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Harmonic Elimination Using Generalised Unified Power Quality Conditioner

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ABSTRACT

Generalized unified power quality conditioner (GUPQC) is a device which is used to compensate voltage and current harmonics by injecting voltage and current into the feeder. In which one voltage source converter is connected in shunt to compensate current harmonics and rest of the converters are connected in series to compensate voltage harmonics. These voltage source converters are linked to common energy storage device. In this paper, capacitor is used as an energy storage device. Fuzzy controller and PI controller is secondhand to sense voltage and current harmonics in the waveform and offer pulses for voltage source converter to inject voltage into the feeder to reduce voltage and current harmonics. Results are verified using MATLAB simulation

Index Terms: Generalized unified power quality conditioner, unified power quality conditioner, Capacitor, voltage source inverter, Harmonics, PI controller Fuzzy controller.

I. INTRODUCTION

One of the major difficulties in distribution side is power quality problems. Major power quality problems are voltage sag, voltage swell, notching, harmonics and noise. This problems cause voltage and current waveform to get distorted. This distortion causes sensitive loads to get damaged and cause a major problem in industries and cause major loss. To compensate voltage sag, swell and harmonics IUPQC is used, which consist of two voltage source converter linked back to back [1]. Inorder to overcome the disadvantages of IUPQC, Generalized unified power quality conditioner is used which consist of three voltage source converters [2]. There is also a new concept in which there is no injection transformer is used [3]. There is also another one concept to compensate voltage sag, swell, which is called UPQC. This can be used for three phase four wire system [4]. The three voltage source converters are connected in such a manner that one connected as shunt and other connected in series to the distribution line [5]. There are various reference frames used. Synchronous reference frame system is used to provide the error signals to injecting voltage [10]. Series APF and shunt APF are used to compensate voltage and current harmonics, is a new control scheme [11]. The voltage from the voltage source converter contains harmonics this harmonics can be eliminated using series and shunt active filters connected in the system [12]. Controller used in this paper is PI controller and fuzzy controller, which compares the actual voltage with the reference voltage and produce the error signal.

II. GENERAL GUPQC CONFIGURATION

GUPQC is used to compensate voltage and current harmonics in distribution side. Fig 1 shows the basic configuration of generalized unified power quality conditioner. It has three voltage source converters. It is used to compensate voltage sag and voltage swell to protect sensitive load.

Each voltage source converters are connected back to back through a common DC link. These VSC's inject three phase voltage into the feeder. In this voltage source converter one is connected as shunt and the

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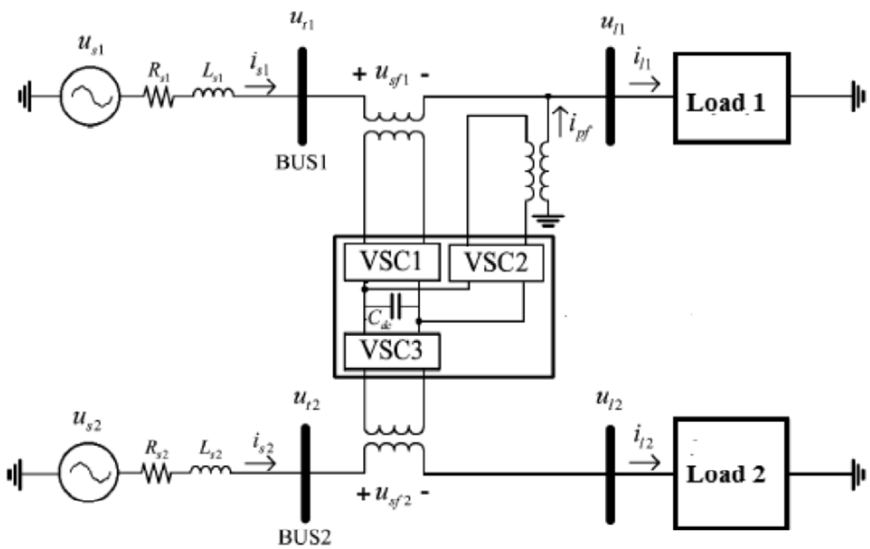

Figure 1: Schematic Diagram of GUPQC

rest are connected as series compensator. Shunt connected voltage source converter are operated as current source converter to compensate current harmonics and series connected voltage source converter are operated as voltage source converter to compensate voltage harmonics. Other than voltage source converter GUPQC also consist of capacitor, filters and controller.

