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Voltage Modulated Direct Power Control for A Weak Grid Connected Voltage Source Inverter Based On Series Voltage Regulator

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Abstract – **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 As a result, voltage levels at changed points in network become autonomous of load changes and remain within specified limits. Note that nominal power obligatory by the SVR is very low (eg 2.7%) associated to load request since 5% voltage regulation. In this job, the regulator is associated to the midpoint of the network, but it can also be associated to other places to get the same optimal rating. In this document, we have designed a three-phase voltage basis (VSI) inverter with voltage moderated direct power control (VM-DPC) associated to a weak power grid. If conservative vector present control (VCC) technique is applied, PLL system may cause system to be unhinged. Compared to the traditional VCC technique, chief benefit of proposed VM-DPC method is to eliminate the PLL system. Furthermore, to inject nominal active power into the weak grid, VSI system must also produce a convinced amount of reactive power. Analysis based on eigenvalues shows that required power within a specific operating range.**

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

I. INTRODUCTION

Voltage source converters (VSC) are extensively used in smart grids in modern power grids, flexible AC drive systems, or renewable vigour bases (such as wind and solar). One of key strategies in VSC is the grid connected voltage source inverter (VSI), which is generally controlled as a present foundation that injects present into grid. For network connected VSI, conventional vector present control strategies are generally used to afford acceptable control performance. However, the network related VSI using normal vector current control strategy is reported to be weak and to have stability and performance issues. Furthermore, as the diffusion of renewable vigour into modern power grids continues to increase, the maintenance of stability or high control excellence providing by the grid-connected VSI becomes increasingly important. A extensively used VSI control system is course present control, where a phase protected loop (PLL) is used for network synchronization. In new years, adverse effect of PLL on the stability of the small VSI signal has been stated. It has been found that by presenting negative incremental confrontation at low incidences, the PLL can reduce stability of VSI. The VSI frequency coupling dynamics presented by PLL has also been clearly revealed. The incidence variety of negative resistance is resolute by bandwidth of PLL. Therefore, a low bandwidth PLL is generally used to improve VSI stability, which seriously impairs the dynamic performance of the system. Furthermore, even if PLL is intended to have very low bandwidth, VSI is still problematic to maintain stability in extremely weak network conditions, in this case the network impedance is close to 1: 3 pu. [2][3] Wang recently short harmonic constancy caused by grid-connected VSI in current power grids, where small VSI signal dynamics tend to present negative checking, which can be in changed frequency ranges, depending on the two controls on the Inverter Device. Converter or power scheme situations. Therefore, to ensure stable VSI operation under weak network conditions, a PLL-free control strategy is required. Another control method, Direct Power Control (DPC), has been studied for network connected VSI to directly control prompt active power and reactive power without using an internal loop present regulator or PLL system. However, the main disadvantage of these methods is the adjustable swapping frequency based on the switching state, which can lead to an unexpected wideband harmonic spectrum, i.e. it is not easy to project a line filter correctly. To achieve a constant switching incidence, many DPC strategies have been future. Some of them use spatial vector inflection or calculate required converter voltage vector in each switching cycle[4][19]. In addition, taking robustness into account, slider mode control is applied to DPC method to ensure fast chasing presentation of active or sensitive power, and taking into account the inherent dissipation of the system, passive DPC-based control is proposed. Though, there are still uninvited fluctuations in active power or responsive power. One of best regulator algorithms, Model Predictive Control (MPC) -DPC, is designed intuitively bearing in mind multivariate conditions, nonlinearity, and system constraints. In each sampling period, MPCDPC selects a sequence of voltage vectors or computes duty cycle. MPC-DPC also affords a constant converting frequency. However, this can cause an additional computational burden. Recently, Gui et al. Presented DPC network voltage modulation (GVM-DPC), which solves the main downside of the DPC technique, i.e. steady state presentation[17] The linear invariant time system (LTI) is obtained through the distribution generator (DG) based on the importance of photovoltaic (PV) energy based on GVM-DP (PV) and its integration. VSI designs and analyzes the system. This chapter will present the challenges facing microgrid applications.DG and micro grid will be discussed in detail. Through an adequate bibliographic survey, the process of the passive distribution network to its active technical state is discussed. The gap in the literature comes from the existing technical and economic benefits and challenges. Since the microgrid can operate in standalone interactive mode with the network, detection of these modes has been emphasized in the scope of current research. PV focuses on DG-based integration. Here we discuss the latest developments in PV (existing literature), PV integration via voltage source converters (VSC), and grid synchronization. This article discusses the importance of distributed PV based generation in current and future Indian power scenarios. Since the damping curve of the photovoltaic system is small, the main objective is to improve the stability of independent DG controller. [5][6]

