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Design and Analysis Of A Upqc Power Flow Control Using Distribution Transformer

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Abstract- Unified power quality conditioners (UPQCs) allow the mitigation of voltage and current disturbances that could affect sensitive electrical loads while compensating the load reactive power. Diverse control techniques have been proposed to evaluate the instantaneous output voltage of the series active power filter of the UPQC but, in most cases, these controllers only can compensate a kind of voltage disturbance.

Keyword - Active filters, harmonics, power conditioners, power quality, voltage flicker, voltage imbalance.

I. INTRODUCTION

An important issue to be addressed during fault is the intermittent power in the wind farm terminals, because it causes severe impact on wind power generation and power system balance (Shi et al 2014). The wind farms constructed with induction generator have poor fault ride through (FRT) capability and they get tripped out during severe grid faults. The tripping of wind farms during a fault will exacerbate the situation and lead to system instability (Vittal et al 2010).

It becomes necessary to require WTGs to stay connected to the grid for reliable power system operation. Several compensation devices used for improving FRT fail due to intermittent power. Farias et al (2010) have investigated the impact of three phase short circuit, voltage and lagging phase jump related issues on wind farm integration. It proposes a compensation strategy to retrofitting the existing installed fixed speed induction generators based wind farms. But, intermittency is not considered in these investigations. No proper investigation is done to handle the energy that the grid cannot absorb during severe fault. Ramirez et al (2011) have discussed this issue and provided a solution by connecting a resistor across the dc link of voltage source inverter to dissipate a part of the active power generated in the wind farm and the remaining power is fed to the faulted network. This method cannot give a complete solution for the aforementioned problem and cannot be applied to large scale wind farms.

II.UNIFIED POWER QUALITY CONDITIONER

The schematic outline of a solitary stage Unified Power Quality Conditioner is appeared in Figure UPQC comprises of two IGBT based Voltage source converters (VSC), one shunt and different arrangement which are associated with a typical DC interface. The shunt converter is associated in corresponding to the heap. It gives VAR pay to the heap and supply consonant flows. At whatever point there is droop in supply voltage then arrangement converter infuses reasonable voltage to conquer list in supply. Hence, UPQC improves the Power quality by alleviating issues because of burden current music and by power factor revision.

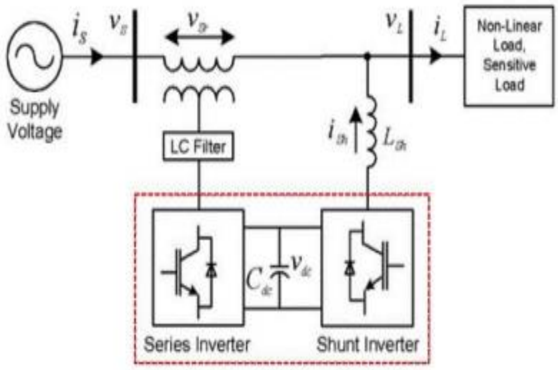


Figure 1.UPQC basic Structure.

The key components of the system are as follows:

1. Series converter

VSC associated in arrangement with the AC supply line. It goes about as a line voltage source to repay voltage disturbances. It is utilized to limit line voltage vacillations from the heap supply voltage and feeds to shunt part of the gadget to devour current music created by unbalance load.

2. Shunt converter

VSC which is associated in corresponding with the AC supply line. It goes about as a present source to dispense with current disturbances and wipes out the receptive current in the heap circuit. It improves the Power factor of burden and goes about as DC-interface voltage controller for the decrease of the DC capacitor rating.

3. Energy stockpiling

The DC capacitor bank is commonly utilized. it is associated between Midpoint-to-ground is separated into two sections, which are masterminded in arrangement together. The impartial point's auxiliary transformer is associated with the DC interface midpoint legitimately. Since both three-stage transformers are associated in Y/Yo structure, the zero-succession voltage will show up in essential twisting of transformer which is associated in arrangement to alleviate the zero-grouping voltage of the inventory power framework. There would not be any zero-succession current stream in the essential side of the two transformers. At the point when the voltage unsettling influence happens the framework current is adjusted. Different other vitality stockpiling gadgets can be utilized, for example, batteries, superconducting loops, super capacitors, flywheels, and so forth.