III. PROPOSED MODEL

Fig. 2 shows the basic block diagram proposed in this paper. It consists of three voltage source converter, three filters and an energy storage device. This voltage source converter produce three phase output which is injected to the feeder to compensate voltage sag, swell and harmonic, which are series connected and the shunt connected.

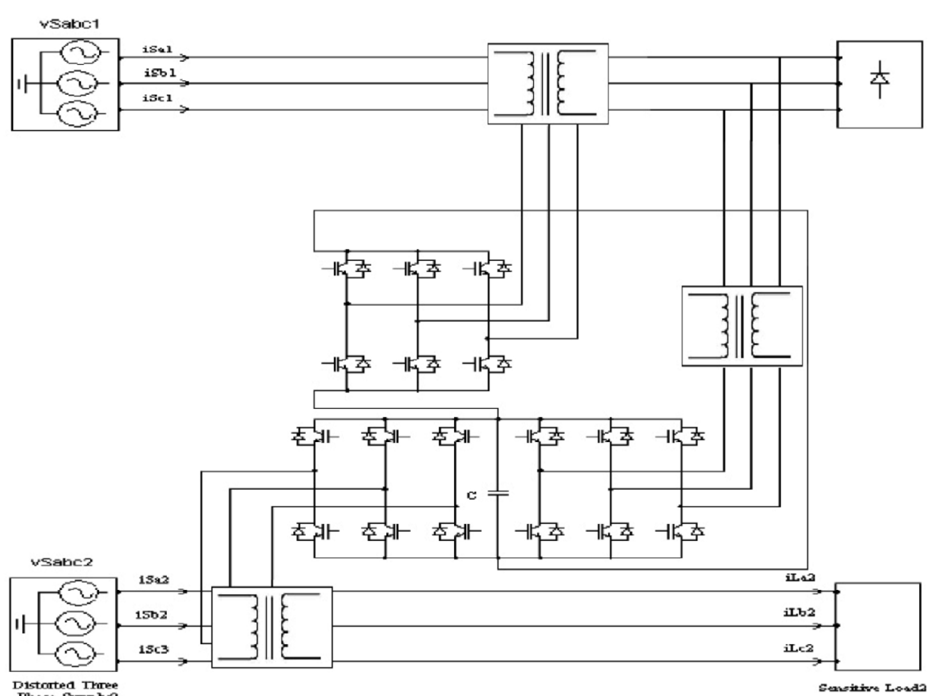

Figure 2: Basic block diagram of GUPQC

(A) Fuzzy Controller

The Controller used to produce error signal in this paper is fuzzy controller. A fuzzy logic system has four blocks as shown in Fig. 3. Crisp input information from the device is converted into fuzzy values for each input, using the fuzzification block. The universe of discourse of the input variables limits the required scaling for precise per-unit operation. The scaling is vital because, the fuzzy systemcan be retrofitted with other devices by just altering the scaling of the input and output. The decision-making-logic determines how the fuzzy logic operations are executed, and together with the knowledge base, the outputs of each fuzzy IF-THEN rule, the output is determined. Those are combined and converted to crisp values with the defuzzification block. Fig 3 shows the basic block diagram for the fuzzy logic controller.This fuzzy logic controller produce error signals which is required for the PWM generator to produce pulses.

