An Enhancement of Power Quality in Grid Coordinated Wind Energy Conversion System Using Fuzzy Controlled UPQC

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Abstract: In renewable wind power connected to the electrical grid is the one of the configuration used in nature. Due to uncertainty in wind speeds. It Injection of the wind power into an electric grid affects the power quality. In this proposed scheme, Unified Power Quality Conditioner (UPQC) is connected at a point of common coupling to mitigate the power quality issues. The battery energy storage is integrated to sustain the real power source under fluctuating wind power. The effectiveness of proposed scheme relives the main supply source from the reactive power demand of the load and the induction generator. The development of the grid co-ordination rule and the scheme for improvement in power quality norms as the grid has been presented. The UPQC control scheme for the grid connected wind energy generation system is simulated using MATLAB/SIMULINK environment.

KEYWORDS: voltage sag, current harmonics, Wind Energy Conversion System (WECS), Unified Power Quality Conditioner(UPQC), Power Quality (PQ).

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INTRODUCTION

Any problem manifested in voltage, current or frequency deviation that ends up in failure of customer instrumentation is thought as power quality problem. Low power quality affects electricity consumer in many ways. The lack of quality will cause loss of production, injury to equipment and human health. Therefore it's obvious to keep up high standards of power quality. Though these features and their indirectly connected pc primarily based enhancements are unit key problems to an economical terminal operation, we have a tendency to should not forget the foundation upon that we have a tendency to area unit building. Power quality is that the mortar that bonds the foundation blocks. Power quality conjointly affects terminal operative economics, crane installations, the environment, and initial investment in power distribution systems to support new crane installations. As we have a tendency to area unit all conscious of instrumentation crane performance necessities still increase at Associate in nursing astounding rate. Next generation instrumentation cranes already within the bidding method would force average power demands of 1500 to 2000 kW virtually double the whole average demand 3 years past. The speedy increase in power demand levels, a rise in instrumentation crane population, SCR device crane drive retrofits and also the massive AC and DC drives desires the power and dominant these cranes can increase awareness of the power quality issue within the terribly close to future. The dearth of quality will cause loss of production, injury to instrumentation and human health. So it's obvious to keep up high standards of power quality.

Any power problem that ends up in failure or mis-operation of customer equipment manifests itself as an economic burden to the user or produces negative impacts on the surroundings. Once applied to the instrumentation crane trade, the problems that degrade power quality include

- Voltage Sags or Dips
- Voltage Swells
- Harmonics
- Distortion

In order to fulfill PQ standard limits it should be necessary to incorporate some variety of compensation. Modern solutions is found within the sort of active rectification or active filtering. A shunt active power filter is appropriate for the suppression of negative load influence on the provision network, however if there area unit provide voltage imperfections, a series active power filter is also required to supply full compensation. In recent years, solutions primarily based the appliance of FACTS ideas in distribution systems has resulted in a very new generation of compensating devices. A unified power-quality conditioner (UPQC) is that the extension of the unified power-flow controller on versatile ac transmission systems (FACTS) have appeared. (UPFC) idea at the distribution level. It consists of combined series and shunt converters for cooccurring compensation of voltage and current imperfections in a very provide feeder. Recently multi-converter FACTS devices like Associate in Nursing interline power-flow controller (IPFC) and also the generalized unified power-flow controller (GUPFC) area unit introduced. The aim of those devices is management to regulate to manage the power flow of multi-lines or a sub network instead of control the power flow of one line by, as an example a UPFC.

In the proposed work, the PQ issues voltage sag and current harmonics area unit simulated and analyzed within the grid connected alternative energy system. To reinforce PQ, the planned FLC primarily based UPQC is enforced for effective and economical mitigation of each voltage sag and current harmonics. The performance of the planned system is valid by examination the simulation results with standard PI controlled UPQC.

UNIFIED POWER QUALITY CONDITIONER SYSTEM

There are numerous control techniques to be had to discover the reference values of the voltage and the current of UPQC. The Figure 1 indicates the block diagram for control techniques of UPQC device. The idea of instantaneous active energy (p) and reactive energy (q) and its application in shunt filter reference current generation, the synchronous reference frame principle, the fuzzy logic control (FLC) for the control of UPQC technique are a number of the above referred to control techniques. Based on the above discussion, d-q principle with hysteresis current manage mode is appropriate for parallel mode operation of UPQC device and d-q principle with PWM voltage control mode is appropriate for interruption mode operation. The hysteresis control technique is straightforward to put in force and it has more suitable device stability, increased reliability and mitigates power quality problems.

