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PERFORMANCE COMPARISION ANALYSIS OF 2 LEVEL VSI DSTATCOM WITH 5 LEVEL MMC DSTATCOM BY USING CARRIER BASED PULSE WIDTH MODULATION METHOD

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Abstract: The performance of a two-level voltage source inverter (VSI) D-STATCOM and a five-level modular multilevel converter (MMC) D-STATCOM was compared using carrier-based pulse width modulation (PWM) method. The analysis was carried out by simulating the two systems under different operating conditions and load disturbances. The comparison was based on parameters such as voltage and current harmonics, total harmonic distortion (THD), power factor, and voltage regulation.

The results showed that the five-level MMC D-STATCOM had lower voltage and current harmonics and THD compared to the two-level VSI D-STATCOM. The five-level MMC D-STATCOM also exhibited better voltage regulation and power factor. However, the two-level VSI D-STATCOM had lower switching losses and was more efficient at low power levels.

Overall, the study showed that both D-STATCOM systems had their advantages and disadvantages, and the choice of system should depend on the specific application and requirements. The carrier-based PWM method was found to be an effective control method for both systems.

Introduction:

DSTATCOM stands for "Distribution Static

Compensator" and is a power electronic device used in electrical power systems to improve power quality. It is a shunt-connected device that can inject a controllable current into the system to mitigate various power quality issues such as voltage sag/swell, harmonics, flicker, and unbalance.

DSTATCOM typically consists of a voltage source converter (VSC), a DC capacitor, and a control system. The VSC is used to generate a compensating current that cancels out the unwanted harmonic or reactive power component of the load current. The DC capacitor acts as an energy storage device, providing the necessary energy to the VSC. The control system is responsible for measuring the system parameters and generating the appropriate compensating current.

DSTATCOM is a cost-effective solution compared to traditional solutions such as large capacitors, reactors, and transformers. It is also a versatile solution that can be used for a variety of power quality problems, making it an attractive option for modern power systems.

Literature Review

In recent years, power quality issues have become increasingly important due to the growth of renewable energy sources and the increasing use of nonlinear loads. The voltage-source converter (VSC)-based distribution static synchronous compensator (DSTATCOM) has become a popular solution for mitigating power quality issues, such as voltage sags, swells, and harmonics.

The two-level voltage-source inverter (VSI) DSTATCOM is a widely used topology for voltage compensation in power systems. However, it suffers from several drawbacks, such as low voltage and current ratings, high harmonic distortion, and poor dynamic response. To overcome these limitations, researchers have proposed the use of multilevel converters, such as the modular multilevel converter (MMC).

In recent years, several studies have been conducted to compare the performance of two-level VSI DSTATCOM and MMC DSTATCOM under various operating conditions.

One study compared the performance of two-level VSI DSTATCOM and MMC DSTATCOM under different fault conditions, such as three-phase faults, single-phase faults, and unbalanced faults. The results showed that the MMC DSTATCOM provided better fault ride-through capability and faster transient response than the two-level VSI DSTATCOM.

Another study compared the performance of two-level VSI DSTATCOM and MMC DSTATCOM in terms of harmonic distortion reduction and voltage regulation. The results showed that the MMC DSTATCOM provided better harmonic distortion reduction and voltage regulation than the two-level VSI DSTATCOM.

A recent study compared the performance of two-level VSI DSTATCOM and five-level MMC DSTATCOM using a carrier-based pulse width modulation (PWM) method. The results showed that the five-level MMC DSTATCOM provided better voltage regulation and harmonic distortion reduction than the two-level VSI DSTATCOM. However, the two-level VSI DSTATCOM had a faster dynamic response than the five-level MMC DSTATCOM.

TWO LEVEL VSI DSTATCOM

A two-level VSI (Voltage Source Inverter) DSTATCOM (Distribution Static Synchronous Compensator) is a type of power electronic device used to regulate and control the power flow in electrical grids.

