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HARMONICS ELIMINATION IN ISOLATED POWER SYSTEM USING COMPENSATORS

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ABSTRACT

Isolated power systems are often affected by harmonics due to the presence of non-linear and sensitive loads. The invention of power electronics and advanced control technologies have made it possible to mitigate power quality problems and maintain the operation of senstive loads. In analyzing the power system disturbances harmonics are some of the severe problems to the sensitive loads. In this paper series compensation method is used to protect sensitive loads against those disturbances. The effectiveness of the compensator to reduce the harmonic distortion due to the presence of nonlinear loads in the network is studied. The modeling and simulation of the proposed series compensator was implemented in Matlab Simulink work space. Simulation results show that the proposed series compensator is efficient in mitigating voltage harmonics and thus improve the power quality of the isolated power system.

KEYWORDS: Power system harmonics, Power quality problems, Series compensator, non-linear loads.

INTRODUCTION

Isolated power systems present in rural areas are characterized by limiting generating capacity. In such isolated systems use of sensitive loads are much more affected by the power quality problems. Invention of power electronics and advanced control technologies have made it possible to mitigate power quality problems and maintain the operation of sensitive loads. Power quality problems are characterized by a wide range of disturbances such as flickers, voltage sags/swells, flickers and harmonics distortions (Roger et al. 2002).

The proposed method mitigates the problems caused by voltage sag and harmonics. In the proposed system harmonics are created by the connection of controlled six pulse converter to the main drive load. The generated harmonics all these factors affect the sensitive load, which is connected in parallel to the main drive load.

The proposed system protects the sensitive load by mitigating the harmonics using series compensation technique. The block diagram in figure 1.0 is implemented in MATLAB Simulink and the results are evaluated to show the effectiveness of the series compensator.

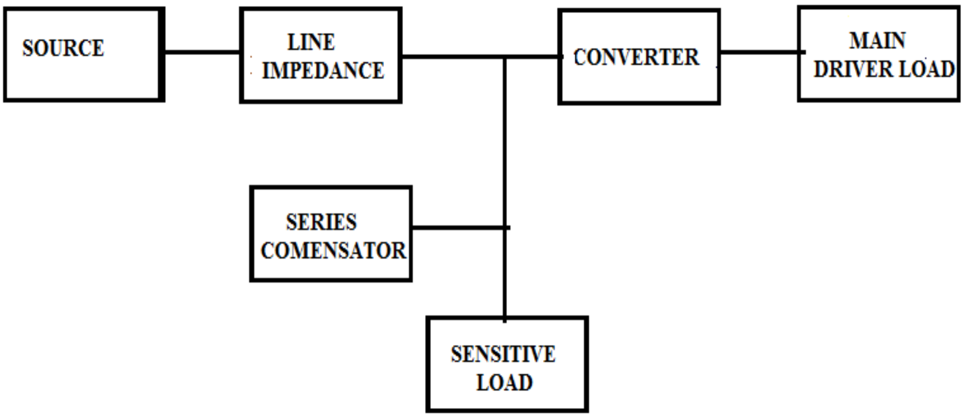

Figure 1: The basic structure of Series Compensator.

Electrical Power Quality Problems

It is expected that power systems, ideally, should provide their customers with an uninterrupted flow of energy at smooth sinusoidal voltage and frequency. However, in practice, the isolated systems are affected by the distortions caused by large Motor Starting, non – linear loads and power electronic devices. Power disturbances occur on all electrical systems, the sensitivity of electronic devices makes them more susceptible to the quality of power supply. For some sensitive devices, a momentary disturbance can cause equipment failure (Devaraju et al. 2010). A power voltage spike can damage valuable components.

Methods to improve power quality issues

To achieve improve power quality in tradition method passive filters are connected at the sensitive load terminals (Wang et al.2007). It has some shortcomings that the as the source impedance or load condition changes, resonance between the filter is created. An active filter, connected at the sensitive load terminal, helps in injecting harmonic currents of the same magnitude but of opposite polarity to cancel the harmonics present there. This paper introduces series compensator and its operating principle. At the end MATLAB SIMULINK model based simulated results were presented to validate the effectiveness of the proposed control method of Series Compensation.

