Comparative Analysis of An Active Power Flow Control For Advanced Voltage Support In Grid Connected Converter

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Abstract- *Supporting the grid and improving its reliability have recently become major requirements for large distributed generation units. Under most grid faults, the accuracy of the traditional voltage support schemes (VSSs) is dramatically affected due to the existence of the zero-sequence voltage. where the active power is zero, when the traditional VSSs have been used only in the STATCOM applications. This paper proposes an advanced VSS in the converter-interfaced units, called zero-sequence compensated voltage support (ZCVS), to accurately regulate the three-phase voltages of the connection point within the pre-set safety limits. The proposed scheme not only compensates the zero-sequence component but also considers the active power injection. Unlike the traditional methods, the proposed VSS is adapted even in resistive distribution systems. The contribution of this paper is, however, ternate. As the second contribution, the limited active power oscillation (LAPO) is proposed to be augmented to the ZCVS. This feature limits the oscillation to a specified value which provides an adjustable dc-link voltage oscillation setting while simultaneously supporting the ac host grid, even under severe unbalanced faults.*

Keywords- zcvs , vss, active power oscillations, dc voltage ripples, fault ride through, LVRT grid codes.

I. INTRODUCTION

Power converters are critical components for interfacing distributed energy resources to power grids. The safe and proper operation of the grid-connected converters (GCCs) has thus been a substantial challenge for network operators. This becomes more challenging under various fault conditions. Different control strategies, which are mainly based on symmetric sequences, were studied to ride through grid faults by a GCC. Each of these studies pursues particular objectives related to the quality of the injected current, dc-voltage ripple reduction, voltage profile regulation, or maximum allowable voltage/frequency support, multiple objectives, such as minimized fault currents, minimized power oscillations, and maximized power flows, are addressed with analytical expressions of the controlling parameters of a GCC under unbalanced faults. References studied two control techniques for the static synchronous compensators (STATCOMs) to regulate the positive and negative sequences of the point of common coupling (PCC) voltage, where the active power delivery is considered zero. The basic requirement in the voltage support is to avoid the over-voltage and under-voltage at the PCC whenever possible. If the rated power of the GCC and the connecting line impedance are not small, the three-phase voltages can be regulated at the pre-set safety limits, i.e., and the proposed scheme was only applied to the STATCOM application where the reference current only consists of the reactive components. However, the effect of the active power in regulating the voltage should not be ignored at the distribution level. The proposed scheme was only applied to the STATCOM application where the reference current only consists of the reactive components. However, the effect of the active power in regulating the voltage should not be ignored at the distribution level.

II. LITREATURE SURVEY

In the existing systems, little work has been carried out on the phase voltage regulation of a GCC under unbalanced conditions. First, they do not consider the zero-sequence voltage component whereas it exists in most unbalanced faults. Their accuracy are thus severely affected by the zero sequence component of the PCC voltage which will be shown later in this paper. Second, these methods have been only applied in inductive grids, i.e. assuming very high X/R ratio. Third, all of the existing strategies are formulated assuming zero active power delivery.

In This paper proposes an analytical technique to limit the active power oscillations and enhance dc-bus voltage stabilization, called limited active power oscillation (LAPO). As the third contribution, the maximum active power delivery (MAPD) is also formulated. Both of these strategies, i.e. LAPO and MAPD, can be simultaneously applied with the proposed VSS.

III. EXISTING SYSTEM

A grid fault or unbalanced loading can cause unbalanced voltage condition at the PCC of a GCC. The basic requirement in the voltage support is to avoid the over-voltage and under-voltage at the PCC whenever possible. If the rated power of the GCC and the connecting line impedance are not small, the three-phase voltages can be regulated at the pre-set safety limits, i.e., Min Vset, and Max Vset . However, the effect of the active power in regulating the voltage should not be ignored at the distribution level since: (1) the resistance of the lines in the distribution system is not egligible; and, DGs inherently generate and inject the active power to the system. The positive and negative sequences of the reactive current component were obtained for regulating the phase voltages in an inductive grid.