EXISTING METHOD

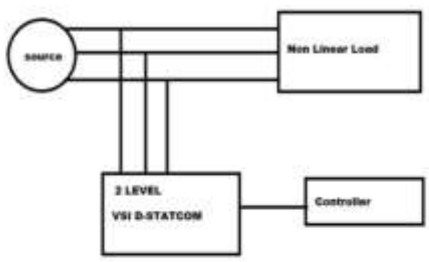

Fig. 2 LEVEL VSI D-STATCOM

DSTATCOM is typically used to mitigate voltage sag/swell and harmonic distortion caused by non-linear loads, such as electric motors or electronic devices.

The two-level VSI DSTATCOM consists of a voltage source inverter (VSI) with two levels of output voltage (positive and negative). The VSI is connected to the distribution system through a coupling transformer,

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which provides galvanic isolation and allows for bidirectional power flow.

The VSI generates a controllable output voltage that is injected into the distribution system to mitigate voltage fluctuations and improve the power quality. The output voltage can be controlled by adjusting the switching frequency and duty cycle of the VSI.The DSTATCOM can also be equipped with a control system that allows it to compensate for reactive power and harmonics in the system. The control system uses feedback from sensors to measure the voltage and current in the system, and then generates control signals to adjust the output voltage of the VSIOverall, a two-level VSI DSTATCOM is an effective and efficient solution for mitigating power quality issues in electrical grids, and can help improve the reliability and stability of the power system.

FIVE LEVEL MMC DSTATCOM

A five-level Modular Multilevel Converter (MMC) is a type of power electronics-based converter used in high-voltage direct current (HVDC) transmission systems and other power applications. The five-level MMC is a type of multilevel converter that consists of a series of sub-modules that are connected in series to form a high-voltage converter.

The five-level MMC consists of five voltage levels that are generated by the sub-modules. Each sub-module consists of a number of low-voltage power semiconductor devices (such as insulated-gate bipolar transistors or IGBTs) that are connected in a specific configuration to generate the desired output voltage waveform. The sub-modules are connected in series using a high-frequency switching mechanism to generate the overall high-voltage waveform.

PROPOSED METHOD

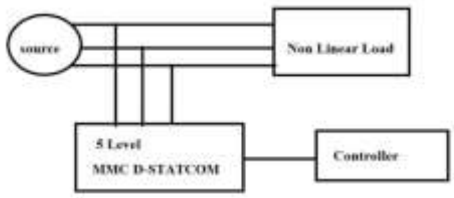

Fig. 5 Level MMC D-STATCOM

The five-level MMC has several advantages over other converter topologies. One of the main advantages is its ability to generate a high-quality, low-distortion output voltage waveform with fewer sub-modules than other multilevel converters, which can lead to a more compact and cost-effective design. Additionally, the five-level MMC has a high efficiency over a wide range of operating conditions and can operate with high reliability.

HYSTERESIS CURRENT CONTROLLER

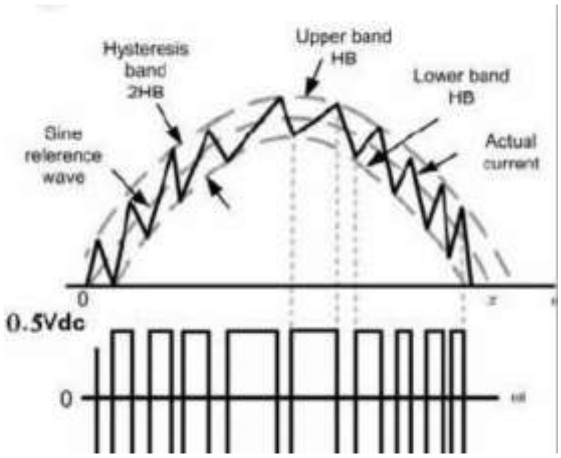

Fig. Hysteresis Current Controller

The purpose is to present a comparative study on basic hysteresis current controller techniques for grid connected inverters. Hysteresis current controllers are best known for robustness, fast error tracking, better dynamic response and ease of implementation than other controllers proposed in literature. To improve

