Journal of Critical Reviews

ISSN- 2394-5125 Vol 7, Issue 4, 2020

Review Article

MITIGATION OF VOLTAGE SAGS AND STABILITY ANALYSIS OF DISTRIBUTION SYSTEM BASED ON UPQC USING SUBSTANTIAL TRANSFORMATION INTRINSIC ALGORITHM (STIA)

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Received: 28.12.2019 ***Revised: 09.01.2020*** ***Accepted: 04.02.2020***

Abstract
The quality of power is important one of the distribution system, and it identify the voltage and current based distribution system power quality problem. The Voltage sag and swell is also to create power quality problem. In this power quality problem creates the frequency oscillation in the distribution system, so the output stability is affected. Because of this limitation, design of these improved model of controlling are properly required. The UPQC (Unified Power Quality Conditioner) is utilized to compensate the power quality problem and reduce the unbalanced voltage of this system. The proposed Substantial Transformation Intrinsic Algorithm (STIA) based UPQC is used to analysis the unbalanced voltage of this power distribution system. This proposed UPQC system is inject the real power to the transmission line, so the unbalanced voltage is compensate. Such that the injected voltage is controlled with help of series nd shunt active filter, and the angle of voltage injection is also controlled. The proposed STIA technique is used to give the proper pulse of this shunt and series converter to optimize the power quality problem with help of injecting the real power in this transmission line. The proposed Substantial Transformation Intrinsic Algorithm (STIA) method has run through the SIMULINK model, and this system attain the good performance, reduce the losses and increase the stability of power transmission line.

Keywords: Series Active Power Filter, Voltage Sags, Substantial Transformation Intrinsic Algorithm (STIA), Shunt Active Power Filter, UPQC (Unified Power Quality Conditioner)

DOI: http://dx.doi.org/10.31838/jcr.07.04.160

INTRODUCTION

The Unified Power Quality Conditioner (UPQC) is based on the converter circuit is used to minimize the power quality (PQ) issues. In this circuit is connected in series and parallel combinations by a common active filter using DC link. To alleviate the problem, active filters in series and parallel respectively PQ the terminal voltage and load current. With all power quality issues affecting the operation of critical loads, voltage sag is a critical issue in distribution systems. The ratio of the propagation from high voltage level dip, voltage sag phase jump as well. The different operations available in the literature to reduce unbalanced voltage, and minimum UPQC loads. In operation from active filter injected voltage with voltage source and relaxed phase current.

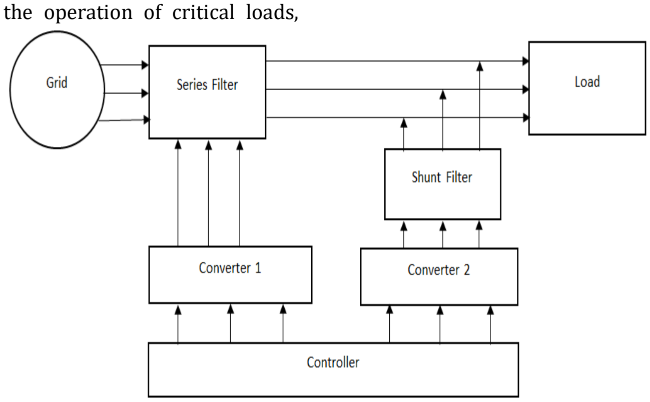

Figure 1: Basic block diagram of UPQC

In this operation, series and shunt active filter is used to inject the real power into the system, reducing the voltage sag. Therefore, the amount of power injection is more active. This problem can work with UPQC because voltage dips are quadrature injected to overcome current and voltage sources. Under some condition voltage dips, the voltage injection is not enough to reach the rated load voltage of series active filter. In this case, the minimum actual power reaches the rated load voltage SEAPF injection, and this working condition is called UPQC and minimum active power operation. These types of operation are reduced by the available injection voltage by active filter, in the negative sequence voltage must be injected active filter. Therefore, there is UPQC that may not be able to maintain the rated load voltage. It can be overcome by the proposed mitigation measures. To achieve this, the minimum voltage for the fundamental wave exit angle at the relaxation voltage terminal must be calculated and the same source in series with the injection. Typically, recesses are still a few cycles, and the reference voltage must be generated over time. This method has been confirmed by detailed simulations and experiments. Actual power is compared to injection UPQC, and minimum activity UPQC operation.

