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Advanced Voltage Support and Active Power Flow Control in Grid-Connected Converters Under Unbalanced Conditions

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Abstract
Large distributed generation units have recently become crucial requirements for supporting the grid and increasing its reliability. The presence of the zero-sequence voltage significantly affects the accuracy of traditional voltage support schemes (VSSs) during the majority of grid faults. Additionally, the traditional VSSs have only been utilized in STATCOM applications with zero active power. Zero-sequence compensated voltage support (ZCVS), an advanced VSS for converter-interfaced units, is proposed in this paper to precisely regulate the three-phase voltages at the connection point within pre-set safety limits. In addition to compensating for the zero-sequence component, the proposed plan takes active power injection into account. The proposed VSS, in contrast to the more conventional approaches, can be applied to resistive distribution systems. However, this paper's contribution is ternary. The addition of the limited active power oscillation (LAPO) to the ZCVS is proposed as the second contribution. Even under severe unbalanced faults, this feature supports the ac host grid and limits the oscillation to a predetermined value, providing an adjustable setting for the dc-link voltage oscillation. Thirdly, the ZCVS is included in the formula for the maximum active power delivery (MAPD) to the AC grid. Using selected simulation and experimental test cases, the successful outcomes of the proposed support scheme and complementary strategies are demonstrated

1. Introduction

For stand-alone or grid-connected distributed generation units at the utility level, the most common power electronics converter is a single-phase or three-phase voltage source converter. Renewable energy has gained a great deal of importance over the past few decades as the focus has been on lowering emissions from the production of electricity using fossil fuels. Because it is free and abundant, renewable energy can be used as a substitute for power generation. There are numerous renewable resources available, each with its own benefits and drawbacks. Wind and solar power are the most widely used renewable energy sources. The wind power plant, which consists of the wind turbine and its mechanical and electrical control system, is set up at a high cost to extract power from the wind. However, the electrical and mechanical systems of solar energy, as well as the installation of the panels, come at a high initial cost. Solar power plants, on the other hand, are mechanically simpler to maintain than wind turbines because replacing a wind turbine requires replacing an older one with a more recent one. An advanced voltage support scheme (VSS) that addresses these three issues is being used in this project. First, under unbalanced fault conditions, it accurately regulates phase voltages within the current safety limits and fully compensates for the zero-sequence component. Grid codes typically establish safety voltage limits to ensure that GCCs continue to function normally. Second, resistive grids, such as typical distribution systems, can be used with the proposed method. Thirdly, the proposed VSS takes into account the GCC's active power transfer as well. The phase voltage regulation of a GCC in unbalanced conditions in the existing system has received little attention.

However, there are three drawbacks to the presented approaches. First, they overlook the presence of the zero-sequence voltage component in the majority of unbalanced faults. The zero-sequence component of the PCC voltage, which will be demonstrated later in this project, thus has a significant impact on their accuracy. Second, because they assume a very high X/R ratio, these techniques have only been used in inductive grids. Thirdly, no active power delivery is assumed in the formulation of any of the existing strategies. In this section, two complementary approaches to the current's active and reactive parts are suggested. The first strategy, LAPO, aims to reduce active power oscillations, which are essential for enhancing dc-bus voltage stabilization. MAPD, the second strategy, aims to support the voltage with ZCVS while simultaneously delivering the maximum active in relation to the rating current. If the active and reactive components are replaced or satisfied, these strategies can also be obtained for resistive grids and grids of any X/R valued

Fig.1 Windmill

2. Literature Review

One of the most common issues affecting network operation are grid faults. By injecting reactive power during the sag and postfault operations, distributed generation for power plants can assist in reducing the negative effects of these perturbations. As a result, voltage collapse and cascade disconnection can be avoided. The goal of the proposed reactive power control is to keep the maximum and minimum phase voltages at the point of common

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coupling within the limits set by grid codes for continuous operation[1] with the help of the reactive power control.

For grid connection, multi-MW wind turbine generators (WTG) at large offshore wind power plants may be outfitted with full scale converters (FSC) and voltage source converters (VSC) based high voltage direct-current (HVDC). This would reduce the DC voltage overshoots in the VSC and HVDC by minimizing power oscillations. The electro-magnetic transients (EMT) simulation model incorporates the mathematically derived formulation for negative sequence current injection[2].

