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UNIFIED POWER QUALITY CONDITIONER FOR VOLTAGE COMPENSATION IN MICROGRID

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Abstract

A new power conditioner control system with unified power quality metrics has been developed to improve the power quality (PQ) in microgrids (UPQC). A microgrid (MG), which combines the production of electricity from unconventional or renewable energy sources, presents a practical option for the production of electricity in the future. The percentage of power generation from renewable sources inside the MG framework is increasing quickly. The UPQC is tasked with addressing problems such load demand changes, compensation for voltage sag and swell, harmonic compensation, etc. The source voltage and load current of a microgrid are predicted using the control technique using both fundamental and harmonic components. The simulation results show that the proposed method can provide the desired power quality even in the presence of a variety of disturbances. It was tested in a single-phase power distribution system. The results are also contrasted and shown in relation to the Power Quality monitoring done in microgrid power stations.

Keywords: Energy efficiency and renewable energy, Harmonic compensation, Load demand variations, Microgrid, Power quality (PQ), Power quality conditioner, Voltage sag and swell.

1. Introduction

The sag, swell, flicker, voltage notch, and harmonic disturbances that are normally caused by power system faults, non-linear loads such power electronic devices, and dynamic system response exist in a microgrid system. On the other hand, the increased usage of fragile electronic circuits in homes and businesses, as well as the privatisation and competition in the electric energy networks, made the improvement of power quality one of the main problems in the electrical industry [1]. Power electronic devices are being seriously explored as a remedy for power quality problems due to their quick response times and versatility.

UPQC (Fig. 1) is one of these contraptions, which has certain capability in making strides the control quality status. In show disdain toward of the reality that the UPQC, with the credibility of implanting energetic and responsive control in course of action and parallel branches, can astonishingly compensate the control quality events, its change work depends on applying a suitable control procedure [2]. All electric control problems or disturbing effects inside the supply systems that prevent end-user equipment from functioning properly are referred to as electrical control quality (PQ) difficulties. They cover a wide range of diverse issues with time periods ranging from steady state to tens of nanoseconds. In order for the microgrid system to function, four crucial groups of PQ unsettling influences must be experienced as frequently as is humanly possible.

- Voltage droop and brief blackouts are unpleasant effects brought on by breaker repairs and inadequate voltage regulations.
- End-user nonlinear loads that interact with the distribution framework's equipment to cause harmonic mutilation issues
- Due to the microgrid's inherent inequality, there are small and slow fluctuations in voltage (counting voltage flash driving to light flash), current, and recurrence from the stated values.

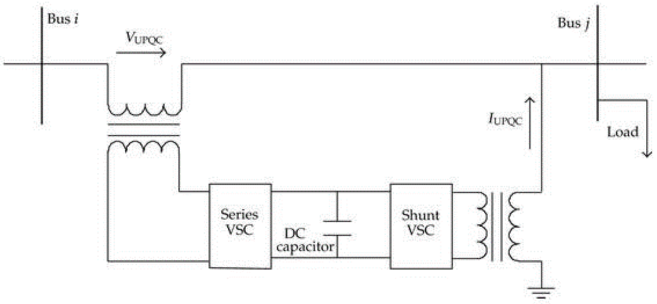

Fig. 1. Block diagram of UPQC system.

2. Proposed Diagram

The UPQC is one of the specific control devices used at electrical control conveyance systems to improve the control quality of transport system customers. The use of UPQC can be used to alter the features of voltage and current imbalances, eliminate current clamour, account for responsive control, kill voltage clamour, advance voltage control, correct voltage hang or swell, and avoid voltage interferences.

A device similar in architecture (Fig. 2) to a coupled control stream conditioner is a coupled control quality conditioner (UPQC) (UPFCThe UPQC uses two voltage source inverters (VSIs), each of which is connected to a single dc essentiality capacity capacitor [2]. The other VSI is connected to the same line using a shunt, while one of these two VSIs is planned to be connected to the ac line. In a control dissemination structure, a UPQC is used to simultaneously execute arrangement and shunt emolument. Unbalance, twisting, and even DC components may be found in a control dissemination structure. A UPQC must therefore provide shunt or arrangement compensation when operating in this environment.

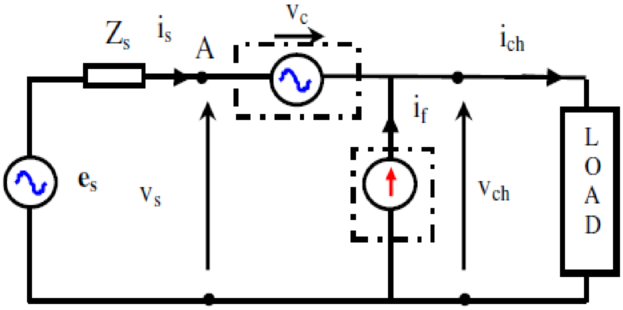

Fig. 2. Circuit diagram of UPQC system.