LITERATURE REVIEW

It is proposed that an online optimization method operate optimally to identify the reactive power for changes in load demand in the open UPQC (UPQC-O) point distribution network. The optimization method of the optimization method is to open the UPQC (UPQC-O) point, which is the distribution of the load requirements, and the setting is to determine the reactive power / personal VAR (optimum operation) [1]. It is a detailed description that is proposed, accompanied by sizing, stability analysis and multiple power supplies, including series flow, single-stage photovoltaic (PV) and parallel power converters, distributed generation (DG). Research system (UPQC) integrated with sensory, three-phase power quality uniformity control system [2]. With this work, the best VA rated UPQC converter in the survey, the system for compensation [3]. Its power quality is improved by using a UPQC. A power system that creates more complex network stations connected through transmission and distribution line load centers. To increase the performance of the new concept of supply system came in called a custom device [4].

It discussed and discussed the use of an analog control and distribution system UPQC as one of the FACTS device with three-phase nonlinear unbalanced mass balancing the increase in load power [5]. With this model correction means to reduce the voltage distortion UPQC. In fact, the device can improve power quality and has become a reliable power supply. It seriously affects power factor [6]. The model describes a biogeography-based optimization (BBO) of a modified harmonic cancellation technology UPQC connected SG. By properly selecting the angle and harmonic switching at the same time, the lower order harmonics have equal magnitude from the other converters by injecting the opposite phase in the same order as eliminating harmonic suppression [7]. The topology show can use a single line ground loop distribution system (EPDS) application for consumer only access, for local or remote locations, for economic reasons. As the consequences of loads are developed in these regions, access to the power distribution systems will benefit [8].

A model for UPQC (MLC-UPQC) based multi-level conversion that eliminates the need for conversion and DSP or FPGA. The proposed system, there by requiring a reduction of cost and complexity, using ANN controller [9]. It describes the deadline of UPFQ application explains the delivery of airships. The UPQC proposal to increase the provision is connected to an attenuated DC voltage without giving any paid capacity. Proposed term also requires a circuit configuration in series with the active shunt filter, voltage coordinate UPQC DC required [10]. The model shows a reduction in harmonics in the distribution network, based on harmonics of the input and load current. DC link voltage to reduce UPQC loss. A small capacitance is introduced in series with the shunt filter coupled inductor [11]. The 9-switch UPQC (NSUPQC) has been proposed, but semiconductor devices such as reference amplitude and phase shift are not limited, but add a certain limit of double nominal DC link voltage stress drawbacks. To overcome these problems [12].

Introduce a new control space vector modulation method to solve the problem Investigation work operation and single phase tripod UPQC (TL-UPQC) are linked by the general switching leg properties of introduction [13]. For research, analysis, and practical application of series-parallel power lines, we propose a Universal Unified Power Quality Regulation (UPQC) that can be connected to two power distribution systems [14]. Based on a unified power image adjustment is presented to increase the power quality. M3C-UPQCis has four identical arm multi-level converters and associated filter inductors [15]. The model is based on research and optimal size of the UPQC requirements of the compensation system. General UPQC optimization strategy, determine the parallel conversion system, evaluate the basic size of the series converter, and proposed a series transformer [16].

Screw UPQC harmonic unbalance ends the combination of two filters, a series and shunt active filter connected in the system [17]. The model UPQC performance series shares a common DC link capacitor for active filters (SAPF) and parallel combinations of parallel / active filters (PAPF). This control avoids using any transform to generate the reference voltage / current and thus avoids performing complex calculations to achieve [18]. Mathematical model coordinates, and placement model EL UPQC passive, and to improve UPQC, EL control based on passive mixing depending on controller design. The proposed method passively mixes the detection method and the base controller, so that the load and the sinusoidal power supply is stable [19]. A new model is proposed to reduce the UPQC switch topology in way to increase semiconductor utilization and thus decrease the total number of switches. The proposed topology is to use only ten switches to achieve and maintain, while minimizing the lack of use of all performance benefits of the switch UPQC VA rating, which does not increase the switches [20]. The UPQC design method refers to the UPQC (UPQC-SPAC) phase angle control algorithm for concave design. The voltage shift load is reduced as the voltage sag is determined to a predetermined value and required to give the compensation of using reactive power to distribution network during health operation [21].

