Design of Unified Power Quality Conditioner and EMI Filter for Wind Power Systems Subject to Unbalanced and Harmonic Distorted Grid

Er.V. Manjula and V. Baby

Abstract--- In the grid, uneven voltage and harmonics distortion are in most of the power quality issues in wind energy transformation system (WECS). To reduce the effect enrolled its various and THD distortion. The resonant current controller can individually realize the fundamental and harmonic current controllers and combined to form voltage command for a unified power quality conditioner (UPQC) based on superposition theorem. Not only the computing time but also the harmonic currents in the feeder can be effectively reduced along with the proposed approach. The analysis of compensation characteristics of different HPF (Hybrid Power Filters) configurations is carried out. The design of the control method is based on both the schemes of the hybrid filter, different control strategy and power circuit design are considered. The fundamental current and distribution system harmonic currents are independently controlled by a current detecting scheme. The elimination of harmonic current is performed by using hybrid power filters.

Keywords--- Wind Turbine, Unified Power Quality Conditioner (UPQC), EMI Filter.

I. INTRODUCTION

Unified power quality conditioners (UPQCs) consist of combined series and shunt active power filters (APFs) for simultaneous compensation of voltage and current disturbances and reactive power. They apply to power distribution systems, being connected at the point of universal coupling (PCC) of loads that generate harmonic currents. Diverse topologies have been proposed in the literature for UPQCs in single-phase configurations, i.e., two IGBT half bridges or multilevel topologies, but this paper focus on the commonly employed general structure depicted in figure 1. As can be seen, the power converters share a dc-transport and, contingent upon their functionalities; utilize a detachment transformer (arrangement APF) or an inductance (shunt APF) as voltage or current connections. The arrangement APF must remunerate the source voltage unsettling influences, for harmonics, dips or over-voltages, which may crumble the activity of the neighborhood stack while the shunt APF constricts the unwanted load current parts (symphonious streams and the principal recurrence segment which adds to the receptive load control). Additionally, the shunt APF must control the dc-transport voltage to guarantee the remuneration ability of the UPQC. Functionalities are carried out by applying diverse control strategies which can operate in the time domain, in the frequency domain or both. Time domain methods, such as PQ or dq based methods, allow the fast compensation of time-variant disturbances but make more complex their selective compensation. In this sense, frequency domain methods are more flexible, but their dynamical response is slower. This paper proposes a new control technique for UPQCs based on a filtering approach. The proposed method operates both in the time and frequency domains allowing the selective compensation of voltage and current harmonics with fast

Er.V. Manjula., M.E., Ph.D., Associate Professor, Department of Electrical and Electronics Engineering, Vinayaka Mission's Kirupananda Variyar Engineering College, Vinayaka Mission's Research Foundation (Deemed To Be University), Salem, Tamilnadu, India. E-mail: manjbees@yahoo.co.in
V. Baby, M.E(Power System Engineering), PG Scholar, Department of Electrical and Electronics Engineering, Vinayaka Mission's Kirupananda Variyar Engineering College, Vinayaka Mission's Research Foundation (Deemed To Be University), Salem, Tamilnadu, India. E-mail: babytneb@gmail.com

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dynamical responses. Moreover, the impact of dips and over-voltages can be attenuated by applying the proposed controller. Wind energy is one of the most available and utilizable forms of renewable energy. Among the different renewable energy sources, wind energy has emerged as the possible source of electrical power and is economically spirited with the conventional sources. Since then there has been an increasing attempt to build wind-driven generators for use in isolated communities with minor resources in the type of water power or coal power, and at places which cannot be efficiently connected to public supply networks. Another motive for the worldwide concern in developing wind power plants is the rapidly increasing demand for electrical energy and the resultant depletion of fossil fuels, namely, coal and oil, whose reserves are limited.