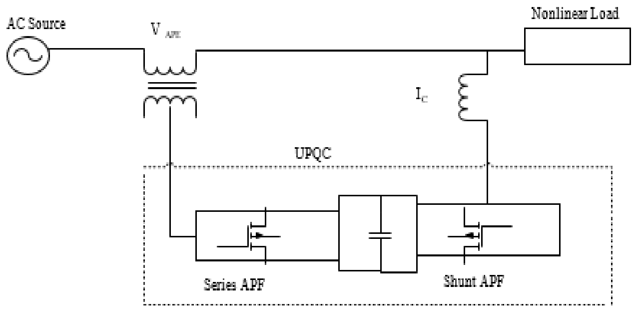

Fig.1 Block diagram of UPQC

Control Scheme of Series Active Filter

The Park's transformation methodology is employed for generation of unit vector signal. The particular voltage and also the reference are converted to dq0 from ABC coordinates and each area unit compared in dq0 reference frame. When the comparison each area unit once more born-again to ABC arrangement. From PLL (phase barred loop) Ø may be generated that is needed for Park's transformation and inverse Park's transformation. The switch pulses needed for VSI conduction area unit generated from the comparison of chosen output voltage(Vc*) with the detected series APF output voltage (Vc) in a very hysteresis voltage controller.

Control Scheme for Shunt Active Power Filter

The shunt (APF) is generally connected in parallel to the system that indicates the harmonics content. To eliminate the harmonics, the equal quantity of harmonic compensating current is injected in opposite part w.r.t the harmonic current. The control theme includes the transfer of supply current from a-b-c to d-q frame. In nonlinear load the supply current includes each oscillating still as dc part. The dc part is merely positive sequence part however the periodical part includes positive, negative and 0 sequence parts. To keep up the DC link voltage this active filter can absorb some active power from the ability system. The shunt active filter eliminates the harmonics part present within the supply current & create the supply current wave type pure sinusoidal by acting as a current controlled voltage source inverter.

DFIG-BASED WIND POWER SYSTEM MODEL

The proposed circuit shown in Fig. 2 consists of a turbine connected to a DFIG. The DFIG is simulated as associate induction machine having 3-phase supply within the mechanical device and 3-phase provide within the rotor. The rotor coupled via 2 powers convertors: the rotor-side convertor (RSC) and therefore the grid-side converter (GSC). The RSC ensures a decoupled active and reactive stator power management, P and q per the reference torsion delivered by the maximum power point tacking control (MPPT). The GRC controls the power flow exchange with the grid via the rotor, by maintaining the DC bus at a continuing voltage level.

Due to the intermittent and variable nature of wind generation, it's fascinating to work out the best generator speed that extracts the maximum power from the rotary engine. MPPT permits variable-speed turbine to work at associate best rotation speed as a operate of wind speed and capture the most power from the obtainable wind energy.MPPT methodology regulates the rational speed of the generator so as to maintain the TSR to associate optimal worth at that the ability extracted is maximum. It needs each the wind speed and also the rotary engine speed to be measured or calculable additionally to the information of the best TSR of the rotary engine so as to be ready extract maximum potential power. Fig. 3 shows the diagram of a MPPT control with TSR control.

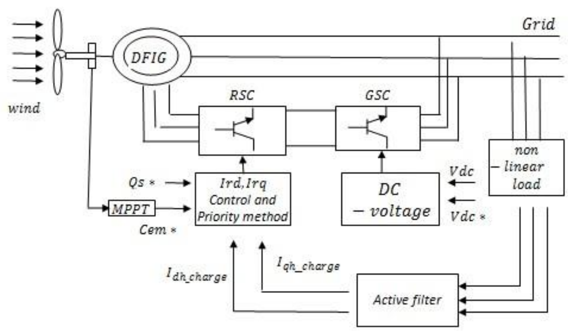

Fig. 2 Block diagram of the wind power system based in DFIG.

