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# Enhanced Virtual Synchronous Generator Control for Parallel Inverters in Microgrids -A Review

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***Abstract***– *Renewable vitality usage originates from the stand point of ecological preservation and fossil fuel shortage. Current studies suggest that in medium and long terms, photovoltaic execution can be found in various parts of the world. In the absence of active input power, grid-tied voltage source converter (VSC) is operated in the reactive power generation mode, which powers control circuitry and maintains regulated DC voltage. Control scheme has been implemented so that the grid-connected converter continuously serves local load.Adata-based maximum power point tracking (MPPT) has been implemented at maximum power which performs power quality control by reducing total harmonic distortion (THD) in grid-injected current under varying environmental conditions.*

***Keyword***-, *VSC, Micro grid, Inverter, Converter,*

## I. Introduction

The integration of intermittent energy sources in power grids has accelerated the necessity of energy management in a multigeneration source network to ensure a reliable and continuous power supply. The microgrid concept illustrates these issues by associating a variety of distributed energy sources and loads in a power network capable of an islanding operation with the main grid [1]. of microgrids are expected to impact the economical, environmental, and electricity supply quality and reliability aspects [2]. Indeed, the coordination strategies of controllable local grids can have many drivers, such as reducing carbon dioxide emissions related to energy generation, guaranteeing a low cost of energy, and maintaining high continuity and/or quality of electric supply. Although no current international consensus on the definition has been established, microgrids refer to a small scale of the power network, with voltage levels used on the distribution network (≤20 kV) and power ratings ranging up to 1 MW [3]. However, some microgrid projects in islands tend to exceed these average values. The off-grid operation mode provided by the microgrid involves the management of several generation sources, both renewable and carbon emitting, combined with conventional and controllable loads. Power electronic and electricity storage devices (such as batteries, flywheels, and ultracapacitors) are also used to manage power fluctuations and supply energy during the transient and steady-state operation of the islanded microgrid. A large variety of devices connected to the local network may combine alternative and dc operating equipment.

Hence, power electronic converters are used to link these elements of various frequencies (nature) to ensure correct operation of generation, storage, and nonconventional loads.

Today, microgrids use ICTs, such as sensors and smart meters, to evaluate the power flows and balance production and consumption using local energy management systems (EMSs). An EMS includes hardware and software capable of monitoring and controlling power generation units and unconventional loads for safe grid operation and quality of supply.

Furthermore, the quasi totality of the cumulated installed PV systems in 2013 is grid connected. The expansion of PV installations is expected to continue in the near future, even though the development has begun to create some disturbances in the energy market, such as overproduction in the German market and the consequent negative energy prices (June 2013). The major problem expected will be due to the stochastic nature of the PV resource and its rapid growth, making it necessary to take measures to improve its integration into the electrical power system. The ultimate goal is the transformation of conventional stochastic PV sources in advanced systems with some degree of controllability, which can modify their output power depending on the grid conditions or system operator [8]. In particular, from the grid side, the objective is making PV systems participate in the frequency and voltage regulation

through active and reactive power control (ancillary services) and to contribute to the fault ride-through capability improvement during faults (avoiding as much as possible the loss of generation capacity in case of a fault).

The simplest solar cell model consists of diode and current source connected parallelly. Current source current is directly proportional to the solar radiation. Diode represents PN junction of a solar cell. Equation of ideal solar cell, which represents the ideal solar cell model, is:

$$I = I_L - I_s\left(e^{\frac{V}{n \cdot V_T}} - 1\right) \quad \text{eq(1)}$$

IL - light-generated current [1] (A),

Is - reverse saturation current [2] (A) (aproximate range $10^{-8}$ A/m$^2$)

V - diode voltage (V), VT - thermal voltage (see equation below),

VT = 25.7 mV at 25°C

n - diode ideality factor = 1...2 (n = 1 for ideal diode)

