TWO SERIES AND ONE SHUNT CMI BASES UPFC SYSTEM FOR HARMONIC SUPPRESSION

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Abstract- The Unified Power Flow Controller has capability to reduce harmonics present in the power system and maintain the stability of overall system. But the performance of it not as much good which can sustain in every condition. So there is need for better controller which can be implemented with the Cascades Multilevel Inverter (CMI) and gives better stability than the previous configurations. In this work a UPFC is proposed which is based on two series and one shunt cascaded multilevel inverter (CMIs), with the utilization of transformer. The proposed design has lower total harmonic distortion (THD) and faster dynamic response. The system design with the outcomes is explained in the proposed methodology and simulation results sections. Fixed series capacitors help in expanding steadiness confines in an interconnected power system. With transmission open access, every transmission system owning utility will build their transmission ability to pull in more utilities to utilize its transmission facilities. Many existing power systems have already made the utilization of series compensation to expand their transmission limit. By series compensation, the measure of reactive power consumed by the line is decreased in this manner expanding the measure of reactive power transfer to the less than desirable end and enhancing the voltage profile at the less than receiver end. This is one of the optional advantages of utilizing series compensation. Under system unsettling influence conditions like three phase faults or line tripping, controllable series compensation helps in damping power system oscillations.

1. INTRODUCTION

Electrical energy is the back bone for the development of the modern generation. With the mechanical development of a country there is dependably an expanded prerequisite of electrical energy. The expanded interest for electric energy requires expanding the transmission capacities. However, the inherent thermal, dielectric and dependability cutoff points of power system confine the power exchange, leading to the under usage of the current transmission assets. Traditionally, or mechanically exchanged shunt and series capacitors, reactors and synchronous generators were being utilized. In any case, wear and tear in the mechanical segments, expansive exchanging homeless people and moderate reaction were the issues with these devices. There was a more noteworthy requirement for an option innovation based on strong state devices with quick reaction qualities. The need was further fuelled by overall rebuilding of electric utilities and troubles in getting grant and right of path for the development of new overhead transmission lines [3]. This together with the innovation of thyristor switch opened the entryway for the improvement of power electronic devices based controllers known as adaptable air conditioning transmission systems controllers [4]. It gives off an impression of being a promising idea, which gives a path to the most extreme use of the current transmission offices. FACTS controllers give quick and dependable control over the three fundamental transmission parameters, i.e., voltage extent, phase edge and line impedance to encourage ideal power system execution. Certainties devices are broadly ordered into two sorts to be specific thyristor based devices and voltage source inverter based devices. Static var compensator, thyristor controlled series capacitor, and so on., are the thyristor based FACTS devices [12]. Static synchronous compensator, static synchronous series compensator and unified power flow controller are the voltage source inverter based FACTS devices.

The UPFC is a champion among the most adaptable device. It can't simply play out the components of the static synchronous compensator (STATCOM), thyristor switched capacitor (TSC) thyristor controlled reactor (TCR), and the phase point controller additionally gives additional adaptability by joining a segment of the components of the above controllers [1]. The primary capacity of the UPFC is to control the flow of genuine and reactive power by infusion of a voltage in series with the transmission line. Both the greatness and in addition the phase edge of the voltage can be fluctuated freely. Genuine and reactive power flow control can take into account power flow in endorsed courses, transmission lines loading is nearer to their warm cutoff points and can be used for enhancing transient and little signal strength of the power system.

1.1 FACTS Controller

Flexible AC Transmission System (FACTS): Alternating current transmission systems consolidating power electronic-based and other static controllers to upgrade controllability and increment power transfer capacity.

The different fundamental FACTS- devices Application are:

- Power flow control
- Increase of transmission capability
- Voltage control
- Reactive power compensation, stability improvement
- Power quality improvement
- Power conditioning

1.2 Operation of UPFC

The UPFC is a device which can control at the same time every one of the three parameters of line power flow (line impedance, voltage and phase angle) .It is a one of the FACTS family that used to ideal power flow in transmission. The UPFC is a blend of static synchronous compensator (STATCOM) and static synchronous compensator (SSSC).Both converters are worked from a typical dc interface with a dc stockpiling capacitor. The genuine power can uninhibitedly flow in either course between the two-ac branches. Each converter can freely produce or assimilate reactive power at the ac output terminals [6]. The controller gives the gating signals to the converter valves to give the coveted series voltages and at the same time drawing the fundamental shunt streams, to give the required series infused voltage, the inverter requires a dc source with regenerative abilities. The conceivable arrangement is to utilize the shunt inverter to bolster the dc transport voltage.

