ENHANCEMENT OF VOLTAGE REGULATION USING D-STATCOM IN PV DISTRIBUTION SYSTEM

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ABSTRACT

The objective of this project presents a novel control of photovoltaic (PV) solar system as a FACTS device STATCOM, termed PVSTATCOM, for power oscillation damping (POD) in transmission systems. In the proposed control, as soon as power oscillations due to a system disturbance are detected, the solar farm discontinues its real power generation function very briefly (few tens of seconds) and makes its entire inverter capacity available to operate as a STATCOM for POD. As soon as power oscillations are damped, the solar farm restores real power output to its pre-disturbance level in a cramped manner, while keeping the damping function activated. This results in much faster restoration than that specified in grid codes. During nighttime, the solar farm performs POD with its entire inverter capacity. It is shown from EMTDC/PSCAD simulations that the proposed control provides significant increase in power transfer capacity on a 24/7 basis in systems that exhibit both local inertial and inter area oscillatory modes. The proposed PV-STATCOM is about 50-100 times cheaper than an equivalent STATCOM for providing POD at the same location. This novel control can potentially bring large savings for transmission utilities and open up a new revenue making opportunity for solar farms for providing POD.

1. INTRODUCTION

Photovoltaic systems have been increasingly used in the generation of electrical energy because of the cost of energy produced from fossil fuels is rising day to-day and there by photovoltaic energy becomes a promising alternative source for fossil fuels. The most important operational requirement in power network at both transmission and distribution levels. Whenever there is a penetration of photovoltaic cell power to the low voltage distributed grid. Power quality is the major problem that occurs between grid to end user transmission lines. In this paper one of the FACTS controller devices D-ST A TCOM is used to improve the voltage regulation thereby the power system stability. DSTATCOM is the one of the power quality compensating device which will rectifies the power quality problems such as voltage sag and swell which occurs in high voltage power transmission lines. The use of distributed energy resources is increasingly being pursued as a supplement and an alternative to large conventional central power stations. Distribution Static Compensator (DSTATCOM) is proposed for compensation of reactive power and unbalance caused by various loads in distribution system.

2. METHODOLOGY

Static synchronous compensator (STATCOM) systems and methods are disclosed. An example STATCOM system includes a reactive component configured for electrical connection to a power network. For example, the reactive component may be a capacitor bank. The system also includes an inductor electrically connected in series with the reactive component. Further, the system includes a converter electrically connected in series with the reactive component and the inductor. A method may include using the static synchronous compensator system to provide one of reactive power and active power to the power network The aim of this project is to model D-STATCOM in real time for voltage sag mitigation during load changes caused by the fault. This project is conducted to achieve the following objectives:

1) To design D-STATCOM with phase shift control strategy for mitigating the voltage sag.
2) To develop a hardware in loop (HIL) system by using low-cost microcontroller.
3) To validate the hardware in loop (HIL) in voltage sag mitigation.

3. MODELLING OF PROJECT

3.1 COMPONENTS DESCRIPTION

3.1.1 ARDUINO UNO MICROCONTROLLER

Arduino Uno Rev. 3 Microcontroller Board is based on the Microchip Technology ATmega328 8-bit Microcontroller (MCU). Arduino Uno features 14 digital input/output pins (six of which can be used as PWM outputs), six analog inputs, and a 16MHz quartz crystal. Uno also includes a USB connection, a power jack, an In-Circuit Serial Programming (ICSP) header, and a reset button. This Arduino MCU board contains everything the user needs to

support the MCU. The user can get started by connecting the Uno to a computer with the USB cable or by powering it with an AC/DC adapter or battery. The Uno can be programmed with Arduino Software (Integrated Development Environment). The ATmega328 on the Uno comes preprogrammed with a boot loader that allows the user to upload new code to the MCU without the use of an external hardware programmer.

3.1.2 POWER SUPPLY

Power supply is an electrical device which supplies electric power to an electrical load. The first function of a power supply is to convert electric current from a source to the correct voltage, current and frequency to power up the load. As a result, power supplies are also referred to as electric power converters. Some power supplies are separate standalone pieces of equipment while others are built into the load appliances that they power.