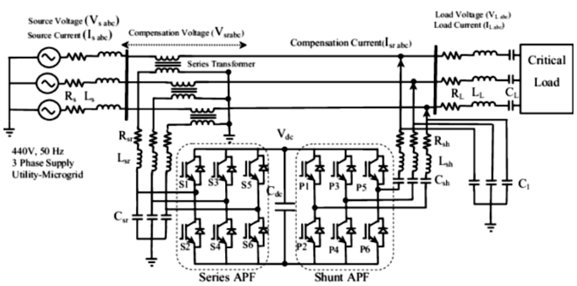

Figure 1: Wind Power based UPQC Model

The growth of wind energy for electrical power generation got to improve when, in the early decades of the twentieth century, aviation equipment resulted in an enhanced accepting of the forces acting on blades moving through the air. This resulted in the development of turbines with two or three edges. The grouping of wind energy power system presents, and that requires indication of voltage stability, regulation, power quality problems.

II. LITERATURE REVIEW

For working out all power quality associated problems, Unified Power Quality Conditioner (UPQC) is one of the most well-known devices that are used. To pay damages the unbalance of both source voltages and load currents, it formulates apply of series and shunts active power filters. Concurrently, the UPQC is one of the primary custom power devices (CPD), which can work out both the current and voltage related problems. The series APF counteracts the voltage-based distortions, whereas the shunt APF eradicates the current-based alterations. For harmonic obliteration and simultaneous compensation of voltage and current, UPQC is frequently used and accordingly, it improves the power quality offered for other harmonic sensitive loads such as Wind Energy Conversion System based Squirrel-Cage Induction Generators (WECS-SCIG). In recent years, dramatically increasing the penetration of wind farms in the electrical power system, caused the importance behavior of wind turbines under grid faults and low voltage conditions or other disturbances. Faults or low voltage in the grid cause voltage sag at the point of universal coupling (PCC). Voltage sag and other voltage disturbances will decrease the electrical torque of (SCIG); consequently, the active power of WECS-SCIG will be reduced. Whereas, the mismatch between mechanical and electrical power make increasing the speed of the rotor of SCIG. By increasing of rotor speed, the wind farm absorbs more reactive energy that can cause more depression in voltage magnitude. After clearing the fault, if the rotor speed does not change over its critical speed, SCIG can get the equilibrium point. Otherwise, if the wind generators are unable to withstand against faults, it must be disconnected from the grid, and it may cause a cascading voltage collapse and the breakdown of the rest of wind farm generators. To overcome these mentioned drawbacks, it is necessary to mitigation voltage sag with a fast dynamic response technique. Some literature studied methods of control of UPQC. The UPQC that executes quadrature sort of voltage injection in the sequence is named as UPQC-Q. To locate and classify the different types of Power Quality (PQ) events or disturbances, a lot of PQ associated algorithms have been improved at present. The researchers for PQ study have operated a broad range of techniques. To improve the PQ, non-natural neural networks and fuzzy logic is mostly used also. A UPQC, where the DC link capacitor discharging time has been diminished by installing a bias voltage generator has been proposed in the reference. The input of the bias voltage generator has been produced through. The Power Quality of the system has been enhanced ultimately. Usually, regulating the voltage between the two dynamic converters is the purpose of the dc link capacitor. Current control structures for selective harmonic compensation in active power filters. All controllers under scrutiny perform the harmonic compensation by using arrays of resonant controllers, one for the fundamental and one for each harmonic of interest, to achieve zero phase shift and unity gain in the closed-loop transfer function for selected harmonics. The complete current controller is the superposition of all individual harmonic controllers and may be implemented in various reference frames. The analysis is focused on the comparison of harmonic and total closed-loop transfer functions for each controller. It emerges that the fourth one has superior behavior and robustness and can stably work at higher frequencies than the others. However, the voltage regulating the time of the capacitor is too elevated due to longer discharging time. In the text, for regulating the dc link voltage, many soft computing methods such as fuzzy logic, neural network, ANFIS, neuro-fuzzy, etc., are offered. The genetic algorithm (GA) plays an imperative role in optimizing the output of neural network and fuzzy logic in the dc link voltage rule process. The conventional GA can never guarantee stable optimization response times. Based on the possibilities in ratio to fitness values the genetic operators are changed in traditional GA. Especially, the dissimilarity between the shortest and the longest optimization response time is a lot larger than with conventional gradient techniques. The adaptive GA offered top results attained when compared to convention GA. Other than, the computational difficulty of adaptive GA is elevated than classical GA, as it takes more time to touch the solution. In this document, the cuckoo search algorithm (CSA) based NFC will be suggested for developing the performance of UPQC to solve these problems.

