POWER QUALITY IMPROVEMENT OF NOVEL PWM BASED 15 LEVEL INVERTER FOR MODIFIED UNIFIED POWER QUALITY CONDITIONER (UPQC)

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Abstract - The unified power quality conditioner (UPQC) is a traditional power device, which mitigates the voltage and current related PQ problems in the power distribution systems. In this paper describes the UPQC topology for an application with non-stiff source is proposed. The proposed topology enables UPQC to have a reduced harmonics. Here, the unified power quality conditioner (UPQC) deals with a solution to compensate the voltage sags and swells and to protect sensitive loads. In order to apply the MLI consists of fifteen levels inverter in the distribution systems with voltage in range of kilovolt, series converter as one of the important component of UPQC should be implemented based on the multilevel converter which have the capability to handle voltage in the range of kilovolts and power of several megawatts. Hence, the proposed configuration of UPQC based on asymmetrical cascade Multicell converters for power quality analysis. The main property of this asymmetrical CM converter is to increase the number of output voltage level with reduced number of switches. Also, in order to achieve the pre-sag compensation strategy and the voltage sag/swell detection with verified the simulation results under Matlab/Simulink platform.

Keywords: Pulse Width Modulation (PWM), Multilevel Inverter (MLI), Power Quality (PQ), Voltage Sag, Shunt and Series Controller

1. Introduction

With the new progress of power electronics and digital control technology, the renewable energy the production of the power electronics devices, nonlinear loads and unbalanced loads have corrupted the power quality (PQ) in the power distribution network.

Custom power devices have been proposed for increasing the value and reliability of electrical power. It is used to retain balanced, distortion free actual voltage at the load. The shunt part of the UPQC is known as distribution static compensator (DSTATCOM), and it is used to balance load reactive power, harmonics and balance the load currents thereby production the source current balanced and distortion free with unity power factor. For occurrence, active filters proposed for harmonic solutions are increasing their functions from harmonic compensation of nonlinear loads into harmonic separation between utilities and consumers, and harmonic damping throughout power distribution systems.

Voltage evaluations of dc-link capacitor largely influence the compensation performance of an active filter. In general, the dc-link voltage for the shunt active filter has greatly higher value than the peak value of the line-to-neutral voltage. This is done in order to make sure a proper compensation at the peak source voltage. The literature is mention about the current distortion edge and loss of control limit, which state that the dc-link voltage should be greater than or equal to $\sqrt{6}$ times the phase voltage of the system for distortion-free compensation. Unified PQ conditioner (UPQC) is a resourceful tendency power device which consists of two inverters connected back-to-back and deals with both load current and supply voltage imperfection. UPQC can parallel act as shunt and series active power filters. The series part of the UPQC is known as dynamic voltage restorer (UPQC 15 MLI).

Due to the aforesaid criteria, many researchers have used a higher value of dc capacitor voltage based on its application. The main purpose of a UPQC is to balance for voltage flicker/imbalance, reactive power, negative-sequence current, and harmonics. In further words, the UPQC has the ability of improving power quality at the tip of installation on power distribution systems or industrial power systems. Similarly, for series active filter, the dc-link voltage is maintained at a value equal to the peak of the line-to-line voltage of the system for proper compensation. To reduce the dc-link voltage storage capacity, few attempt be made in literature. A hybrid filter has been discussed for motor drive applications. The filter is connected in parallel with diode rectifier and tuned at seventh harmonic frequency. While a well-designed work, the design is specific to the motor drive application, and the reactive power compensation is not considered, which is an important feature in UPQC applications. In case of the three-phase four-wire system, neutral-clamped topology is used for UPQC.

This topology enables the self-governing control of each leg of both shunt and series inverters, but it requires capacitor voltage balancing. Four-leg VSI topology for shunt active filter has been planned for three-phase four-wire system. These topologies avoid the voltage corresponding of the capacitor, but the independent control of the inverter legs is not feasible. Linear quadratic regulator (LQR) control method is used to manage the operation of the series and shunt VSIs of the UPQC LQR coordination ensure that the UPQC operates acceptably without depleting the incomplete energy of the dc link capacitors. Hysteresis control is used to produce accurate switching signals for the two voltage source inverter. To conquer the evils associated with the four-leg topology, the author planned a T-connected transformer and three-phase VSC- based DSTATCOM. Still, this topology increases the cost and weight of the UPQC because of the existence of extra transformer. In predictable 11 levels multi-level inverter is implementing but harmonics is injected. In order to realize the 15 level inverter is proposed for power quality development.

2. Modified UPQC Configuration

UPQC can concurrently act as shunt and series active power filters. The series part of the UPQC is known as dynamic voltage restorer (DVR). It is used to preserve balanced, distortion free supposed voltage at the load. The shunt part of the UPQC is known as distribution static compensator (DSTATCOM), and it is used to compensate load reactive power, harmonics

Unified PQ conditioner (UPQC) is a flexible tradition power device which consists of two inverters connected back-to-back and deals with both load current and supply voltage imperfection and stability the load currents thus making the source current objective and distortion free with unity power factor.

Development of power electronics and digital control technology, the renewable energy sources are progressively more being related to the distribution systems. On the other hand, with the rise of the power electronics devices, nonlinear loads and unbalanced loads have corrupted the power quality (PQ) in the power distribution network. Convention power devices have been proposed for increasing the feature and reliability of electrical power. The schematic block diagram of UPQC structure is shown in figure 1.

