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Static Var Compensator with Minimized-Equipped Capacitor for Industrial and Grid Applications

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ABSTRACT*:* The electric power system network consists of many buses, individual elements connected together and to form a large, complex network capable of generation, transmission and distribution of electrical energy over large geographical areas. The power system network is developing each and every day in order to meet the increasing power demand which increases every day. The power demand is reduced either by installing new generating stations, or by extending the range of the existing load ability limits. As a result, the existing transmission lines are heavily loaded than ever before and one impact of this is the threat of reducing stability. So Voltage instability is a major problem which attracting worldwide interest because of its result of voltage collapses. In earlier, power system stabilizers (PSS) are used for improving small signal stability. FACTS controllers are currently being incorporated with the power system for dynamic performances. In this project, STATCOM is proposed for improving voltage stability

KEYWORDS*:* voltage stability, maximum loading point, STATCOM

I. INTRODUCTION

REACTIVE power compensation is one of the valuable applications for power electronics technology. For ac power transmission and distribution system, various types of static reactive power compensator have been proposed. Shunt compensation is widely used to improve power factor and volt-age stability. A static synchronous compensator (STATCOM) based on voltage source converter (VSC) can be said to be the most advanced shunt-type reactive power compensator. In contrast with thyristor-based reactive power compensators, the STATCOM can directly generates reactive power and has good harmonics characteristics due to the use of full-controlled semi-conductor switches. A series compensation is also studied for the ac power trans-mission and distribution. A static synchronous series compensator (SSSC) , is a VSC connected to the grid in series, usually by a transformer. That can be considered to be a series compensation version of the STATCOM. Usually series compensator is required to inject only small percentage of voltage compared to the system voltage, since the purpose of using series compensation is cancelling existing unwanted series inductance. Therefore, line-frequency switching can be an option since generated harmonic components in total voltage and impact to the current can be within an acceptable amount. A gate-commutated series capacitor (GCSC) is another type of series compensator, which is a series-connected ac capacitor with a semiconductor shunt switch as shown in Fig. 1(a), and is operated with line-frequency switching. A magnetic energy recovery switch (MERS) is also proposed as a series compensator, which consists of a single-phase VSC as shown in Fig. 1(b), and operated with line-frequency switching. The MERS has also a distinctive feature, which is drastically reduced capacitance of the equipped capacitor compared to one for usual voltage source type compensators like STATCOM and SSSC. This feature is same as for the GCSC and its control method and resulting characteristics are similar to the GCSC. The capacitance becomes like one of fixed ac capacitors; therefore, it can be said that the GCSC and MERS are basically series capacitor, but have some controllability by semiconductor switches.

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II. LITERATURE REVIEW

[1] J.A.Wiik, F.D.Wijaya, and R. Shimada:, "Characteristics of themagneticenergy recovery switch (MERS) as a series FACTS controller," *IEEETrans. Power Del.*, vol. 24, no. 2, pp. 828–836, Apr. 2014.

A Multilevel Voltage-Source Inverter with Separate DC Sources for Static Var Generation

With long-distance ac power transmission and load growth, active control of reactive power (var) is indispensable to stabilize the power systems and to maintain the supply voltage. Static Var Generators (SVGs) using voltage-source inverters have been widely accepted **as** the next generation reactive power controllers of power systems to replace the conventional var compensators, such **as** Thyristor Switched Capacitors (TSCs) and Thyristor Controlled Reactors (TCRs) Fig. 1 shows a typical 48-pulse inverter for static var generation applications. The 48-pulse inverter consists of eight 6-pulse inverters connected together through eight zigzag-connection or Wye Delta and Delta/Delta connection transformers, in order to reduce harmonic distortion using the harmonic neutralization (cancellation) technique .These transformers, which are also called harmonic neutralizing magnetics

(1) Most expensive equipment in the system
(2) Produce about 50% of the total losses of the system,
(3) Occupy up to 40% of the total system's real estate, which is an excessively large area,
(4) Cause difficulties in control due to DC magnetizing and surge overvoltage problems resulting from saturation of the transformers in transient states.