4.The Low-pass channel (LPF)

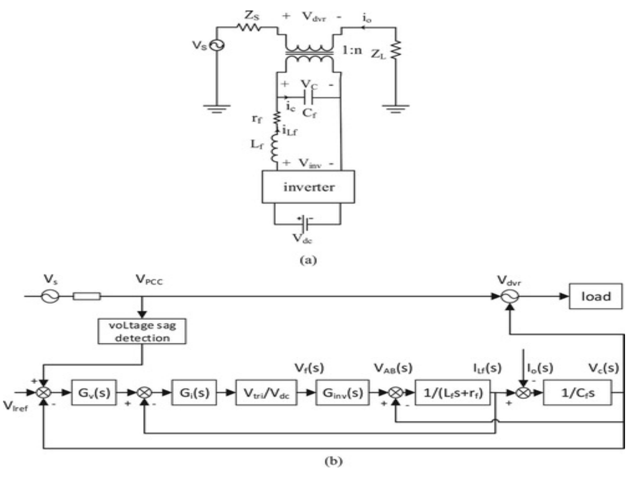
Due to high-recurrence exchanging mode high recurrence segments are created at the yield side of arrangement converter to constrict these LPF is utilized.

5. High-pass channel (HPF)

In current exchanging mode swells delivered can be devoured by applying HPF at the yield of shunt converter. f) Series and shunt transformers are utilized to infuse the repaying voltages and flows for electrically division of UPQC converters.

III.CONTROL ALGORITHM OF DVR UNIT

In series side (DVR unit), the control unit must be able to track the instructions quickly and accurately within the acceptable range of error. According to the equivalent block diagram of DVR series compensator in Figure .1, we can get the closed loop control method of DVR output voltage as is shown in Figure 2. Figure 1. Double closed loop control strategy. (a) Equivalent block diagram of DVR output filter (b) Control block diagram of DVR.



In Figure 1 , VSVS is the system voltage, VdvrVdvr is the output voltage of DVR setup. VlrefVlref is the instruction voltage. GV(s)GV(s) is the controller of voltage outer loop, Gi(s)Gi(s) is the controller of current inner loop, Vtri/VdcVtri/Vdc is the voltage transformation, Ginv(s)Ginv(s) is the inverter bridge modulation model which is in relationship with Vdc/VtriVdc/Vtri.

In order to improve the dynamic performance of the system, instantaneous value feedback of capacitor voltage structure is used as voltage outer loop of control system. After adjustment of proportional integral block, error signal of voltage outer loop can be used as the reference signal of the inner loop of inductance current. In this capacitor voltage outer loop and inductor current inner loop control strategy, controller of inductor current inner loop is Gi(s)Gi(s) and it is designed with PI controller; controller of capacitor voltage outer loop is Gv(s)Gv(s) and it is made up of GvGv with PI controller. The modulation of inverter bridge is Ginv=vdc/vtriGinv=vdc/vtri and it is affected by DC bus voltage VdcVdc. During the running time of the DVR, fluctuating of current and voltage is inevitable. In order to eliminate the influence of DC voltage fluctuation on the whole system, proportion link is introduced to the output side of inductor current inner loop.

By doing this, the influence of DC bus voltage fluctuation on system can be eliminated effectively. By using fast voltage detection algorithm and phase locked algorithm, the voltage amplitude and phase of the PCC point are obtained. The voltage of PCC is compared with the instruction voltage VlrefVlref, then we can get DVR's output command voltage VDVR-ref VDVR-ref which is concluded in the first summation unit. Through capacitor voltage outer loop and inductor current inner loop, the output command voltage VDVR-ref V DVR-ref can be transformed to control voltage VcVc, then we can get the output voltage VdvrVdvr, the VdvrVdvr and PCC voltage are connected on the load in series to ensure the load voltage to be a stable sinusoidal voltage.