3.1.3 PHOTO VOLTAIC SYSTEM:

A photovoltaic (PV) system is composed of one or more solar panels combined with an inverter and other electrical and mechanical hardware that use energy from the Sun to generate electricity. PV systems can vary greatly in size from small rooftop or portable systems to massive utility-scale generation plants. Although PV systems can operate by themselves as off-grid PV systems, this article focuses on systems connected to the utility grid, or grid-tied PV systems. The light from the Sun, made up of packets of energy called photons, falls onto a solar panel and creates an electric current through a process called the photovoltaic effect. Each panel produces a relatively small amount of energy, but can be linked together with other panels to produce higher amounts of energy as a solar array. The electricity produced from a solar panel (or array) is in the form of direct current (DC). Although many electronic devices use DC electricity, including your phone or laptop, they are designed to operate using the electrical utility grid which provides (and requires) alternating current (AC). Therefore, in order for the solar electricity to be useful it must first be converted from DC to AC using an inverter. This AC electricity from the inverter can then be used to power electronics locally, or be sent on to the electrical grid for use elsewhere.

3.1.4 TRANSMISSION LINE

Transmission lines are used for purposes such as connecting radio transmitters and receivers with their antennas (they are then called feed lines or feeders), distributing cable television signals, trunk lines routing calls between telephone switching centres, computer network connections and high speed computer data buses. RF engineers commonly use short pieces of transmission line, usually in the form of printed planar transmission lines, arranged in certain patterns to build circuits such as filters. These circuits, known as distributed-element circuits, are an alternative to traditional circuits using discrete capacitors and inductors. Ordinary electrical cables suffice to carry low frequency alternating current (AC) and audio signals. However, they cannot be used to carry currents in the radio frequency range above about 30 kHz, because the energy tends to radiate off the cable as radio waves, causing power losses. RF currents also tend to reflect from discontinuities in the cable such as connectors and joints, and travel back down the cable toward the source. These reflections act as bottlenecks, preventing the signal power from reaching the destination. Transmission lines use specialized construction, and impedance matching, to carry electromagnetic signals with minimal reflections and power losses. The distinguishing feature of most transmission lines is that they have uniform cross sectional dimensions along their length, giving them a uniform *impedance*, called the characteristic impedance, to prevent reflections. The higher the frequency of electromagnetic waves moving through a given cable or medium, the shorter the wavelength of the waves. Transmission lines become necessary when the transmitted frequency's wavelength is sufficiently short that the length of the cable becomes a significant part of a wavelength. At microwave frequencies and above, power losses in transmission lines become excessive, and waveguides are used instead which function as "pipes" to confine and guide the electromagnetic waves. At even higher frequencies, in the terahertz, infrared and visible ranges, waveguides in turn become lossy, and optical methods, (such as lenses and mirrors), are used to guide electromagnetic waves

3.1.5 STATIC SYNCHRONOUS COMPENSATOR (STATCOM

A staticsynchronous compensator (STATCOM), also known as a static synchronous condenser (STATCON), is a regulating device used on alternating current electricity transmission networks. It is based on a power electronics voltage-source converter and can act as either a source or sink of reactive AC power to an electricity network. If connected to a source of power it can also provide active AC power. It is a member of the FACTS family of devices. It is inherently modular and electable.These compensators are also usable to reduce voltage fluctuations. A STATCOM is a voltage source converter (VSC)-based device, with the voltage source behind a reactor. The voltage source is created from a DC capacitor and therefore a STATCOM has very little active power capability. However, its active power capability can be increased if a suitable energy storage device is connected across the DC capacitor. The reactive power at the terminals of the STATCOM depends on the amplitude of the voltage source. For example, if the terminal voltage of the VSC is higher than the AC voltage at the point of connection, the STATCOM generates

reactive current; conversely, when the amplitude of the voltage source is lower than the AC voltage, it absorbs reactivepower.[5] The response time of a STATCOM is shorter than that of a static VAR compensator (SVC),[6] mainly due to the fast switching times provided by the IGBTs of the voltage source converter. The STATCOM also provides better reactive power support at low AC voltages than an SVC, since the reactive power from a STATCOM decreases linearly with the AC voltage (as the current can be maintained at the rated value even down to low AC voltage).