Where R is the radius of wind turbine, λ_{opt} is the optimal TSR of the turbine and G is the inverted gain of the reducer.

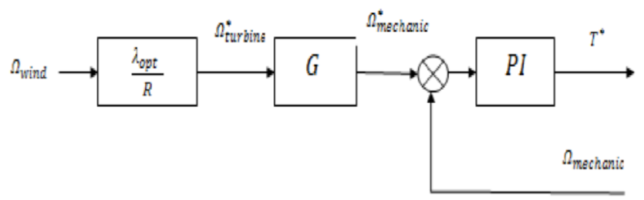

Fig. 3. MPPT control.

DESIN OF UPQC CONTROLLERS

4.1PI Control Proportional Integral (PI) management in VSI provides superior management over ancient Pulse width Modulation or sinusoidal Pulse width Modulation (SPWM). So as to get a smooth fascinating wave at the output side, the switch frequency should be constant and will be freelance of output frequency and this will be achieved by PI management. The Advantages of PI management are

• Fixed inverter switch frequency leads to noted harmonics.

Instant control and wave shaping.

PI Control Structure

When a load is connected to the inverter output, the output voltage at the load aspect is detected by means sensors and it's feedback to a comparator compares this load output with the reference signal (desired signal) and it produces the voltage error signal. This instant error is fed to a proportional-integral (PI) controller. The integral term within the PI controller improves the tracking by reducing the instant error between the reference and also the actual voltage. The error is forced to remain among the vary outlined by the amplitude of the triangular undulation. The ensuing error signal is compared with a triangular carrier signal and intersections decide the shift frequency and pulse width.

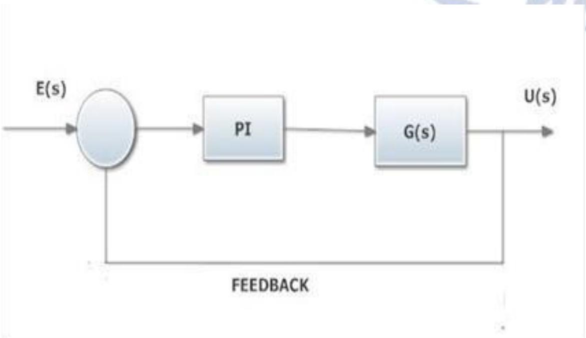

Figure .4 PI controllers with feedback

PI controller is a feedback controller that detects the error value that is that the distinction of the signal and also the desired or reference signal is shown within the Figure 4 PI controller works to reduce this error by dominant the system inputs. PI controller has 2 components particularly Proportional (P) and Integral (I). Proportional part reduces the error whereas Integral part reduces the offset. P depends on present error and that i depend upon past errors. So, step response of a system are often improved by exploitation PI controller.

4.2 Fuzzy Logic Controller

Fuzzy Logic Controller (FLC) has one amongst the foremost in operations of the fuzzy set group theory. Its main aspects are linguistic exploitation variables rather than numeric variables. FL control technology knowledge's the behavior of systems depends on human potential. It's designed on the principles of internal control. FL makes it simple methodology for reaching a particular conclusion on the idea of ambiguity, ambiguous, inaccurate, noisy or missing input data.

A Fuzzy interface changes the input data to acceptable linguistic values. A knowledge domain composed of databases and basic linguistic definitions and control rule set. Fuzzy call logic assortment controls action from control data rules and directions for linguistic variables. A Defuzzification interface that surrenders a non fuzzy control action from an inferred fuzzy management action.

This FLC is enforced with UPQC to perform voltage correction by series APF and through the parallel APF for current regulation. Nonparallel APF, the faulted sag voltage is compared with the reference voltage. The error voltage is processed through Fuzzy controller and its output is born-again to three phase through unit vector generation, then it's fed into Pulse width Modulation (PWM) generator to supply gate pulses to Series APF specified this could be able to inject the desired voltage for the mitigation of voltage sag.

- A Fuzzification interface alters input data into appropriate linguistic values.
- A knowledge domain that contains of a knowledge base together with the essential linguistic definitions and control rule set.
- A higher cognitive process Logic that collects the fuzzy control action from the knowledge of the control rules and also the linguisticvariable descriptions.

- A Defuzzification interface that surrenders a non fuzzy control action from an inferred fuzzy control action.

