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# Implementation of Unified Power Quality Conditioner Based On Variable Phase Angle Control Technique for Three Phase Three Wire System

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**ABSTRACT:** As one of the most promising solutions to mitigate the power quality (PQ) problem of the modern power systems, unified power quality conditioner (UPQC) draws many attentions. Since the UPQC consists of two sets of power converters, it will greatly increase the manufacturing investment of the setup. In this work, the optimal VA ratings of the converters in the UPQC are investigated due to system compensating requirements. The phase angle control (PAC) method is discussed and illustrated to have the feature of changing the online VA loading by adjusting the corresponding displacement angle. Based on the variable PAC method, a two-stage algorithm is utilized to optimize the ratings of the shunt and series converters in order to obtain the maximum utilization rates of the power converters in the UPQC. Moreover, the corresponding control algorithm is utilized to reduce the proposed UPQC online VA loadings for the different compensating operations. The proposed UPQC are compared with other approaches to highlight the advantage of the proposed optimization algorithm.

The proposed algorithms are also validated with the simulation and the real-time control hardware-in-loop (CHIL) results of the designed system. The proposed algorithms are simulated using MATLAB Simulink.

## I. INTRODUCTION

Voltage sags and swells are always the issue for the power systems. These issues could lead to undesired shutdown of sensitive loads and cause financial losses for power systems. Furthermore, the growing use of unbalanced and nonlinear power electronic loads increases voltage and current distortions in power systems. This will degrade the power quality (PQ) of the systems and further reduce the grid power factor. The distorted current injected into the power system will cause the overheating of capacitors and transformers, tripping of protective relays, and reducing the accuracy of smart meters. Therefore, action is urgently needed to avoid the damage of the power systems caused by the aforementioned PQ problems.

As one of the solutions, the unified power quality conditioner (UPQC) was proposed to mitigate the PQ problems of the source and load sides. After that, UPQC has drawn more and more attentions of researchers because of its outstanding performance in solving the PQ problems in the power system. Since the UPQC consists of two sets of power converters, it increases the manufacturing cost of the setup. This is why the UPQC has not been commercialized.

The reduction of the ratings of the UPQC without compromising the compensation abilities becomes essential, as it will increase the

utilization rate of the converters and reduce the manufacturing cost of the systems. In this way, the whole system will have higher competitiveness.

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## II. PROPOSED SYSTEM

A phase angle control method is used to control a power flow of voltage regulation in the electric power transmission system, the method is Unified Power Flow Controller (UPFC)Phase-fired control (PFC), also called phase cutting or "phase angle control", is a method for power limiting, applied to AC voltages. It works by modulating a thyristors, SCR, or other such gated diode-like devices into and out of conduction at a predetermined phase of the Appling method. The main causes of a poor power quality are harmonic currents, poor power factor, supply-voltage variations, etc. To mitigate power quality problems, we have various equipment's like active filter, passive filter, unified power flow controller and unified power quality conditioner etc. Among from them unified power quality conditioner was widely studied by many researchers as an eventual method to Improve power quality of electrical distribution System. To obtain the proper operation from UPQC, we need to control power filters of UPQC method.

### BLOCK DIAGRAM

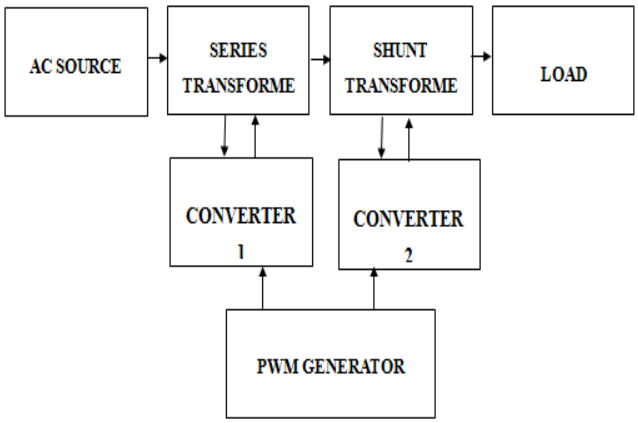


**Figure: Proposed system block diagram**

### BLOCK DIAGRAM EXPLANATION:

**Basic configuration of UPQC**

UPQC mainly consists of:-

**Series APF: -** In a transmission line series APF is generally connected in series. It is connected to the transmission line with the transformer.

