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A Review - HVDC Application of SOLAR POWER and its Control

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ABSTRACT: Previously, Solar PV plants interconnected with Grid generates DC power. Then DC power is converted into AC power through inverters and connected to AC grids for transmission purpose. Now days, the trend of using HVDC transmission network becomes popular. With HVDC transmission, the transmission and distribution losses become minimized. Transmission of power from solar plant to grid through HVDC is discussed in this paper. Due to modern technology, automatic monitoring and control is necessary for HVDC transmission over long distance for protection against theft, faults etc. MATLAB simulink is used for the interconnection of solar plant and AC grid through HVDC and PLC simulink is used for HVDC control.

KEYWORDS: HVDC, PV plants, DC, AC, MATLAB, PLC, PPM, NASA, SCADA.

I. INTRODUCTION

With modernization, the demand for electricity is rising day by day [1]. Electricity is generated from two forms of energy:

1. Renewable.
2. Non Renewable.

New methods of generating electricity are:

1. Solar and Solar thermal plant grid integration.
2. Hydro plant grid integration.
3. Roof top PV solar array system.

Due to bad impacts of non renewable sources of energy on environment, coal is replaced with renewable energy like solar. Hence efficiency of electricity production is improved [1]. Sun is available 300 days in India, so solar energy is a key role of electricity generation in India. Solar energy is a clean energy. The trend of generating electricity through PV solar plants is increasing. It meets the requirement and makes energy independent till 2030.
Among all renewable energy sources, solar energy is the best and reliable source. Solar energy is a low cost energy. Most of the electricity is produced by thermal plant. But according to NASA study carbon dioxide emission is reduced from 380 PPM to 350 PPM [2].

A. Solar Power

Due to government support and less cost solar power viable in economic terms. Sun rays hit on the PV solar array and power generated is stored and converted into DC by converter in String monitoring box and pass to inverter for conversion of DC power into AC power. AC power is then transmit to consumers by substations or grids. Transformers are used to step up or down the voltage level.

B. HVDC Transmission

Generation and demand balancing at a required level is important in industrialization. HVDC is a low cost transmission medium for large distances [3]. HVDC transmission contributes to the sustainable and reliable transmission system to meet electricity need. HVDC was first discovered in 1930s in Sweden. The main component is converter which acts as an interface with AC transmission system. It improves grid performance in the event of power disturbances. Power can be easily reversed without changing control mode.

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C. PLC Control

Protection and control ensures gird stability [4]. In bad environmental conditions or in large power plants, it is difficult to detect the fault at a proper location. So automation is necessary for large plants and such conditions. PLC is used as a communication system for automatic fault detection and recovery, meter reading and control of plants. Theft control is the basic problem in the electricity so it is difficult to detection theft over large distances transmission. Hence PLC or SCADA is used for this purpose.

II. LITERATURE SURVEY

[1]. Suprava Chakraborty et. al. [2014] presented that previous HVDC grid is a solution for reducing transmission losses in power generated through solar plants. DC- DC bypass diode is used to generate high voltage DC voltage. Simulation results are presented in P- SIM software.
[2]. Alwin Vinifred Christopher et. al. [2014] explained that electrical theft is the main non technical loss in the power system. This paper provided the scheme for detection and monitoring of theft control. Any theft is detected with differential change in narrow band carrier signal.Matlab software is used for simulation.
[3]. M. Rosa et. al. [2012] proposed a paper in which remote monitoring system to measure the temperature of small wind power using power line communication technology is presented. The network behavior was analyzed with network analyzed software. Turbine temperature is controlled and results will be observed.
[4]. F.J. Sanchez Pacheco el. al. [2011] emphasized in this paper that in PV solar plants, all the information is gathered through monitoring system. Faults present in solar plant due to high wind, rain etc is necessary to find at proper location, so automatic control is the best medium for these types of problems.
[5]. Stefano Galli et. al. [2011] stated the applications of PLC in smart grids. Studies on electrical and topological properties of a sample power distribution system are showed in this paper.
[6]. Zhanqing Yu et. al. discussed the experimental research on EMI of PLC system of 500 KV HVDC converter station. During switch operation transient disturbances is presented.

III. PROBLEM FORMULATION

With the advancement in technology, the need of electricity in the world is rising day by day. Burning of fossil fuels create huge amount of pollutants in the environment. 50% of the world's electricity is produced from fossil fuels like thermal, gases and oil. But these sources tackle number of challenges such as rising prices, security and climate change risk.
Non fossil fuels are the future of the electricity demand. Solar, wind and hydro plants are the main sources of the non fossil fuels. These types of sources generate massive electricity. Solar PV plants are the practical ways to clean up our environment from emission of CO2 and global warming. A solar plant does not have noise, leaking pipelines and cooling problems. It also has no moving parts.
A solar PV plant with HVDC transmission improves the efficiency. It is possible to transfer electricity over thousand of kilometers through HVDC lines. If we connect several areas through a single HVDC line in series, this formulation reduces the losses during transmission and need for transformers and DC to AC converters. It transports power economically over large distances.
Mathematically

1. **Minimize the Co_2 emission in the environment**:

   Min Co_2 emission = Min $\sum$ Emission from Fossil Fuels

   $$= \text{Min} \sum E_{coal\,(t)} + E_{oil\,(t)} + E_{gas\,(t)}$$

   $$= \text{Min} \sum E_{FF(T)} \quad (1)$$

   Subject to Electricity generation

A. **Maximize the efficiency**:

   Max efficiency = Max $\left(\frac{Energy\ \ output\ \ from\ \ solar\ \ cell}{Input\ \ energy\ \ from\ \ sun}\right)$ (2)

   Subject to Solar Equipment

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IV OBJECTIVE OF THE STUDY

1. Comprehensive literature survey related with solar energy, HVDC transmission and PLC control etc.
2. To compare the efficiency and emission produced in thermal and solar plant.
3. Analyze the benefits of solar power on non renewable energy.
4. Modeling of PV solar plant interconnected with Grid through HVDC using MATLAB SIMULINK environment.
5. Control of HVDC transmission line in PLC.

V. METHEDOLOGY ADOPTED

1. Analyze and Comparison of the efficiency and emission of solar power on other modes of power have been studied.
2. Model of PV solar plant interconnection with AC grid through HVDC has been made using MATLAB software.
3. Model of HVDC control has been made in PLC Rockwell's software.

VI. SCOPE OF THE RESEARCH

1. Grid Stability.
2. Reliability.
3. Minimization of Cost.
4. Reduction in emission.
5. Generation and Demand balancing.
6. Automatic Control.

VII. CONCLUSION

Solar power is the best source to produce electricity in the world. The study shows that HVDC transmission has lesser cost than AC system and is used for interconnection of solar plant with grid for reliability and stability of grid. PLC is used for monitoring of HVDC line over large distances.

VIII. ACKNOWLEDGEMENT

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