MATERIALS AND METHODS

In principle, the combined active power filters is series and shunt to the UPQC with connected common DC link. The UPQC shunt inverter is worked in current control mode, so that a unique Substantial Transformation Intrinsic Algorithm (STIA) is used to provide current equal to the control as it is determined by the set reference current value UPQC. In addition, by maintaining the shunt converter, it work as a most important role in the bus voltage to achieve the desired characteristics in the system from the UPQC setting reference value. Inverter shunt current is injected to cancel harmonics caused by non-linear loads.

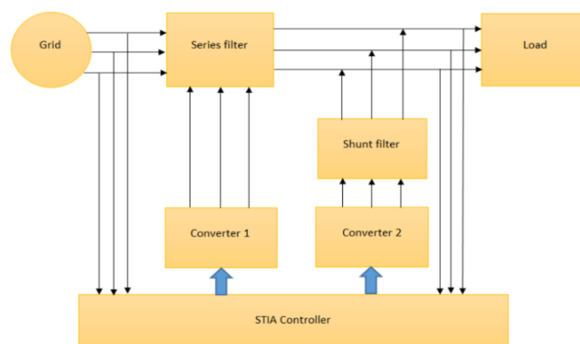

Figure 2: Proposed system block diagram

The current problem is mostly reduce with help of the shunt active power filter and voltage related problem is minimize with help of the series active power filter. The APF installations have a wide range of practical implementations, because of the requirements of modern circulating system power supply voltage and better quality current consumption. However, the connection of two separate devices to compensate for the voltage and current associated with power quality issues is not to be an independent and effective solution.

Modelling and consideration of the UPQC system

The three-phase UPQC and the schematic diagram show in Figure 3. Mainly the series transformer is used as a shunt converter to equalizing the harmonics current and voltage stabilization also maintain sinusoidal output. Both of this converter is used for compensator can control the DC voltage regardless of the value of the network voltage, since it is directly connected to the series transformer, and shunt inductor with the harmonics, swells, sags and imbalances of the output voltage must be filtered. In this case, the UPQC model can be segmented into two independent models, each with compensation.

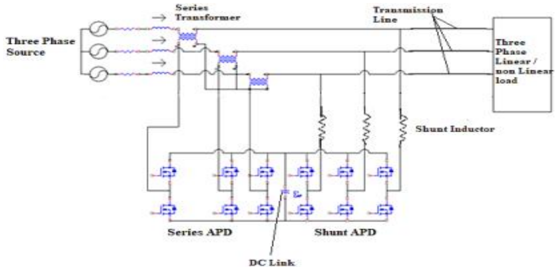

Figure 3: Schematic diagram for three phase UPQC system

Control Strategies of UPQC

The proposed UPQC control technique is used to generate the pulse to converter for the two branches of the UPQC and the APF in series. The efficiency of UPQC compensation is based on the calculation of this pulse generator with a low losses to compensate for distortion, the sag voltage or undesirable state. In the old model is reported in the results for the distorted and / or asymmetrical input / common voltage differences, and they involve a lot of analysis. The STIA control having a simple diagram making it possible to obtain effective compensation of the source current harmonics, compensation and deformation of the reactive power and / or of the unbalanced input / sector voltages under suppression of the voltage harmonics.

Series Active Filter

The theoretical analysis based on d-q of the VSC series are represented in figure 4, the voltage at the charging terminals (VTS) and the voltage at the PCC (VL). The pulsed gate signals are extracted to generate a series of VSCs. The basic theory of Park $\boldsymbol{abc}$ can be used for the $\boldsymbol{dq}$ conversion method to convert three-phase load voltages (VLA, VLB, VLC) into two-phase rotation reference coordinate systems, which can be evaluated,