1. Principle of Dvr

Dynamic voltage restorer (DVR) protects the load from voltage disturbances. DVR maintains the load voltage at a predetermined level during any source voltage abnormal conditions such as voltage sags/swells or distortion. The working principle of the DVR can be explained through the fig 3.1. Under normal operating conditions, let the three phase voltage phasors Va1, Vb1 and Vc1. During abnormal conditions, the phase voltage vectors may be altered to Va2, Vb2 and Vc2. DVR does not supply any real power in the steady state. This implies that the phase angle difference between DVR voltage phasor and current phasor must be 900 in the steady state. DVR injects the required compensating voltage through transformer. The transformer is connected in series to the load. DVR operates only during the abnormal conditions and remains idle during normal operating conditions. During operation, DVR has a capability to supply and absorb active and reactive power. Dynamic voltage restorer corrects the load voltage by supplying reactive power generated internally on the occasion of small fault. DVR develops active power when it is required to balance larger faults. It requires dc energy device to develop the active power. Usually, dc capacitor banks are used as the dc energy storage device. Most often caused voltage disturbances are voltage sags as they can cause load tripping. Dynamic voltage restorer (DVR) is a series controller connected in series to the load. DVR injects voltage in series to the load through the injection transformer and voltage source converter. The injecting transformer injects the required voltage vector (magnitude and angle) which adds to the source voltage to restore the load voltage to pre-abnormal condition. The components of DVR are:

1. Energy Storage: - usually batteries are used to provide the required energy for compensation of load voltage during abnormal conditions. In online monitoring and conditioning systems, required energy for compensation is drawn from supply line feeder through a rectifier and a capacitor. In low power applications, photovoltaic cells can also provide energy.

2. Inverter circuit: - Since the loads in distribution system operate with ac power supply, inverter is required to invert the dc power from the energy storage into ac power. Usually for normal three phase supply, three phase voltage source inverter is used. Three phase VSI cannot control the output voltage instead only transform the dc signal to corresponding ac with same magnitude. Hence requires large energy storage for high voltage injection. Moreover, voltage source inverter output waveform shape is step waveform (treated as highly harmonic content waveform) and hence requires a filter at the output of the inverter to modify the step output into sinusoidal.

3. Series injection transformers: - Three single phase injection transformers are used to inject the voltage at the load end. Usually 1:1 ratio is used, but if required step up transformer can also be used. The injection transformers are provided with suitable MVA rating, the primary winding voltage and current ratings, short circuit impedance values.

4. Filter Unit: - Since the semiconductor devices exhibit non-linear characteristics resulting in distorted waveforms associated with high frequency harmonics at the inverter output. Hence to minimize the harmonics, a harmonic filtering unit is required. In turn the filtering unit can cause voltage drop and phase shift in the fundamental component of the inverter output. To overcome this problem, multilevel topology can be used in voltage source inverter which has double impact in reducing filter size and energy storage requirement simultaneously.

5. Controller and auxiliary circuits: - By-pass switches, breakers and protection relays are some auxiliaries to the Dynamic Voltage Restorer (DVR) block. In addition to all these, PWM controller is required to generate pulses to the inverter in accordance to the abnormality in load voltage. Most often PI controller is used. When tuning becomes difficult, PI controller is tuned with proper methodology.

2. Location of The Dvr

High total inserted DVR impedance increases the potential load voltage fluctuations if the load is non-linear and /or has a fluctuating load behavior. When DVR is connected to the medium voltage level, it protects a large consumer or group of consumers. Inserting a large DVR at the MV-level will only increase the supply impedance for a low voltage load slightly. Some of the advantages of the high rated DVR at the medium voltage level are:

- If the distribution system is operated as a three wire system with isolated or inductor grounded system, injection of positive and negative sequence system is significant.
- The costs per MVA to protect are expected to be lower if one large central DVR is located at the medium voltage level instead of decentralized low voltage units. Some of the disadvantages of the high rated DVR at the medium voltage level are:
- Protecting a large load requires a medium voltage DVR otherwise the losses in the DVR will be too high.
- During ground faults in the medium voltage system the phase to ground voltages can increase with $3^{1/2}$, and a higher isolation level may of the injection transformers must be ensured.