II. RELATED WORK

The power to switch to renewable incomes is to switch dynamism manufacture to dispersed nodes, so Pulse Width Modulation (PWM) voltage source inverter (VSI) becomes a generally used border route among renewable resources or power grid .The extensive use of PWM inverters in control grid makes constancy examination of grid connected VSIs the main alarm of electrical engineers. Numerous educations have shown that constancy of the network connected VSI is influenced by controller or filter strictures .In addition to filters or control parameters, a weak power grid will also disturb constancy of the network connected VSI .Weak lattice is usually defined as a low short circuit (SCR) lattice, that is, high impedance or low inertia continuous (H), which is a typical feature of microgrids. As a outcome, power or frequency will be slanted in the weedy grid. Besides, if the power at common switching point (PCC) has harmonic components at natural frequencies of LCL filters. the network connected VSI may become unhinged. If voltage supply path is used to decrease reply time of closed circuit scheme, the situation will be more complicated.[10][11][13] Equally, connexion path in the control plane may cause the system to tend to be unstable in the lattice with current harmonics .Therefore, the constancy examination of the inverter in the weak current network is a complex difficult which requires a detailed dynamic model. Root locus state planetary or Nyquist impedance based techniques have been described for stability examination of grid connected VSI .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. [14][8] In the dynamic analysis of network connected VSI through the state space method, a abridged model is usually measured for system (circuit) or regulator. If you need to investigate the effects of simultaneous changes in circuits and control parameters, this vulgarization makes constancy the whole system is difficult to analyze.[9][10]

III. PROPOSED SYSTEM

A typical circular DC microgrid setup, where multiple power bases are coupled to bus 0 and the loads are associated to the outstanding buses. This scheme is widely used due to its easiness and cost efficiency [1]. Also, for this configuration, development of the load leg is easy. The change in the voltage of the loaded bus is main restraint, which was explained in the first part. The voltage of the buses away from the load (like buses 3 and 4 here) may drop below the specified limit due to load. The recommended SVR must be related in correct position to keep all node voltages within a deviation of 5%. The input side of SVR is associated through the network through stations A and B. The output side is associated in sequence by network (between bus 2 and bus 3). Depending on the connection, the SVR output will withstand the lowest voltage (Vsvro) associated with line drop or will resist up to the nominal line current (Isvro), while the SVR input will withstand nominal DC mains voltage (V1) and lowest current (Iin) In this work, a new design method is proposed to ensure that when the active power of load suddenly changes, there is enough gain margin and phase margin to achieve stable operation. The main contributions of this work are:

- Accurate model of AC grid stability with voltage controlled 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.

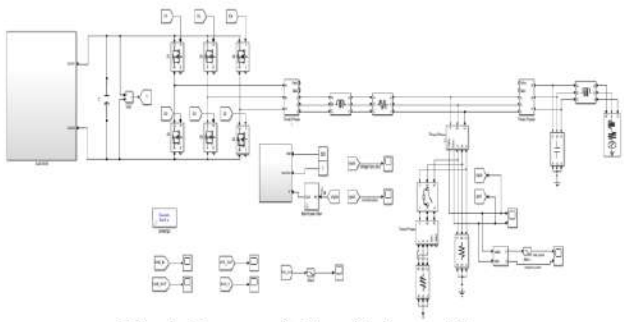

Fig.1. Proposed Simulink model.

Topology: The recommended SVR topology is shown in Figure 1. SVR consists of a DAB and a full-bridged DC-DC converter. The two jumpers (primary and secondary) on the DAB are used to produce high incidence square wave voltages at transformer terminals. The phase shift among the two rectangular waves can be attuned to regulator the control flow from V1 to V2 and vice versa. The energy flow always flows from bridge producing the main tetragonal wave to other bridge [20]. Please note that DAB works in power regulator mode. When output current (Iinb) and the input voltage (V1) change, the DAB output voltage (V2) always maintains its reference value. The DAB constant output voltage is associated to input of full-bridged DC-DC converter. The full bridge operates in power governor mode with unipolar inflection [21] to produce an adjustable DC voltage (Vsvro). Therefore, under stable and transient circumstances, obligatory amount of power by the proper divergence can be further in series with the DC network. In this planned configuration, the SVR controls voltage on bus 3 by adding a controlled series voltage with the proper divergence.

One of the key plans in VSC is the grid associated power source inverter (VSI), which is generally measured as a present foundation that injects present into grid. For network associated VSI, conventional vector current regulator strategies are generally used to deliver acceptable control presentation. Though, the network related VSI using standard vector current control strategy is described to be weak and to have stability and performance issues.

