

PV-STATCOM: A NEW SMART INVERTER FOR VOLTAGE CONTROL IN DISTRIBUTION SYSTEMS.

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ABSTRACT

This project presents a novel smart inverter PVSTATCOM in which a PV inverter can be controlled as a dynamic reactive power compensator - STATCOM. The proposed PVSTATCOM can be utilized to provide voltage control during critical system needs on a 24/7 basis. In the nighttime, the entire inverter capacity is utilized for STATCOM operation. During a critical system disturbance in the daytime, the smart inverter discontinues its real power generation function temporarily (for about a few seconds), and releases its entire inverter capacity for STATCOM operation. Once the disturbance is cleared and the need for grid voltage control is fulfilled, the solar farm returns to its pre-disturbance real power production. The Low Voltage Ride Through (LVRT) performance of the PV-STATCOM is demonstrated through both EMTDC/PSCAD simulations and laboratory implementation using dSPACE control. This proposed PV-STATCOM with a response time of 1-2 cycles, can provide an equivalent service as an actual STATCOM in a given application and possibly seek revenues for providing this service.

Keywords: . Index Terms—Photovoltaic (PV) Solar system, Smart Inverter, STATCOM, Voltage Control, Power Factor Correction, Flexible AC Transmission System (FACTS), Distributed Generators.

1. INTRODUCTION

SMART Inverters (also previously known as Advanced Inverters) represent a paradigm shift in the integration of Distributed Energy Resources (DER). These inverters can perform multiple functions involving both reactive and real power control in addition to their main task of converting DC power to AC power. A unique concept of utilizing PV solar farms as STATCOM during night time for providing different grid support functions as well as for providing the same benefits during daytime with inverter capacity remaining after real power generation was

proposed in 2009. STATCOM is a Voltage Source Converter (VSC) based Flexible AC Transmission System (FACTS) device. It can provide dynamic reactive power compensation with a response time of 1-2 cycles, and can provide rated reactive current for voltages as low as 0.2 pu. The utilization of PV solar farm as STATCOM, termed PVSTATCOM, was demonstrated for increasing the connectivity of neighbouring wind farms and enhancing the power transmission capacity during night and day. The controller design of a Voltage Source Converter based Distribution STATCOM (DSTATCOM) on an RTDS and its subsequent laboratory implementation with DSP/FPGA platform is presented in .

2.LITERATURE SURVEY

They explained that multifunction solar cells can produce more power from solar energy with respect to single junction cells. They further explained that very less research has been done on the identification of correct interconnection of multi junction solar cells using power electronic design. They worked over Maximum Power Point Tracking (MPPT) by efficiently designing it for single power point for multiple solar modules. It reduced the design complexity and helped to produce the result in much lower money spent over lengthier MPP tracking systems. They discussed and researched over capacity transmission lines which increases the synchronization with multiple grids. It is highly required to increase the transmission rate and they broke the design of larger grids into smaller segmented grids.

They explained the combined initiative about the AC-DC micro grids. In an individual AC or DC grid multiple process of DC-AC-DC or AC-DC-AC transformations take place. Multiple directional converters work together to produce the output in combine AC/DC grid. They explained the combined initiative about the AC-DC micro grids. In an individual AC or DC grid multiple process of DC-AC-DC or AC-DC-AC transformations take place. Multiple directional converters work together to produce the output in combine AC/DC grid. Their result shows the power wastage got controlled to its maximum level. It helped to provide lighter power with lower cost and higher efficiency.

3.PROPOSED METHOD

The main purpose of this paper is to design a new smart inverter for voltage control in distribution systems. The proposed PVSTATCOM can be utilized to provide voltage control during critical system needs on 24/7 basis.

4. PV STATCOM

A New Smart Inverter for Voltage Control in Distribution Systems. It presents a novel smart inverter PV-STATCOM in which a photovoltaic inverter can be controlled as a dynamic reactive power compensator-STATCOM.

Power is the very essential input for the growth of any economy. Therefore, it is considered as a core industry as it facilitates development across a variety of sectors,

such as agriculture, manufacturing, railways, education, commercial etc. to expel economic development. To meet the high GDP rates the energy needs of the country are unavoidable. To have sustainable growth and social evolution, it is necessary to meet the energy demand by utilizing the nonconventional energy resources like wind, biomass, hydro, co-generation, etc. The need to incorporate the renewable energy like wind energy into power system is to make it possible to reduce the environmental impact on conventional plants.