Modeling of Series Compensator

The simple power system model shown in Figure 2.0 is used to explain the principle of the proposed mitigation method. The upstream generators are aggregated and represented as an ideal voltage source.

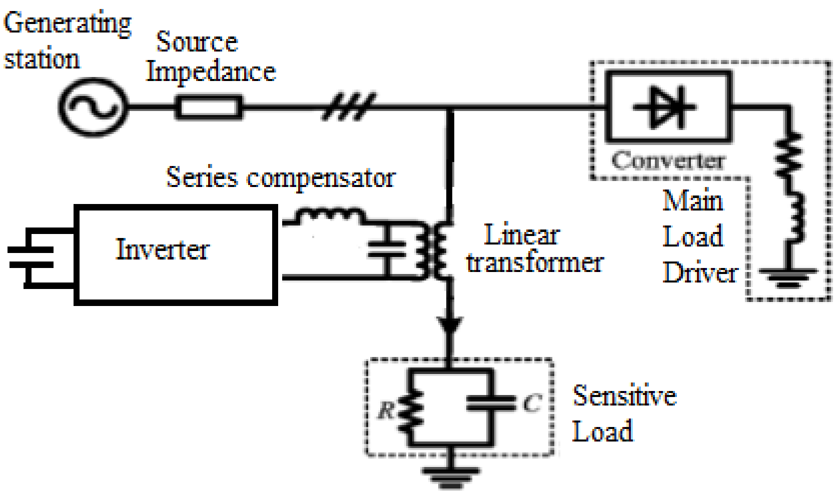

Figure 2: The basic structure of Series Compensator.

The main drives are modeled as a lumped resistive-inductive load connected to the source through a power converter, with a six-pulse rectifier. The sensitive loads are supplied through point of common coupling and are modeled by the resistor R in parallel with the capacitor C. The SC is connected upstream from the sensitive load through an injection transformer. It is series connected with the sensitive load. The function of the SC is to ensure that the voltage across the sensitive load terminals is of high quality. The central part of the SC is a voltage source inverter.

SIMULATION RESUTLS AND DISCUSSIONS

Simulation is performed in two stages. The first simulation for constructed for the actual system without series compensator.

Actual System Without Compenator

In this system a three phase input voltage of 230V per phase is applied using three single phase supply in Simulink. The line impedance is added using the RLC series branch tool.

Voltage measurement blocks are inserted to measure the value of input voltages. A scope is added to view the waveform of the input voltage. The three phase supply voltage is the given to the converter to convert three phase ac supply into DC supply. Main driver load is connected to this DC supply and the voltage measurement block is connected to measure the voltage. The gate of the converter is supplied using a 6 pulse generator. The pulse generator is responsible for producing the harmonics in the voltage of the connected system. Sensitive load is added in parallel with the lines using parallel RL load. Measurement block is added to measure voltage and current of the system.