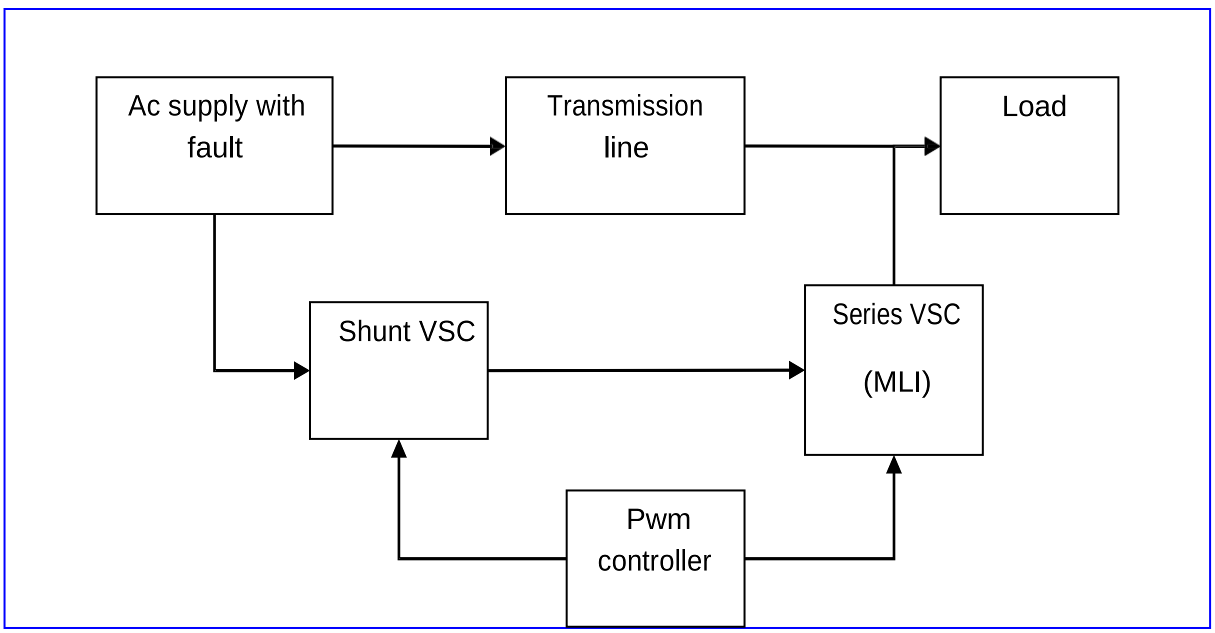


Figure 1. Schematic Block Diagram of UPQC Topology

Voltage rating of dc-link capacitor largely influences the performance of an active filter. In general, the dc-link voltage for the shunt active filter has greatly superior value than the peak value of the line-to-neutral voltage.

This is done in order to make certain proper compensation at the peak source voltage. When the dc-link voltage is less than this limit, there is inadequate resultant voltage to make the currents through the inductances so as to way the reference currents. The primary condition of reactive power compensation is the magnitude of reference dc-bus voltage should be greater than the peak voltage at the point of common coupling (PCC). The voltage source inverter based UPQC configuration is shown in figure 2.

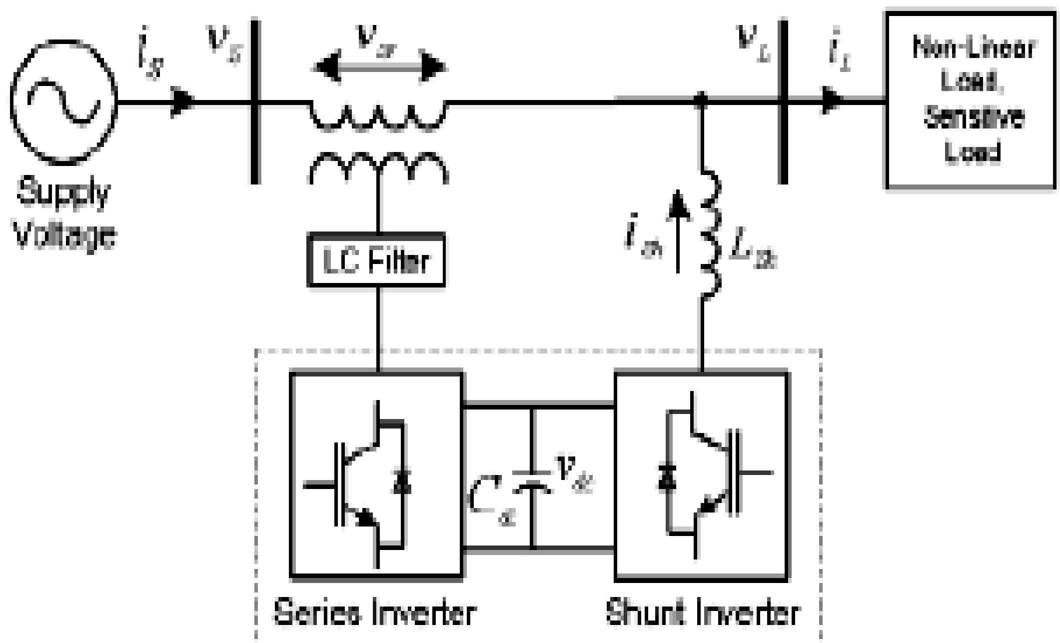


Figure 2. VSI Based UPQC structure

With high value dc-link capacitor, the voltage source inverters (VSIs) become large, and the switches used in the VSI also need to be rated for higher value of voltage and current. This in turn increases the cost and size of the VSI. To reduce the dc-link voltage storage capacity, few attempts were made in literature. A hybrid filter has been discussed for motor drive applications. The electrical equivalent circuit diagram of UPQC is indicated in figure 3.

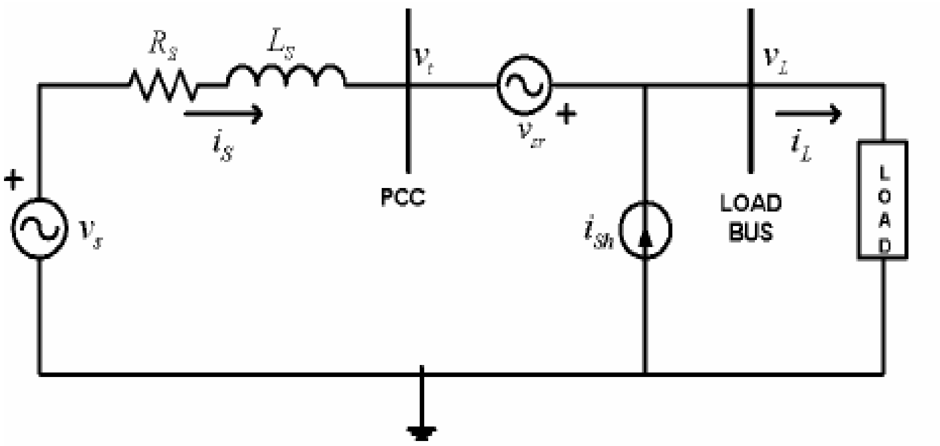


Figure 3. UPQC Equivalent Circuit Diagram

In this paper, a UPQC topology with concentrated dc-link voltage is designed. The topology consists of capacitor in series with the interfacing inductor of the shunt active filter. The series capacitor enable the reduction in dc-link voltage condition of the shunt active filter and at the same time compensate the reactive power required by the load, so as to sustain unity power factor, without compromise its concert.