The integration of wind energy into on hand electrical power system induces power quality problems like voltage regulation, stability, harmonic distortion, voltage sag/swell and poor power factor. The power quality is primarily customer-focused measure and is significantly affected by the operation of a distribution and transmission network. In this proposed scheme one of the Flexible AC transmission system (FACTS) device i.e., STATCOM is connected at point of common coupling (PCC) with a battery energy storage system (BESS) to mitigate power quality problems. Since, STATCOM connected to the grid provides reactive power support to wind generator as well as to loads. The BESS is integrated to sustain real power source under changeable wind or solar power.

In the event of sudden load change or change in voltage profile during short circuit at point of common coupling STATCOM responds fast and stabilises the voltage and also helps to maintain power quality norms during such sudden and unexpected challenges.

This proposed PV cell STATCOM control scheme for grid connected wind energy generation for power quality improvement has following objectives.

- Unity power factor at the source side.
- Reactive power support only from STATCOM to wind Generator and Load.
- Simple bang-bang controller for STATCOM to achieve fast dynamic response.

5. BLOCK DIAGRAM

The single line diagram of the study system is depicted in Fig. 5.1. The study system comprises a 10 kW PV solar system operating as PV-STATCOM connected through a -Y isolation transformer to a 208 VL-L distribution system equivalent model having impedance parameters (R_g , L_g). The total 10 kVA constant-impedance RLC load for a nominal voltage of 208 V is connected at the PCC. The PV system utilizes a 10 kVA two-level six-pulse IGBT-based VSC operating with a switching frequency of 10 kHz. An LCL filter is used to mitigate the harmonics generated by the inverter. In Fig. 2, R_f represents the sum of IGBT ON-state resistance and internal resistance of filter inductor, while L_f models the filter inductance. Generally, to limit the VSC current ripple, the reactance of the filter inductor is selected between 0.1 to 0.25 pu . C_f

represents the filter capacitor in Delta configuration with a damping resistor R_d . C_f is chosen to limit the reactive power exchange below 0.05 pu of the inverter rating.

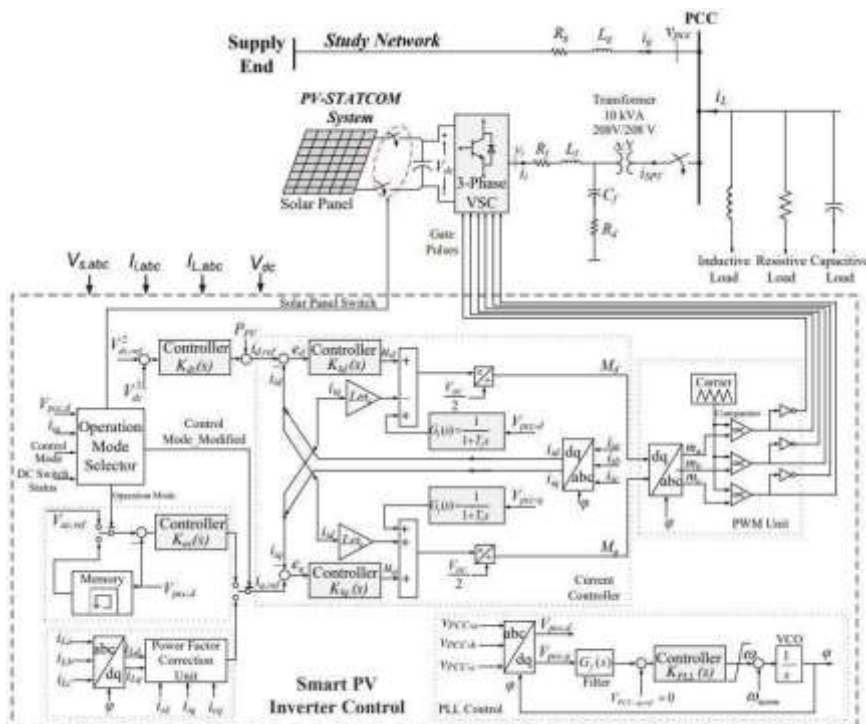


Fig: Modeling of the study system and control components

In the above diagram the PI controller is replaced with the fuzzy logic controller. Fuzzy logic Control basically consist of three components:

