Performance Study on PV Integrated UPQC under Unbalanced load Conditions

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***Abstract* - The design and standard performance of a 3-phase single-stage solar photovoltaic integrated-unified power quality conditioner described in this article (PV-UPQC). Shunt and series attached voltage control scheme are connected back-to-back with standard DC-link in the PV-UPQC. The drain compensator serves a dual purpose: it extracts electricity from the PV array it also correcting for load voltage harmonics. PVUPQC's performance improves as a result of this. The suggested structure provides the best of clean energy generation with improved power supply. The project strength and deformation capabilities are estimated using MATLAB-Simulink simulations under a non-linear load. Overvoltage fluctuations are used to test the study's validity. In other words, only the R-phase provides sag/swell circumstances, while the remaining two phases provide continuous supply. The system's method is measured using a fuzzy management system under imbalanced load circumstances such as sag and swells.**

I.INTRODUCTION

With the progress of computer chips, the penetration of strength loads has increased dramatically. Voltage observation is caused by non-linear currents at the dc link, especially in distribution networks. Because of the switching nature of PV energy sources, growing penetration of such infrastructures, such as weak utility grid, causes voltage quality issues, such as power system and swells, which actually results to grid disruption. The electricity quality issues are causing frequent false trips and malfunctions of electric power systems, tele communication technologies, and heat saturation of inductors and capacitors. Present electric utilities have power quality concerns on both the load and infrastructure sides, which are major challenges.

There has been a lot of study on combining electricity generation with finite impulse response filtering. Despite the fact that shunt active filtering can regulate both load current and voltage, it would do so by injecting switching frequency. As a result, shunt proactive filtering is unable to manage both PCC volts and grid flow input power factor at the same time. Maximum voltage performance standards for complex electronics workloads, series digital filters have been recommended for use in small residences and commercial buildings [1]. An active power line conditioner is superior to parallel and series voltage filters (UPQC).

The production of a carrier frequency is a major difficulty in PVUPQC supervision. Approaches for generating reference signals may be divided into two categories: period and spectral methods. Because real-time performances need less processing, time-domain techniques are widely employed. Torque ripple theory and instantaneous three phase theory are both often utilized methods.

When utilizing the stationary reference philosophy technique, the main problem is that when the load is kept imbalanced, the D-axis current has double high frequency components. Low pass screens with low cut-off frequencies are used to eliminate the double high frequency components [2]. As a result, our dynamic behavior is weak. A MAF (moving average filter) can be used to gather intrinsic load active present and screen the d-axis potential, which offers optimum attenuation with reducing controller frequency. “An MAF-based d-q supposition control is utilized to improve performance characteristics during load grid current extraction”. The primary benefits of this idea are as follows:

1. Clean renewable energy development and improved electricity quality are combined. The development of synchronized voltage or current performance.
2. Stack regulation has been improved.
3. Under a variety of development conditions such as power losses and swells, weight imbalance, and irradiation fluctuation, it remained stable.

With the help of the Mat lab software, the proposed technique is briefly examined in steady - state and transient circumstances.

II.SYSTEM CONFIGURATION AND DESIGN

The PV-UPQC setup is shown in Figure 1. It's made for a three-phase system. A shared DC-bus connects the series and parallel flash suppressors. At the load side, a shunt buffer is connected. The solar PV array is directly linked to the DC-link through a reverse current diode [5]. The series attenuator adjusts for grid voltage sags and swells using a voltage management technique.

Bidirectional communication inductors connect the voltage source inverter capacitors to the grid. The voltage generated is introduced into the grid through a series injection transformer [2]. Ripple filtered are used to filter waves that are created when converts are swapped. A nonlinear load, consisting of a bridge rectifier and a voltage-fed load, is used [6].

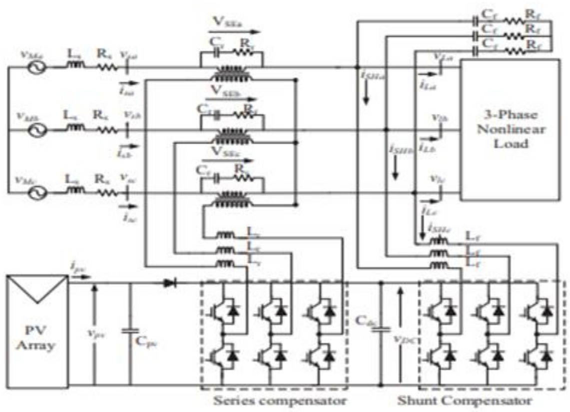


Fig.1. System Configuration PV-UPQC

A. Design of PV-UPQC

The PV-UPQC design approach begins with the precise size of a PV array, DC-link resistor, and other components. The PV array is connected directly to the DC-link, that is sized to match the MPP energy to the Dc power [1].

