Analyses of Stability and Power Flow in a Versatile Decentralized Generation System Using UPQC

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Abstract—
An allocated generation machine that includes a single-level photovoltaic (PV) machine built into an integrated power quality conditioner (UPQC) is shown in this work. The UPQC serves as a bidirectional link between the DG system and either the grid or a micro grid. DG systems enable active power-line conditioning by injecting solar array-generated energy into the grid. A shunt inverter can be used to form an ac grid in islanded operation whether or not a power storage device is used. The PV-UPQC power flow must be thoroughly evaluated in order to gain a clear understanding of the system's overall performance and how the power converters should be formatted. This is why sizing curves are stated and introduced. Series and parallel inverters can be used to regulate and/or lessen the amount of power they process. For reducing conventional harmonic distortion, an Artificial Neural Network (ANN) controller has been proposed in this study (THD). A thorough study of the PV-UPQC functioning reveals that inverters are powered by active power flow, which is consistent with the findings of the radical expertise. As a result, Dynamic Response's performance can be examined using simulations.

Index Terms—Distributed generation (DG) system, integrated photovoltaic (PV)-unified power quality conditioner (UPQC) system, power flow, stability analysis. Artificial Neural Networks(ANN).

I. INTRODUCTION

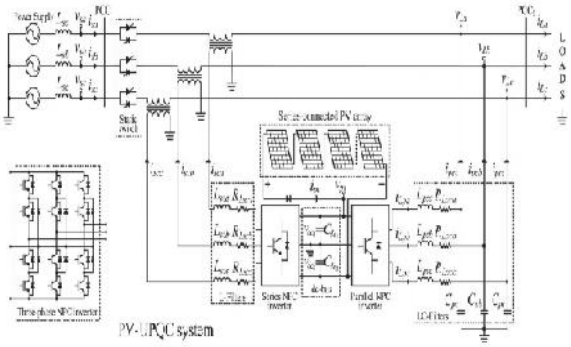
These days, the most important variables in any power distribution system are power quality and system reliability. Supply reliability is the major concern of any consumer. These customers expect not only a constant supply of electricity, but also a high standard of quality from the electricity they do receive. As a result, distribution power systems have been increasingly plagued by power quality issues. IEEE standards are used to specify the power quality at the point of common coupling (PCC) with the utility grid. The most frequently mentioned IEEE standard is IEEE-519. As a result, experts around the world have been attempting to improve the quality of power. Conventional remedies to power quality issues involve passive elements and may not always respond effectively due to the calamitous conditions of the entire power system in accordance. They are available. Power electronic converters are now widely available due to current semiconductor technology's improved power capabilities, ease of control, and low cost. There are several concerns about the environmental impact of semiconductor technology. While increasing the total reactive power required by equivalent loads, nonlinear equipment, such as power electronics converters, introduce harmonic currents into the distribution grid. An increase in system losses and voltage waveform distortions due to harmonic currents means poor power quality. It's also become necessary to have more sensitive loads, which demand precise sinusoidal supply voltages in order to function properly. Because of this, there has been an increase in the need for power conditioning systems. Consequently, some type of compensation is required to keep power quality within the parameters set forth by the applicable standards. Unified Power Quality Conditioner, first introduced by Hirofumi Akagi, is one of the most current technologies for dealing with inconsistencies in both supply voltage and load current. A variety of power quality compensations help to alleviate problems such as voltage imbalance and harmonic distortion by reducing swells, sags, and other symptoms. UPQC is the name given to the cascading combination of series and shunt active filters connected by a dc link capacitor. With the series active filter, voltage imbalances do not effect the end-of-load voltage because the voltage is introduced for the purpose of common coupling (PCC). The fundamental purpose of a shunt-active filter is to manage the common dc link voltage by compensating for the reactive power consumption of the load. With a twin compensation approach and feed forward management loop, this paper depicts a single-stage three-phase four wire grid connected system. This study's primary objective is to enhance electrical quality, which has been a serious problem in recent years. Solar power is a major difference between this model and previous ones, and because it is a traditional source of energy, pollution levels are considerably lower. The main objective of this

model is to improve efficiency, which reduces line losses by reducing voltage imbalance, voltage sags, transients, and harmonic imbalances. Because this type is built for high-power applications, it contains an IGBT that may be used to start the converter based on the reference voltages. Therefore, IGBT is preferred over MOSFET in order to achieve better results.