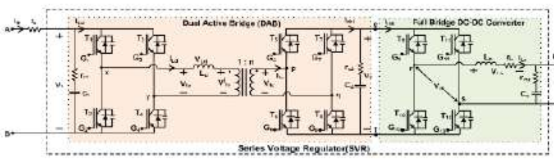

Fig.2. Control Scheme for SVR.

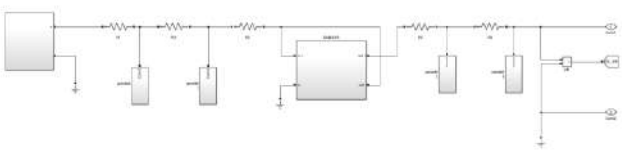

Fig.3.DAB Subsystem.

Figure 4 shows the general SVR control system. The proposed scheme involves of two control modules to guarantee that the bus 3 voltage is inside the quantified limits under changed load situations. Block I controls the power flow or maintains a constant voltage at DAB output. Module II shows control of a full-bridge DC-DC converter that operates in power regulator mode. Voltage Control Figure 4 shows the control of a full-bridged DC-DC converter to regulate the output power of SVR (Vsvro). The line voltage drop (up to bus 3) has been used as a reference for the controller. The reference voltage is produced by following formula.

V*suro= V*grid-V1

The error is shaped in among position and actual output voltage (i.e V*suro= V*suro) svro,Vsvro) which is fed to a PI controller.

The PI controller provides a control signal (i.e., Vc) to produce PWM signals for switches T9 through T12. The PI controller's gain selection should make the voltage circle bandwidth 10 times less than converting incidence

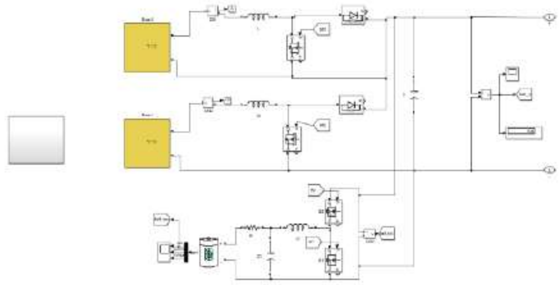

Fig. 4. Solar Sub System.

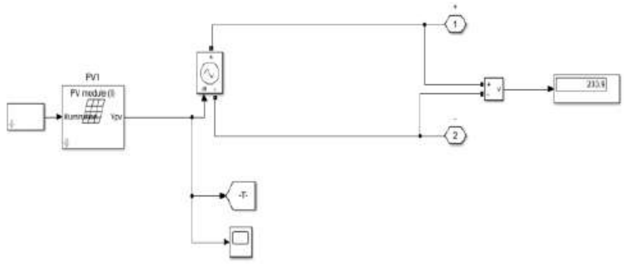

Fig.5. PV Panel Sub System.

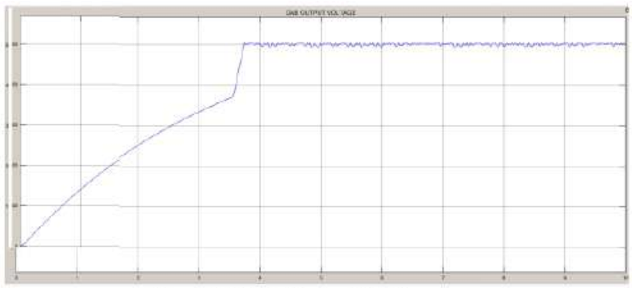

Fig.6. DAB Output Voltage.

Therefore, it is possible to manage energy flows forward and backward during brownouts and brownouts, respectively. The conduction of the switching device in

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the DAB occurs at zero power, which reduces the transferring loss of converter. SVR can dynamically adjust the DC microgrid bus voltage for various situations loading conditions.

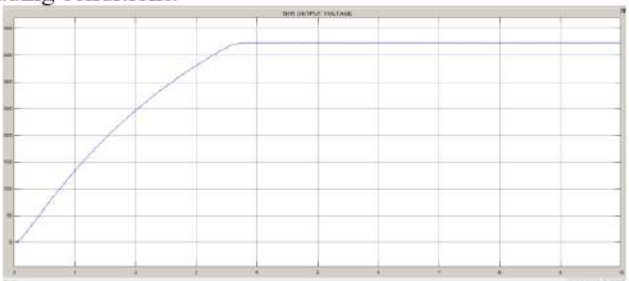

Fig.7.SVR Output Voltage.