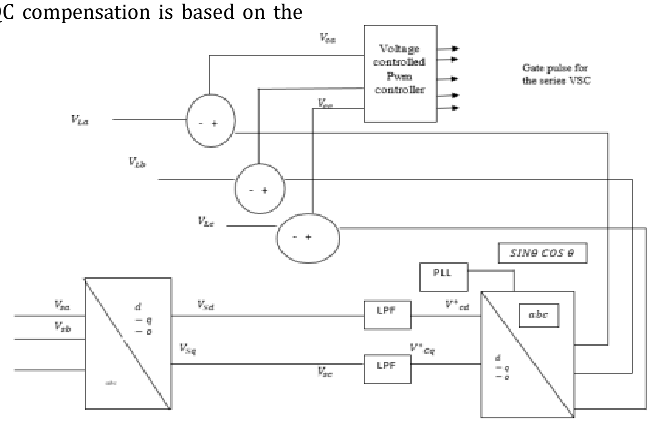

Figure 4: Control block diagram for the series converter

$$\begin{vmatrix} V_{Ld} \\ V_{Lq} \\ V_{Lo} \end{vmatrix} = \frac{2}{3}\begin{vmatrix} \cos\theta & \sin\theta & \frac{1}{2} \\ \cos(\theta-\frac{2\pi}{3}) & \sin(\theta-\frac{2\pi}{3}) & \frac{1}{2} \\ \cos(\theta+\frac{2\pi}{3}) & \sin(\theta-\frac{2\pi}{3}) & \frac{1}{2} \end{vmatrix}\begin{vmatrix} V_{La} \\ V_{Lb} \\ V_{Lc} \end{vmatrix} \quad (1)$$

Pulsed or oscillating components of voltage and unwanted harmonics are eliminated using a filter called Low pass filter. The q axis of d axis component are V_{Ld} and V_{Lq}.The LPF output on the three-phase voltage can be evaluated as,

$$V_{dc} = V_{Ld} \quad (2)$$
$$V_{qc} = V_{Lq} \quad (3)$$

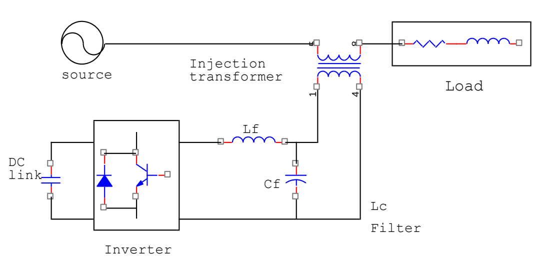

Figure 5: Series Converter Circuit diagram

Where V_{dc} and V_{qc} are the DC reference voltage of the reference frame dqo. The generated reference voltage (VL *) is evaluated using a derived unit vector. A proposed STIA is used to plot a unit vector ($\sin\theta, \cos\theta$) at the normal frequency. The voltage of the reference signal is now compared to the pulse signal generated by the actual charge voltage detected.

Shunt Active Filter

The control strategy of APF. The DC bus voltage, which reduces the reason for compensating the active filter in series with the UPQC power circuit, reduces the active from the active part of the power system is absorbed by the shunt APF active power injected into the power system active power loss. For this purpose, the DC voltage is compared to that reference value and the desired active current reference is taken by the synchronization module. The parallel APF, control strategy used in this study is to use a synchronous reference frame.

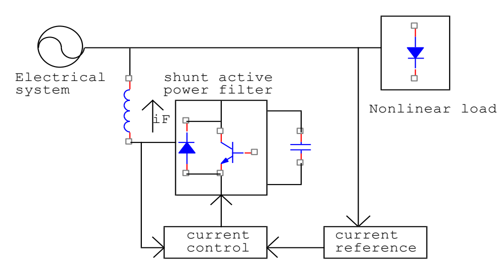

Figure 6: Shunt Active filter

The principle of technology is described below,

$$\begin{bmatrix} i_a \\ i_b \end{bmatrix} - \sqrt{2/3}\begin{bmatrix} 1 & -\frac{1}{2} & \frac{1}{2} \\ 0 & \frac{\sqrt{3}}{2} & -\frac{\sqrt{3}}{2} \end{bmatrix}\begin{bmatrix} i_{L_a} \\ i_{L_b} \\ i_{L_c} \end{bmatrix} \quad (4)$$

The (d-q) reference frame and i_a and i_b currents expression are given by:

$$\begin{bmatrix} i_d \\ i_q \end{bmatrix} - \begin{bmatrix} sin(\theta_{est}) & -cos\,(\theta_{est}) \\ cos\,\theta est & sin\,\theta est \end{bmatrix} \begin{bmatrix} i_\alpha \\ i_\beta \end{bmatrix} \quad (5)$$

The harmonic components and i_d current is transformed to DC and using a LPF:

$$\begin{bmatrix} i_\alpha \\ i_B \end{bmatrix} - [\frac{\overline{id}+\overline{id}}{i_q}] \quad (6)$$

