

Reduction of Harmonic Distortion in Power System During Fault Occurrence

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Abstract
Electric powers is the main power sources utilize in our current industries. Disturbance in Power quality occurs due to changes in the magnitude of voltages and frequency. Power quality problem comes with the wide usage of nonlinear loads. During normal operation, highly nonlinear loads are the major cause of power quality disturbance and harmonics distortion. When the faults are established, harmonics are produced in the power system for a short interval of time, and voltage unbalanced are observed. It makes the quality of voltage change, produced some harmonics distortion in the system and power losses happened in the system. It is necessary to identify Power quality disorder and to improve power quality. This research work purposes to reduce the harmonics distortion using harmonics filter with thyristor device. MATLAB Model and simulation of the Power quality disturbance can provide waveform and data, which can be voltage and current. There are many harmonic minimization methods to increase the power quality and to support in a literature. In order to reduce the harmonics distortion, several controls technique such as active filter, passive filter, p-q method, Diode switch and harmonics filter with thyristor device are used. This research further explains how harmonic distortion is reduced. Results show that the harmonics filter and control thyristor give the improved results of power quality by reducing harmonics while another technique gives high Total Harmonics Distortion. The simulation model is also developed for the reduction of harmonics which occurred during the fault occurrence:
Keywords: Control devices, Thyristor, Power system, Harmonics filter, Harmonics, Power quality.

1. INTRODUCTION

Power quality is a steady state voltage that stays within specific range of frequencies and voltage magnitude. Power quality is a suitable term to define the quality of voltage, power and current. The efficiency of electronic devices are directly linked with the power quality [1]. The electrical power production comprises electricity generation (AC power), Electric power transmission and ultimately power supply to an electricity meter located to the locations of end user. Power quality trouble has come with the large utilization of nonlinear loads [2]. Due to nonlinear load produce some harmonics in the power system and power quality is disturbs due to harmonics. Power Quality has become a major problem to power consumers to each level of utilization.

Harmonics in Power System.

Any change in Voltage waveform and frequency waveform are called harmonics. Harmonics are the main issue on a power network. Power issue occurs on a voltage, current or frequency deviations and result in failure or improper operation of user equipment. The growing use of automatic equipment's produces many harmonics in sharing network because non-sinusoidal current spent by non-linear loads. Along to increasing demand for better power quality i.e. generally defined any change to the voltage, current, or frequency they affects with the regular operation of electrical equipment. Harmonics cause distortion on current and voltage waveforms resultant in the fall to the power network. The first step is harmonic investigation which has much importance is Method of investigation and control of harmonics. Harmonics exist on power system also has produces disturbance to source voltage, source current. [3]

Cause of Harmonics in Power System.

Nonlinear loads (AC loads where the current is not proportional to the voltage. Under this conditions, the voltage behavior are no longer proportional to the current. Nonlinear loads are Computer, Laser printer, converter, Refrigerator, TV etc.) Are widely used in productions of an energy [4]. They mainly generate the harmonics inside the power network. Heavy loads pull the current that might be irregular. The use of continuous voltage do not result in a continuous transfer supply which is useful to continuous voltage for a nonlinear device. During fault occurrence in the power system, the power quality is disturbed due to harmonics distortion in the power system and causes disturbance of voltage and frequency of the system [5]. This disturbance increases Harmonic Distortion. The harmonics are also generated in a power system due to linear loads (AC electric loads where the voltage and current behavior are continuous. These condition of a current at any time is proportionate to voltage on power systems, synchronous generator generate continuous voltages and loads pull continuous currents. In these situation harmonic distortion are creates because of the continuous voltage are small [6].

Effects of harmonics in Power System.