3. OPERATION OF DVR

The DVR can be operated in three different modes which are described as

1. Bypass mode:- the Dynamic Voltage Restorer (DVR) is bypassed mechanically or electronically during high load currents and downstream short circuits. In this mode the DVR cannot inject a voltage to improve the voltage quality.

2. Standby mode: - The supply voltages are at rated level and the DVR is ready to compensate for voltage sag. During standby mode the DVR can have secondary tasks and operation modes.

3. Loss less mode: - The DVR performs no switching and the losses in the DVR are minimized to conduction losses.

4. Harmonic blocking mode and voltage balancing mode- The DVR improves the load voltage and compensate for poor background voltage quality. The DVR has to perform switching and is expected to inject a relatively small voltage.

5. Capacitor emulation mode- The DVR is controlled to operate as in inserted series capacitor, thereby it can compensate for large line inductance and for inductance inserter in conjunction with the DVR. 3. Active mode: Whenever voltage sags are detected, DVR injects the missing voltage. In this mode DVR should ensure the unchanged load voltage with minimum energy dissipation for injection due to high cost of capacitors. The available voltage injection strategies are pre-sag, phase advance, voltage tolerance and in phase method.

IV. VOLTAGE INJECTION METHODS

Since the dynamic voltage restorer injects the compensating voltage in order to maintain the load voltage constant, there are certain limitations in compensating the voltage sags. The factors influencing the compensation are finite power rating, different load conditions and different types of voltage sag. Load characteristics dictate the control strategy of dynamic voltage restorer as some loads are sensitive to phase angle jump and others are tolerant to phase angle jump. The injection compensating voltage is categorized as three methods.

1. Pre-sag Compensation- In this method DVR continuously tracks the supply voltage. The DVR injects the missing voltage between during sag and pre-sag voltages to the system. During the compensation, DVR has to compensate both magnitude and angle.

2. In-phase compensation- In this method, injected voltage is independent of the load current and pre-fault voltage. The injected voltage is always in-phase with supply voltage. The added advantage of this method is to minimize the magnitude of injected voltage for constant load voltage magnitude. The phase angles of pre-sag and load voltage are different and magnitude of load voltage is same as pre-fault voltage.

3. Phase-Advance Compensation- Active power is injected to sensitive loads continuously in both pre-sag compensation and In-phase compensation methods. In both methods, DVR restoration time and performance are confined due to limited energy storage capacity of dc link which limits the active power injection. Phase advance methods proves to better compared to other methods as it associates only reactive power injection instead of active power. The injected active power is made zero by injecting compensating voltage perpendicular to load current.

V. DVR LIMITATIONS

Every circuit which has advantages will also have few disadvantages. A DVR has limited capabilities and the DVR will most likely to face voltage sag outside the range of full compensation. Some of the limitations of DVR are:

- Voltage limit: The design is limited in the injection capability to keep the cost down and to reduce the voltage drop across the device in standby operation
- Current limit: The DVR has a limitation in current conduction capability to keep the cost down.
- Power limit: Power is stored in the DC link, but the bulk power is often converted from supply itself or from a larger DC storage. An additional converter is often used to maintain a constant DClink voltage and rating of the converter can introduce a power limit to the DVR.
- Energy limit: Energy is used to maintain the load voltage constant and the storage is normally sized as low as possible in order to reduce cost. Some sags will deplete the storage fast, and adequate control can reduce the risk of load tripping caused be insufficient energy storage.

VI.RESULT AND SIMULATION

The system consists of UPQC which has to improve the power quality of a grid-connected system feeding non-linear load. The UPQC considered here consists of control circuitry which is based on sinusoidal current control strategy. The load consists of converter-fed resistive load. The performance of UPQC for a 3-φ 3-Wire (3P3W) system has been realized with the simulation through MATLAB Simulink 2016a software. Different aspects of UPQC control has been simulated along with the circuit for a 3P-3W system. The simulation parameters are presented in Table 4.1.

