PERFORMANCE OF UNIFIED POWER QUALITY CONDITIONER IN DISTRIBUTION SYSTEM FOR POWER QUALITY IMPROVEMENT

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Abstract— The power quality is more concerned issue that is becoming increasingly important to electricity consumers at all levels of usage. The power quality is the combination of voltage and current quality. The main causes of a poor power quality are harmonic currents, poor power factor, supply voltage variations etc. The quality of power is affected by many factors like harmonic contamination due to non-linear loads such as thyristor power converters, rectifiers, voltage and current flickering due to arc in arc furnaces, sag and swell due to the switching of the loads etc. One of the many solutions is the use of a combined system of series and shunt active filter like unified power quality conditioner. The UPQC is one of the APF family members where series and shunt APF functionalities are integrated together to achieve superior control over several power quality problems simultaneously. This device mitigates any type of voltage and current fluctuations and power factor correction in a power distribution network. This paper proposes a new configuration that consist of series active power filter, shunt active power filter, photovoltaic system and wind generation system connected across DC link capacitor. The proposed system can compensate voltage sag/swell, voltage interruption and harmonics from current and also supply active power to the system. The performance of proposed system is evaluated by using MATLAB/SIMULINK software.

Index Terms—Unified Power Quality Conditioner (UPQC), Power Quality (PQ), Renewable Energy Resources (RES), Photovoltaic Array (PV),Wind Generation System (WGS).

I. INTRODUCTION

To provide quality power has become today's most concerned area for both power suppliers and customers due to the deregulation of the electric power energy market. Efforts have been made to improve the power quality. Aspects on power quality can be classified into three categories that is, voltage stability, continuity of supplying power and voltage waveform. The power quality is the set of limits of electrical properties that allows electrical system to function in their intended manner without significant loss of performance or life. The use of non-linear loads in the power system will lead to the generation of current and voltage harmonics which in deteriorates the power quality.

The Unified Power quality Conditioner is a custom power device that is employed in the distribution system to mitigate the disturbances .It is a type of hybrid APF and is the only versatile device which can mitigate several power quality problems related with voltage and current simultaneously. Therefore UPQC is multi functioning device that compensate various voltage disturbances of the power supply, to correct voltage fluctuations and to prevent harmonic load current from entering the power system. In other words ,the UPQC has the capability of improving power quality at the point of installation on power distribution systems or industrial power system [7].

The market liberalization and government's incentives have further accelerated the renewable energy sector growth. Long transmission lines are one of the main causes for electrical power losses. Therefore emphasis has increased on renewable energy systems which lead to energy efficiency and reduction in emissions [2]. PV system and wind energy systems are recognized as most mature, clean and cost efficient renewable energy sources in the electricity market.

II.DEFINITION OF POWER QUALITY

Power quality has different meanings to different people. Institute of Electrical and Electronic Engineers (IEEE) Standard IEEE1100 defines power quality as "the concept of powering and grounding sensitive electronic equipment in a manner suitable for the equipment". There is a broad range of power quality problems associated with power systems based on time such as long duration variations, short duration variations and other disturbances. All electrical devices are prone to failure or malfunction when exposed to one or more power quality problems. The main reasons for concern with power quality (PQ) are as following:

1.End user devices become more sensitive to PQ due to many microprocessor based controls.

2.Large computer systems in many businesses facilities.

3.Power electronics equipment used for enhancing system stability, operation and efficiency. These are major sources of bad Power Quality.

4.Continuous development of high performance equipment: Such equipment is more susceptible to power disturbances.

The users always demand higher power quality. Some basic criterions for power quality are constant rms value, constant frequency, symmetrical three-phases, pure sinusoidal wave shape and limited THD.

III . SOURCES OF POOR POWER QUALITY

Sources of poor Power Quality are listed as follows:

- Adjustable –speed drives
- Switching Power supplies
- Arc furnaces
- Electronic Fluorescent lamp ballasts
- Lightning Strike
- L-G fault
- Non- linear load
- Starting of large motors
- Power electronic devices

IV. NEED OF POWER QUALITY

There is an increased concern of power quality due to the following reasons:

1. New-generation loads that uses microprocessor and microcontroller based controls and power electronic devices, are more sensitive to power quality variations than that equipments used in the past.

2. The demand for increased overall power system efficiency resulted in continued growth of devices such as high-efficiency adjustable-speed motor drives and shunt capacitors for power factor correction to reduce losses. This is resulting in increasing harmonic level on power systems and has many people concerned about the future impact on system capabilities.

3. End users have an increased awareness of power quality issues. Utility customers are becoming better informed about such issues as interruptions, sags, and switching transients and are challenging the utilities to improve the quality of power delivered.

4. Most of the networks are interconnected these days. Integrated processes mean that the failure of any component has much more important consequences.

V. POWER QUALITY PROBLEMS, CAUSES AND ITS CONSEQUENCES.

Power quality is very important term that embraces all aspects associated with amplitude, phase and frequency of the voltage and current waveform existing in a power circuit. The increasing number of power electronics based equipment has produced a significant impact on the quality of electric power supply. Therefore, it is obvious to maintain high standards of power quality.

The various power quality problems are:

- ➢ Voltage sags

- Micro-interruptions
- Long interruptions
- Voltage spikes
- Voltage swells
- Voltage fluctuations
- Voltage unbalance
- Noise
- Harmonic distortion

The Power quality problems details are described below.

