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MODULATION AND CONTROL OF TRANFORMER LESS UPFC

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ABSTRACT

The brand-new combined power flow device without a transformer (UPFC) modulation and control method is described in this paper. It is common knowledge that the conventional UPFC, which consists of two back-to-back inverters, needs large, frequently intricate zigzag transformers for separation in order to achieve high power ratings with desired voltage wave form. A fully substations-free UPFC built on an innovative configuration of two cascade multilevel inverters (CMIs) is being developed. suggested as a solution to this issue. The new UPFC has a number of benefits over the conventional technology, including the absence of a transformer, excellent effectiveness, low cost, and quick changing response; thin and light. This article's primary topics are modulation and control for this new transformer-free UPFC. Improved fundamental frequency modulation (FFM) for high efficiency, regardless of total harmonic distortion (THD), and low management of dc-link voltage balance, dc-link active and reactive power management, etc. Experiments based on a 4160 V test setup are used to validate the brand new UPFC with the suggested control method. In this paper, both the steady-state and the dynamic-response outcomes will be given.

KEYWORDS: Cascaded Multi-level inverter, Unified Power Flow Controller.

INTRODUCTION

The Unified Power Flow Controller, a component of the Flexible AC Transmission System is utilized to manage and control power flow in power networks. It comprises of two voltage source converters linked back-to-back through a shared DC link and a series converter in the power line. The two control modes are voltage management mode and phase-angle management mode. modes available for standard UPFC s. In voltage control mode, the UPFC controls the series substations active electrical output and the shunt substations reactive electrical output to regulate the voltage magnitude at the site of connection. When in phase-angle control mode, A adjustable voltage is injected by the Unified Power Flow

Controller in series with the voltages at the two ends of the series transformer to regulate the voltage variance between the two of the substations-angle mismatch .employing batteries which ultimately results in the same issues with transformers as described above (such as heavy, expensive, lossy, and sluggish to respond). The only useful inverter technique to achieve high voltages is the cascade multilevel inverter (CMI).A crucial function for cascade multilevel inverters (CMI) in transformer less UPFC s (Unified Power Flow Controllers). An electronic power device called a transformer Voltage regulation in electricity transmission lines is accomplished by UPFC. control the active and reactive power transfer on transmission lines, and lessen power system oscillations. Multiple H-bridge inverter modules that are linked in series to create a voltage waveform that resembles a staircase make up cascading multilevel inverters. A CMI output voltage waveform is a stepped waveform with high voltage levels and little distortion, making it ideal for high power uses. Two CMI s are linked in series with a shared DC-link capacitor in a transformer-less UPFC, and each CMI is linked in parallel to a shunt capacitor. A single CMI is linked in succession. To regulate the current power circulation, one Cascade Multi level Inverter is linked in parallel with the power line; to regulate the reactionary power flow, the other Cascade Multi level Inverter is attached to the switched capacitance. Managing the movement of active and reactive power on the transmission line is the main responsibility of the cascade multilevel inverters in a transformer less UPFC. The UPFC can inject or absorb active and reactive power to the line of transmission, changing the voltage and angle of phase to control the power transfer on the connection. of each inverter's output voltage. The required reactive power correction is provided from The shunt capacitors in tandem connected to each inverter. In order to operate transformer-less UPFC s, cascade multilevel inverters are essential because they offer a method of regulation transmission line's active and reactive electricity flow. They are the perfect option for high-power applications due to their high voltage and minimal distortion output voltage waveform.