II.PROPOSED TOPOLOGY MODELING

2.1 PV-UPQC System Evaluation:

UPQC, as shown in Fig. 2.1, consists of a custom-built power system with series and shunt active filters coupled back-to-back in the dc aspect and a frequent DC capacitor. It uses two VSIs (voltage supply inverters) connected to a single DC power storage capacitor. It is possible to connect two VSIs in series or parallel. The linked shunt active filters are used to compensate for unbalanced loads, rectify the power factor, and maintain the average voltage across the DC storage capacitor. One of the features of this circuit is to remove the switching frequency harmonics that are generated by the shunt voltage-supply-inverter (VSI) that is connected to the frequent DC storage capacitor at the dc facet via the shunt interface inductor. The shunt coupling transformer is used to match the voltages of the network and the VSI.



By injecting voltage in succession with the source voltages, the correction of series active filter payback is carried out while ensuring that the load voltages are balanced, undistorted, and that their magnitudes remain constant. A DC storage capacitor and a series VSI are used to conduct this voltage injection. Based on observed supply and/or load voltages, the control approach generates the necessary switching signals for the series VSI switches. The switching harmonics present in the series VSI output voltages, which now lack the proper sign shape but still contain the series low pass by filter, are removed. As a result, it is possible to modify the injected voltages' amplitude, frequency, phase shift, and harmonic content.

Three fundamental parameters must be chosen when designing a UPQC energy circuit:
• shunt interface inductors; D.C. link capacitor; D.C. link reference voltage

2.2 Control Methodology:

This method is used to create the reference template and modulation methods since the design elements of the current controller largely impact the performance of the active power filter. The inverter gating signals are produced by the control system of a shunt active power filter by computing the current reference waveform for each phase of the inverter and keeping the dc voltage constant. The property of closely matching the reference signal generated to correct for the distorted load current with the least amount of error and delay determines the active power filter's compensation efficiency.

Hysteresis manipulation is a good choice for shunt active filter applications. 2.2.1 Control of the shunt active filter. A hysteresis controller was consequently used inside the UPQC simulation model. Because of its improved response speed, dependability, and advanced device stability, the hysteresis controlling strategy is frequently used.

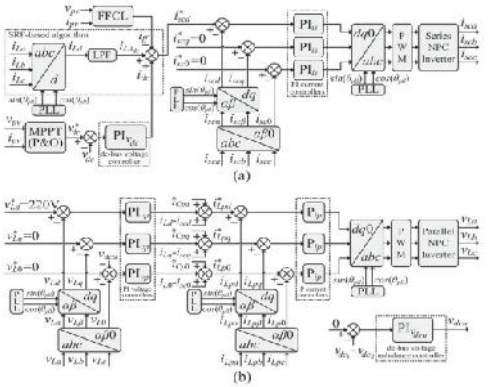


Figure 2.2- Signal float diagrams of the series and parallel-NPC-inverter control loops (a) reference series current control loop and current generation (b) parallel output voltage manipulate loop.

2.2.2 Control of the series active filter:

Injecting the proper voltage between the "point of common coupling (PCC)" and load requires adjusting the UPQC's series component, which produces balanced, distortion-free load voltages of the necessary size. There are two UPQC terms that are defined based on the angle of the injected voltage: UPQC-Q and UPQC-P. The injected voltage in the main example, "UPQC-Q," should be kept at 90 degrees such that the series compensator uses no active energy in a stable condition.

In the second case, "UPQC-P," the injected voltage is in phase with both the deliver voltage and current, so the collection compensator only uses the active energy provided by the shunt compensator through the dc connection. The series compensator needs more capacity in the quadrature voltage injection (UPQC-Q) scenario, but the shunt compensator's VA score is lower, and it also partially offsets the weight's reactive energy requirement in the UPQC-P' scenario, so the shunt compensator is assumed to handle the entire load. The shunt compensator is assumed to also supply the kinetic energy pumped through the collecting compensator. In this case, the series compensator's VA rating will decrease, while the shunt compensator's VA rating would rise.