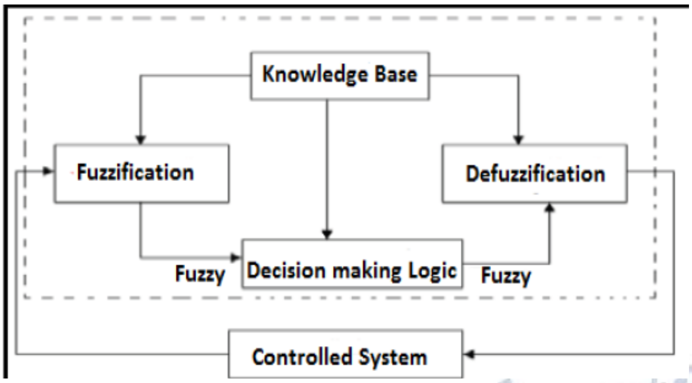

Fig.5 Basic structure of fuzzy logic controller

In this paper, a complicated control strategy, FLC is enforced at the side of UPQC for voltage correction through Series APF and for current regulation through Shunt APF. Error and alter in Error are the inputs and Duty cycle is that the output to the fuzzy logic Controller as shown in fig.6and7.

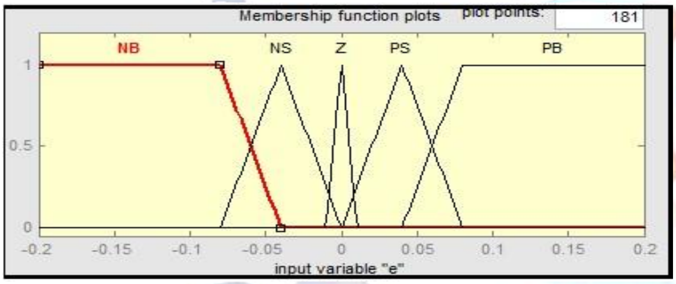

Fig.6Error as input

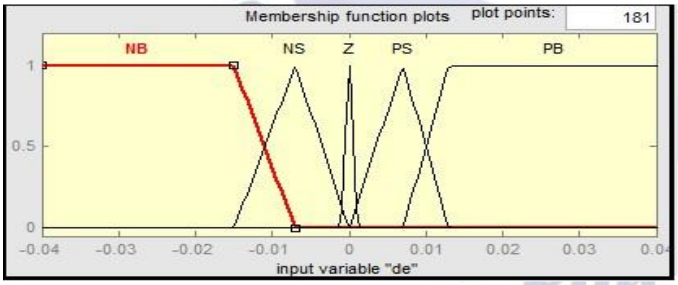

Fig.7 Change in error as input

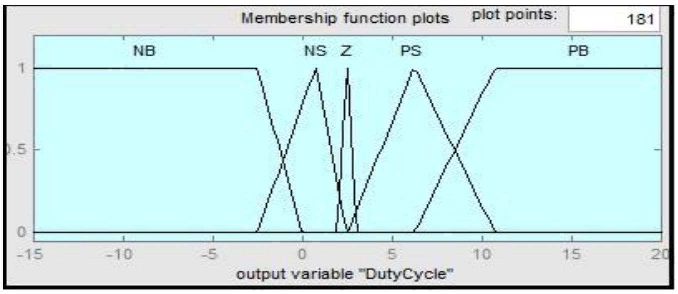

Fig.8 Output variables to defuzzification process

In the decision-making process, there is rule base that links between input (error signal) and output signal. Table 1.shows the rule base exercised in this proposed Fuzzy Logic Controller.

e \ de	NB	NS	Z	PS	PB
NB	PB	PS	NS	NS	NB
NS	PS	PS	NS	PB	NB
Z	NB	NB	NS	PS	PB
PS	NS	NS	PB	NB	PS
PB	NS	NS	PB	PB	PB

Table .1 Fuzzy rule representation

SIMULATION RESULTS

The simulation of PQ issues and therefore the implementation of UPQC beside projected FLC and standard PI controller are shown by the following cases.

5.1 UPQC with PI controller

The UPQC is enforced with typical PI controller to compensate each voltage sag and load current harmoncs within the system. The values of P&I are chosen by trial and error technique applicable for compensation. The simulation results for each supply voltage and load current and thd spectrum for load current is additionally shown in below fig.11.

