Total Harmonics Distortion (THD) and Unbalance Regulation of Grid and Load Voltages by PV Tied UPQC with ANN Technique

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Abstract: **An Artificial Neural network based Unified Power Quality controller (UPQC) is proposed in this paper. An unbalanced grid voltage and Load voltage are compensated by the UPQC in the single-phase power system. The Renewable energy source solar energy is connected to the grid. Perturb and observe *algorithm* (*P&O*) is used to track Maximum power from the Solar panels. This system UPQC is used to compensate the supply voltage and load voltage at the same time in a power distribution network. The grid and load voltage unbalances are regulated, and the Total Harmonics Distortion (THD) of the grid and load voltages is controlled by the UPQC via an Artificial Neural Networks (ANN) controller. In MATLAB/Simulink, the results are simulated and analysed.**

Keywords: **Photo voltaic (pv), maximum power point tracking(mppt), perturb and observe *algorithm*(*p&o*), unified power quality controller(upqc), artificial neural networks (ann).**

I INTRODUCTION

Concerns about global warming and the state of the environment have sped up the adoption of renewable energy sources in recent years. Distributed generation from renewable sources has increased quickly in recent years. This has helped satisfy load demands while decreasing reliance on traditional energy sources like petroleum. Distributed generation (DG) technologies, such as solar and wind rotor systems, benefit greatly from microgrid installations. Almost all load and load-side equipment is very sensitive to power quality issues. Each kind of load category will get electricity from the microgrid at a distinct power quality [8], selectable by a switch. Extra power quality (PQSs) such as the apf and the dynamic constant power source may be implemented and provide energy to sensitive loads [9–11]. Existing PQS of all types may be readily implemented at any network site to improve energy efficiency; however, this does need dedicated space for PQS and incurs an additional cost. Alternately, the power quality may be enhanced by the incorporation of a microgrid electric inverter [12]. Supplying that converted energy to the grid grid underneath the grid power control is the primary function of the inverter, which is utilized in the micro grid to convert the DC producing power into such an AC system. Alterations to the inverter's control or topology may, however, be made to accommodate for harmonics or voltage.

Modern power electronics have made custom devices such as DSTATCOM, DVR, and UPQC available to help mitigate energy quality issues. The sags/swells in the grid voltage are offset with DVR connected to the grid series [8]. DSTACOM, the parallel shunt compensation system connected to the PCC, offsets power quality issues including reactive currents, harmonics, and load imbalances [9]. UPQC provides for a VAR load requirement so that supply voltage and current are always in phase; no further power factor adjustment equipment is therefore needed.

- It decreases supply current harmonics to enhance nonlinear loading utility current efficiency.
- UPQC retains the rated load end voltage even when the voltage is supply sag.

This article deals with UPQC's implementation in the distribution system with PV Arrays. There are two voltage sources inverters for UPQC. The main objective of the inverter series is to separate the subtraction and delivery mechanism harmonically. Furthermore, the inverter series can compensate for voltage flicker/impact and regulate voltage and harmonic offset on the utility-consumer PCC.

II PHASE SYNCHRONIZATION TECHNIQUES

This paper examines the techniques for the phase synchronisation integrated so far in UPQC control system. Phase synchronization consists of two common techniques used in past: (PLL).and recent techniques such as the fundamental component extraction, artificial neural network (ANN) and unit vector. In this article the synchronisation one-phase power system technique is classified for the intended application of UPQC. Over the years, three-phase works on UPQC have become more common in comparison with single-phase system, particularly as power device applications and nonlinear loads are broader in the three-phase context. This paper, examines the synchronisation technique itself in order to prevent redundancy, and then highlights the suitability of each single-phase device implementation technique.

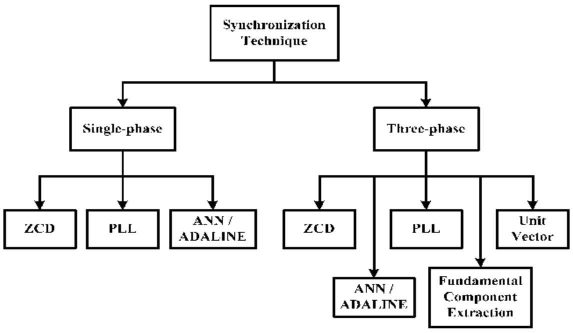


Fig.1. Block diagram of Synchronizationtechniques to SAPF. Zerocrossing detection (ZCD); artificialneuralnetwork (ANN), Phase − lockedloop(PLL).