Harmonics have a huge effects such as the protective device damages, damage in transmission lines and electric devices, and short-life electric equipment's. Harmonics not only increases the losses in the system but also produces unwanted disturbance to source voltage, source current etc [7]. In past research work two type of filters are utilized to decrease the harmonic distortion i.e. the active filter & the passive filter. Active harmonic filters is an electric devices they have to remove the unwanted harmonics on the network to adding negative harmonics on the network. The active filters is usually presented to the small voltage networks. The active filters contain of energetic modules lake a IGBT-transistors and remove much different harmonic frequencies. These types of a signal would be single-phase AC, three-phase AC. But the other hand, passive harmonic filters contain to a passive devices like a resistors, inductors, and capacitors. Unlike active filters which they can utilize only for small voltages. For the distribution network, the maximum value of 5^{th} harmonics voltage on the housing area investigated to minimized its acceptable level to a 4% and this is the total harmonics distortion (THD) is lower than its acceptable level of 5% in continuous observation of harmonics maintenance, it has been described particularly that, the maximum value of 5th harmonics voltage in the power distribution network increased 7% under small load situations at night. It can be considered to be 50% [8]. This means 10% of total loss is caused by harmonics in the simulated feeder. It is also has pointed out another important principle. The concentration reveals that the actual measurement proposes the 5^{th} harmonics voltage increases at night due to harmonics propagation because of series and parallel or any harmonics resonance between link inductor and shunt capacitor for power factor improvement, which are installed in the distribution network to this harmonics compensation and harmonics damping is viable which effectively solves harmonics pollution into the power distribution network. The customers and end users are answerable for keeping the current harmonics created in the equipments within the specified limits [9]. Modeling and simulation of the Power quality disturbance can be a voltage for the Power quality detection and analysis. At that time, the waveform could help for the know Power quality automatically, so the MATLAB Implementation and simulation has a very high numerical value [10]. That's why it is necessary to build a model the Power quality trouble in the voltage variation. It is needed to evaluate and research on Power quality disturbance systematically. The MATLAB model will be analyzed for voltage change and harmonic disturbance. The present study focuses on the reduction of harmonics using Thyristor control device with harmonics filter on different load changing simulation platform. The simulated results will be compared to previous research work.

2. PLANT DESCRIPTION:

In this research work, THD is reduced by using harmonics filter with thyristor device for various load through FFT analyzer, and voltage unbalance calculation is performed. MATLAB Simulink is used for the implementation of proposed research work.

