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Modelling the Combination of Upqc and Photovoltaic Array

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Abstract: Power quality is one of major concerns in the present era. It has become important, especially, with the introduction of sophisticated devices, whose performance is very sensitive to the quality of power supply. Power quality problem is an occurrence manifested as a nonstandard voltage, current or frequency that results in a failure of end use equipments. Custom power devices including power electronics interface can be the effective solution for increasing power quality problems because they can provide fast response and flexible compensation. One of those devices is the Unified Power Quality Conditioner (UPQC). It has prominent capability of improving the quality of voltage and current at the point of installation on the power distribution systems or industrial power systems.This project presents combined operation of UPQC and photovoltaic

Key words: PWM, UPQC, FACTS, APF, BESS, DSTATCOM

INTRODUCTION

General: Nowadays, modern industrial devices are mostly based on electronic devices such as programmable logic controllers and electronic drives. The electronic devices are very sensitive to disturbances and become less tolerant to power quality problems such as voltage sags, swells and harmonics. Voltage dips are considered to be one of the most severe disturbances to the industrial equipments. Voltage support at a load can be achieved by reactive power injection at the load point of common coupling.

There are two approaches to the mitigation of power quality problems. The solution to the power quality can be done from customer side or from utility side First approach is called load conditioning, which ensures that the equipment is less sensitive to power disturbances, allowing the operation even under significant voltage distortion. The other solution is to install line conditioning systems that suppress or counteracts the power system disturbances. Currently they are based on PWM converters and connect to low and medium voltage distribution system in shunt or in series [1-5].

Series active power filters must operate in conjunction with shunt passive filters in order to compensate load current harmonics. Shunt active power filters operate as a controllable current source and series active power filters operates as a controllable voltage source.

Both schemes are implemented preferable with voltage source PWM inverters, with a dc bus having a reactive element such as a capacitor.

However, with the restructuring of power sector and with shifting trend towards distributed and dispersed generation, the line conditioning systems or utility side solutions will play a major role in improving the inherent supply quality; some of the effective and economic measures can be identified as follows.

Energy Storage Systems: Storage systems can be used to protect sensitive production equipments from shutdowns caused by voltage sags or momentary interruptions. These are usually DC storage systems such as UPS, batteries, superconducting magnet energy storage (SMES), storage capacitors or even fly wheels driving DC generators[7]. Enough energy is fed to the system to compensate for the energy that would be lost by the voltage sag or interruption.

Though there are many different methods to mitigate voltage sags and swells, but the use of a custom Power device is considered to be the most efficient method. For example, Flexible AC Transmission Systems (FACTS)

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for transmission systems. Just as FACTS improves the power transfer capabilities and stability margins, custom power makes sure customers get pre-specified quality and reliability of supply. This pre-specified quality may contain a combination of specifications of the following: low phase unbalance, no power interruptions, low flicker at the load voltage, low harmonic distortion in load voltage, magnitude and duration of overvoltage and under voltages within specified limits, acceptance of fluctuations and poor factor loads without significant effect on the terminal voltage There are many types of Custom Power devices [2-8].

Some of these devices include: Active Power Filters (APF), Battery Energy Storage Systems (BESS), Distribution STATic synchronous Compensators (DSTATCOM), Distribution Series Capacitors (DSC), Dynamic Voltage Restorer (DVR), Unified Power Flow Controller (UPFC), Unified Power Quality Conditioner (UPQC), Solid State Fault Current Limiter (SSFCL) [8], Static Var Compensator (SVC), Thyristor Switched Capacitors (TSC) and Uninterrupt.