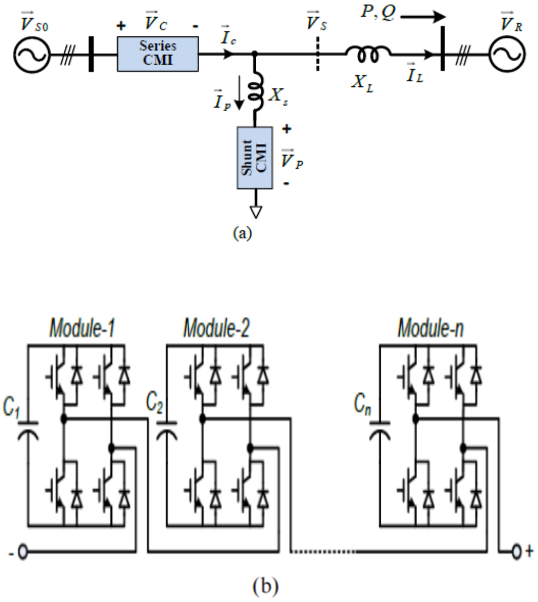

Fig. 2. Novel substations-less UFPC,

(a) substations-less Unified Power Flow Controller Standard Setting up,

(b) Cascaded substations Converter Period.

PROBLEM IDENTIFICATION

For voltage conversion, the conventional UPFC needs a big transformer, which results in a high installation cost, a large physical size, and substantial power losses because of the transformer's inherent losses. Transformers also complicate the system and cost more to maintain because they are more prone to failure. The transformer also restricts the UPFC s ability to manage high voltages and currents, which limits some high-power applications where it can be used. Leakage inductance, another issue with the transformer-based UPFC, can result in high-frequency oscillations and lessen system reliability.

METHODOLOGY

A power electronic device used in power transmission systems to manage The substations-less UPFC controls voltage, regulates both reactive and active power flow on transmission lines, and lessens power system fluctuations. using cascade multilevel inverters.

A shared DC-link capacitor connects two CMI s in series to create the transformer less UPFC. Each H-bridge inverter module in a CMI is made up of a flying capacitor, four power electronic switches, and a DC source. Each CMI is made up of a succession of these inverter modules. The flying capacitor works as a voltage balancing element to keep the inverter modules voltage levels equal. In order to control the active electricity flow, a few CMI is connected in series with the line of transmission to regulate the active electrical flow, and another is connected together with a shunt capacitor to regulate the reactionary flow of electricity. The required reactive power correction is provided by the shunt capacitor. The following explanation explains how the transformer less UPFC with CMI operates:

Control of active power flow: The CMI linked in series with the transmission line controls the flow of active power by releasing or absorbing active power into the line. To do this, a control algorithm that modifies the output voltage's amplitude and phase angle is used to regulate the CMI' s output voltage.

Control of reactive power: By injecting or absorbing reactive power into the transmission line, the CMI connected in parallel with the shunt capacitor regulates the reactive power flow. Controlling the outgoing voltage enables this.

of the CMI using a control method that modifies the output voltage's amplitude.

Voltage control: The shared DC-link capacitor serves as both a reliable voltage source for the CMI s and a voltage regulator for the transmission line. A control algorithm that modifies the output voltage of each CMI is employed to control the power by regulating the voltage across the DC-link capacitor.

Power system oscillation damping:

By injecting or absorbing the distribution line with active and reactive electricity at the proper phase and magnitude, the transformer-less UPFC using CMI can also be used to reduce power system oscillations.

Overall, the transformer less UPFC using CMI offers a versatile and adaptable approach to managing power flow on transmission lines, regulating voltage and reducing power quality issues. a system's fluctuations. More precise control over the output voltage pattern is possible with CMI use, which may result in less distortion and better performance.

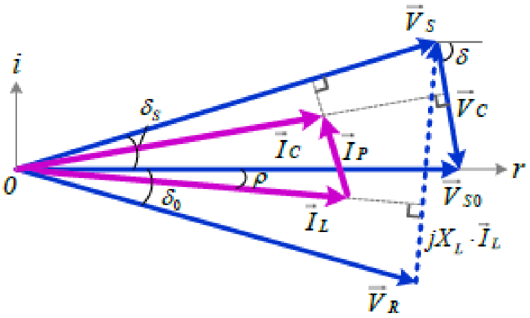

Fig. 3. Transformer-free phasor schematic UPFC.

