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Simulation of Interline Power Quality Conditioner

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Abstracts

This paper proposes to improve the power quality of two feeders in a distribution for a new connection of IUPQC. A UPQC consists of a series dynamic-voltage restorer (DVR) and a shunt active power filter (APF) both joined together by a common DC bus. It is demonstrated how this device can be connected between two independent feeders to regulate the bus voltage of one of the feeders while regulating the current across a load in the other feeder. Since the UPQC is connected between two different feeders (lines), this connection of the UPQC will be called an interline UPQC (IUPQC). The structure, control and capability of the IUPQC are discussed in this paper. The efficacy of the proposed configuration has been verified through simulation studies using Matlab.

Keywords: IUPQC, UPQC, DVR.

Introduction

A quality power supply is essential for proper operation of industrial processes which contain critical and sensitive loads. For Power Quality improvement, the developers of power electronics devices such as FACTS and Custom Power Devices have introduced an emerging branch of technology providing the power system with versatile new control capabilities. Like Flexible AC Transmission Systems (FACTS) for Transmission systems, the new technology known as Custom Power pertains to the use of power electronics controllers in a distribution system. Just as FACTS improves the power transfer capability and stability margins, custom power makes sure consumers get pre specified quality and reliability of supply. Voltage sags And swells in the medium and low voltage grid area Considered to be the most frequent type of Power Quality Problems. Their impact on sensitive loads is severe. Different solutions have been developed to protect Sensitive loads against such disturbances. Among these IUPQC is the most effective device. These are different categories, natural phenomenon are lightning strikes on a transmission line or distribution feeders, falling off tree branches on a transmission line or distribution feeders, second category consists of contributes to voltage sags, voltage swells, harmonics, etc. those are transformer energization, usage of power electronic loads like UPS, ASDS, capacitor or feeder switching. To define power quality, long duration voltage variations, short duration voltage variations, transients, voltage imbalance.

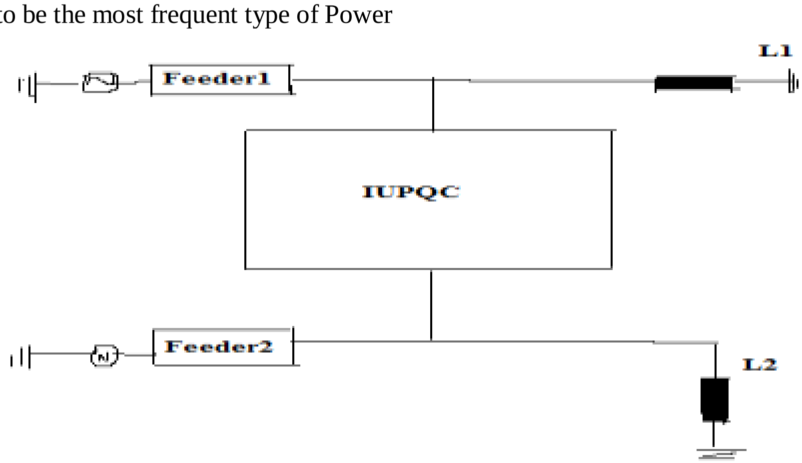

Fig 1.0 single line diagrams for IUPQC.

Interline power quality conditioner (IUPQC)

As the power quality problems are originated from the utility and customer side, the solutions should come from both and are named as utility based solutions and customer Based solutions respectively. The best examples for those Two types of solutions are FACTS devices (Flexible AC Transmission Systems) and Custom power devices. FACTS devices are those controlled by the utility, Whereas the Custom power devices are operated, Maintained and controlled by the customer itself and installed at the customer premises. Both the FACTS devices and Custom power devices are based on solid state power electronic components. As the new Technologies emerged, the manufacturing cost and the reliability of those solid state devices are improved; hence the protection devices which incorporate such solid state Devices can be purchased at a reasonable price with better performance than the other electrical or pneumatic devices available in the market. Some of these Custom Power Devices are: Series-connected compensator like a DVR (Dynamic Voltage Restorer), Shunt-connected compensator like DSTATCOM (Distribution STATic COMpensator), Series and shunt compensator like UPQC (Unified Power Quality Conditioner), IUPQC (Interline Unified Power Quality Conditioner) and SSTS (Solid State Transfer Switch). Among these, the IUPQC is an effective custom power solution, which consists of two back to back connect IGBT based voltage sourced bi-directional converters with a common DC bus.