When the "UPQC-P" manipulating technique is employed, the supply voltage is in phase with the injected voltage and as a result, the load voltage is also in phase, negating the need to compute the attitude of the reference load voltage. As a result, the reference load voltage is obtained by multiplying the reference magnitude by the reference load voltage (which is constant) utilising a source voltage-phase-locked sinusoidal template. After that, the reference series filter voltage is determined. We can draw the conclusion that the UPQC-P algorithm is superior since it involves the least amount of computation when comparing the two approaches for figuring out the reference voltage of a series compensator. In the UPQC-P case, the voltage rating of the series compensator is drastically reduced. Furthermore, when the load is "purely resistive," the UPQC-Q adjustment mechanism is inactive. Instead, the UPQC-P control approach was employed.

III. ANN's introduction:

Numerous electrical applications make use of neural networks. Artificial neural networks are a form of technology. The phrase "smartmanipulate" has recently come to refer to a wide range of methodologies that combine traditional manipulation with emergent strategies that are entirely based on physiological metaphors, including ANNs, fuzzy logic, and ANNs, which have been studied for decades in the pursuit of knowledge and achieving human-like computational performance. These benefit from their slow pace, high fault tolerance, and adaptability. The fundamental and intricately interconnected processing elements of an artificial neural network (ANN) as a computing system are their dynamic state responses to external inputs. Because they have the potential to provide solutions to several computer science and artificial intelligence problems that standard serial computers have hitherto been unable to address, ANN models have recently been a rapidly growing area of study. Neural networks are more suited to achieving human-like performance in the control of robotics, image recognition, voice processing, and other tasks.

3.1 Controller for ANN:

To improve the performance of the compensating device, an ANN controller of the multilayer back propagation type is used. The MATLAB toolbox is used to train the ANN. Levenberg Marquardt Back propagation is the training method used by the ANN controller. A first-order optimization method called the Gradient Descent (GD) Method is used to determine the local minimal of a given function. This method is robust when it starts off evolving far from the closing minimal, but it has poor very last convergence. The LM lower back propagation algorithm, which interpolates between the GD and the Gauss Newton (GN) algorithms, is the second order optimization set of rules. Despite starting off extremely far from the previous optimum in terms of evolution, the resilient LM approach provides a solution. The LM set of rules is superior to both the GN set of rules and the GD method.

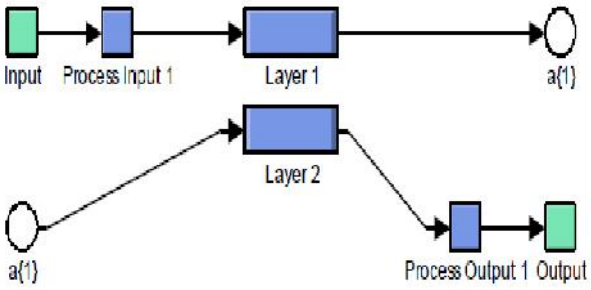


Fig 3.1 ANN controller

1V. SIMULATIONS AND RESULTS

A UPQC simulation version was developed in MATLAB/Simulink to analyse UPQC circuit waveforms and assess dynamic and steady-state performance as well as voltage and current ratings.

The results of the ensuing not exceptional site case study simulations are provided.

1. Short-lived three-phase fault situations.
2. Long-lasting three-phase fault situations.
3. Dynamic load and three-phase fault circumstances
4. Harmonic compensation
5. The DC link voltage regulation is likewise confirmed for the cases mentioned above.

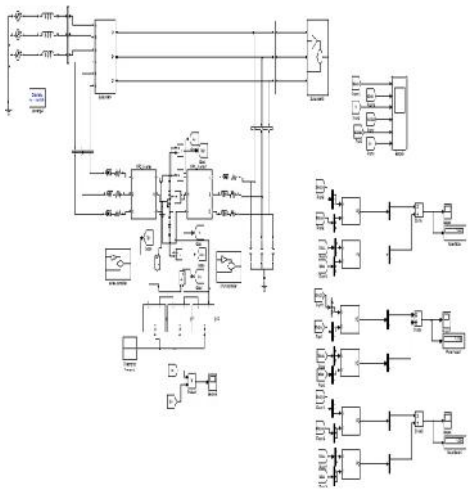


Figure 4.1: PV-UPQC system simulation block diagram coupled to conventional electricity distribution system.