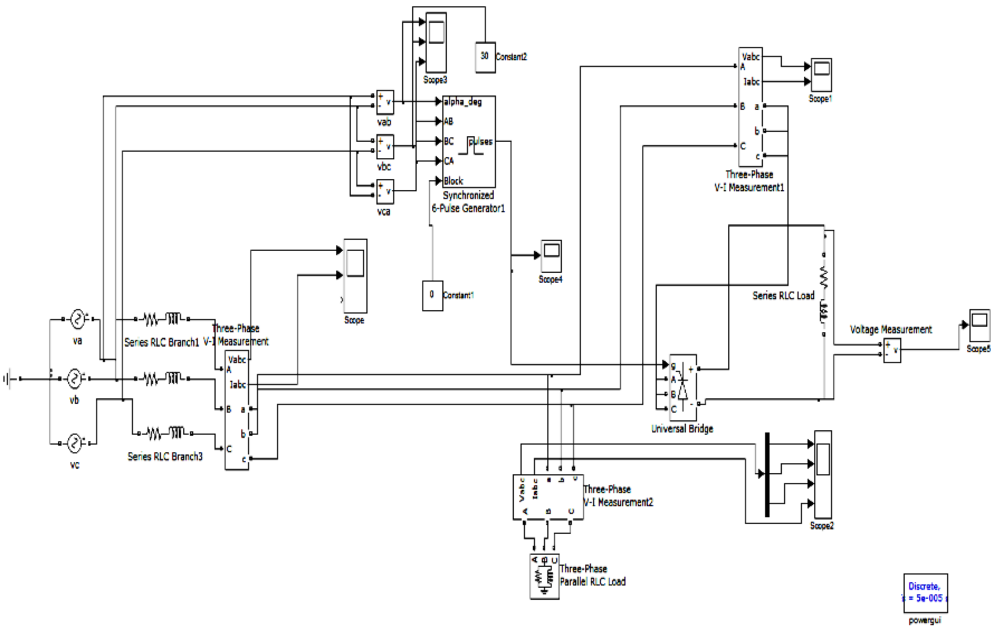

Figure 3: MATLAB Simulink for uncompensated system.

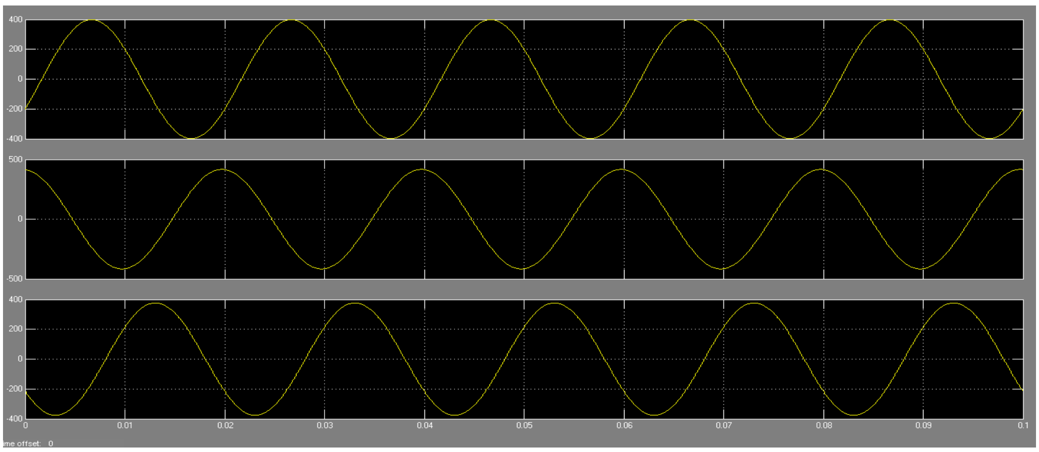

Figure 4: Input voltage waveform.

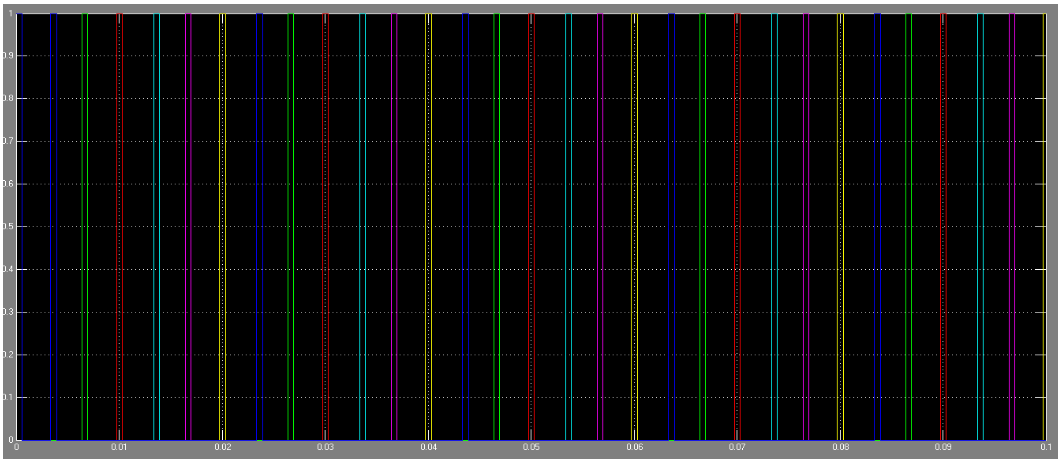

Figure 5: Pulse waveform for converter gate terminal.