1. Matlab Modelling Of Upqc:

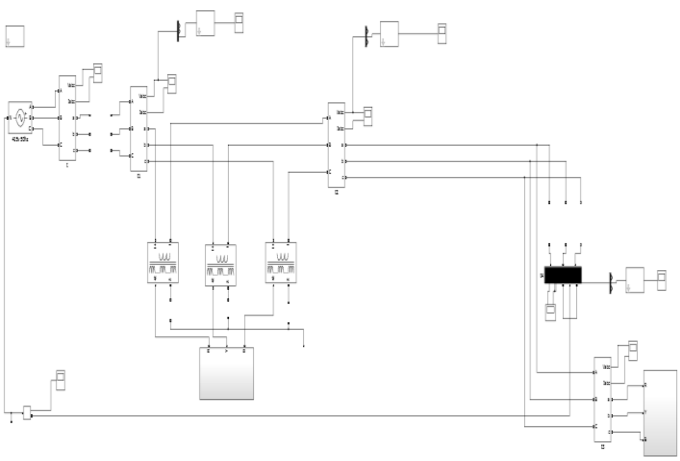


Fig .1 Model of Linear and Nonlinear load.

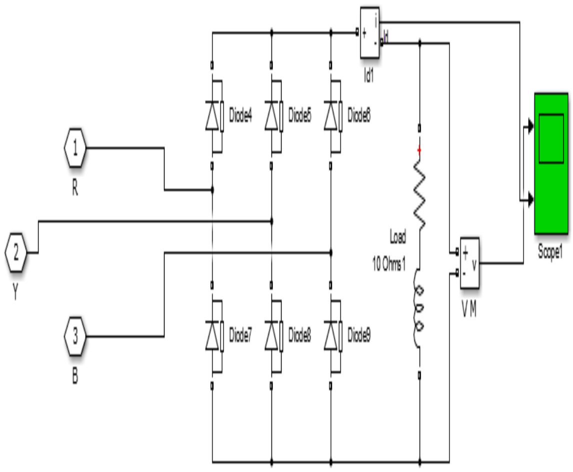


Fig .2 Nonlinear load.

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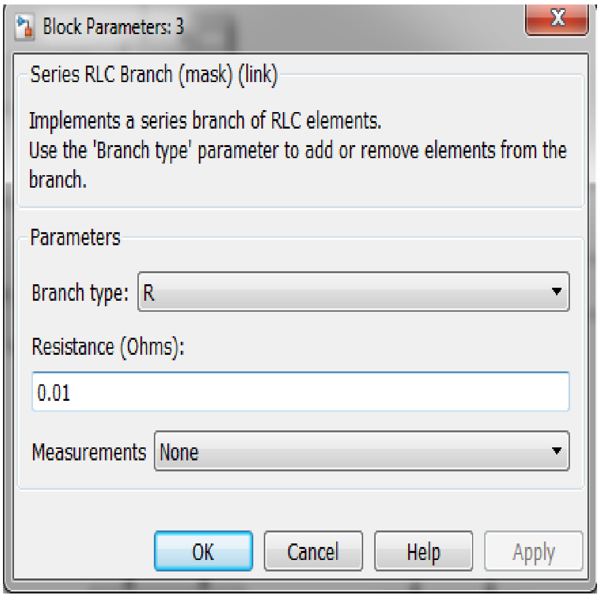

Fig .3 linear load GUI input value.

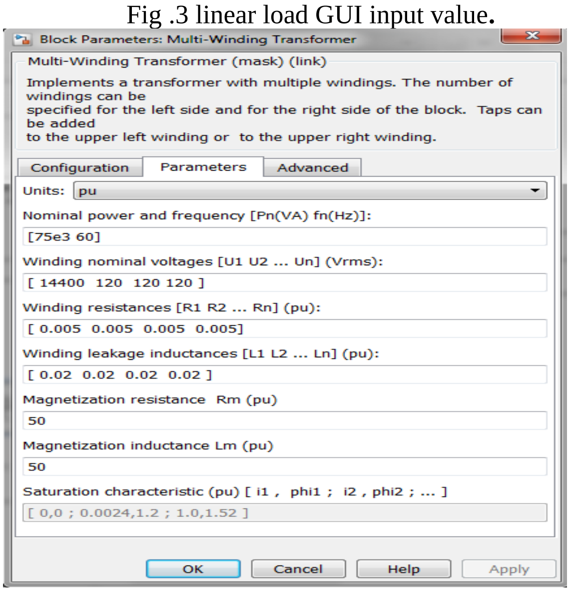

Fig .4 Transformer parameters.