FUNDAMENTAL FREQUENCY MODULATION FOR CMIS

The process of regulating the cascaded multilayer inverter's output voltage at the primary frequency of the AC power system is known as the basis for frequency modulation CMI s in transformer less UPFC. Low switching loss, high efficiency, and exceptionally low total harmonic distortion (THD) of the output voltage are all achieved in the UPFC using this modulation technique. In comparison to other modulation methods, the fundamental frequency modulation technique has a number of benefits, including high efficiency and a low THD of the output voltage. By removing the high-frequency overtones from the output voltage waveform, it also aids in lowering the switching losses in the CMI. Finally, it should be noted that the fundamental frequency modulation method is crucial for regulating the CMI' s output voltage in transformer less UPFC s. This method aids in enhancing the UPFC 's effectiveness and power quality, making it a hopeful option for a number of power system applications. The output voltage waveform of CMI is split into a fundamental component and a harmonic component using the primary frequency modulation method. The fundamental frequency of AC power source is then used to modulate the fundamental component with a sinusoidal waveform. Several harmonic elimination methods, including selective harmonic removal and altered pulse width control are used to reduce the harmonic component. (SHE-PWM).

ADVANCED SWITCHING ANGLES FOR LOWEST TOTAL HARMONIC DISTORTION

the control strategy and switching angles need to be optimized in a transformer less UPFC using a cascaded multilevel inverter to obtain the lowest possible THD. The inverter's operation and how the output voltage is produced are both governed by the management strategy. The output waveform is produced by the inverter toggling between various voltage levels at specific instants, which are determined by the switching angles.The suitable modulation technique must be chosen in order to optimize the control strategy because it affects how reference signals for the output voltage are produced based on the desired voltage and current wave forms. There are many different modulation methods accessible, each with their own benefits and draw backs for instance, the width of the pulse modulation) and selective harmonic elimination (SHE). The employed modulation method must be capable of producing the desired voltage pattern with the least possible THD.Choosing the points at which the inverter switches between various voltage levels to produce the output waveform entails optimizing the switching angles. This can be accomplished using a variety of optimization methods, including linear programming, genetic algorithms, and particle swarm optimization (PSO). (LP). While observing other constraints like the highest voltage rating of the switches and the inverter's power rating, the optimization's goal is to reduce the THD of the output voltage. In a transformer less UPFC using a cascaded multilevel inverter, minimizing THD requires optimizing the management strategy and switching angles.

SUBSTATIONS-LESS UPFC WITH POWER TRANSFER AND DC-LINK VOLTAGECONVERTERS

A. Unified Power Flow Controller System Nonlinear Models

To develop and evaluate the suggested substations-less UPFC's efficiency with vector-oriented control (VOC), dynamic models are required. Among these moving models are Power system dynamic model This model simulates the power system's dynamics and is used to assess the system's stability and transient reaction. Modeling the voltage source converter's dynamics, the converter's behaviour during transients and steady-state function is done using the converter dynamic model. Dynamic model of the multiple the H-bridge cascaded inverter: The behaviours of system are simulated by this cascaded H-bridge multilevel inverter and is used to examine how the inverter behaves under rapid and steady-state conditions .Modeling the behaviour of the control system using a control system dynamic model is employed to examine how the control system behaves both in steady-state function and transients.

These dynamic models can be combined to create the total dynamic model of the transformer-free UPFC system

B Controlling the flow of electricity and total DC voltage

Designing a management system with the ability to separately control active power P and reactive power Q in the line while keeping the capacitor voltages of both CMI s at the predetermined level is the goal. Stage I through Stage III make up the three stages of the overall control mechanism.

In Stage I : The voltage source converter's DC-link voltage is controlled by a PI processor. (VSC). The DC-link voltage controls the active power P and reactive power Q of the device. The proportional-integral controller's output is fed into a current controller in phase II.

In Stage II: The AC current of the VSC is regulated using a current controller that can separately control the active and elements of the stream that are reactive.

In Stage III: The capacitance charges of both CM Is are controlled by a voltage converter. The PWM block gets the voltage substations output and uses it to produce the switching impulses for the CMI..