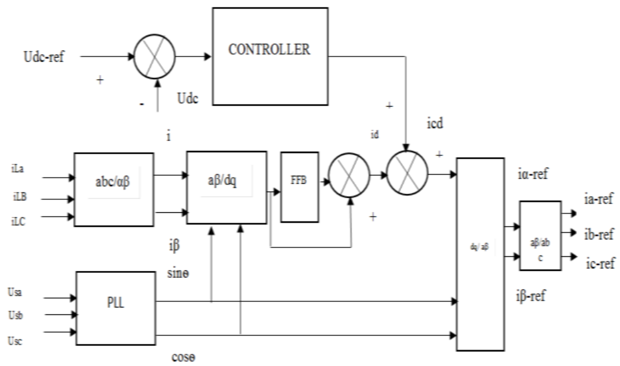

Figure 7: Control block diagram for Shunt controller

The reference current $\mathbf{i_a}$-ref and $\mathbf{i_\beta}$-ref are given by:

$$\begin{bmatrix} i_\alpha & -ref \\ i_\beta & -ref \end{bmatrix} - \begin{bmatrix} sin(\theta_{est}) & -cos\,(\theta_{est}) \\ cos\,\theta est & sin\,\theta est \end{bmatrix} - 1 \begin{bmatrix} i_d \\ i_q \end{bmatrix} \quad (7)$$

$$\begin{bmatrix} i_\alpha & -ref \\ i_\beta & -ref \end{bmatrix} - \begin{bmatrix} sin(\theta_{est}) & -cos\,(\theta_{est}) \\ -cos\,\theta est & sin\,\theta est \end{bmatrix} - [\frac{\overline{id}+\overline{id}}{i_q}] \quad (8)$$

The currents reference in the (abc) frame are given by:

$$\begin{bmatrix} i_a & -ref \\ i_\beta & -ref \\ i_c & -ref \end{bmatrix} - \sqrt{2/3} \begin{bmatrix} 1 & -\frac{1}{2} & \frac{1}{2} \\ 0 & \frac{\sqrt{3}}{2} & -\frac{\sqrt{3}}{2} \end{bmatrix} \begin{bmatrix} i_\alpha & -ref \\ i_\beta & -ref \end{bmatrix} \quad (9)$$

Finally, the current compensation $\boldsymbol{icomp - a, icomp - b}$ **and** $\boldsymbol{icomp - c}$ are given by

$$\begin{bmatrix} i_{comp} & -a \\ i_{comp} & -b \\ i_{comp} & -c \end{bmatrix} - \begin{bmatrix} i_a & -ref \\ i_\beta & -ref \\ i_c & -ref \end{bmatrix} \begin{bmatrix} i_{L_a} \\ i_{L_b} \\ i_{L_c} \end{bmatrix} \quad (10)$$

Principle of control method of active power filter like shunt filter based on synchronous reference current to identified this method is given by Figure 7.

Substantial Transformation Intrinsic Algorithm

The problem of the system is solved with help of UPQC to provide voltage and reactive power compensation is dealt using method. The Substantial Transformation Intrinsic Algorithm objective function considered is minimization of power losses in the distribution network subjected to network operational constrictions. Mathematically the problem can be formulated as given in equation,

Minimization of,

Step 1: Read the input data for line and bus voltage to the system.

Step 2: Set the input volt at all nodes to 1p.u. Assume epsilon (ϵ) as the convergence criteria and maximum iterations (max_iter).

Step 3: Here, $\boldsymbol{PT_{Loss}}$ is the whole loss of real power that occurs in the network, $\boldsymbol{P_{Loss}}$, j is the j-th real power loss in the branch, and number of branches in the network is nb.

The network operational limitations are given as:

$$\boldsymbol{P_{Tloss}} = \sum_{j=1}^{nb} \boldsymbol{P_{loss} \cdot j} \quad (11)$$

$$\boldsymbol{P_{loss} \cdot J} = ((\boldsymbol{I_{branch} \cdot I})^2 . \boldsymbol{R_{branch} \cdot I}) \quad (12)$$

Step 4: Voltage at each node in the network must be within the prescribed limits.

Vmin ≤ Vi ≤ Vmax (13)

Step 5: The reactive power provided by UPQC at any node must not reach the total demand of reactive power on the network.

0 ≤ QUPQC ≤ QD (14)

Step 6: The voltage at the optimal location is maintained at substation voltage.

