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Analysis of Grid Connected Solar Farm in ETAP Software

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ABSTRACT

In today's day to day life the energy requirement growth will increasing rapidly. The use of renewable energy is important to provide rapid increased energy demand. Solar energy provides free energy from sun which is pollution free, clean and maintenance free energy. This paper aims to analyse the performance analysis of grid connected solar farm. This analysis consists of load flow analysis, active power flow at different irradiance, reactive power analysis and short circuit analysis on impact of 1-ϕ and 3-ϕ. To accomplish this proposed system modelling is done in ETAP (Electrical Transient Analyzer Program) software.

Keywords:ETAP (Electrical Transient Analyzer Program), load flow analysis, solar farm, short circuit analysis.

I. INTRODUCTION

Over the past few years, the requirement for renewable energy resources has increased rapidly due to the decreasing fossil fuels and its adverse impacts on environment. From different types of renewable energy resources the solar energy gives more cleanly and pollution free energy [1]. India is most promising country for the development of solar power systems. It is because most part of the country includes high number of sunny days and daily irradiance. Also it provides high efficiency, better reliability and low cost for generating electrical energy [1]-[2].

The main objective of this paper was to analyze the performance of the grid connected solar farm. The analysis includes load flow analysis, active power flow at different irradiance and cable lengths, reactive power analysis at grid side of the solar farm and short circuit analysis. There are different types of the analyzer program which are helps in analysis of solar farm including solar panels, for providing better performance of the system. The performance analysis of solar farm model was simulated in ETAP (Electrical Transient Analyzer Program) software for appropriate operation. The overview of solar farm was simulated in ETAP as a single line diagram. The solar farm included 20 solar panels each of 315 W per panel connected 30*40 in series and parallel respectively constituting total capacity of each solar panel was 378 KW. The overall capacity of solar farm was 7560 KW; the system was internally connected through cables. The solar farm was monitored for analysis on 132 KV voltage level at bus 1. Adaptive Newton – Raphson method was implemented for load flow analysis at different irradiance.

II. AN OVERVIEW OF THE SOLAR FARM FOR ANALYSIS

Solar farm was designed included 4 networks with total capacity of 7560 KW. All networks comprise 1630 KW and each solar panels capacity is 378 KW. Grid (U1) operates at 132 KV bus voltage connected in series with transformer (T1) with capacity of 50 MVA. Further the networks 1, 2, 3 and 4 are connected in parallel through step-up transformer T2, T3, T4 and T5 respectively with capacity of 2.5 MVA at 33 KV. The solar panels are connected to these step-up transformers at 1/33 KV.

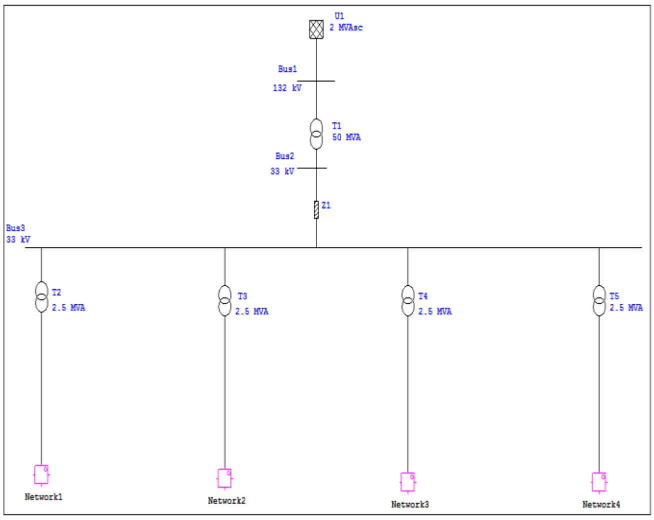

Figure 1. Single Line Diagram of the Solar Farm

III. SOLAR SYSTEM

Solar farms are designed using photovoltaic technology for conversion of electricity directly from sunlight by using solar cells. The number of solar cells electrically connected in series and parallel to form a solar module and number of solar modules connected together to form an array. This structure is useful for increasing production of electric energy [3].

