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Unique Facts Device for Power Quality Mitigation

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Abstract:- STATCOM devices play a vital role in modern power systems, providing flexible and efficient solutions for voltage control, enhancing power quality, supporting renewable integration, and improving overall grid reliability and performance. A STATCOM (Static Synchronous Compensator) is a device used in power systems for voltage control, power flow control, and reactive power compensation. It is a type of Flexible AC Transmission System (FACTS) technology that uses power electronics to manage the flow of electricity on the grid. A STATCOM works by generating or absorbing reactive power (VARs), which helps to regulate voltage levels on the electrical network. Unlike traditional compensators that use capacitors and inductors for reactive power management, a STATCOM uses a voltage source converter (VSC) and can provide variable reactive power support regardless of the AC system voltage. This makes it highly effective in stabilizing grid voltage, particularly under rapidly changing load conditions or during disturbances.

Keywords:- *FACTS, Reactive power, STATCOM, MATLAB.*

I. INTRODUCTION

Reactive power is a fundamental concept in the field of electrical engineering, particularly in the context of AC (Alternating Current) power systems. It's essential for understanding how power systems operate, and for designing and operating electrical networks efficiently. In AC power systems, power is divided into two types: real power and reactive power. Real power (measured in Watts, W) is the power that actually performs work, such as turning a motor or lighting a bulb. Reactive power (measured in Volt-Amps Reactive, VARs), on the other hand, is the power that oscillates back and forth between the source and the load. It does not do any real work but is essential for maintaining the voltage levels necessary for real power to be transferred.

Reactive power is crucial for maintaining voltage levels in a power system. If there is not enough reactive power, voltage levels can drop, leading to inefficient system operation and even blackouts. Many electrical devices, like motors and transformers, need reactive power to generate magnetic fields for their operation.

Reactive power is generated by capacitors and inductors. Inductors (like coils in motors) consume reactive power, while capacitors provide it. Proper management of reactive power is essential for the stability and efficiency of power systems. It helps in reducing losses and maintaining the capacity of transmission lines. Understanding reactive power is crucial for anyone involved in the generation, transmission, and distribution of electric power. It's a key factor in ensuring that electrical systems operate efficiently, reliably, and safely. As power systems evolve with new technologies and renewable energy sources, the importance of effectively managing reactive power continues to grow.

STATCOM (Static Synchronous Compensator) plays a pivotal role in reactive power compensation in modern electrical power systems.

II. PROPOSED METHOD

STATCOMs are capable of both generating and absorbing reactive power. This flexibility allows them to maintain appropriate voltage levels in the power system by dynamically adjusting the amount of reactive power supplied or absorbed. STATCOMs are highly effective in maintaining a constant voltage level within the power grid, even under fluctuating load conditions. This is crucial for the stability and efficiency of the power system.

They provide dynamic voltage support, which is especially important during transient conditions such as sudden changes in load or generation capacity. This helps in maintaining grid stability. By adjusting reactive power, STATCOMs can optimize the power factor of the system, leading to more efficient power usage and reduced transmission losses.

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Power systems can experience oscillations due to disturbances. STATCOMs can provide damping to these oscillations, improving the overall stability of the system. They can increase the power transfer capacity of transmission lines by managing reactive power flow, which reduces the likelihood of line overloading and voltage instability. Renewable energy sources like wind and solar power are inherently variable and can cause voltage fluctuations. STATCOMs help in smoothing out these fluctuations, thus facilitating the integration of renewables into the grid.

A. Working

The working of a STATCOM (Static Synchronous Compensator) involves advanced power electronic technology and control systems.

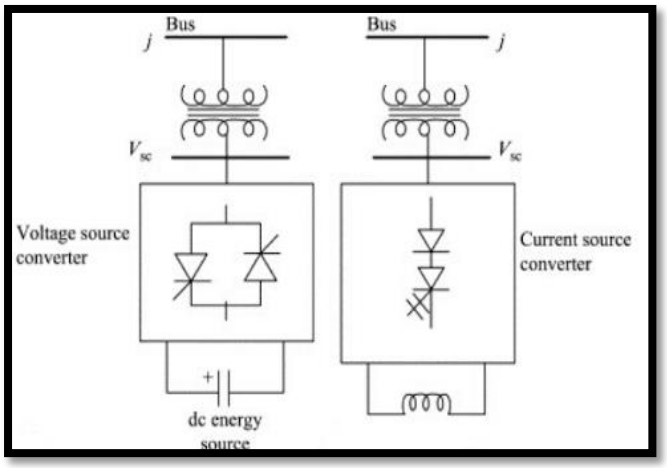

Fig1 Diagram of STATCOM

From figure 1 fundamental components are as follows;

B. Core Components

- Voltage Source Converter (VSC): The heart of a STATCOM is the Voltage Source Converter. This converter uses power electronics (such as IGBTs - Insulated Gate Bipolar Transistors) to convert AC power to DC and vice versa.