Proposed System

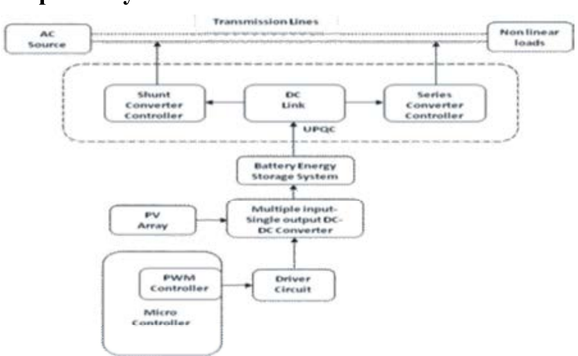


Fig. 2.0: Proposed system

MISO DC-DCconverter and the two converters of UPQC are connected to aDC linkthat is connected to the Battery Energy StorageSystem (BESS) as we The BESS acts as a DC link voltge maintainer, especially at the times that there is not sufficientirradiation of sun such as nights and cloudyweathers. On thother hand, the photovoltaic arrayscharges BESS during theday. Each component oftheproposed system described in thefollowing sections.The instaneous power theory is used to control the proposed system.This scheme include photovoltaic energy sources to loads and maintaining.

DC link voltage as well as other condition task. The theory is based on converting three axis parameters into two axis by transfer matrix.The active and reative power can be decomposed by DC and AC harmonic componenet which consist of negative sequence component and harmonic component.because the zero sequence power never produces a constant DC component without its associate AC components. The proposed system should compensate fully power.when it applied to the three phase four wire networks and the additionalactie powercomponent drawn from supply loads to be injected [9-11].

If shunt inverter is used simultaneouss for reactive,negative and harmonics component. When series converter of the proposed confugration is used simultaneously for charge control of battery. The actve reative power control is becoming the main issue and the proposed system still satisfy the compensation demand of load such as negative harmonic component. when ppv power delivered to local loads by shunt converter. It should be noted that it is so difficult to compensate reative power and harmonic current using series converter only and because the signal from converter output terminal must be passed from filter.the filter parameter strongly depends on the system parameters like load size and transformers turns ratio.

Control Objectives of Upqc: The shunt connected converter has the following control objectives:

- To balance the source currents by injecting negative and zero sequence components required by the load.
- The compensate for the harmonics in the load current by injecting the required harmonic current.
- To control the power factor by injecting the required reactive current (at fundamental frequency).
- To regulate the DC bus voltage.

The series connected converter has the following control objectives:

- To balance the voltages at the load bus by injecting negative and zero Sequence voltages to compensate forthose present in the source.
- To isolate the load bus from harmonics present in thesource voltages, by injecting the harmonic voltages.
- To regulate the magnitude of the load bus voltage by injecting the required active and reactive components (at fundamental frequency) depending on the power factor on the source side.

- To control the power factor at the input port of the UPQC (where the source is connected. Note that the power fathe output port of theUPQC (connected to the load) is controlled by the shunt converter.
- A UPQC is employed in a power transmission system.

Buck Converters (dc-dc): A buck converter (dc-dc) is shown. Only a switch is shown, for which a device as described earlier belonging to transistor family is used. Also a diode (termed as freewheeling) is used to allow the load current to flow through it, when the switch (i.e., a device) is turned off. The load is inductive (R-L) one. In some cases, a battery (or back emf) is connected in series with the load (inductive). Due to the load inductance, the load current must be allowed a path, which is provided by the diode; otherwise, i.e[10]., in the absence of the above diode, the high induced emf of the inductance, as the load current tends to decrease, may cause damage to the switching device. If the switching device used is a thyristor, this circuit is called as a step-down chopper, as the output voltage is normally lower than the input voltage. Similarly this dc-dc converter is termed as buck one.

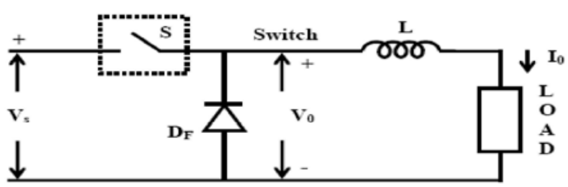


Fig. 2.3: Buck converter

The output voltage is same as the input voltage, when the switch is ON, during the period, T. The switch is turned on at t= 0 and then turned off at t=$T_{ON.}$ This is called ON period. During the next time interval, T > t >T_{ON}, the output voltage is zero, i.e.v_0=0, as the diode, now conducts. The OFF period is T_{off} = T -$T_{ON,}$ with the time period being T = T_{ON}+ T_{OFF}. The frequency is f =1/T. With T kept as constant, the average value of the output voltage is derived.