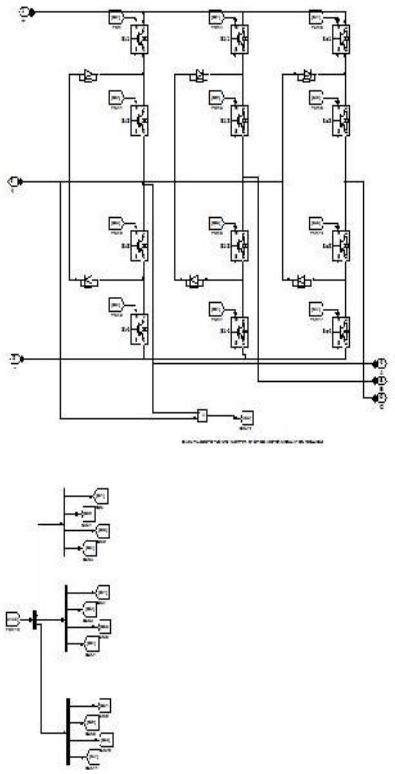


Figure 4.2: MATLAB software setting of an NPC inverter.

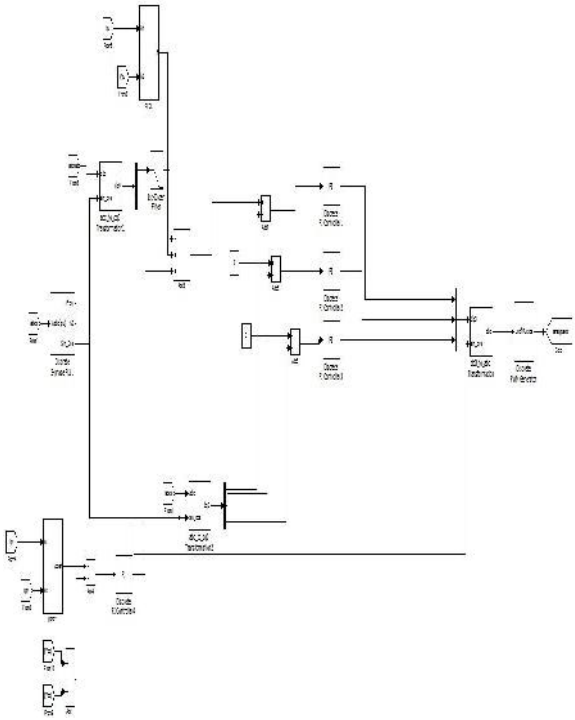


Figure 4.3: Series converter simulation block diagram

The preceding is simulated for several instances. The results achieved in various scenarios are displayed below.

Case 1:

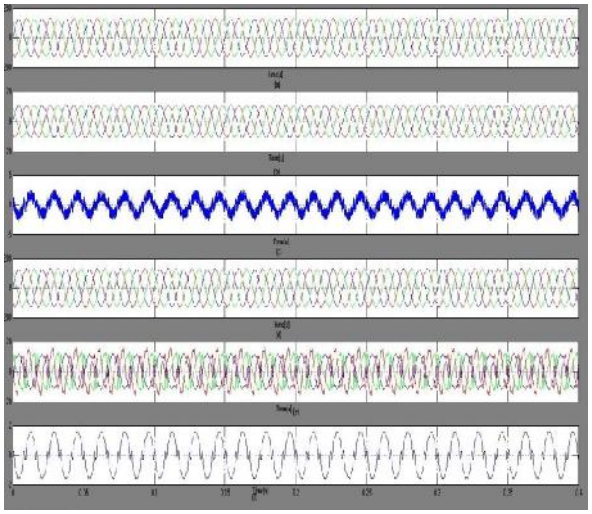


Figure 4.4: OPM 1 (load 1): PV-UPQC using simply the active power filter with Ppv=0W.