This allows us to equivalent the dc-link voltage requirements of the series and shunt active filters with a common dc-link capacitor. Advance, in this topology, the system impartial is related to the negative terminal of the dc bus. This will keep away from the necessity of the fourth leg in VSI of the shunt active filter and allow self- determining control of each leg of the shunt VSI with single dc capacitor. The model studies are carrying out using PSCAD simulator, and complete outcome are accessible in the paper.

3. Description of Fifteen Levels Inverter

A Unified Power Quality Conditioner (UPQC) is a device similar in construction to a Unified Power Flow Conditioner (UPFC). The UPQC, just as in a UPFC, employ two voltage source inverters (VSIs) connected to a D.C. energy storage capacitor. One of these two VSIs is connected in series with A.C. line while the other is connected in shunt with the A.C. system.

A UPQC used to combine the operation of a Distribution Static Compensator (DSTATCOM) and Dynamic Voltage Regulator (UPQC 15 MLI) together. One of the serious problems in electrical system is increasing the number of electronic component of devices that are used by industry as well as residence. These devices, which require high-quality energy to work properly, at the same time, the most dependable ones for injections of harmonics in the distribution system. Therefore, devices that reduce this drawback have been developed. The single phase 15 levels inverter simulation circuit diagram is shown in figure 4.

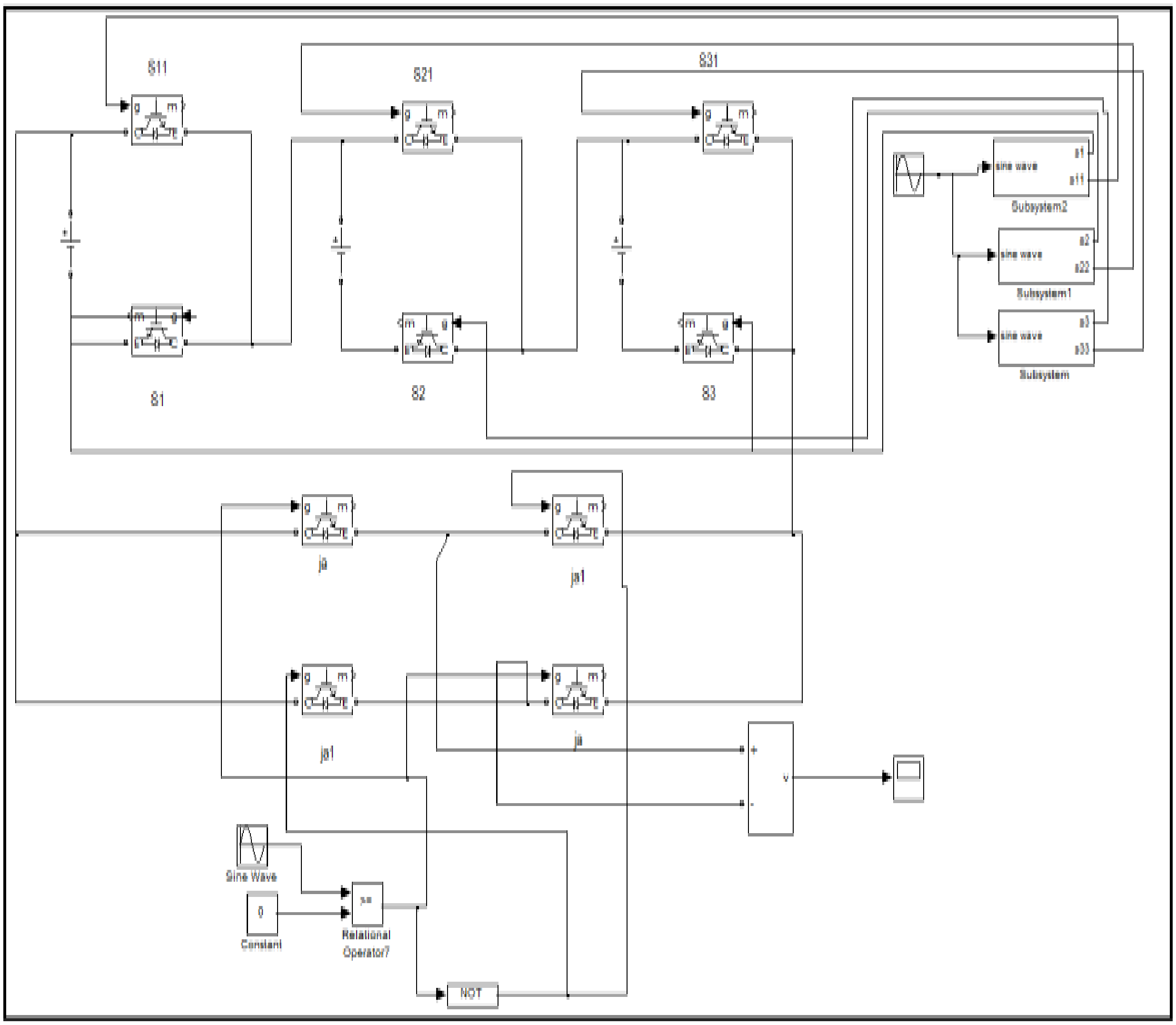


Figure 4. Simulink Diagram for single phase 15 level inverter

The main purpose of the new configuration of unbalanced CM converter in evaluation with the conventional asymmetrical CM converter is decrease in the number of essential high-frequency switches by 50 percent whereas only 4 low-frequency switch are added. As a result, the cost, size and the power loss of the new design of asymmetrical CM converter is decreased. A new Sinusoidal pulse width modulation (SPWM) is developed under such pattern mentioned in below figure 5.

