International Journal of Scientific Research in Engineering and Management (IJSREM)
Volume: 07 Issue: 05 | May - 2023 SJIF 2023: 8.176 ISSN: 2582-3930

System Study and Planning for Expansion of Grid connected Photovoltaic System

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Abstract – **In present scenario entrance of renewable source in the power system network in the grid system has been increase. Out of these Solar energy is intermittent in nature which can produce enormous amount of energy. In this paper we discuss about the impact of connecting PV system to the IEEE -9 bus system. A typical distribution network is random in nature. The power consumption in each bus as well as PV location and rating is random. But the major problem is we don't have idea which buses is most appropriate and which bus provide better Power Factor improvement, because the Power factor plays important role in grid system.In this paper our main focus is to find out the best location to connect the PV solar panel among 9 buses by the using of ETAP Software. With the help of ETAP Software we find a best location in IEEE -9 bus system which improve the buses Power Factor.The comparison of PV bus connected to different bus is analyzed with Single Line Diagram. All of these proposed schemes are simulated in ETAP software. There have been several cases considered and the results are presented in various examples to verify the proposals.**

Keywords: Power Factor Improvement, Power Quality Problems, ETAP Software.

I .INTRODUCTION

In the recent years entrance of renewable source in the power system network in the grid system has been increase. These renewable energy sources has low environmental impact as compared to other conventional energy sources i.e. Coal, Petroleum. There are various type of renewable energy source such as solar, wind, biomass and geothermal etc. Out of these Solar energy is intermittent in nature which can produce enormous amount of energy. In this paper we discussed about two conditions to solve the problem of power quality by using ETAP Software.In our both condition we take Power Factor is a key point .Because Power Factor play an important role in IEEE 9bus system. In this IEEE -9 bus has different rating of buses and important loads (i.e. hospitals, industries) are connected which requires uninterrupted power supply at their specified Power Factor.If our bus power factor is decreased causes an excessive high current which can damage our costly devices. Obviously PV solar panel can improve the Power Factor because it is work at unity Power factor but in IEEE -9 bus if one of the Generator is in shut down condition the power factor is decrease. Further we discuss in IEEE -9 bus system what is the best loacation to connect our PV solar panel which improve our Power Factor at condition when one of the Generator is shut down or fault condition.The outcome of this condition is that we get a best location which improve our bus Power Factor . In our second part at condition when one of the generator is in shut down and our PV solar pannel is not connect in best location then how it can imrove bus Power Factor. In this situation we connect a Capacitor bank at specified bus location,which is not only capable to improve

nearest bus but also improve other buses which is connected to nearer PV panel.Study result in this condition is that our bus Power Factor in IEEE -9 bus sysyem is improve which is mention in our result and discussion chapter. The results are represented in Single Line diagram using ETAP software.

II. POWER FACTOR IMPROVEMENT

(a) Power Factor : In electrical engineering the Power Factor of electrical system is defined as the ratio of working power absorbed by the load to the apparent power flowing through the circuit.The ideal Power Factor is one(unity).This condition is possible only when there is no reactive power through the circuit ,hence apparent power is equal to real power.
(b)Need of Power Factor Improvement: $P = VI\cos\emptyset$. According to this relation current is inversely proportional to the Power Factor, hence higher the Power Factor cause lower in the current flowing through the circuit.Less current flow requires less cross sectional area therefore it saves conductor and cost.That is why the Electrical Power Factor should maintained near to Unity.

A.Assumptions before load flow analysis

While solving load flow analysis and compare different Power Factor improvement results, we need to take some assumptions to avoid the complex solution. Some of the assumptions are:

(i) An IEEE -9 bus system is taken. The Load Flow analysis of 9 bus system is done with the help of ETAP Software.

(ii)In this system has 9 no.of buses ,two Generator Units(Gen 1,Gen 2),fives lumped loads (Lump 1,Lump2,Lump3,Lump4,Lump 5) and four transformers(T1,T2 ,T3,T4).

(iii)One of the Generator (Gen 1) is in shut down condition .

III. LOAD FLOW ANALYSIS

In Electrical Engineering load flow analysis is a numerical analysis of the flow of power in the interconnected sysyem.The load flow study usually uses simplified notation such as single line diagram and pu system.The ETAP Load flow Analysis module calculates the bus voltages, branch power factors, currents, and power flow throughout the electrical system. ETAP allows for swing, voltage regulated, and unregulated power sources with multiple power grids and generator connections. It is capable of performing analysis on both radial and loop systems. ETAP allows you to select from several different methods in order to achieve the best calculation efficiency.

Steps for System analysis in ETAP Software:

Step 1: An IEEE- 9 bus system is taken. System model is implemented and executed in ETAP and Load flow analysis is performed. The Load Flow analysis of 9 bus system is done with the help of ETAP Software.