1. Voltage Sags: A decrease of the normal voltage level between 10 and 90% of the nominal rms voltage at the power frequency, for durations of 0, 5 cycle to 1 minute.

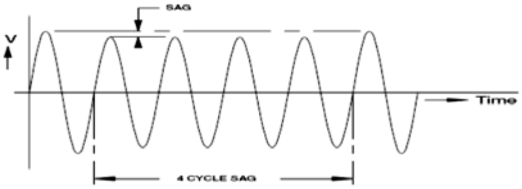


Fig. 1 Voltage Sags

Causes:
- Faults on the transmission or distribution network.
- Faults in consumer’s installation.
- Connection of heavy loads and start-up of large motors.

Consequences:
- Malfunction of microprocessor-based control systems (PCs, PLCs, ASDs, etc.) that may lead to a process stoppage.
- Tripping of contactors and electromechanical relays.
- Disconnection and loss of efficiency in electric rotating machines.

2. Micro-Interruptions: Total interruption of electrical supply for duration from few milliseconds to one or two seconds.

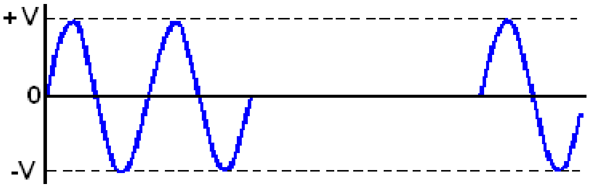


Fig.2 Micro-Interruptions

Causes:
- Opening and automatic reclosure of protection devices.
- Insulation failure, lightning and insulator flashover.

Consequences:
- Tripping of protection devices.
- Loss of information and malfunction of data processing equipment.
- Stoppage of sensitive equipment (such as ASDs, PCs, PLCs).

3. Long Interruptions: Total interruption of electrical supply for duration greater than 1 to 2 seconds.

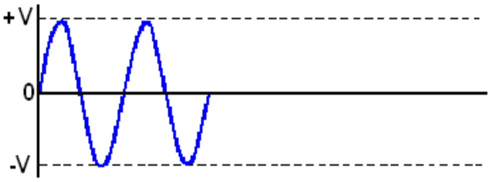


Fig.3 Long Interruptions

Causes:
- Equipment failure in the power system network.
- Storms and objects (trees, cars, etc) striking lines or poles, fire.
- Human error, bad coordination or failure of protection devices.

Consequences:
- Stoppage of all equipment.

4. Voltage Spikes: Very fast variation of the voltage value for durations from a several microseconds to few milliseconds.

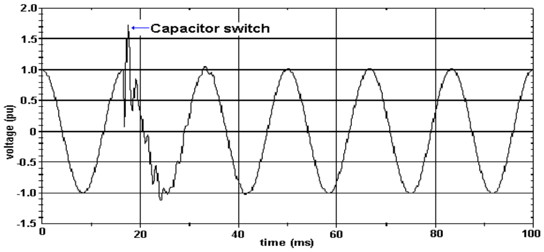


Fig.4 Voltage Spikes

Causes:
- Lightning.
- Switching of lines or power factor correction capacitors.
- Disconnection of heavy loads.

Consequences:
- Destruction of components and of insulation materials.
- Data processing errors or data loss.
- Electromagnetic interference.

5. Voltage Swells: Momentary increase of the voltage, at the power frequency, outside the normal tolerances, with duration of more than one cycle and typically less than a few seconds.

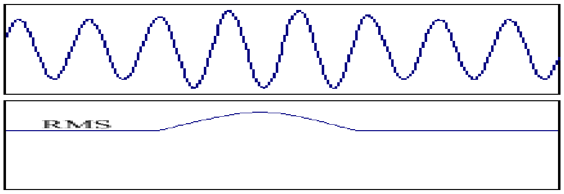


Fig. 5 Voltage Swells

Causes:
- Start/stop of heavy loads.
- Poorly dimensioned power sources.
- Poorly regulated transformers.

Consequences:
- Flickering of lighting and screens.
- Damage or stoppage or damage of sensitive equipment.

6. Voltage fluctuation: Oscillation of voltage value, amplitude modulated by a signal with low frequency.

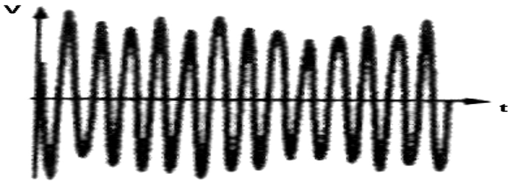


Fig.6 Voltage Fluctuations

Causes:
- Arc furnaces.
- Frequent start/stop of electric motors (for instance elevators).
- Oscillating loads.

Consequences:
- Most consequences are common to under voltages.
- Flickering of lighting and screens.

7. Voltage Unbalance: A voltage variation in a three-phase system in which the three voltage magnitudes or the phase-angle differences between them are not equal.

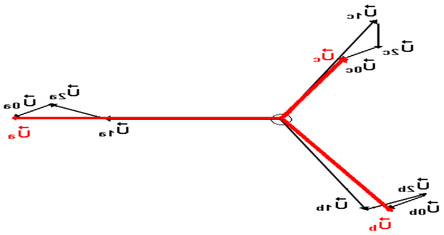


Fig.7 Voltage Unbalance

Causes:
- Large single-phase loads (induction furnaces, traction loads).
- Incorrect distribution of loads by the three phases of the system.

Consequences:
- The most affected loads are three-phase induction machines.
- Increase in the losses.