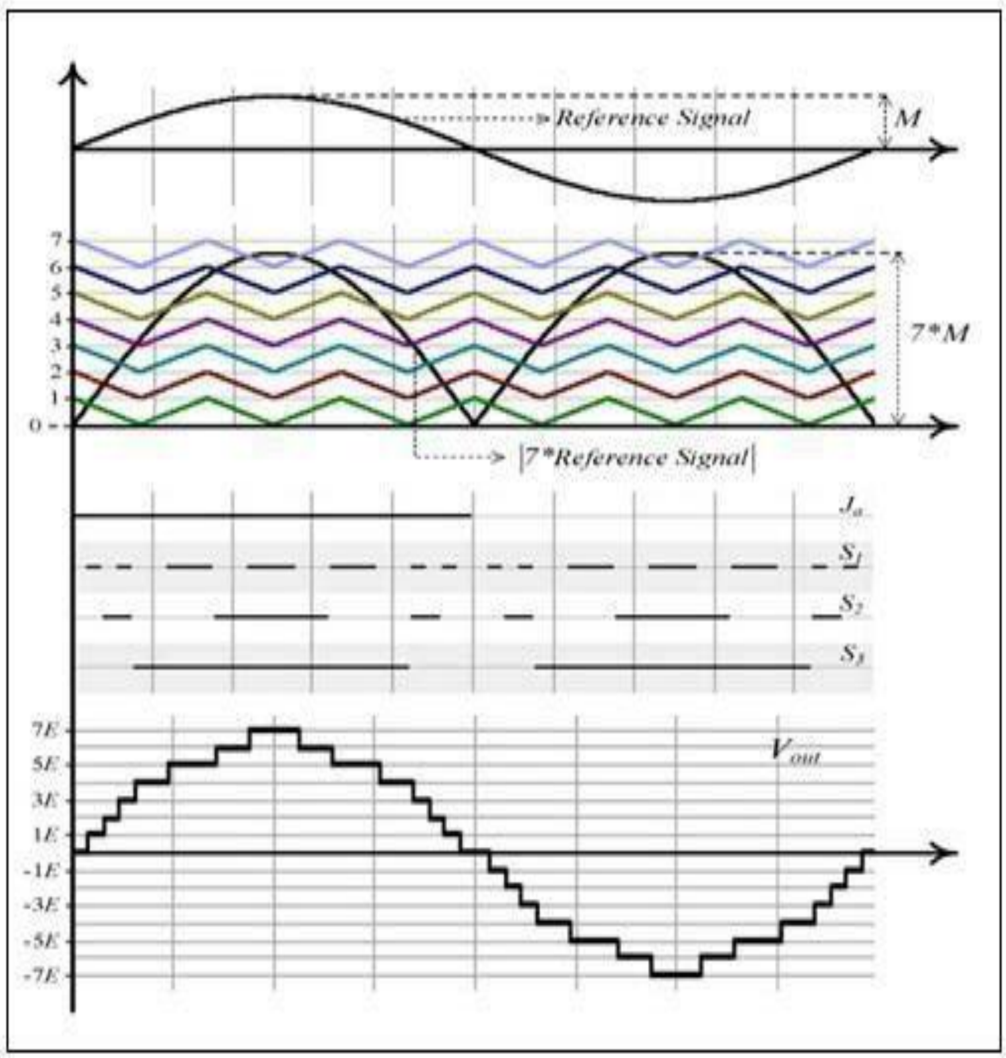


Figure 5. Sinusoidal Level Shifted Based PWM

Depending on the phase angle of the grid voltage during the disturbance, the UPQC 15 MLI has to inject higher voltage amplitude to return the correct voltage magnitude, because the phase bound of the grid has to be compensated by the UPQC 15 MLI; therefore, the system has to be designed for the highest voltage. This approach is able to compensate any kind of voltage sag/swell as well as balanced or unbalanced voltage sag/swell with or without any phase-variations in each grid phase voltages. The main reasons mentioned advantages, excellent performance particularly in the case of phase jumps in the grid voltage and the ability of compensation for any kind of voltage sags and swells.

4. Simulation Study

This is a normal 440V, 50Hz, three phase voltage. This voltage is used to provide the thyristor called as MOSFETs. This voltage mainly depends on the MOSFETs ratings and the load. For high power applications the voltage is proportionately increases to supply the required load current levels. Three-phase electric power systems have at least three conductors carrying irregular current voltages that are balance in time by one-third of the period. The proposed overall system configuration is shown in figure 6.