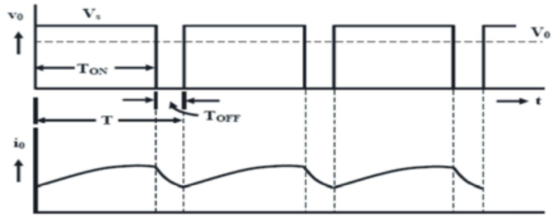
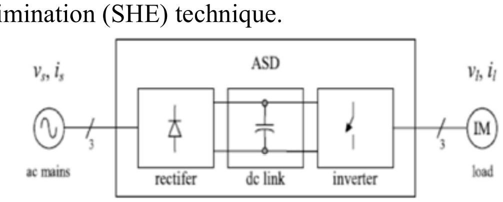


Fig. 2.4: Output voltage and current waveforms

The duty ratio is k = (T_{ON} / T) = (TON /T_{ON}+T_{OFF}) its range being 1.00>k>0.00. Normally, due to turn-on delay of the device used, the duty ratio (k) is not zero, but has some positive value. Similarly, due to requirement of turn-off time of the device, the duty ratio (k) is less than 1.0. So, the range of duty ratio is reduced. It may be noted that the output voltage is lower than the input voltage. Also, the average output voltage increases, as the duty ratio is increased. So, a variable dc output voltage is obtained from a constant dc input voltage. The load current is assumed to be continuous The load current increases in the ON period, as the input voltage appears across the load and it (load current) decreases in the OFF period, as it flows in the diode, but is positive at the end of the time period.

1voltage Source Inverters: According to the type of ac output waveform, these topologies can be considered as voltage source inverters (VSIs), where the independently controlled ac output is a voltage waveform. These structures are the most widely used because they naturally behave as voltage sources as required by many industrial applications, such as adjustable speed drives (ASDs), which are the most popular application of inverters. Similarly, these topologies can be found as current source inverters (CSIs) [11], where the independently controlled ac output is a current waveform. These structures are still widely used in medium-voltage industrial applications, where high-quality voltage waveforms are required. Static power converters, specifically inverters, are constructed from power switches and the ac output waveforms are therefore made up of discrete values. This leads to the generation of waveforms that feature fast transitions rather than smooth ones.For instance, the ac output voltage produced by the VSI of a standard ASD is a three-level waveform. Although this waveform is not sinusoidal as expected its fundamental component behaves as such. This behavior should be ensured by a modulating technique that controls the amount of time and the sequence used to switch the power valves on and off. The modulating techniques most used are the carrier-based technique (e.g., sinusoidal pulse width modulation, SPWM), the space-vector (SV) technique and the selective-harmonic-elimination (SHE) technique.



Full-Bridge VSI: This inverter is similar to the half-bridge inverter; however, a second leg provides the neutral point to the load. As expected, both switches S1+ and S1- (or S2+ and S2-) cannot be on simultaneously because a short circuit across the dc link voltage source Vi would be produced. There are four defined (states 1, 2, 3 and 4) and one undefined (state 5) switch states.

The undefined condition should be avoided so as to be always capable of defining the ac output voltage. It can be observed that the ac output voltage can take values up to the dc link value Vi, which is twice that obtained with half-bridge VSI topologies. Several modulating techniques have been developed that are applicable to full-bridge VSIs. Among them are the PWM (bipolar and unipolar) techniques.