III. Proposed Architecture

This project presents a combination of the unified power quality conditioner (UPQC) and EMI for refining the SCIG terminal power quality. The positive sequence component at grid frequency is first extracted from the distorted SCIG terminal voltage for voltage-sourced inverter (VSI) synchronization. The unbalanced elements can also be found by subtracting the positive sequence component from the distorted voltage. Once the positive and negative sequence components are determined, the defect of unbalance in voltage, as well as the positive sequence component, can both be compensated by the unified power quality conditioner (UPQC). The SCIG stator from specific harmonic currents distortion, an EMI control design that focuses on the low-order harmonic currents was presented. The SCIG torque pulsation incurred by the deformations such as the harmonic current and unbalanced voltage can then be alleviated with the compensation of the unified power quality conditioner (UPQC) and the EMI.

Block Diagram

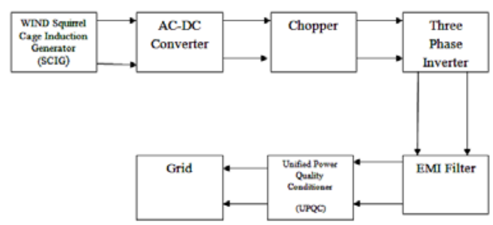

Figure 2: Proposed Architecture

Block Diagram Description

- Three phase inverters are used for variable-frequency drive applications and high power applications such as HVDC power transmission.
- An EMI filter, or an electromagnetic interference filter, is a passive electronic device which is used to suppress conducted interference that is present on a signal or power line. EMI filters can be used to suppress interference that is generated by the device or by other equipment to make a device

more immune to electromagnetic interference signals present in the environment.

- Unified power quality conditioner (UPQC), which aims at the integration of series-active and shunt-line conditioner. The main purpose of a UPQC is to compensate for voltage imbalance, reactive power, negative-sequence current, and harmonics.

Block Diagram Description

(i) WIND Squirrel Cage Induction Generator (SCIG)

That describes each part of our windmill. This windmill is a variable speed turbine with squirrel cage induction generator with vector control. The windmill could be divided as follows: Also, the power rating of the converters is reduced compared to the generator and load power rating due to the low power requirements of the power converters to SCIG excitation control and to supply the load. It is also presented the whole proposed WECS and the system operating modes according to the turbine speed. It is also presented the proposed system as a whole and the system operating modes according to the turbine speed. The simulation of the proposed WECS has performed in conjunction with the dynamic wind turbine model of 1 kW, and the results confirm the effectiveness to supply unbalanced and non-linear loads, the converters power rating reduction and operation with variable turbine speed.

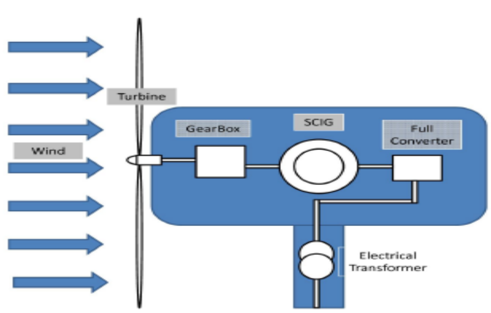

Figure 3: SCIG with Full Power Converter Applied to Windmills

Asynchronous Induction generators are widely used in windmills due to the several advantages, such as robustness, mechanical simplicity, and low price. Induction machines operate in the generating and motoring modes fundamentally in the same manner except for the reverse power flow. Therefore, the equivalent circuit and the associated performance are valid for the different slip. If the rotor is driven by a prime mover above the synchronous speed, the mechanical power of the prime mover is converted into electrical power to the utility grid via stator winding. SCIG feed only through the stator and generally operate at low negative slip, approximately one or two percent.

