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A Review on Series Voltage Regulator and PV based Voltage Modulated Direct Power Control for Grid Connected

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Abstract- We have designed voltage modulated direct power control (VM-DPC) for a three-phase voltage source inverter (VSI) connected to a weak power grid. If the conventional vector flow control (VCC) method is PLL, then the PLL system may make the system unstable. Compared to the traditional VCC method, eliminating the PLL system is the major advantage of the proposed VM-DPC method. In addition, the VSI system must also generate a certain amount of reactive power to inject the rated active power into the weak power grid. Analysis based on eigenvalues shows that, using the proposed method, the system tracks the required dynamics within a specific workspace.

Keywords- SVR, VM-DPC, DC-DC converter, Voltage source converters (VSC), DAB.

I. INTRODUCTION

The use of wind energy is a rapidly developing field. In Europe, the installed capacity of wind power production has increased by 36% annually for 5 consecutive years. In northern Germany, wind turbine production is the fastest growing industry. In addition, wind energy accounts for 7% of Danish electricity consumption. Most European countries have plans to increase their share of wind power.

The increase in the proportion of wind energy in the power system makes it necessary to establish a friendly grid interface between the wind turbine and the grid in order to maintain the power quality. In addition, power electronics are experiencing rapid development, which is mainly due to two factors. The first factor is the development of a fast semiconductor valve that can quickly change and handle high power. The second factor is the control field.

The introduction of computers as real-time controllers makes it possible to adapt to advanced and complex control algorithms. Together, these factors make it possible to connect cost-effective and network-friendly converters to the network. This paper mainly studies the forced commutation voltage source which is connected to the grid in wind energy applications. When the first part of the project started, the goal was to determine the best electrical system for the wind turbine in terms of efficiency, cost and performance.

Another aim is to study the voltage angle control method and its applicability in the control of grid connected voltage source converters in wind turbine systems. A simple, inexpensive analog controller is used for this implementation. To increase the system bandwidth, a linear quadratic control method is considered. The purpose of the second part of the project is to study the performance of the vector current control method when parameter changes, delay time and mains voltage distortion affect the vector current control.

To reduce non-linearity and shut-off time of the valve, the valve compensation function is implemented in the controller. A conversion angle detector that synchronizes the voltage source converter with the mains voltage is critical to the vector current control. One of the purposes is to study various synchronization methods that can be implemented in the control computer. In addition, the high current bandwidth of the vector stream control may allow further applications. The higher power quality of the entire hybrid wind farm can reduce the total cost of the wind farm. The report contains two parts. The first part briefly discusses the concept of wind turbines, electrical systems used in wind turbines, control principles, and modulation techniques for voltage source converters.

In addition, contributions and comments from the included papers are introduced and the conclusions stated. The second part of the report contains nine articles, which are divided into four parts. The first part introduces wind power, wind turbines, various electrical systems and hybrid wind farms. The second part studies the voltage source converter connected to the grid by means of a voltage angle regulator. In the third part, the vector current control in the mains voltage source converter is studied. In addition, four synchronization methods suitable for digital implementation are proposed. One of the proposed methods is a new transformation angle detector based on

the introduction of 4 based on the space vector filter. In the last part, the harmonics of the voltage source converter are examined. The current harmonic attenuation of two filters (L filter and LCL filter) of low frequency filter and medium frequency filter is compared. In addition, the effect of the high-pressure derivative from the quick-change valve is resolved.

Power source converters (VSC) are widely used in smart grids in modern power grids, flexible AC transmission systems and renewable energy sources (such as wind and solar). One of the key features of VSC is the mains power supply (VSI), which is normally controlled as a power source that injects power into the grid. A widely used control scheme for VSI is vector flow control, where a phase-locked loop (PLL) is used for grid synchronization, where VSI's small signal dynamics tend to introduce negative attenuation, which may vary.

The frequency range depends on the specific controller of the converter and power system conditions. Therefore, to ensure stable operation of VSI under weak grid conditions, a control strategy without PLL is required.

1. Photovoltaic Integration:
Through Voltage Source Converter as PV is acting as a source of direct current (DC) power, it is integrated with the alternating current (AC) microgrid network for DC-AC conversion. Between VSC and Current Source Converter (CSC) [25], VSC is widely accepted in power system applications. The power flow between VSC to Point of Common Coupling (PCC) is dependent on DC link voltage and current and thus synchronised control is required, which is easy to design. VSC requires reverse conducting electronic switches. Insulated Gate Bipolar Transistor (IGBT) power electronic switches are commercially available option. On the other hand forced commutated CSC requires bipolar electronic switches.

