

# International Journal of Innovative Research in Science, Engineering and Technology

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## Single Stage Three-Phase PV System Applied to Microgrid for Power Quality Improvement

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**ABSTRACT:** This paper proposes a single-stage three-phase four-wire grid-connected photovoltaic (PV) system operating with a dual compensating strategy and feedforward control loop (FFCL). Besides injection of active power into the grid, the PV system operates as a unified power quality conditioner (UPQC), suppressing load harmonic currents and compensating reactive power. Furthermore, regulated, balanced, and harmonic-free output voltages are provided to the load. Since the PV-UPQC is based on a dual compensation strategy, the series converter operates as a sinusoidal current source, whereas the parallel converter operates as a sinusoidal voltage source. Thus, seamless transition can be achieved from the interconnected to the islanding operation modes, and vice versa, without load voltage transients. Moreover, to overcome problems associated with sudden solar irradiation changes, fast power balance involving the PV array and the grid is obtained, since the FFCL acts on the generation of the series inverter current references. As a result, the dynamic responses of both inverter currents and dc-bus voltage are improved. Detailed analysis involving the active power flow through the inverters is performed allowing proper understanding of the PV-UPQC operation. Experimental results are presented to evaluate both dynamic and static performances of the PV-UPQC tied to the electrical distribution system.

**KEYWORDS:** Unified Power Quality conditioner (UPQC), Feedback Control Loop (FFCL), Photovoltaic (pv) system

### I. INTRODUCTION

The production of electrical energy from renewable energy sources (RES) has grown a lot in recent decades, mainly due to increased demand for electricity, as well as the global intensive efforts to overcome the harmful environmental impacts caused by pollutant energy sources, such as oil, coal, natural gas, and others. Distributed generation (DG) systems based on RES have contributed to find new modern solutions for planning conventional power systems [1]. Inserted in this scenario, solar energy has emerged as a promising RES due to its abundance across the earth's surface. In particular, by means of photovoltaic (PV) cells, PV panels have been properly designed to produce energy by converting sunlight into electricity. Normally, grid-connected PV systems can be deployed by means of single-stage (S-S) or double-stage (D-S) power conversion [2], [3] S-S PV systems are usually composed of only a grid-tied inverter (dc/ac converter) [4]–[9]. In this case, the PV array is directly connected to the dc-bus of the grid-tied inverter. On the other hand, in D-S PV systems, an additional dc/dc converter is placed between the PV array and the inverter [10]–[12]. In this configuration, the maximum power point tracking (MPPT) is performed by the dc/dc converter [11]. Considering SS-PV systems, the task to perform the MPPT is assumed by the grid-tied inverter, combined with the advantage of achieving more efficiency when compared to DS-PV systems [7], [8]. In both the mentioned PV system topologies, the dc/ac converter controls the amplitude of the currents injected into the grid, in order to guarantee the balance between the power produced to the PV array and that absorbed by the grid. In most applications, PV systems are connected to the electrical distribution system, as well as microgrids where local generation is carried out [1], [13], [14]. Besides energy production, and according to a suitably adopted control strategy, PV systems can also carry out other roles in a microgrid, such as active filtering and/or reactive power compensation. In other words, PV systems can perform tasks similar to those performed by conventional parallel active

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power filters (P-APF) [11], [15],[16].In this paper, an S-S 3P4W grid-connected PV system with combined operation with a unified power quality conditioner (UPQC) is presented. The power circuit of the system, which is denominated PV-UPQC, is composed of two back-to-back con-nected neutral-point clamped (NPC) inverters. Thereby, series-parallel active power line conditioning, as well as injection of active power into the grid and load can be simultaneously per-formed. As a result, apart from the role of P-APF (load har-monic suppressing and reactive power compensation), the PV-UPQC system is also able to provide regulated, balanced, and harmonic-free output voltages.

## II. LITERATURE REVIEW

[1]. **B. Singh and J. Solanki, Load compensation for diesel generator- based isolated generation system employing DSTATCOM, Jan./Feb. 2011.**This paper presents the control of distribution static synchronous compensator (DSTATCOM) for reactive power, harmonics and unbalanced load current compensation of a diesel generator set for an isolated system. The control of DSTATCOM is achieved using least mean square-based adaptive linear element (Adaline). An Adaline is used to extract balanced positive-sequence real fundamental frequency component of the load current and a proportional-integral (PI) controller is used to maintain a constant voltage at the dc-bus of a voltage-source converter (VSC) working as a DSTATCOM.