Step 7: Set the iteration count (t) to one. Perform backward sweep to find the branch currents.

$$Si = Pi + jQi$$

$$,= \left(\frac{Si}{vi}\right) = \left(\frac{pi+jQii}{Vi}\right) \quad (15)$$

$$Ibranc\ h,j = ILoad\ ,i + ILoad\ ,beyond\ node\ i$$

Step 8: Perform transmission voltages.

$$VL = VS - (Ibranc\ h,j \times Zbranc\ h,j\ )$$

Here VL=VS is the receiving end voltage of jth branch and VS is the sending end voltage of jth branch.

Step 9: Check for the convergence criteria

$$\Delta(t) = |abs\ (Vi)t - abs\ Vi\ t{-}1$$

Here t is the iteration number.

If $\Delta(t)$ >ϵ or iteration count< max

Increase the iteration count and repeat the steps from 3 to 5 else go to step 6.

Step 10: Evaluate the power loss as given in equation (1)

Step 11: Stop process

Flowchart

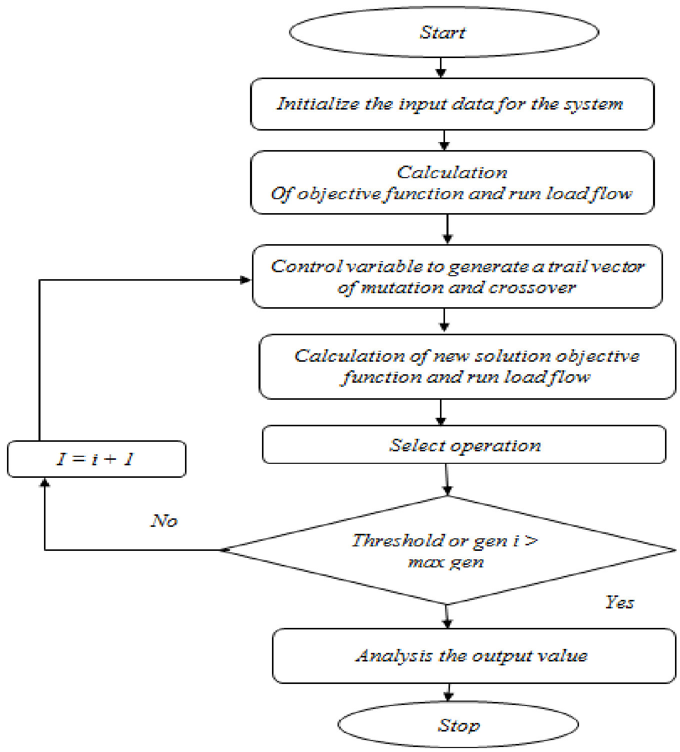

Figure 8: Proposed STIA flowchart

From **figure 8** shows the proposed optimizing procedures for the STIA based UPQC provide better performance and stable output power.

RESULTS AND DISCUSSION

The proposed Substantial Transformation Intrinsic Algorithm (STIA) based UPQC was developed by using 2018 Simulink software, and it shown in **figure 9.** In this proposed system a Substantial Transformation Intrinsic Algorithm technique is used to balance the power and maintain the balanced voltage of output. The experimental results of the improved algorithm are compared with the methods. MATLAB 2018a is the most common manipulation and operating software. According to the specific operation and innovative condition for implementing the algorithm for progression belongs to the respective methods to view and analyze simulation result in image processing.

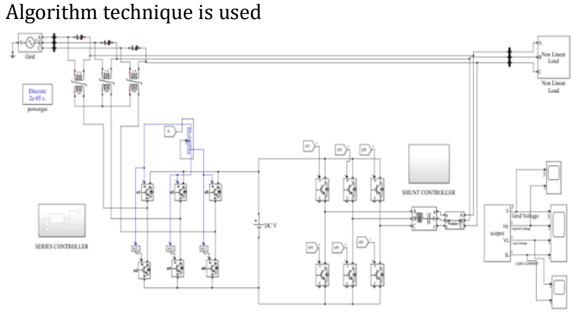

Figure 9: Proposed STIA Simulink system

The above **diagram** gives the simulation model of the proposed Substantial Transformation Intrinsic Algorithm (STIA) based Unified power flow conditioner

