

Multi Converter Based Power Quality Improvement in Renewable Energy System Using UPQC Compensator

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Abstract- This paper investigates the power quality improvement on green energy source at generating side and grid side of power system. Now a day's increasing the utility of power due to industrials and cultivations, such that problems also increases the sag, swell, real power, reactive power, transients and harmonics it will causes the disturbances in power system, to overcome this problems in this paper use the matrix and boost converter at one of the renewable energy generating side and unified power quality conditioner (UPQC) in grid system. The modeling and simulation with renewable energy sources connected one of the 50 bus system using unified power quality conditioner (UPQC).digital simulation using MATLAB/SIMULINK is done and the results are presented .The effect of UPQC on real power, reactive power, sag, swell, transients and harmonics is also presented.

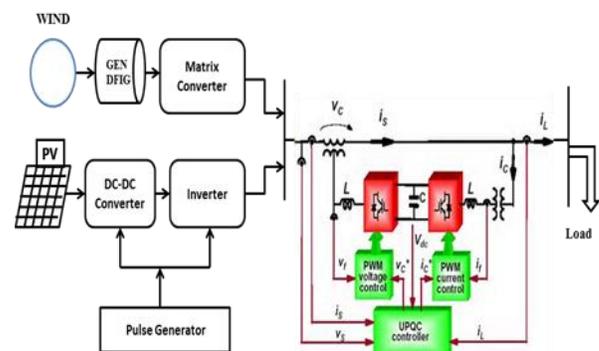
Index Terms- Wind and Solar Energy, DFIG, Matrix Converter UPQC, voltage fluctuation, weak Grid.

I. INTRODUCTION

The renewable energy sources wind and solar connected to the grid through (matrix and boost) converters. The wind energy obtained from the kinetic energy of air due to temperature and pressure of land and water. The DFIG is variable wind from kinetic energy convert to electrical energy with help of mechanical turbine and varying the rotor excitation through the back to back converter from the grid power. Above super synchronous speed operation it fed power from both stator and rotor to the grid with constant voltage and frequency matches with grid. The matrix converter uses the matrix of switches so that any of the input phase voltage can be connected to any of output of load phases, there is exactly one switch for each of possible connection between supply and load. Its provides bidirectional power flow, sinusoidal input/output currents, and controllable input power factor. The pv panel absorb the solar radiation from the sun by maximum power point tracking and converted to dc current by using of photovoltaic method. By using of the boost increase the voltage level and gives to the inverter through the dc link, it will smooth the voltage level. The inverter operates based on the power electronics switches to turn ON and OFF of the switches depend upon the grid power matches, it synchronization with grid. Whenever heavy load is connected tapping from the grid voltage sag, swell, real, reactive power and also harmonics problems occur to overcome this FACTS controller device compensation to overcome this

problems .In this paper the unified power quality conditioner used to overcome the problems.

II. BLOCK DIAGRAM



III. OPERATING PRINCIPLE OF UPQC

Due to the extensive use of power electronic based equipments/loads almost in all areas, the point of common coupling (PCC) could be highly distorted [1]-[3]. The switching ON/OFF of high rated load connected to PCC may result into voltage sags or swells on the PCC. There are several sensitive loads, such as computer or microprocessor based AC/DC drive controller, with good voltage profile requirement; can function improperly or sometime can lose valuable data or in certain cases get damaged due to these voltage sag and swell conditions. One of the effective approaches is to use a unified power quality conditioner (UPQC) at PCC to protect the sensitive loads. A UPQC is a combination of shunt and series APFs, sharing a common dc link. It is a versatile device that can compensate almost all power quality problems such as voltage harmonics, voltage unbalance, voltage flickers, voltage sags & swells, current harmonics, current unbalance, reactive current, etc. The Unified Power Quality Conditioner (UPQC) has evolved to be one of the most comprehensive custom power solutions for power quality issues relating to non-linear harmonic producing loads and the effect of utility voltage disturbance on sensitive industrial loads. To investigate the performance of the proposed control schemes for the UPQC, simulations are carried out and validated with experimental results.