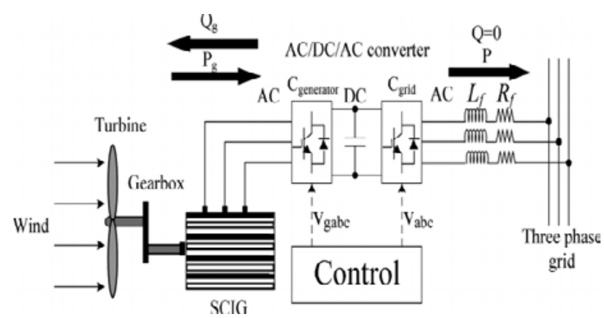

Figure 4: Wind Power Generation System AC/DC/AC Converter

The slip, and hence the rotor speed of a SCIG varies with the amount of power generated. The generator will always draw the reactive force from the grid. Reactive power consumption is partly or fully compensated by capacitors to achieve a power factor close to unity and make the induction machine to self-excite. The speed varies over a very small range above synchronous speed as it is coupled with the grid, hence commonly known as a fixed-speed generator. When an external mechanical power source drives such an induction machine, the residual magnetism in the rotor produces an Electromotive Force (EMF) in the stator windings. This EMF is applied to the capacitor bank causing current flow in the stator winding and establishing a magnetizing flux in the machine. An induction generator connected and excited in this manner is capable of acting as a standalone generator supplying real and reactive power to a load.

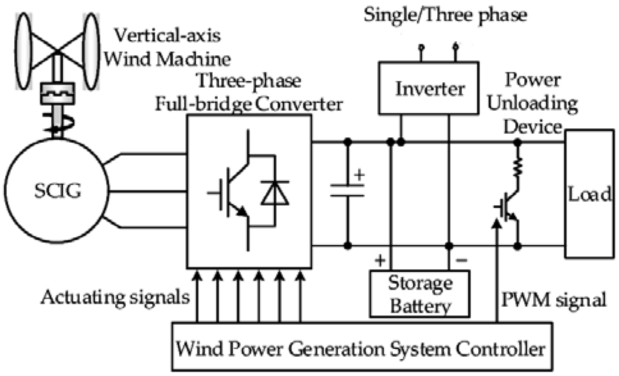

Figure 5: Wind Power Generation System Controller

As the direct connection of a SCIG to the grid would draw high inrush current, this accelerates to its synchronous speed using wind power and then is connected to the network. Therefore wind turbines with SCIG are typically equipped with a soft starter and an installation for reactive power compensation because this high in-rush current can cause severe voltage disturbances in a weak grid. SCIG have a steep torque-speed characteristic, and therefore fluctuations in wind power are transmitted directly to the network.

AC-DC Converter

With robust, advanced high-voltage converters, power factor correctors, a variety of controllers and supervisors/ housekeeping ICs, together with innovative architectures and extended temperature ranges, integrated solutions and met all switching-mode power supply design needs. New generation AC-DC converters reduce power consumption and increase efficiency, essential for powering the majority of mains equipment. Electric power is transported on wires either as a direct current (DC) streaming in one course at a non-swaying steady voltage or as an exchanging current (AC) streaming in reverse and advances because of a variable voltage. AC is the overwhelming strategy for transporting power since it offers a few points of interest over DC, including lower dissemination expenses and basic method for changing over between voltage levels on account of the innovation of the transformer. AC power that is sent at high voltage over long separations and after that changed over down to a lower voltage is a more effective and more secure wellspring of vitality in homes.

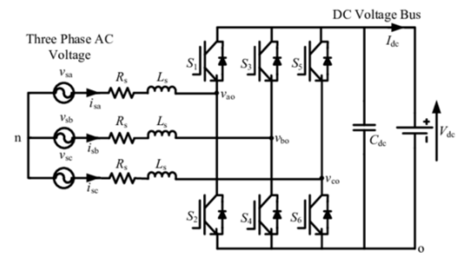

Figure 6: AC-DC Converter

Converters steer an alternating current, as its voltage additionally exchanges, into receptive impedance components, for example, inductors (L) and capacitors (C), where it is put away and incorporated. This procedure isolates the power related with the positive and negative possibilities. Channels are utilized to smooth out the vitality spared, bringing about the making of a DC input for different circuits. This circuit can take numerous structures however dependably contains similar fundamental components, and may have at least one phases of change. The converter portrayed is known as a 'forward converter'', which is higher productivity than somewhat more straightforward engineering; a 'flyback converter.' Although not discussed in detail, a flyback converter differs from a forward converter in that its operation depends upon energy stored in the air gap of the transformer in the circuit. Apart from this difference, they can utilize the same essential blocks.