- Fuzzification
- Rule Base
- Defuzzification

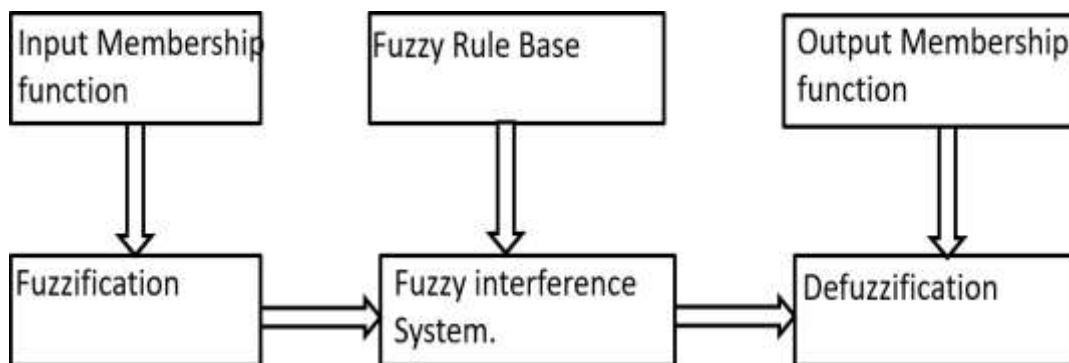


Fig: Block diagram of Fuzzy logic Controller.