Series APF is a voltage source inverter connected in series with transmission line. It is used to compensate or mitigate the problems which comes due to voltage distortions and voltage unbalances. The series APF injects a compensating voltage so that load voltage will be perfectly balanced and regulated. Controlling of series inverter is done by PWM (pulse width modulation) techniques. Here we used Hysteresis band PWM techniques as it implementation is easy. Also its response is fast. Its details are explained in subsequent sections.

**Shunt APF:** - In a transmission line shunt APF is generally connected in parallel. Shunt APF is used to compensate for distortions & harmonics which are produced due to current. Due to non- linear load there is harmonics in load current, so to keep source current completely sinusoidal and distortion free we uses Shunt APF. Shunt APF injects compensating

current so that the source current is completely sinusoidal and free from distortions. Controlling of Shunt APF is done by hysteresis band PWM techniques. In hysteresis band PWM techniques output current follows the reference and current and is within the fixed hysteresis band.

**Series Transformer: -** The necessary voltage which is generated by series APF so that the voltage at load side is perfectly balanced and regulated i.e. Sinusoidal is injected into the transmission line with the help of these

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transformers. The series transformer turns ratio should be suitable so that injected voltage is suitable such that it injects a compensating voltage which will completely make the load side voltage balanced and also it reduces the current flowing through series inverter.

**Low Pass Filter: -** Low pass filter is used at the output of series inverter so that the high frequency voltage components are removed which is produced due to switching of Voltage source inverter

**High pass filter: -** High pass filter is used at output of shunt inverter so that the ripples which are produced due to currents switching are absorbed.

**DC link capacitor: -** The two voltage source inverter are connected back to back through a DC capacitor. DC capacitor is provides a DC voltage for working of both the inverter. The DC capacitor also provides a real power difference between source and load during the transient period and also acts as a energy storage elements.

During steady state real power supplied by source should be equal to the sum real power demand of load & a small amount of power which compensates for active filter. DC capacitor voltage should be equal to reference value but due to disturbance in real power balance between source and load due to change in load conditions the DC capacitor value is changed from reference value

## III. SIMULATION DIAGRAM

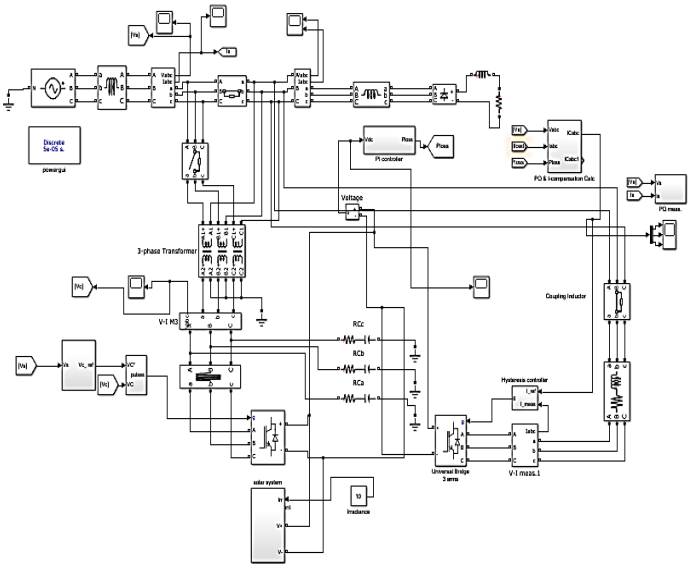


**Figure :Simulation circuit diagram**

**SOURCE VOLTAGE**

The input power has different variation in the output peak of the current waveform denote the fluctuation