The relationship is obtained by disregarding converter losses.

$$V_L I_C + V_S I_S = 0 \tag{1}$$

Decompose the load current I_L and source voltage Vs into the two components shown by

$$I_L = I_L + I_L' \tag{2}$$

$$V_S = V_S + V_S' \tag{3}$$

where I_L only includes fundamental frequency components in the positive sequence. V_s is subject to similar criticisms. The remaining load current (I_L) and source voltage (V_s), including harmonics. The power factor at the load bus affects I_L, which is not unique.

The necessary stack voltages, source streams, critical recurrence components, and crucial recurrence components must all be in a positive configuration to achieve the control goals [3].

$$P_L = |V_L^* \, I_S^*| \cos \theta_l \tag{4}$$

where $V_L{}^*$ and $I_S{}^*$ are Voltage at load bus and current source. θ_i is the angle between voltage and current.

According to Eq. (1), a UPQC can be thought of as a hybrid of a DVR and a STATCOM with no active power flow across the DC link under the presumptive operational conditions [4]. Thus, power transfer between the shunt and series converters may be necessary to achieve the goal of voltage regulation at the load bus.

2.1. Distorted components

Extricated from the supply voltage and stack current are the damaged parts, such as noises. These frame references must be incorporate into the setup in order to produce the stack voltage and supply current with no distortion [5]. As shown in

Fig. 1, for instance, the basic component V_f is extracted from the distorted source voltage V_s in order to achieve voltage consonant stipend. The consonant components V_h are then obtained by deducting V_f from vs at this point. Using a controller and the arrangement dynamic channel, V_h moulds the reference that will be incorporated into the arrangement [6]. For present consonant compensation, the same procedure is applied without restriction.

2.2. Model-based control

The trading signals for the VSIs of the course of action and shunt channels of the UPQC are chosen by a model-based helped control. The UQPC is utilized to delineate the control scattering course of action in this multi-input, multi-output state-space show [7]. The show can take under consideration the impedances that are shown interior the different components and inside the line. An encouraged control plot is at that point connected to the exhibit at that point. For the VSIs of the format and shunt channels of the UPQC, it'll build exchanging groupings. In this way, it decides what has to be imbued into the system while taking the coupling impact and the voltage drop through different impedances into consideration [8]. The UPQC's operation is at that point enhanced as distant as is practicable.

2.2.1. Control design

The UPQC system's control circuit is depicted in Fig. 3. Shunt and series correction are performed using voltage source inverters. It should be well known that both voltage source inverters are controlled by a single dc interface capacitor. One of the voltage source inverters is connected to the ac framework in parallel, while the other is connected to the ac framework in arrangement, both through infusion transformers [5]. The shunt compensation circuit is made up of an inverter coupled in parallel and its control circuit. The series compensation circuit, on the other hand, is made up of an inverter coupled in series with the appropriate control circuit.

Since it is causal, the spread of the flag around the critique circle happens quickly. Chemically, some irreversible reactions or electronically, a dynamic circuit component with access to a helper control supply that can provide control pick-up to amplify the flag as it spreads from input to output, characterise the typical notion of bolster forward [9]. The flag is transported from source to stack by the nourish forward.

The DC capacitor voltage must be at least 150% of the highest line-line supply voltage for the UPQC to function properly. Either a fuzzy controller or a PI controller can be used to manage the capacitor voltage consistently. In this manner, the UPQC control structure has been divided into control circuits for the shunt compensator and arrangement compensator. We presumptively allow the UPQC to carry out the taking in two capacities.

- The feeder or source current (i_s) is converted to balanced sinusoids through the shunt compensator.
- The load voltage (v_l) is converted to balanced sinusoids through the series compensator and also regulate it to a desired value.

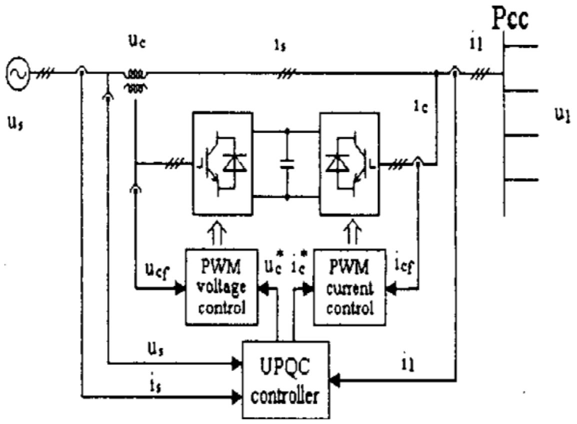

Fig. 3. Control design of UPQC system.