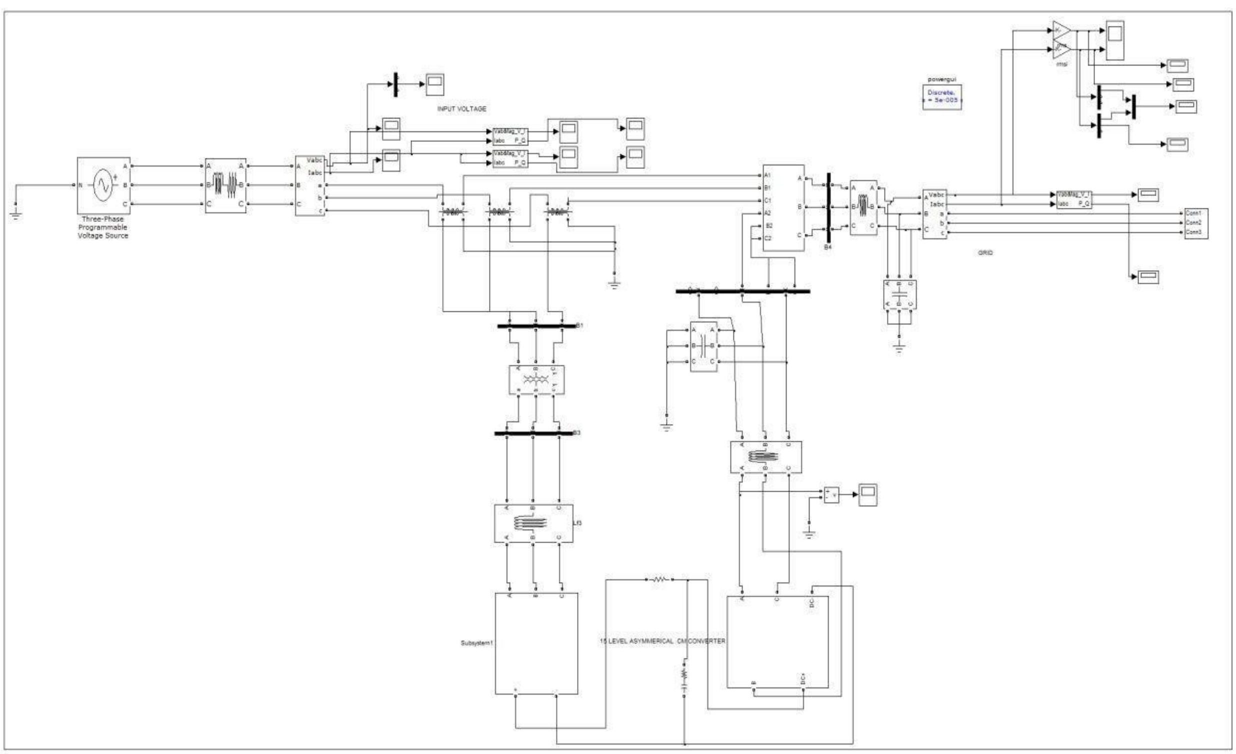


Figure 6. Overall System configuration in Simulink platform

Three-phase systems are arranged in delta (Δ) or star (Y) (also denoted as wye in some areas). A wye system allows the use of two different voltages from all three phases, such as a 230/400V system which provide 230V among the neutral (centre hub) and any one of the phases, and 400V across any two phases. A delta system arrangement only provides voltage magnitude, though it has a better redundancy as it may continue to operate normally with one of the three supply windings offline, albeit at 57.7% of total capacity. Harmonic currents in the neutral may become extremely large if non-linear loads are associated. The corresponding simulation results are depicted in figures 7 to 13.

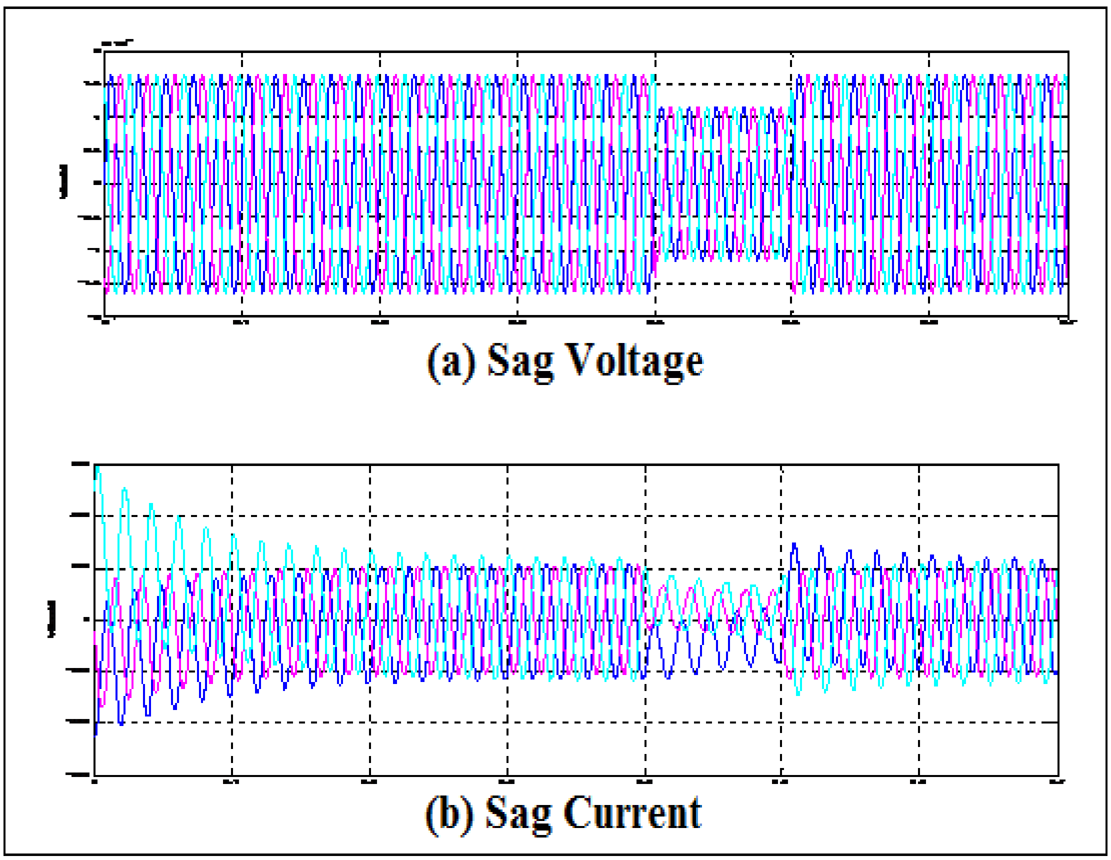
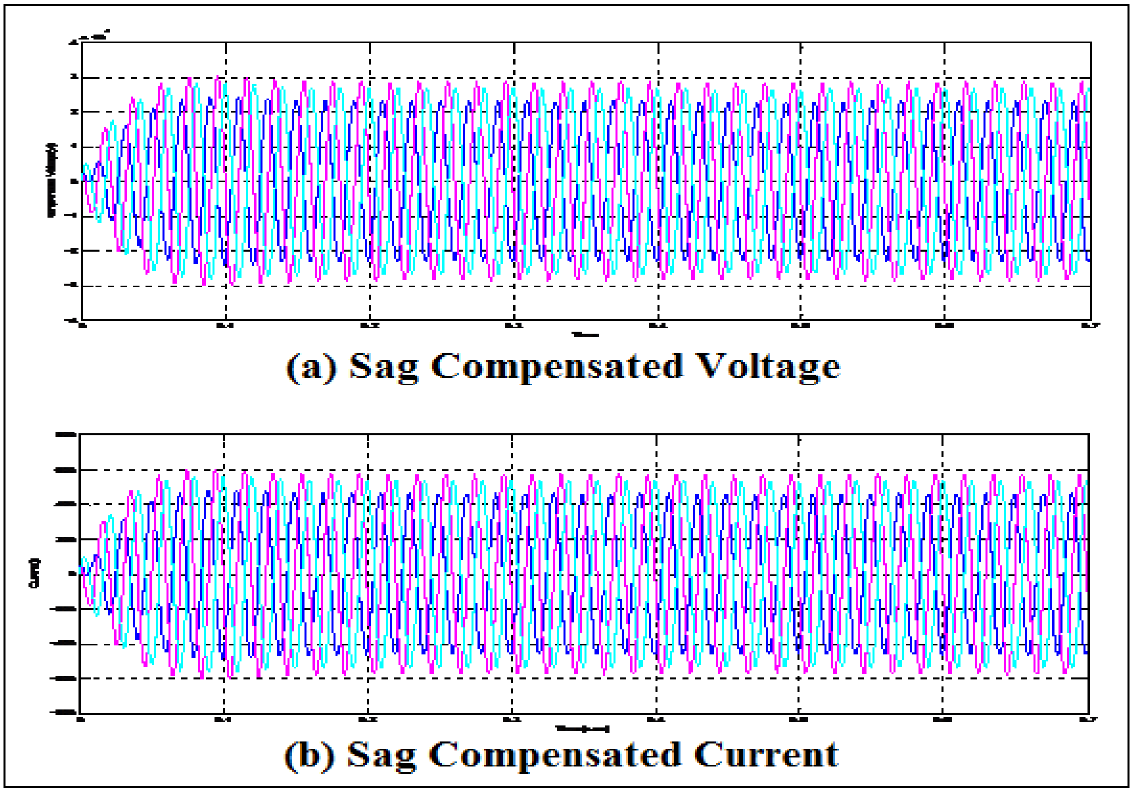