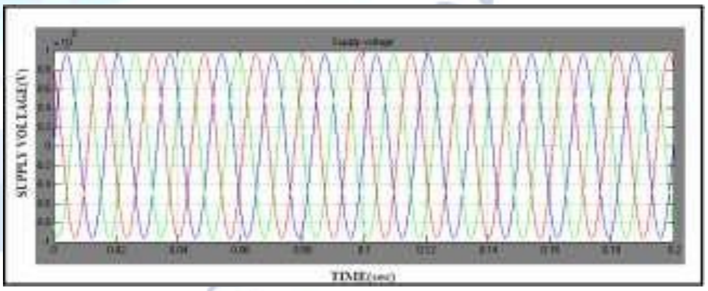

Fig.9Source Voltage

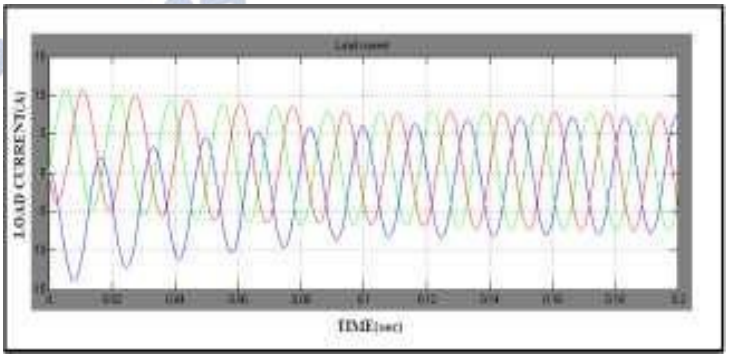

Fig.10 Load Current

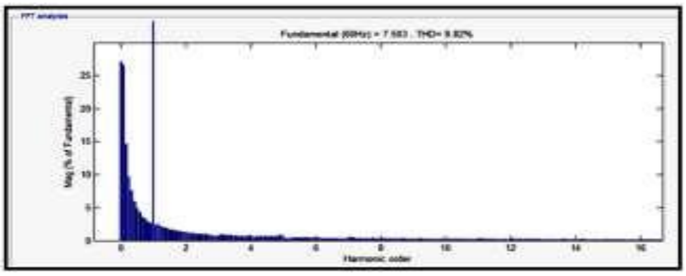

Fig.11THD Value of Load Current

5.2 UPQC with Fuzzy controller

The detailed Simulation of the proposed UPQC with fuzzy logic Controller is shown and also the design values also are shown. The proposed fuzzy logic controller based mostly UPQC is place into service to compensate each voltage sag/swell and load current harmonics. Here voltage sag is made between 0.6 sec and 0.7sec.Voltage swell is made between 0.8sec and 0.9sec. Series inverter injects the remunerated voltage to compensate the sag and swell.