The frequency modes of the disturbances that need to be eliminated ought to be included in the stable closed-loop system in order to provide means for rejecting fast and dynamic voltage disturbances and ensuring perfect regulation of the voltage at the point of common coupling (PCC). A dual sequence voltage control is suggested to take into account unbalanced voltage disturbances[3].

What's Grid? A network of synchronized power providers and consumers that is connected by transmission and distribution lines and is managed by one or more control centers is known as an electric grids.

It consists of:

- power stations: often located near energy and away from heavily populated areas.
- electrical substations to step voltage up or down.
- electric power transmission to carry power long distances.
- electric power distribution to individual customers, where voltage is stepped down again to the required service voltage(s)

Grids almost always operate with synchronized three-phase alternating current (AC) frequencies, which means that voltage swings occur almost simultaneously in all distribution areas. AC power can be transmitted throughout the region as a result, connecting numerous electricity generators and consumers and potentially making redundant generation and electricity markets more effective. The "power grid," which includes the combined transmission and distribution network, is a component of the delivery of electricity.

Power Quality is both the capacity of an equipment to consume the power that is supplied to it and the capacity of a power grid to supply power to consumers in an effective manner. Power Quality is the measurement, investigation, and enhancement of the sinusoidal waveform at the rated voltage and frequency in technical terms.

The economics of operating a terminal, the dependability of cranes, our environment, and the initial investment in power distribution systems to support new crane installations are all impacted by power quality. The economics of the operation of the container terminal, the dependability of the terminal equipment, and the other customers served by the same utility service are all affected by the power quality in the container terminal environment

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Fig.2 Solar Panels

3. Proposed System

voltage drop to increase or decrease inside the circuit, if the voltage drop is larger at the output, the signal will be passed, otherwise, it is rejected by the filter.

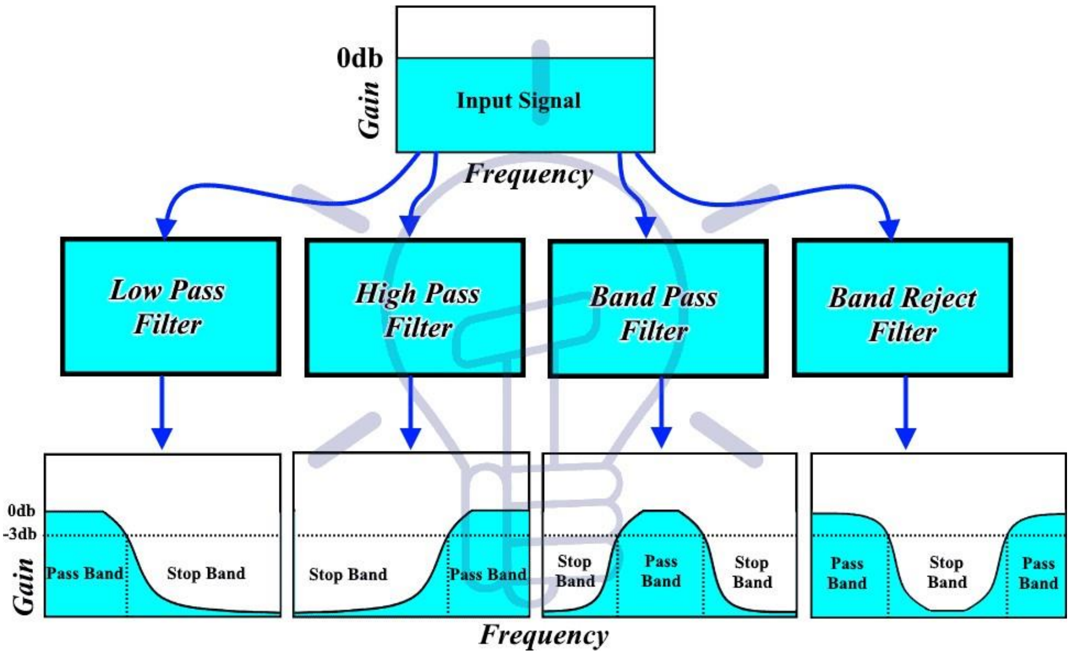

Fig.3 Proposed Structure

The cut-off frequency of the filter is what determines the frequencies of the passband and stopband. There is no attenuation at any frequency below the cut-off frequency. In contrast, any other signal with a higher frequency than the cut-off frequency will be blocked. Filter with High Pass:

A high pass filter is a type of filter that blocks (rejects) all low-frequency signals while allowing high-frequency signals to pass unimpeded. The filter blocks any signal whose frequency is lower than the cut-off frequency. whereas full amplitude is transmitted for any

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signal with a frequency higher than the cutoff frequency.