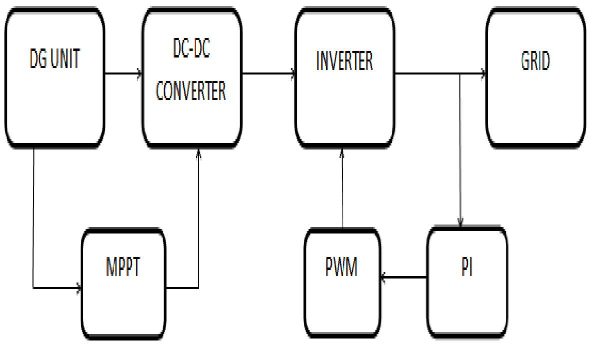

Fig. 1. Block diagram of existing system

Two complementary strategies are proposed to be applied to the active components of the current.

The first strategy, i.e. LAPO, aims to limit the oscillations on the active power which is critical to improve the dc-bus voltage stabilization. Furthermore, the second strategy, i.e. MAPD, intends to deliver the maximum active power with respect to the rating current while simultaneously supporting the voltage with ZCVS.

IV. PROPOSED SYSTEM

The control output is fed to inverter PWM signal generator. The difference between the injected current and the reference current is known by error signal. The design of the conventional PI controller dependent on the knowledge of the expert, in this work the trial and error method has been used to determine the parameters Kp and Ki. The key contribution in this paper is the proposed approach to find the optimal PI parameters in order to ensure that the steady-state error of the system is reduced to minimum.

The objective of an optimal design of currents PI controller for given plant is to find a best parameters Kp and Ki of PI control system such that the performance indexes on the transient response is minimum. The proposed controller (PI-ACO) has better dynamic performance and robustness.

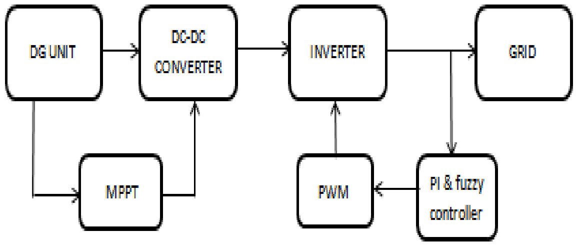

Fig.2. block diagram of proposed system

The control method applied to SAPF has demonstrated good performance for harmonic elimination and reactive power compensation. In severe unbalanced conditions, the required negative reactive component of the current obtained by ZCVS may become high. Negative-sequence current and voltage components give rise to large oscillations in the active power. Therefore, the LAPO strategy is proposed to obtain the a limit for the negative reactive current component which does not cause exceeding the pre-set maximum allowable active power oscillation.

V. FUZZY CONTROLLER

Fuzzy Logic resembles the human decision-making methodology. It deals with vague and imprecise information. This is gross oversimplification of the real-world problems and based on degrees of truth rather than usual true/false or 1/0 like Boolean logic. the values are indicated by a number in the range from 0 to 1. Here 1.0 represents absolute truth and 0.0 represents absolute falseness. The number which indicates the value in fuzzy systems is called the truth value.

The working of the FIS consists of the following steps –

A fuzzification unit supports the application of numerous fuzzification methods, and converts the crisp input into fuzzy input.

A knowledge base - collection of rule base and database is formed upon the conversion of crisp input into fuzzy input.
The defuzzification unit fuzzy input is finally converted into crisp output.

Methods of FI S :

Let us now discuss the different methods of FIS. Following are the two important methods of FIS, having different consequent of fuzzy rules –

- Mamdani Fuzzy Inference System
- Takagi-Sugeno Fuzzy Model (TS Method)

Mamdani Fuzzy Inference System

This system was proposed in 1975 by Ebhasim Mamdani. Basically, it was anticipated to control a steam engine and boiler combination by synthesizing a set of fuzzy rules obtained from people working on the system.