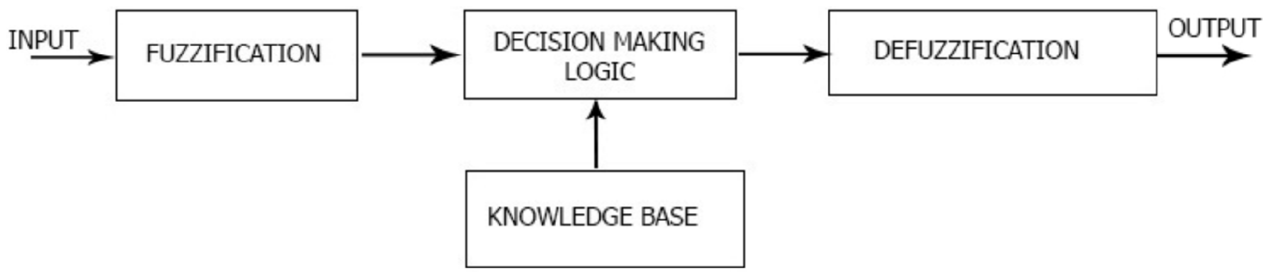

Figure 3: Basic block diagram of Fuzzy controller

(B) PI Controller

In this paper PI controller is compared with fuzzy controller and PI controller is generally a PID controller. Where PID controller is composed of proportional part integrated part and derivative part. Derivative part is sensitive which means that it is prone to noises. But usually there will be some tolerable noises in the system. When a controller responds to such noises it origins the system to be unstable which can be avoided using PIcontroller. This controller relates reference voltage with the actual voltage and produce error signal. This error signal is liable for the generation of pulses required for the voltage source converter. Fig. 4 shows the basic block diagram of PI controller.

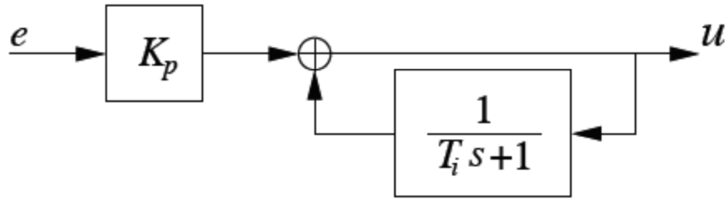

Figure 4: Basic Block Diagram of PI controller

(C) Voltage source converter

In this paper, three voltage source converters are used. They are connected back to back through a capacitor. It consists of six switches which is usually IGBT. These switches are given pulses from pulse generator. Voltage source converter converts dc voltage into ac voltage. Dc voltage source used in this paper is a capacitor. Fig 4 shows basic diagram for voltage source converter.

(D) Filters

Output from the voltage source converter contains harmonics. This harmonics can be removed by means of filters in series with the output from the voltage source converter. Filters are a combination of inductor and capacitor connected in such a way to compensate the harmonics.

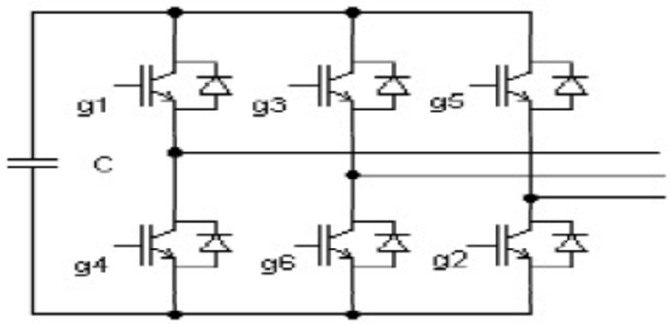

Figure 5: Voltage Source Converter

(E) Injecting Transformer

There are three injecting transformers used, which will isolate the high voltage side feeder from the voltage source converters.

(F) Nonlinear Load

Load used in this paper is non-linear load which is a diode bridge rectifier connected with a series connected resistor and inductor. Distortion of supply voltage is caused due to the presence of this nonlinear load.

IV. SIMULATION RESULT

A three phase supply voltage of 415V is supplied to the feeder. Due to the presence of nonlinearload in a feeder distortion in both current and voltage wave form occurs. This distortion is not tolerable to the other loads connected in the system. Nonlinear load is connected during the entire operation between 0S to 0.5S. So GUPQC must be active during the entire process of operation to compensate the harmonics due to nonlinear load. Fig 6 shows the waveform for harmonic voltage compensation due to the presence of nonlinear load by GUPQC using PI controller.