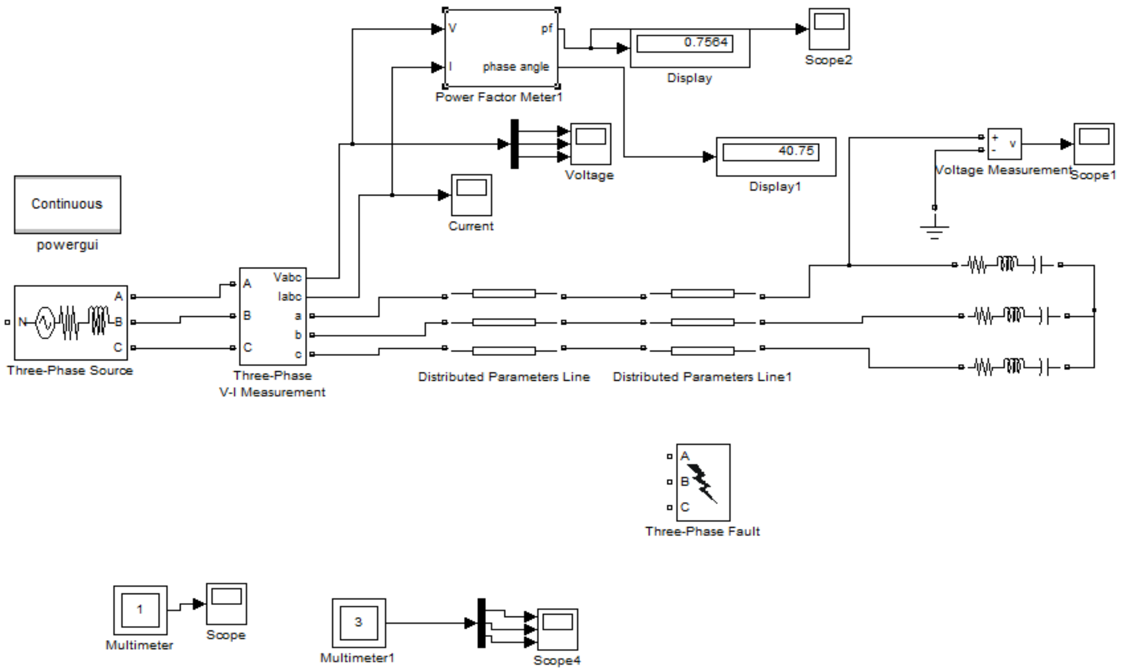

Figure 1. Single Phase without Ground Fault.

Single Phase without Ground Fault. Select the total run time as 0.35s and set a single phase grounding fault between 0.11s - 0.15s.Factors of the module in the model shown in Fig. 1 is set to the following:

Power module: Use the voltage source to neutral grounding the phase voltage to the three-phase voltage source is 380V and power station frequency is 50 Hz.

Transmission lines module: Implement the single parameter line which is 44 km long. Failure module: three-phase fault breaker is located between line 1 and line 2, it is set as phase A single phase to ground fault. The fault takes place in 0.11s and it's cut off in 0.15s.Fault location resistance and fault location grounding resistance are selected for 0.001 Ω.

Load module. Select RL load, R = 10 Ω, L=0.005 H.

Measurement units: Three phase Voltage and current measurements are put on the circuit for measure voltage and current wave on the power side and the load side, the multimeter is put on the fault point to measure the voltage and current on it. Power GUI:

The Powergui block opens a graphical user interface (GUI) that shows straight values of measured current and voltages and all other state variables (inductor currents and capacitor voltages). The Powergui block permits changing the starting positions in order to run the simulation for some initial value. Select the phase simulation frequency 50 Hz and discreet time is 0s.The three phase voltage sources are connected in Y to a neutral manufacture that can be internally grounded and made accessible [11].