(a) Voltage Magnitude of a DC-Link (Vdc): "The Vdc depends on modulation and phase wise voltage. It should be more than double the peak of per-phase voltage of the three phase system".

$$Vdc = \frac{2\sqrt{2Vll}}{\sqrt{3m}}$$

Where

Depth of modulation (m) = 1

VLL = grid line voltage.

For 415V line voltage, the minimum DC-bus voltage necessary is 677.7V. DC-bus voltage is set at 700V approximately, identical to MPPT operating voltage of PV array at Standard conditions.

B) DC-Bus Capacitor Rating (Cdc): The DC-link capacitor is sized depending on power and DC-bus voltage requirements. The energy balance is given as,

$$Cdc = \frac{3KaVphIsht}{0.5 \times (Vdc2 - Vdc12)}$$

$$\frac{3 \times 0.1 \times 1.5 \times 239.6 \times 34.5 \times 0.03}{0.5 \times (700 - 77.79)}$$

$$9.3\mu f$$

Where

Vdc = average DC-bus voltage = 700V

Vdc1= minimum DC-bus voltage = 677.69V

A= overloading factor = 1.2

Vph = per-phase voltage= 239.60V

t = minimum time required for attaining steady value after a disturbance = 30 ms

Ish = per-phase current of shunt compensator =57.5A

k factor = variation in energy during dynamics. = 0.1

The value of Cdc is equal to 9.3 mF.

a) Shunt Suppressor Bidirectional communication Inductor (Lf). The ripple flow, operating frequency, and Dc generator all have a role. Lf is the value of the interface circuit,

$$Lf = \frac{\sqrt{3mVdc}}{12afshIcr} = \frac{\sqrt{3} \times 1 \times 700}{12 \times 1.2 \times 10000 \times 6.9}$$

$$= 800\mu H \cong 1mH$$

Where

m= depth of modulation =1

a = pu value of maximum overload=1.2

fsh= switching frequency = 10kHz

Icr,pp= inductor ripple current = 20% of rms phase current of shunt compensator. =1mH

Vdc=700V,

b) The PV-UPQC is designed to compensate for sag/swell (0.3pu), which is 71.88 V. Load Current

Separator (Kse): The PV-UPQC is designed to compensate for sag/swell (0.3pu), which is 71.88 V. As a result, the injector voltage is 71.88 V, leading to a lower proportional gain for something like the operational amplifier. The pulse width should be close to unity to run the series absorber with the lowest distortion.

$K_{SE}= V_{vsc}/V_{SE} =_{3.33} \approx 3$

The rating of Kse is SSE.

SSE = 3 × 72 × 46 = 10 kVA

"The current in series VSC is equal to grid current. The supply current at sag state of 0.3 pu is equal to 46 A. Therefore, VA rating is calculated as 10 kVA".

c) Interfacing Inductor of Series Compensator(Lr):

$Lr = \sqrt{3} \times \frac{mVdcKse}{12afselr} = \frac{\sqrt{3}\times1\times700\times3}{12\times1.2\times10000\times7.1}$

=3.6mH

Where m = depth of modulation =1

a = pu value of maximum overload = 1.5

fse = switching frequency = 10 kHz

Ir = inductor current ripple= 20% of grid =3.6mH

Vdc=700 V

III.CONTROL OF PV-UPQC

The shunt stabilizer compensates for problems with load power efficiency such as load fault current & load voltage level. Using the MPPT algorithm, the shunt compensator also provides electricity from the photovoltaic Panel. By injecting an appropriate voltage in parallel with transmission line, the series modulator protects the client to voltage regulation power quality concerns.

A. Control of the Shunt Compensator

The shunt generates peak energy by operating the Solar OV array at max power. The resistance value for the DC-link is generated using the Mathematical model. The Flc keeps the DC-link voltage constant.

For fiscal stimulus using the SRF approach, a shunt absorber acquires the active core pillar of the load-current. The PCC voltage is the PLL input. ILd is filtered to gain Harmonic components ILdf without any performance degradation and a MAF (autoregressive integrated moving filter) is used as the frequency response.

$$MAF(S) = \frac{1 - e^{-Tws}}{Tws}$$

Where

Tw = window length of average filter.

The equivalent current component is

$$Ipvg = \frac{2\,Ppv}{3Vs}$$

Where

Ppv = PV array power

Vs = magnitude of the PCC voltage.

The reference grid current (I*sd) present in the d-axis is

$$I^*_{sd} = I_{Ldf} + I_{loss} - I_{pvg}$$

I*sd is changed to domain reference of abc grid current. To generate the gating pulses, I*sd is equated with sensed grid currents by hysteresis current controller.