Though bipolar power electronic switches like Integrated Gate Commutated Thyristor (IGCT), Gate Turn Off thyristor (GTO) are commercially available, switching speed and cost are two major limitations for them. Thus these switches are effective for high power converter applications (especially industrial applications). Before grid integration (AC power operation) the PV systems are incorporated with high frequency transformer or bulky low frequency transformer at AC side of the VSCs [26] to step up the low output voltage of the PV system to utility grid voltage. The safety feature is added due to galvanic isolation but the expense and efficiency is reduced from these transformers to the PV system.

An improved solution in terms of size, expense and efficiency is introduced by removing the transformer interfacing. The transformerless PV conversion with different circuit configurations and modulation schemes is one of the recent research developments [27, 28].

II. LITERATURE SURVEY

The power to switch to renewable resources is to switch energy production to distributed nodes, so Pulse Width Modulation (PWM) voltage source inverter (VSI) becomes a widely used interface circuit between renewable resources and power grid 2]. The widespread use of PWM inverters in the power grid makes the stability analysis of grid connected VSIs the primary concern of electrical engineers. Several studies have shown that the stability of the network connected VSI is influenced by the control and filter parameters [3] - [9].

In addition to filters and control parameters, a weak power grid will also affect the stability of the network connected VSI [10] - [15]. Weak lattice is usually defined as a low short circuit (SCR) lattice, that is, high impedance and low inertia constant (H), which is a typical feature of microgrids. As a result, voltage and frequency will be distorted in the weak grid. Furthermore, if the voltage at the common switching point (PCC) has harmonic components at the natural frequencies of LCL filters [10], [11], the network connected VSI may become unstable. If the voltage supply path is used to reduce the response time of the closed circuit system, the situation will be more complicated. Similarly, the coupling path in the control plane may cause the system to tend to be unstable in the lattice with current harmonics [14], [15].

Therefore, the stability analysis of the inverter in the weak current network is a complicated problem which requires a detailed dynamic model. Root locus state space and Nyquist impedance based techniques have been reported for stability analysis of grid connected VSI [9] - [19]. Impedance-based techniques use bulky equivalent circuits, so it is not possible to simply investigate the effect of individual circuits and control parameters on system stability. In the dynamic analysis of network connected VSI through the state space method, a simplified model is usually considered for the system (circuit) or regulator. If you need to investigate the effects of simultaneous changes in circuits and control parameters, this simplification makes the stability the whole system is difficult to analyze.

CZ Ally et al. (2019) provides a chemical battery energy storage system (BESS) with frequency compensation technology such as virtual inertial response (VIR) to solve the problem of frequency fluctuations in island grids caused by inverter current generation (such as PV). The problem is integrated. When the inverter phase-locked loop (PLL) and lattice impedance are negatively affected by the low short-circuit ratio (SCR), the inverter connected to BESS may encounter performance and stability problems. To solve this problem, this work proposes a robust proportional integrated control unit (R-PI) for power control of the inverter inner loop. R-PI was synthesized using the structured H infinite method using

MATLAB, and its performance was compared to the conventional proportional integral controller (PI) designed by the conventional frequency forming method. Sensitivity analysis including dynamic effects of PLL was performed for the altered SCR. The analysis was verified by time domain simulation in MATLAB The results show that both R-PI and PI can maintain the stability of the inverter when in the worst case the SCR is 2. 7.2 to 2 changes and R-PI can maintain this performance throughout SCR change.

Zhou Wenxiang et al. (2018) Multi-inverter grid connected systems are usually in a weak grid environment with large grid impedance changes, leading to strong coupling between inverter and grid impedance in the grid connected power generation system, creating resonance problems. Much research has been done on active source active dampers, but small virtual harmonic impedances are difficult to obtain. Therefore, its ability to suppress resonance of the networked system is limited. Regarding the above problems, this paper proposes a control strategy for voltage source active dampers. Active damper actuators can virtualize less harmonic impedances to reshape the impedance of the common switching point, effectively suppressing system harmonics and system-level resonance. Finally, taking the dual inverter system as an example, resonance suppression is performed. The effect is theoretically analyzed and the feasibility and efficiency of the proposed voltage source active damper control method is verified through experiments.

Wang Jiangfeng et al. (2016) forward voltage control (VFFC) is widely used because of its good low-frequency harmonic suppression and easy to implement functions, but it will impair system stability under poor grid conditions. Based on the impedance analysis method, the stability of the single-phase grid-connected inverter with VFFC is investigated. Using this method, it is easy to obtain the unstable mechanism and the unstable region caused by the VFFC. Based on this, it is only necessary to add phase-offset compensation to stabilize the system and avoid real-time lattice impedance detection. Simulation and experimental results verify the accuracy of the analysis results and the proposed control method.