Transformer

A transformer is comprised of wires wound on a common core that couple into each other by electromagnetic induction. This is imperative when associating with high voltage (mains) sources – alluded to as 'disconnected' transformation as the inductive coupling disengages the mains from the sequential circuit, a substantially more secure situation than the direct association. This coupling by an electromagnetic field, as opposed to an immediate copper circuit, called 'galvanic disengagement' limits the most extreme vitality that can cause electric stun or unsafe starting release to the put-away vitality in the transformers attractive field transition lines. The capacity (identified with size and materials) of the transformer to store vitality is an important thought in converter plan as it manages how well the transformer can give the vitality to keep up the coveted voltage potential under changing burden conditions.

(i)Regulation

We require a consistent voltage exhibited to a heap circuit, independent of the dynamic impedance of the heap. Externally this, over or under voltage conditions may happen, prompting misleading circuit conduct or even circuit damage. This is particularly true with low voltage digital electronics where supply voltages must be tightly constrained within a window of a few percents of a nominal value. Reactive elements do not have any in-built control of this. The way an AC/DC converter achieves a tightly controlled window of an output voltage is by conditionally controlling the energy stored in the low impedance reactive store source.

(ii)Voltage Control Mode

The regulation circuit senses output voltage compares it to a reference voltage to create an error function. The error signal modifies the switching ratio to bring the output closer to the desired level. This is the simplest method of control.

(iii)Voltage Control Mode

Both output voltage and inductor current sensed, and the combination used to control the duty cycle. This inner ‘current sensing loop' enables faster response time to load change but is more complex than voltage control mode. Further complicating the regulation element, over and above the method of control, the way a converter acts as a commutation cycle is called a continuous or discontinuous mode of operation. An endless mode of operation is one where the inductor current never falls to zero (if the converter topology has one). This is a lower output ripple and therefore lower noise mode of operation, but as the inductor is always conducting, it is continuously dissipating some energy in its non-ideal series conduction losses. In discontinuous mode, the inductor current is allowed to go to zero, causing the load to obtain power from the storage capacitors. This is a higher efficiency mode of operation but does potentially have more ripple and poorer regulation control.

Chopper

A chopper is a static device which is utilized to get a variable dc voltage from a steady dc voltage source. A converter is also known as the dc-to-dc converter. The thyristor converter offers greater efficiency, faster response, lower maintenance, smaller size and smooth control. Choppers are broadly utilized as a part of trolley cars; battery worked vehicles, footing engine control, control of many engines, and so forth. They are additionally utilized as a part of regenerative braking of dc engines to return vitality to supply and even as dc voltage controllers.

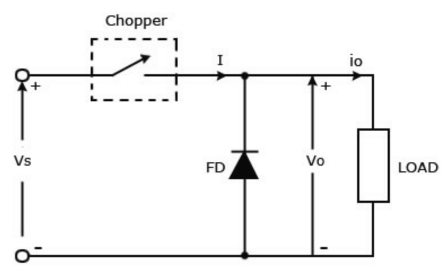

Figure 7: Choppers

Choppers are of Two Types

- Step-down choppers Step-up choppers
- step-down choppers
- The output voltage will be not as much as the information voltage while in step-up choppers yield voltage will be more than the input voltage.

Inverter

The inverter is characterized as an Electrical device which changes over the Direct current source into the Alternating current source. The fundamental wellspring of electrical power is the battery which is a DC source. The DC yield of the battery is kicked or helped by the prerequisite and afterward changed over into AC utilizing a DC-AC inverter. An inverter can change a dc input voltage to asymmetric ac output voltage of the coveted extent and recurrence. The yield voltage waveforms of perfect inverters ought to be sinusoidal. Be that as it may, the waveforms of down to earth inverters are non-sinusoidal and contain certain music. The contribution of the inverter is a settled DC voltage which is ostensibly gotten from the batteries, and the yield of the inverter is, for the most part, a settled or a variable recurrence Alternating voltage, the AC voltage size is likewise factor.