IV. SYSTEM CONFIGURATION

The system configuration for UPQC is shown in the Fig.1. The voltage at PCC may be or may not be distorted depending on the other non-linear loads connected at PCC. Also, these loads may impose the voltage sag or swell condition during their switching ON and/or OFF operation. The UPQC is installed in order to protect a sensitive load from all disturbances. The UPQC consists of two voltage source inverters connected back to back, sharing a common dc link. Each inverter is realized by using six IGBT switches. One inverter is connected parallel with the load, acts as shunt APF, helps in compensating load harmonic current, reactive current and maintain the dc link voltage at constant level. The second inverter is

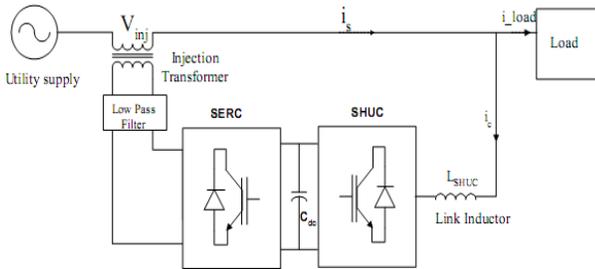


Fig.1 Block Diagram of UPQC

connected in series with the line using series transformers, acts as a controlled voltage source maintaining the load voltage sinusoidal and at desired.

V. STEADY STATE POWER FLOW ANALYSIS

The UPQC is controlled in such a way that the voltage at load bus is always sinusoidal and at desired magnitude. In the following analysis the load voltage is assumed to be in phase with terminal voltage even during voltage sag and swell condition. In this particular condition, the series APF could not handle reactive power and the load reactive power is supplied by shunt APF alone [5].

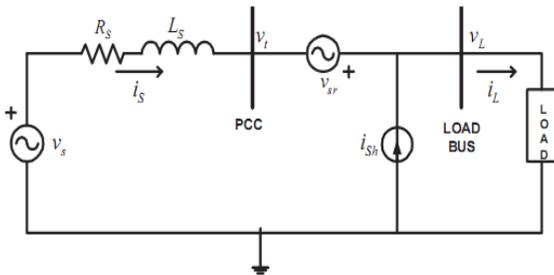


Fig.2 Equivalent Circuit of a UPQC

The source voltage, terminal voltage at PCC and load voltage are denoted by \$V_s\$, \$V_t\$ and \$V_L\$ respectively. The source and load currents are denoted by \$i_s\$ and \$i_L\$ respectively. The voltage injected by series APF is denoted by \$V_{Sr}\$, whereas the current injected by shunt APF is denoted by \$i_{sh}\$. Taking the load voltage, \$V_L\$, as a reference phasor and suppose the lagging power factor of the load is \$\cos \Phi_L\$ then we can write; [5]

$$V_L = V_L \angle 0^\circ \quad (1)$$

$$I_L = I_L \angle -\Phi_L \quad (2)$$

$$V_t = V_L(1+k) \angle 0^\circ \quad (3)$$

Where factor \$k\$ represents the fluctuation of source voltage, defined as,

$$k = \frac{V_t - V_L}{V_L} \quad (4)$$

The voltage injected by series APF must be equal to,

$$V_{Sr} = V_L - V_t = -k V_L \angle 0^\circ \quad (5)$$

The UPQC is assumed to be lossless and therefore, the active power demanded by the load is equal to the active power input at PCC. The UPQC provides a nearly unity power factor source current, therefore, for a given load condition the input active power at PCC can be expressed by the following equations,

$$P_t = P_L \quad (6)$$

$$V_t \cdot i_s = V_L \cdot i_L \cdot \cos \phi_L \quad (7)$$

$$V_L(1+k) \cdot i_s = V_L \cdot i_L \cdot \cos \phi_L \quad (8)$$

$$i_s = i_L / (1+k) \cdot \cos \phi_L \quad (9)$$

The above equation suggests that the source current \$i_s\$ depends on the factor \$k\$, since \$\phi_L\$ and \$i_L\$ are load characteristics and are constant for a particular type of load. The complex power absorbed by the series APF can be expressed as,