Feed Forward control: Feed forward control refers to a component or pathway within a control system that transmits a controlling signal from a source within the system, frequently a command signal from an outside operator to a load anywhere in the system's external environment [10]. Unlike a control system that modifies the output to account for how it affects the load and how the load itself may alter unexpectedly, a control system with merely feed forward behaviour reacts to its control signal in a pre-defined manner without adapting to how the load reacts.

Feed Back control: A system can be controlled internally via a feedback mechanism, process, or signal. A feedback loop is the name for such a loop. Esmin et al. [11], in systems with an input and an output, positive feedback refers to feeding back a portion of the output in a way that increases the input, and negative feedback refers to feeding back a portion of the output in a way that partially opposes the input. A control system's input comes from an external signal source, and its output goes to an external load. The signal propagation from input to output is referred to as "feed forward" in this context.

The proposed control law (that consists of the FB and FB controls) for the UPQC is given by

$$u = u_{ff} + u_{fb} \tag{5}$$

where u_{ff} is the FF control law and u_{fb} is the FB control law.

In order to achieve energy conservation during the sag phase, the controller will automatically adjust the supply current to rise so that the supply power can return back to its previous level [1]. The supply power increases when the sag in vs recovers at t=0.3 seconds. Bae et al. [12], when the sag is cleared, the supply current is once more regulated to decrease so that the supply power can increase to its previous level and the energy conservation is maintained.

2.2.2. Simulation results

Figure 4 represents the simulation diagram for the Sag condition without controller and their corresponding output voltage and current waveform variations in the sag condition are also mentioned in Figs. 5 and 6. In the output waveforms due to sag and without controller there will be a high THD.

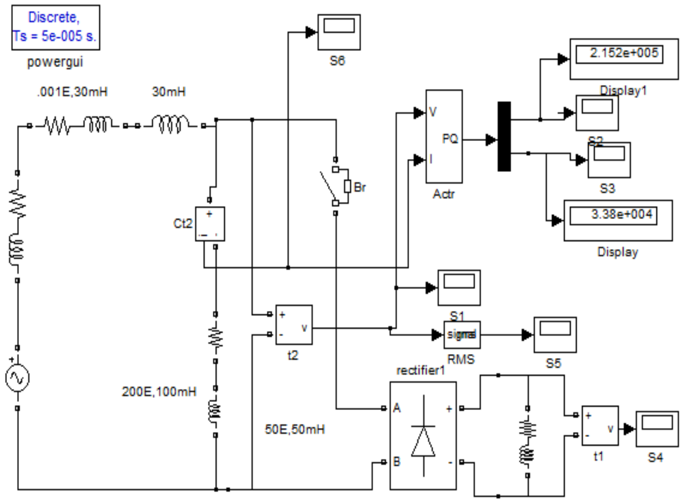

Fig. 4. Simulation without UPQC controller.

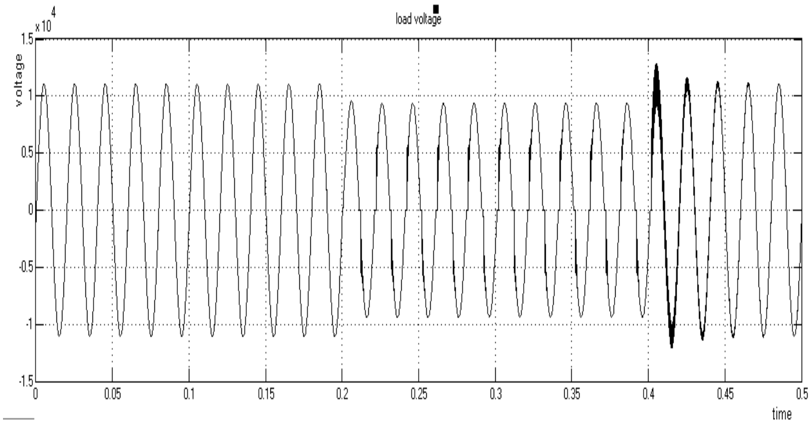

Fig. 5. Output voltage waveforms without UPQC controller.