Filter for Band Pass:

Any frequencies below or above its passband are blocked by this kind of filter, which allows a specific frequency band.

The lower and upper cutoff frequencies of this kind of filter are the two cutoff frequencies. where the positive/negative and active/reactive components are denoted, respectively, by the superscripts "+" and "-" and the subscripts "p" and "q." Finding these current components should be done in such a way that they can support voltage in any grid condition. The mathematical representations of the injected active/reactive currents in terms of the ac-side voltages.

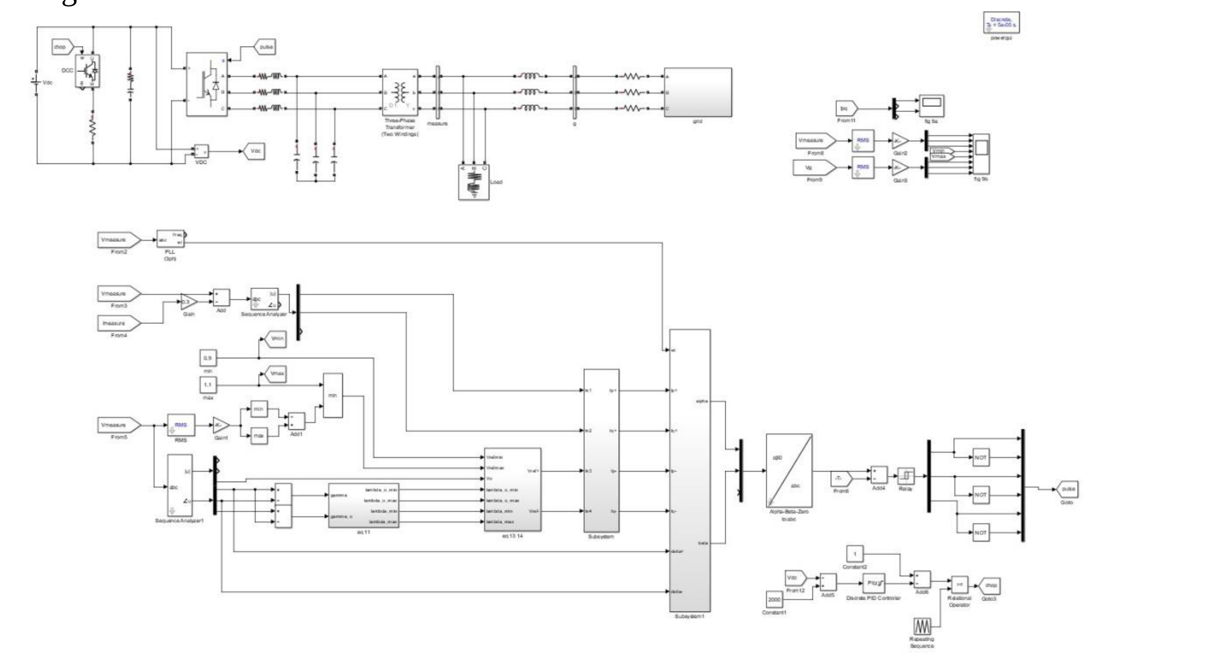

Fig.4 Simulink Model

4. Conclusion

To precisely regulate the phase voltages of a three-phase GCC within predetermined safety limits, this paper proposes an advanced VSS. There are three main issues with current methods: first, ignoring the zero-sequence voltage component causes their performance to be inaccurate in the majority of cases; Second, only inductive grids can use them; Thirdly, it is suggested that there be no active power delivery. These three issues are addressed by the proposed ZCVS method. In addition, the proposed plan enhances two complementary objectives that are connected to active power delivery. To begin, in order to analytically determine a limit for the injected negative reactive current, the LAPO is proposed under severe unbalanced faults. On active power, this feature provides adjustable, limited oscillation, improved dc voltage, and support for the ac-side voltage. Second, it is proposed that the MAPD expressions can be used to maximize the active power of a distributed energy resource even under severe imbalances while maintaining phase voltage regulation. Emerging distributed generation units benefit significantly from the proposed VSS and two complementary strategies. Simulation and experimental tests are used to confirm that the proposed schemes have produced successful outcomes

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