III PHASE-LOCKED LOOP (PLL) TECHNIQUE

The phaselockedloop (PLL) approach, which is explained in this article, has been extensively employed because of its simple system of control and effectiveness in dealing with a variety of grid circumstances. PLL is an ancient technology that has been effectively used to many different areas, including systems, communication, and measurement, in recent years. Structure-wise, it the basic PLL was then further enhanced for the UPQC as a synchronous SRF-based PLL (or simply SRF-PLL). In single phase systems, SRF-PLL technology has been successfully implemented.

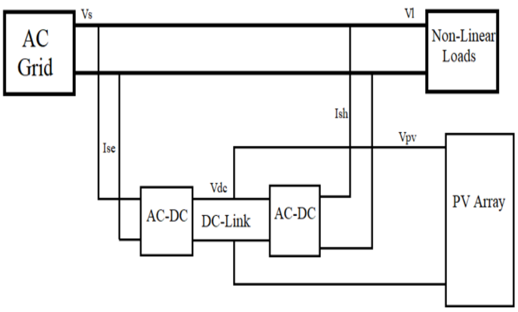


Figure 2. Circuit diagram of a proposed PV tied UPQC.

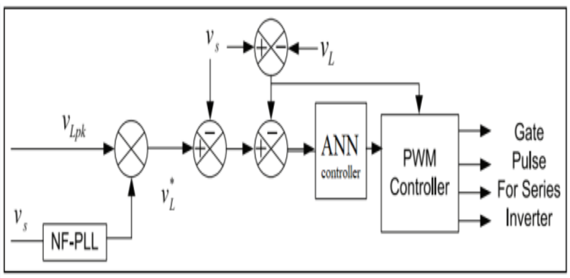


Figure 3. Control structure of ANN

Time-Domain UPQC Management Three-phase p-q and d-q theories, as well as the synchronous reference system, are the most prevalent contexts for using such methods. In this setting, the voltage or current signals are sent to the ABC frame's static (p-q' theory) or asynchronous (d-q theory) frames to liberate the fundamental and harmonic quantities [13]. However, in d-q theory, current is dealt with no matter the source of energy, but in p-q theory, real and reactive power spontaneous forces are computed. One unique aspect of both the p-q theory and the d-q theory is that the active and reactive capabilities of elements are interpreted as direct current (DC) quantities. DC amounts.
The early p-Q phase theory has drawbacks in terms of distortion and/or our imbalance in the supply voltages. In order to overcome these restrictions, the original p-q theory has indeed been revised into what is now known as p-q-r[5].
As an added bonus, both the p-q and d-q concepts in 3 parts were modified so that the same techniques could be used to single-phase APFs, such as UPQC systems. A d-q-o axis (SRF) independent controller regulates the incoming and outgoing voltage of UPQC to control the speed and differentiate the device's operation using a PI control (d-q-o axes). When permitted, the PI control helps reduce steady-state errors in the SRF based controller via the use of continuous check references (V&I). The transition from a-b-c to d-q may be thought of as the park transformation. With utility voltage disturbances like harmonics or imbalances, the 3 phase PLL is utilized in conjunction with a 3 phase PLL system. The controller's primary focus on d-q values makes it a potent tool. Conventional SRF analysis allows for the removal of harmonics from supply voltages or currents.
The current harmonic correction process begins with a transmission of the distorted currents to two fixed coordinates through a - transformation. From then, cosine and sinus functions are used to transform the values measured in the fixed frame in the process loop into those measured in the rotating frames that are synchronized with them (PLL). The conventional SRF method is also referred to as the "d-q approach." The suggested SRF control system makes use of equations for the d-q-0 transformation, filters, and a modified PLL algorithm. You won't have to do as much math, and the process is fast and easy. Successful operation on DSP systems is also possible. Learning occurs mostly via direct experience [3].
It goes without saying that these problems are beyond the capabilities of current computers, but that compact energy-efficient packages will really solve them. There is hope that less technically complex computer solutions may be developed via brain modelling. The ANN is made up of networks of artificial neurons. In essence, it is a group of interconnected, relatively straightforward nonlinear pieces with some degree of learnability [15]. Time and effort can be saved by using ANN since it just needs small samples of data to solve problems. The mathematical models used to create the state-of-the-art in data analytics are very basic ANNs.