Steps for Computing the Output
Following steps need to be followed to compute the output from this FIS –

Step 1 − Set of fuzzy rules need to be determined in this step.
Step 2 − In this step, by using input membership function, the input would be made fuzzy.
Step 3 − Now establish the rule strength by combining the fuzzified inputs according to fuzzy rules.
Step 4 − In this step, determine the consequent of rule by combining the rule strength and the output membership function.
Step 5 − For getting output distribution combine all the consequents.
Step 6 − Finally, a defuzzified output distribution is obtained.

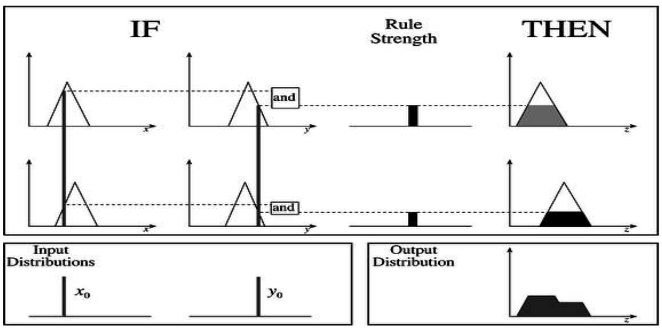

fig.3. block diagram of mamdani fuzzy interface system.

VI. SIMULATION RESULTS

To demonstrate the effectiveness of the proposed ZCVS scheme with LAPO and MAPD strategies, three test cases are studied and implemented in this paper. The operation of a GCC under the unbalanced ac-side condition is usually studied by assuming a constant dc voltage source in the dc-side for simplicity. This is a common assumption in most studies. To realistically emulate a renewable energy resource, the dc voltage regulator is used in this paper. Therefore, the dc-link voltage controller generates the active power command of the GCC.

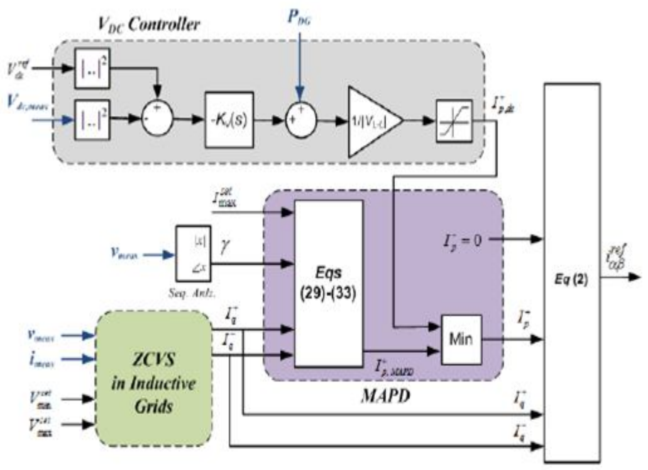

Fig. 5.1. proposed control diagram to maximize the active power delivery

A. Test Case A: Traditional VSS vs Proposed ZCVS Method

This section presents the simulation results of the traditional voltage support scheme (TVSS) and the proposed ZCVS method. Between t=0.4s and t=0.6s, a single phase fault happens on phase A (i.e. the magnitude of phase A is decreased to 0.8 p.u.). From t=0.6s, each phase voltage experiences different sags to show and compare the performances of the traditional and proposed methods. For example, the magnitudes of phase voltages a, b, and c are respectively 0.6p.u., 0.5p.u., and 0.75p.u. between t=1s and t=1.2s, the obtained Iq+ and Iq- by the TVSS and ZCVS for different fault conditions, TVSS fails to precisely regulate the phase voltages within the pre-set voltage limits. Over-voltages up to 1.18 pu (on phase B between t=0.6s and t=0.8s) and under-voltages down to 0.83 pu (on phase A between t=0.4s and 0.8s and on phase B between t=1.4s and t=1.6s) occur whereas the voltage accepted limits are set to ±0.1 pu around the nominal value. However, the proposed ZCVS method demonstrates successful results. The phase-voltages of the PCC are precisely regulated between the VMIN and VMAX, the voltage ripples are considerably lower when the ZCVS is applied.