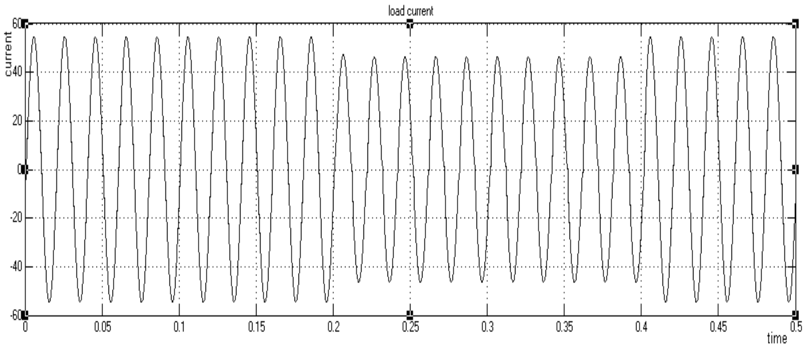

Fig. 6. Output current waveforms without UPQC controller.

Figure 7 represents the simulation diagram for the Sag condition with controller (Unified Power Quality Conditioner) and their corresponding output voltage and current waveform variations in the sag condition are also mentioned in Figs. 8 and 9. In the output waveforms due to sag and with controller (UPQC) the THD is reduced to approximately 50%.

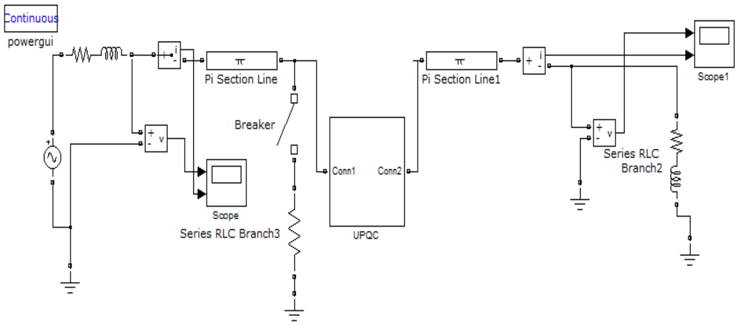

Fig. 7. Simulation with UPQC controller.

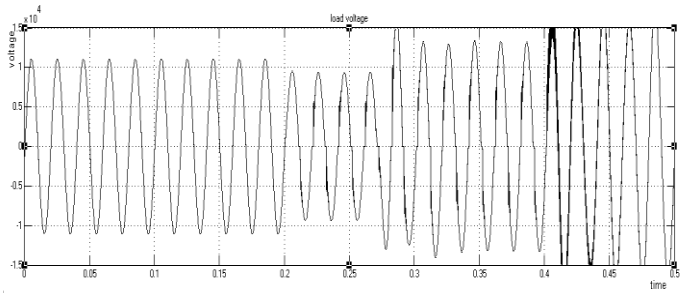

Fig. 8. Output voltage waveforms with UPQC controller.

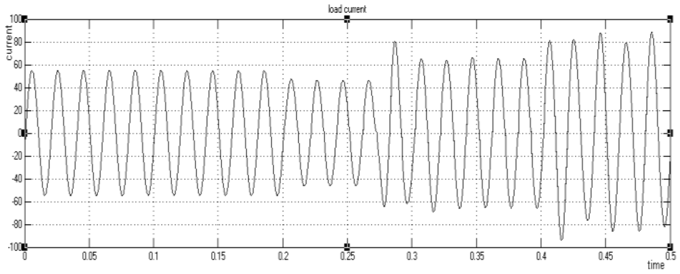

Fig. 9. Output current waveforms with UPQC controller.

Table 1 represents the measurements of THD for Sag condition with and without controller. From the table, it is inferred that 50% of reduction in THD occurred by using the UPQC controller.

Table 1. Measurements of total harmonic distortion (THD) for Sag.

Parameter	Without UPQC Controller	With UPQC Controller
Sag condition: THD value	8.88%	4.98%

3. Conclusion

In this study, a Unified Power Quality Conditioner (UPQC) has been controlled using a model-based approach. The suggested loop shape also offers a practical way to keep the supply voltage from fluctuating at a high frequency while yet maintaining adequate control performance. The study's findings indicate a methodical approach to the control design of the Unified Power Quality Conditioner (UPQC), offering a comprehensive answer to a number of power quality issues like load demand variations, voltage sag and swell compensation, power correction in a microgrid system. It is concluded that this paper has demonstrated a systematic approach to the control design of UPQC, providing an overall solution to a variety of power quality problems encountered in a power distribution system. The Power Quality issues can be minimized by other advanced methods, and we can obtain a better solution, which gives improved voltages and reduction of harmonics within a fraction of seconds.

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