8. Noise: Superimposing of high frequency signals on the waveform of the power-system Frequency.

Fig.8 Noise

Causes:
- Electromagnetic interferences.
- Improper grounding may also because.

Consequences:
- Disturbances on sensitive electronic equipment.
- May cause data loss and data processing errors.

9. Harmonic Distortion: Voltage or current waveforms assume non-sinusoidal shape.

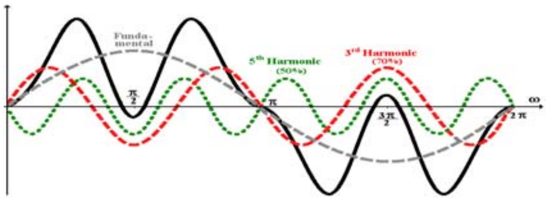


Fig.9 Harmonic Distortion

The waveform corresponds to the sum of different sine-waves with different magnitude and phase, having frequencies that are multiples of power-system frequency.

Consequences:
- Increased probability of occurrence of resonance.

- Nuisance tripping of thermal protections.
- Electromagnetic interference.
- Increase in the losses.
- Loss of efficiency in electric machines (e.g. 5th harmonic).

VI.GENERALISED DIAGRAM OF UPQC SYSTEM

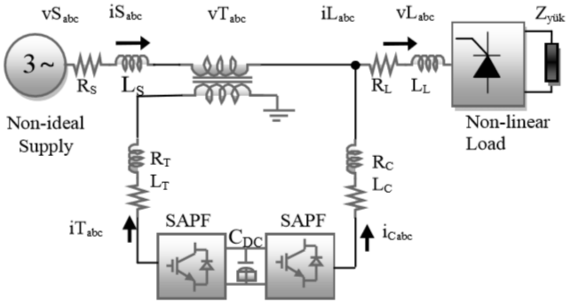


Fig.10 Generalised diagram of UPQC system

Fig.10 shows the generalised diagram of UPQC system. The UPQC is a combination of a series active power filters and shunt active power filter in cascade via a common DC link capacitor. Series active filter and shunt active filter compensate the power quality problems of the source voltages and source currents respectively. The series component of the UPQC is responsible for mitigation of supply side disturbances such as voltage sag/swells, flicker, voltage unbalance and harmonics. The shunt component is responsible for mitigating the current quality problem such as poor power factor, harmonics in the supply current and load voltage resp.

VII. OPERATION OF UPQC

The powers due to harmonic quantities are negligible as compared to the power at fundamental component, therefore, the harmonic power is neglected and the steady state operating analysis is done on the basis of fundamental frequency component only. The UPQC is controlled in such a way that the voltage at load bus is always sinusoidal and at desired magnitude. Therefore the voltage injected by series APF must be equal to the difference between the supply voltage and the ideal load voltage. Thus the series APF acts as controlled voltage source. The function of shunt APF is to maintain the dc link voltage at constant level. In addition to this the shunt APF provides the VAR required by the load, such that the input power factor will be unity and only fundamental active power will be supplied by the source. The equivalent circuit of UPQC was shown in the Fig.11

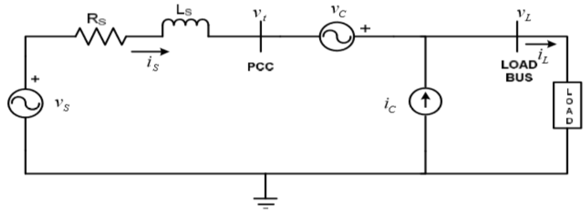


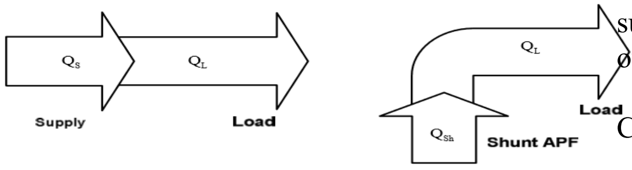
Fig.11 Equivalent circuit of a UPQC

Where, v_S = source voltage
v_t = terminal voltage at PCC load
v_L = load voltage
i_S = source current
i_L = load current
v_c = voltage injected by series APF
i_c = current injected by shunt APF
k = fluctuation of source voltage i.e.

$$k = \frac{v_t - v_L}{v_L}$$

Case I

The reactive power flow during the normal working condition when UPQC is not connected in the circuit is shown in the Fig. 12(a). In this condition the reactive power required by the load (Q_L) is completely supplied by the source only. When the UPQC is connected in the network and the shunt APF is put into the operation, the reactive power required by the load is now provided by the shunt APF alone; such that no reactive power burden is put on the mains. So as long as the shunt APF is ON, it is handling all the reactive power even during voltage sag, voltage swell and voltage harmonic compensation. The series APF does not take any active part in supplying the load reactive power demand. The reactive power flow during the entire operation of UPQC is shown in the Fig. 12 (b).



(a) No UPQC (b) Shunt APF ON

Fig.12 (a)-(b) Reactive power flow

Q_S =Source reactive power
Q_L =Load reactive power
Q_{Sh} =Shunt APF reactive power

Case II

If k<0 i.e. $v_t<v_L$,series injected power (P_{sr}) will be positive, means series APF supplies the active power to the load. This condition is possible during the utility voltage sag condition, Is will be more than the normal rated current. Thus we can say that the required active power is taken from the utility itself by taking more current so as to maintain the power balance in the network and to keep the dc link voltage at desired level.