2.2 Single Phase to Ground Fault Model using Thyristor and Harmonics Filter Block:

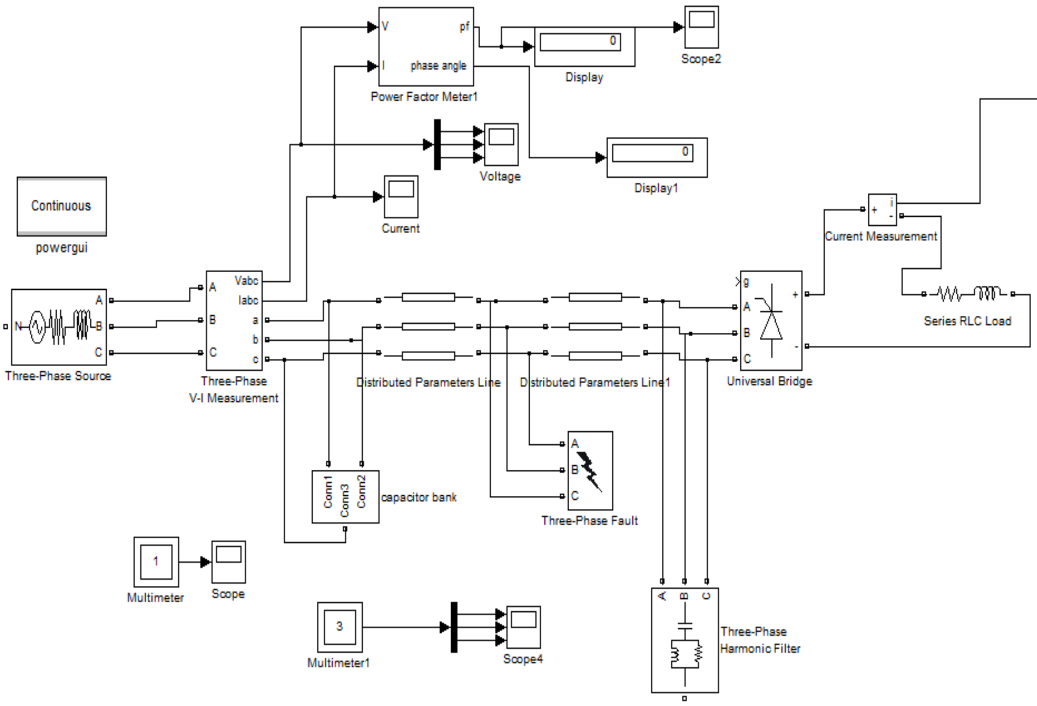

Figure 2. Single Phase to Ground Fault Model using Thyristor and Harmonics Filter Block.

You should be identify the source inside resistance and inductance may directly to entering R and L values or indirectly varying and identifying the source inductive short-circuit level and X/R ratio. (This parameter is available only if Internal and Specify short-circuit level parameters are selected). Phase to phase rms (v) 380 v, and Phase angle is zero degree, Frequency is 50 Hz, Source of resistance 0.8929 Ohm and Source inductance 16.58e-3 (h)

Three-Phase V-I Measurement:

Three-Phase V-I Measurement blocks are utilized for calculate three phase voltages and current on a network. The phasors peek value are shown in the Powergui and stay in peak RMS values even the output signals are changed to Pu.

Distributed Parameter Line:

Implement Number of phase line is 3, Frequency used for RLC specification is 50Hz, Resistance per unit length (ohms/km) are [0.01273 0.3864], Inductance per unit length (H/km) are [0.9337e-3 4.1264e-3], Capacitance per unit length F/km), Line lengths are 50km, Measurement to Phase-to-ground voltage.

Series RLC Branch:

L letter defines to inductor, and C letter defines to the capacitor. Negative value is acceptable for resistance, inductance, and capacitance. Resistance is 10 Ohm, and Inductance is 0.005 H and Capacitance 0.001F

Three-Phase Fault:

An external connection is supplied to the component so that the user may connect any type of external fault circuit directly to the fault common point. Fault resistance is 0.001 ohm and Ground resistance 10ohm and external control of fault timing is transition status is [1,0,1..], Transition time [0.11 0.15] and snobbery resistance is 1e4.
Description:
In this model 900W load are used and we saw the power factor is 0.9339, Voltage THD is 0.03% and Current THD is 0.02%. After all, we came up with the result that when we use harmonics filter and capacitor bank; harmonics will be reduced, power factor will improve, and best power quality produced.

2.3 Modeling: Among them, the UA, UB, UC are the voltage of phase A, B, and C receptively. When phase A happens single phase earthing fault,

$$U_{A-D} = 0$$

$$U_{B-D} = U_B - U_A = \sqrt{3}\, U_A e^{-J\,150^0}$$

$$U_{C-D} = U_C - U_A = \sqrt{3}\, U_A e^{J\,150^0}$$

The voltage to earth of phase A is equal to 0, and the voltage of phase B, C of the fault spot raise up to 31/2 of the original. Build the voltage disturbance separate parameter line as a transmission line, and series RLC branch as a load.

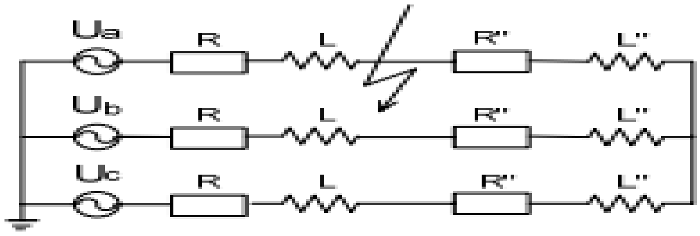

Figure 3. Single phase ground fault schematic diagram.