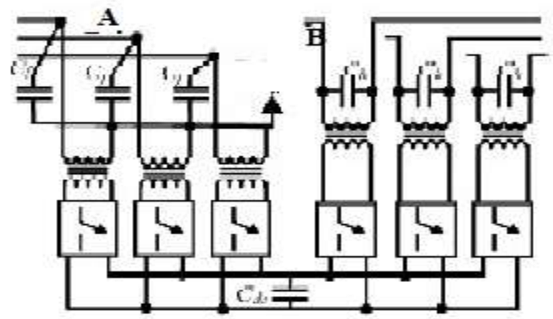

Fig 2.0 IUPQC distribution system

The complete structure of a three-phase IUPQC with Two such VSCs is shown in Figure.4 The distribution Sides of the shunt-connected transformers (VSC-1) are Connected in star with the neutral point being Connected to the load neutral. The secondary winding Of the series connected transformers (VSC-2) are Directly connected in series with the bus B-2 and load L-2. The AC filter capacitors CF and Cook are also Connected in each phase to prevent the flow of the Harmonic currents generated due to switching. The six Inverters of the IUPQC are controlled independently. The switching action is obtained using the output Feedback control. The feeder impedances are denoted by the pairs (Rs1, Ls1) and (Rs2, Ls2). It can be seen that the two feeders Supply the loads L-1 and L-2. The load L-1 is assumed To have two separate components an unbalanced part (L-11) and a non-linear path (L-12). The currents Drawn by these two ladies are denoted by il1 and il2, Respectively. We further assume that the load L-2 is a Sensitive load that requires an uninterrupted and regulated voltage. The shunt VSC (VSC-1) is connected to bus B-1 at the End of Feeder-1, while the series VSC (VSC-2) is
Connected at bus B-2 at the end of Feeder-2. The Voltages of buses B-1 and B-2 and across the sensitive Load terminal is denoted by Vt1, Vt2, and Vl2, Respectively.

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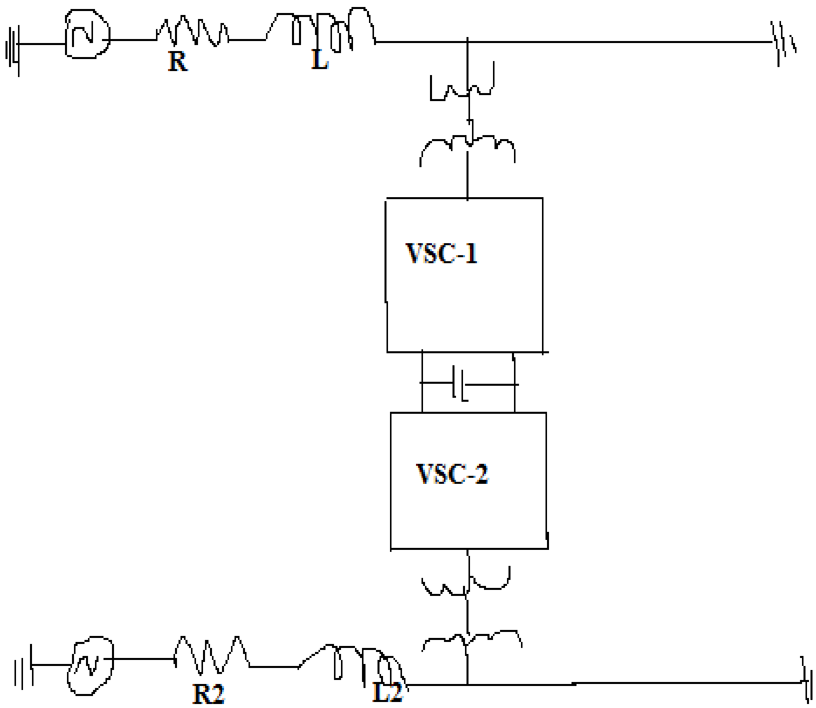