1.3 Advantages of UPFC

The UPFC can play out the capacity of STATCOM and SSSC and phase point controller. Other than that the UPFC likewise gives an additional adaptability by consolidating a portion of the capacity above. UPFC has additionally an extraordinary capacity to control genuine and reactive power flow all the while on a transmission system and also to direct the voltage at the transport where it's associated. The UPFC can likewise expand the ability of the power flow to the load request until its reach its farthest point in the brief time frame .in the meantime the UPFC additionally can build the security system by expands the breaking point of transient solidness, blame and the over load request .Lastly the UPFC likewise can decrease the estimation of the reactive power And will ideal the genuine power flow through the transmission line.

1.4 Theory of UPFC

The Unified Power Flow Controller (UPFC) was proposed first time for genuine kill time control and dynamic compensation of ac transmission systems. The Unified Power Flow Controller is comprises of two exchanging converters, which are considered as voltage sourced inverters utilizing gate thyristor valves, as represented in Fig.1.1. These inverters, marked "VSC1" and "VSC2" in the figure are worked with a typical dc interface given by a dc stockpiling capacitor. With this plan the ac power converter in which the genuine power can openly flow in either bearing between the ac terminals of the two inverters and each inverter can freely create and in addition assimilate the reactive power at its own particular ac output terminal .Since the series converter of the UPFC can infuse a voltage with variable greatness and phase edge it can exchange genuine power with the transmission line with the assistance of series transformer. However an UPFC overall (both converter) can't supply or assimilate genuine power in steady state (aside from the power attracted to adjust for the losses).Unless it has a power source at DC terminals. In this way the shunt branch is required for adjust (from the system for any genuine power drawn/provided by the series branch and the misfortunes. at the point when the power adjust is not kept up, at that circumstance the capacitor can't stay at a steady voltage. Shunt branch likewise can autonomously exchange reactive power with the system.

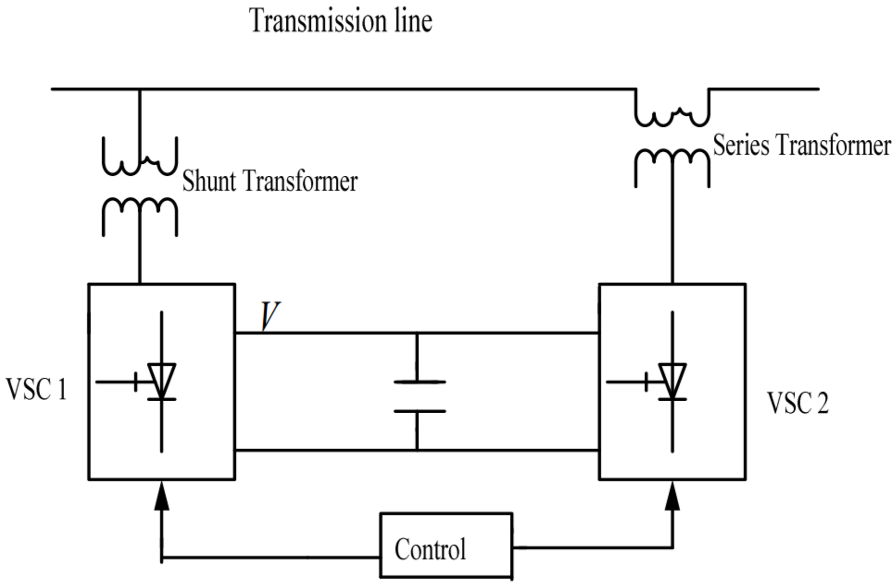

Figure: 1.1 The Schematic diagram of UPFC.

