

A Novel STATCOM Model for Dynamic Power System Simulations

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ABSTRACT: Power system oscillation is one of the important aspects in modern power system. Currently, power engineers are much more concerned about stability problem due to blackout a Static Synchronous Compensator is a member of the FACTS family that is connected in shunt with system. The STATCOM consists of a solid state voltage source converter with GTO thyristor switches or other high performance of semi-conductor and transformer. The STATCOM can electrically reactor and capacitor by injecting a shunt current in quadrature with the line voltage. The reactive power (or current) of the STATCOM can be adjusted by controlling the magnitude and phase angle of the output voltage of the shunt converter this study presents the PT controller law of STATCOM. The simulation results are tested on a sample system.

I. INTRODUCTION

A STATCOM (or Static Synchronous Compensator) is a voltage regulating device. It is based on a power electronics voltage-source converter and can act as either a source or sink of reactive AC power. It is a member of the flexible AC transmission systems (FACTS) family which detects and instantly compensates for voltage fluctuations or flicker, as well as controls power factor.

1. SOURCE

A Voltage source is a two terminal device which can maintain a fixed voltage. An ideal voltage source can maintain the fixed voltage independent of the load resistance or the output current.

2. LINE IMPEDANCE

The characteristic impedance of a transmission line is the ratio of the voltage and current of a wave travelling along the line. When the wave reaches the end of the line, in general, there will be a reflected wave which travels back along the line in the opposite direction.

Block diagram

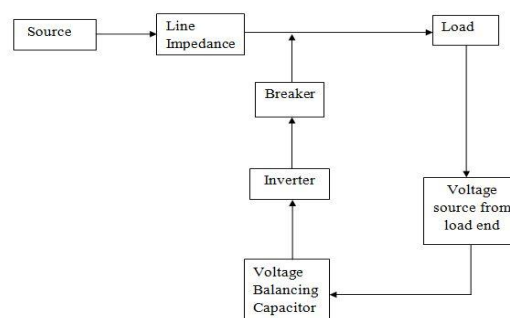


Fig 1. