Improved Hybrid UPQC Performance with Fuell Cell and Photovoltaic-Battery Unit

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Abstract—This work concentrateon Unified Power Quality Conditioner (UPQC), Fuel cell with battery along with Photovoltaic unit integration for enhancing the performance aspects of the distribution network. Nowadays all most all the applications are integrated with energy components. Because of the better response in critical conditions from the integrated systems. It is essential to use a compensator to compensate power quality problems due to continuous automation. There are various devices are available for conditioning of power supply. UPQC will takes care of voltage-current associated problems and supports for all kind of disturbances. This work focus on the UPQC working and correction of voltage and currents in a distribution system includes a DC-DC converter. The series-shunt controller is take care for executing the UPQC to address non-linear loads. The implementation of the this method is simulated in MATLAB.

Keywords: Powerproblems, Battery, Distribution Network, Harmonic Distortion, Fuell Cell and Non-Linear Load.

I. INTRODUCTION

In the distribution network, there are plenty type of loads may present and used by different types of users in the increased manner. Due to automated devices, every one forced to work on the different kind of power electronic converters. Normally non-linear types of loads may cause the power quality problems and becomes an headache. As a whole these type of problems become a never ending solution to distribution engineers to find the solution for the same. This kind of disturbances may cause spoil the network and individual equipment performance. As being a customer, expects the good quality of supply with out interruptions. Due to urbanization, this type of problems are increases [1]. The delicate equipment inject harmonics into the system and nonfunctioning of the devices that are generally used in daily life face the voltage problems. Out of the quality conditioners, Unified Power Quality Conditioner (UPQC) is also the best conditioner take care of power variations. The UPQC has a single structure which holds both series and shunt compensator based on voltage source converter technique. Shunt compensator used for current disturbances and series rectifies voltage profiles [2-3] both are using the same dc link. Series structure behave like DVR and shunt acts as STATCOM. The battery along with supercapacitor can

be used for the DC link for shorter duration of time [11-12].

The fuel cell combined with photovoltaic units supplied for the DC link for a span of short periods. Fuel cell modules are employing in most of the fields such as hybrid interfaces, medical fields, defence related equipmets and also used in domestic appliances. The three phase, three wire design with a non-linear load of diode-bridge rectifier in the DC side. In paper [9] explains about utilization of Bi-directional full bridge DC-DC converters in UPQC. The permitted THD of source current for all working conditions is 5% as per IEEE standards. Batteries are least cost effective devices for removing power variations. They are employed in remote applications, plug-in hybrid electric vehicles and toys etc. Battery-Fuel cell integration is one of the most trusted method. It improves the battery life, power enhancement etc. [4-6].

PV is one of the freely unexaust energy source, very little maintenance. Because of these advantages PV is mostly employed in urban electricity systems, irrigation systems, residential and industrial systems. Hybridization of the enrgy modules is one of the useful and emerging concept is becoming more famous in many fields for sharing of loads, density, energy storage concepts and quick release of power for smaller duration of times [7] and [8].Battery, FC-PV system is one of the economical choices for saving of battery standard life, power quality improvement and it also have the capacity in reducing the peak power of battery. This combined system is focused to enhance the capacity of the UPQC, DC/DC converter and FC-PVBattery (FC-PVBat) system is used to reduce THD content, settingof powerfactor at point of installed. This work is summarized as: Section 2; explains the FC-PVBat based UPQC. Section 3; explains the Scheme of series and shunt converter control and DC-DC converter. Section 4; shows results analysis. Section5; presents conclusion.

II. FC-PVB AT BASED UPQC

The arrangement of FC-PVBat based UPQC shown in Fig 1. The voltage source inverters for compensators are used with insulated gate bipolar transistors (IGBT's). In this work, synchronous reference frame methodology for the hybrid UPQC in integration with DC-DC converter to modulate voltage at the FC-PV Bat module for the expected performance.

A. Series Converter

The aim of the series active filter is to remove the harmonics voltage harmonics [10]. The phase voltages are supplied at point of interconnection which results into two unit vectors (sinwt, coswt).

The source voltages V_{sa} , V_{sb} , V_{sc} are transformed into d-q-0 from a-b-c, presented in eq. (3.1).

III. SERIES AND SHUNT CONVERTER CONTROL

$$\begin{bmatrix} V_{sd} \\ V_{sq} \\ V_0 \end{bmatrix} = \frac{2}{3} \begin{bmatrix} \cos\theta & \cos\left(\theta - \frac{2\Pi}{3}\right) & \cos\left(\theta + \frac{2\Pi}{3}\right) \\ -\sin\theta & -\sin\left(\theta - \frac{2\Pi}{3}\right) & -\sin\left(\theta - \frac{2\Pi}{3}\right) \\ \frac{1}{2} & \frac{1}{2} & \frac{1}{2} \end{bmatrix} \begin{bmatrix} V_{sa} \\ V_{sb} \\ V_{sc} \end{bmatrix}$$
(3.1)



Fig. 1: Arrangement of Combined FC-PVBat UPQC.



Fig. 2: Simulation of FC-PV Bat UPQC.

D. Shunt Converter

Shunt compensator is employed to address the link voltage as well and to maintain the load current under non linear loads.

The I_{d}^{*} , I_{a}^{*} values are

$$I_d^* = i_{dDC} + i_{out}$$
(3.2)

$$\mathbf{I}_{\mathbf{q}}^* = \mathbf{i}_{\mathbf{q}\mathbf{D}\mathbf{C}} + \mathbf{i}_{\mathbf{q}\mathbf{r}} \tag{3.3}$$

The two reference currents (i_{d}^{*}, i_{q}^{*}) are used to generate the reference load currents, to correct the current magnitude at shunt APF.

The Inverse Park transformation is used transform abc to dqo domain which is given in eq. (3.6).

$$\begin{bmatrix} V_{La}^{*} \\ V_{Lb}^{*} \\ V_{Lc}^{*} \end{bmatrix} = \frac{2}{3} \begin{bmatrix} \cos \theta & -\sin \theta & 1 \\ \cos \left(\theta - \frac{2\Pi}{3} \right) & -\sin \left(\theta - \frac{2\Pi}{3} \right) & 1 \\ \cos \left(\theta + \frac{2\Pi}{3} \right) & -\sin \left(\theta - \frac{2\Pi}{3} \right) & 1 \end{bmatrix} \begin{bmatrix} V_{d} \\ V_{q} \\ V_{0} \end{bmatrix}$$
(3.4)

The control strategy of shunt active filter senses the current values and is examined with the reference currents to obtain switching pulses. The DC-DC converter is having two full-bridges [9], it works in the dual direction. The working voltage of the fuel cell varies between 60-75V, while the dc link voltage is 680V.

IV. RESULTS

A. Sag -Swell Compensation

In the supply voltage, sagis created during 1.5 sec to 3.0 sec and the corresponding injection voltages are shown in Fig.3 and the similarly corresponding voltages and currents shown in Fig.4,whenever a swell is applied between time slot 6.0 sec to 7.5sec. To enhance the load voltage, the battery will support in combination with FC-PV, It will inject the power to the series compensator, we can observe the same and it can be monitored that the load voltages get its original position.



Fig.3: Sag Compensation

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Fig.4 :Swell Compensation.

B. Correction of Unabalanced Currents

The currents are become unbalanced from 9.0 sec to 10.5 sec when the system is disturbed by isolating the breaker. The system needs reactive power which isprovided by the FC shown in Fig.5. Harmonics content of source current and the load voltage shown in Fig. 6 (a) & (b). By interpreting, the percentage THD of load current is increased due to disturbance. The source current has the THD of 0.76% and load voltages are 1.02%.



Fig.5: Correction of Unbalanced Currents.





Fig. 7: Power Factor Correction.

The imlementation of Fuel cell –Photovoltaic battery hybridization of UPQC results are shown in Table 1 with THD values. The UPQC handles the voltage and current variations under abnormal conditions.

FABLE	1:	RESULTS	OF	COMBINED	UPQC	WITH	FC-P	VBAT
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Control Technique	Parameter	%Thd
UPQC with FC-PV-	Source Current (Amps) (i _{Sabe rms})	0.76%
Bat	Load Voltage (Volts) (V _{Labc rms})	1.02%

V. CONCLUSION

This paper explains about the Hybrid arrangement of UPQC along with the FC-PVBat. The UPQC prfectly corrects the current, voltage associated problems and decreases the Fuelcell. In all operating working strategy, the perentage THD of source current within allowable range as per IEEE standards. The THD of the source current is 0.76%. The implementation of hybrid configuration for the UPQC is address under linear, nonlinear load under MATLAB environment.

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References

- [01] B. Han, B. Bae, H. Kim and S. Baek, "Combined operation of unified power-quality conditioner with distributed generation," in *IEEE Transactions on Power Delivery*, vol. 21, issue no. 1, pp. 330-338, (2006)
- [02] Astha Shrivastava, Sujata Gupta "Review on Super Capacitor-Battery based Hybrid Energy Storage System for PV Application", International Journal of Advanced Engineering, Management and Science (IJAEMS), vol-3, issue-4, (2017)
- [03] V. Khadkikar and A. Chandra, "A New Control Philosophy for a Unified Power Quality Conditioner (UPQC) to Coordinate Load-Reactive Power Demand Between Shunt and Series Inverters," in *IEEE Transactions on Power Delivery*, vol. 23, issueno. 4, pp. 2522-2534, (2008)\
- [04] S. Sumathi, L. Ashok Kumar, P. Surekha, "Solar PV and Wind Energy Conversion Systems", Green Energy and Technology, Springer, ISSN 1865-3529.
- [05] Anne Labouret and Michel Villoz Solar Photovoltaic Energy, IET RENEWABLE ENERGY SERIES
- [06] Wenlong Jing, Chean Hung Lai, Wallace S.H. Wong, M.L. Dennis Wong, A comprehensive study of batterysupercapacitor hybrid energy storage system for standalone PV power system in rural electrification
- [07] Jie Li , Yu Chen, Yunda Liu, Research on a Standalone Photovoltaic System with a Supercapacitor as the Energy Storage Device, ELSEVIER, Energy Procedia, 2012 International Conference on Future Energy, Environment, and Materials

- [08] Alicia Arce, Alejandro del Real and Carlos Bordons, MPC for battery/fuel cell hybrid vehicles including fuel cell dynamics and battery performance improvement, pp.1-30.
- [09] Zhe Zhang, Ziwei Ouyang, Ole C. Thomsen, Michael A. E. Andersen, Analysis and Design of a Bidirectional Isolated DC-DC Converter for Fuel Cells and Super-Capacitors Hybrid System, TPEL-Reg-2010-11-1023. R2
- [10] Yang Zhang, Shengfa Zhang, Jiahong Chen," The Applications of Bidirectional Full-bridge DC-DC Isolated Converter in UPQC", Electrical Machines and Systems, ICEMS 2008, pp.1916 – 192, (2008)
- Bhim Singh, Ambrish Chandra, Kamal Al-Haddad -Power Quality: Problems and Mitigation Techniques, WILEY, ISBN: 978-1-118-92205-7, (2015)
- [12] Anaya-Lara O, Acha E."Modeling and Analysis Of Custom Power Systems by PSCAD/EMTDC", IEEE Transactions on Power Delivery, Volume 17, Issue: 2002, Pages: 266-272.
- Bollen, M.H.J.,"Voltage sags in Three Phase Systems", Power Engineering Review, IEEE, Volume 21, Issue :9, September 2001, PP: 11-15.