1.5 UPFC Operation

The voltage sources Vsh and Vse mentioned are obtained by converting DC voltage to AC voltage. The transformation from DC voltage to AC voltage is achieved by utilizing standard scaffold circuits. These extension circuits utilize GTO as their building pieces. Since these circuits change over DC voltage to AC voltage, they are named as voltage source converters (VSC). The control system related with VSC enables it to adjust its greatness and phase point. The expression "inverter" has additionally been utilized to indicate the VSC.

Consider now the association of two VSC associated back to back with a typical DC connect capacitor "C" as appeared in Fig. 1.2 Such a course of action takes into consideration all the three capacities in particular series, shunt and phase edge compensation to be unified in one unit. Inverter 1 is associated with a shunt transformer and the inverter 2 is associated with a series transformer.

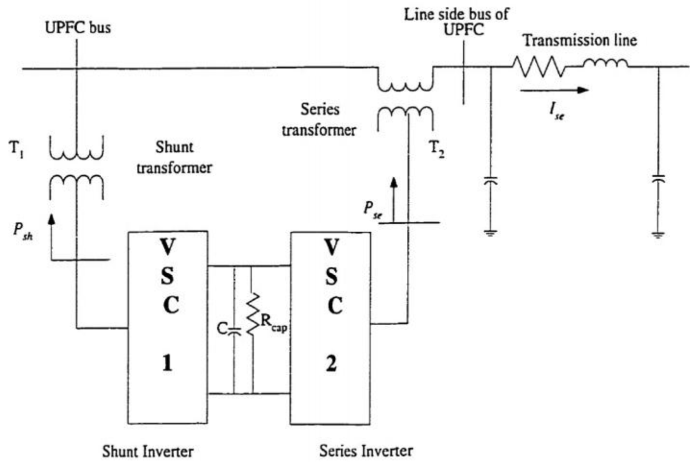

Figure: 1.2 UPFC constructions

It is readily observed that the VSC associated with the shunt transformer can play out the capacity of a variable reactive power source like that of shunt compensator. In addition, the inverter 1 can charge the DC interface capacitor. Inverter 2 can give series or phase point compensation by infusing a series voltage of appropriate phase relationship. On account of series compensation, inverter 2 can work autonomous of the inverter 1, as inverter 2 supplies/expends just reactive power and does not have any genuine power exchange with inverter 1. In such a case, the DC connect capacitor voltage will in a perfect world be consistent.

2. LITERATURE SURVEY

1. F. Z. Peng, Y. Liu, S. Yang, S. Zhang, D. Gunasekaran and U. Karki,[1] The ordinary unified power-flow controller (UPFC) that comprises of two consecutive inverters requires cumbersome and regularly convoluted zigzag transformers for isolation and achieving high voltage. This exploration work proposes a totally transformer-less UPFC based on an inventive design of two cascade multilevel inverters (CMIs). The exceptional arrangement and control of the two CMIs as a power-flow controller make it conceivable to freely control active and reactive power flows over a line. The new UPFC offers a few advantages over the traditional innovation, for example, transformer-less, light weight, high effectiveness, high unwavering quality, minimal effort, and quick dynamic reaction. The transformer-less UPFC is consequently exceptionally suited for quick and circulated power flow control, for example, wind and sun oriented power transmission. Trial comes about based on 13.8-kV/2-MV•A transformer-less UPFC model are appeared to approve the hypothetical investigation and working standard.

2. D. Gunasekaran, S. Yang and F. Z. Peng, [2] Recently, a novel transformer-less unified power flow controller (T-UPFC) has been proposed. The T-UPFC is a reasonable contender for performing power flow control in interconnected synchronous AC grids. By methods for expository expressions, this exploration work gives the general device power rating of such a system when used to control power flow through the line as far as possible. By methods for these outcomes, it is demonstrated that the appraisals of T-UPFC are just a portion (two tenths) of that of consecutive VSC based HVDC converter extends economically being executed to give power flow control in interconnected synchronous grids. The examination and results in this exploration work delineate the reasonable advantages of this innovation.