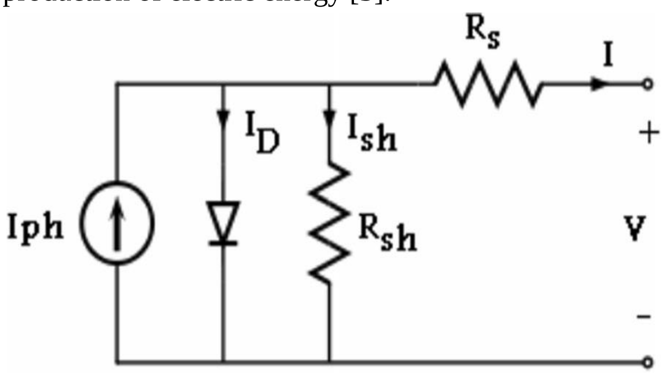

Figure 2. Equivalent circuit of solar cell

The equivalent circuit of solar cell is shown in fig. 2. Where Iph is current source, Rsh is shunt resistance and Rs is series resistance. The Rsh value is very large and Rs value is small, so for simplification these values are neglected. K presents Boltzmann constant, N is represents diode ideality factor and T represents the cell temperature. The equivalent circuit of solar array is shown in fig. 3. The load current equation is shown below [4].

$$I = I_{PH} - I_S\left[exp\frac{q(V+IR_S)}{NKT} - 1\right] - \frac{(V+IR_S)}{R_{SH}} \qquad (1)$$

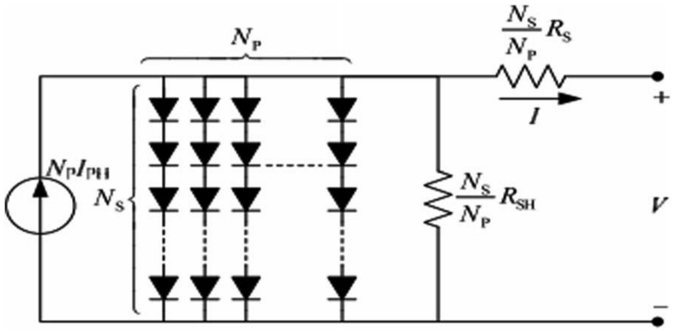

Figure 3. Equivalent circuit of solar array

The photovoltaic systems are of two type's namely stand-alone system and grid connected system [2]. This paper is focuses on the grid connected solar system and the solar cell was made by polycrystalline silicon.

Grid connected systems are directly connected to the utility grid and there is no need to use of battery storage. In this system the generated electric energy is directly convert to the alternating current by use of inverter and supplied to utility grid [5]. Utility grid supplies reactive power to the system, so the compensation of the reactive power is necessary to prevent voltage profile.

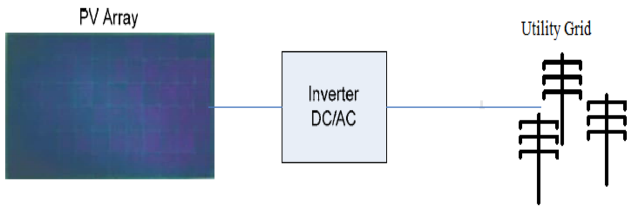

Figure 4. Grid Connected Solar System

IV. RESULTS AND DISCUSSION

a) Load flow analysis

In ETAP, load flow analysis was performed power flow analysis for individual networks and voltage drop calculations with accurate and reliable results. In this paper adaptive Newton-Raphson method was executed for the load flow analysis. Active power flow at grid was around 6448 KW and for individual network active power flow was 1623 KW.

Table I

Active power flow

Network	Actual (KW)	Simulation (KW)
Total (At Grid)	7560	6448
Network 1	1890	1623

Network 2	1890	1623
Network 3	1890	1623
Network 4	1890	1623

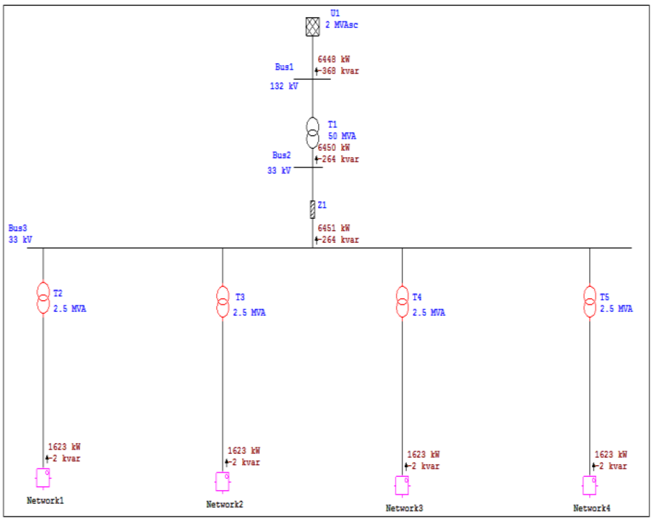

Figure 5. Active power flow

b) Active power flow at different irradiance

The output of the solar module is directly proportional to the incident irradiance. The irradiations are varies depending on the position of the sun and weather throughout the day. The power output changes at different irradiations as per the position of sun in the sky. The results are shown in table 2 below.

Table II

Active power at different irradiance

Irradiation (W/m2)	Active power output (KW)
147	881
237	1435
660	3957
854	5054
892	5265
912	5375
937	5513
950	5584

The simulated analysis shows that the active power output of the solar plant varies with changes in incident irradiance. The analysis shows that higher incident irradiance gives higher active power as shown in table 2.