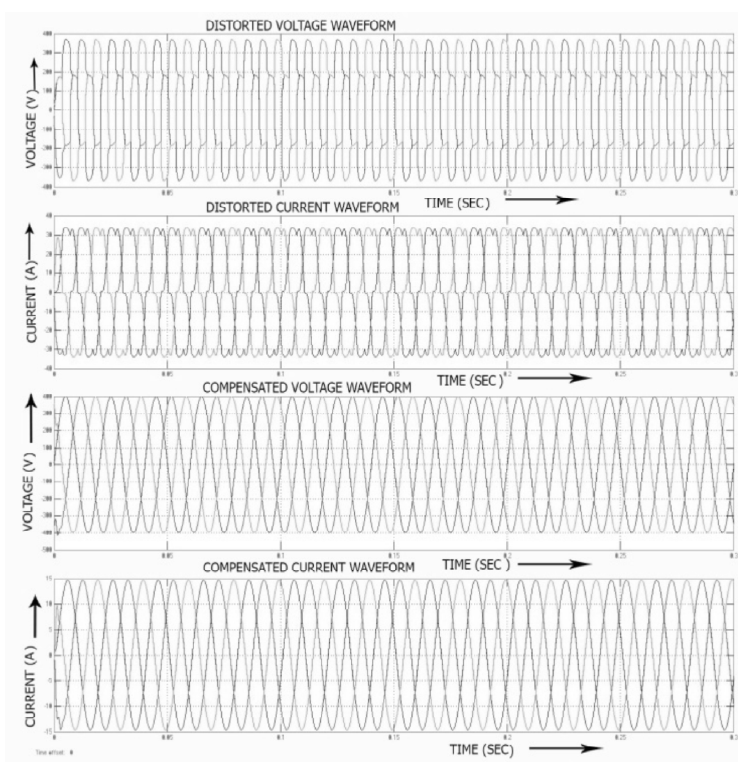

Figure 6: Harmonic voltage compensation due to nonlinear load by GUPQC using PI controller

Fig. 7 shows the harmonic distortion value for the load voltage due to the presence of nonlinear load. Due to the presence of nonlinear load, the voltage harmonics value is 28.35% which have to be compensated. The value of harmonics is high because GUPQC is not connected to the feeder. Fig 9 shows the value of THD which is 4.98% when we connect GUPQC in the system for compensation by using PI controller.

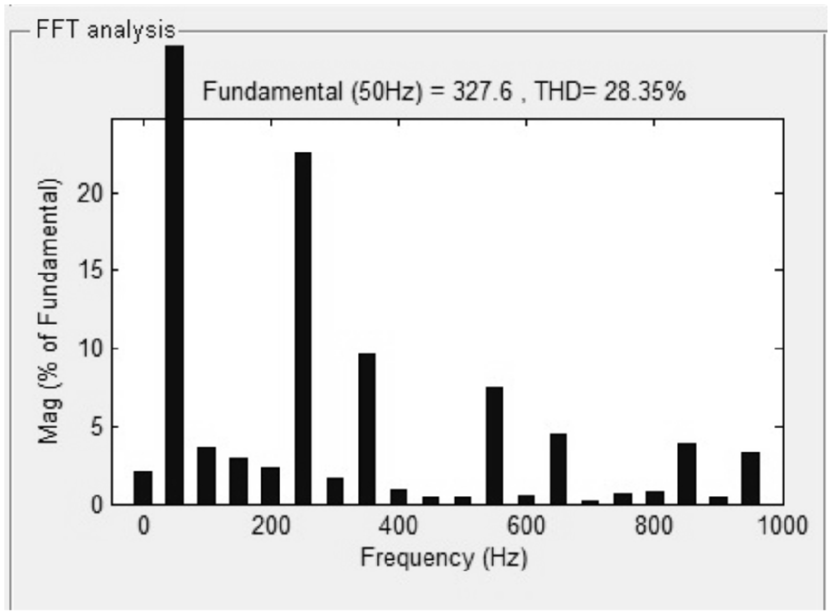

Figure 7: Harmonic value for nonlinear load without GUPQC

Fig. 8 Shows the THD value for voltage waveform due to the presence of nonlinear load without compensation.