3. W. Zhang, D. Xu, P. N. Enjeti, H. Li, J. T. Hawke and H. S. Krishnamoorthy, With boundless use of power electronic converters in high power systems, there has been a developing enthusiasm for system dependability investigation and fault tolerant capacities. This examination work introduces a far reaching audit of ordinary fault tolerant methods with respect to power electronic converters if there should arise an occurrence of power semiconductor device disappointments. These procedures can be arranged into four classifications based on the kind of equipment repetition unit: switch-level, leg-level, module-level, and system-level. Likewise, different fault tolerant techniques are surveyed by cost, intricacy, execution, and so forth. The plan of this audit is to give a definite picture with respect to the flow scene of research in power electronic fault handling mechanism.

3. UPFC MODELING

Analysis of stability of interconnected power systems with UPFC requires legitimate load flow and dynamic models for UPFC. Frequency area and time space observation requires demonstrate for UPFC that accurately show the interaction between the series and the shunt inverter. With a legitimate load flow and dynamic model for UPFC, one can therefore break down the impact of UPFC on power system soundness.

3.1 Load Flow Models

Different load flow models have been utilized to demonstrate the UPFC in varying level of many-sided quality and have been talked about here quickly. As specified in part 1, an UPFC comprises of two inverters associated back to back with a DC connect capacitor.

3.2 Dynamic Model

The dynamic model for an UPFC is focused round the dynamics of the DC connects capacitor. It is outstanding that the DC interface capacitor dynamics is an element of the series and the shunt inverter control factors. The requirement for including the DC interface capacitor dynamics while leading dynamic reviews emerges from the fact that it gives the connection between the series and the shunt inverter operation as far as genuine power adjust. Exchange of genuine power between the series infused voltage by the series inverter and the transmission line current causes the DC interface capacitor voltage to either increment or lessening relying upon the course of genuine power exchange between them. The decline/increment of the DC connect capacitor voltage is detected by the shunt inverter which retains/supplies the vital genuine power through the shunt transformer to control the DC interface capacitor voltage. The models display in the writing shift on the premise of the model utilized for the shunt and series inverter. The dynamic models for UPFC accessible in the writing have been partitioned into shunt inverter and series inverter displaying.

4. PROBLEM STATEMENT

Electrical energy is the back bone for the development of the society. With the industrial growth of a nation there is always an increased requirement of electrical energy. The increased demand for electric energy requires increasing the transmission capabilities. It has been demonstrated that the new UPFC can achieve the same controllability as the traditional UPFC [1]. However, the traditional UPFC consisting of two back-to-back inverters requires isolation and zigzag transformers. The UPFC consisting of two CMIs offers several advantages over the traditional UPFC, such as completely transformer-less and highly modular structure, light weight, high efficiency, high reliability, low cost, and fast dynamic response. The transformer-less UPFC is, therefore, very well suited for fast and distributed power flow control of wind and solar power transmission.

