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Review on Improvement of Power Quality by Using Customer Devices

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ABSTRACT: Cost of various energy storage technologies is decreasing rapidly and the integration of these technologies into the power grid is becoming a reality with the advent of smart grid. Interline Power Flow Controller (IPFC) is one product that can provide improved voltage sag and swell compensation with energy storage integration. Ultra capacitors (UCAP) have low-energy density and high-power density ideal characteristics for compensation of voltage sags and voltage swells, which are both events that require high power for short spans of time. The novel contribution of this paper lies in the integration of rechargeable UCAP-based energy storage into the IPFC. With this integration, the UCAP-IPFC system will have active power capability and will be able to independently compensate temporary voltage sags and swells without relying on the grid to compensate for faults on the grid like in the past. UCAP 3 is integrated into dc-link of the IPFC through a bidirectional dc–dc converter, which helps in providing a stiff dc-link voltage, and the integrated UCAP-IPFC system helps in compensating temporary voltage sags and voltage swells, which last from3 s to 1 min. Complexities involved in the design and control of both the dc–ac inverter and the dc–dc converter are discussed. The Interline Power Flow Controller (IPFC) proposed a new concept for the compensation and effective power flow management of multi-line transmission systems. In its general form, the IPFC employs a number of inverters with common dc link, each to provide series compensation for a selected line of the transmission system. Because of the common dc link, any inverter within the IPFC is able to transfer real power to any other inverter and thereby facilitate real power transfer among the lines of the transmission system.

KEYWORDS: DC - DC converters, sag / swell, UCAP (Ultra Capacitor), IPFC (Interline Power Flow Controller), Energy storage integration

I. INTRODUCTION

Nowadays people are encouraged to use renewable energy sources (e.g. solar energy, wind energy). The reasons are that renewable energy sources are clean and infinite. They can replace some of fossil energy sources to reduce greenhouse gas emissions and air pollution. A major drawback of using these renewable energy sources is they require higher installation cost initially as compared to conventional energy sources. But using renewable, energy source in rural countryside is likely a cheap solution in comparison with developing a complete electrical network. In order to improve the reliability and efficiency of distributed power generation, the renewable energy source systems need to be connected to the electrical network.

Conventional power system consists of centralized type network system and integration of renewable energy sources tend to be of distribution type network system. This means that most of renewable energy sources will first be connected to the centralized distribution networks. The conventional distribution networks are not flexible to accommodate the structure of distributed power generation. The effect of this can be noticed in terms of power quality. In particular, voltage profile will be mainly affected. In these kind of applications, the super capacitor based energy storages well fulfil above requirement. However, only few papers describe the internal relationship of each inverter and converter; and only few papers present the control strategies for each inverter and converter in different configurations. In this research, we need therefore to develop the control principles of shunt, series or dual coupled inverters with super capacitor based energy storage, to achieve precise and fast response in each sub system [1].

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The Flexible AC Transmission System (FACTS) initiative, considerable effort has been spent in recent years on the development of power electronics-based power flow controllers. From a technical approach standpoint these controllers either use thyristor-switched capacitors and reactors to provide reactive shunt and series compensation, or employ self-commutated inverters synchronous voltage sources to modify the prevailing transmission line voltage and thereby control power flow [2]. It is a well-established practice to use reactive power compensation to increase the transmittable power in ac power systems. Fixed or mechanically switched capacitors and reactors have long been employed to increase the stead state power transmission by controlling the voltage profile along the lines. During the last decade it has been convincingly demonstrated that both the transient and dynamic stabilities (i.e. first swing stability and damping) of the power system can also be improved, and voltage collapse can be prevented, if the reactive compensation of transmission lines is made rapidly variable by solid-state, thyristor switches and electronic control [3]. In its general form the Interline Power Flow Controller employs a number of dc to ac inverters each providing series Compensation for a different line. In other words, the IPFC comprises a number of Static Synchronous Series Compensators [2], [4].However, within the general concept of the IPFC; the compensating inverters are linked together at their dc terminals. With this scheme, in addition to providing series reactive compensation, any inverter can be controlled to supply real power to the common dc link from its own transmission line. Thus, an overall surplus power can be made available from the underutilized lines which then can be used by other lines for real power compensation. In this way, some of the inverters, compensating overloaded lines or lines with a heavy burden of reactive power flow, can be equipped with full two-dimensional, reactive and real power control capability [2].

Voltage disturbance is the common power quality problem in industrial distribution systems. The voltage disturbance mainly encompasses voltage sags, voltage swells, voltage harmonics, and voltage unbalance [10].

Problems with power quality that result in costly loss of production to critical processes create a dilemma for both the serving utility and the energy consuming customer [11].

II.LITERATURE SURVEY

1. DVR for power quality improvement

This paper presents a control system based on a repetitive controller to compensate for key power-quality disturbances, namely voltage sag, harmonic voltages, and voltage imbalances, using a dynamic voltage restorer (DVR). The control scheme deals with all three disturbances simultaneously within a bandwidth. The control structure is quite simple and yet very robust; it contains a feed forward term to improve the transient response and a feedback term to enable zero error in steady state. The well-developed graphical facilities available in PSCAD/EMTDC are used to carry out all modelling aspects of the repetitive controller and test system. Simulation results show that the control approach performs very effectively and yields excellent voltage regulation [5].

2. Super Capacitor Based Energy Storage to Improve Power Quality

Distributed power generation will be formed in many weak distribution networks, after renewable energy sources are connected to them. It is very important to increase the reliability and efficiency of using these renewable energy sources. By using DV (Dynamic Voltage Restorer), the power quality problem in distributed power generation (e.g. voltage fluctuation) can effectively be solved. In this paper, super capacitor based energy storage will be used as the peak power unit, to ensure the power quality on the both sides of the DVR during short time and on the one side of the DVR during long time duration. The proposed control methods of each inverter and converter have been verified in Matlab simulation and tested in our laboratory. High power quality can be achieved in distributed power generation with the presented systems [1].

3. Improvement of power quality by using facts devices

While energy storage technologies do not represent energy sources, they provide valuable added benefits to improve stability, power quality, and reliability of supply. Battery technologies have improved significantly in order to meet the challenges of practical electric vehicles and utility applications. Flywheel technologies are now used in advanced non-polluting uninterruptible power supplies. Advanced capacitors are being considered as energy storage for power quality

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applications. Superconducting energy storage systems are still in their prototype stages but receiving attention for utility applications. The latest technology developments, some performance analysis, and cost considerations are addressed. This paper concentrates on the performance benefits of adding energy storage to power electronic compensators for utility applications [6].

4. UPFC A New approach to power transmission control

This paper shows that the Unified Power Flow Controller (UPFC) is able to control both the transmitted real power and, independently, the reactive power flows at the sending and the receiving end of the transmission line. The unique capabilities of the UPFC in multiple lines Compensation are integrated into a generalized power flow controller that is able to maintain prescribed, and independently controllable, real power and reactive power flowing the line. The paper describes the basic concepts of the proposed generalized P and Q controller and compares it to the more conventional, but related power flow controllers such as the Thyristor-Controlled Series Capacitor and Thyristor-Controlled Phase Angle Regulator [7].

III. SYSTEM MODEL AND PROBLEM FORMULATION

In this paper, we consider improvement of power quality by using customer devices. In this section, an improved voltage sags & swells compensation with energy storage integration. We then discuss the using IPFC we can improve voltage sag & swell.

What is IPFC?

IPFC consists of N voltage source inverters (VSI) by which the compensation of N lines is done. These inverters have a common dc link through which they are connected to each other and exchange active power with each other. It is obvious that the algebraic sum of the exchanging powers through inverters and lines should be zero. Otherwise, dc link voltage (which consists of a capacitor) and, in result, the output voltages of the inverters will be changed.

IPFC consist of no. series VSCs injected into two separate transmission lines. The no. of VSCs is connected back to back by a DC link. Since the IPFC can control the magnitude & phase angle of injected voltage in the both lines. It has 4 degrees of freedom in control. IPFC is able to transfer real power between compensated lines in addition to compensate reactive power for each individual line, independently. So it can equalize both real and reactive power flow between the lines, transfer power demand from overloaded to under loaded lines, compensate against resistive voltage drops, and increase the effectiveness of the system for dynamic disturbances[12].

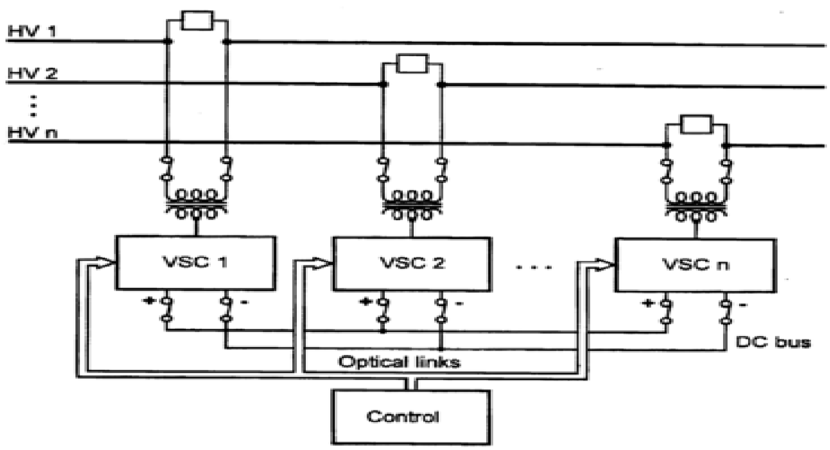

Fig 1 A Generalized Interline Power Flow Controller for Power Transmission Management

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CIRCUIT DIAGRAM

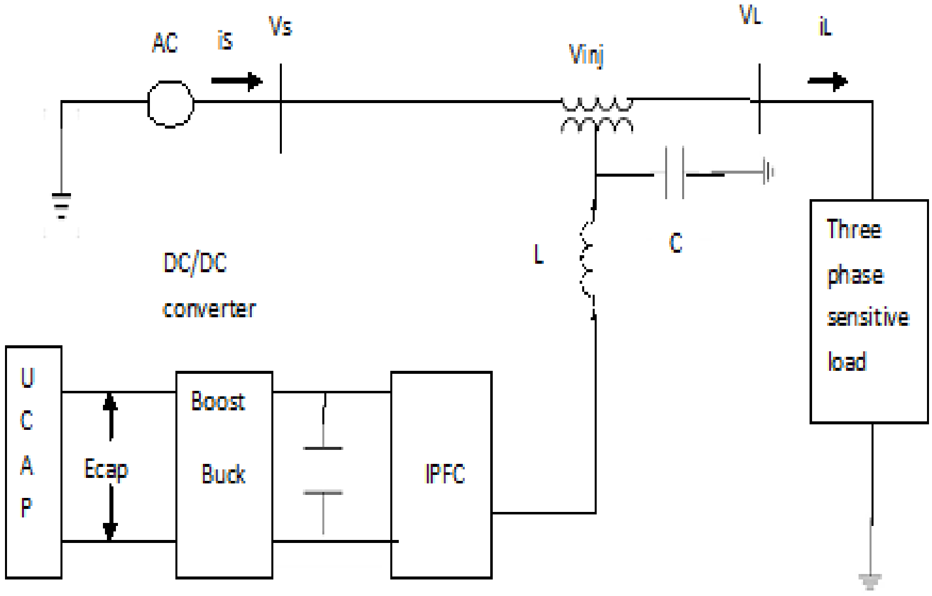

Fig 2 One line diagram of IPFC with UCAP energy storage

The concept of using the IPFC as a power quality product has gained significant popularity since its first use. The usage of the IPFC with rechargeable energy storage at the dc-terminal to meet the active power requirements of the grid during voltage disturbances. In order to avoid and minimize the active power injection into the grid, the authors also mention an alternative solution which is to compensate for the voltage sag by inserting a lagging voltage in quadrature with the line current. Due to the high cost of rechargeable energy storage, various other types of control strategies have also been developed. Caps have low-energy density and high-power density ideal characteristics for compensating voltage sags and voltage swells, which are both events that require high amount of power for short spans of time. UCAPs also have higher number of charge/discharge cycles when compared to batteries and for the same module size; UCAPs have higher terminal voltage when compared to batteries, which makes the integration easier.

UCAP-based energy storage integration to an IPFC into the distribution grid is proposed and the following application areas are addressed:

1) Integration of the UCAP with IPFC system gives active power capability to the system, which is necessary for independently compensating voltage sags and swells.

2) Experimental validation of the UCAP, dc–dc converter, and inverter their interface and control.

3) Development of inverter and dc–dc converter controls to provide sag and swell compensation to the distribution grid.

4) Hardware integration and performance validation of the integrated DVR-UCAP system

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The one-line diagram of the system is shown in Fig. 2. The power stage is a three-phase voltage source inverter, which is connected in series to the grid and is responsible for compensating the voltage sags and swells; the model of the IPFC and its controller is shown. Therefore, the output of the dc–dc converter should be regulated a for providing accurate voltage compensation. The objective of the integrated UCAP-IPFC system with active power capability is to compensate for temporary voltage sag & voltage swells. There are various methods to control the series inverter to provide voltage restoration and most of them rely on injecting a voltage in quadrature with advanced phase, so that reactive power is utilized in voltage restoration. Phase advanced voltage restoration techniques are complex in implementation, but the primary reason for using these techniques is to minimize the active power support and thereby the amount of energy storage requirement at the dc-link in order to minimize the cost of energy storage. However, the cost of energy storage has been declining and with the availability of active power support at the dc-link, complicated phase-advanced techniques can be avoided and voltages can be injected in- phase with the system voltage during voltage sag or a swell event. The choice of the number of UCAPs necessary for providing grid support depends on the amount of support needed, terminal voltage of the UCAP, dc-link voltage, and distribution grid voltages. It is practical and cost-effective to use three modules in the UCAP bank. A UCAP cannot be directly connected to the dc-link of the inverter like a battery, as the voltage profile of the UCAP varies as it discharges energy. Therefore, there is a need to integrate the UCAP system through a bidirectional dc–dc converter, which maintains a stiff dc-link voltage, as the UCAP voltage decreases while discharging and increases while charging. The amount of active power support required by the grid during a voltage sag event is dependent on the depth and duration of the voltage sag, and the dc–dc converter should be able to withstand this power during the discharge mode. The dc–dc converter should also be able to operate in bidirectional mode to be able to charge or absorb additional power from the grid during voltage swell event. The bidirectional dc–dc converter acts as a boost converter while discharging power from the UCAP and acts as a buck converter while charging the UCAP from the grid. Average current mode control, which is widely explored in literature [8], is used to regulate the output voltage of the bidirectional dc–dc converter in both buck and boost modes while charging and discharging the UCAP bank. This method tends to be more stable when compared to other methods such as voltage mode control and peak current mode control.

IV. CONCLUSION

In this paper, the concept of integrating UCAP-based rechargeable energy storage to the IPFC system to improve its voltage restoration capabilities is explored. With this integration, the IPFC will be able to independently compensate voltage sags and swells without relying on the grid to compensate for will be included in the full-version of this paper. Results from simulation and experiment agree well with each can equalize both other thereby verifying the concepts introduced in this paper. The Interline Power Flow Controller is a new member of inverter-based family of FACTS controllers. IPFC also employs the voltage-sourced dc to ac inverter (converter) as a basic building block. However whereas all the others aim to compensate a single transmission line the IPFC is conceived for the compensation and power flow management of multi-line transmission system. In particular, the IPFC real and reactive power flow in the lines, Relieve the overloaded lines from the burden of reactive power flow, compensate against resistive as well as reactive voltage drops and provide a concerted multi-line counter measure during dynamic disturbances.

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REFERENCES

[1] Y. Chen, J. V. Mierlo, P. V. Bosschet, and P. Lataire, "Using super capacitor based energy storage to improve power quality in distributed power generation," in Proc. IEEE Int. Power Electron. Motion Control Conf.(EPE-PEMC), 2006, pp.537–543.

[2] GYUGYI L., SEN K.K., SCHAUDER C.D., 1999. The interline power flow controller concept: a new approach to power flow management in transmission systems, IEEE Transactions on Power Delivery, vol. 14, no. 3, pp.1115-1123.

[3] Gyugyi, L., *Dynamic Compensation of AC Transmission Lines by Solid-state Synchronous Voltage Sources*,IEEE Transactions onPower Delivery, Vol. 9, No. 2, April1994.

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[4] Gyugyi, L., et al., *Static Synchronous Series Compensator: A Solid-State Approach to the Series Compensation of Transmission Lines*, IEEE Transactions on Power Delivery, Vol. 12, No. 1, January 1997.

[5] P. R. Sanchez, E. Acha, J. E. O. Calderon, V. Feliu, and A. G. Cerrada, "A versatile control scheme for a dynamic voltage restorer for power quality improvement," *IEEE Trans. Power Del*., vol. 24, no. 1, pp. 277–284, Jan.2009.

[6] P.F. Ribeiro, B. K. Johnson, M. L. Crow, A. Arsoy, and Y. Liu, "Energy storage systems for advanced power applications," *Proc. IEEE*, vol. 89,no. 12, pp. 1744–1756, Dec. 2001.

[7] GYUGYI L., SHAUDER C.D., WILLIAMS S.L., RIETMAN T.R., TORGERSON D.R., EDRIS A., 1995. The unified power flow controller: a new approach to power transmission control. IEEE Transactions on Power Delivery, vol. 10, no. 2, pp.1085-1093.

[8] S. Santoso, M. F. McGranaghan, R. C. Dugan, and H.W. Beaty, *Electrical Power Systems Quality*, 3rd ed. New York, NY, USA: McGraw-Hill,Jan.2012.

[9] R. W. Erickson and D. Maksimovic, *Fundamentals of Power Electronics*,2nd ed. Norwell, MA, USA: Kluwer,2001.

[10] A. Elnady and M. M. A. Salama, "Mitigation of voltage disturbances using adaptive perceptron-based control algorithm," IEEE Trans. Power Del., vol. 20, no. 1, pp. 309–318, Jan. 2005.

[11] N. H. Woodley, L. Morgan, and A. Sundaram, "Experience with an inverter-based dynamic voltage restorer," IEEE Trans. Power Del.,vol. 14, no. 3, pp. 1181–1186, Jul. 1999

[12] MOGHADAM M.F., ABYANEH H.A., FATHI S.H., KHEDERZADEH M., 2011. Voltage compensation with interline power flow controller (IPFC) using all degrees of freedom, 6th IEEE Conference on Industrial Electronics and Applications, pp. 2179-2184.