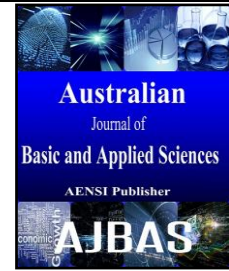




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Iupqc Implementantation For Power Quality Improvement On Distribution Network

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ABSTRACT

Power and quality of power have its significance in all electrical works. It is very important to maintain a balanced power in all system. In this paper the distributed side of power system is analyzed for voltage sag and swell. Whenever these faults occur it is important to protect the load, so we use some device to isolate the fault from source to load. Here a custom power device namely Interline Unified Power Quality Conditioner (IUPQC) is used to balance the power. IUPQC is used with a new control technique such as the series filter is designed as current controlled and the shunt filter is designed as voltage controlled. The existing technique is compared with another algorithm namely, fuzzy control technique. By using IUPQC, result is observed for voltage sag, swell mitigation, voltage unbalance and reactive power compensation. This paper embellishes how IUPQC can improve the power quality by mitigating all these PQ disturbances. The proposed configuration of the IUPQC is developed and verified for various Power Quality disturbances by simulating the model using MATLAB simulink software

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INTRODUCTION

One of the most complex systems made by man is electrical power system due to the wide geographical enclosure with different static and dynamic behavior. The power system is used for transactions of electric power between different utilities and individual consumers. Power system consists of a three-phase grid to which all generating stations feed energy and from which all substations tap energy. The electrical energy which reaches the substation is transmitted to distribution transformer and then from the transformer, the energy is fed to various loads. A power system is mainly divided into three parts, they are generation, transmission and distribution system

Here it is mainly focused on distributed system. Power distribution in power system is the final stage to deliver electric power to the customers. Primary distribution lines carry this medium voltage power to distribution transformers located near the customer's premises.

Distribution transformers again lower the voltage to the normal utilization voltage of household appliances and typically feed several customers through secondary distribution lines at this voltage. The range of lower transmission voltage to medium

voltage ranging between 2 kV and 35 kV with the use of transformers. Commercial customers are connected to the secondary distribution lines through some drops. So the customers demanding a much higher amount of power can be connected directly to the primary distribution level or the sub-transmission level.

Problem Analysis:

Power and power quality are frequently used terms for electrical engineers. Power quality can be simply defined as the interaction of electrical power with electrical instrument. If electrical instrument operates perfectly and reliably without any damage or stress, we could say that the electrical power is of best quality. On the other hand, if the electrical instrument malfunctions then it is unreliable, or is damaged during normal usage, we suspect that the quality of power is poor.

Present era is very keen about PQ. Modern electrical system consists of large amount of electronic devices such as programmable logic controllers and adjustable speed drives. These electronic devices are very sensitive to disturbances and thus industrial loads become less tolerant to power quality problems such as voltage sags, voltage swells, and harmonics. Due to these problems the

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consumer/ load side is getting affected. To boost the system performance of distribution system, the theory of custom power was introduced to distribution systems. In a custom power system, the customer acquire particular power quality from a utility or a service provider at the instrument installed by the customer in coordination with the utility, which includes an acceptable combination are minute power interruptions ,magnitude and duration of voltage reductions within specified limits, low harmonic voltage and low unbalance.

As the power quality problems are originated from utility and customer side, the solutions should come from both and are named as utility based solutions and customer based solutions respectively. The best examples for those two types of solutions are FACTS devices (Flexible AC Transmission Systems) and Custom power devices. In those devices we are using IUPQC here. In order to eliminate the power quality issues that affect the consumer side, custom power device known as IUPQC is introduced between the distribution side and that of the load (Bruno, W., 2013).

Normally custom power device UPQC and IUPQC has almost similar in construction. The difference between UPQC and IUPQC structure is, in UPQC series compensator is voltage controlled and shunt compensator is current controlled but in case of IUPQC this one is reversed i.e., series compensator is current controlled and shunt compensator is voltage controlled (Srinivas Bhaskar Karanki, 2013). Fuzzy control technique is implemented in IUPQC. The main objective of this work is to:

- Compensate the voltage sag.
- Compensate the voltage swell.
- Reactive power compensation.

In existing systems UPQC is designed for one feeder. Raphael J. Millnitz dos Santos in 2014 showed an alternative PQ conditioner, which consists of two single phase current source inverters where the series active filter (SAF) is controlled by a current loop and the passive active filter (PAF) is controlled by a voltage loop (Raphael, J., 2014).

Since both grid current and load voltage are sinusoidal, and therefore, their reference also sinusoidal. Some authors also concentrated on the control scheme used in these devices.