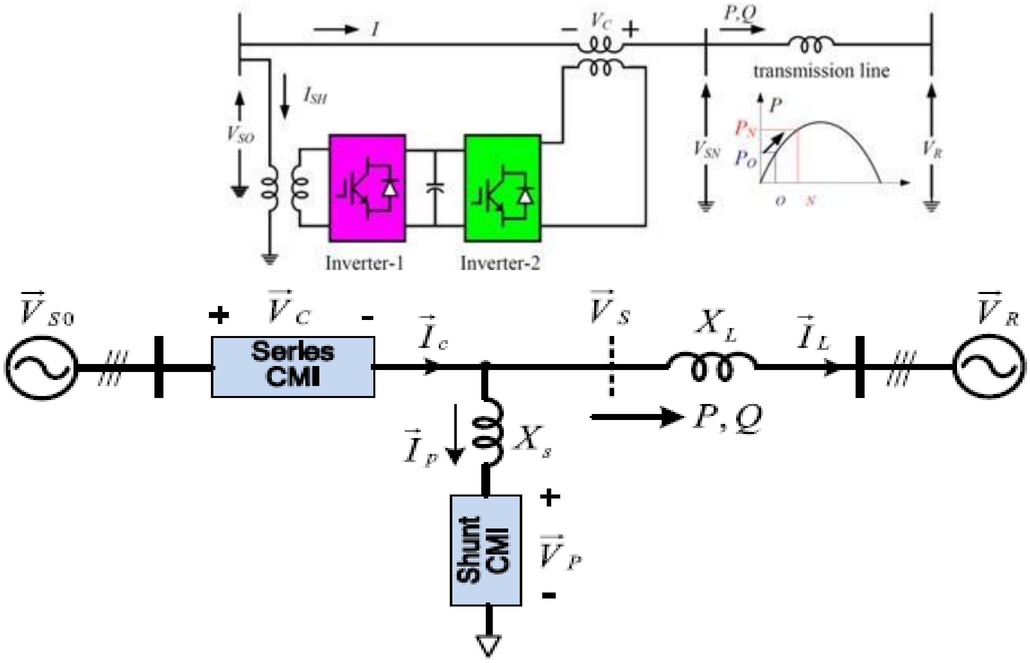

Figure: 3 Conventional UPFC

5. PROPOSED WORK

The proposed work has been implemented and simulated on MATLAB figure 4 demonstrate the proposed UPFC control system having 2 machine 2 converters one is a series converter and another is one shunt converter.

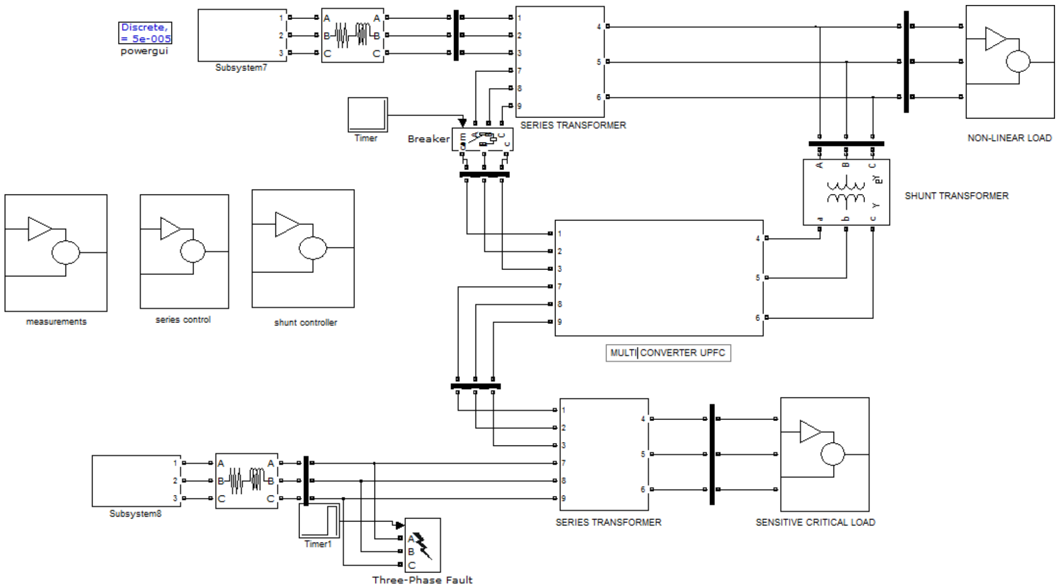

Figure: 4 Proposed UPFC has two machine 2 converters (2 series converters & 1 shunt converter)