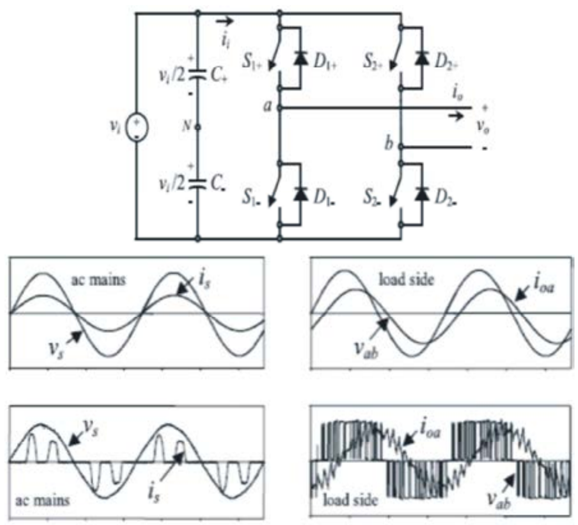


Fig. 2.5: The ac output voltage produced by the VSI

Single-phase VSIs cover low-range power applications and three-phase VSIs cover the medium- to high-power applications. The main purpose of these topologies is to provide a three-phase voltage source, where the amplitude, phase and frequency of the voltages should always be controllable. Although most of the applications require sinusoidal voltage waveforms (e.g., ASDs, UPSs, FACTS, VAR compensators), arbitrary voltages are also required in some emerging applications (e.g., active filters, voltage compensators).

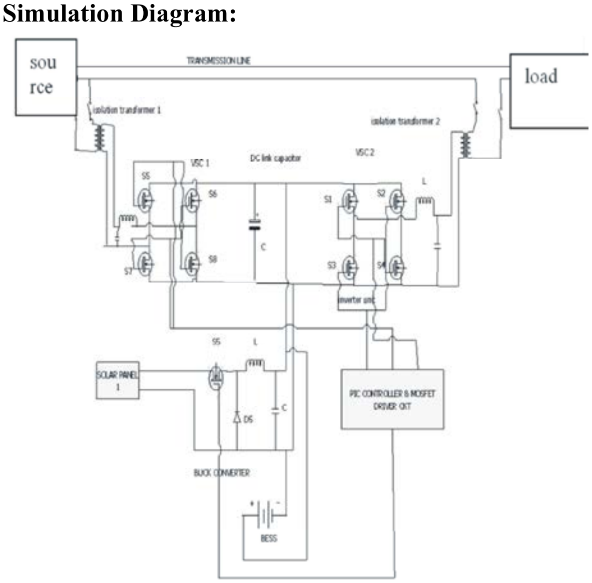
Solar Panel: A solar panel (photovoltaic module or photovoltaic panel) is a packaged, interconnected assembly of solar cells, also known as photovoltaic cells. The solar panel can be used as a component of a larger photovoltaic system to generate and supply electricity in commercial and residential applications. Because a single solar panel can produce only a limited amount of power, many installations contain several panels. A photovoltaic system typically includes an array of solar panels, an inverter and sometimes a battery and interconnection wiring.

Fig. 2.6: Solar Panel

Depending on construction, photovoltaic panels can produce electricity from a range of frequencies of light, but usually cannot cover the entire solar range (specifically, ultraviolet, infrared and low or diffused light). Hence much of the incident sunlight energy is wasted by solar panels and they can give far higher efficiencies if illuminated with monochromatic light.

Therefore another design concept is to split the light into different wavelength ranges and direct the beams onto different cells tuned to those ranges. This has been projected to be capable of raising efficiency by 50%. The use of infrared photovoltaic cells has also been proposed to increase efficiencies and perhaps produce power at night. Currently the best achieved sunlight conversion rate (solar panel efficiency) is around 21% in commercial product, typically lower than the efficiencies of their cells in isolation.