To solve these problems, a diode-clamped multilevel inverter and a flying-capacitor multilevel inverter have been proposed for SVG applications [6, 7,9, 121]**.** These multilevel inverters can eliminate the transformers required in an **SVG** using conventional 6-pulse inverters; however, they encounter new problems.

[2] T. Takaku, T. Isobe, J. Narushima, H. Tsutsui, and R. Shimada, "Power factor correction using magnetic energy recovery current switches," Electr.Eng. Jpn., vol. 160, no. 3, pp. 56–62, 2015.

Fuzzy-based Static VAR Compensator Controller for Damping Power System Disturbances

During the past few years, the electric power industry has experienced a huge increment in power consumption. The growth in demand for electricity supply such as growth of loads and generation, lack of new transmission lines and competitive electricity market pressure has made power systems nowadays operating closer to their static and dynamic limit. Despite of the fact that bulk power transfers are increasing, the growth of electric power transmission facilities is restricted . In addition with the aging of power transmission network, the control of power-transmission is required to be fast and reliable.

Power systems are also often subject to low frequency electro-mechanical oscillations resulting from electrical disturbances and consequence of the development of interconnection of large power system . The oscillation of the generators rotors cause the oscillation of other power system variables (bus voltage, transmission lines active and reactive power, etc which constraints the capability of power transmission, threatens system security and damages the efficient operation of the power system .

Low frequency oscillation can be categorized to as local and inter-area mode. Local mode oscillation typically range between 1-2 Hz consists of the oscillation of a single generator or a group of generators against the rest of the system, while inter-area mode typically range between 0.1-1 Hz consists of the oscillation among groups of generators. Generally, power system stabilizers (PSS) are applied on selected generators to damp local oscillation modes effectively.

The fast progress in the field of power electronics has widened the option for power industry to improve power system stability via utilization of the controllable flexible alternating current transmission system (FACTS). Besides their capability to control transmission grid and increasing transmission capacity, FACTS devices also offer an alternative option to mitigate power system oscillation. According to IEEE, FACTS device is "a power-electronic based system and other static equipment that provide control of one or more ac-transmission system parameters to enhance controllability and increase power-transfer capability". Initially, FACTS device was developed to solve rising

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system problems due to the limit in transmission line construction, to facilitate the increasing power export and/or import and wheeling transaction among utilities . FACTS devices have cover a number of technologies that enhance the security, capacity and flexibility of power transmission systems. By installing FACTS devices, the power systems will able to increase existing transmission network capacity while maintaining or improving the operating margins necessary for systems stability.

As PSS been applied to damp local oscillation modes, Static VAR Compensator (SVC) which is one of the FACTS devices, has been used as a supplementary controller to improve transient stability and power oscillation damping of the system. Most of these controllers are designed based on conventional method i.e designed based on the linearized model for the sake of simplicity. However, conventional controller cannot provide satisfactory performance over a wide range of operation points and under large disturbances since power system is a non-linear system .

Recently, fuzzy logic controller (FLC) draws quite an attraction for researchers to design an effective control theory in enhancing power system stability due to its easiness in design also capability of tolerating uncertainty and imprecision in system parameters and operation condition changes [5]-[10]. This paper discussed one of the method in SVC implementation based on a simple fuzzy logic combined with the conventional proportional-integral (PI) controller. The fuzzy-based SVC (F-SVC) controller combining both advantages of FLC and the existing PI controller so that it can give better performance in damping inter-area oscillation as well as other parameters such as terminal voltage and transmission line active power. The F-SVC controller is been tested in a 2-machines 3-bus power system. Simulation is done in MATLAB / Simulink to perform its effectiveness in damping oscillation after being subjected to a three phase fault at Bus 1 for 0.1 second. Performance of the system implemented with the F-SVC controller is compared with the system implemented with the conventional SVC.

The above drawbacks have been rectified in this paper and the REACTIVE power compensation and also the harmonics level suppression have been achieved successfully.