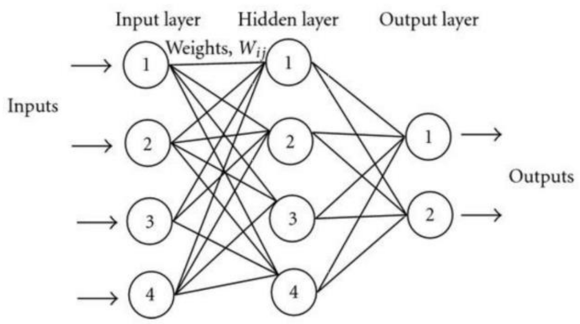


Figure 4. ANN structure

In the experiment, source voltage $vs(k)$is first measured and compared with an estimated voltage$vfund_{est(k)}$.Note that k refers to the digital implementation sampling rate.

IV RESULTS

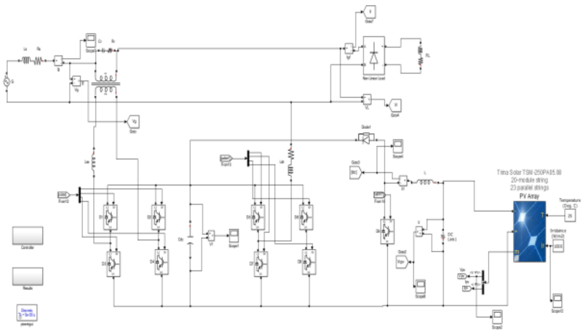
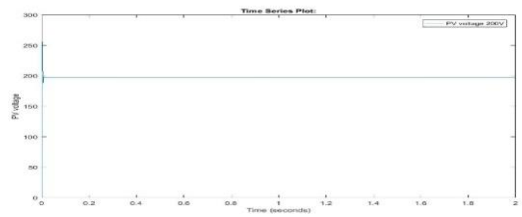
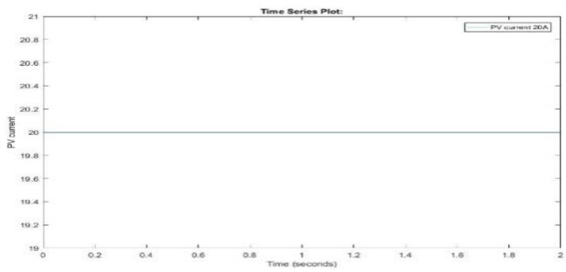


Figure 5. Simulation diagram of the PV tie UPQC system



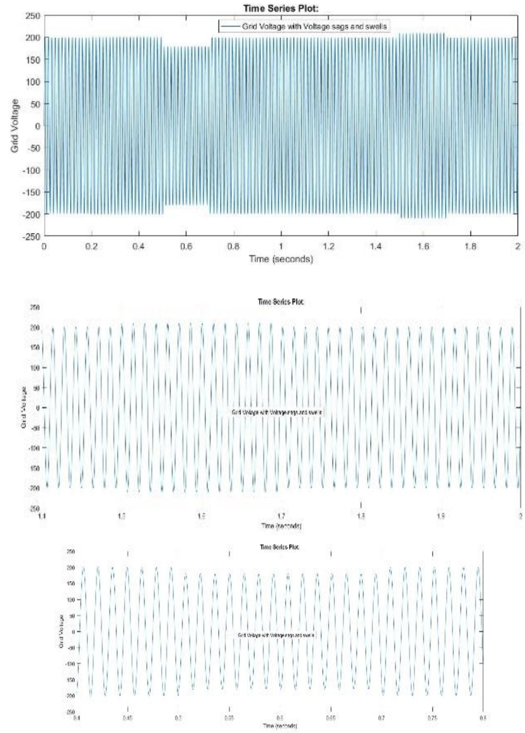
(a)



(b)

Figure 6.a) Voltage of the PV system. b) Current of the PV system

A PV tied UPQC is operated by MPPT technique to extract the maximum power by using the P&O technique with the ANN controller here we get the maximum power of 220 volts and the currents of 20 amps without any interruptions within a short period of time t=0.1 seconds the voltages and currents are settled down.