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the power quality of grid connected inverter, different methods of hysteresis current controller are studied under dynamic conditions. An Analytical study has been carried out on the basis of Total harmonic distortion (THD) and maximum switching frequency. Single band hysteresis control (SBHC), double band hysteresis control (DBHC), modified double band hysteresis control (MDBHC) and variable band hysteresis control (VBHC) techniques are discussed. All the analytical and experimental results are compared with a constant hysteresis band. Simulation and hardware results are presented to validate the analysis and performance of controllers for steady state and dynamic condition.

HYSTERESIS

Hysteresis can be define as the dependence of a system which is not only on its current environment but also on its past environment. In other words, it is deficiency or lagging behind. This dependence arises because of the system could be more than one internal state. To predict its future development, either its internal state or its history must be known. However, loops may also occur because of a dynamic lag between input and output. This effect also often referred to as hysteresis, or rate-dependent hysteresis. It the operation principle of Hysteresis band PWM for an inverter. The control circuit generates the sine reference current wave of desired magnitude and frequency, and it is compared with the actual phase current wave. As the current exceeds a prescribed hysteresis band, the output was set to high. However, when the current starts to decay, the output goes to low. The actual current wave was forced to track the sine reference wave within the hysteresis band by backand-forth (or bang-bang) switching of the upper and lower switches. The inverter then essentially becomes a current source with peak to peak current ripple, which was controlled within the hysteresis band.

CARRIER BASED PULSE WIDTH MODULATION

Pulse Width Modulation (PWM) is a modulation technique used in power electronics to control the power supplied to electrical devices such as motors, inverters, and converters. In PWM, the power switching device is turned on and off rapidly, with a variable duty cycle, to generate a waveform with a desired average voltage or current.

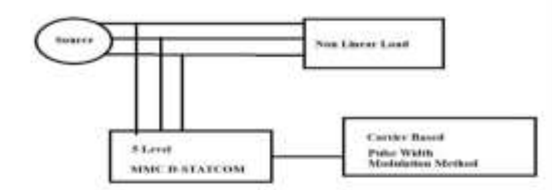

Fig. Carrier Based Pulse Width Modulation Technique

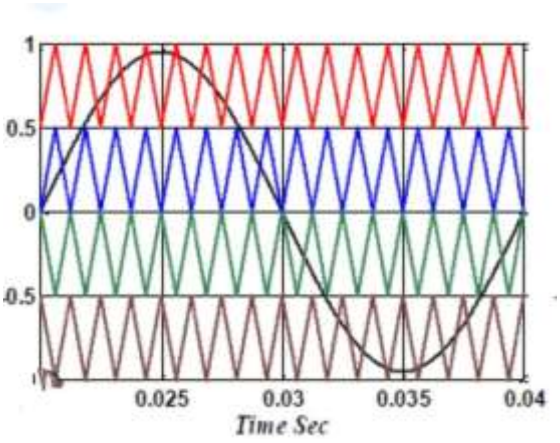

Fig. Carrier signal

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Simulink is integrated with MATLAB®, providing immediate access to an extensive range of tools that let you develop algorithms, analyze and visualize simulations, create batch processing scripts, customize the modeling environment, and define signal, parameter, and test data.