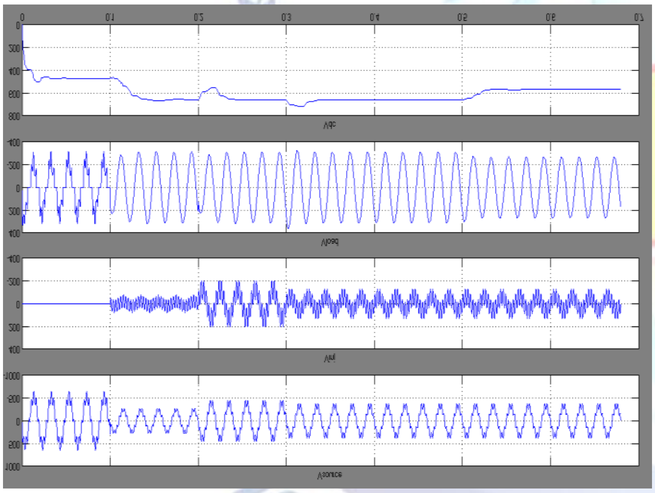

Fig.12Load, Injected and Source voltage of proposed model with UPQC

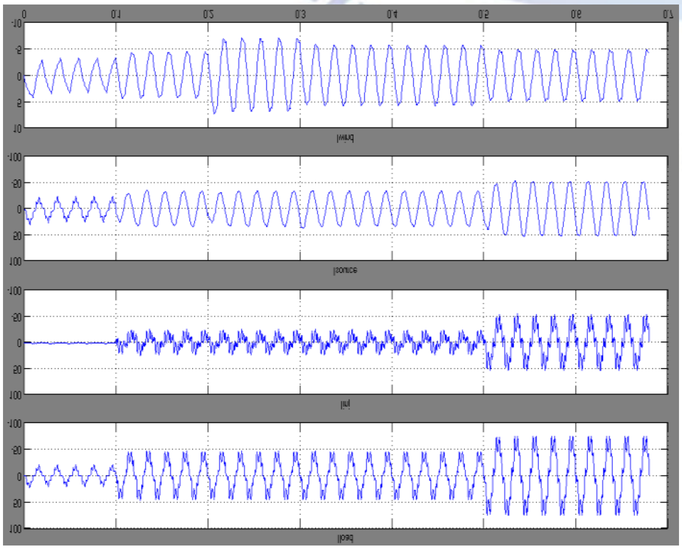

Fig.13Source, Injected, Load current and wind current of proposed model with UPQC

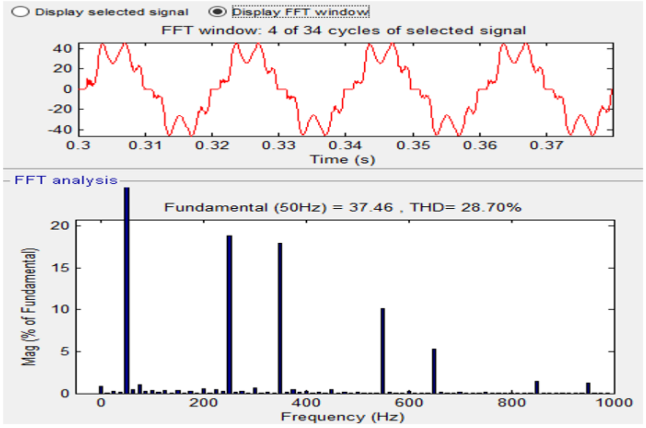

Fig.14%THD of Current without compensation

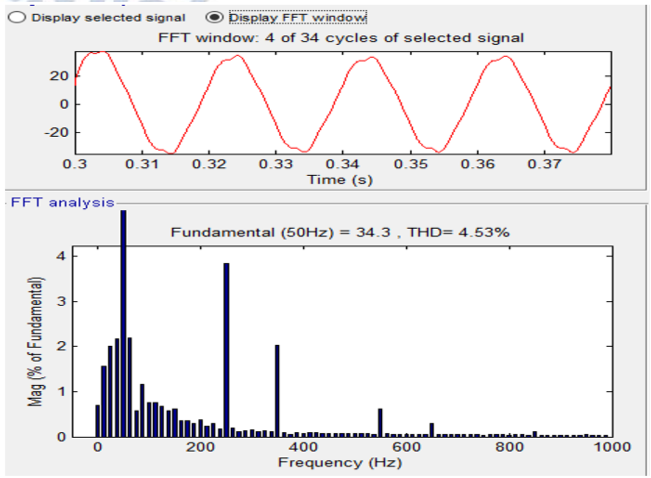

Fig.15%THD of Current with Fuzzy based UPQC

System	Load Current in %THD
Uncompensated	28.70%
UPQC With PI Controller	8.82%
UPQC With Fuzzy Controller	4.53%

CONCLUSION

In this project, the FACTS device (UPQC) based control scheme for power quality improvement in grid connected wind generating system and with nonlinear load is presented. The power quality problems and its consequences on the consumer and electrical utility area unit presented. The operation of the system developed for the UPQC in MATLAB/SIMULINK for maintaining the power quality is to be simulated. It has a capability to wipe out the harmonic components of the load current. It maintains the supply voltage and current in-phase and support the reactive power demand for the wind generator and load at PCC within the grid system, so it provides a chance to reinforce the utilization factor of transmission line. So the integrated wind generation and FACTS device UPQC have shown the outstanding performance in maintaining the voltage profile as per demand.Thus the proposed scheme within the grid connected system fulfills the power quality requirements and maintains the grid voltage free from distortion and harmonics.

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