A Grid Connected PV System of Solar Panels

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Abstract— A significant component of the energy balance in most regions and power systems, photovoltaic (PV) energy is expanding at a rapid rate each year. In this work, the effect of attaching a PV power grid will be explored with real-time modeling of the plant using RSCSD software (RTDS). Studying the effects of changes in the power factor of loads, PV saturation, overtones introduced into circuit by PV inverter, and the PV system's anti-islanding capability. Finally, the dependability and grid connectivity of a standard grid-connected PV system are examined using the Achievement Ratio (PR) of the PV system. With a constantly rising yearly rate, photovoltaic (PV) energy is gradually playing a significant role in the energy balance in most regions and power networks. With the help of real-time system simulation using RSCSD software on the Interactive Digital Simulator, it study aims to investigate the impact of joining a PV power system (RTDS). The effects of changing the power factor of loads, shifting the penetration of PV, adding oscillations to the circuit via the Inverters, and the PV system's anti-islanding properties are all investigated. Finally, the dependability and grid connectivity of the PV system are assessed using the Perform Ratio (PR) of a typical grid-connected PV system.

Keywords: Fault Ride Through, Insulated Gate Bipolar Junction Transistor, Maximum Power Point Tracking, Perturb and Observe, Phase Lock Loop, Anti-islanding ,Grid connected PV, Harmonics, , Performance Ratio (PR), RSCAD, RTDS

I. INTRODUCTION

The Indian continent has a significant push for solar energy. By the end of February 2020, 42 solar projects had been erected across the country, bringing the generation capacity to up to 34.4 GW. Figure 1.1 shows the rise of solar installations on a year-by-year basis. Due to its pragmatism, renewable radiation is becoming more and more in demand. Table 1.1 collates the developer installation of PV systems. The table shows that the grid-connected function of solar power production plays a crucial role in its production. Two layers make up the grid-connected operation; the first is the DC-DC conversion, which uses the MPPT technology and a DC-DC boost converter as its components. The MPPT methods known as incremental conductance and perturb n' observation are the most used (PO). In this layer, the PV's Current output voltage is managed with PO-MPPT and amplified to the necessary level with a DC converter. The second layer involves utilising an inverter to convert from DC to AC while maintaining grid connectivity. The dual tasks of an inverter are to integrate solar power into the current utility system and to convert DC to AC [1-3].

A. Low Voltage Ride through

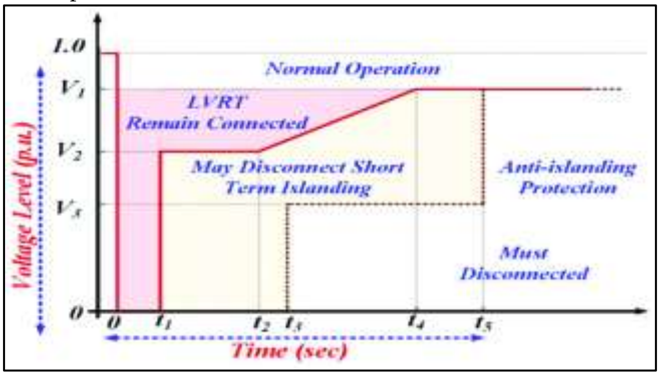
Power quality is a concern for system operators and utility since there has been a huge penetration of stochastic renewable sources especially PV. While designing and controlling grid feeding photovoltaic (PV) inverters the biggest challenge is meeting the grid code of voltage limit as well as frequency. International grid requirements demand low-voltage ride-through (LVRT) capability and maintaining grid functionality during fault conditions and smooth post fault recovery.

Based on conventional control methods, PV systems should be disconnected from micro-grids during grid faults conditions, due to the converter stability and protection. However, in recent years, a well-known requirement has set for PV systems called low-voltage ride-through (LVRT) capability, which is been applicable for other distributed generations regarding regenerative loads, compensation systems and energy storage applications. In other words, the PV systems must be able to stay in connected to the microgrid for power quality enhancement under grid faults and to enhance voltage profile. The unregulated output power of PV power station under abnormal conditions can be regulated through grid-friendly converters, and the power system reliability can be guaranteed depending on the performance of these power converters. Over the years, numerous LVRT control techniques have been proposed and introduced related to renewable energy technologies, which is obvious from increasing growth of relevant papers that have been published in assorted journals and proceedings.

When fault occurs grid side, if quick disconnection of PV plants (PVPs) is carried out it may influence the grid-stability, particularly with large capacity PVPs. Hence, FRT requirements of the modern grid codes insists PVPs to remain connected when the grid voltages undergoes sags for a specific period. This is required to make sure there is no loss of power generated due to commonly voltage sags. To fulfil the reactive power demand at the time of fault to maintain the FRT profile additional control strategies are needed to be incorporate in the control architecture of the grid connected PVP. This architecture may be within the inverter control system or external circuit need to be connected.