SIMULATION RESULTS

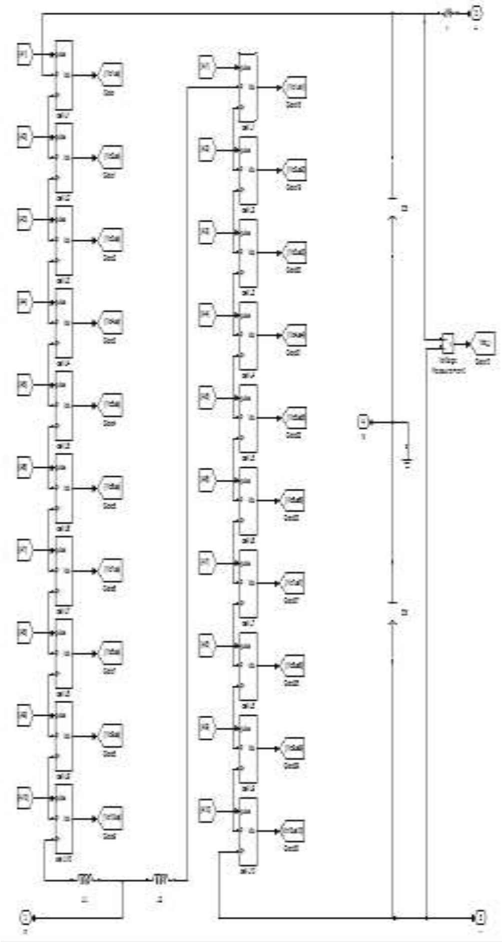

Fig. Simulation of Structure of a single-phase MMC inverter structure

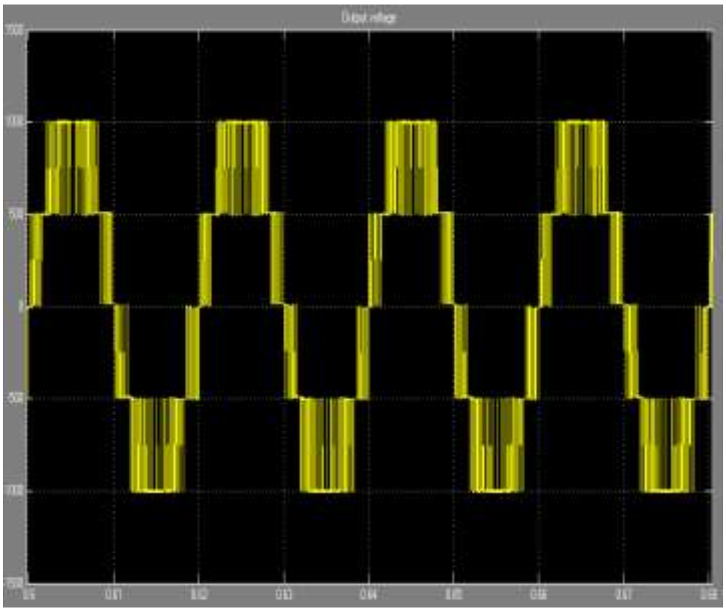

Fig. Simulated output voltage of a 5-level inverter

CONCLUSION

The performance comparison analysis of two level VSI DSTATCOM with five level MMC DSTATCOM by using carrier-based pulse width modulation (PWM) method reveals that the 5-level MMC DSTATCOM provides better power quality and system stability compared to the 2-level VSI DSTATCOM.

The 5-level MMC DSTATCOM is capable of producing five levels of output voltage, including the zero voltage level, which results in a high-quality output voltage with low harmonic distortion and fast response time. In contrast, the 2-level VSI DSTATCOM can produce only two levels of output voltage, resulting in higher harmonic distortion.

The carrier-based PWM method is a widely used technique to control the output voltage of both types of DSTATCOMs. However, the 5-level MMC DSTATCOM provides better power quality due to its ability to generate a high-quality output waveform with low harmonic distortion, while the 2-level VSI DSTATCOM produces a less refined output waveform with higher harmonic distortion.

In summary, the performance comparison analysis shows that the 5-level MMC DSTATCOM is a superior choice for applications that require high power quality and system stability, while the 2-level VSI DSTATCOM may be suitable for less demanding applications. However, the selection of the appropriate DSTATCOM for a specific application should be based on a detailed analysis of the system requirements and constraints.

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