3. RESULTS and DISCUSSION:
Voltage Balance Representation When No Fault Occur:
Magnitude of this wave in the first phase starts from 0 and goes to 270V after reaching this position its magnitude starts to decrease and goes to -270V after that it starts to increase and then goes to 270V again

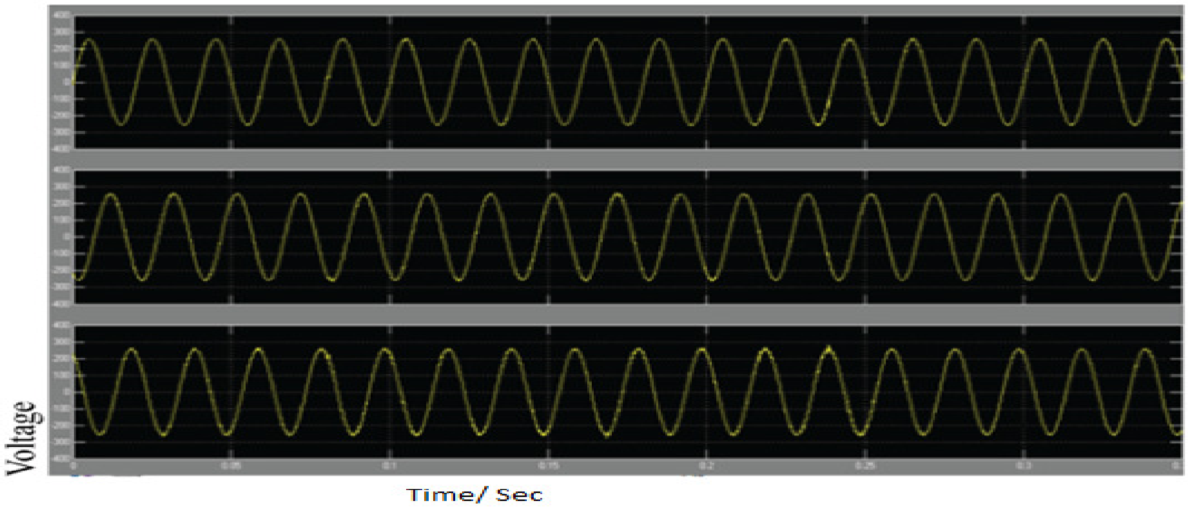

Figure 4. Voltage balance representation.

This cycle continues. In second phase magnitude 220V and goes to 270V after reaching this position its magnitude starts to decrease and goes to -270V after that it starts to increase and then goes to 270V again this cycle continues. In third phase magnitude of this wave starts from 210V and goes to -270V after reaching this position its magnitude starts to increase and goes to 270 after that it starts to decrease and then goes to -270V
of this wave starts from

Voltage Unbalance Representation when Single Phase to Ground fault occur:
Select a simulation time 0.35s to a single phase grounding fault b/w 0.11s-0.15s. Components of the element in

the model shown in Fig-4 are set as following:

Transmission lines module: Adopt the isolated parameter line which is 44 km long, three-phase faults breaker are situated between line 1 and line 2, it's set on phase A single phase to ground fault. The fault took place in 0.11s and its cut off 0.15s. Fault point resistance and fault point grounding resistance are selected to 0.001 Ω. Load module: Select R and L load, R = 10 Ω, L=0.005 H.

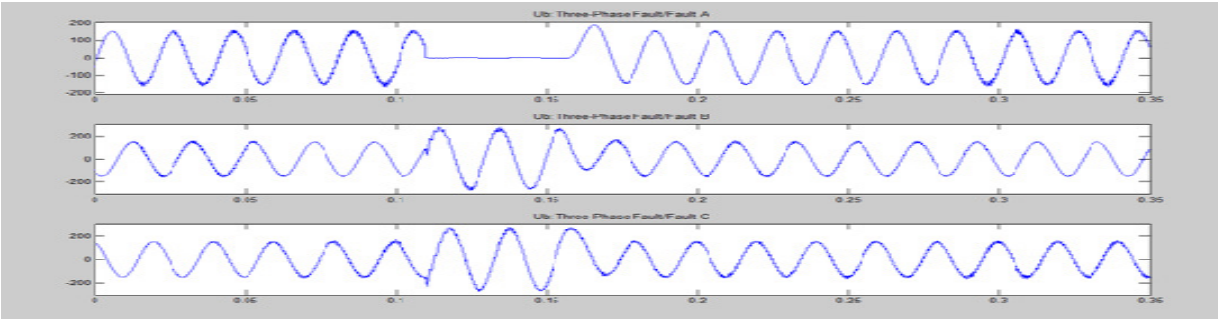

Figure 5. Voltage Unbalance Representation.