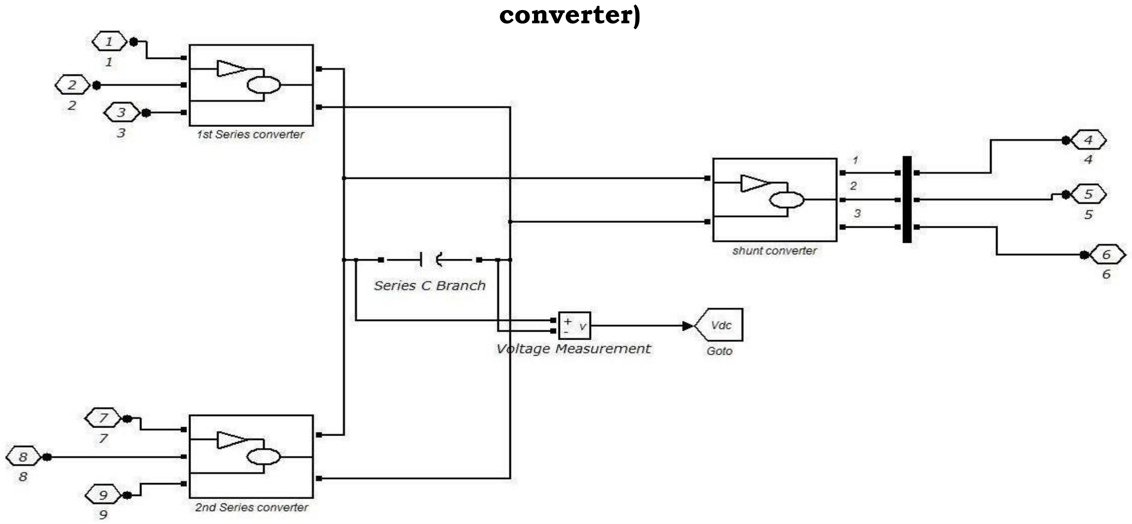

Figure: 5 UPFC with two Series and one Shunt CMI

A unified power flow controller consists of two voltage source inverters (VSI) connected back to back with a common DC coupling capacitor as shown in Fig.4. Such an arrangement allows for ail the three functions namely series, shunt and phase angle compensation to be unified into one unit. Inverter-1 is connected to the power system through a transformer. Figure 6.2 illustrate the UPFC with two Series and one Shunt CMI.

6. SIMULATION MODEL RESULTS ANALYSIS

UPFC being a multi-variable controller, it is necessary to look into its overall effect on power system stability. Frequency domain (small-signal stability) and time domain analysis (transient stability) has been conducted to look into the stability improvement with UPFC. Small-signal stability analysis for power systems with UPFC controlling the real power, reactive power flow in the transmission line/line side bus voltage, DC link capacitor voltage and the UPFC bus voltage simultaneously has been conducted to look into its effect on interconnected power systems. The performance of the proposed system has given with waveform in figure 4 DC Capacitor Voltage Waveforms. Fig. 6 Shunt Currents in the Proposed System. Fig. 7 THD of Proposed System.