Aswad Adibet.al (2018) This article introduces the stability analysis of a voltage source inverter (VSI) with an asymmetric weak grid. The large grid impedance associated with the weak grid can make the network connected VSI unstable. The latest study on the stability of weak power grids focuses only on the impedance of symmetrical grids, with little attention directed to the impedance of asymmetric grids. Based on the established state space model of the grid-connected VSI, taking into account the impedance of the asymmetric grid, the stability analysis of VSI in the asymmetric weak grid is investigated. The study of the root locus of the eigenvalues of the model shows that an asymmetric increase in the lattice impedance under equilibrium can cause the initially stable system to become unstable. Through simulation and experimentation of three-phase 208V grid connected three-phase hardware settings for symmetrical and asymmetric weak grids, the results were verified.

Yan Du et al. (2017) because of the interaction between the increased lattice impedance and the inherent impedance of the inverter, the stability of the grid connected voltage source inverter (VSI) in the weak lattice is diminished. To improve the stability of LSI-filtered VSI, a method for forming impedance phase is proposed. Using this output current feedback compensator can greatly improve the phase margin at the intersection of impedances. A simple parameter design method is also introduced to simplify the design process. Simulation and experimental results verify the effectiveness of the proposed method and design method.

Challenges Regarding Nonlinear Feedback Controller Design- the nonlinear controllers for VSC have to be robust for both bounded/ unbounded uncertainties. Existing literatures are well defined for bounded uncertainties. But situation where microgrid instability is a detection parameter (islanding event by active anti-islanding scheme), and the uncertainty arises due to that at the controller level (protection tasks can't be able to bound its variations), the existing controllers will be erroneous. Thus a new control design is focused by composing backstepping based virtual feedback law and Lyapunov Finite time SMC for the present research, to obtain relaxed, regulated system response during such uncertainties. The target is to achieve improved stability limit for PV based VSC integrated microgrid with active islanding detection property.

Problem Formulation from Present Literature-A detailed literature description is presented; the role of DGs and microgrids in modern active distribution network is described in an elaborate manner. From the discussion of integration of DGs to microgrid two major challenges are highlighted: detection of microgrid operational modes (i.e. grid connected and autonomous modes) for safe and reliable grid application, design of independent DG control for stable grid behaviour. In section 1.2 the importance of solar PV in DG based microgrid is illustrated. Advantages like sustainability, environmental improvements are key advantages for PV based DGs, especially in a country like India where the solar irradiation is available more than 300 days in a year. To cope with the growing energy.

Rogelio Ruzcko Tobias (2020) et.al The ability of renewable resources to provide energy has a very great potential. It can provide sustainability for the needs of the future, especially now that fossil fuel sources are gradually diminishing. Although renewable energy is very promising, it is still not yet fully integrated in teaching in

schools. There are many renewable sources but almost all of it is dependent on solar energy and to increase awareness and knowledge of its potential, this study aims to provide a training module focusing on the renewable energy of the sun. The training module will be able to show how energy conversion works. Also, the training module uses developing innovations for harnessing solar energy to increase its efficiency.

Because it will be used as laboratory equipment, testing for efficiency and transportability were conducted. With planning, testing, and evaluation the researchers were able to develop a training module that is efficient with 0.15 percent - 7.40 percent coefficient of variance out of thirty (30) trials, and at the same time transportable and inexpensive that is ideal for the goal of this research to implement the teaching of renewable energy to schools.

Yan Li (2019) et.al with the increasing penetration of the wind and solar generation in the power grid, the renewable energy integration planning and evaluation are essential for a more comprehensive understanding of power system operational economics. For specific power grid, the maximum feasible renewable integration capacity can be calculated and thus provide the useful guidelines for government, independent system operators and investors to make planning and operational decisions toward higher penetration of renewable power: Planning study and electrical system design should be done before actual construction of the wind and solar power plant.

The planning studies generally analysis the adequacy and flexibility of the power system, which including resource characteristics analysis, production simulation and reliability analysis. The Electrical system design generally analysis the connection mode and stability, which including interconnection and transmission design, power flow and stability analysis, power quality analysis. In technical aspect, modeling, methodologies and evaluation indices related to integration planning and evaluation are the most important parts should be considered in future activities.

Yun Sha (2020) et.al With the clean transformation of power system, conventional thermal power units can no longer meet the spinning reserve demand due to the mass access of intermittent renewable energy such as wind power and photovoltaic (PV). As a new form of renewable energy generation, concentrating solar power (CSP) has the comparable dispatching performance to conventional thermal power, which has significant advantages in promoting the consumption of renewable energy and participating in system auxiliary services. Therefore, take high renewable energy penetrated system including CSP, wind power, PV and thermal power as the research object. With the goal of reducing operating costs and load shedding costs, a robust economic dispatching model for high renewable energy penetrated system with CSP providing reserve capacity is established, which is on the basis of traditional unit commitment model, considering the constrains including output restriction constraints, ramping ability constraints and thermal energy storage capacity constraints to model the operation of CSP providing reserve capacity. An example of actual data in northwest province of China is calculated in case study, in which the traditional dispatching model of CSP providing reserve capacity is taken as a reference. The results show that the method proposed in this paper can not only improve the economy of system but also reduce the occurrence of load shedding, which is helpful to enhance the reliability of power system.