The general aim of this paper is to propose a simplified custom power device IUPQC where SAF is controlled by a current loop and the PAF is controlled by a voltage loop. Also the output is analyzed with and without using fuzzy control technique.

Device Description:

The general representation as single-line diagram of an IUPQC is laid out in Fig.1, which consists of two feeders, Feeder-1 and Feeder-2, which are from two different substations and also supply the system loads L-1 and L-2. The supply voltages are symbolized by V_1 and V_2 . It is assumed that the IUPQC is connected to two buses Bus-1 and Bus-2, the voltages of which are denoted by V_{1b} and V_{2b} , respectively. further two feeder currents are denoted by I_1 and I_2 while the load currents are denoted by i_{L1} and i_{L2} . The load L-2 voltage is denoted by V_{L2} .

The purpose of the IUPQC is to hold the voltages V_{1b} and V_{L2} constant against voltage sag or swell, momentary interruption and transitory interruption etc. in either of the given feeders. It has been demonstrated that the UPQC can absorb power from one feeder (say Feeder-1) to hold V_{L2} constant in case of a sag in the voltage V_1 . This can be accomplished as the two VSCs are supplied by a common dc capacitor. But basically IUPQC is nothing but the device UPQC kept in between two individual feeders, (called feeder-1 and feeder-2). UPQC consists of two back to back connected IGBT based voltage source bidirectional converters or Voltage Source Converters (VSCs) (called VSC-1 and VSC-2) with a common DC bus. VSC-1 is connected in shunt with feeder-1 while VSC-2 is placed in series with the feeder-2 (Kian Hoong Kwan, 2012).

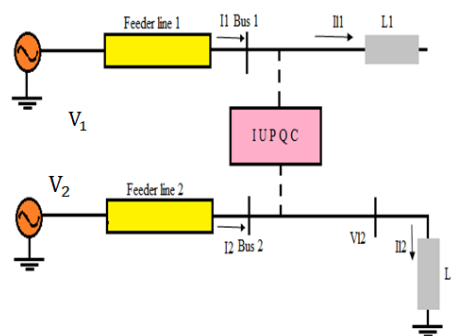


Fig.1: Single-line diagram of an IUPQC.

The aim of control strategy is to maintain constant voltage magnitude at the point where a

sensitive load is interfaced, under system disturbances. The important issues in the design of

the control strategy are the generation of reference currents or voltages for compensation and the generation of the compensating current or voltage based on the reference currents or voltages

Control Technique Used:

The control technique used in this work is Fuzzy control. Table.1 indicate the Fuzzy rule table. The mapping of the input variables to the output are replicated in Fuzzy using IF-THEN rules. $V_{ref} = 1$
Rule Base

If $V_m < V_{ref}$ then I_{ref} is P

If $V_m > V_{ref}$ then I_{ref} is N

Inference & Defuzzification

The inference mechanism for this work is traced from Mamdani's max- min (or sum-product) (Jindal, A.K., 2007).

As in this work, instead of using conventional (PI) controller as mentioned in references a FLC is being used as the control technique in IUPQC for the better analysis of PQ problems. Here seven labels of fuzzy subsets; negative large (NB), negative medium (NM), negative small (NS), zero (ZE), positive small (PS), positive medium (PM), positive large (PB). The control rule base table can improve the performance. In which the row and column represents the error and its changes respectively (Rama Rao, R.V.D., Subhransu sekhar dash, 2011).

Table 1: Fuzzy Rule Based Table.

$E(k)$ ΔE	NB	NM	NS	ZE	PS	PM	PB
NB	NB	NB	NB	NB	NM	NS	ZE
NM	NB	NB	NB	NM	NS	ZE	PS
NS	NB	NB	NM	NS	ZE	PS	PM
ZE	NB	NM	NS	ZE	PS	PM	PB
PS	NM	NS	ZE	PS	PM	PB	PB
PM	NS	ZE	PS	PM	PB	PB	PB
PB	ZE	PS	PM	PB	PB	PB	PB

IV Output Analysis:

Generally in industries we use inductive loads, loads are important for analysis and simulation of the dynamic behavior of electric power system. In the system configuration of simulink model, an IEEE 14 bus system is designed representing distribution system with the following specification mentioned in Table.1 and Table.2. In which IUPQC is connected in 11th bus. A fault is given to that line to analysis the working of IUPQC. Whenever a distortion occurs in source side it is corrected before it reaches the load, thus the load is protected.

In the above Fig.2 voltage sag represent the source side voltage & current and load side voltage & current. Voltage swell the increase in the RMS voltage level to 110% - 180% of nominal value the power frequency for durations of ½ cycle to one (1) minute& it is observed at 0-0.5sec. In load voltage this swell is suppressed to normal value.