$$S_{Sr} = V_{Sr} \cdot i_s^* \quad (10)$$

$$[1]$$

$$P_{Sr} = V_{Sr} \cdot i_s \cdot \cos \phi_s = -k \cdot V_L \cdot i_s \cdot \cos \phi_s \quad (11)$$

$$Q_{Sr} = V_{Sr} \cdot i_s \cdot \sin \phi_s \quad (12)$$

$$\phi_s = 0, \text{ since UPQC is maintaining unity power factor}$$

$$P_{Sr} = V_{Sr} \cdot i_s = -k \cdot V_L \cdot i_s \quad (13)$$

$$Q_{Sr} \approx 0 \quad (14)$$

The complex power absorbed by the shunt APF can be expressed as,

$$S_{Sh} = V_L \cdot i_{sh}^* \quad (15)$$

The current provided by the shunt APF, is the difference between the input source current and the load current, which includes the load harmonics current and the reactive current. Therefore, we can write;

$$i_{sh} = i_s - i_L \quad (16)$$

$$i_{sh} = i_s \angle 0^\circ - i_L \angle \phi_L \quad (17)$$

$$i_{sh} = i_s - (i_L \cdot \cos \phi_L - j i_L \cdot \sin \phi_L) \quad (18)$$

$$i_{sh} = (i_s - i_L \cdot \cos \phi_L) + j i_L \cdot \sin \phi_L \quad (19)$$

$$P_{Sh} = V_L \cdot i_{sh} \cdot \cos \phi_{sh} = V_L \cdot (i_s - i_L \cdot \cos \phi_L) \quad (20)$$

$$Q_{Sh} = V_L \cdot i_{sh} \cdot \sin \phi_{sh} = V_L \cdot i_L \cdot \sin \phi_L \quad (21)$$

When a sag is detected such that \$|V_{s2}| < |V_{s1}|\$ (rated), then for UPQC-Q, \$V_{inj}\$ is calculated from as. [21]

$$V_{inj2} = (V_{s1} - V_{s2})$$

Now from PWM method \$\sqrt{2} V_{inj} = MI (V_{dc}/2)\$, where \$MI\$ is the desired modulation index (\$MI\$). Therefore,

$$MI = (2\sqrt{2} \cdot V_{inj}) / V_{dc}$$

If x is the p. u. sag to be mitigated, minimum dc link voltage would be $V_{dc} = 2\sqrt{2} * \sqrt{x(2-x)} * V_{s1}$, for maximum value of $MI = 1$ (taking the injection transformer turns ratio to be 1:1).

VI. CONTROL SCHEMES FOR UPQC

The control strategy is basically the way to generate reference signals for both shunt and series APF. The effectiveness of the UPQC depends on its ability to follow the reference signals with a minimum error to compensate the voltage sag and swell or any other undesirable condition. The series APF acts as a controlled voltage source. The shunt APF acts as a control source for maintaining the DC link voltage. The shunt APF also provides required var to the load such that the power factor at PCC is unity and only fundamental active power is supplied by the source. The voltage injected by series APF can be varied from 0° to 360° . The series injected voltage has to be in phase (out of phase) with PCC voltage to compensate voltage sag swell.

VII. SIMULATION RESULTS

The IEEE 50 bus system is modeled using matlab and it is simulated using the blocks of simulink. Each line is represented by the respective impedance. The generators in the network are represented as voltage sources and Renewable energy source. The load at the load bus is represented as combination of R and L. The stimulant model of 50 bus system is shown in Fig. 1. The voltage of bus 21 is shown in Fig. 2. Real and reactive powers at bus 21 are shown in Figures 3 and 4. Total harmonic distortion at Fig 5. The MATLAB simulink model of IEEE Fifty bus system with Unified power quality conditioner compensator is shown in Fig.6. Voltage, real, reactive and total harmonic distortion wave foam at Fig.7,8,9,10. The wind model and its wave foams at Fig.11,12. The matix converter and its wave foams at Fig.13,14. The modeling of upqc ,solar mode,output of solar,boost converter with solar model and its wave foam shows at Fig.15,16,17,18,19.