Voltage to the Power Side on the Single Phase grounding Fault:

Phase A voltage alongside power fall on the vibration when single phase to ground fault occurs on 0. 11s "voltage of phase B and C increase. After fault occurs disconnects in 0.15s" short circuit faults is cut off .Because of the existence of dc (direct current) elements in shorting current, the voltage to phase A is a small than initial voltage on this time. With the decrease of dc element, voltage of phase A recovers to continuous. When the fault is cut off, voltages of phase B, C fall to normal. Voltage unbalance calculation Assume the following phase-phase voltages were measured:

A = 130 V B = 310 V C= 400 V

Average Voltage = 130+310+400/3 =840/3=280v

Maximum Voltage Deviation from Average = 280−130V = 150V voltage Unbalance = (150/280)×100=53.57% when the fault is cut off. The voltage of phase A, B and C on a fault point can be find through the multimeter, the voltage is represented in Fig.5

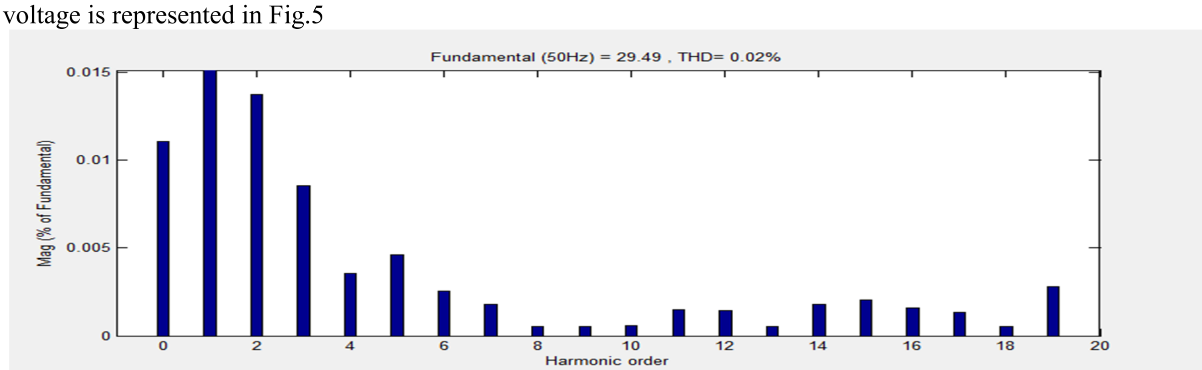

Figure 6. THD calculation on 900W load of voltage side Using FFT analyzer**.**

The voltage on phase A is disturbed when the three phase fault producer is closed in 0.11s. The voltage on a phase A is 0, while voltage on the phase B and C increase. The voltage on the ground on phase B and C before fault is 160V.

THD calculation on 900W load of current side Using FFT analyzer:

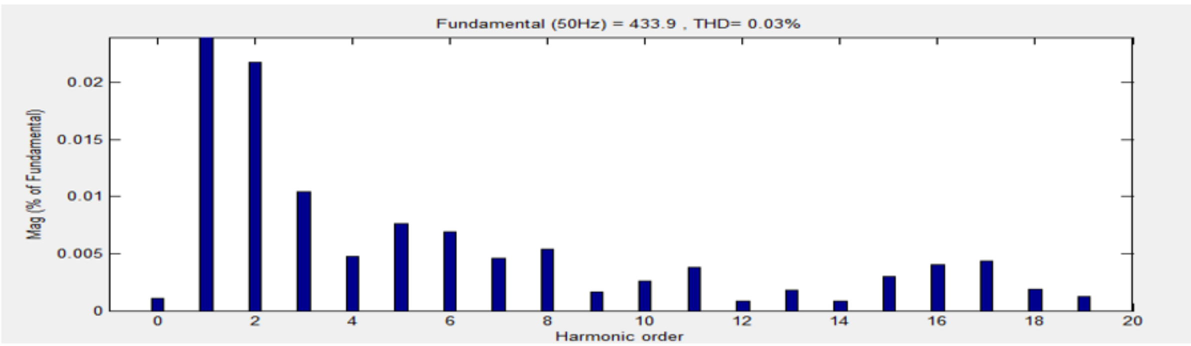

Figure 7. THD calculation on 900W load of current side Using FFT analyzer.

In this models we saw that when the capacitor bank and harmonics filter are connected on 900W load we saw at 900W load the power factor is 0.9339, Voltage THD is 0.03% and Current THD is 0.02%. While in the other previous research, at 900W load the power factor is 0.5936, Voltage THD is 0.07% and Current THD is 0.16%. At 10W load, power factor is 0.93, Voltage THD is 0.09% and Current THD is 0.09% and in the other previous research, the power factor is 0.0906, Voltage THD is 0.24% and Current THD is 0.29%. After all, we came up with the result that when we use harmonics filter and capacitor bank; harmonics will be reduced, power factor will improve, and best power quality is produced

Table 1: **Double Phase Fault Harmonics Calculation using Thyristor and Capacitor:**

Applied voltage	THD voltage	THD current	Power factor	LOAD
380v	0.09%	0.09%	0.93	10w
380v	0.04%	0.07%	0.93	100w
380v	0.16%	0.24%	0.93	200w
380v	0.03%	0.05%	0.93	300w
380v	0.09%	0.13%	0.93	400w
380v	0.03%	0.05%	0.93	500w
380v	0.25%	0.35%	0.93	600w
380v	0.20%	0.30%	0.93	700w
380v	0.23%	0.34%	0.93	800w
380v	0.02%	0.03%	0.93	900w

Table 2: Comparison of Harmonics between Diode and Thyristor:

Applied voltage	THD voltage Of Diode	THD current Of Diode	THD voltage Of Thyristor	THD current Of Thyristor	LOAD
380v	2.04%	11.28%	0.09%	0.09%	10w
380v	1.73%	9.19%	0.04%	0.07%	100w
380v	1.53%	7.96%	0.16%	0.24%	200w
380v	1.47%	7.50%	0.03%	0.05%	300w
380v	1.40%	7.16%	0.09%	0.13%	400w
380v	1.39%	7.04%	0.03%	0.05%	500w
380v	1.38%	6.91%	0.25%	0.35%	600w
380v	1.35%	6.76%	0.20%	0.30%	700w
380v	1.34%	6.70%	0.23%	0.34%	800w
380v	1.33%	6.65%	0.02%	0.03%	900w

6 Conclusion:

This study has presented the power quality problems such as distortions and harmonics. The design and applications of control device thyristor and harmonics filter to reduce harmonics and comprehensive results were presented. The performance of the proposed technique proves that the thyristor can give the better results through simulation, theoretical calculation and Total Harmonics Distortion (THD) reduction. The proposed system performs better than the traditional methods in mitigating harmonics and distortions. In this research MATLAB simulation platform is valid to evaluate voltage variation and minimize the harmonic problem. Although the simulation are simple, effective and highly relevant the waveform of voltage unbalances and voltage harmonics are obtained from the simulation. We analyze the voltage and current consist of harmonic concluded FFT analyze. The simulation results and the calculation analysis represented to the better results they can offer data and basis for finding and tell of harmonics distortion and problem of PQ and further control measures. In future work, Modified-PWM STATCOM can be used to further minimize the harmonics of a power system when the highly non-linear load is used.

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