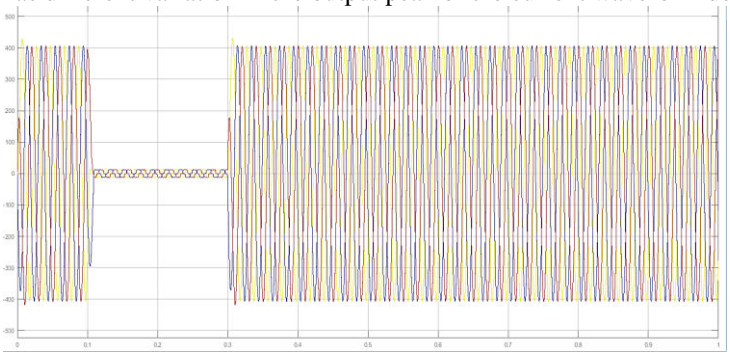

**Figure :Input voltage with sag**

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**LOAD WAVEFORM**

The input power has optimized sinusoidal output of the power waveform denote without any fluctuation.

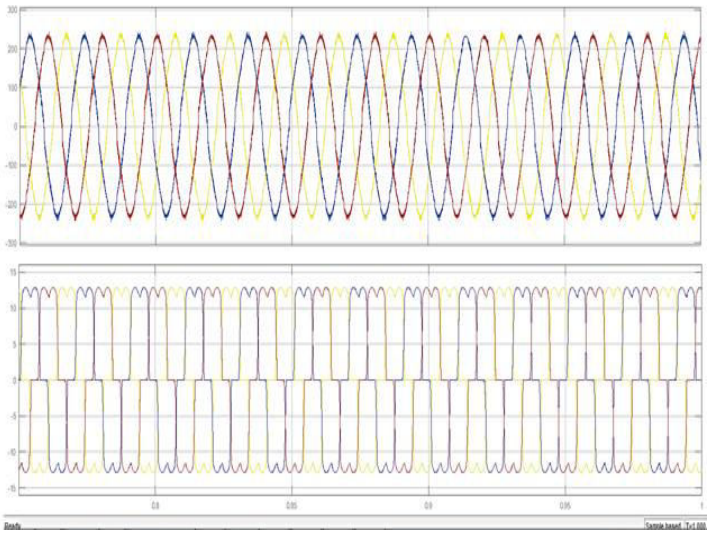

**Figure:Output wave forms without fluctuations**

**3.5 HARDWARE OUTPUT TABULATION:**

| Hardware | Specification | Input Ranges | Output Ranges |
|---|---|---|---|
| Generating power | Input source | 0-230V | 230V |
| Microcontroller | PIC (16f877a) | 5V DC | 5V DC |
| Inverter | Output power | 24V DC | 24V AC |
| Transformer | Output power | 24v AC | 230V AC |
| AC lamp | Output load | 230V DC | 4A |

## IV. CONCLUSION

Based on the variable PAC method, a two-stage algorithm is proposed to select the minimum ratings of the shunt converter and series converter of the UPQC in order to obtain the maximum utilization rates of the power converters in the UPQC. The corresponding control algorithm has ensured the safe operation of the designed UPQC. The performance of the de- signed UPQC has verified the feasibility of the proposed algorithms. The advantages and promising application of the pro- posed algorithm are outlined as follows:

- The minimum VA rating of UPQC is selected by using the variable PAC method. It will increase the utilization
  rate of the converters and reduce the manufacturing cost of the system.
- The proposed control method can guarantee the smooth changeover of the
  displacement angle during the transient state. 3) The proposed algorithms can be
  applied in the advanced UPQC topologies, e.g., transformerless UPQC, to increase the utilization rate of the converters in the system.

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**Future Scope:**

- The UPQC model can be enhanced and enriched to terminate the power quality problems in a power system. The various ways for doing that:
- The prototype of this UPQC model can be established in laboratory.
- UPQC model can be established for three phase four wire system for the non-linear load and unstable voltage.
- Here the UPQC model developed was right shunt UPQC, further we can develop model for left shunt UPQC.
- We can connect wind turbines, solar energy system that is renewable source of energy to UPQC to get improved power in consumer ends during serious conditions.