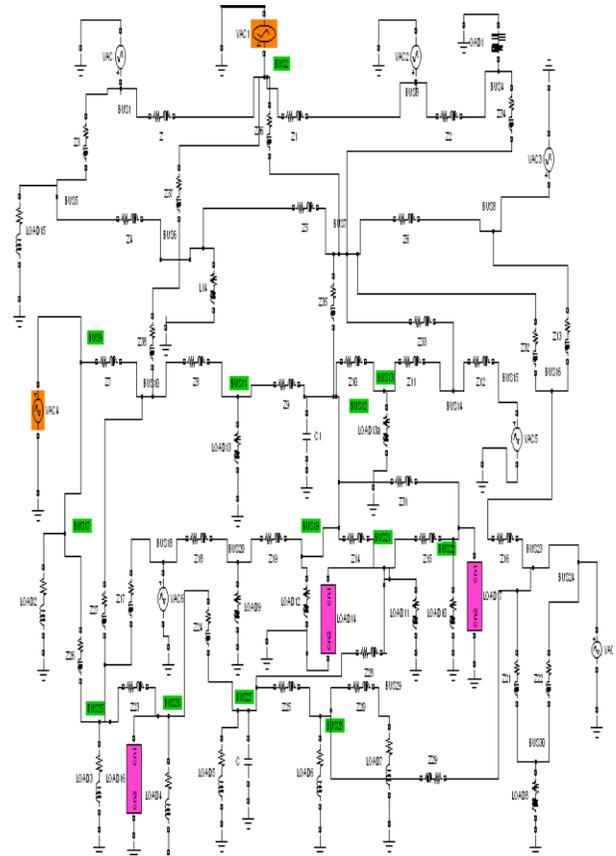


Fig.1. Modeling Of Fifty Bus System Without Upqc

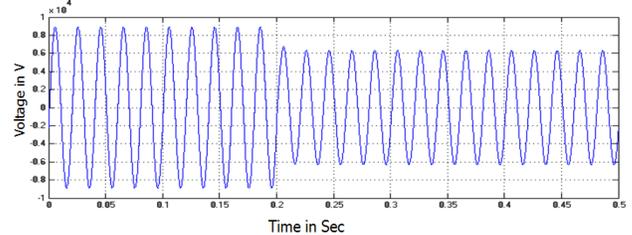


Fig.2. Voltage At Bus-21

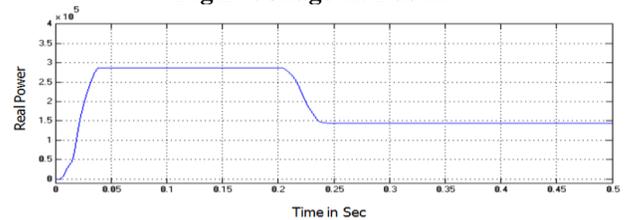
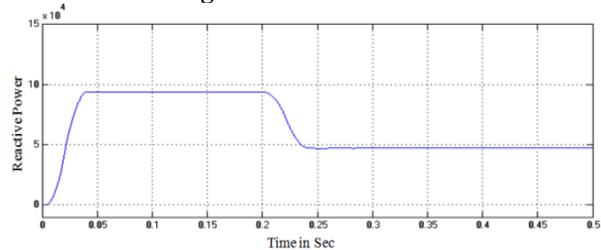


Fig.3. Real Power At Bus 21



Reactive Power At Bus 21

Fig.4.