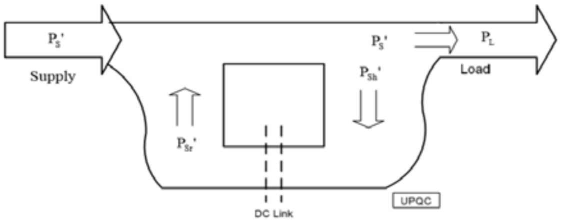


Fig. 13 Active power flow during voltage sag condition

P_s'= Power Supplied by the source to the load during voltage sag condition
P_{sr}'= Power Injected by Series APF in such way that sum $P_{sr}' + P_s'$ will be the required load power during normal working condition i.e. P_L
P_{sh}'= Power absorbed by shunt APF during voltage sag condition
$P_{sr}' = P_{sh}'$

This active power flows from the source to shunt APF, from shunt APF to series APF via dc link and finally from series APF to the load. Thus the load would get the desired power even during voltage sag condition. Therefore in such cases the active power absorbed by shunt APF from the source is equal to the active power supplied by the series APF to the load. The overall active power flow is shown in Fig.13.

Case III

If k > 0, i.e. $v_t > v_L$, P_{sr} will be negative, this means series APF is absorbing the extra real power from the source. This is possible during the voltage swell condition, i_S will be less than the normal rated current. Since v_s is increased, the dc link voltage can increase. To maintain the dc link voltage at constant level the shunt APF controller reduces the current drawn from the supply. In other words we can say that the UPQC feeds back the extra power to the supply system. The overall active power flow is shown in Fig. 14.

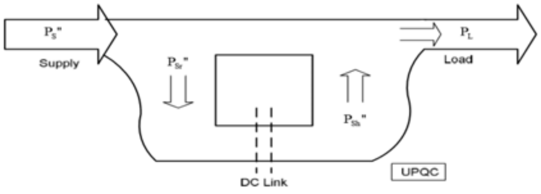


Fig.14 Active power flow during voltage swells condition

P_s''= Power Supplied by the source to the load during voltage swell condition
P_{sr}''= Power Injected by Series APF in such way that sum $P_s'' - P_{sr}''$ will be the required load power during normal working condition
P_{sh}''= Power delivered by shunt APF during voltage swell condition
$P_{sr}'' = P_{sh}''$

Case IV

If k=0, i.e. $v_L = v_t$, then there will not be any real power exchange though UPQC. This is the normal operating condition. The overall active power flow is shown in Fig.15.

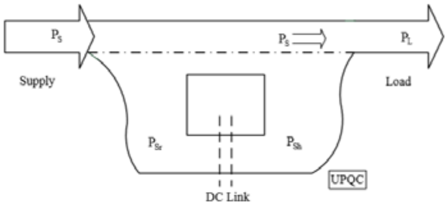


Fig.15 Active power flow during normal working condition

The phasor representations of the above discussed conditions are shown in the Fig. 16 (a) – (d). Fig. 16(a) represents the normal working condition, considering load voltage v_L as a φ_L is lagging power factor angle of the load. During this condition i_S will be exactly equal to the i_L since no compensation is provided. When shunt APF is put into the operation, it supplies the required load VARs by injecting the leading current such that the source current will be in phase with the terminal voltage. The phasor representing this is shown in Fig.16 (b). The phasor representations during voltage sag and voltage swell condition on the system are shown in the Fig. 16 (c) and Fig.16 (d) respectively. The deviation of shunt compensating current phasor from quadrature relationship with terminal voltage suggests that there is some active power flowing through the shunt APF during these conditions.

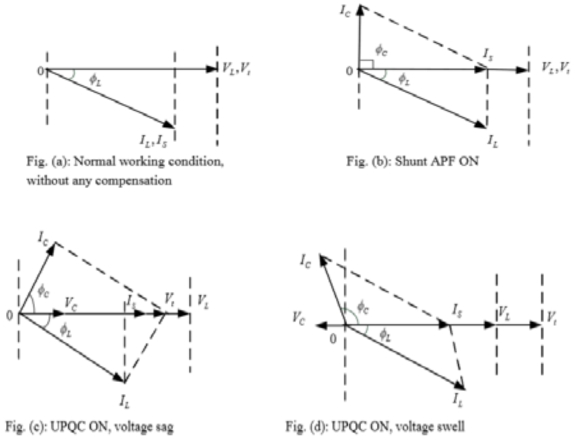


Fig. (a): Normal working condition, without any compensation

Fig. (b): Shunt APF ON

Fig. (c): UPQC ON, voltage sag

Fig. (d): UPQC ON, voltage swell

Fig.16 (a)-(d) Phasor representation of all possible conditions

VIII. CONFIGURATION OF PROPOSED SYSTEM

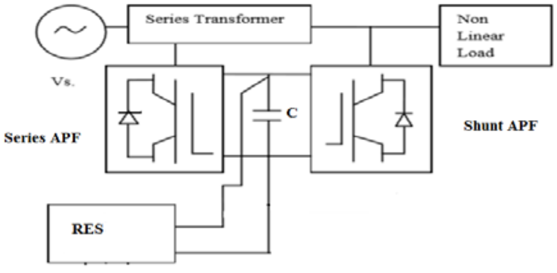


Fig.17 Configuration of proposed system

Fig.17 shows the configuration of proposed system. The proposed system composed of series and shunt active power filter, PV array and wind generating system connected to DC link capacitor . The advantage of proposed combined system is voltage interruption compensation and active power injection into the system. The Renewable Energy Sources consist of photovoltaic array and wind generation system. The shunt active power filter is usually connected across the loads to compensate for all current related problems such as current harmonics, power factor improvement whereas the series active power is connected in series with the line through series transformer. It acts as controlled voltage source and can compensate all voltage related problems such as voltage harmonics ,voltage sag, voltage swell etc.