3.1.6 DISTRIBUTION LOAD

Distributed loads are forces which are spread out over a length, area, or volume. Most real-world loads are distributed, including the weight of building materials and the force of wind, water, or earth pushing on a surface. Pressure, load, weight density and stress are all names commonly used for distributed loads.

4. CIRCUIT DIAGRAM
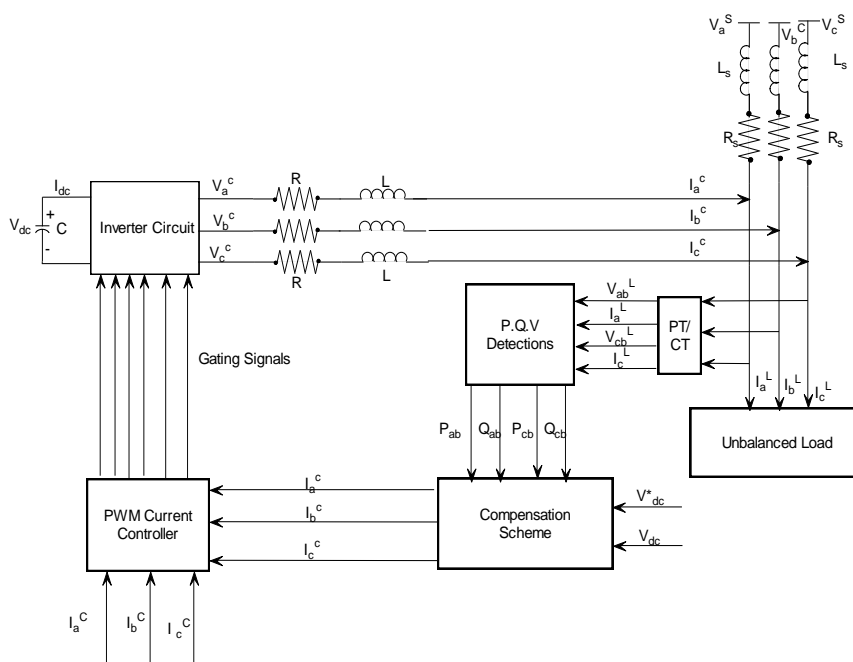
5. CIRCUIT DIAGRAM OPERATIONS

The compensation current commands $I_{ab}I_{bc}I_{cc}$ are calculated with line to line voltage V_{ab}^L, V_{cb}^L and line currents I_a^L, I_c^L. The instantaneous compensation currents are obtained with the aid of the synchronous signal $\sin\omega t$. Additionally, the Dc link voltage is maintained by supplying a real part of compensation current $I_{r\,via}$ PI controller. With the same synchronous signal $\sin\omega t$, the instantaneous current for active power balance is also yielded. Combining above to currents generates the three phase command currents $(I_a^c)^*$, $(I_b^c)^*$, $(I_c^c)^*$ for the D-STATCOM. A current, regulated PWM inverter is employed as the power stage of D-STATCOM. The error signals from the reference signals $(I_a^c)^*$, $(I_b^c)^*$, $(I_c^c)^*$ and the actual compensation currents $(I_a^c)^*$, $(I_b^c)^*$, $(I_c^c)^*$ are used as the input of the CRPWM inverter. A Distribution STATIC COMPENSATOR (DSTATCOM) is a voltage source converter (VSC)-based power electronic device. Usually, this device is supported by short-term energy stored in a dc capacitor.The D-STATCOM filters distribution bus current such that it meets the specifications for utility connection. If properly utilized, this device can cancel the effect of poor load power factor such that the current drawn from the source has a near unity power factor and the effect of poor voltage regulation.

The two main objectives in D-STATCOM connection are:

- Load compensation of unbalanced systems
- Power factor correction

6. CONCLUSION

In this paper, a new idea for the voltage regulation of radial distribution systems with DG unit at the transformer bus was presented. The proposed idea was based on the combination of two different control methods which are OLTC action and static compensator. The idea was to use the OLTC action in the predefined range (based on the permitted range of voltage) and allow STATCOM to manage the rest of the voltage violations. Simulation results revealed that the proposed method enables us to efficiently manage the voltage control problem of a radial MV distribution system in the worst working conditions

ACKNOWLEDGEMENT

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