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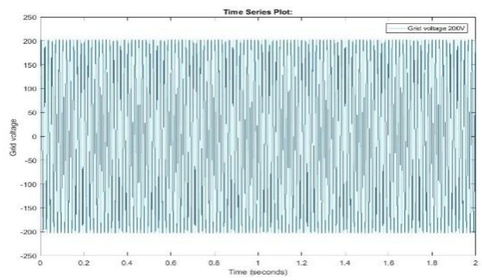
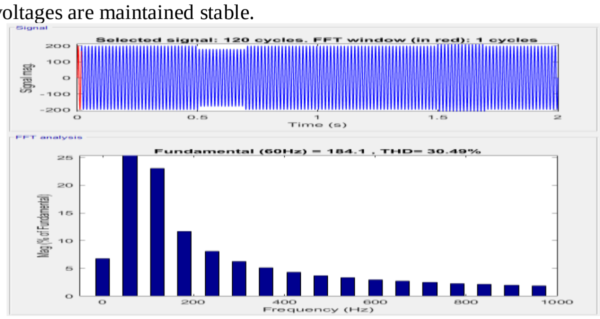


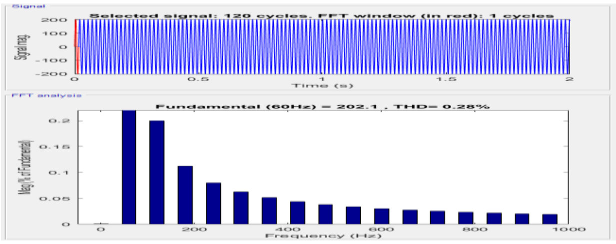
(b)

Figure 7. a) Grid voltages sags and swells b) Grid voltage without sag/swell with ANN controller

In the figure 7. The voltages of the grid with PI and ANN are shown, at the time t=0.5 to 0.7 voltage sag is occurred and at time t=1.5 to 1.7 voltage swell is occurred in the figure 7.(a), where as in figure 7. (b) Voltage sag/swells are controlled by using the ANN controller, grid voltages are maintained stable.



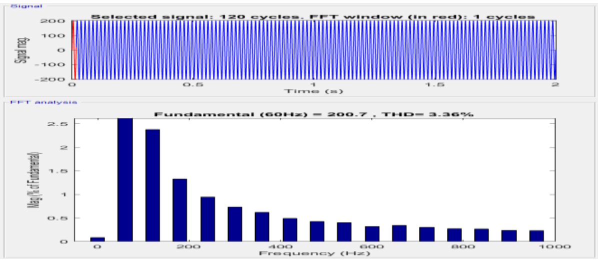
(a)



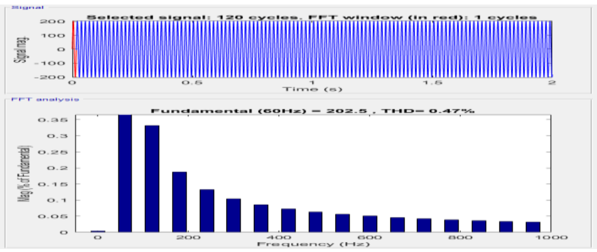
(b)

Figure 8. a) THD of the grid voltage with PI b) THD of the grid voltage with ANN

Figure 8. a)b) shows that the THD of the grid voltages are measured by using the FFT analysis with the PI controller the THD is 30.49% with the 60Hz, whereas the THD of the Proposed ANN controller is 0.28% with the 60Hz.



(a)



(b)

Figure 9. a) THD of the Load voltage with PI b) THD of the Load voltage with ANN

Figure 9. a)b) exposes the THD of the Load voltages are measured by using the FFT analysis with the PI controller the THD is 3.36% with the 60Hz, whereas the THD of the Proposed ANN controller is 0.47% with the 60Hz.

V CONCLUSION

Validation of the effectiveness of variable current and voltage offsets, but also their combination, for the PV UPQC was performed using MATLAB/Simulink. When power conditioning VSIs with low ratings are utilized, variable compensation may save a lot of money. Only by eradicating the loads caused by harmonics can the utility and also the user be held accountable for their actions. Through the use of a Synchronous Frame (SRF), series control techniques, and shunt conversion devices, UPQC is able to eliminate volume fluctuations, transients, distortions, and harmonics at the DC-link voltage, all of which originate in the delivery system. For the purpose of dampening current and voltage spikes, this study details a PV connection to the grid using UPQC. Power system disruption mitigation and grid synchronization issues are viewed as particularly challenging in a highly asymmetric grid when conventional PLL-based control is present. Therefore, UPQC is solving the voltage power quality problems concurrently. The non-linear recharging currents can be accommodated, and the charging voltage can be guaranteed to be sinusoidal over all three phases if the suggested dual-unified power quality is used. The control was also very efficient in reducing source-side load and voltage disturbances. An important benefit of the suggested control scheme over competing designs was that it required no complex computations or coordinate transformations in order to implement series and shunt active filter control. It reduces the overall harmonic components of the demand voltages so that power efficiency is maintained. THDs are lower when utilizing the Pid parameters in the ANN controllers for UPQC compared to when using no UPQC at all.

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