5	Impedance	Bus 1 H_1	Bus 5 H_5	5.40	22.30	22.95	4.9200000
2_3	Impedance	Bus 2 H_2	Bus 3 H_3	4.70	19.80	20.35	4.3800000
2_4	Impedance	Bus 2 H_2	Bus 4 H_4	5.81	17.63	18.56	3.4000000
2_5	Impedance	Bus 2 H_2	Bus 5 H_5	5.70	17.39	18.30	3.4600000
3_4	Impedance	Bus 3 H_3	Bus 4 H_4	6.70	17.10	18.37	1.2800000
4_5	Impedance	Bus 4 H_4	Bus 5 H_5	1.34	4.21	4.42	
6_11	Impedance	Bus 6 L_6	Bus 11 L_11	9.50	19.89	22.04	
6_12	Impedance	Bus 6 L_6	Bus 12 L_12	12.29	25.58	28.38	
6_13	Impedance	Bus 6 L_6	Bus 13 L_13	6.62	13.03	14.61	
7_8	Impedance	Bus 7 Z_7	Bus 8 T_8		17.62	17.62	
7_9	Impedance	Bus 7 Z_7	Bus 9 L_9		11.00	11.00	
9_10	Impedance	Bus 9 L_9	Bus 10 L_10	3.18	8.45	9.03	
9_14	Impedance	Bus 9 L_9	Bus 14 L_14	12.71	27.04	29.88	
10_11	Impedance	Bus 10 L_10	Bus 11 L_11	8.21	19.21	20.89	
12_13	Impedance	Bus 12 L_12	Bus 13 L_13	22.09	19.99	29.79	
13_14		Bus 13 L_13	Bus 14 L_14	17.09	34.80	38.77	

To the above IEEE 14 bus system a STATCOM is connected at the week bus which is denoted by the load flow solution using newton raphson method. The weak load bus is considered to be 14th bus which has the lowest voltage pu value and the voltage pu values of all the buses are shown in the fig.2 below.

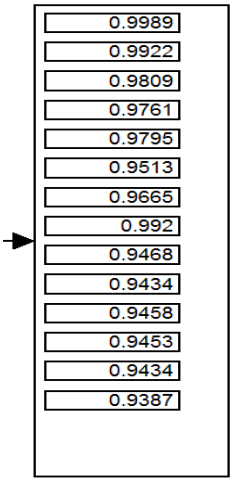

Figure 2. pu Voltages of IEEE 14bus system without STATCOM

III. RESULTS AND DISCUSSION

The figure with IEEE 14 bus system with STATCOM connected at the 14th bus is shown modeled in MATLAB Simulink is shown below.

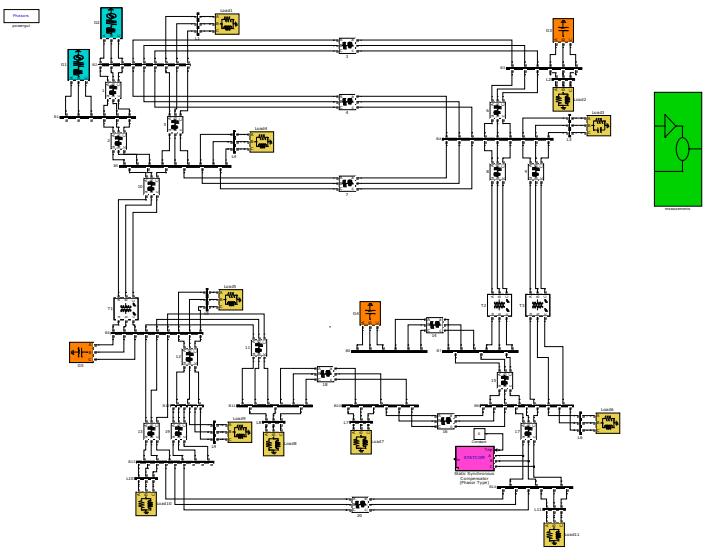

Figure 3. MATLAB Simulink modeling of IEEE 14 bus system with STATCOM at 14th bus

The After connection of STATCOM at the 14th bus the voltage pu of the 14 bus system is impriovised as a result of injection of reactive power from STATCOM stabilizing the buses connected nearer to the

STATCOM device. The voltage pu values of the 14 bus system are shown below in fig.4

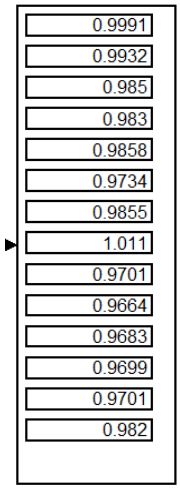

Figure 4. pu Voltages of IEEE 14bus system with STATCOM at 14th bus

It can be cleared that the voltage at 14th bus is improvised to 0.982 from 0.9387 representing without STATCOM and with STATCOM the bus voltages are now in the permissible range i.e., between 0.95 to 1.05. A graphical representation of bus voltage comparison can be seen in the fig.5 below.

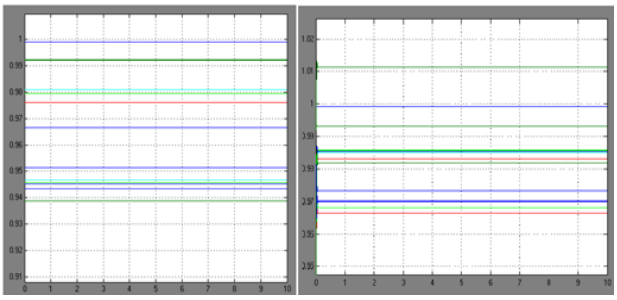

Figure 5. Comparison of voltages for IEEE 14 bus system with and without STATCOM

IV.CONCLUSION

With the above representation and comparison of graphs with the help of MATLAB software it can be observed that the voltages of the buses have been improved and set to IEEE standard range (0.95 to 1.05) and stable with respect to no FACTs device in the 14 bus IEEE distribution bus system. All the analysis and modeling with graphical representations of the bus system with STATCOM at bus 14 are carried out in MATLAB Simulink software with genuine results

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