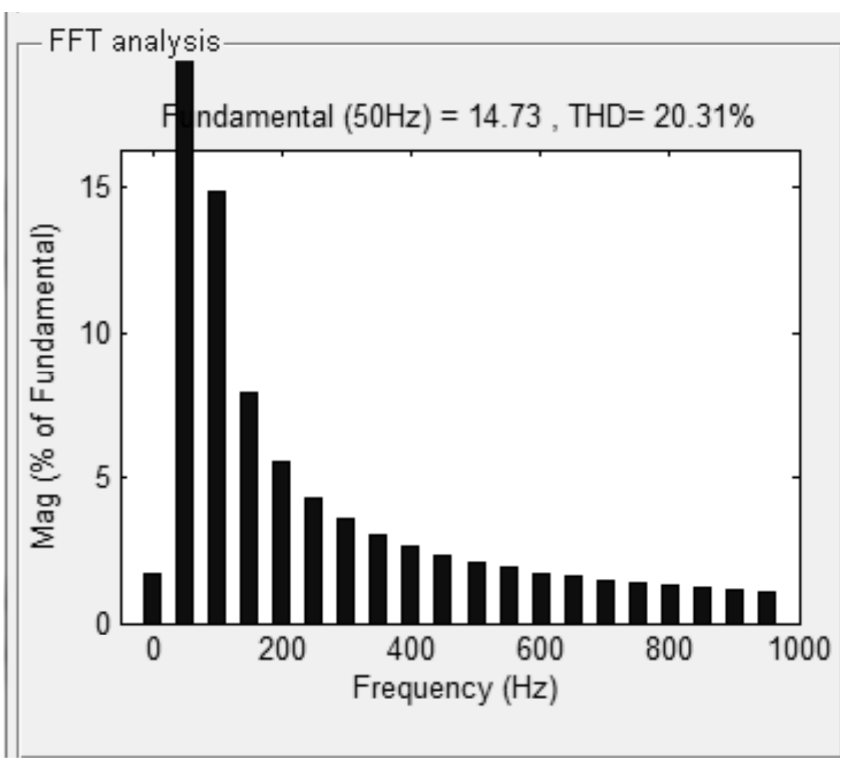

Figure 8; THD value of current waveform without compensation

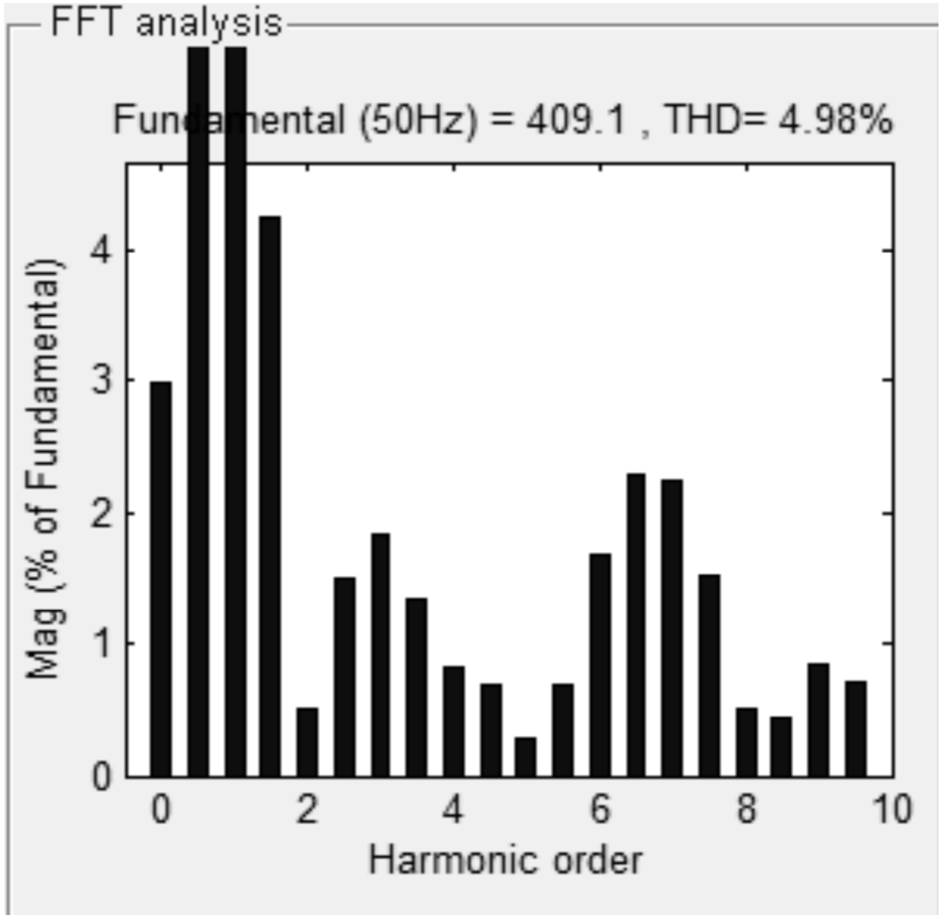

Figure 9: THD value when connecting GUPQC using PI controller

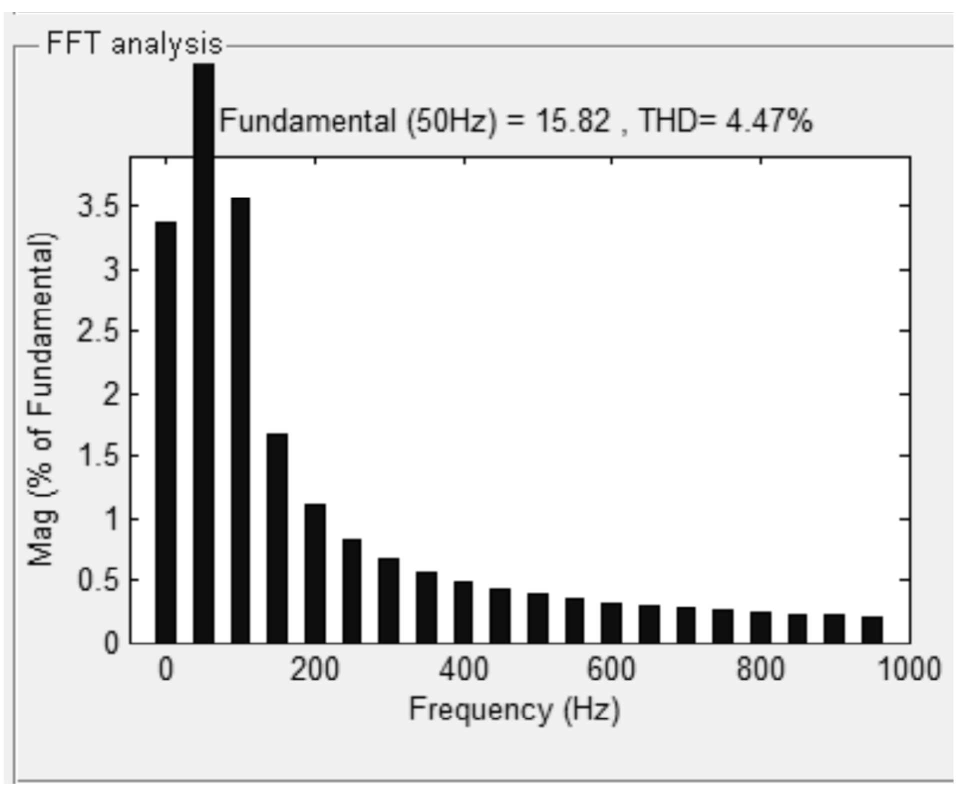

Figure 10: Shows the THD value for current waveform after adding GUPQC using PI controller.

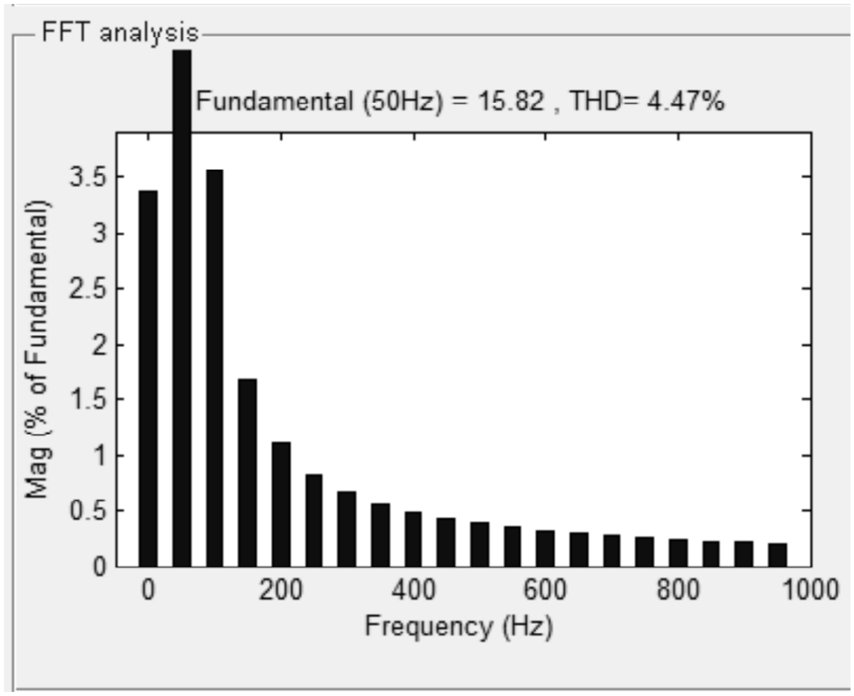

Figure 10: THD value for current compensation using GUPQC with PI Controller

Fig. 11 shows the voltage compensation waveform due to the presence of nonlinear load but in this PI controller is replaced with fuzzy controller and the values of THD value between both controllers are compared. Fig 12 shows the THD value for voltage which is compensated by using GUPQC using fuzzy controller. THD value is reduced to 3.55% when using fuzzy controller. THD value is reduced to a considerable value when compared with PI controller for compensating the voltage.