Khaled Touafek (2017) et.al Photo Energy conversion is a direct conversion that allows the generation of electricity by photovoltaic cells and heat by thermal collectors. Much of the solar irradiation is lost by reflection and another great part is lost by heating of the solar cells. The concept of hybrid photovoltaic thermal (PVT) collector consists of superimposing the two electrical energy and thermal functions. The heat transfer fluid (water) is channeled, allowing easy circulation to outside. The weakening and falling thermal efficiency allowed finding new solutions that solve this problem by integrating heat exchangers below the solar cells.

The creation of hybrid PVT water collector with reflectors allowing increasing the electrical power while allowing the temperature of the thermal heating to decrease, hence improvement of electrical and thermal efficiency. In this work we have realized hybrid photovoltaic water collectors with reflectors. This is in the aim to concentrate the solar fluxes and increase the electrical and thermal performances of the latter. The main results were presented. Both electric and thermal efficiencies of studied hybrid collector were improved.

Ershun Du (2018) et.al Achieving high renewable energy penetrated power systems requires considerable operational flexibility to hedge the variability and uncertainty of variable renewable energy (VRE) generation. Compared with VRE sources, concentrating solar power (CSP) is an emerging controllable renewable generation technique that utilizes solar thermal power to generate electricity. The operational dispatchability of CSP would contribute to the power system transition toward high renewable penetration.

In this paper, we explore how the generation portfolio will change toward high renewable energy penetrations, how much cost is involved, and what role CSP will play in realizing a high renewable energy penetrated power system. This study relies on a stochastic two-stage generation and transmission expansion planning model with CSP plants. The model captures the uncertainty and variability of renewable generation and the flexibility limits of thermal plants. With the target of achieving a

renewable-dominated minimum-cost system with an expected renewable energy penetration level, the investments of both generation and transmission facilities are optimized. A case study on IEEE test systems with renewable technology cost data in 2050 is performed to analyze the value of CSP toward high renewable energy penetrated power systems.

III. METHODOLOGY

In this work, the voltage regulator based grid system will be design In this work design a voltage modulated direct power control (VM-DPC) for a three-phase voltage source inverter (VSI) connected to a weak grid, where the PLL system may make the system unstable if the conventional vector current control (VCC) method is applied.

Compared with the conventional VCC method, the main advantage of the proposed VM-DPC method is that the PLL system is eliminated. Moreover, in order to inject the rated real power to the weak grid, the VSI system should generate some certain amount of reactive power as well. An Eigen values based analysis shows the system with the proposed method tracks its desired dynamics in the certain operating range. This article introduces concept of a new Serial Regulator (SVR) to control the DC bus voltage of the radial DC microgrid.

The planned SVR uses an active double-bridge DC-DC converter, tracked by a full-bridge DC-DC converter. Injects a dynamic power in series with the DC network to recompense for the drop in resistance in network Accurate model of AC grid stability with voltage modulated direct power.

- Control (VM-DPC) by eliminate the PLL.
- Control analysis of AC grid with damping ratio of Band Pass Filter (BPF) variation.
- By using Three Phase Voltage Source Inverter (VSI) used to converter for DC to AC from DC link to AC grid.
- To synchronization the voltage to Gird connected load by controlling the VSI using the VM-DPC technique**.**

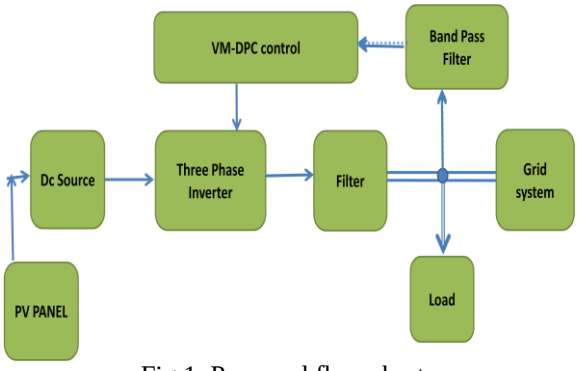

Fig 1. Proposed flow chart.

IV. CONCLUSION

If high power quality is required, the recommended electrical system consists of a power source converter connected to the power supply. The alternative is a thyristor inverter. Direct drive permanent magnet generators with voltage source converters such as rectifiers have become a promising alternative to ordinary synchronous generators and diode rectifiers.

A simple and inexpensive voltage angle control method is shown to control wind turbine applications. The extended version of the voltage angle controls a linear square controller, has higher performance and can function as expected.

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