- DC Energy Storage: This is typically a capacitor bank that stores energy in DC form. It provides the energy necessary for the VSC to generate AC power.

- Control System: A sophisticated control system is essential for managing the operation of the STATCOM. It constantly monitors the power system's parameters and adjusts the STATCOM's output accordingly.

C. Basic Operation

- Conversion of Power: The VSC converts the AC voltage from the grid to DC voltage, stores it in the DC capacitor bank, and then inverts it back to AC. This process is continuously adjusted to control the phase and magnitude of the AC output.

- Generation or Absorption of Reactive Power:If the system needs more reactive power (e.g., during under-voltage conditions), the STATCOM generates reactive power by leading the grid voltage (the AC output voltage of the STATCOM leads the AC system voltage).Conversely, if there is excess reactive power (e.g., during over-voltage conditions), the STATCOM absorbs reactive power by lagging the grid voltage (the AC output voltage of the STATCOM lags behind the AC system voltage).

D. Voltage Control

The key to the STATCOM's functionality is its ability to control the output voltage amplitude and phase angle. By varying these, the STATCOM can either inject or absorb reactive power.This is done in real-time, based on the instantaneous requirements of the power system, as detected by the control system.

- Synchronization with Grid

The output of the STATCOM needs to be perfectly synchronized with the grid voltage. This is crucial for seamless operation and for ensuring that the reactive power is effectively transferred to or from the grid.

E. Benefits of the STATCOM's Working Principle

- Dynamic Response: The use of power electronics allows the STATCOM to respond very quickly to changes in the grid, much faster than traditional compensators like synchronous condensers.
- Versatility: It can provide or absorb reactive power as needed, making it more versatile compared to traditional methods which can only do one or the other.
- Voltage Support: By adjusting reactive power dynamically, STATCOMs support voltage levels effectively, enhancing grid stability.

F. Applications

STATCOMs are used in a variety of applications such as wind farms, solar power plants, industrial plants, and in general power transmission and distribution networks to improve power quality and stability.