IX .PV ARRAY MODELLING

PV arrays are built up with combined series/parallel combinations of PV solar cells, which are usually given by an equation as in (1).

$$V_C = \frac{AkT_C}{e} \ln\left(\frac{I_{ph} + I_0 - I_C}{I_0}\right) - R_S I_C \quad \text{-------(1)}$$

Where the symbols are defined as follows:

A: curve fitting factor

e: electron charge (1.602 × 10-19 C).

k: Boltzmann constant (1.38 × 10-23 J/^{o}K).

I_c: cell output current, A.

I_{ph} : photocurrent, function of irradiation level and junction temperature (5 A).

I_0 : reverse saturation current of diode (0.0002 A).

R_s : series resistance of cell (0.001 Ω).

T_c : reference cell operating temperature (20 °C).

V_c : cell output voltage, V.

Both k and Tc should have the same temperature unit, either Kelvin or Celsius. The curve fitting factor A is used to adjust the I-V characteristics of the cell obtained from (1) to the actual characteristics obtained by testing. Eq. (1) gives the voltage of a single solar cell which is then multiplied by the number of the cells connected in series to calculate the full array voltage. Since the array current is the sum of the currents flowing through the cells in parallel branches, the cell current I_C is obtained by dividing the array current by the number of the cells connected in parallel before being used in (1), which is only valid for a certain cell operating temperature Tc with its corresponding solar irradiation level Sc. If the temperature and solar irradiation levels change, the voltage and current outputs of the PV array will follow this change. Hence, the effects of the changes in temperature and solar irradiation levels should also be included in the final PV array model. A method to include these effects in the PV array modelling is given by Buresch [4]. According to his method, for a known temperature and a known solar irradiation level, a model is obtained and then this model is modified to handle different cases of temperature and irradiation levels. Let (1) be the benchmark model for the known operating temperature Tc and known solar irradiation level Sc as given in the specification. When the ambient temperature and irradiation levels change, the cell operating temperature also changes, resulting in a new output voltage and a new photocurrent value. The solar cell operating temperature varies as a function of solar irradiation level and ambient temperature. The variable ambient temperature Ta affects the cell output voltage and cell photocurrent. These effects are represented in the model by the temperature coefficients C_{TV} and C_{TI} for cell output voltage and cell photocurrent respectively as:

$$C_{TV} = 1 + \beta_T \left(T_a - T_x \right)$$ ----------(2)

$$C_{TI} = 1 + \frac{\gamma_T}{S_C} \left(T_x - T_a \right)$$ ---------(3)

Where C_{TV}=temperature coefficient of cell output voltage,

C_{TI}=temperature coefficient of cell photocurrent

$\beta_T = 0.004$ and $\gamma_T = 0.06$ for the cell used and $T_a=20^0$C is the ambient temperature during the cell testing. This is used to obtain the modified model of the cell for another ambient temperature Tx. Even if the ambient temperature does not change significantly during the daytime, the solar irradiation level changes depending on the amount of sunlight and clouds. A change in solar irradiation level causes a change in the cell photocurrent and operating temperature, which in turn affects the cell output voltage. If the solar irradiation level increases from Sx1 to Sx2, the cell operating temperature and the photocurrent will also increase from Tx1 to Tx2 and from Iphl to Iph2, respectively. Thus the change in the operating temperature and in the photocurrent due to variation in the solar irradiation level can be expressed via two constants, C_{SV} and C_{SI}, which are the correction factors for changes in cell output voltage V_C and photocurrent Iph, respectively:

$$C_{SV} = 1 + \beta_T \alpha_S \left(S_x - S_C \right)$$ ------------(4)

$$C_{SI} = 1 + \frac{1}{S_C} \left(S_x - S_C \right)$$ -----------------(5)

Where S_C is the benchmark reference solar irradiation level during the cell testing to obtain the modified cell model. Sx is the new level of the solar irradiation. The temperature change, ΔT_C, occurs due to the change in the solar irradiation level and is obtained using

$$\Delta T_C = \alpha_S \left(S_x - S_C \right)$$ ----------------(6)

The constant α_S represents the slope of the change in the cell operating temperature due to a change in the solar irradiation level and is equal to 0.2 for the solar cells used. Using correction factors C_{TV}, C_{TI}, C_{SV} and C_{SI}, the new values of the cell output voltage V_{CX} and photocurrent Iphx are obtained for the new temperature Tx and solar irradiation Sx as follows:

$$V_{CX} = C_{TV} C_{SV} V_C$$ ---------------(7)

$$I_{phx} = C_{TI} C_{SI} I_{ph}$$ -----------(8)

V_C and Iph are the benchmark reference cell output voltage and reference cell photocurrent, respectively.