The answer time of the SVR during transients is determined by power controller (i.e. the second phase of control circuit) or capacitor associated through the SVR output. Here, the SVR adds the proper series power with the appropriate schism to compensate for voltage drop athwart the line resistor. Figure 9 (c) and (d) shows the SVR input and output voltage, respectively. Also pay attention to the DAB output voltage

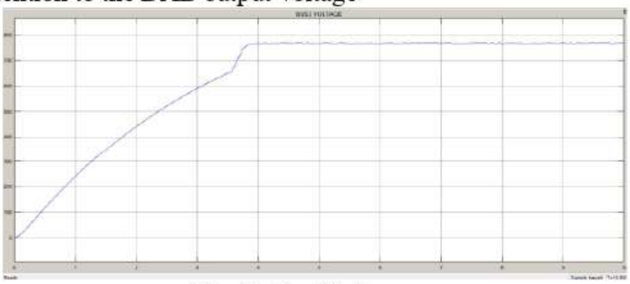

Fig. 8 . Bus Voltage.

The DC bus voltage is relative to maximum power of network input. What to look for: DC bus voltage is approximately ~ 1,414 x RMS line voltage. The total bypass admission of buses i and yiivi is the bypass current flowing from bus i to ground. Where VR is the reference voltage vector (n-1) × 1-dimensional that contains the relaxed bus voltage on each element.

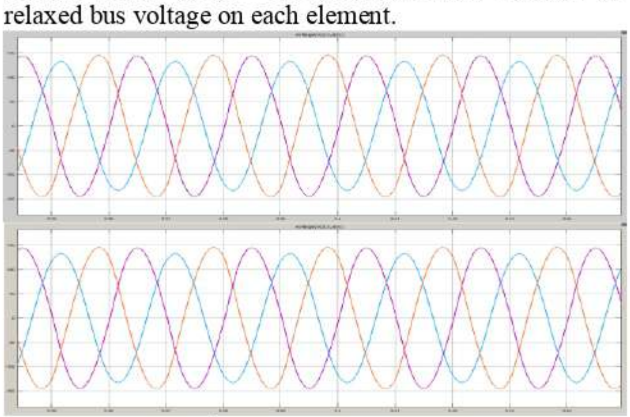

Fig .9. Constant Power.

Figure 9 show the solar power output curve and daily load when a constant amount of energy is received from the public power system. The constant power circuit works by calculating the voltage across the load and the current drawn. The charging power limit curve representing the current and voltage amplitude of the charging current within a certain range, the charging circuit can be operated safely

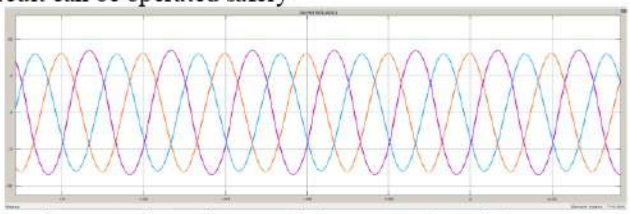

Fig. 10 Voltage (Vpcc, abc) Current (IL, abc).

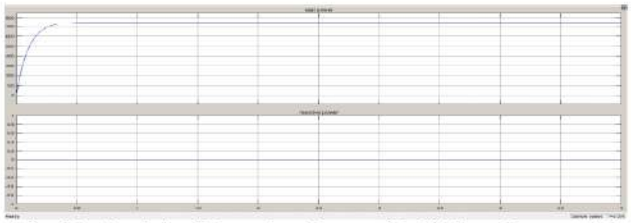

Fig.11. Real And Reactive Power (P,Q) Vary Power AT 2.5 Second.

Furthermore, at 0.8 s, when the VSI regulates the active power of 3: 5 kW and the reactive power of 2: 0 kvar, the converter load connects to the PCC or consumes 1.0 kW of active power, as shown in Figure 13. When VSI adjusts the active power or responsive power to 0: 5 kW and 2: 0 kvar, individually, function of the proposed control method

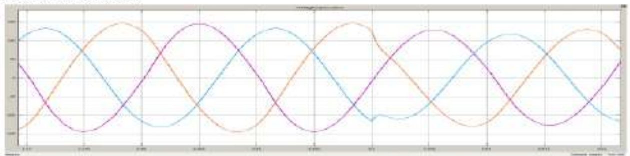

Fig .12.Voltage (Vpcc, Iabc).

The dynamic characteristics of the current vary according to the voltage level in Vpcc relative to Iabc. Therefore, the required dynamic characteristics must be selected to obtain a suitable working area for the DC microgrid.