Step 2: After load flow analysis, the initial parameters of the system e.g. bus voltages, bus frequency, bus power angles, bus Power factor, generator power angles, generator power rating , current flow are studied.

Step 3: For expansion of grid connected Photovoltaic System a 100 KW Solar panel is used in this project. In IEEE -9 bus System there are 9 buses and our aim is to analyses which bus perform maximum power factor improvement.

Step 4: Our Solar Panel is rated for 33 KV ,so we connect solar panel in all 33KV bus one by one and load flow analysis is performed .

Step 5: Due to any reason if Generator 1 is shut down or any fault occurs in Generator 1, we connect solar panel is connect in all 33KV bus one by one and load flow analysis if performed.

Step 6: Out of these if we connect PV solar panel across bus 3,the Power factor improvement is better as compare to others. When we connect PV solar panel in

other buses(i.e. bus 4 ,bus 2, bus 6) the Power factor is **0.56** and we connect PV solar panel in bus 3, the Power factor is become 1(unity) and this the best location to connect solar panel in this IEEEE 9 bus system.

Step 7: When we connect PV solar panel any other buses (i.e. bus 4,bus 2,bus 6) there is problem arise. The Power factor of bus 2 and bus 6 are decrease. To solve this problem ,we connect a Capacitor bank across bus 3 which is connected through relay system. When the pf of decreased due to connection of other buses ,the relay send trip signal, and capacitor bank is connected to bus 3.

Step 8: The Advantage of connection of Capacitor bank to bus 3 is not only improve the bus 4 Power factor(0.84 to 0.88) but also it improve bus 5 Power factor(0.85 to 0.97).

Step 9: Study and Planning for expansion of grid connected Photovoltaic system is done in ETAP Software.

IV. RESULT AND DISCUSSION

4.1 System analysis in ETAP Software:

(i) An IEEE- 9 bus system is taken. System model is implemented and executed in ETAP and Load flow analysis is performed. The Load Flow analysis of 9 bus system is done with the help of ETAP Software which is shown in figure.

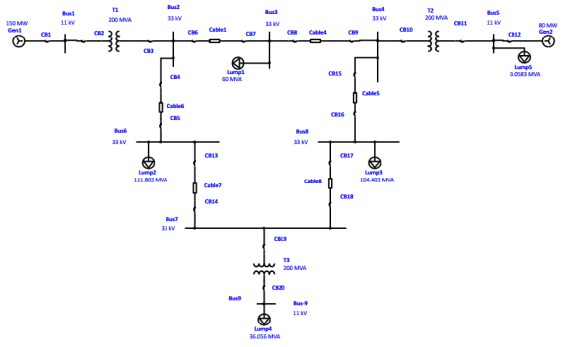

Figure: - IEEE- 9 bus System in ETAP software.

(ii)After load flow analysis, the initial parameters of the system e.g. bus voltages, bus frequency, bus power angles, bus Power factor, generator power angles, generator power rating , current flow are studied. Here two generators(G1,G2) are closed and buses are operating in their normal Pf. The list of percentage Pf of each bus is shown in table .

	Bus 4	Bus2	Bus6	Bus7	Bus8	Bus3
Bus 1	85.05	85.05	85.05	85.05	85.05	85.05
Bus 2	73.94	73.99	73.86	73.88	73.91	73.96
Bus 3	100	100	100	100	100	100
Bus 4	83.79	83.71	83.67	83.63	83.59	83.75
Bus 5	83.75	83.75	83.75	83.75	83.75	83.75
Bus6	98.78	98.78	98.78	98.78	98.78	98.78
Bus7	98.48	98.48	98.48	98.48	98.48	98.48
Bus8	98.31	98.31	98.31	98.31	98.32	98.31
Bus9	98.4	98.39	98.4	98.4	98.4	98.39

Table:- The Percentage Pf at different buses when both generators are connected without Solar panel.

(iii)For expansion of grid connected Photovoltaic System a 100 KW Solar panel is used in this project. In IEEE -9 bus System there are 9 buses and our aim is to analyses which bus perform maximum power factor improvement. Our Solar Panel is rated for 33 KV ,so we connect solar panel in all 33KV bus one by one and load flow analysis is performed .

Due to any reason if Generator 1 is shut down or any fault occurs in Generator 1, we connect solar panel in all 33KV bus one by one and load flow analysis if performed.

(iv)Let us take an example, and connect PV panel to Bus 4.Here Gen 1 is in shutdown condition and Gen 2

is in operation .We have seen the power factor of bus 3 is decrease which is shown in figure . We know that in buses many type of loads are connected (industries, hospitals) which requires uninterrupted power supply .The pf of bus 3 is decrease from unity to 0.56. And we know that low Pf cause high current, heating problems. Similarly buses(bus2,bus6) gives same result. So we want to improve Pf near about unity.