Three Phase Voltage Source Inverter

A three-phase inverter converts a DC input into a three-phase AC output. Its three arms are normally delayed by an angle of 120° to generate a three-phase AC supply. The inverter switches each have a proportion of half and exchanging happens after each T/6 of the time T (60° edge interim). The switches S1 and S4, the switches S2 and S5 and switches S3 and S6 supplement each other. In the accompanying three-stage inverter circuit process the three single-stage inverters put over a similar DC source. The post voltages in a threeø stage inverter are equivalent to the shaft voltages in the single stage half scaffold inverter. Three phase inverters can be operated into two different types of modes of conduction, i.e., 120-degree conduction mode and 180-degree conduction mode.

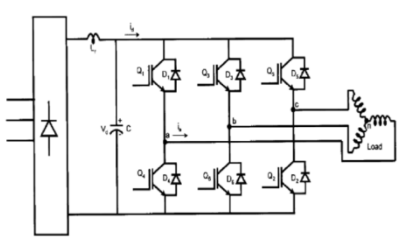

Figure 8: Three Phase Voltage Source Inverter

Electro Magnetic Interference Filter (EMI)

An EMI filter, or an electromagnetic interference filter, is a passive electronic device which is used to suppress conducted interference that is present on a signal or power line. EMI filters can be used to suppress interference that is generated by the device or by other equipment to make a device more immune to electromagnetic interference signals present in the environment.

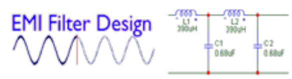

Figure 9: EMI Filter Design

Most EMI filters consist of components that suppress differential and common mode interference.

Electromagnetic interference (EMI), also called radio-frequency interference (RFI) when in the radio frequency spectrum, is a disturbance generated by an external source that affects an electrical circuit by electromagnetic induction, electrostatic coupling, or conduction. The disturbance may degrade the performance of the circuit or even stop it from functioning. In the case of a data path, these effects can range from an increase in error rate to a total loss of the data. Both human-made and normal sources produce changing electrical streams and voltages that can cause EMI: vehicle start frameworks, cell phones, tempests, the Sun, and the Northern Lights. EMI as often as possible influences AM radios. It can likewise influence cell phones, FM radios, and TVs, and also perceptions of radio space science. EMI can be utilized deliberately for radio sticking, as in electronic fighting.

Unified Power Quality Conditioner (UPQC)

The Unified Power Quality Conditioner is a tradition power device that is engaged in the distribution system to diminish the disturbances that affect the performance of sensitive and critical load. It is a type of hybrid APF and is the only versatile device which can mitigate several power quality problems related with voltage and current simultaneously, therefore, is multi-functioning devices that compensate various voltage disturbances of the power supply, to correct voltage fluctuations and to prevent harmonic load current from entering the power system. UPQC has shunt & series compensation capabilities for harmonics, reactive power, voltage disturbances, and power flow control. Normally a UPQC consists of two voltage source converters with a common DC link designed in a single phase, three phase three wire, or three phase four wire configurations. One converter is connected in series through a transformer between the source & the critical load at the PCC and operates as a voltage source inverter (VSI). The other converter is connected in shunt at the PCC through a transformer and operates as a current source inverter.

Unified Power Quality Conditioner (UPQC) is an integration of shunt active power filter and series active power filter. The basic circuit of UPQC is the series portion compensates for supply voltage harmonics, and voltage unbalances, acts as a harmonic blocking filter and damps power system oscillations. The shunt portion compensates load current harmonics, reactive power and loads current unbalance. Additionally, it controls the DC interface capacitor voltage. The power provided or consumed by the shunt divide is the power required by the arrangement compensator and the power required to cover misfortunes. A Unified Power Quality Conditioner that works in synchronous voltage and current control modes. UPQC consolidates the activities of a Distribution Static Compensator (DSTATCOM) and Dynamic Voltage Restorer (DVR). In the voltage control mode, it can make transport voltage at stack terminal sinusoidal against any unbalance, consonant or glimmer in the source voltage or unbalance or symphonious in the heap current. In the present control mode, it draws an adjusted sinusoidal current from the utility transport regardless of unbalance and symphonious in either source voltage or burdens current.