Fig 3.0 Typical IUPQC Distribution system

Proposed IUPQC system

The structure of the IUPQC connected to a distribution system is shown in Fig. 1. As shown in this figure, the feeder impedances are denoted by (*Rs1*, *Ls1*) and (*Rs2*, *Ls2*). It can be seen that two feeders Feeder-1 and Feeder-2 are connected to two different substations that supply the system loads L1 and L2. The IUPQC is connected to two buses BUS1 and BUS2 with voltages *ubus1* and *ubus2*. The supply voltages are denoted by *us1* and *us2* while load voltages are denoted by *ul1* and *ul2*. Finally, two feeder currents are denoted by *is1* and *is2* while load currents are denoted by *il1* and *il2*. The IUPQC consists of one series and one shunt converter which are connected to two adjacent feeders with being supplied from a common DC link. This topology provides power transfer between two adjacent feeders through DC link and it is very advantageous instead of conventional UPQC topology in a single feeder. In the proposed configuration, VSC1 is connected in parallel with load L1 at the end of Feeder-1 and VSC2 is connected in series with BUS2. The aims of the IUPQC are listed below:

1) To compensate for reactive and harmonic components of nonlinear load current (*il1*);

2) To regulate the load voltage (*ul2*) against sag/swell, interruption and disturbances in the system to protect the sensitive/critical load L2. In order to achive these two goals, shunt VSC (VSC1) operate as a current controller while the series VSC (VSC2) operate as a voltage controller.

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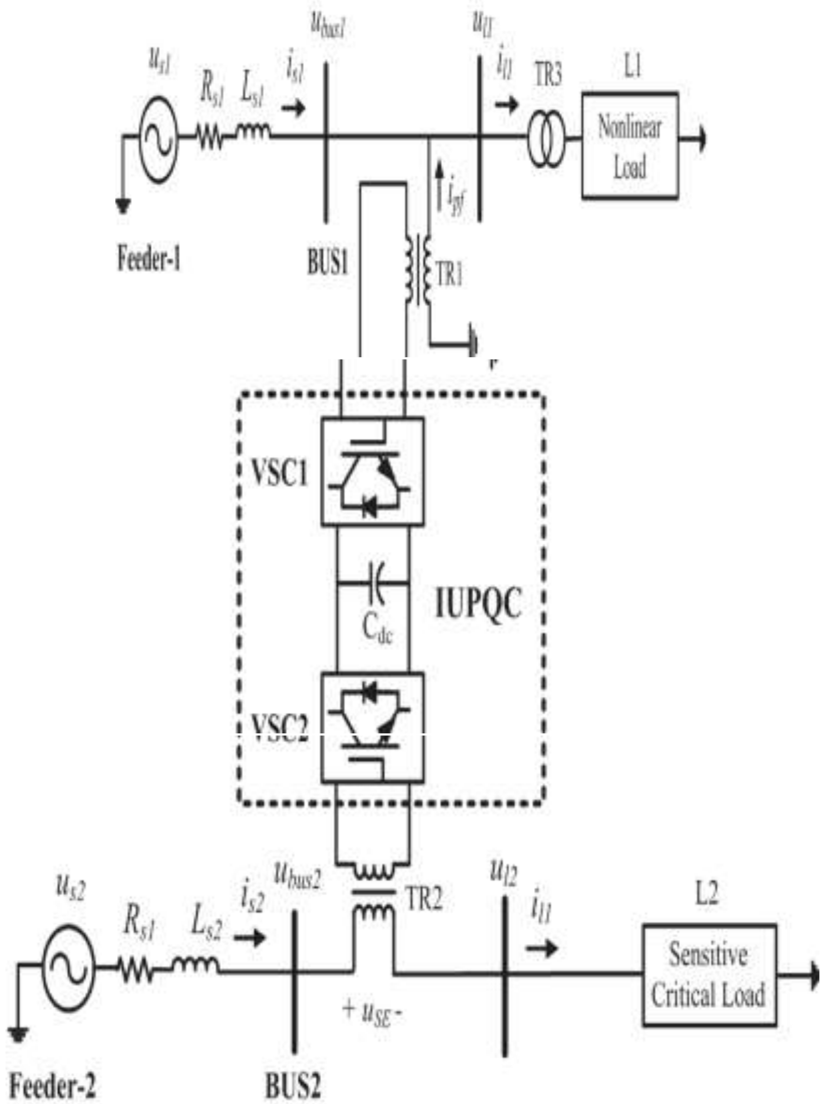