Thermal voltage VT (V) can be calculated with the following equation:

$$V_T = \frac{k \cdot T}{q} \quad \text{eq.(2)}$$

k - Boltzmann constant = $1.38 \cdot 10^{-23}$ J/K, T - temperature (K)

q - charge of electron = $1.6 \cdot 10^{-19}$ As

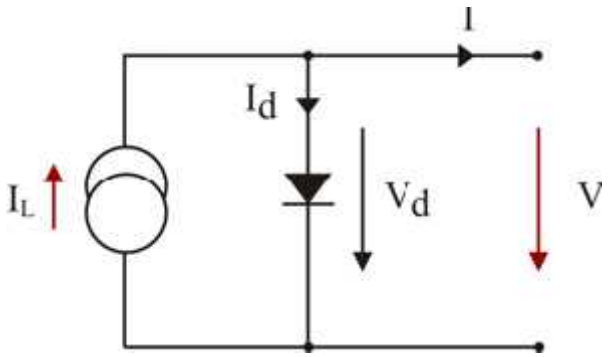


Figure 1: Ideal solar cell model

## II. Literature Survey

Jia Liu, et. al. [1] "Enhanced Virtual Synchronous Generator Control for Parallel Inverters in Microgrids " author proposed , an enhanced virtual synchronous generator control is proposed, with which oscillation damping and proper transient active power sharing are achieved by adjusting the virtual stator reactance based on state-space analyses. Furthermore, communication-

less accurate reactive power sharing is achieved based on inversed voltage droop control feature (V–Q droop control) and common ac bus voltage estimation. Simulation and experimental results verify the improvement introduced by the proposed enhanced VSG control strategy.

Rahul Kumar Agarwal,et al. [2] " LMF Based Control Algorithm for Single Stage Three-Phase Grid Integrated Solar PV System" author proposed control algorithm has been based on a LMF adaptive filtering technique. This technique has been designed for grid integration of SPV system. The simulation results have depicted that THD of the grid currents is within limits and maximum power is extracted from the SPV system. The response of the proposed system configuration has proved to be effective and reliable in comparison with existing conventional control algorithms. Moreover, the experimental results have shown that the single stage SPV system has less losses in the converter system giving rise to high efficiency as compared to the double stage SPV system. The performance of proposed LMF based control algorithm has been found with less oscillations in the weight signals than the conventional LMS control algorithm. The static error as well as MSE involved with the LMF control is lower than the MSE involved with LMS control. In comparison with other conventional control algorithms, LMF is less complex, stable and has a high DSP speed of about 0.26 MOPS (million operations per second). Eventually, it reduces the harmonics on the grid side below 5 % which is the IEEE-519 standard limit for THD.

Akhil Gupta et al. [3] " Power quality improvement of solar photovoltaic transformer-less grid connected system with maximum power point tracking control" author proposed a transformer-less single-stage grid-connected solar photovoltaic (PV) system with active reactive power control. In the absence of active input power, grid-tied voltage source converter (VSC) is operated in the reactive power generation mode, which powers control circuitry and maintains regulated DC voltage. Control scheme has been implemented so that the grid-connected converter continuously serves local load. data-based maximum power point tracking (MPPT) has been implemented at maximum power which performs power quality control by reducing total

harmonic distortion (THD) in grid-injected current under varying environmental conditions. Standards (IEEE-519/1547) stipulates that current with THD greater than 5% cannot be injected into the grid by any distributed generation (DG) source. MPPT tracks actual variable DC link voltage while deriving maximum power from PV array and maintains DC link voltage constant by changing the converter modulation index. Simulation results with the PV model and MPPT technique validations demonstrate effectiveness of the proposed system.

Arun Kumar Verma et al. [4] " Grid Interfaced Solar Photovoltaic Power Generating System with Power Quality Improvement at AC Mains" author proposed a novel concept of utilizing solar photovoltaic (SPV) generating systems to improve the power factor to unity or to regulate a voltage at point of common coupling (PCC) of a three phase system. A three-phase VSC (voltage source converter) of this system eliminates harmonics currents, balances loads and compensates reactive power for power factor correction (PFC) or zero voltage regulation (ZVR) at AC mains. The VSC consists of a DC bus capacitor at its DC bus which is fed by SPV energy. DC voltage PI controller regulates the DC bus voltage at the time of load variation. The grid interfaced solar PV power generating system is tested for PFC and ZVR mode of operation along with harmonics currents elimination and load balancing of linear and nonlinear loads.