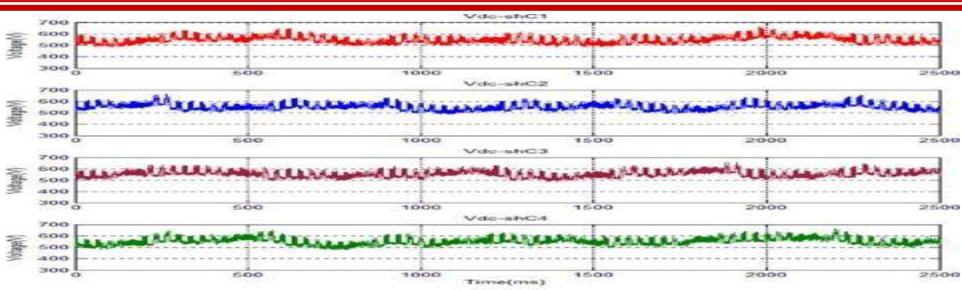

Figure: 6 DC Capacitor Voltage Waveforms of Transformer less UPFC using CMI

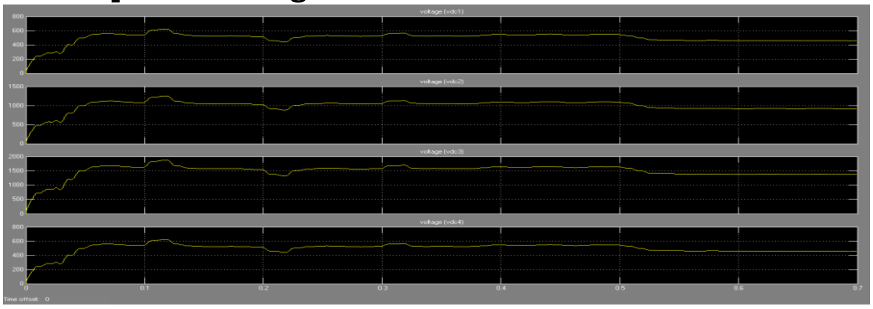

Figure: 7 DC Capacitor Voltage Waveforms of proposed work

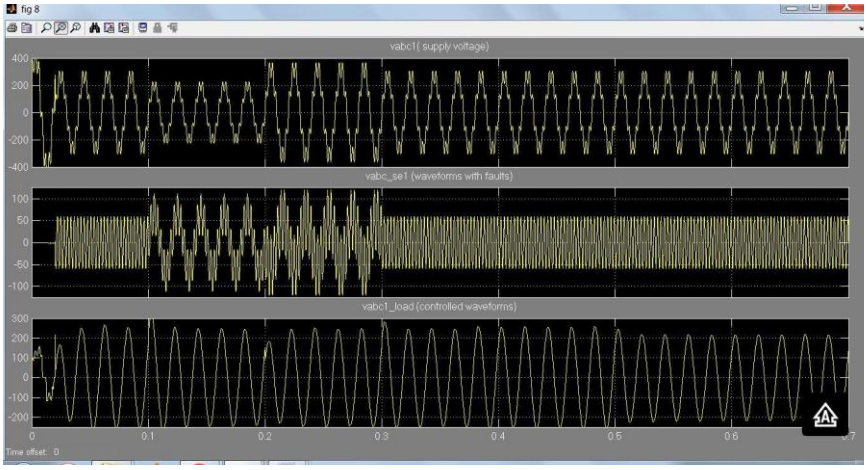

Figure: 8 Fault installed but it is compensated

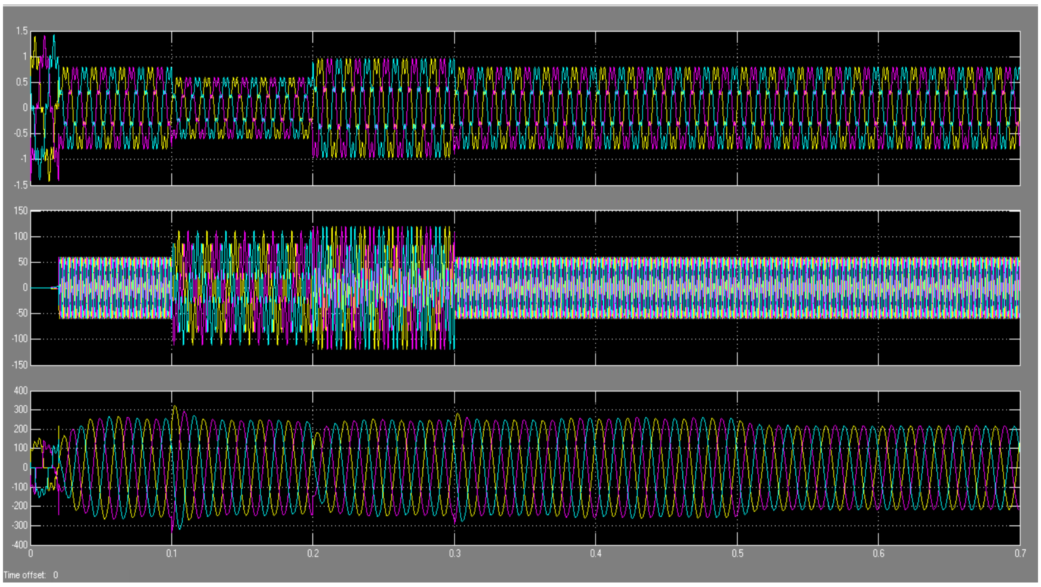

Figure: 9 Compensated Three Phase Waveforms

7. CONCLUSION

Improvement in power oscillation damping has involved the series inverter controlling the real and reactive power flow in the transmission line with the shunt inverter controlling The UPFC bus voltage and the DC link capacitor voltage. With this strategy, it has been mentioned earlier that increase/decrease in the transmission line reactive power achieved by injecting an in-phase voltage by the series inverter is actually supplied by the shunt inverter. Thus the cause and the effect are on two portions of the UPFC. The cause being the injection of in-phase series voltage by the series inverter and the effect is seen as a change in shunt inverter reactive power. This represents an indirect control with respect to transmission line reactive power flow. A new UPFC is based on two series and one shunt cascaded multilevel inverter (CMIs), with the utilization of transformer.

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