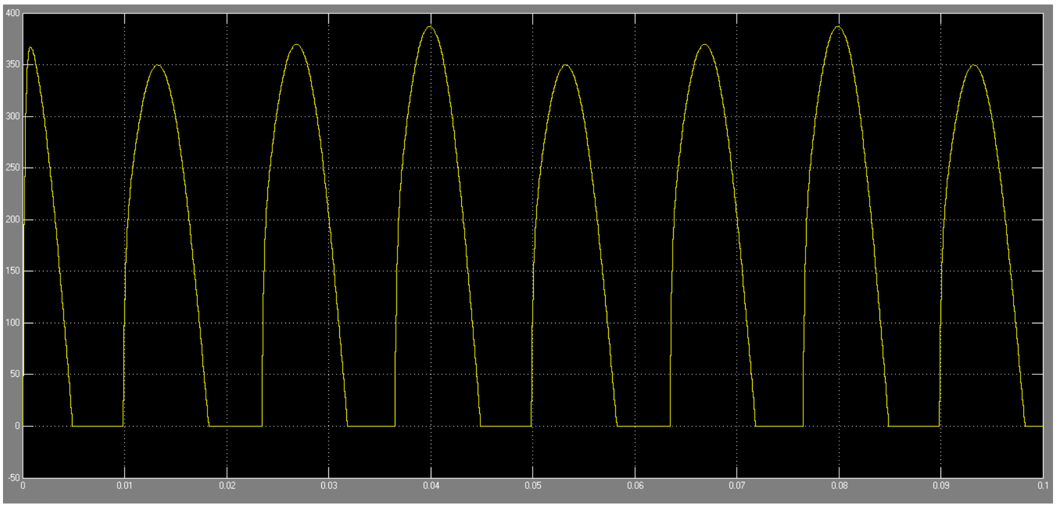

Figure 6: Output voltage of the converter across the main driver load.

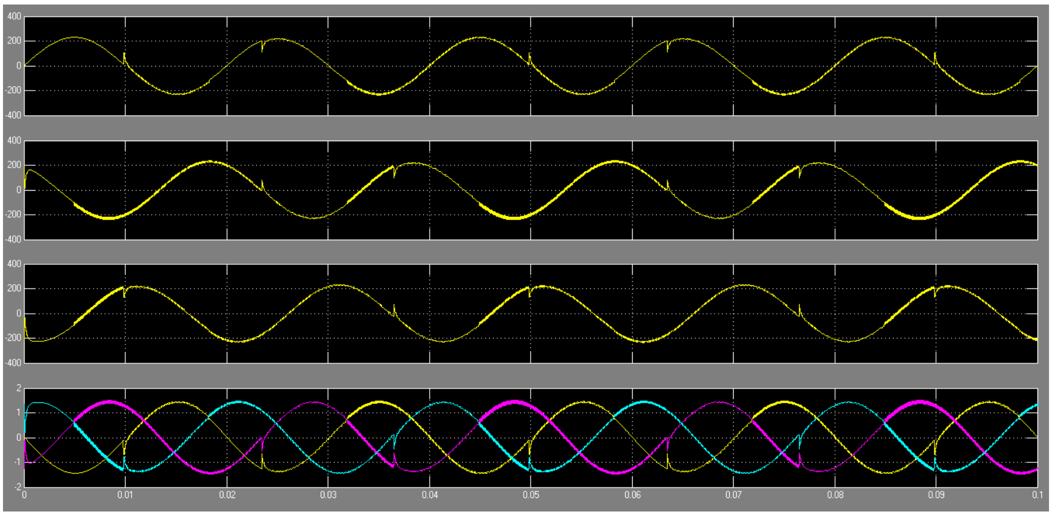

Figure 7: Voltage & Current waveform of sensitive load with harmonics.