The following goals are intended to be attained by the general control system:

Independent regulation The current controller in stage II, which is designed to separately regulate both the proactive and reactive elements of the current, enables the separation of active and reactive power. The capacitance volts of both Cascade Multi Level Inverter Is were to be maintained at the predetermined values by the voltage control system in step III.

C. Stage balance regulation alongside unique DC management are crucial for ensuring the safety and effectiveness of the system in transformer less UPFC s using CMI s. By implementing an inner control loop that separately controls the voltage of each H-bridge capacitor, the individual DC control is accomplished. A proportional-integral (PI) controller is usually used for this, which modifies the duty cycle of each H-bridge in order to maintain the desired capacitor voltage. On the other hand, an outer control loop that controls the active power moving through each phase of the system is responsible for achieving the phase balance control.

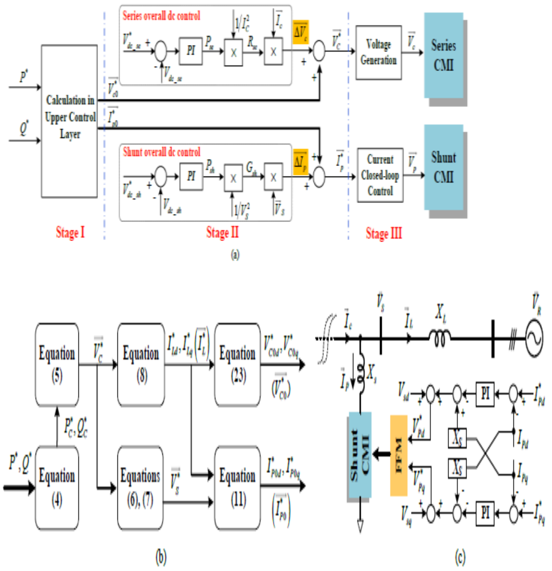

Fig. 4. Control framework for substations-less Unified Power Flow Controller, demonstrating (a) a comprehensive control diagram to regulate power flow and the voltage regulation of dc capacitors that store energy (b) an in-depth calculation from P*/Q* for V*_CO and I*_PO, and (c) electricity closed-loop management for shunt cascade multi level inverter

D. Execution and Administrative Design

The approach to regulate for transformer less Unified power flow controller using CMI has three stages: voltage control, power flow management, as well as personal DC control. By adjusting the voltage magnitude and phase angle of the output of the voltage regulator, the voltage control stage makes sure that the voltage across the load is maintained within a specified range. VSC. The power flow control stage regulates the active and reactive power flow in the line by adjusting the output of the VSC.The individual DC control stage is responsible for maintaining the voltages across each H-bridge's capacitance module at a given value by controlling the amount of charge transferred to each capacitor. This is achieved by using an outer control loop and an inner control loop Every single one among the H-bridge modules' all power usage is controlled by the outer flowing electricity is distributed equally to every an H-bridge module by the inner circuit, composed of three phases.

In addition, phase balance control is implemented to ensure that the power is distributed equally among the three phases, and the capacitor voltages are balanced. This is achieved by using a a proportional-integral processor to modify the output voltage of the voltage supply converter's angle of phase. The control system architecture is implemented using a digital signal processor (DSP) and a field-programmable gate array (FPGA) to provide high-speed computation and real-time control. The control signals are generated based on the feedback data from both current and voltage devices that are attached to the system in the proper places. The control system is designed to ensure reliable and efficient operation of the transformer less UPFC using CMI.