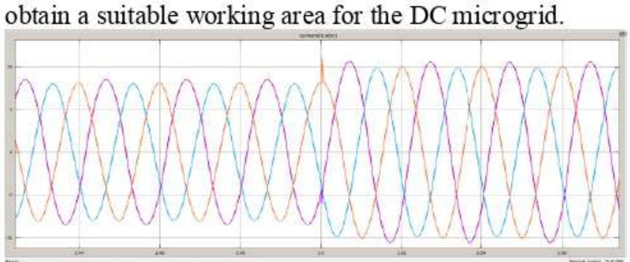

Fig.13.Current (IL, abc).

We also tested the effect of network frequency changes. the frequency changes from 48: 5 Hz to 50 Hz at 0: 8 s, or returns to 49: 5 Hz at 0:85 s. You can see in Figure 14 that VSI quickly syncs the new network frequency. Therefore, we can arrange that the planned control process is vigorous to changes in network incidence. In this case, we also use different BPF parameters (i.e. 0: 3).

It can be seen that when network incidence changes, both active power or mercurial power change.

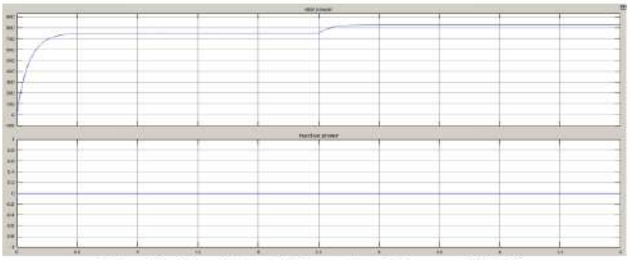

Fig.14. Real And Reactive Power (P,Q).

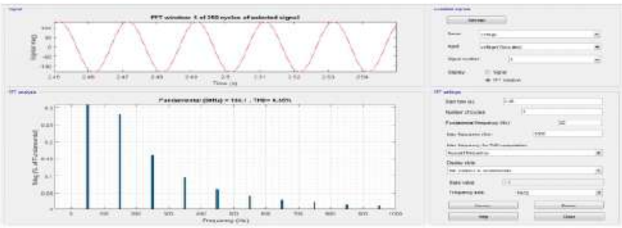

Fig. 15.Total Harmonic Distortion (THD).

Stability Analysis In this section, we use proposed method to study the eigenvalues of the error dynamics. Based on these eigenvalues, we examine constancy of weak VSI associated to the network. First, let's define BPF transfer purpose used in this study as follows:

$$G_{bpf} = \frac{2\omega_c s}{s^2 + 2\omega_c s + \omega_0^2},$$

Where $\omega_c = \zeta\omega_0$ is resonance bandwidth, ω_0 is resonance frequency, and ζ is damping ratio

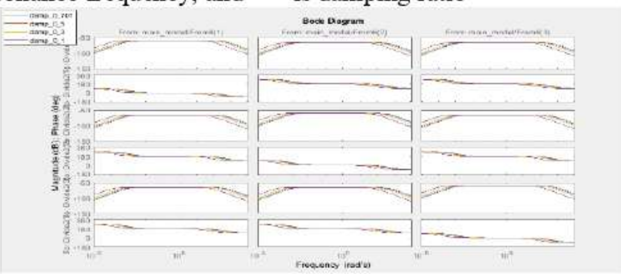

Fig.16. damping ratio.

IV. CONCLUSIONS

The SVR dynamically adjusts the DC microgrid bus voltage for various load conditions. The optimal SVR location can keep the DC power distribution system stable. This article presents a VM-DPC stratagem for a three-phase VSI related to a weak network, where the PLL scheme can make scheme unbalanced. We use BPF to connect weak electrical network to the VSI system to apply GVM-DPC concept. Through an exhaustive analysis based on eigenvalues, the system remains stable within this working variety. Also, to inject nominal active power into the weak grid, the system must generate a convinced quantity of sensitive control to withstand the voltage in the PCC. Finally, the reproduction or new outcomes show that the proposed method works well on weak grids.. In proposed method, we tested with DC link we have to improvise into multiple output This system can be used in the application of renewable energy source solar, wind, fuel cell This system can also implemented in the single phase home applications . This article introduces the concept of a new series of DC microgrid regulators. Topologically, this is a cascade of a dual active bridge (DAB) or a full bridge DC / DC converter associated in serial input-parallel or output mode. The dc / dc converter can produce positive or negative voltages, so it can handle power flows back and forth during brownouts and brownouts, respectively. The conduction of the switching device in the DAB occurs at zero voltage, which condenses the substituting loss of converter.

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