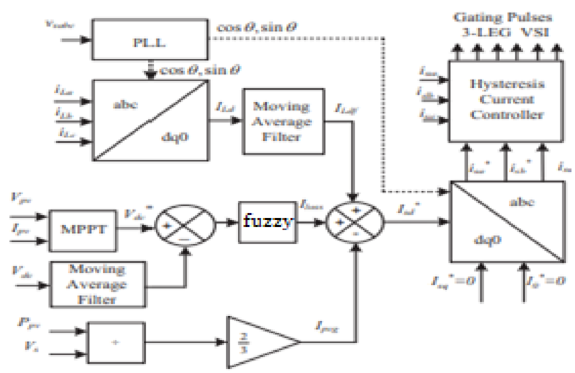


Fig.2. Control Structure of Shunt Compensator

B. Control of Series Compensator

Here, the series compensator inserts voltage in identical phase similar to grid voltage. The primary component of a PCC voltage is gained by using PLL. The discrepancy between it load benchmark and the PCC potential, which is comparable to the real series compensating voltages, determines the sinusoidal waveform. It is fed into Fuzzy controllers to generate appropriate reference messages. To create positive sequence for the voltage regulator, these reference signals are converted to the abc domain and fed using a (PWM) width modulation (spwm control technique.

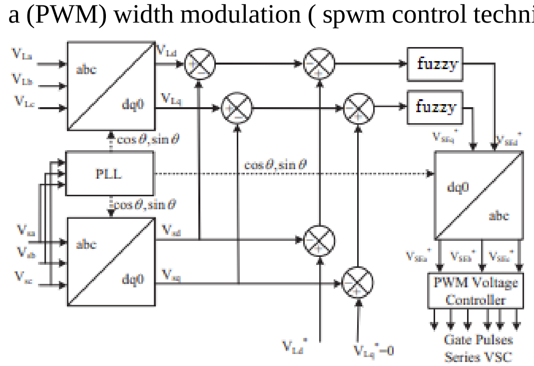


Fig.3. Control Structure of Series Compensator

Fuzzy logic control:

Pattern recognition is a non - linear and non logic that allows for the definition of alternative standards between traditional assessments in order to deal with ambiguous, incorrect, and emotional decision-making issues. Mathematical models are used to help machines reason more intelligently. It's a logical calculated procedure based on the 'IF-THEN' application is needed that mimics human algorithmic form processing. There are four parts to a fuzzy set of rules:

1. Fuzzification
2. Fuzzy Inference
3. Rule base
4. De-fuzzification

The process of transforming arithmetic variables (real number) into linguistic variables (fuzzy number) is termed as Fuzzification.

IV.SIMULATION STUDIES

The PV-steady UPQC's and static gaze performances is investigated using Matlab program. The load is a multiple diode bridge-rectifier with R-L load that contains a regressive load. This step size utilized by the solver is 1e-6s. The component is subjected to a variety of dynamic statements conditions, such as PCC voltage fluctuations and swells.

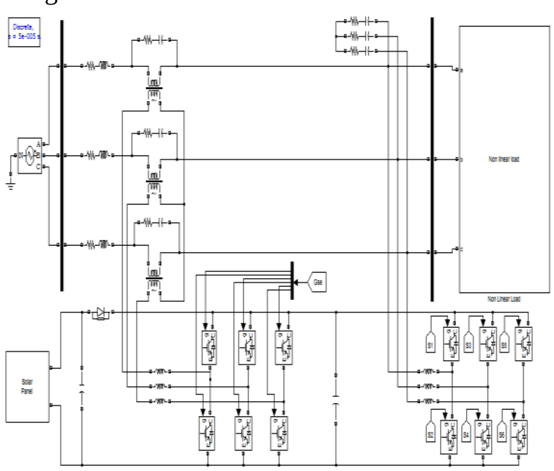


Fig: 4.simulation modeling of the proposed system

Among0.8s to 0.85s, “voltage swell (0.3pu) is present. and from 0.7s to 0.75s, a voltage sag (0.3pu) The series compensator re composes grid voltage by inserting a proper voltage vSE to opposite phase with the grid voltage disruption to keep the load-voltage at rated voltage”.

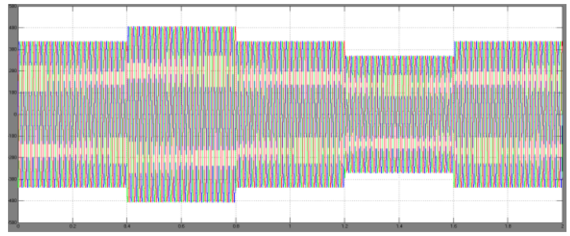


Fig:5.Source voltage due to voltage swell and sag conditions

Fig: 5. Performance of PV-UPQC under Voltage Sag/Swell Settings

1. Performance of PV-UPQC at Load Unbalancing Condition:

At t=0.8s phase-b of load is separated. The grid current is sinusoidal. It is at a unity PF (power factor). Due to decrease in total effective load, the current injected into the grid increases. DC-link voltage is stable, kept near 700 V ideal voltages.