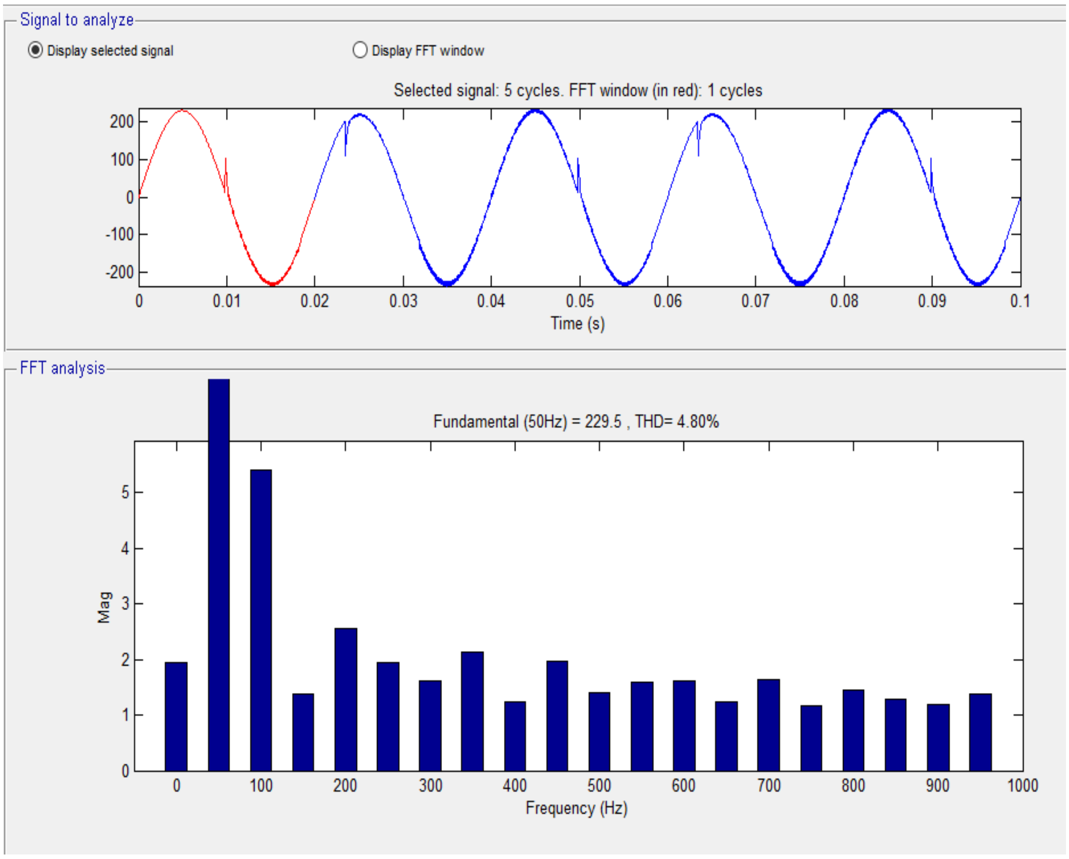

Figure 8: Harmonics measurement of uncompensated system of sensitive load.

DISCUSSION

Harmonics are injected using the 6 pulse generator to the AC to DC converter. The effect of harmonics created for the sensitive load is shown in figure 7. The figure shows the harmonics in both voltage and current waveforms. The value of total harmonic distortion is studied using the FFT analysis. Figure 8 shows that the harmonics of 4.8% is present in the sensitive load voltage.

Circuit with Series Compensator

Second simulation is performed with compensator to reduce the harmonics in the sensitive load. A DC supply with RC filter is connected to the inverter circuit to convert DC to AC. Compensator LC is added in series with the sensitive load. Linear transformer is used to inject the voltage to the transmission line.