(a)grid voltages(Vsa,Vsb,Vsc)
(b)grid currents(Isa,Isb,Isc,Isn)
(c)load voltages(Vla,Vlb,Vlc)
(d)load currents(Ila,Ilb,Ilc)

(e)load currents(Iln)[neutral]

Case 2:

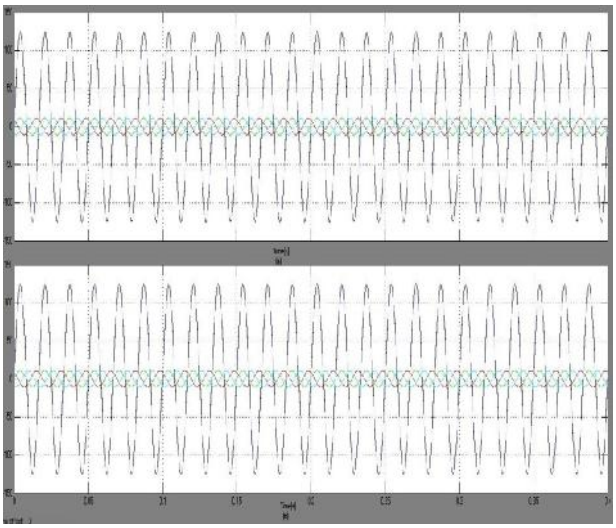


Figure 4.5: OPM 2 (load 2): PV-UPQC injecting active power into the grid with Pl=0W and Ppv=3000W (a)grid voltage (Vsa) and grid currents (Isa,Isb,Isc) (b)load voltage (Vla) and parallel-NPC-inverter currents (Ipca,Ipcb,Ipcc)

Figure 4.5 depicts static findings for a PV-UPQC system injecting active power into the grid, with the load removed and only active power injected into the grid, and we can see that the source currents are sinusoidal and in opposite phase to the relevant utility voltage.

Case 3:

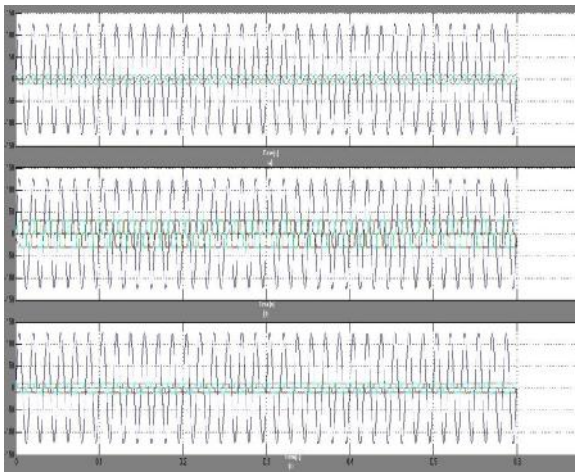


Figure 4.6(a) -OPM 3 (load 2):PV-UPQC performs active power injection and active filtering with Ppv>Pl a)Grid voltage(Vsa) and grid currents(Isa,Isb,Isc)

(a) Load voltage(Vla) and parallel NPC inverter currents(Ipca,Ipcb,Ipcc)
(b) Load voltage(Vla) and load currents(Ila,Ilb,Ilc)

V.CONCLUSION

A single-stage, three-phase, four-wire grid-connected PV system that can act as both an FFCL and a UPQC with a dual compensating technique was proposed in this study. The PV-UPQC system's two back-to-back linked three-level NPC inverters were used. Series-parallel power line conditioning could be done by the PV-UPQC system in addition to supplying active power from the PV setup. In order to assess the system's static and dynamic performance, perturbed grid voltage conditions such harmonics, sags, and unbalances were used. In addition to series compensation, effective power factor correction was achieved by suppressing load harmonic currents and compensating load reactive power. The effect of the FFCL on the current references for series converters. The effectiveness of the FFCL using the series converter current references was sufficiently tested with rapid changes in solar irradiation. In this study, an artificial neural network (ANN) controller is suggested for lowering overall harmonic distortion (THD). As a result, both DG systems and AC microgrids may benefit from the suggested PV-UPQC system.

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