6. SIMULATION RESULTS

BLOCK DIAGRAM

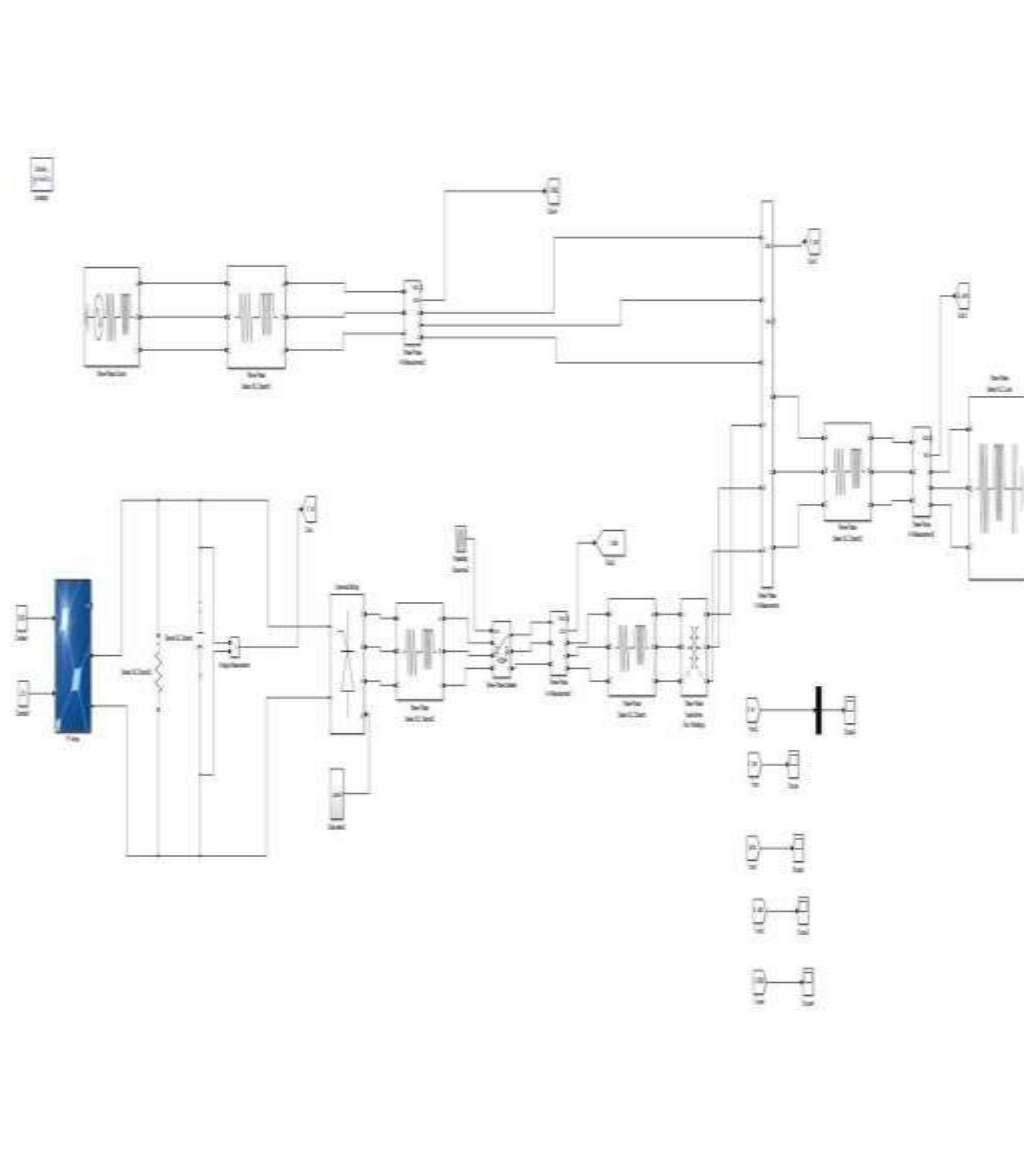


Fig: Simulation Block diagram

RESULTS