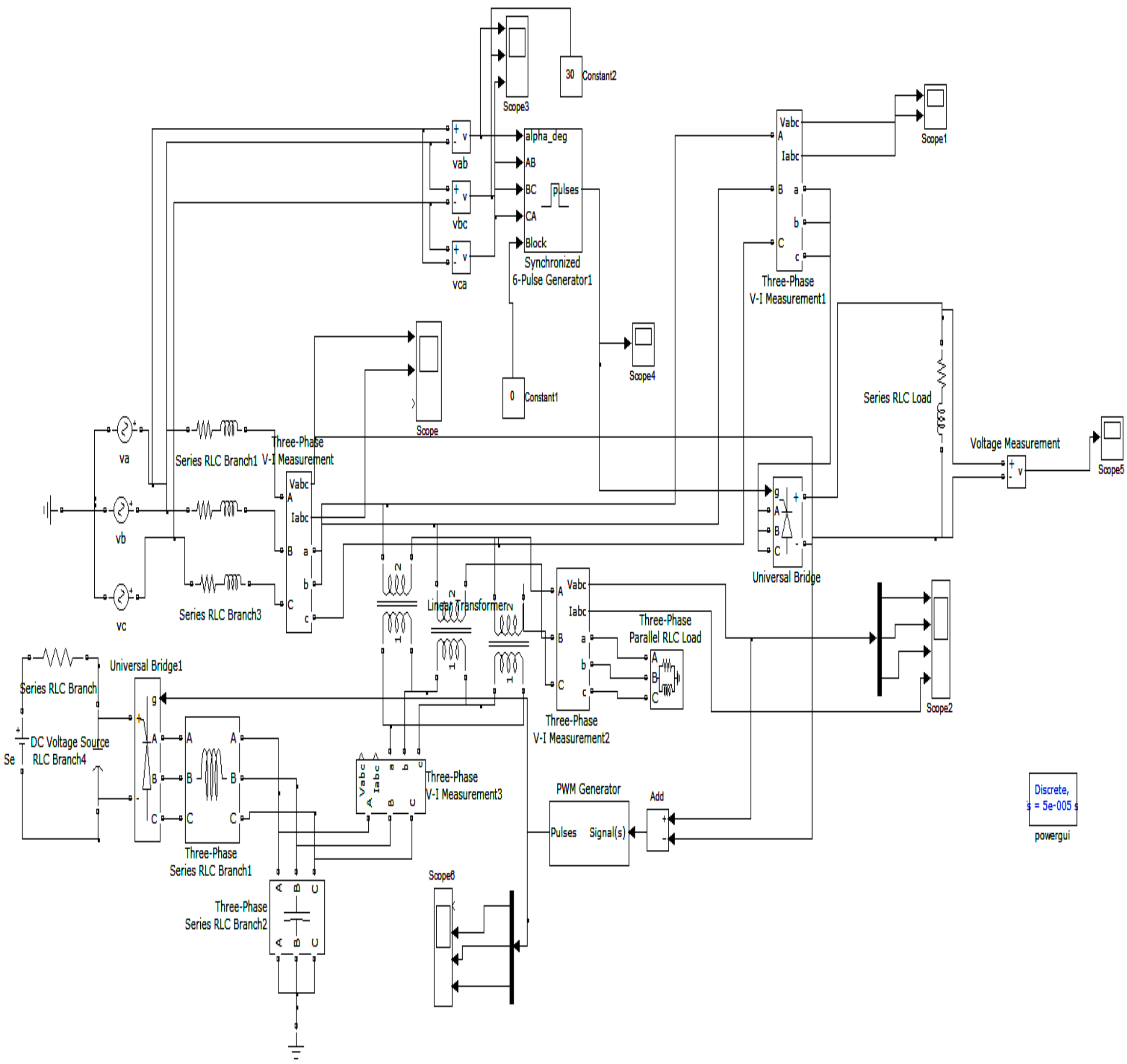

Figure 9: MATLAB Simulink for the system with series compensator.