[2]. **R. Gupta, A. Ghosh, and A. Joshi, Characteristic analysis for multisampled digital implementation of fixed-switching-frequency closedloop modulation of voltage-source inverter, Jul. 2009.**In this paper, a fixed-switching-frequency closed-loop modulation of a voltage-source inverter (VSI), upon the digital implementation of the modulation process, is analyzed and characterized. The sampling frequency of the digital processor is considered as an integer multiple of the modulation switching frequency. An expression for the determination of the modulation design parameter is developed for smooth modulation at a fixed switching frequency. The variation of the sampling frequency, switching frequency, and modulation index has been analyzed for the determination of the switching condition under closed loop.

[3]. **B. T. Ooi, J. C. Salmon, J. W. Dixon, and A. B. Kulkarni, A threephase controlled-current PWM converter with leading power factor, Jan. 1987** Experimental tests performed on a three-phase bipolartransistor controlled-current PWM power modulator show that it can operate with near-sinusoidal currents at 60 Hz with a 360-degree power angle range. Because of its capability to operate with leading power factor and good waveform, the PWM converter is a promising alternative to the thyristor Graetz bridge.

## II. PROPOSED SYSTEM

### SYSTEM DESIGN

The complete power circuit scheme of the proposed S-S 3P4W grid-tied PV system is composed of two back-to-back connected NPC inverters and their respective passive filtering el-ements, and three single-phase coupling transformers employed to connect the series NPC inverter to the grid.The distributed generation source, without storage, is composed of a PV array, which is formed by a single string with twenty series-connected PV panels, making possible the direct connection between the PV array and the dc-bus of the inverters.

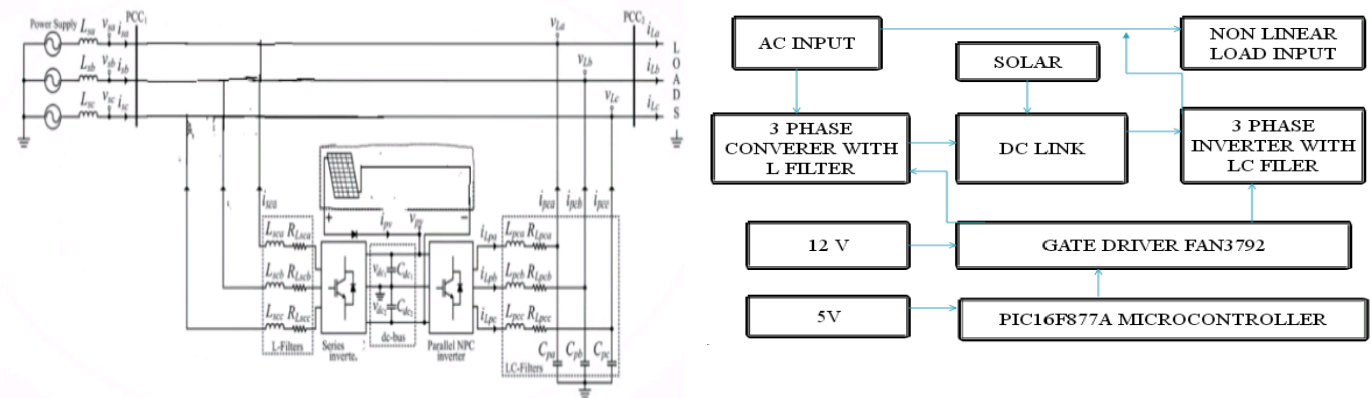
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## Block Diagram:



### 1. Microcontroller PIC16F877A

Microcontroller PIC16F877A is one of the PIC Micro Family microcontroller which is popular at this moment, start from beginner until all professionals. Because very easy using PIC16F877A and use FLASH memory technology so that can be write-erase until thousand times. The superiority this Risc Microcontroller compared to with other microcontroller 8-bit especially at a speed of and his code compression. PIC16F877A have 40 pin by 33 path of I/O.