Figure 7. Voltage and Current waveform for input condition



(a) Sag Compensated Voltage

(b) Sag Compensated Current

Figure 8. Sag Compensated Voltage and Current Waveforms

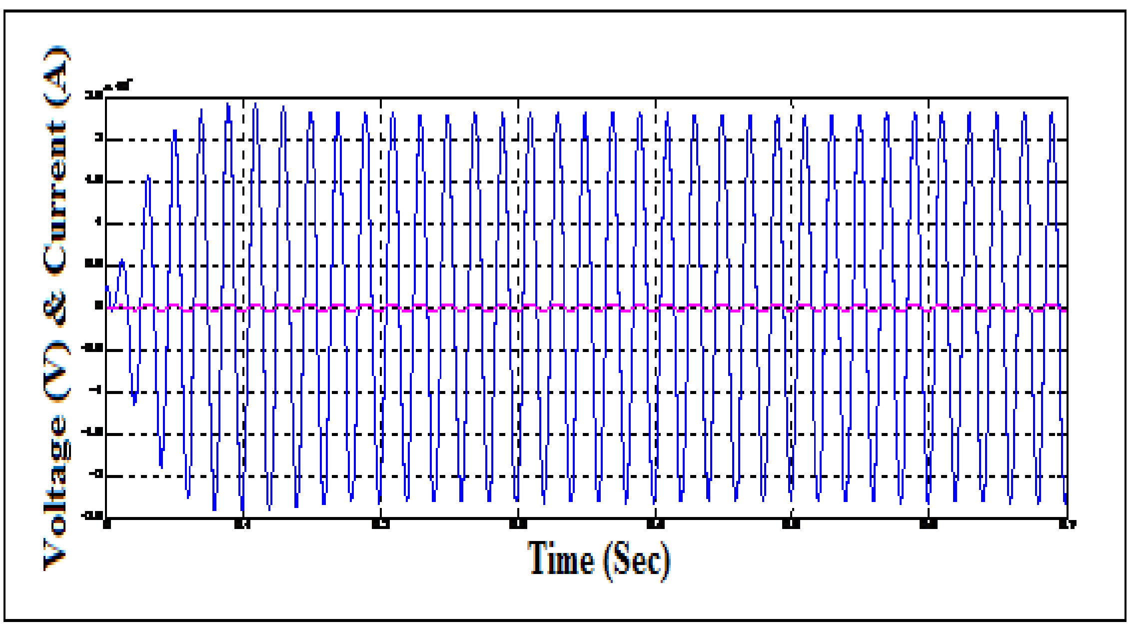