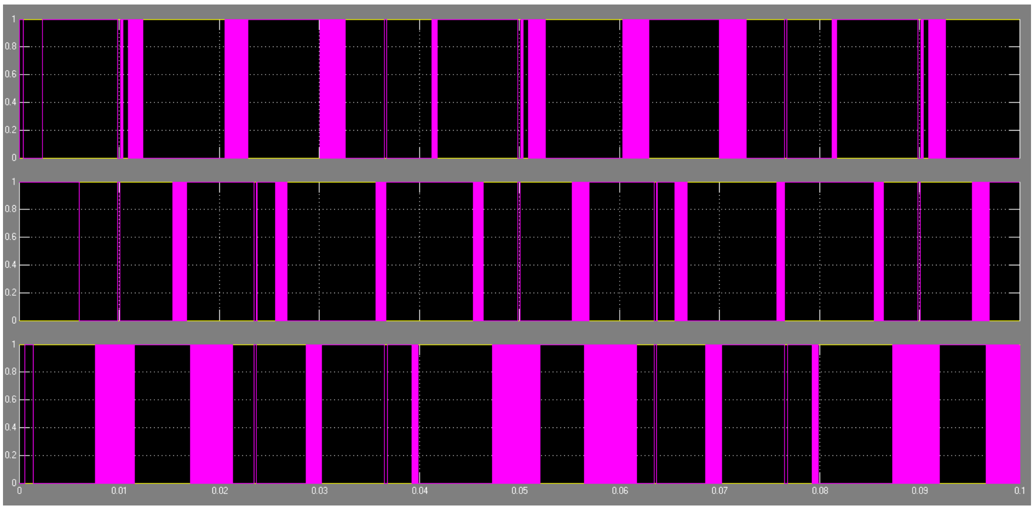

Figure 10: Pulse waveform for the inverter circuit.

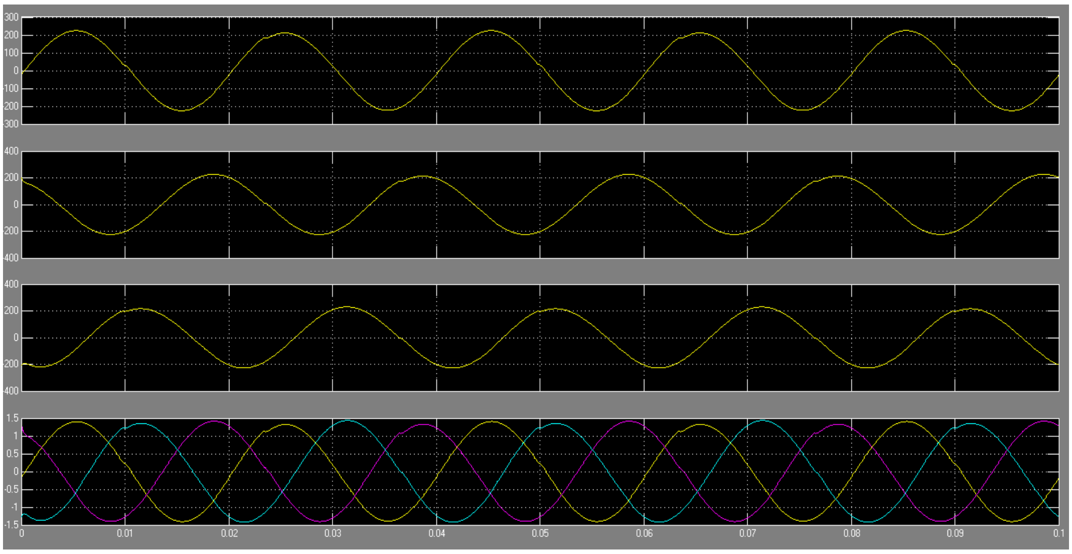

Figure 11: Voltage and current waveforms of sensitive load.