The effects of the changing temperature and solar irradiation level are modeled inside the block called Effect of Temperature & Solar Irradiation. This block represents the equations given from (2) to (8) with the modification of (7) and (8) as follows.

$$V_{CX} = C_V V_C \qquad \text{-------------(9)}$$

$$I_{phx} = C_I I_{ph} \qquad \text{-------------(10)}$$

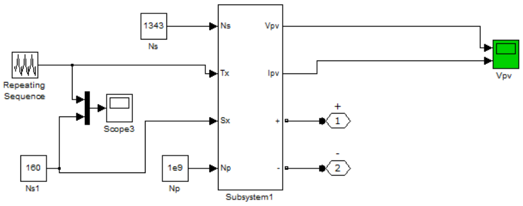


Fig.18 Operational functional block diagram of the PVA model

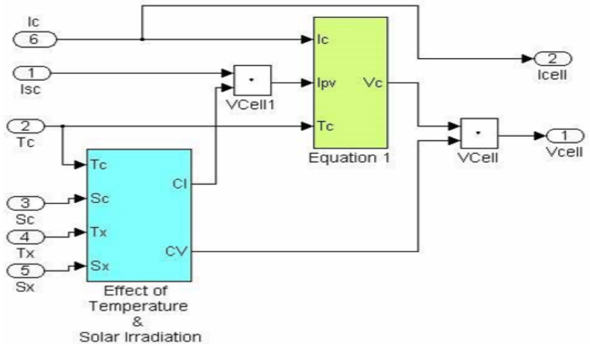


Fig.19 Modeling stage 1

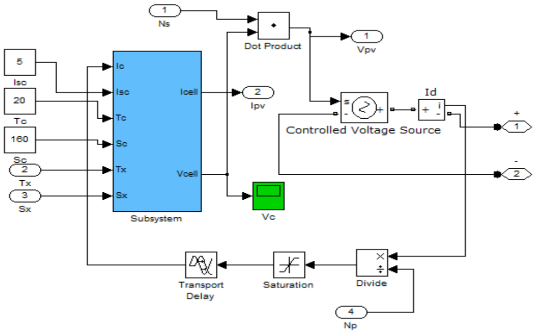


Fig.20 Modeling stage 2

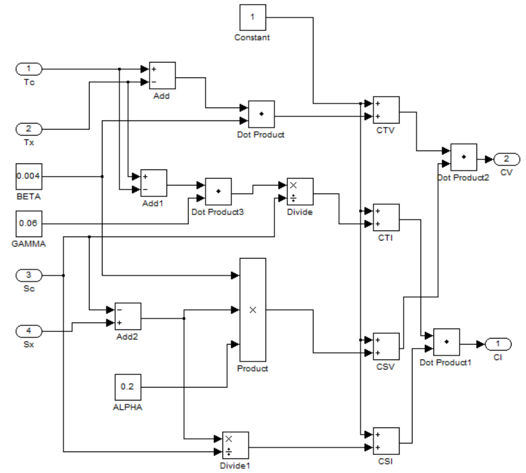


Fig.21 Internal Model for equation 2,3,4 & 5

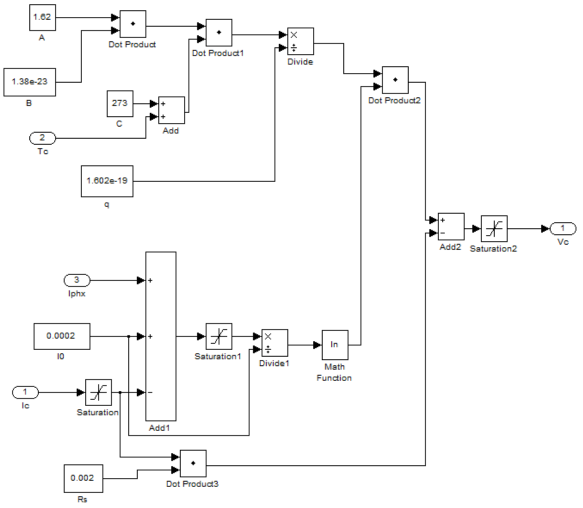


Fig.22 Internal Model of equation 1

X.WIND GENERATION SYSTEM MODELLING

Wind turbines produce electricity by using the power of the wind to drive an electrical generator. Passing over the blades, wind generates lift and exerts a turning force. The rotating blades turn a shaft inside the nacelle, which goes into a gearbox. The gearbox adjusts the rotational speed to that which is appropriate for the generator, which uses magnetic fields to convert the rotational energy into electrical energy.Fig.23 shows configuration of wind generation system.

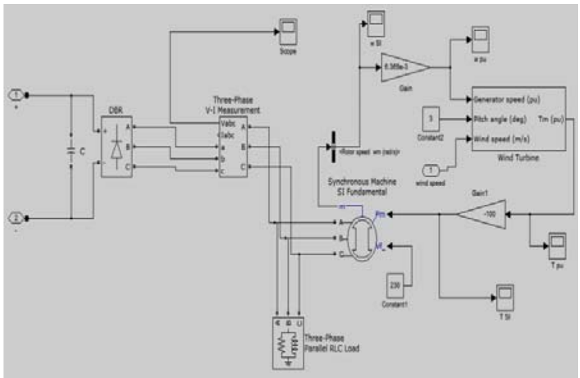


Fig.23 Configuration of Wind Generation System (WGS)

XI. SIMULINK DIAGRAM

Fig.24 shows the SIMULINK Diagram of proposed UPQC system with RES and Fig.25 shows SIMULINK Diagram of RES (PV array and Wind Generation system).