Figure 9. Power Factor Correction for sag condition

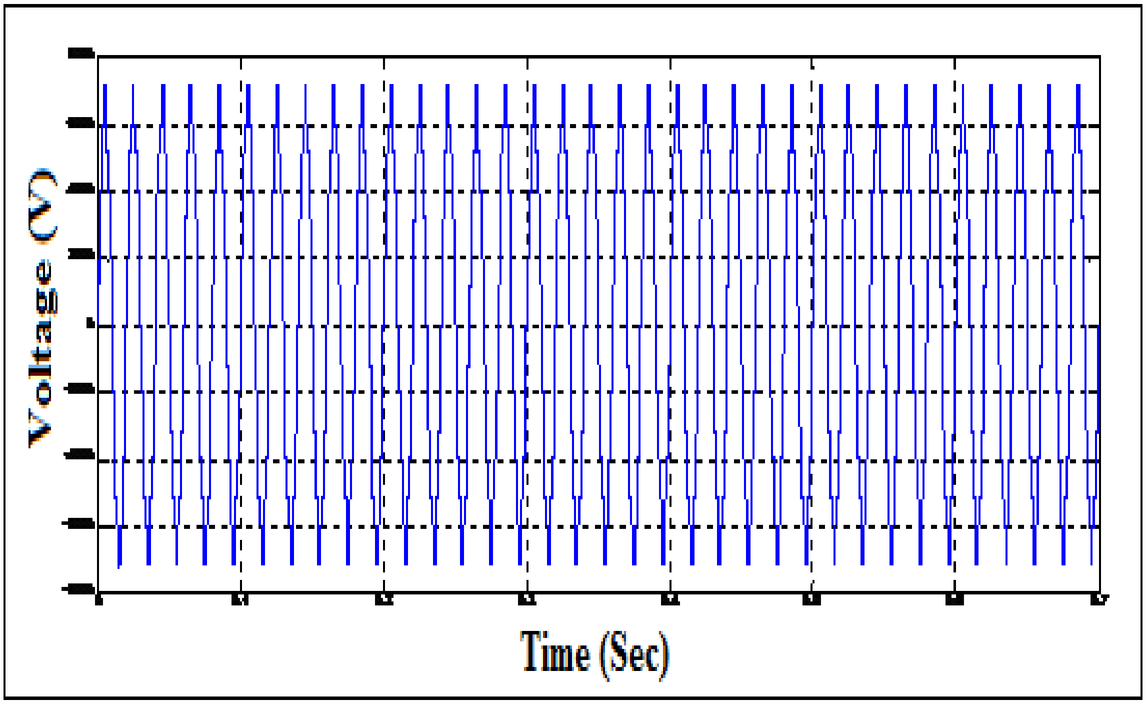


Figure 10. Voltage Waveform of 15 levels inverter

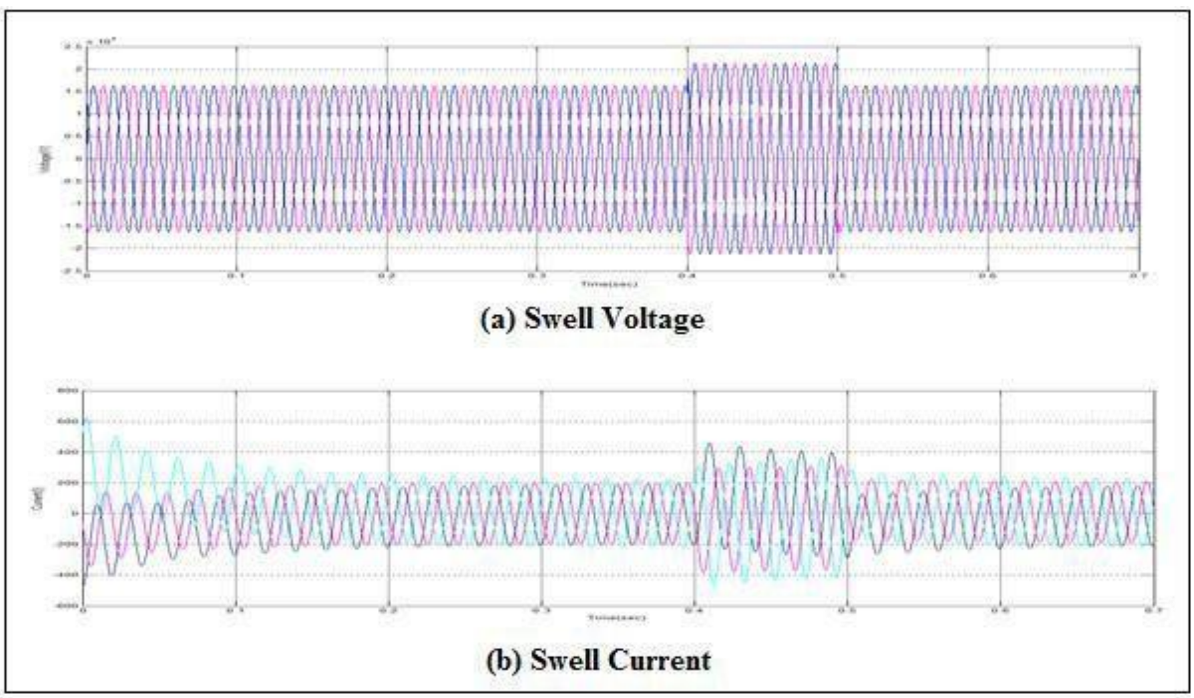
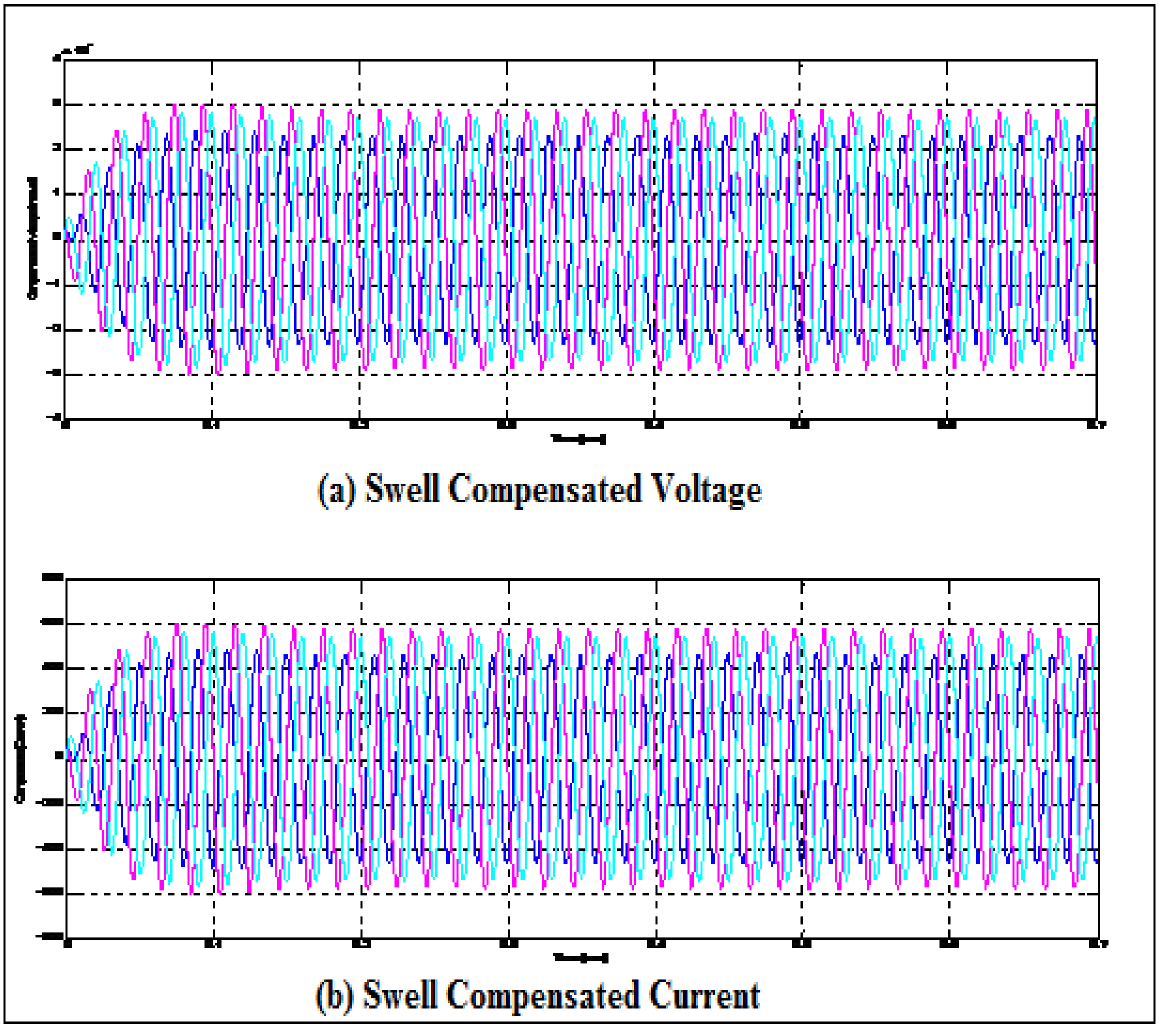