PIC16F877A perfectly fits many uses, from automotive industries and controlling home appliances to industrial instruments, remote sensors, electrical door locks and safety devices. It is also ideal for smart cards as well as for battery supplied devices because of its low consumption. EEPROM memory makes it easier to apply microcontrollers to devices where permanent storage of various parameters is needed (codes for transmitters, motor speed, receiver frequencies, etc.). Low cost, low consumption, easy handling and flexibility make PIC16F877A applicable even in areas where microcontrollers had not previously been considered (example: timer functions, interface replacement in larger systems, coprocessor applications, etc.). In System Programmability of this chip (along with using only two pins in data transfer) makes possible the flexibility of a product, after assembling and testing have been completed. This capability can be used to create assembly-line production, to store calibration data available only after final testing, or it can be used to improve programs on finished products.

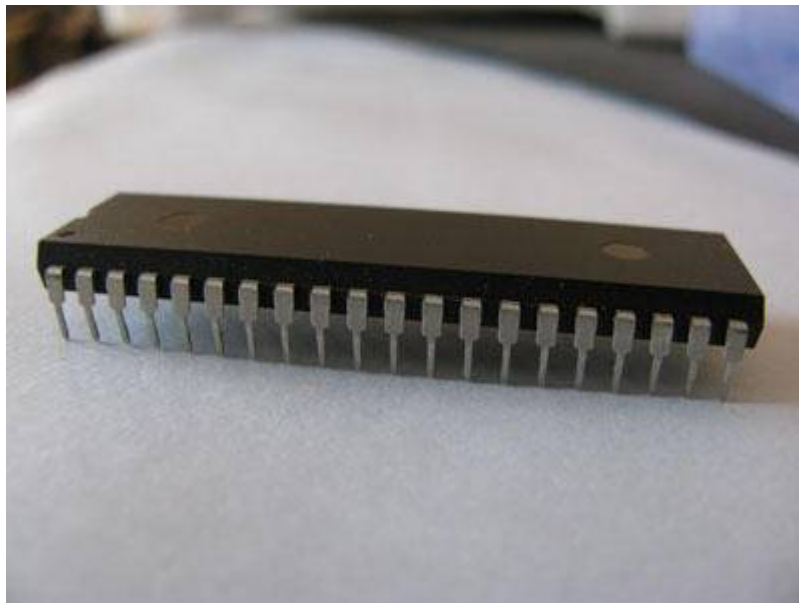
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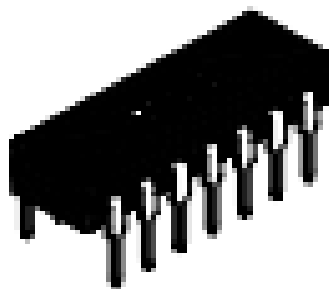
### PIC microcontrollers



### III. GATE DRIVER (FAN7392):

The FAN7392 are high voltage, high speed power MOSFET and IGBT drivers with independent high and low side referenced output channels. Proprietary HVIC and latch immune CMOS technologies enable ruggedized monolithic construction. Logic inputs are compatible with standard CMOS or LSTTL output, down to 3.3V logic. The output drivers feature a high pulse current buffer stage designed for minimum driver cross-conduction. Propagation delays are matched to simplify use in high frequency applications. The floating channel can be used to drive an N-channel power MOSFET or IGBT in the high side configuration which operates up to 500 or 600 volts.