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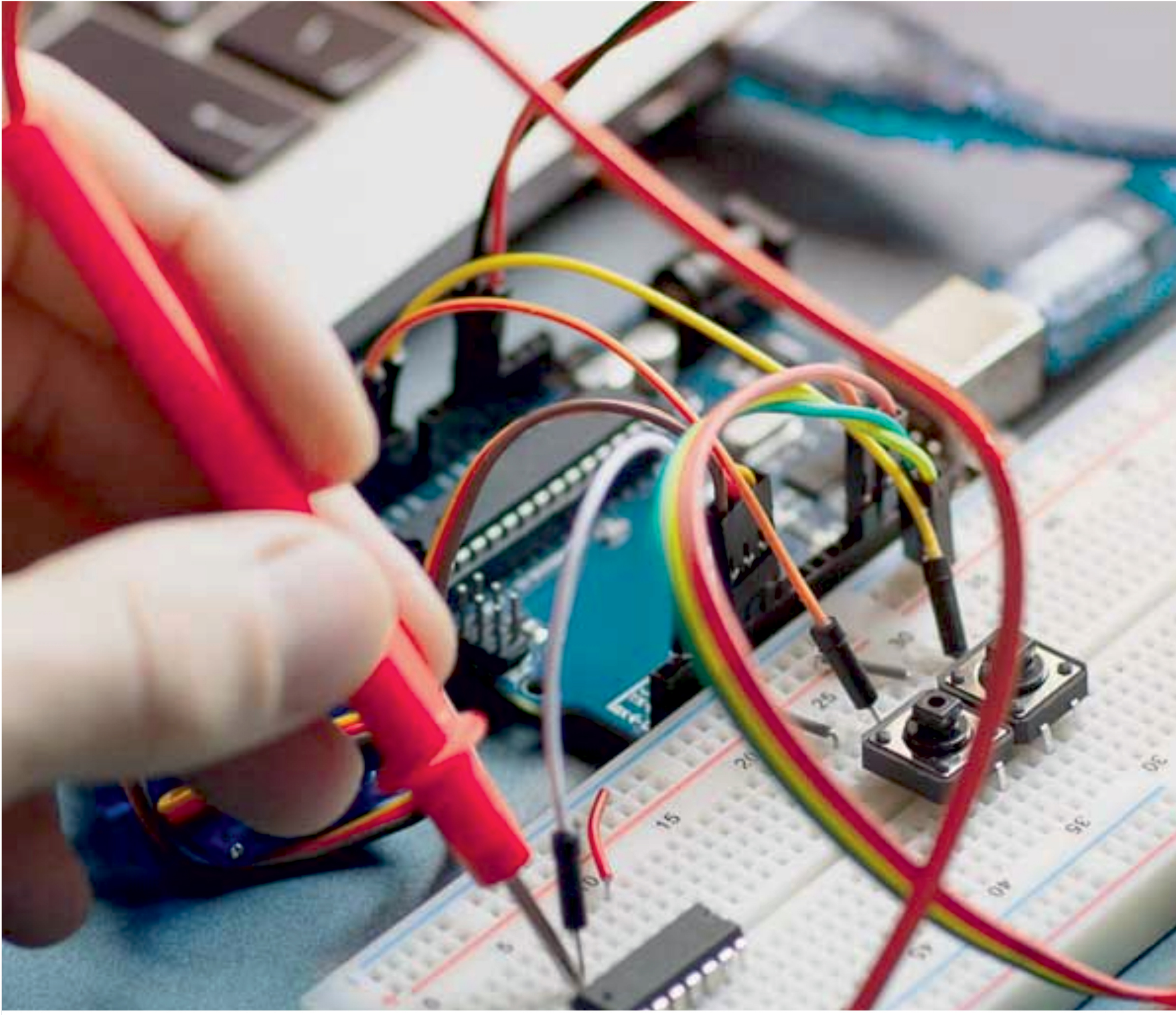


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