In order to fulfil the FRT characteristics to accommodate the penetration of significant PVPs into power utility while the occurrence of the voltage sag, the control system must be capable of the following measures: (a) fast and accurate fault identification to inform the system to switch from steady-state operation mode to the faulty one; (b) safe guard the PV inverter and other sensitive devices from the over-current that occurs at AC side; (c) safe guard the capacitor of the DC-link and the inverter from the DC-link over-voltage at DC side of the converter; (d) injection of the required quantity of reactive currents to assist the grid voltage recovery; and (e) guarantee that the PVP stays coupled to the grid for a stable operation. These measures may be classified based on their strategies for improving the FRT capability of the grid tied PVP such as, by applying: • Sag detection unit. • Protection circuits/devices only during grid faults. • Reactive current injecting controllers/devices during grid faults. •

Suitable control structures during both grid faults and steady state operation.



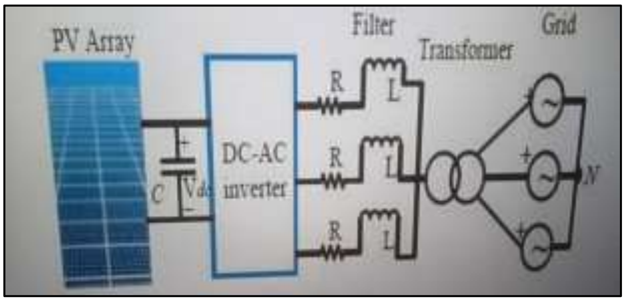
II. GRID CONNECTED PV PLANTS (GCPV)

GCPV could have two configurations, i.e., single-stage and two stage systems, depending on the conversion systems and power. The direct connection of PV-array to the DC side of the inverter is called single stage conversion.

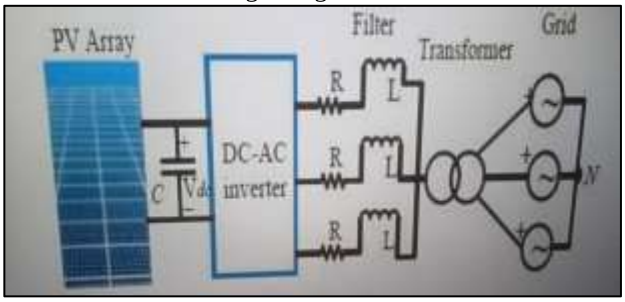
The two-stage conversion system consisting of DC-DC converter part as a first stage exists between the PV array and the inverter, and then followed by the second stage, which is the inverter part to invert the available DC power to AC power. In both topologies control of the inverter plays an important role to maintain the quality of supply of the input side and grid side. The priority of the input controller is to obtain the maximum available power from the PV energy systems, while controlling the grid power flow in a way to maintain PQ issues. The utmost responsibility that the controller plays is to ensure the grid synchronization.

Inverter control techniques may be current-controlled (CC) or voltage-controlled (VC). In CC current signals are considered as reference signals to generate control and in VC voltage signals are referenced. However, the CC inverters are more popularly utilized in grid-connected PV operation when compared to VC inverters.

However the increased installation of GCPV had made them as the part of conventional power plant with innovation in converter topologies. Hence new manifesto and rules regarding the operation of GCPVs were imposed by some countries, which are known as the modern grid codes (GCs) requirement. In the past, GCs required PV systems to disconnect from the grid whenever a fault occurred. However, recently, with this remarkable increase in the integration of PV plants into the power grid, the interruption may cause operational and stability problems to the grid and customers, and may lead to blackouts (Honrubia-Escribano et al., 2018). To solve this issue, one of the most essential requirements is the LVRT or FRT capability that should be met by GCPVs via the PV inverters (Rodrigues et al., 2014). Thus, it is important to analyze PV power's impacts on power grid and impacts of grid disturbances such as grid faults on PV farm generators.



Single stage GCPV



Dual stage GCPV

III. PROPOSED WORK

The controller's main responsibility is to maintain grid synchronisation. There are also workable modern (CC) or wattage convert control techniques (VC). Societal contexts in Ccc & voltmeter signals in VC are referred to as performance and level to generate control. RC rectifier diodes, in opposition to VC transistor, are more frequently utilised in grid-connected PV operation, as on depicted in Fig. 4.3. This is so because control of methods can be created a significant line voltage with avoiding current harmonic disturbances (Hassainee et al., 2014; Hojabri and Soheilirad, 2014; Parvez et al., 2016). Again, there is literature that provides an in-depth analysis of compressor controls for deployment.

IV. OBJECTIVES

The control scheme makes use of a synchronous reference based controller. A PV system that is grid-connected and 10 parallel and 10 series module of 1STH-215P array type having power rating of 2KW. The voltage of PV system is 350 V and current rating is 80 AThe 3 controllers shown in Figure 3 have actually been used to study the performance of the proposed system;

- For constant maximum irradiance.
- For variable irradiance.
- Under the condition of grid fault;
- The efficiency of the DC fault ride through is enhanced but since a controllable DC-bus voltage even in the absence of fault events on the microgrid or the DC/AC converter. In this study, a constant DC supply system is kept to the Photovoltaic system during such a grid-side fault. Additionally, the suggested control strategy can maintain grid power flow during a fault.