III. BLOCK DIAGRAM

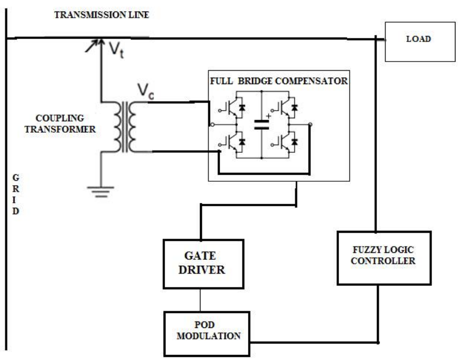

Fig 1 Block Diagram

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BLOCK DIAGRAM EXPLANATION

This paper discusses common understanding between the “VSC-based” and the “capacitor-based” reactive power compensators, and proposes a modulation-controlled full-bridge reactive power compensator with reduced and optimized capacitance.The proposed compensator has advantages from both types, low-harmonics characteristics by the modulation, which comes from the VSC-based compensator, and small required capacitance, which comes from the capacitor-based compensator. Fuzzy logic control method is used to correct the reactive power.POD modulation is implemented to provide the gate pulse to the vsc. This modulation technique has given the proper output

IV. CIRCUIT DIAGRAM

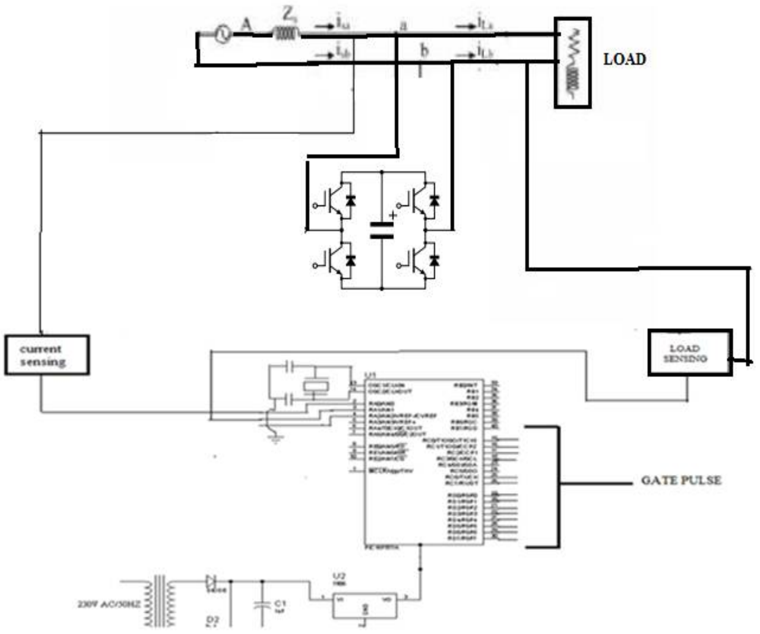

Fig 2 Circuit Diagram

CIRCUIT DIAGRAM EXPLANATION

- A shunt-type full-bridge reactive power compensator with line-frequency switching and reduced capacitance has been proposed.
- Vertical pairs of switches (U-X and V-Y) are controlled with complementally switching like usual voltage-source-type converters, which means either switch is ON and the other is OFF except for dead time (both switches are OFF). This does not change from usual voltage source converters.
- By controlling two pairs of switches, the capacitor can be connected to ac circuit in series alternately with different polarity or shunted.

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V. HARDWARE

POWER SUPPLY

A power supply (sometimes known as a power supply unit or PSU) is a device or system that supplies electrical or other types of energy to an output load or group of loads. The term is most commonly applied to electrical energy supplies, less often to mechanical ones, and rarely to others.

POWER SUPPLY UNIT BLOCK

All digital circuits work only with low DC voltage. A power supply unit is required to provide the appropriate voltage supply. This unit consists of transformer, rectifier, filter and a regulator. AC voltage typically of 230Vrms is connected to a transformer which steps that AC voltage down to the desired AC voltage level. A diode rectifier then provides a full wave rectified voltage that is initially filtered by a simple capacitor filter to produce a DC voltage. This resulting DC voltage usually has some ripple or AC voltage variations. Regulator circuit can use this DC input to provide DC voltage that not only has much less ripple voltage but also remains in the same DC value, even when the DC voltage varies, or the load connected to the output DC voltage changes. The required DC supply is obtained from the available AC supply after rectification, filtration and regulation. Block diagram of power supply unit is shown in Figure