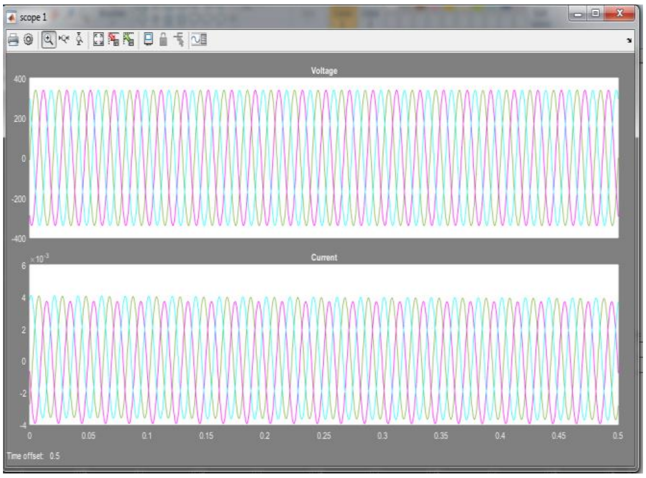

Fig. 5 voltage and current Linear load across outcomes.

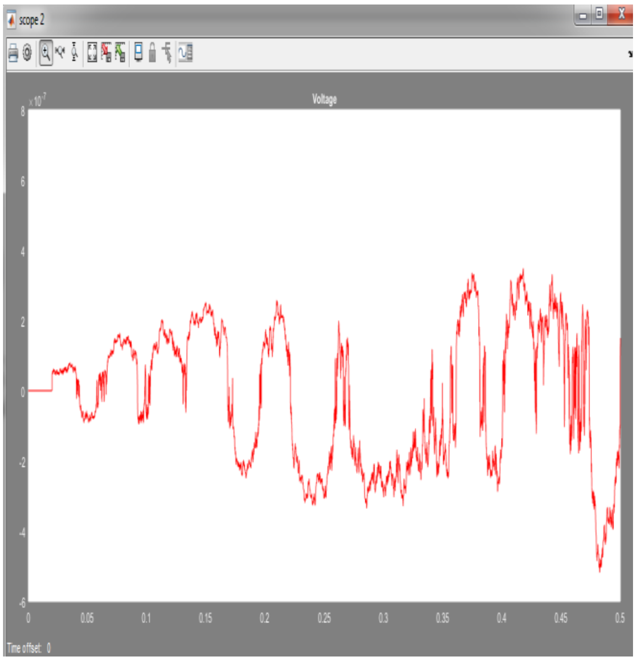

Fig .6 Linear load THD Outcomes.

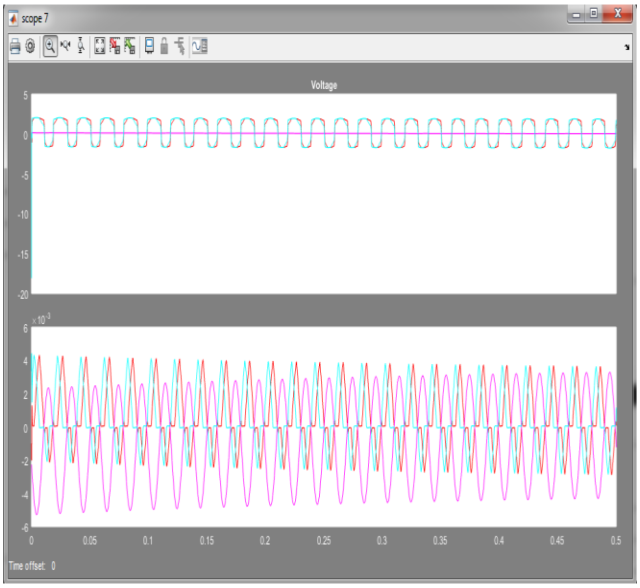

Fig .7 Voltages and current non Linear load across outcomes.