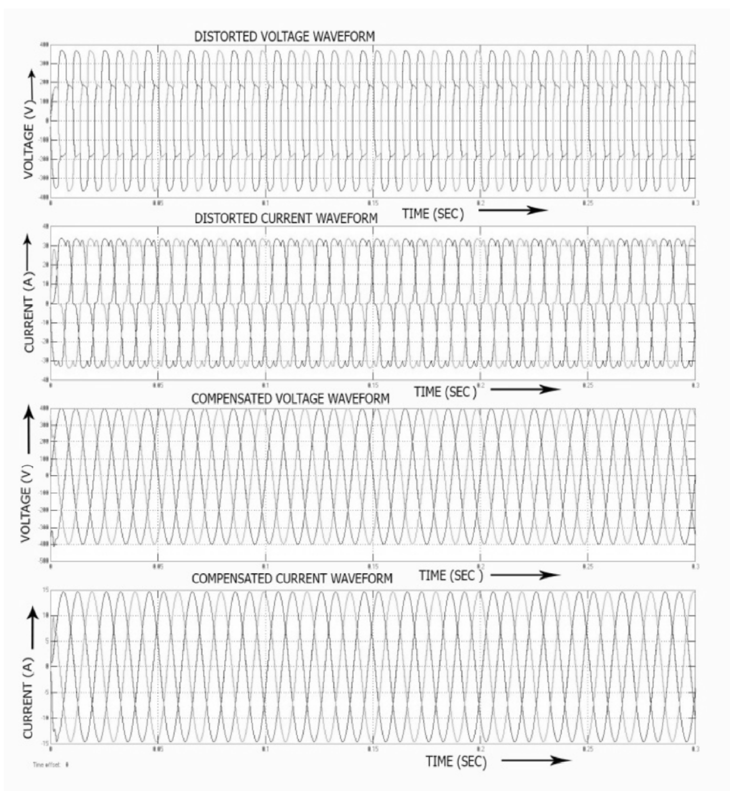

Figure 11: Harmonic voltage compensation due to nonlinear load by GUPQC using Fuzzy controller

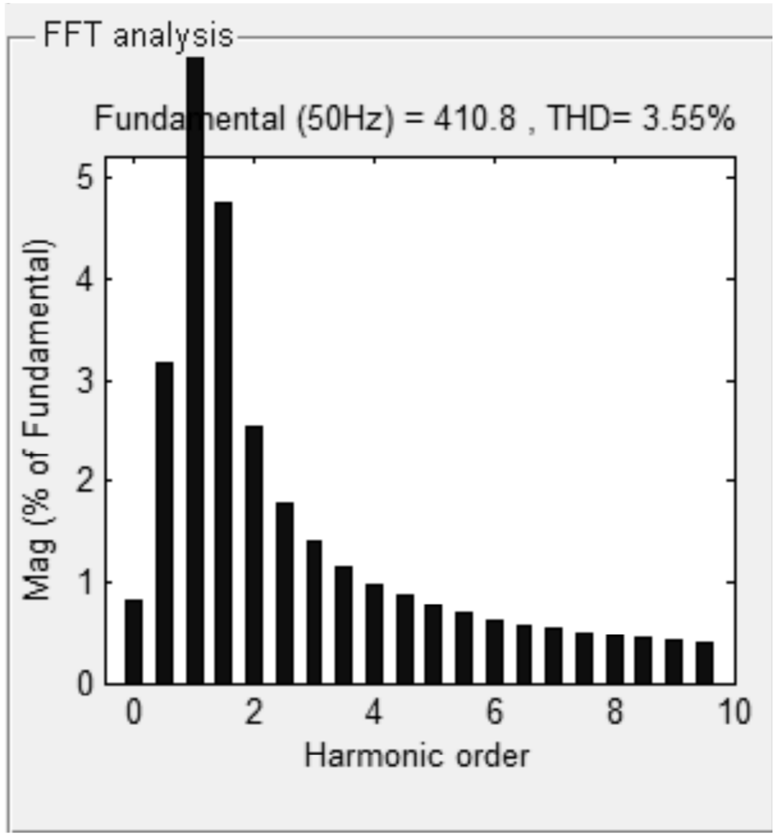

Figure 12: THD For harmonic voltage compensation due to the presence of nonlinear load by GUPQC using fuzzy controller

Figure 13: Shows the THD value for current waveform due to the presence of GUPQC using fuzzy controller.