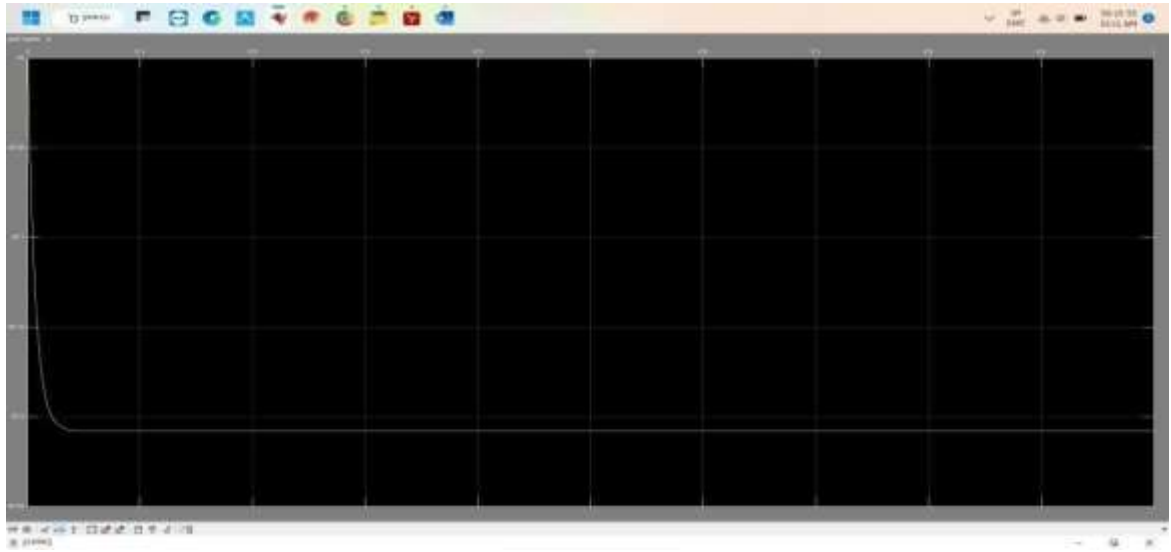


Fig : DC Link Voltage

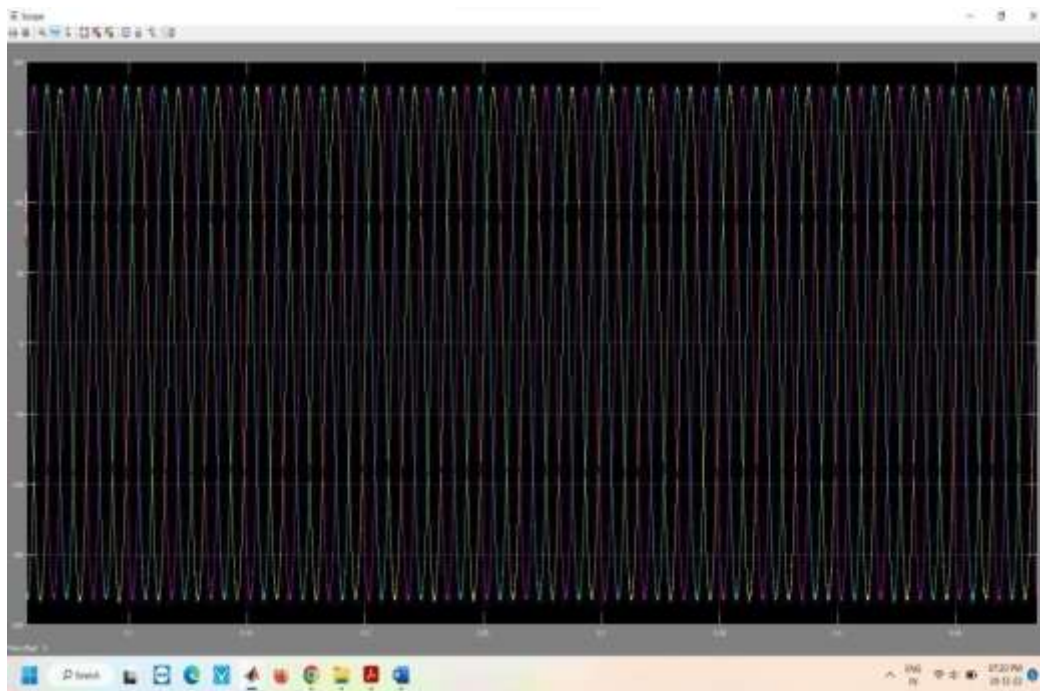


Fig : PCC Voltage