A. Egea-Alvarez et al. [5] "Voltage control of multiterminal VSC-HVDC transmission systems for offshore wind power plants: Design and implementation in a scaled platform" author proposed multiterminal voltage source converter (VSC) HVDC transmission frameworks for the association of seaward wind power plants to the fundamental land air conditioning matrix. A hang based control plan is considered. The hang controllers have been structured base on a blended affectability standard by taking care of an arched enhancement issue with direct lattice disparities. The framework is examined by methods for reenactments and tentatively in a scaled stage. Reproductions demonstrate the control execution during a wind speed change and a voltage list in the principle air conditioning lattice. Exploratory outcomes incorporate wind power changes (increment and decline) and an inevitable VSC misfortune (both considering lattice side and wind ranch VSC misfortune). In every one of the cases, the recreation and the exploratory outcomes have demonstrated a decent framework execution.

S. V. Bozhko,et al. [6] "Control of offshore DFIG-based wind farm grid with line-commutated HVDC connection" author proposed a control answer for mix of huge seaward doubly encouraged enlistment generator based wind ranches with a typical accumulation transport, constrained by a static compensator, into the principle coastal framework, utilizing line-commutated high-voltage direct flow association. The paper's fundamental center is a numerically grounded investigation of the power framework associations. That review created a fitting plant model for formal control structure. A structure method is portrayed and the controlled framework is approved utilizing power frameworks PC supported plan/electromagnetic transient program reproductions, which affirm the elite of the proposed control procedure in both ordinary activity and deficiency conditions.

J. Hu et al. [7] "Predictive direct virtual torque and power control of doubly fed induction generators for fast and smooth grid synchronization and flexible power regulation" author proposed Predictive direct torque control of the electric motors it is basic and has fantastic relentless state and transient execution. Nonetheless, further advancements are still under scrutiny for applications in the field of intensity age. This paper introduces a prescient direct virtual torque and power control technique for a doubly nourished enlistment generator, which permits quick and smooth framework synchronization, and adaptable dynamic and receptive power guideline. In the no-heap mode, prescient direct virtual torque control is utilized to meet the network synchronization conditions. In the network associated mode, prescient direct power control is used to accomplish adaptable dynamic and responsive power guideline. To streamline the control framework structure and improve the unwavering quality, a sensor less rotor position plan is proposed. Moreover, a model-based prescient plan is acquainted with make up for a one-advance postponement in the computerized usage. The proposed control methodology is exceptionally basic and strong. There is steady exchanging recurrence, while the prerequisite of smooth and quick matrix synchronization is satisfied. The progress from no heap to adaptable power guideline is accomplished without changing the exchanging table.

A. I. Andrade et al. [8] "Distributed control strategy for a wind generation systems based on PMSG with uncontrolled rectifier HVDC connection" author proposed a conveyed control system for voltage, recurrence and dynamic/receptive power control of the Point of Common Connection (PCC), AC lattice, of a wind ranch. Each wind turbine utilizes a Permanent Magnet Synchronous Generator (PMSG) with a full consecutive VSI topology associated between the machine terminals and the PCC. A Diode-Thyristor converter topology framing a HVDC connection is utilized for interfacing the wind homestead to the power arrange. The control procedure permits most

extreme power move from the wind turbines to the AC-lattice, with great unique execution during relentless state and transient activity of the AC-matrix. Hang control methodologies are utilized to direct the voltage and recurrence in the AC-network separately. The proposed control procedure has been demonstrated to be vigorous under burden changes in islanded activity, capacitor bank exchanging, and following of intensity reference and wind turbine responsive power conveyance. The control procedure has been approved with PSIM recreations of the framework.