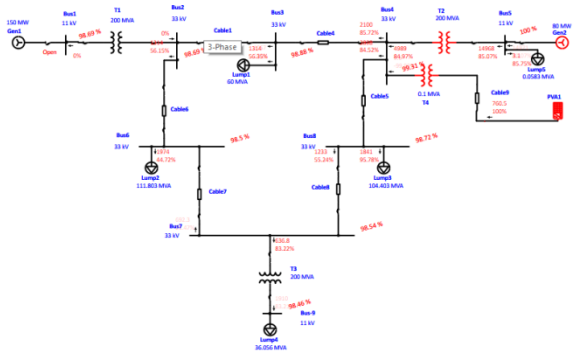

Figure: IEEE 9 Bus System when PV panel is connected to bus 4 .

(v)When we connect PV solar panel to bus 3with Gen 2 is in operation and Gen 1 is at shut down the Pf of bus 3 is improve which is shown in figure. Out of these if we connect PV solar panel across bus 3,the Power factor improvement is better as compare to others which is shown in table . When we connect PV solar panel in other buses(i.e. bus 4 ,bus 2, bus 6) the Power factor is **0.56** and we connect PV solar panel in bus 3, the Power factor is become 1(unity) and this the best location to connect solar panel in this IEEEE 9 bus system.

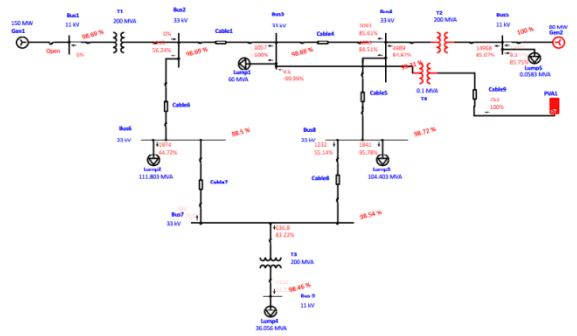

Figure: IEEE 9 bus System when PV solar panel is connected to bus 3.

	PV Panel at Bus 4	PV Panel at Bus 2	PV Panel at Bus 6	PV Panel at Bus 7	PV Panel at Bus 8	PV Panel at Bus 3
Bus 1	98.69	98.69	98.69	98.69	98.69	98.69
Bus 2	98.69	98.69	98.69	98.69	98.69	98.69
Bus 3	56.35	56.02	56.1	100	100	100
Bus 4	84.52	84.49	84.47	84.46	84.44	84.51
Bus 5	85.07	85.07	85.07	85.07	85.07	85.07
Bus6	98.5	98.5	98.5	98.5	98.5	98.5
Bus7	98.54	98.54	98.55	98.55	98.54	98.54
Bus8	98.72	98.72	98.72	98.72	98.72	98.72
Bus9	98.46	98.46	98.46	98.46	98.46	98.46

Table: - Changes in Percentage Power factor at different bus due to PV panel connection when Generator1 Shut down.

(vi)When we connect PV solar panel any other buses (i.e. bus 4,bus 2,bus 6) there is problem arise. The Power factor of bus 2 and bus 6 are decrease. To solve this problem ,we connect a Capacitor bank across bus 3 which is connected through relay system which is shown in figure. When the pf of decreased due to connection of other buses ,the relay send trip signal, and capacitor bank is connected to bus 3. The Advantage of connection of Capacitor bank to bus 3 is not only improve the bus 4 Power factor(0.84 to 0.88) but also it improve bus 5 Power factor(0.85 to 0.97) which is shown in table.

	Bus 3
Bus 1	98.78
Bus2	98.78
Bus3	100
Bus4	88.86
Bus5	97.78
Bus6	98.58
Bus7	98.62
Bus8	98.79
Bus9	98.54

Table:- Power factor improvement due to Capacitor Bank in bus 3.

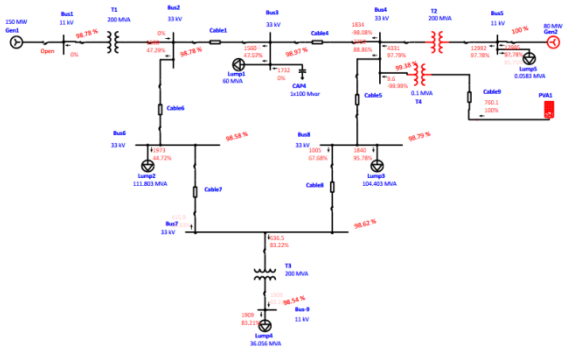

Figure :- IEEE -9 bus System with PV solar pannel at bus 4 and capacitor bank connected to Bus -3.

(vii) Study and Planning for expansion of grid connected Photovoltaic system is done in ETAP Software.

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