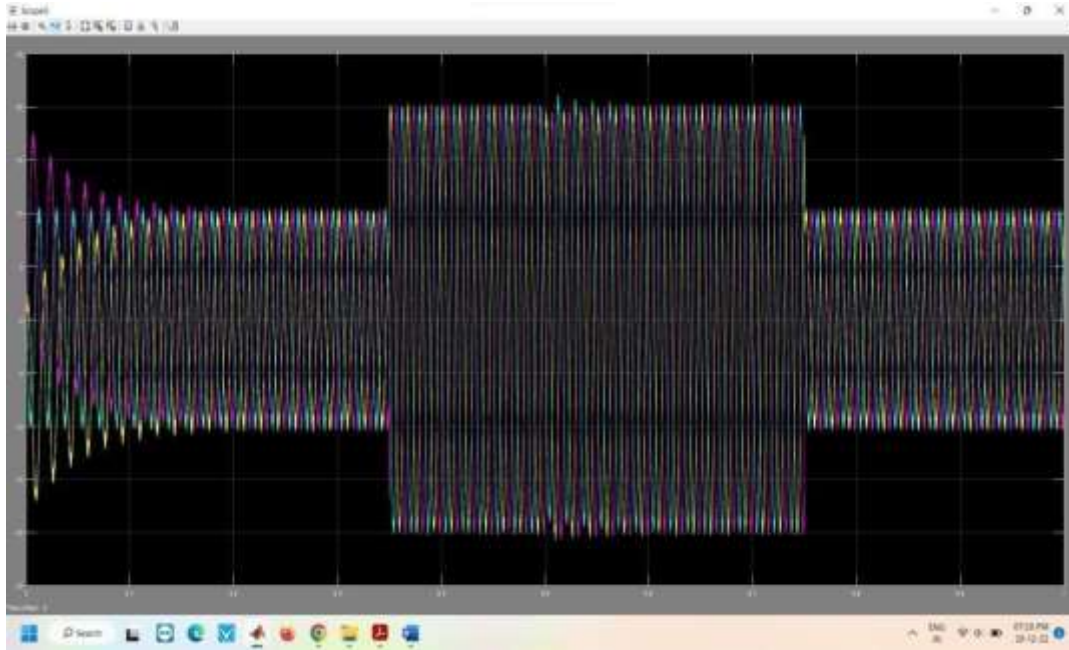


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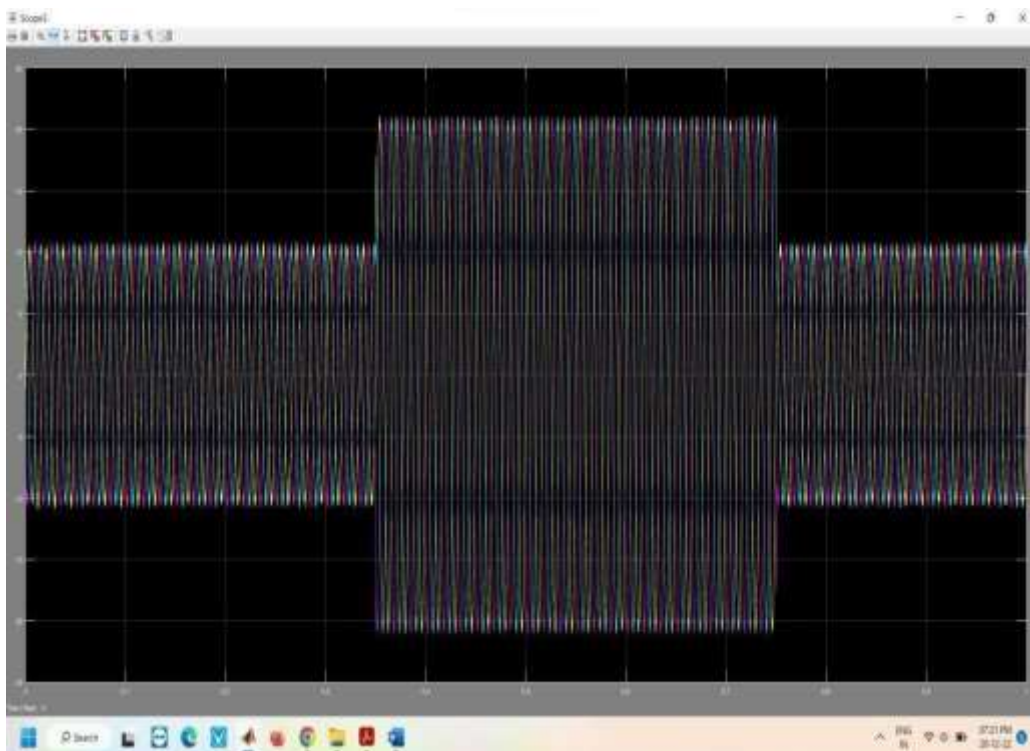