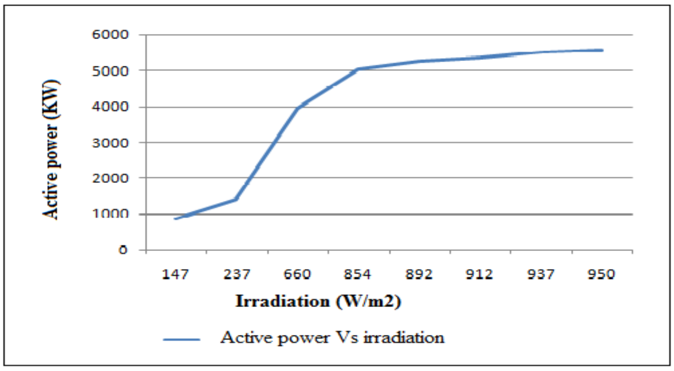

Figure 6. Active power curve at different irradiations

The active power curve shown in Fig.6 clearly shows the power output of the solar farm is directly proportional to the incident irradiance of the sun.

c) Reactive power analysis

The reactive power is very important factor in performance of the system. In the grid connected system the reactive power must be balanced to prevent voltage problems. The load flow analysis shows the absorption of reactive power from the grid as shown in above Fig. 7. The total reactive power at the grid is 1.2 Mvar, and each network consume 0.2 Mvar. The negative sign shows that the grid supplies the power towards opposite direction.

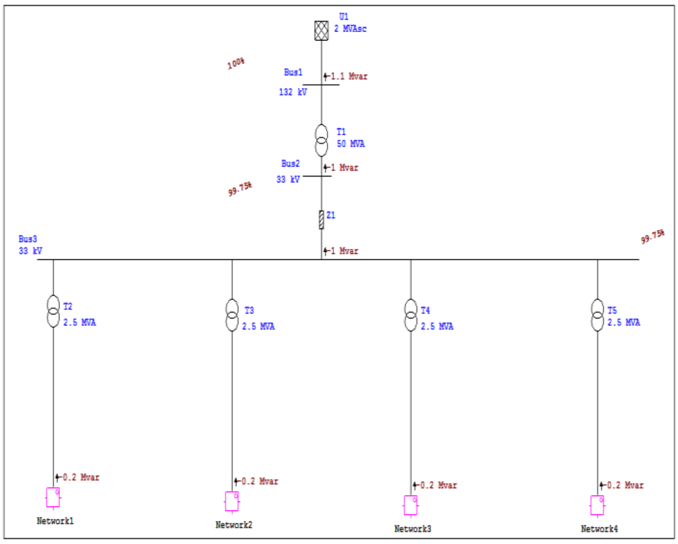

Figure 7. Reactive power drawn from the grid

For balancing the output and to improve efficiency of the solar farm, the compensation of reactive power is very much important. To overcome this capacitor bank was implemented in the system. Capacitor bank was designed with appropriate parameters to improve stability with reducing the reactive power drawn from the grid.

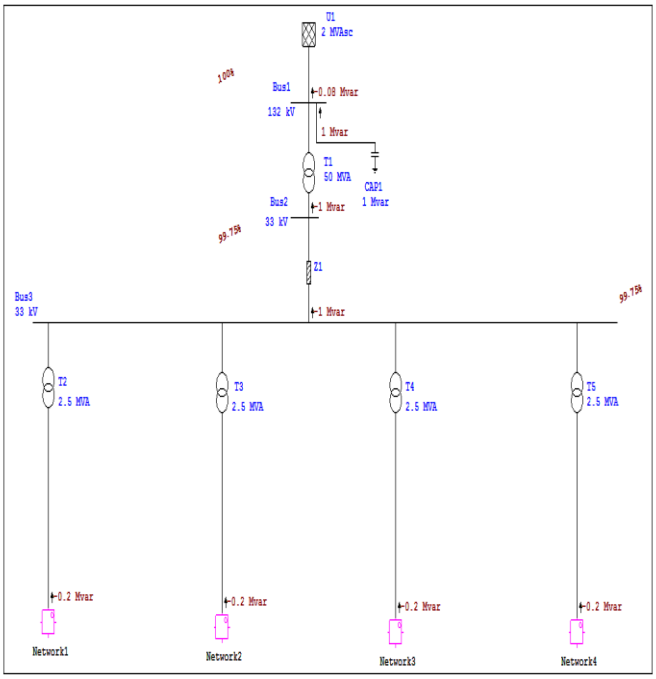

Figure 8. Reactive power compensation using capacitor bank

As shown in Fig. 8 the compensation of reactive power is successfully done using capacitor bank at Bus 1 with 132 kV voltage level. After using the capacitor bank the total reactive power drawn from the grid was 0.08 Mvar. Using the proper sizing of the capacitor bank the stability and efficiency of overall system will be improved.