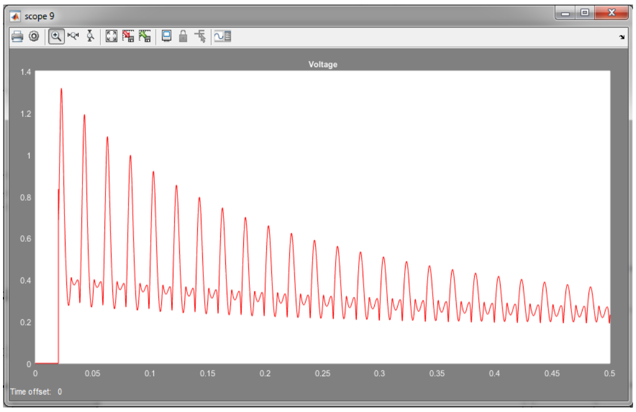

Fig .8 Non Linear load THD Outcomes.

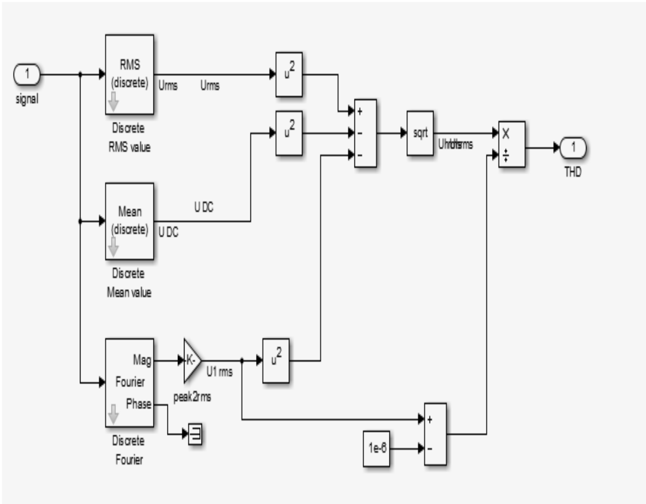

Fig .9 THD calculation Modelling.

Table 1 Fundamental Parameters of proposed system.

S.N.	Parameters	Values
1.	Linear Load THD (%)	$0.5x10^{-7}$
2.	Non Linear Load THD (%)	0.2%
3.	Voltage	395
4.	Current	$4x10^{-3}$
5.	Resistance	0.01Ohm
6.	Inductance	$2x10^{-3}$

V. CONCLUSION AND FUTURE SCOPE

1. Conclusion of This Project:

This work describes Performance of Shunt active power filter with SRF controller. Using Synchronous Reference Frame Algorithm three phase reference current is generated, this is compared with the actual filter current and resultant signal is given to the HBCC, it provides control signal to three phase voltage source inverter. HBCC technique used for the switching pulse generation is found more effective and gives fast response. In this simulation it is found that the THD level is obtain below 0.231% as per the IEEE std for distribution system. In this paper THD obtained within the permissible limits of IEEE std for distribution system.

Synchronous Reference Frame control strategy has been executed and investigated for harmonic cancellation, to reduce the THD of source current, reactive power compensation, load balancing and power factor improvement. To achieve these objectives DC capacitor voltage of the inverter has been controlled through various Artificial Intelligence Techniques keeping fixed reactive power compensation.

2. Future Scope of the Thesis

The thesis presented here concern the development of the various techniques and their validation in different conditions for the enhancement of power quality using Active Filters. This research work can be extended to a multilevel inverter implemented for power conditioning. Three phase three wire system can be extended to three phase four wire system with different conditions like considering the zero sequence voltage present in the system. FPGA based controller for Active Filter can be developed to reduce the hardware requirement.

For sustainable growth in power system, recently Renewable and Non-Renewable Energy source are gaining lot of attention. Hence such energy sources feeding the nonlinear load can be investigated for further work in the field of power quality. Further enhancing the coordinated control of the proposed Distributed Active Filters incorporating the design of adaptive gains can also be implemented. Another attractive aspect that can be investigated is the finding the solutions of power quality issues by other emerging Evolutionary algorithm like Ant Colony Optimization and bacteria forging techniques. Thus, the quality of the power network can be expressively enhanced, and high reliability can be provided.

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