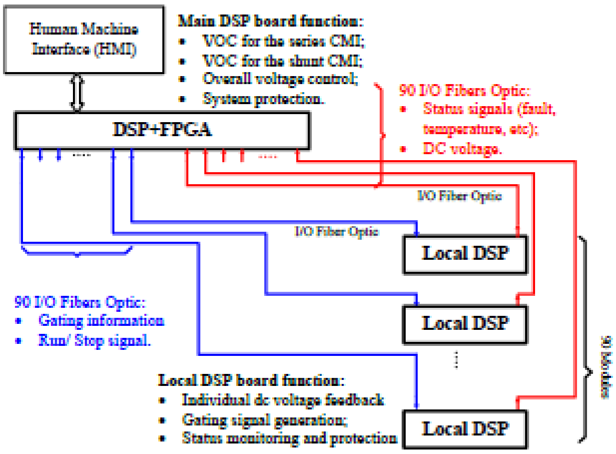

Fig. 5 The management program's design.

SIMULATION MODEL AND RESULTS

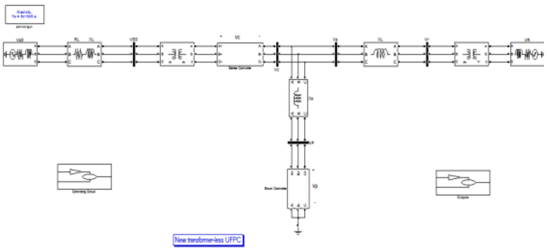

Fig10. Simulation model of UPFC without transformer.

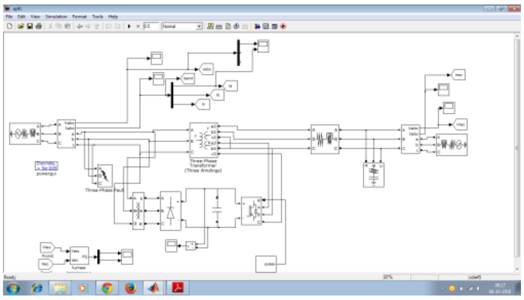

Fig11.Simulation with transformer

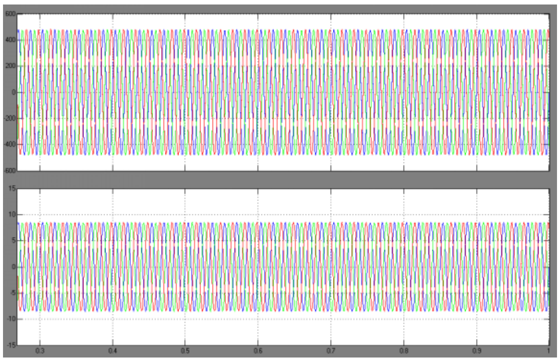

Fig 12.Sending End Voltage and Current

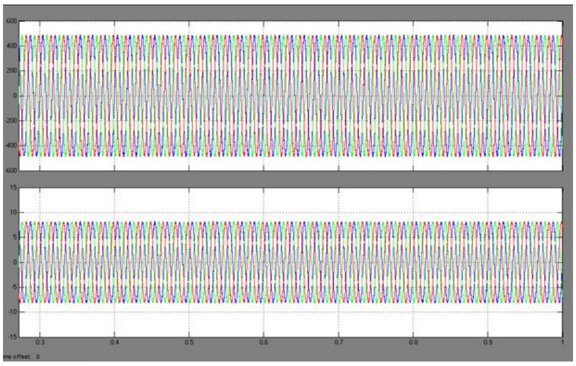

Fig 13. Receiving End Voltage and Current

CONCLUSION

In this article, a modulated and management technique for the transformer-free unified power flow controller is presented.

1) frequency modulation of the CMI to accomplish extremely low transient harmonic distortion (THD) of the voltage output, minimal switching reduction, and high productivity;

2) All UPFC operations, such as controlling the voltage, line impudence compensation, shifting of phase or simultaneous control of voltage, impedance, and phase angle, to accomplish distinct reactive and active power flow control over the communication line;

2) Control the dc voltage of the capacitor balance for the series and shunt CMIs;

3) Quick dynamic reaction (10ms). Everywhere within the grid, the substations-less Unified power flow controller with proposed modulation and management functions can be placed to converters/optimize the transmission of energy over the current grids, reduce transmission congestion, and allow high penetration of green energy sources.

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