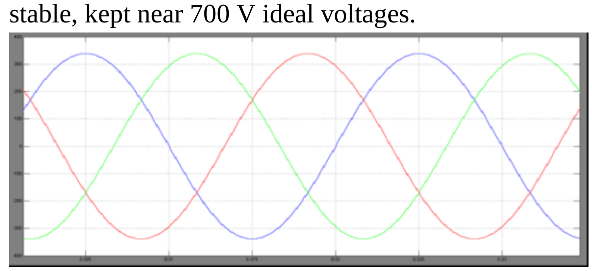


Fig: 6.Source voltage at load unbalanced

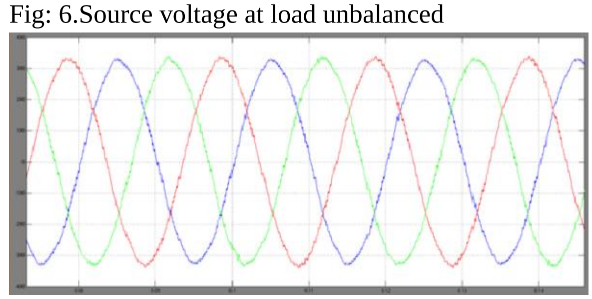
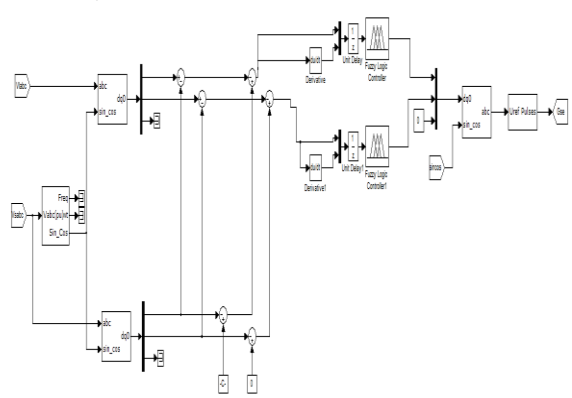


Fig: 7. Load voltage: unbalanced load

2. Performance of a PV–UPQC along with fuzzy control system.



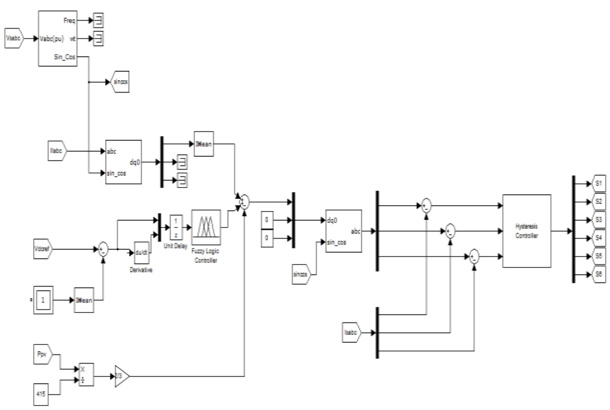


Fig: 8.Simulation model of PWM - shunt converter with fuzzy-logic controller

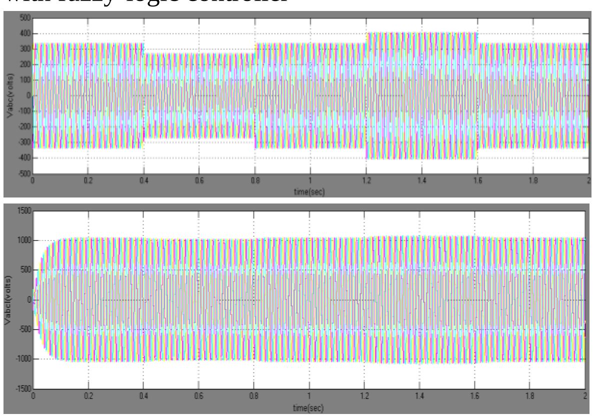


Fig: 9. (a) Simulation results of Source voltage (b) Simulation results of load voltage

V.CONCLUSION

The construction and performances of three-phase PV - UPQC have just been investigated under semi load circumstances. The system appears to be in a stable state. Using MAF improves the performance of d–q control, especially in unbalanced load circumstances (moving average filter). PV-UPQC is an excellent example of a contemporary transmission system that incorporates remote generating and improves power quality.

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