Fig 4.0 distribution system

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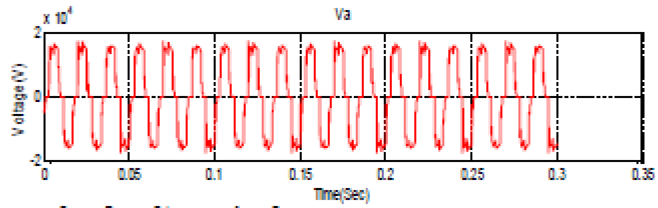
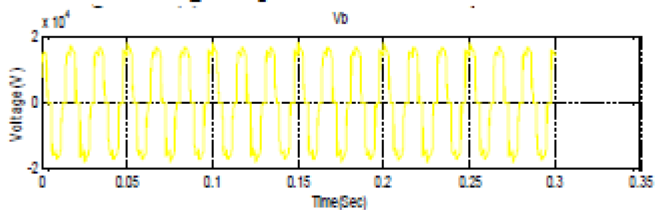
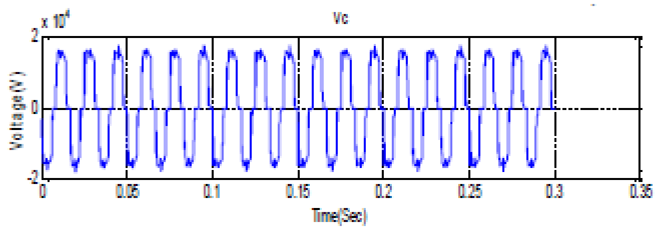
Simulation results



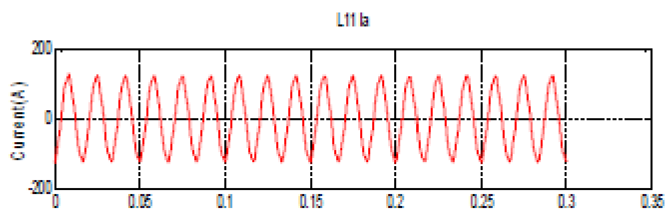
load voltage A phase



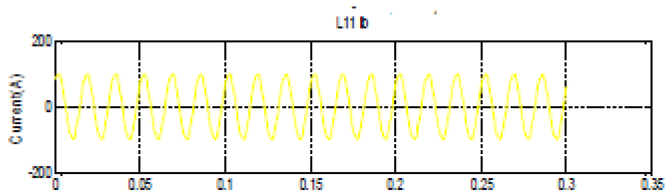
load voltage B phase



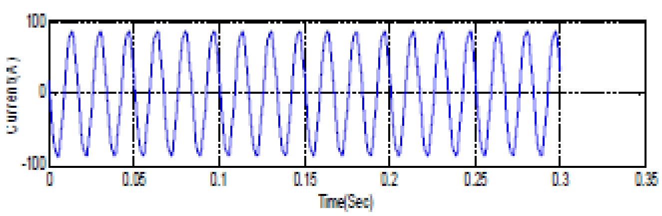
load voltage C phase



current A phase



current B phase



current C phase

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Conclusion

This paper describes a new connection for a unified power quality conditioner (UPQC) to improve the power quality of two feeders in a distribution system. It is demonstrated how this device is connected between two independent feeders to regulate the bus voltage of one of the feeders while regulating the current across a load in the other feeder. From the result, it can be concluded that, whenever there is a voltage swell in either of the feeders, one feeder readily compensates for the other. The structure, control and capability of the IUPQC have been discussed in this paper. The efficacy of the proposed configuration has been verified through simulation studies using Matlab. For all the types of disturbances the Total Harmonic Distortion (THD) after compensation is to be less than 5% which is as per IEEE standards.

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