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III. RESULTS AND SIMULATION

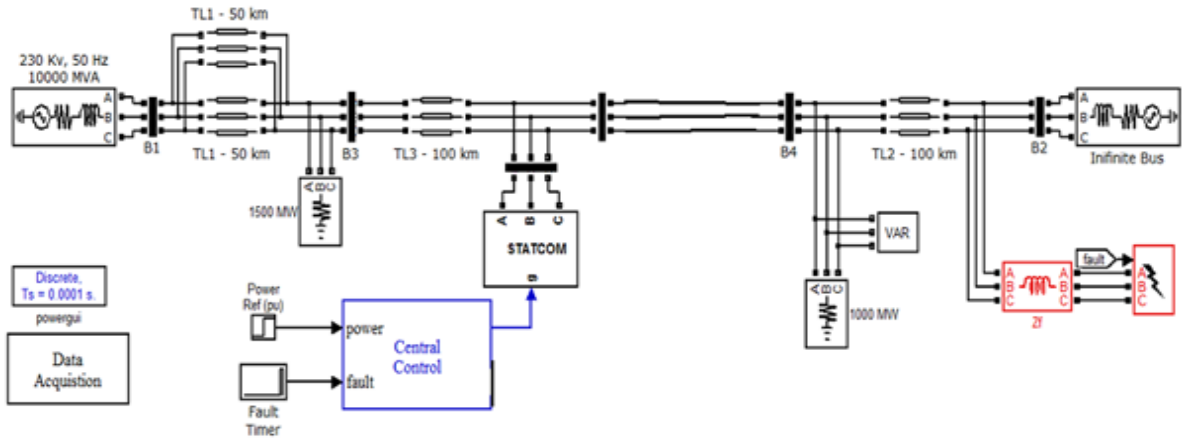

Fig 2 simulation diagram of STATCOM

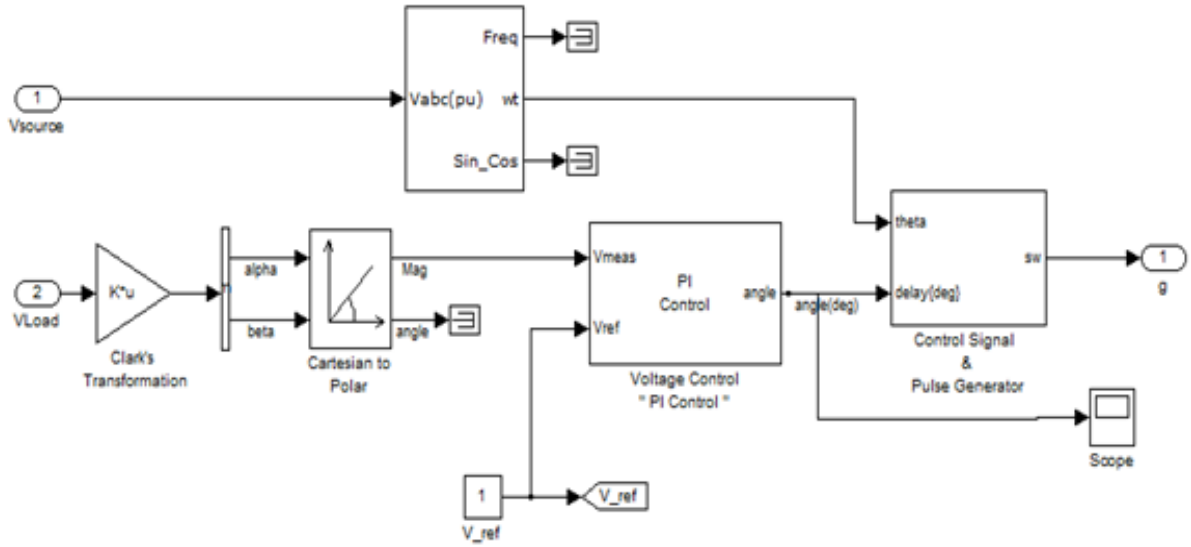

Fig 3.Representation of control circuit

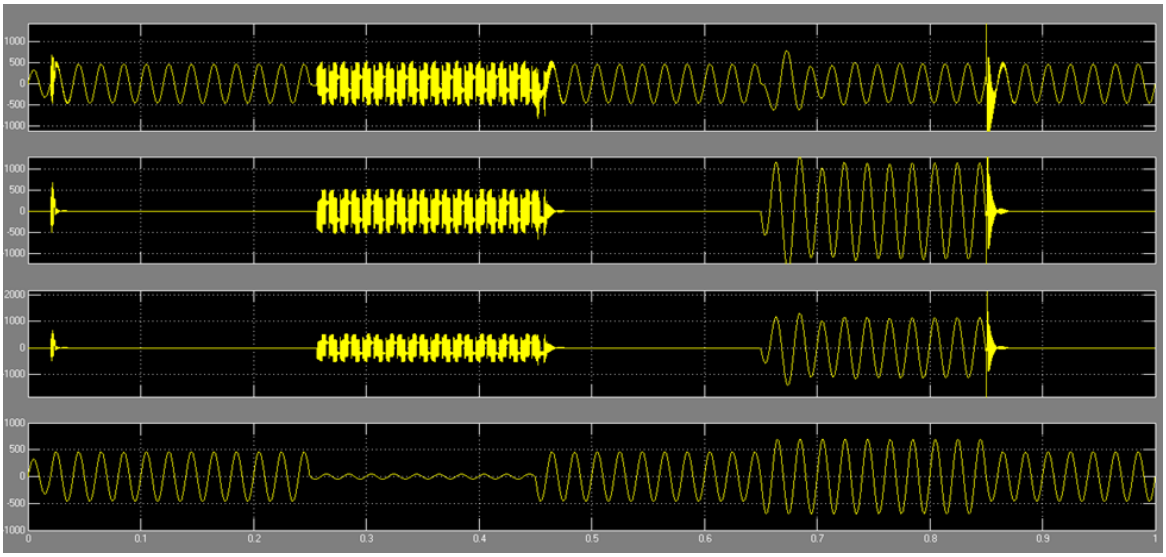

Fig 4.Simulation results

IV. CONCLUSION

The application of STATCOMs in reactive power compensation is a key aspect of modern power system management. Their ability to rapidly respond to changes in the grid and provide a wide range of reactive power makes them invaluable in maintaining system stability, enhancing power quality, and supporting the integration of renewable energy sources. As power systems continue to evolve and face new challenges, the role of STATCOMs is likely to become even more prominent. The working of a STATCOM revolves around its ability to efficiently and rapidly control reactive power through advanced power electronics and control systems.

FUTURE SCOPE

The future research scope of STATCOM (Static Synchronous Compensator) in power systems is quite broad and promising. As electrical grids worldwide are evolving to accommodate more renewable energy sources and to meet the increasing demand for high-quality power.

- **Challenges with Intermittent Sources:** Research is ongoing to improve the effectiveness of STATCOMs in grids with high penetration of intermittent renewable energy sources, such as solar and wind.
- **Grid Stability:** Focus on enhancing the capability of STATCOMs to stabilize grids that are increasingly reliant on renewable sources with fluctuating output.

The future research in STATCOM technology is geared towards making them more efficient, cost-effective, and capable of handling the challenges of modern and future power systems. The integration with renewable energy, advancements in control algorithms, improvements in power quality, and resilience to cybersecurity threats are among the key focus areas. As the demand for reliable and high-quality power grows, along with the push for greener energy sources, the role of STATCOMs and the research surrounding them will be increasingly vital.

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