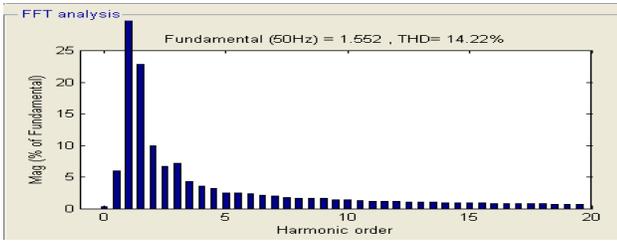


Fig.5. Total Harmonic Distortion(THD)

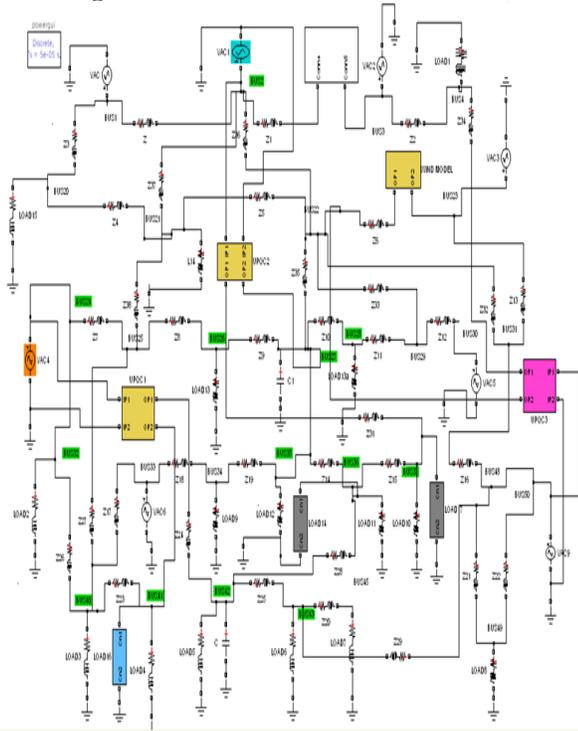


Fig.6. Modelling Of fifty Bus System With Upqc

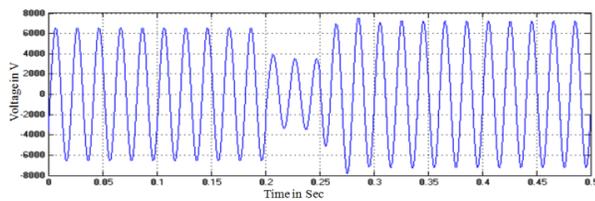


Fig.7. Voltage At Bus 12

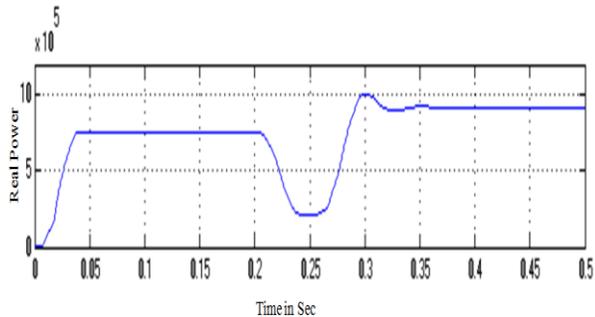


Fig.8. Real Power At Bus 12

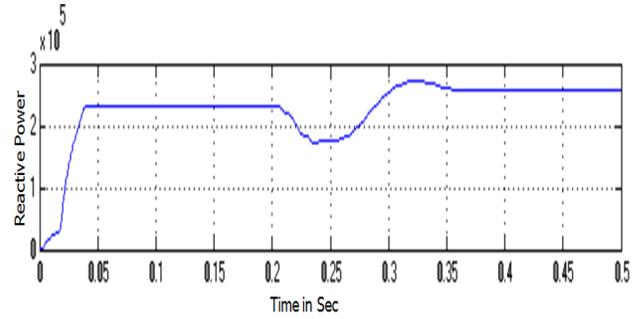


Fig.9. Reactive Power At Bus 12

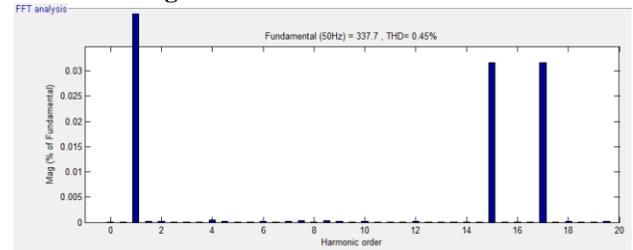


Fig.10. Total Harmonic Distortion (THD)