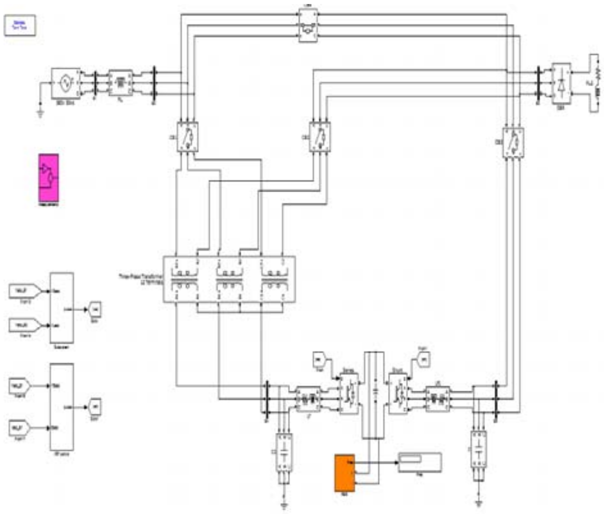


Fig.24 SIMULINK Diagram of proposed UPQC system with RES

Fig.24 shows simulink diagram of proposed UPQC system with RES. The proposed system is composed of series and shunt active power filter, PV array and wind generation system which is able to compensate the voltage sag, swell, harmonics and voltage interruption. The proposed system is able to compensate voltage interruption and active power injection into the system.

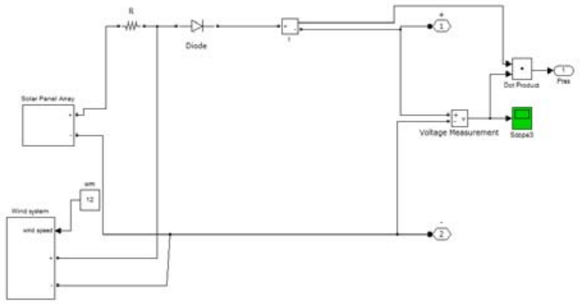


Fig.25 SIMULINK Diagram of RES (PV array and Wind Generation System)

Fig.25 shows Simulink diagram of RES. The RES which consist of solar PV system and wind generation system connected across DC link capacitor. The total power generated by RES is 8.89 kW.

CONTROL PARAMETER

Table I. UPQC Simulation Control Parameter

	Parameter	**Value**
Source	Voltage Vsabc	380 Vrms
	Frequency f	50 Hz
Load		
3-Phase ac Line Inductance	L_{Labc}	3 mH
Shunt APF		
Ac Line Inductance	L_{Cabc}	4 mH
Filter Resistance	R_{Cabc}	6 ohm
Filter Capacitor	C_{cabc}	10 microfarad
Switching Frequency	f_{pwm}	10 kHz
Series APF		
Ac Line Inductance	L_{Tabc}	2 mH
Filter Resistor	R_{Tabc}	6 ohm
Filter Capacitor	C_{Tabc}	20 microfarad
Switching Frequency	f_{pwm}	15 kHz

XII. SIMULATION WAVEFORMS

1. Simulation waveforms before UPQC (i.e. before 0.3 sec) and after UPQC and with addition of RES (i.e. after 0.3 sec)

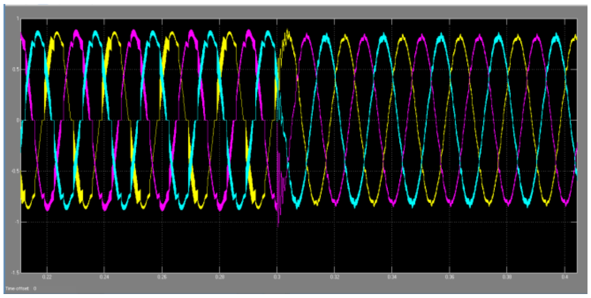


Fig.26 Three phase source voltage before UPQC and after UPQC with RES

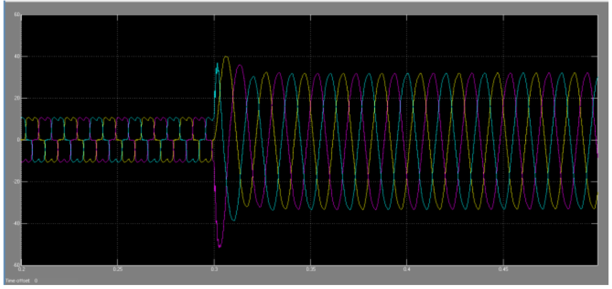


Fig.27 Three phase source current before UPQC and after UPQC with RES

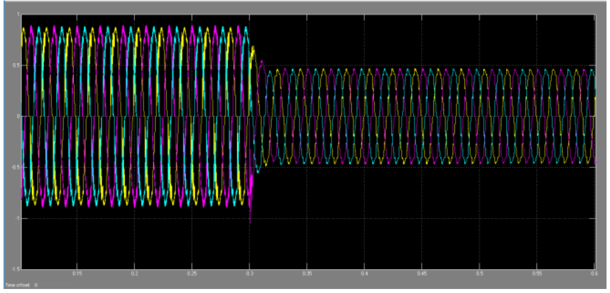


Fig.28 Three phase load voltage before UPQC and after UPQC with RES

Fig.26,27 and 28 shows simulation waveform of three phase source voltage, source current and load voltage before UPQC and after UPQC with RES.From the waveform it is seen that before UPQC (before 0.3 sec),we get distorted waveforms and after UPQC(after 0.3 sec),harmonic content from waveform are eliminated even after addition of RES.