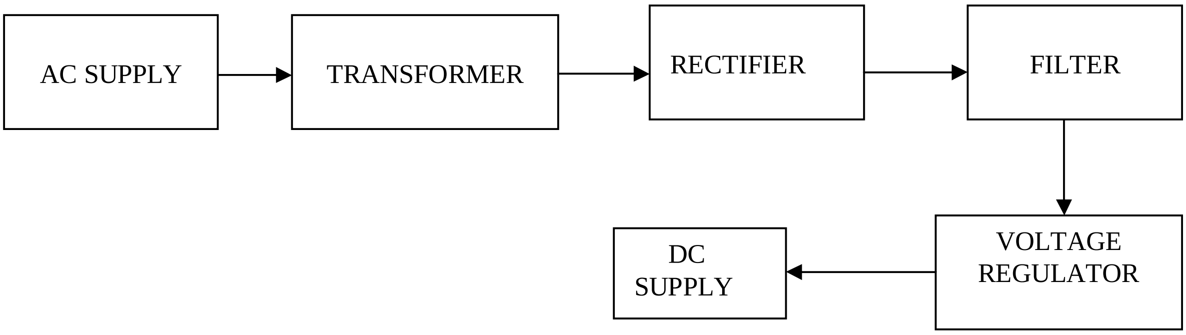

Fig 3 Power Supply Block Diagram

The main components used in the power supply unit are Transformer, Rectifier, Filter and Regulator. The 230V AC supply is converted into 9V AC supply through the transformer. The output of the transformer has the same frequency as in the input AC power. This AC power is converted into DC power through diodes. Here the bridge diode is used to convert AC supply to the DC power supply. This converted DC power supply has the ripple content and for normal operation of the circuit, the ripple content of the DC power supply should be as low as possible. Because the ripple content of the power supply will reduce the life of the circuit. So to reduce the ripple content of the DC power supply, the large value of capacitance filter is used.

This filtered output will not be the regulated voltage. For this purpose IC7805 regulator IC is used in the circuit.

TRANSFORMER

Transformer is a device used either for stepping-up or stepping-down the AC supply voltage with a corresponding decreases or increases in the current. Here, a transformer is used for stepping-down the voltage so as to get a voltage that can be regulated to get a constant 5V.

RECTIFIER

A rectifier is a device like semiconductor, capable of converting sinusoidal input waveform units into a unidirectional waveform, with a nonzero average component.

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FILTERS

Capacitors are used as filters in the power supply unit. The action of the system depends upon the fact, that the capacitors stores energy during the conduction period and delivers this energy to the load during the inverse or non-conducting period. In this way, time during which the current passes through the load is prolonged and ripple is considerably reduced.

VOLTAGE REGULATOR

The LM78XX is three terminal regulators available with several fixed output voltages making them useful in a wide range of applications. IC7805 is a fixed voltage regulators used in this circuit.

VI. RESULTS AND DISCUSSION

Sl.No.	Load	% Harmonics(THD)		Power Factor		Efficiency	
		Conventional Method	Proposed Method	Conventional Method	Proposed Method	Conventional Method	Proposed Method
1	R	7.8	4.5	PF:0.882	PF:0.945	87%	93%
2	RL	7.4	4.1	PF:0.869	PF:0.939	84.8%	91.3%

ADVANTAGES

- Very compact and light.
- Low power consumption.
- Very little heat emitted during operation, due to low power consumption.
- No geometric distortion.
- The possible ability to have little or no flicker depending on backlight technology.

VII. CONCLUSION

This paper describes the influence of STATCOM on the power system voltage stability and improvement of load ability improvement. The STATCOM are able to participate in the power system inter area oscillation damping by changing the compensated reactance or to provide reactive power, when supplementary control strategies is adopted. The IEEE 14 buses are taken as test system is built in Matlab Simulink software and to increase the load in the particular load bus. To find the optimal location of STATCOM by using PSO algorithm, then the STATCOM is connected to the low voltage bus for enhancing the voltage profile and increasing the load ability limits.

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