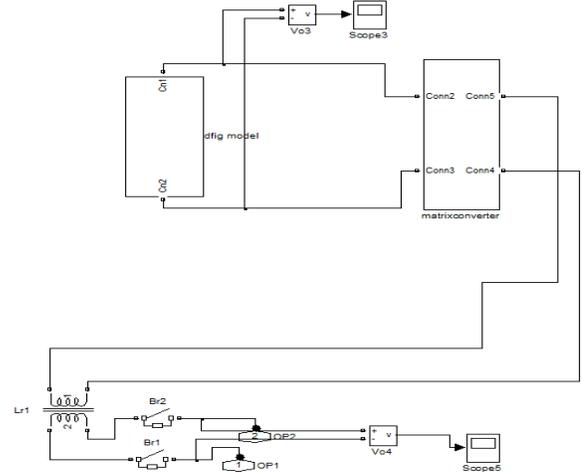


Fig.11. Wind modeling

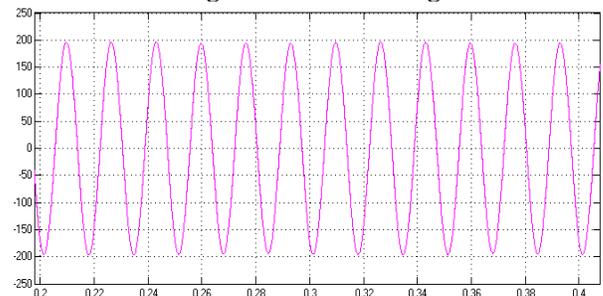


Fig.12. Wind output voltage

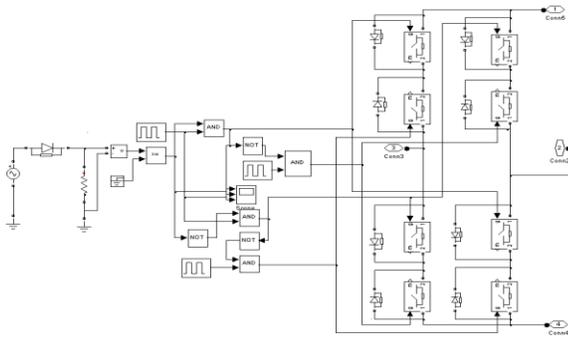


Fig.13. Matrix converter model

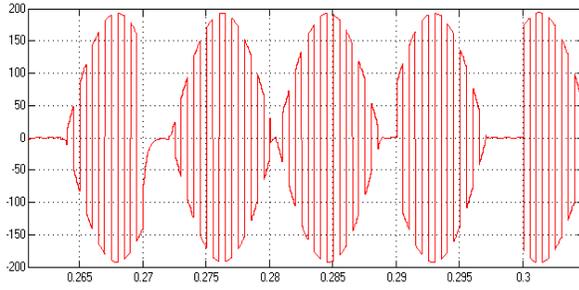


Fig.14. Matrix converter output voltage

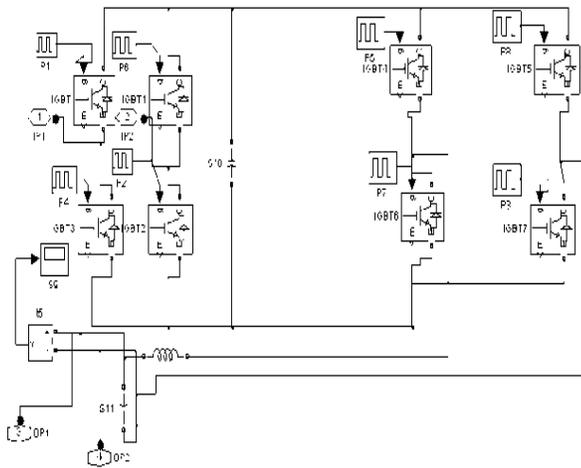


Fig.15. Modeling Of UPQC

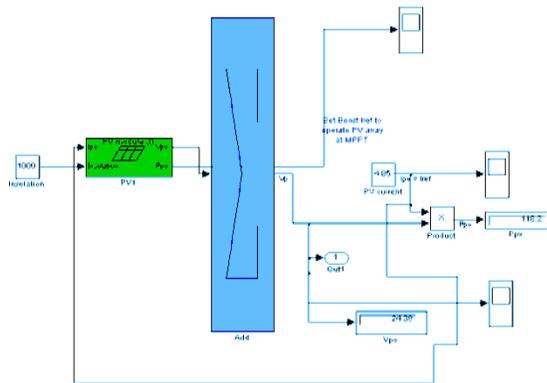


Fig.16. Solar model

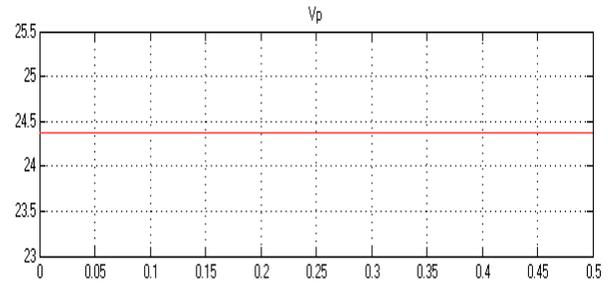


Fig.17. Solar output voltage

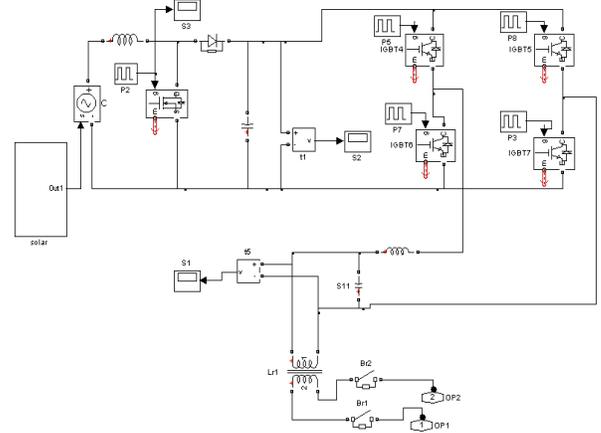


Fig.18. Solar with boost converter

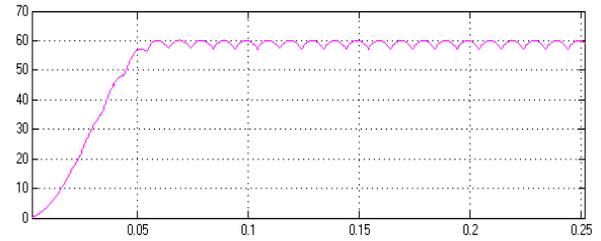


Fig.19. Solar output voltage after boost converter

VIII. TABLE COMPARISON

BUS NO	REAL POWER WITHOUT UPQC (MW)	REAL POWER WITH UPQC (MW)	REACTIVE POWER WITHOUT UPQC (MVAR)	REACTIVE POWER WITH UPQC (MVAR)
BUS1	0.277	0.275	0.304	0.352
BUS2	0.263	0.272	0.301	0.348
BUS3	0.42	0.575	1.32	1.801
BUS4	0.378	2.431	2.210	2.788
Bus-5	0.321	0.442	2.23	2.791
Bus-6	0.311	0.378	2.27	2.810
Bus-7	0.321	0.358	2.26	2.842
.
Bus-50	1.681	2.781	2.89	2.987

IX. CONCLUSION

A 50 bus system is modeled and simulated with and without UPQC. It has been found that the UPQC is controlling the flow of power at capable of a desired point on the transmission line. It is also observed that the UPQC injects a fast changing voltage in series with the line. Based on obtained simulation results the performance of the UPQC has been examined in a 50 bus system, and applications of the UPQC will be extended in future to a complex system to investigate the problems related to the various problems of power issues in the power systems.

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