Simulation Diagram:



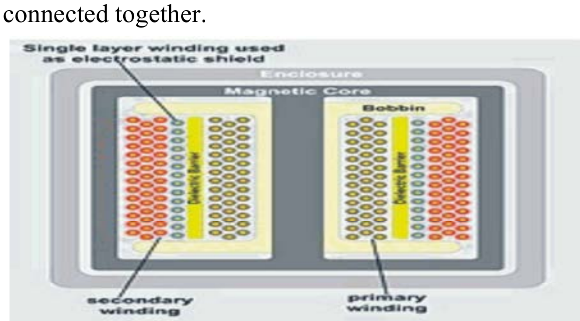
Circuit Diagram Description: Generally, UPQC has two voltage-source converters. The main purpose of the series converter is voltage sag and harmonics compensation. In addition, the series converter has the capability of voltage flicker/imbalance compensation as well as voltage regulation and harmonic compensation at the utility-consumer PCC. The main purpose of the shunt converter is to absorb current harmonics, compensate for reactive power and negative sequence current and regulate the dc-link voltage between both converters [10]. But UPQC has no capability in compensating the voltage interruption because it has not energy storage.

This paper proposes a new configuration of UPQC. Fig. shows the topology of the proposed system. MISO DC-DC converter and the two converters of UPQC are connected to a DC link that is connected to the Battery Energy Storage System (BESS) as well. The BESS acts as a DC link voltage maintainer, especially at the times that there is not sufficient irradiation of sun such as nights and cloudy weathers. On the other hand, the photovoltaic arrays charges BESS during the day. Each component of the proposed system described in the following sections.

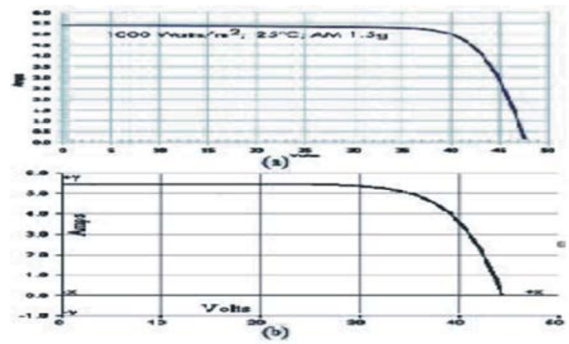
Hardware Components:

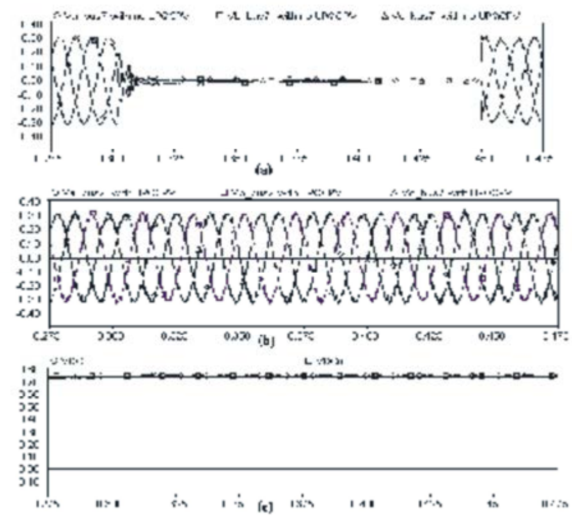
MOSFET (400v/8A)	IRF840
MOSFET DRIVER	IRS2110
PWM CONROL	dsPIC33FJ64MC802
SOLAR PANEL	20v/0.5A
LEAD ACID BATTERY	12v
MATLAB/SIMULINK	version2010a
MPLAB IDE	v8.56
TRANSFORMER	230/12 v

Isolation Transformer: An isolation transformer is a transformer used to transfer electrical power from a source of alternating current (AC) power to some equipment or device while isolating the powered device from the power source, usually for safety. Isolation transformers provide galvanic isolation and are used to protect against electric shock, to suppress electrical noise in sensitive devices, or to transfer power between two circuits which must not be connected together.



Simulation Output:





(a) Source voltage. (b) Load voltage. (c) DC voltage v

CONCLUSION

The proposed system is a powerful tool for power reliability and power quality improvement in distribution networks due to compensation functions. Moreover, it integrates all needed compensation characteristics that can be achieved by a device that is made up from UPQC with a battery energy storage system (BESS) and some Photovoltaic Arrays connected in the dc link. The performance of the proposed system was analyzed using simulations with Matlab and validates the improvement of the power reliability and quality under the severe disturbances such as voltage sag, harmonic distortion,and voltage interruption.

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