### TOP VIEW OF FAN7392:

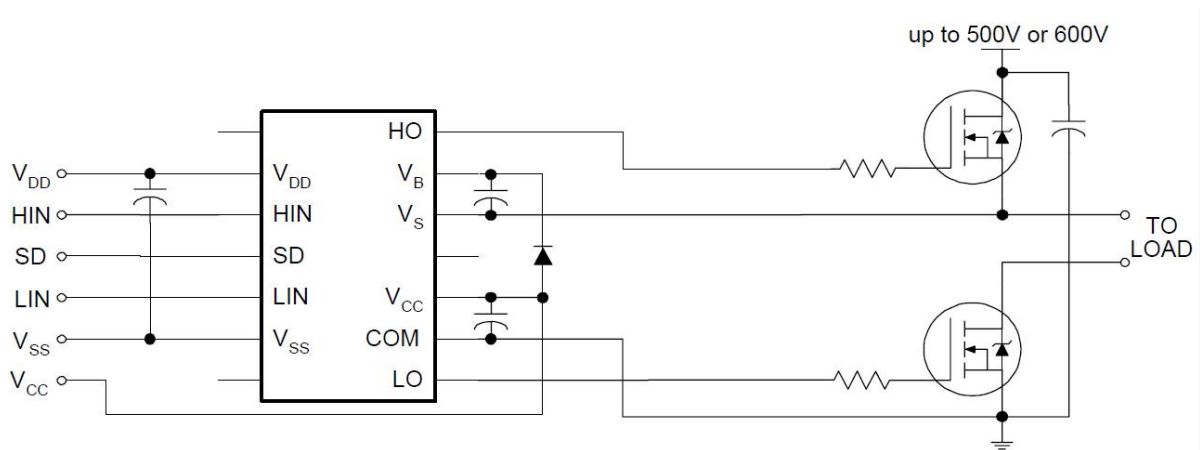


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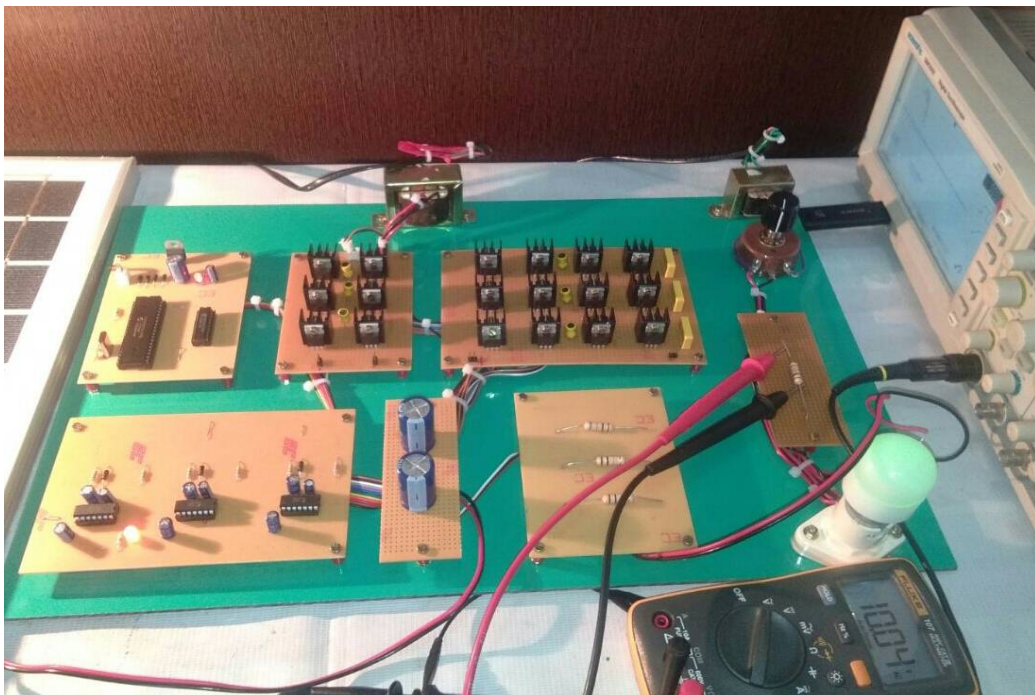


Typical connection of Gate driver

## Features

Gate drive supply range from 10 to 20V Under voltage lockout for both channels CMOS Schmitt-triggered inputs with pull-down Cycle by cycle edge-triggered shutdown logic Matched propagation delay for both channels Outputs in phase with inputs Also available LEAD-FREE

## IV. RESULTS



In Fig.1.UPQCHardware compensating by means of Line



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In Fig.2. UPQC Hardware compensating by means of PV system

## V. CONCLUSION

This paper proposed an S-S 3P4W grid-tied PV system, performing the tasks of a UPQC operating with a dual compensating strategy, as well as the FFCL. The system named PV-UPQC was built by means of two back-to-back connected three-level NPC inverters. Along with providing active power from the PV arrangement, the PV-UPQC system was able to perform series-parallel power-line conditioning. Thereby, both static and dynamic performances of the system were experimentally evaluated under distorted/disturbed grid voltage conditions, including sags, unbalances, and harmonics. Apart from series compensation, suppression of load harmonic currents, as well as compensation of load reactive power were carried out, such that an effective power factor correction was achieved. The effectiveness of the FFCL acting on the series converter current references was properly evaluated under sudden solar irradiation changes. The proposed PV-UPQC system represents a promising solution to be applied to DG systems, as well as ac microgrids.

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