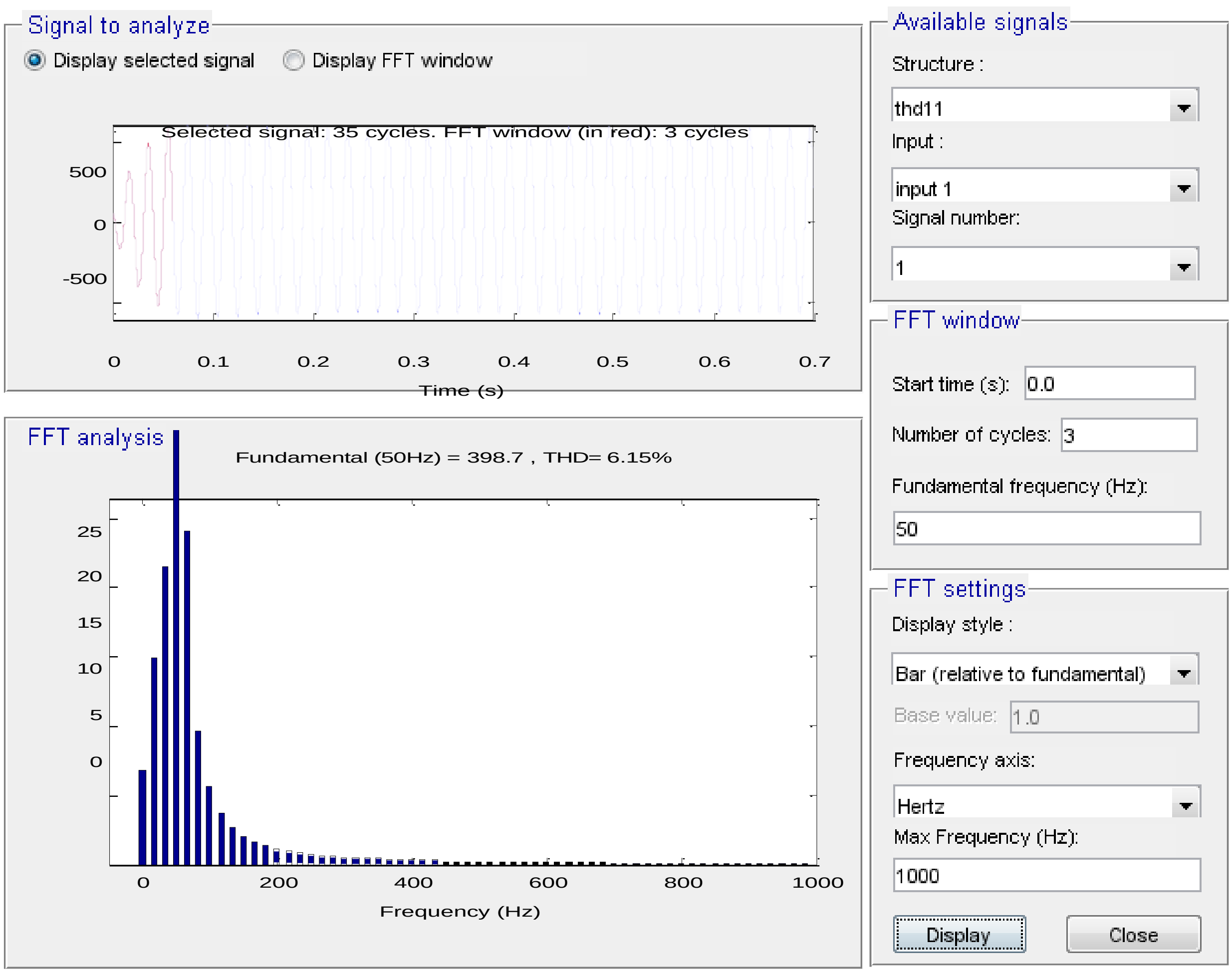
Figure 11. Swell condition based Voltage and Current waveform



(a) Swell Compensated Voltage

(b) Swell Compensated Current

Figure 12. Swell Compensated Voltage and Current Waveform



5. Conclusion

This paper offered the voltage sags/swells troubles in power systems due to the improved integration of sensitive loads into them. UPQC 15 MLI systems are able to compensate these voltage sags/swells. Moreover, the multi-cell converters are very interesting for high-power/medium-voltage applications, and considerably advance the output voltage frequency spectrum, in this project configuration of UPQC 15 MLI based on asymmetrical CM converter has been anticipated to improve the quality of UPQC 15 MLI output voltage and to be used in the distribution systems with voltage in range of kilovolts. In the proposed configuration of UPQC 15 MLI, number of required high-frequency switches is reduced by

50 percent. Therefore, the cost, size and power loss are decreased. Also, new methods based on the SRF have been used to detect the voltage sag/swell and determine the reference series injected voltage of UPQC 15 MLI. As depicted in simulation results, the pre-sag compensation approach and the proposed SRF based detection and determination methods show brilliant performance and good active response time.

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