V. SYSTEM DESCRIPTION

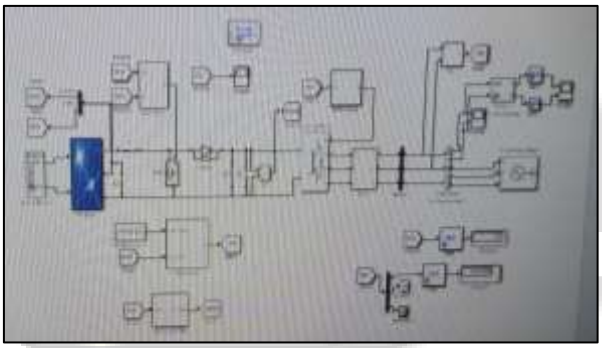
- In the proposed work 10x10 series-parallel solar module of 1Soltec 1STH-215-P is used to design a 20 KW solar system. (Fig 5.1)

- The Vmp, i.e maximum voltage output of one module is 29V, and output for the photo voltaic system design is 111V as shown in Fig-5.3. Using a DC-DC boost converter, the photo voltaic solar system's Dc source is controlled. Figure 5.4 illustrates the input voltage systems engineering. As seen in figure 5.5,
- The boosting converter's power is sustained at (400 V.Given a fixed solar radiation level, the output volt Vpv has to have an effects on the Photovoltaic source's power output, as depicted in Fig. 5.2.
- Utilizing the observe and perturb Maximum power point, the perturb is made by order to improve the solar system's real power consumptioned P [10], [28].

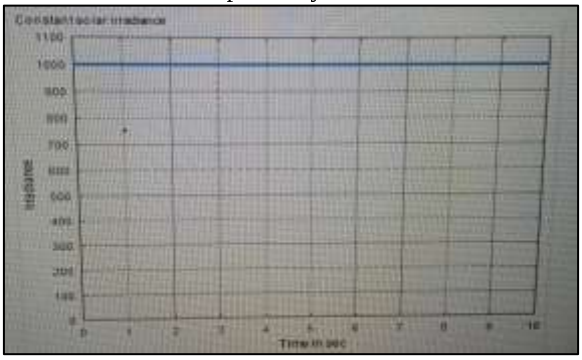
VI. CONTROLLER DESIGN

The goal of the command is to develop a virtual reference signal Vref_ high which causes the input voltage Vdc to obey the required voltage torque Vdc. Figure 5.6 depicts the controller's design, which includes the abc-dq0 transform and PLL.

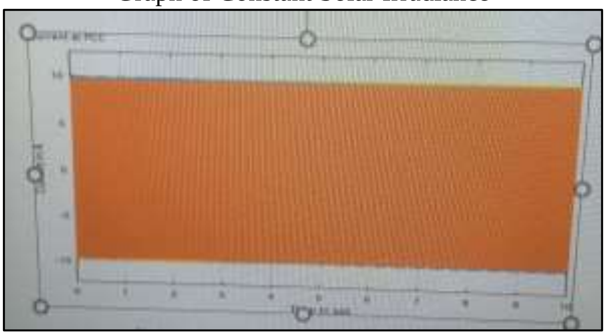
The is capable of fault drive through, meaning is it can maintain steady state DC output on the solar photovoltaic even if a failure occurred on the grid side system.



Model of Proposed System Simulation



Graph of Constant Solar Irradiance



Grid Current for Constant Irradiance of 1000 w/m2

VII. CONTROLLER DESIGN

- The control objective is to design a virtual control input Vref_ peak to make the output voltage Vdc track the Voltage reference Vdc.
- The controller is designed using abc-dq0 transform and PLL.

The design controller has the capability of fault ride through, i.e. it can maintain constant DC output from the solar side when a fault is occur grid side.

The performance analysis of the proposed system has been done under following three operating mode;

1) For constant maximum irradiance.
2) For variable irradiance.
3) Under the condition of grid fault.

VIII. CONCLUSION

The three scenarios of constant irradiance, changing irradiance, and malfunctioning grid-tied PV systems have shown the usefulness of the suggested strategy.

The under-fault PV has been seen to be able to keep FRT even if the system is unable to generate power. The Maximum power point function, solar voltage control, and power flow control have all been integrated into in the dc/ac converter controller in this study. The dc/dc converter controller also controls the dc-bus voltage.

The development of vehicles in recent years has evolved into a field that is heading toward environmentally friendly technology, and the efficiency with which energy and storage sources are used has improved over time. The vehicle's storage system and control system have been the focus of the research. A specially rated ultra capacitor and battery were chosen as the supplies for this study, and several converters including buck, boost, and full-bridge buck-boost converters were simulated. Regarding the distribution of EV batteries in smart settings, there are technical difficulties that need to be addressed. These include energy management techniques and control of the integration of EVs. It also entails the construction of a three-level inverter using MATLAB Simulink.

IX. FUTURE SCOPE

The system has been analysed only for simulation studies, laboratory prototype can also be developed for the future work.

Research and development is a continual and relentless process. For any research work already carried out, there is always room for improvement, which opens up many avenues for further research. As a result of the research in this paper, the following aspects are determined to further the research work.

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