Fig. 6.5 ILabc

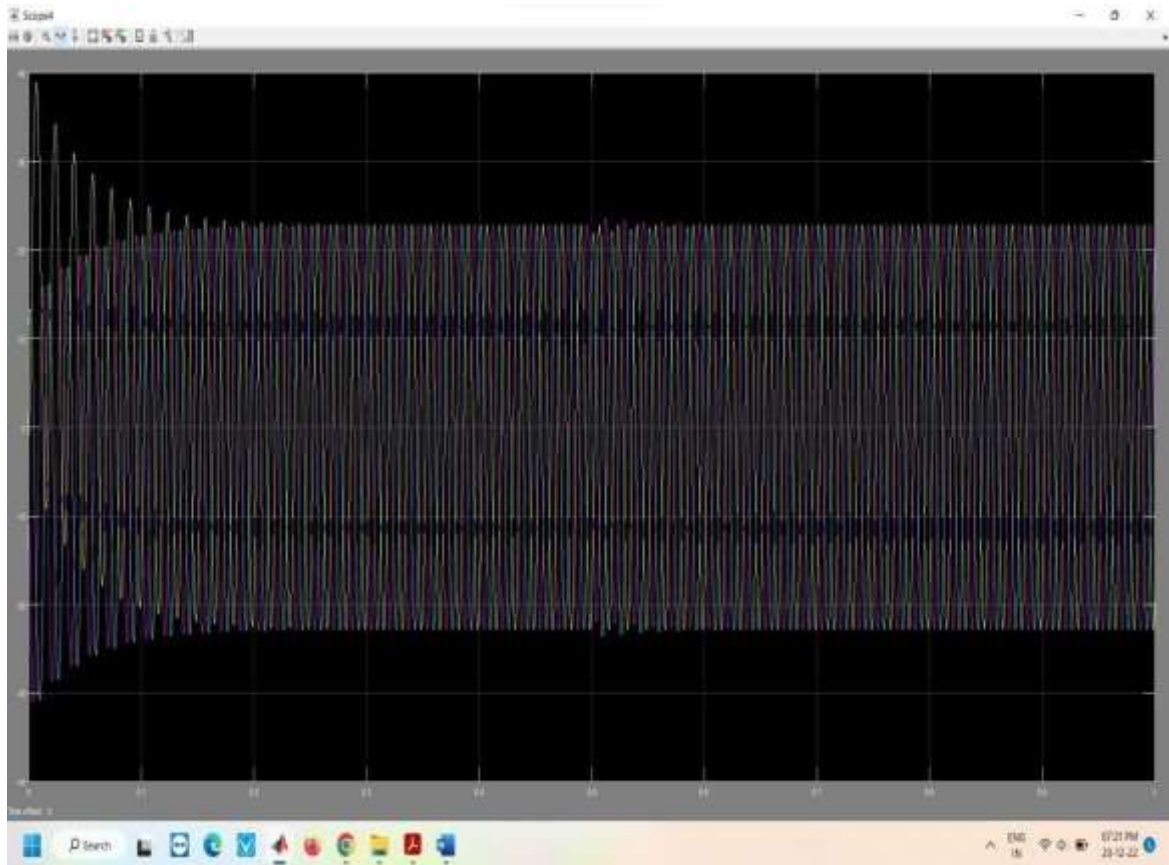


Fig. 6.6 Igrid

7. CONCLUSION

This project presents a novel autonomous smart PV inverter control as STATCOM, termed PVSTATCOM, for voltage control. The smart inverters being presently proposed in literature have the limitation of available reactive power for voltage control during high solar power output. They are unable to provide voltage control during large dips in grid voltage due to large disturbances occurring around noon hours. Moreover, their response time under volt/var control [4] is in the range of 1-2 sec. The proposed smart inverter PV-STATCOM overcomes both these limitations. It operates as a STATCOM with full inverter capacity in night time as well as during any time of the day to provide critical grid support. During a large system disturbance during daytime, it discontinues its real power generation function for a short period, typically a few seconds, and releases its entire inverter capacity for STATCOM operation. It returns to normal pre-disturbance power production as soon as the need for grid support is fulfilled. The response of the proposed smart inverter (1-2 cycles) matches that of an actual STATCOM. The performance of different modes of operation of a 10 kVA PVSTATCOM, during night and day, through both EMTDC/PSCAD software based simulation studies and Laboratory implementation are demonstrated. The Low Voltage Ride Through (LVRT) performance of the proposed smart inverter PV-STATCOM is investigated through

both EMTDC/PSCAD simulation and laboratory implementation studies using dSPACE control. The LVRT tests clearly demonstrate that the proposed smart inverter PVSTATCOM not only meets the LVRT requirement of the Draft IEEE P1547 Standard, but surpasses it by providing dynamic reactive power compensation as STATCOM and successfully regulating the PCC voltage to within the utility acceptable range during the LVRT period.

The LVRT tests further demonstrate that the PV-STATCOM control system continues to remain stable despite transitioning between widely different operating modes. The stability of the PV-STATCOM is ensured by appropriate design of the various PI controllers within the control system to have sufficient gain and phase margins. In addition, during the Full PVSTATCOM mode, the voltage across the solar panels is made slightly less than the open circuit voltage of the solar panels instead of exceeding it. This paper thus presents a novel concept of utilizing a PV solar farm as a STATCOM on a 24/7 basis, for supporting the grid as needed. Such applications will of course require grid code approvals and appropriate agreements amongst the different stakeholders, i.e., the solar farm owner, inverter manufacturer, the interconnecting utility and system operator. This PV-STATCOM function also opens up a potential revenue making opportunity for the PV solar farm by providing similar grid support functions at critical times as an actual STATCOM in a given application.

8. REFERENCES

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