F. Bu et al. [9] "Control and implementation of dual stator-winding induction generator for variable frequency AC-generating system" author proposed control and execution of the double stator-winding enlistment generator for variable recurrence AC (VFAC) producing framework. This generator has two arrangements of stator windings inserted into the stator spaces. The power winding produces VFAC capacity to bolster the heaps, and control winding is associated with static excitation controller to control generator for yield voltage guideline with speed and burden varieties. Based on power balance, a rapid slip recurrence control (ISFC) procedure utilizing data of both yield voltage and yield power is utilized in this framework. A progression of examinations is done on a 15 kW model for check. Results demonstrate that the framework has great static and dynamic execution in a wide speed extend, which shows that the ISFC methodology is reasonable for this framework.

Ravi Nath Tripathi,et al. [10] " SRF Theory Based Grid Interconnected Solar Photovoltaic (SPV) System with Improved Power Quality" author proposed the concept of interconnection of Solar Photovoltaic (SPV) power generating system using Synchronous Reference Frame (SRF) theory based control in indirect current control mode of operation. This proposed theory improves the power factor and voltage at point of common coupling (PCC). Voltage at PCC is maintained through reactive

power compensation. The whole power generating system consists of SPV system, dc-dc boost converter, maximum power point tracking (MPPT), voltage source converter (VSC), ripple filter, different types of loads, interfacing inductor and three phase grid. This system eliminates harmonic currents and load balancing is also possible using it. The grid-interconnected SPV system is tested for two modes i.e. unity power factor mode of operation and voltage regulation mode, with load balancing problems of linear loads.

## III. Method

**Integration Challenges For Grid Connected DG System**

Photovoltaic Solar Panels are the power generating devices which convert solar energy into the electrical energy [4]. For the large scale of the Photovoltaic system, numbers of PV panels are integrated in series in form of a string and these strings are connected in parallel in form of an array. In generally PV solar panels contain the number of PV cells which are connected in shunt and series configuration. The PV cells are the formation of p-n junctions from the doping of p and n-type substrates that can generate DC power upon the incidence of light due to photovoltaic effects on the semiconductors. Increasing penetration level of Renewable based Distributed Generators (DG) in Distribution/Transmission system, utilities faces major challenges when the integration of DGs into the electrical grid [14]. Especially in the case of large DG systems, some common impacts which are affected on the interconnection of Distributed Generation with the utility grid are shown below:

A) Reverse Power Flow:

High diffusion levels of Distributed Generations (DG) on the Distribution System can offset the local loads and leads to reverse power flow from the PCC towards the main grid. This may create the overvoltage condition at PCC and affects the Protection schemes of Distribution system [14].

B)Voltage rise:

The integration of solar panel to a modification in voltage profile of feeders and rises voltages especially at locations nearer to solar plant. The condition of voltage increase can be considerable when big DGs integrated at the end of big and lightly loaded feeders. This situation is shown generally in rural zones. This voltage rise may create voltage destructions at PCC, raises the problem from consumers, and affect the operation of overvoltage protection schemes of DGs [15].

C)Voltage Fluctuations:

Due to the intermittent characteristics of renewable energy based Distributed Generations same as solar, the variation in output can significant impacts on feeder voltages. This voltage fluctuation condition may degrade the power qualities issues on the load sides and raises the complaints from customers [15].

D)Interaction with voltage regulating devices:

Voltage rises and Voltage fluctuations at PCC leads the frequent operations of controlled voltage capacitor banks, Load Tap Changers (LTCs), Line Voltage regulators and other voltage regulation devices which may increase the maintenance and affect life cycles of equipment's. The frequent operations of capacitor

banks create the fluctuations on reactive power supply which disturb the feeder power factor and raise the losses [15].

## IV. Conclusion

This is review analysis of different author research work. We try to design efficient architecture to optimized power quality in PV through STATCOM . Here We analysis different VSC controlling method to control voltage in PV array model, and get idea to design efficient modeling for optimized power quality.

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