B. Test Case B: ZCVS Method with LAPO and MAPD strategies

First, the result of the ZCVS method with LAPO strategy is presented. The maximum acceptable oscillation on the active power is set to 0.08 pu as indicated in Fig 7-(c), the maximum Iq- is calculated where Iq- the active power oscillations are lower than 0.08 pu. As Fig 7-(a) demonstrates, the calculated is higher than Iq-,lqpo. It causes active power oscillations greater than 0.08 pu as depicted. To limit the oscillations, is limited to at t=0.5s and t=0.9s. Therefore, the active power oscillations are limited to 0.08 pu as shown in Fig 7-(c). As a result, the dc voltage ripples are decreased by applying LAPO strategy.

As another complementary strategy, the ZCVS method with MAPD strategy is tested in this section. The value of is set to 1.0 pu, the suitable Ipis calculated such that all phase currents are limited to .The pre-fault active power is 1 p.u. which causes overcurrent. At t=0.5s the chopper in the dc-side is activated to avoid the over current, and the delivered active power becomes zero. At t=0.7s, the active current component obtained is applied. Thus, the MAPD strategy allows delivering maximum allowable active power while simultaneously respects the phase current limit max set I max set I under faulted condition, the ZCVS is still operating accurately even if the MAPD strategy is applied.

C. Test Case C: ZCVS Method under Various X/R Ratios

In the previous test cases, the ZCVS was applied to inductive grids (i.e., X/R>>1). In this test case, the ZCVS is tested in two other systems: a resistive grid (i.e., X/R≈0) and a grid with X/R=1, the successful results of the ZCVS in regulating the phase voltages in these two cases, the ZCVS uses only the active current component in positive and negative sequences in the resistive grid. However, in the grid with X/R=1, both active and reactive currents in positive and negative sequences have been utilized. Fig. 3. Shows the simulink model of the proposed system.

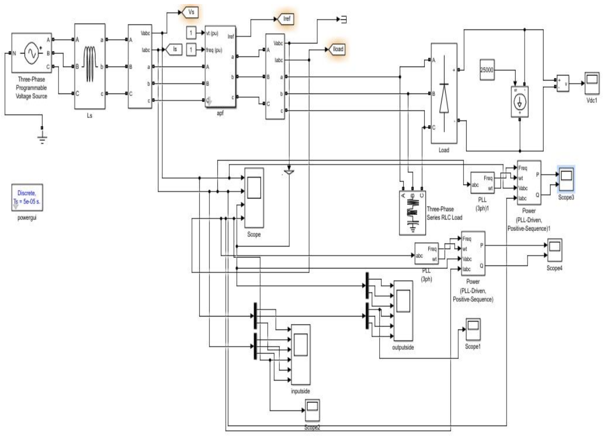

Fig.3. simulink model of proposed system

Description:

A Three phase transformer is directly fed to the three phase ac four wire system. Voltage measurement and current measurement is used to measure the voltage and current flow through the circuit. scope is used to monitor the input and output waveforms of the circuit. The series RLC load is connected with the inverter. Fig. 4 shows the Simulink model of the Active power flow (APF) in the proposed system.