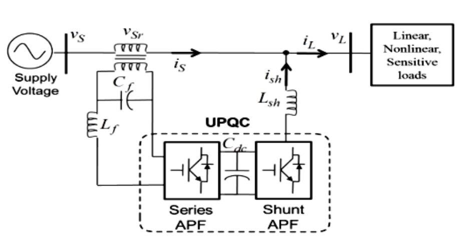

Figure 10: UPQC Model to be Simulated

In the present case, UPQC with right shunt topology is considered. In right shunt topology, shunt active power filter will come right side of series active power filter that is near to load so that the currents flowing through the series transformers will be balanced sinusoidal. UPQC voltage references are calculated based on Fourier series, extraction of fundamental sequence components using half-cycle running (moving) averaging, current recommendations are computed using the instantaneous symmetrical component theory. At the PCC of shunt active power filter, the voltage is load voltage which is balanced sinusoidal after compensating the source voltages by series active power filter. So we can use the instantaneous symmetrical component theory for calculating the source reference currents, which will be in phase with the load voltage, so that source will supply only average active power, remaining part of the oscillating active power and the UPQC will provide total reactive power. A mathematical model for UPQC with right shunt topology considering non-linearity in load is derived.

IV. CIRCUIT DIAGRAM

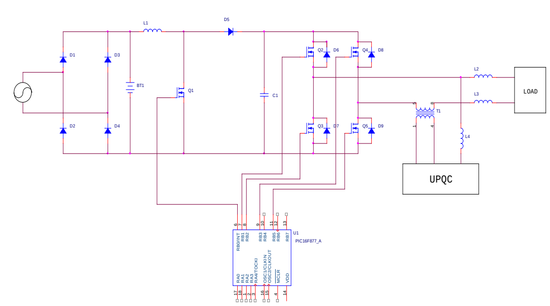

Figure 11: Circuit Diagram for the Proposed UPQC Model

Circuit Explanation

The Main energy sources like wind, which can be compensated, are termed as energy sources in this project. From the various source, the load system is frequently operated without any disturbance. The wind energy power source cannot be stable for connecting the AC bus. So, that condition DC-DC converter is implemented to improve the voltage. The rectified voltage is injected to the Bus system. The output range of the wind source is 24V.After DC-DC converter conversion. Finally, the converted voltage is given to the inverter to convert the DC-AC (24DC-24AC). The reactive power of a UPQC improves the energy then step up transformer will enhance the output voltage from (24-230)

V. RESULT AND DISCUSSION

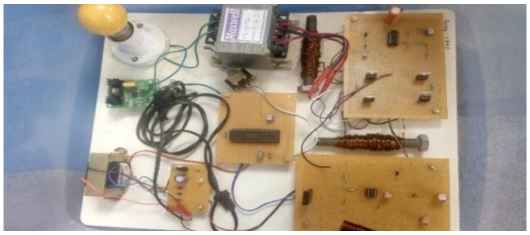

Figure 12: Hardware Model For The Proposed Technique

Hardware Output

Hardware	Specification	Input Ranges	Output Ranges
Wind	Input power	kinetic energy	12V
Fuel cell	Input power	12V	7.5A
Boost converter	Regulating power	12V	0-50v
RECTIFIER	Input power	12V AC	12 V DC
INVERTER	Output power	24vDC	24vAC
Transformer	step-up	24VAC	230VAC
Load	Load	230V	10watts

Advantages

- Improves the accuracy for harmonic detection.
- Capable of separating harmonics from feeder current.
- Harmonic current and unbalanced voltage can then be alleviated with the compensation.

Applications

Industrial applications such as

- Electric vehicle.
- UPS.
- Renewable energy conversion.

VI. CONCLUSION

The SCIG system tapped to the distorted power grid would suffer from the torque pulsation and which would damage the rotor bearings and shorten the SCIG durability. The difficulty in coping with the power quality problem lies in how to identify the distortion component from the distorted voltage or current signal. The wanted distortions can be divided into two categories that are the voltage unbalance and the current harmonic. Because the definition of the energy unbalance is independent to the harmonic distortion, the fundamental component should be resolved from the original voltage signal with the priority. The fundamental positive sequence voltage provides with not only the grid voltage phase for the voltage-source inverter (VSI) to parallel with the power grid but also the degree of the voltage unbalance for the unified power quality conditioner (UPQC) to fast compensate the unbalanced component.

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