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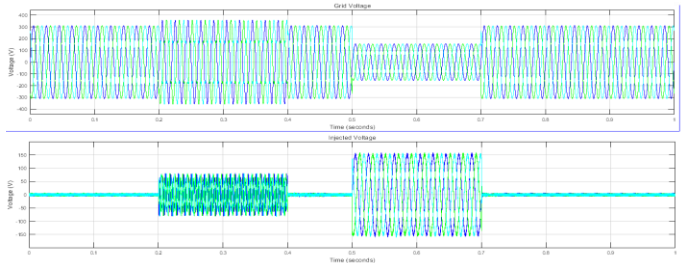

Figure 10: Source Voltage and injected voltage for proposed UPQC model

The system Source voltage is shown in figure 10, and the system Injected voltage, which will improve the sag voltage which is present in the source side waveform.

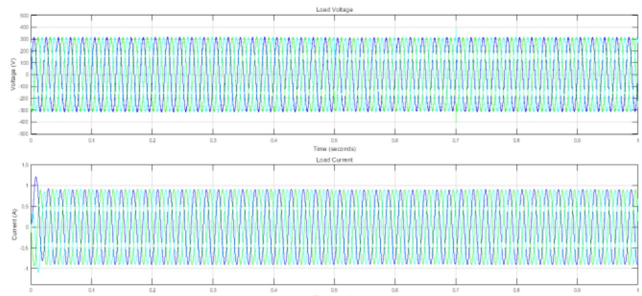

Figure 11: Load voltage and Load Current for proposed UPQC model

Figure 11 shows the stability grid current condition is analyzed to confirm the performance of the UPQC under the proposed Substantial Transformation Intrinsic Algorithm (STIA) based UPQC, and the harmonics are low in this system

Figure 12: THD Analysis of Voltage waveform

The Voltage waveform THD analysis is shown in figure 12 using the proposed Substantial Transformation Intrinsic Algorithm (STIA), and it's given the THD of 0.2%.

Table 1: Performance analysis for UPQC Features of proposed and existing system

Parameters	PI	PID	STIA
Steady state error (%)	1.3	0.8	0.4
Switching loss (%)	0.833	0.91	0.81
With UPQC THD (%)	10.3	7.5	0.2

Table: 1gives the comparative analysis of conventional method and proposed system which are considered for the operating features of the proposed a system.

Switching loss

$$P = P_{on-H} + P_{on-L} + P_D + P_G + P_{ic} \quad (16)$$

Where,

P_{on-H} is conduction loss in high side

P_{on-L} is conduction loss in low side

P_D is dead time loss

P_G is gate charge loss

P_{ic} is operating loss.

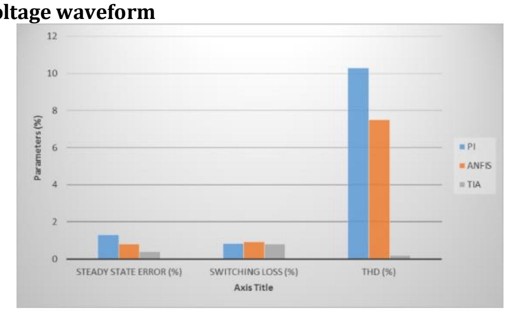

Figure 13: performance analysis of the UPQC system

Figure 13 analysis the performance of conventional method and proposed Substantial Transformation Intrinsic Algorithm (STIA) produce an effective result.

CONCLUSION

One of the new trends in distributed generation systems. These units are integrated to form a distributed generation micro grid local service, a load connected to and from a switching power supply to the load. This work present design and use of new technology Substantial Transformation Intrinsic Algorithm algorithm-specific Unified Power Quality Conditioner (UPQC) customized power quality analysis, improve the performance of electrical equipment, bus system grid connection. Source system using a voltage source converter (VSC) to perform various functions. In addition, before the feed-forward loop, use C to reduce the burden and improve the dynamic response of the PI controller by adjusting the DC bus voltage. This is for switching control of the VSC timing in order to accurately extract a substantially orthogonal control current from the contaminated load current. The UPQC formula is confirmed by experimental results under different operating conditions of the grid system. UPQC programs were run under different operating conditions to confirm the results of the simulation test. The results show its good behavior under dynamic conditions and steady-state condition, such as load imbalance, sunshine change, and voltage sag. Intrinsic UPQC substantial changes, including the proposed algorithm Substantial Transformation Intrinsic Algorithm (STIA) THD is 0.2% of load current and voltage, with equally effective results.

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