Also a sag, which is the opposite of swell, is observed in the system at 0.5sec, which last for 0.1sec at source side, and the source voltage is nearly zero(0), also source current is distorted, with the

help of DVR in IUPQC the voltage is improved to normal voltage level. Thus we can observe that the fault in source side does not affect the load side.

While comparing the result with the existing algorithm PI, we can conclude that while using fuzzy the settling time is marked as 0.614 and in the existing system the time is 0.63. Thus settling time is improved using fuzzy.

The above Fig.4 shows the real power and reactive power of the source side, real power and reactive power of load side. It is observed that without IUPQC, the occurrence of sag & swell can vary the real and reactive components in the system. It is important to maintain the real and reactive power for smooth power flow in the system. During sag the real power at source side is zero(0) and reactive power is -2.8pu. It is corrected to 0.21-1.2pu & to 0.245-1pu respectively. The settling time using PI is 0.95sec and it is reduced in fuzzy as 0.79 sec. The range of real power and reactive power is maintained using the STATCOM part in IUPQC.

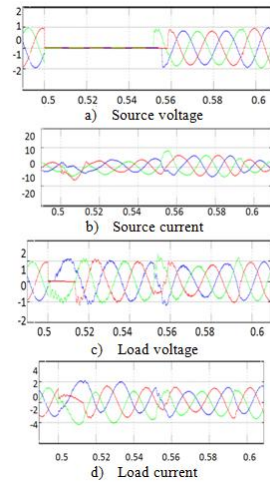
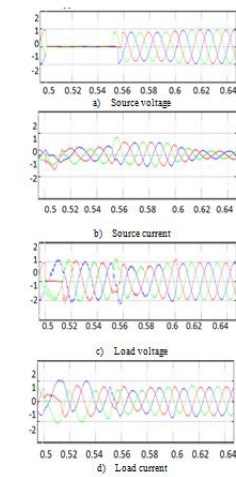
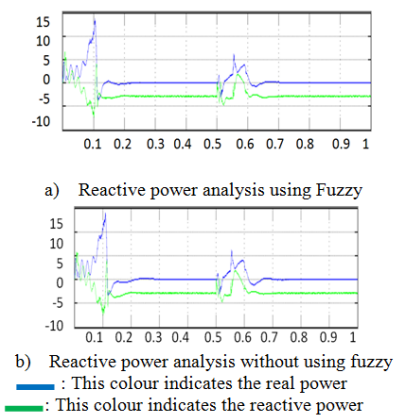
The waveform analysis of the following can be embellished as.

Table 2: Designing Specification.

Input line to line RMS voltage	25x10 ³ V
DC link voltage	2500V
Grid frequency	50Hz

Table 3: Designing Specification.

Nominal phase-to-phase voltage (Vrms)	1
Nominal frequency (Hz)	50
Active power P (W)	0.035
Inductive reactive power (Positive VAR)	0.018
Capacitive reactive power (Negative VAR)	0

A. Voltage Sag And Swell:**Fig. 2:** Result analysis using Fuzzy.**Fig. 3:** Result analysis without using Fuzzy.**B. Reactive Power :****Fig. 4:** Reactive power.

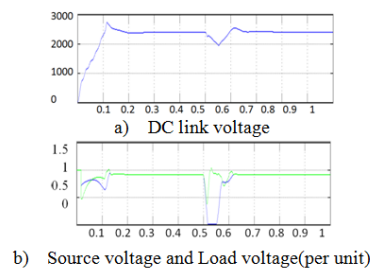


Fig. 5: Analysis while using Fuzzy.

The above graph (Fig.5) shows DC link voltage and source voltage and load voltage in per unit measurement. During time interval 0.5-0.6 the source voltage reaches zero (0). But the load voltage is maintained between 0.5-1V (normal value).

Another important function of STATCOM is to maintain the DC link voltage at a fixed value, here 25KV. It is very important to maintain the DC link voltage since it is the key feature for fault correction. The voltage is maintained in between 1950-2500V even when fault occur in the system. It is observed that DC link voltage can be maintained even if distortions occur in source voltage.

Conclusion:

A simple model of IUPQC is simulated. New control technique, namely, fuzzy control technique is implemented for IUPQC in distribution system for IEEE 14 bus system. By using IUPQC it is observed that during voltage sag and swell at source side during 0.5-0.6 sec does not affect the load side voltage and current. Also it will result in reactive power compensation and Also the settling time is reduced from 0.92 sec to 0.642 sec respectively. Thus it can be concluded that THD is reduced by 0.64%. Here it is embellishes how IUPQC can improve the power quality by mitigating all these PQ disturbances. The proposed configuration of the IUPQC is developed and verified for various Power Quality disturbances by simulating the model using MATLAB simulink software.

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