MODELLING AND CONTROL DESIGN OF THREE PHASE-FOUR WIRE UPQC FOR POWER QUALITY IMPROVEMENT

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ABSTRACT
Unified power quality conditioner is the combination of series active power filter and shunt active power filter. The purpose of series Active power filter is to compensate source side distortions. Purpose of using shunt active power filter is to compensate load side distortions. The neutral current flow is considered to be major distortion in distribution system. In order to harmony the load current and neutral current flow, three phase four wire distribution is used. Fourth leg is used in the shunt part of the inverter for neutral flow current. Unbalance is considered to be serious issue in transmission and distribution system. By using UPQC above problem can be overcome. Hysteresis controller is mainly used to control the gating pulses of the inverter. The simulation results based on MATLAB/Simulink are presented to show the effectiveness of the balanced load current in three phase four wire distribution.

IndexTerms: Active power filter (APF), four-leg voltage-source inverter (VSI) structure, three-phase four-wire(3P4W) system, unified power quality conditioner (UPQC)

I. INTRODUCTION
The Use Of refined equipment/loads at transmission and distribution level has increased considerably in recent years due to the reinforcement in the semiconductor device technology. The equipment needs clean power in order to function properly. At the same time, the switching transaction of these devices generates current harmonics resulting in infected distribution system. The power-electronics-based devices have been used to swamped the major power quality problems [1]. To provide a balance, jazz-free, and constant magnitude power to sensitive load and, at the same time, to restrict the harmonic, instability, and reactive power appealed by the load and hence to make the overall power distribution system more vigorous, the unified power quality conditioner (UPQC) is one of the prime solutions [6–11]. A three-phase four-wire (3P4W) distribution system can be accomplished by providing the neutral conductor along with the three power lines from generation station or by forwarding a delta-star (Δ–Y) transformer at distribution level.

The UPQC installed for 3P4W application generally deal with 3P4W supply [9]. This paper proposes a new topology/structure that can be accomplished in UPQC-based applications, in which the series transformer neutral used for series inverter can be preowned to accomplish a 3P4W system even if the power supplied by utility is three phase three-wire (3P3W). This new functionality using UPQC could be effective in future UPQC based distribution systems.

II. PROPOSED 3P4W DISTRIBUTION SYSTEM UTILIZING UPQC
Generally, a 3P4W distribution system is accomplished by providing a neutral conductor along with three power conductors from generation station or by outlining a three-phase Δ–Y transformer at distribution level. Fig. 1 shows a 3P4W network in which the neutral conductor is yielded from the generating station itself, whereas Fig 2 shows a 3P4W distribution network considering a Δ–Y transformer. Assume a plant site where three-phase three-wire UPQC is already installed to protect a sensitive load and to restrict any entry of distortion from load side toward

![Fig 2 3P4W distribution (neutral is provided by Δ–Y transformer)](image-url)
If we want to upgrade the system now from 3P3W to 3P4W due to installation of some single-phase loads and if the distribution transformer is close to the plant under consideration, utility would provide the neutral conductor from this transformer without major cost involvement. In certain cases, this may be a costly solution because the distribution transformer limits, drawn by nonlinear loads, to control the power distribution system harmonic pollution. At the same time, the use of refined equipment/load has increased significantly, and it needs clean power for its proper operation. Therefore, in future distribution systems and the plant/load centers, application of UPQC would be common. Fig. 4 show the proposed novel 3P4W topology. Recently, the utility service providers are putting more and more restrictions on current total harmonic distortion (THD). At the same time, the use of refined equipment/load has increased significantly, and it needs clean power for its proper operation. Therefore, in future distribution systems and the plant/load centers, application of UPQC would be common. Fig. 4 shows the proposed novel 3P4W topology.

As shown in Fig. 3, the UPQC should necessarily consist of three-phase series transformer in order to connect one of the inverters in the series with the line to function as a controlled voltage source. If we could use the neutral of three-phase series transformer to connect a neutral wire to realize the 3P4W system, then 3P4W system can easily be achieved from a 3P3W system (Fig. 4).

The neutral current, present if any, would flow through this fourth wire toward transformer neutral point. This neutral current can be compensated by using a split capacitor topology [2,9,10] or a four-leg voltage-source inverter (VSI) topology for a shunt inverter [2,11]. The load on the 3P4W system, the current drawn from the utility can be unbalanced. In this paper, a new control strategy is proposed to compensate the current unbalance present in the load currents by expanding the concept of single phase p–q theory [5, 6]. According to this theory, a signal phase system can be defined as a pseudo two-phase system by giving π/2 lead or π/2 lag, i.e., each phase voltage and current of the original three-phase system can be considered as three independent two-phase systems. These resultant two-phase systems can be represented in α-β coordinates, and thus, the p–q theory applied for balanced three-phase system [3] can also be used for each phase of unbalanced system independently.

used in order to take few samples for taking reference value. Positive sequence extraction is taken from load for the generation of output pulses. Both the actual and reference value is taken from the circuit block itself for the purpose of simplification of circuit. Hence hysteresis is advance method of controlling gating pulse of the inverter. The neutral current is taken as a input for the fourth leg inverter in order to avoid sending back to the source. This prevents distortion of the source and hence circuit is protected.
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**Fig 5 Pulse generation model**

The above model explains the control block diagram of UPQC with hysteresis controller. The gating pulse of the circuit is controlled by hysteresis controller.

**Fig 6 Overall Simulink Model**

The UPQC should consist of three-phase series transformer in order to conjoin one of the inverters in the series with the line to function as a stabilied voltage source. If we could use the neutral of three-phase series transformer to co-joint a neutral wire to accomplish the 3P4W system, then 3P4W system can easily be achieved from a 3P3W system. The neutral current, present would flow through this fourth wire toward transformer neutral point. This neutral current can be comproised by using a split capacitor topology or a four leg voltage source inverter (VSI) topology for a shunt inverter.

**PROPOSED SYSTEM PARAMETERS**

<table>
<thead>
<tr>
<th>SYSTEM QUANTITIES</th>
<th>VALUES</th>
</tr>
</thead>
<tbody>
<tr>
<td>System voltages</td>
<td>230V(line to neutral), 50 Hz</td>
</tr>
<tr>
<td>Linear load</td>
<td>Z_La=34+j47.55Ω, Z_Lb=81+j39.6Ω, Z_Lc=31.5+j70.8Ω</td>
</tr>
<tr>
<td>Shunt VSI parameters</td>
<td>C_{dc}=2200µF, L=26MHz, R=1Ω</td>
</tr>
<tr>
<td>Series VSI parameters</td>
<td>C_{se}=80µF, L=5 Mh</td>
</tr>
<tr>
<td>Series interfacing transformer</td>
<td>1:1, 1000V and 700 VA</td>
</tr>
<tr>
<td>PI controller gains</td>
<td>K_p=6, K_i=5.5</td>
</tr>
</tbody>
</table>

**OUTPUT WAVEFORM**

**Fig (a) Before Compensation and (b) After compensation**

**VI CONCLUSION**

This paper presents control and performance of UPQC intended for installation on a transmission line with the help of hysteresis controller. A control system is simulated in unbalanced condition with series inverter and shunt four leg inverter.

Simulation results show the effectiveness of UPQC in active filtering and controlling unbalance in voltage and current through the line. AC voltage regulation and power factor of the transmission line also improved.

**REFERENCES**