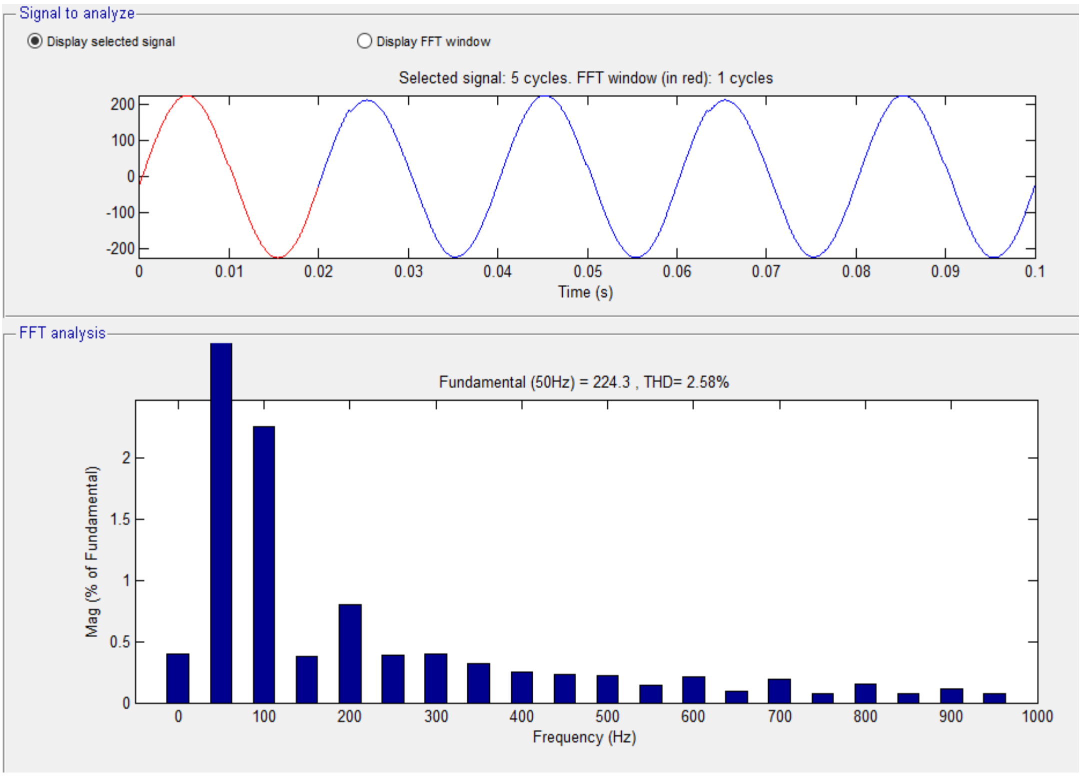

Figure 12: Harmonics measurement of compensated system of sensitive load.

DISCUSSIONS

Pulse for the inverter is given using the signal to pulse converter block. Input voltage signal and voltage injected using linear transformer are compared to generate the pulse for the inverter. Figure 11 shows the voltage and current waveforms of the sensitive load with series compensator. It is clearly evident that the harmonics are almost filtered using the series compensation technique. Also THD analysis shown in figure 12 shows that the harmonics are reduced to 2.5%. Hence it is proved that the series compensation is a better method to remove harmonics in the system.

CONCLUSION

Voltage quality improvement in an isolated power system through series compensation has been investigated. The power system contains significant proportion of fluctuating nonlinear load and a high level of harmonic distortions is observed. The SC is also designed to maintain the fundamental frequency component of the terminal voltage of protected sensitive load. In this paper, a complete simulated series compensator system has been developed by using Matlab Simulink software. It is shown that the simulated SC developed works successfully to improve power quality. PWM technique is used to control the injection voltage of the SC so that it can mitigate the effects of the harmonics and voltage sag has been proposed.

The proposed system performs better in mitigating harmonics and voltage sags. The proposed SC can handle both balanced and unbalanced situations without any difficulties and would inject the appropriate voltage component to correct rapidly and anomaly in the supply voltage to keep the load voltage balanced and constant at the nominal value.

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