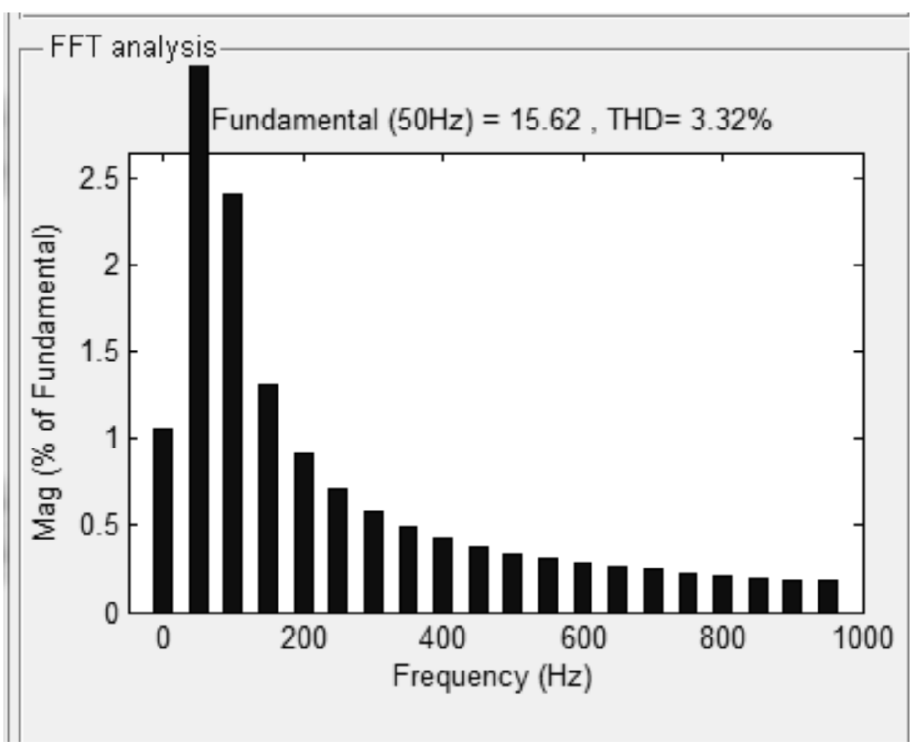

Figure 13: THD value for current waveform using GUPQC with Fuzzy controller

Table 1
Comparison of THD values using PI and fuzzy controller for voltage waveform and current waveform

Case	*Without GUPQC*	*GUPQC(PI Controller)*	*GUPQC(Fuzzy Controller)*
V_{THD}%	28.35%	4.98%	3.55%
I_{THD}%	20.31%	4.47%	3.32%

Harmonics are generated chiefly due to the occurrence of nonlinear load connected in the feeder and it can also be caused due to the switches used in the converter. These harmonics can damage industrial loads. In this paper, the reduction of harmonics in the voltage and current waveform using PI controller and fuzzy controller is compared. Table 1 shows comparison between THD values for voltage and current waveform. Without using GUPQC in the feeder, THD value for voltage waveform is 28.35% and similarly THD value for current waveform is 20.31%. In order to reduce this harmonics PI and fuzzy controllers are used. Using PI controller voltage harmonics is reduced to 4.98% and current harmonics is reduced to 4.47%. Likewise when we use fuzzy controller voltage harmonics is reduced to 3.55% and current harmonics to 3.32%. By comparing both PI and Fuzzy controllers from the above result, it is clearly seen that fuzzy controller reduces harmonics to a higher extend than PI controller.

V. CONCLUSION

In this planned model, the voltage and current distortion due to the presence of nonlinear load is compensated using GUPQC by using both PI and Fuzzy controller. The distorted voltage is compensated to a sinusoidal supply voltage of 415V. THD value for voltage waveform without GUPQC is 28.35% which is reduced to 4.98% using PI controller and 3.55% using fuzzy controller. THD value without GUPQC for current waveform is 20.31%, which is reduced to 4.47% using PI controller and 3.32% using fuzzy controller. It is obvious from the above results that the fuzzy Controller is extremely efficient than the PI controller, in reducing the level of harmonics.

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