d) Short circuit analysis

The ETAP software was considered for short circuit analysis in solar farm. The main factor of the short circuit analysis is to determine the ability of system to return back to the normal state after recovery of fault. In the solar farm the analysis was done for the short circuit faults which are single line-ground fault and three phase short circuit fault. This analysis was performed at the main Bus 1 near to the grid. In the analysis the total simulation time was consider 10 sec for study the impact of both faults and clearing time of the faults. The fault occurred at 2 sec and cleared at 2.5 sec.

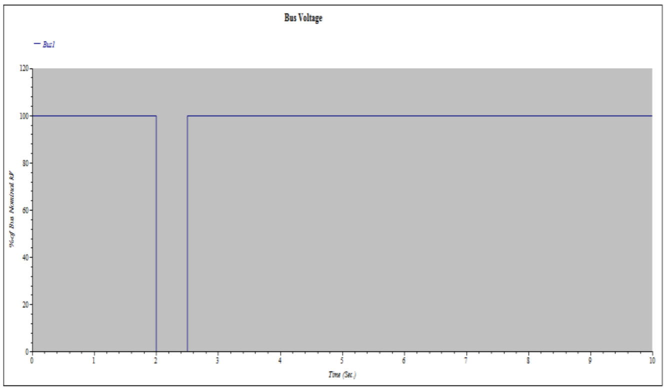

Figure 9. Voltage at Bus 1 during 3- ϕ short circuit fault

Firstly start with 3- ϕ fault, after the occurrence of the 3- ϕ fault the voltage was dropped to almost 0 kV and after clearing the fault the system will return back to the100% normal operating voltage with the clearing time 0.5 sec. Second the 1- ϕ line-ground fault, after occurrence of this fault the system voltage recovered quickly under this analysis.

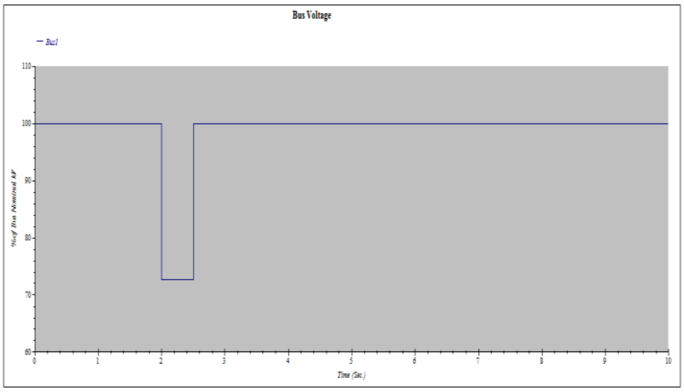

Figure 10. Voltage at Bus 1 during 1- ϕ line-ground fault

V. CONCLUSION

In this paper analysis were carried out includes load flow analysis, reactive power analysis and short circuit analysis. The active power flow at different irradiance was analyzed. The reactive power analysis result shows that high amount of reactive power absorption from the grid. Hence compensation devices are required for reactive power compensation like capacitor bank, SVC's and STATCOM. In this analysis capacitor bank was implemented to compensate reactive power which is cheaper than other devices. The short circuit analysis was used to determine system ability to recover from the fault. The 3- ϕ fault has more severe impact than 1- ϕ line-ground fault on the system.

VI. REFERENCES

[1] Nisha Sharma, Deepak Dalal, "Efficiency and Result Analysis of 50Kw Grid Connected PV System Using MATLAB/SIMULINK," IJAREEIE, Vol. 4, Issue 10, October 2015.

[2] D. B. Raut& A. Bhattrai, "Performance Analysis of Grid Connected Solar PV System Using Matlab/Simulink," Rentech Symposium Compendium, Volume 3, September 2013.

[3] Ram Krishan, Yog Raj Sood and B.Uday Kumar, "The Simulation and Design for Analysis of Photovoltaic System Based on MATLAB," Electrical Engineering Department National Institute of Technology Hamirpur (H.P.) India, IEEE Dec. 2013.

[4] Md. Aminul Islam, Adel Merabet, RachidBeguenane and Hussein Ibrahim, "Modeling Solar Photovoltaic Cell and Simulated Performance Analysis of a 250W PV Module," 2013 IEEE Electrical Power & Energy Conferenc (EPEC), 2013.

[5] S.M.A.Faisal, "Model of Grid Connected Photovoltaic System Using MATLAB/SIMULINK," Department of Electrical & Electronics Engineering Ahsanullah University of Science and Technology Dhaka, Bangladesh.