2. FFT Analysis of proposed system without UPQC and with UPQC with RES

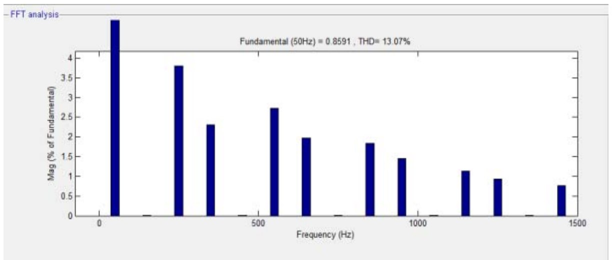


Fig.29 THD of source voltage without UPQC

Fig.29 shows FFT analysis of source voltage without UPQC, here we get THD=13.07%.

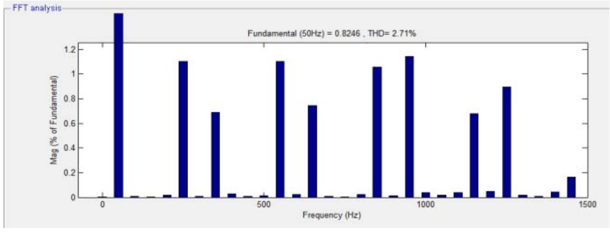


Fig.30 THD of source voltage with UPQC and with RES

Fig.30 shows FFT analysis of source voltage with UPQC and with RES, here we get THD= 2.71%.

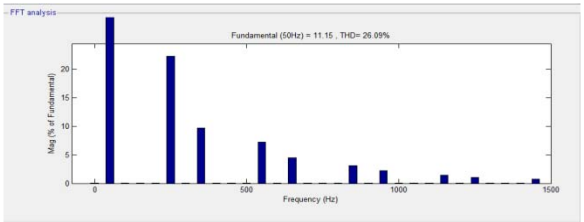


Fig.31 THD of source current without UPQC

Fig.31 shows FFT analysis of source current without UPQC, here we get THD=26.09%.

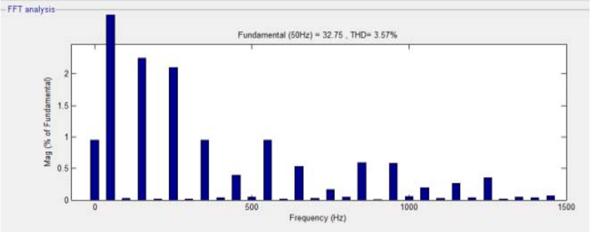


Fig.32 THD of source current with UPQC and with RES

Fig.32 shows FFT analysis of source current with UPQC and with RES, here we get THD=3.57%.

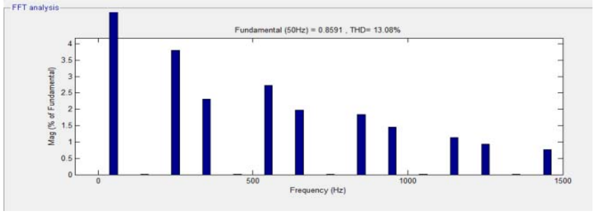


Fig.33 THD of load voltage without UPQC

Fig.33 shows THD of load voltage without UPQC, here we get THD=13.08%

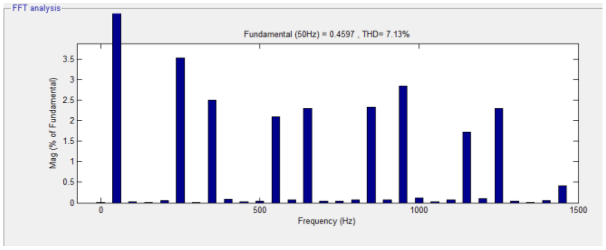


Fig.34 THD of load voltage with UPQC with RES

Fig.34 shows THD of load voltage with UPQC with RES, here we get THD=7.13%

It is observed from the Fig.29 to 34 that source voltage THD improved from 13.07% to 2.71% with addition RES and source current THD improved from 26.09% to 3.57% with addition of RES in similar way load voltage THD improved from 13.08% to 7.13% with addition of RES.

XIII.SIMULATION RESULT

TABLE II:%THD content in source voltage ,source current and load voltage.

Total Harmonic Distortion %THD		
	Without UPQC	With UPQC and With RES
Source Voltage	13.07%	2.71%
Source current	26.09%	3.57%
Load Voltage	13.08%	7.13%

Table II shows % THD content in, source voltage, source current and load voltage without UPQC, and with UPQC and with RES. It is observed from the Table II that source voltage THD improved from 13.07% to 2.71% ,source current THD improved from 26.09% to 3.57% Similarly for the load voltage THD improved from 13.08% to 7.13%.

The obtained results shows that the proposed system allows mitigation of all harmonic components of source current and source voltage is maintained below 5% as per IEEE 519-1992 standard under all load conditions.

XIV. CONCLUSION

This paper describes analysis results of a combined operation of the Unified Power Quality Conditioner with RES (PV array and wind generation system). The proposed system can improve the power quality at the point of installation on power distribution system. The steady state power flow analysis of UPQC under voltage sag and swell condition is also studied. From the simulation result it is observed that the % THD content of source current and source voltage is maintained below 5%, the harmonic limit imposed by IEEE standard 519-1992 under all load conditions.The proposed system's operation is analysed using MATLAB/SIMULINK software and simulation result confirm that the proposed system operates correctly.

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