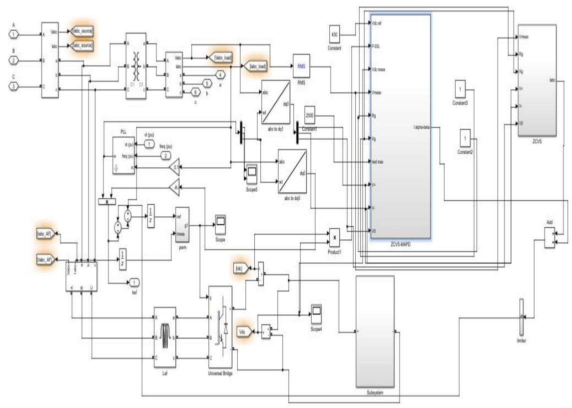

Fig. 4. Simulink model of active power flow

Fig. 5. shows the simulation result of Input voltage and current (V & I) of the proposed system. voltage and current waveforms are in Y axis and the time is in X axis. Fig. 6. figure shows the simulation result of Output voltage and current (V & I) of the proposed system.

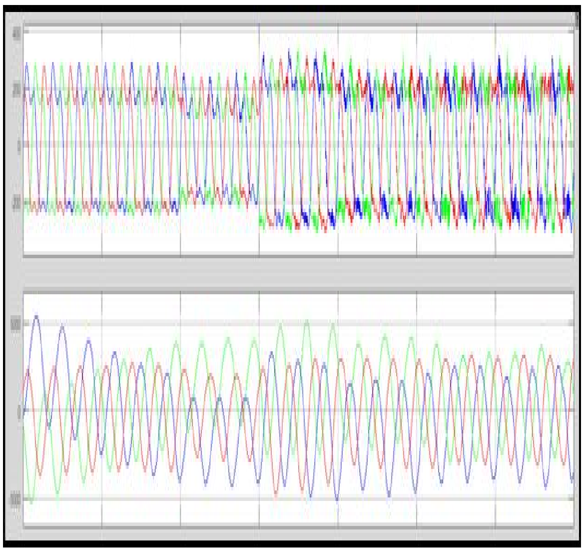

Fig. 5.

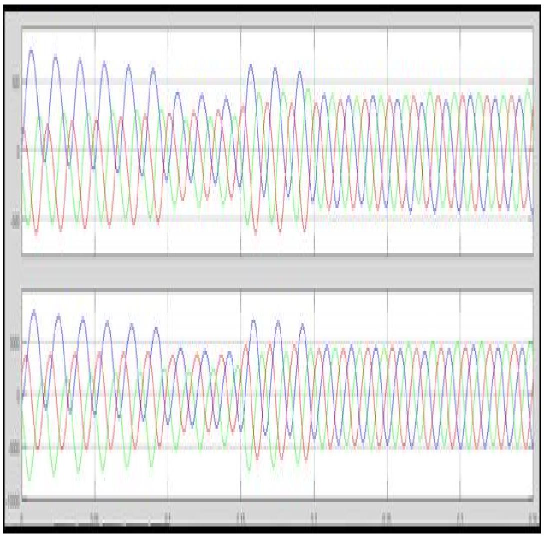

Fig . 6.

Fig. 7. shows the simulation result of Real power(P) and Reactive power(Q) at the input of the proposed system. Fig.8. shows the simulation result of Real power (P) and Reactive power(Q) at the output of the proposed system

VII. CONCLUSION

This paper proposes an advanced voltage support scheme to precisely regulate the phase voltages of a three-phase grid-connected converter within the pre-set safety limits. Existing methods mainly suffer from three problems: (i) their performance becomes inaccurate in most cases because of ignoring the zero-sequence voltage component; (ii) they can be only applied in inductive grids; and, (iii) zero active power delivery is suggested. The proposed ZCVS method addresses these three problems. Moreover, two complementary objectives, related to the active power delivery, are also augmented in the proposed scheme. First, the limited active power oscillation is proposed under severe unbalanced faults to analytically obtain a limit for the injected negative reactive current. This feature provides an adjustable limited active power oscillation, and improved dc voltage while supporting the ac-side voltage. Second, the expressions of the maximum active power delivery are proposed to exploit the maximum allowable active power of a distributed energy resource even under severe unbalances and while still regulating the phase voltages. The proposed voltage support scheme and two complementary strategies bring significant advantages to emerging distributed generation units.

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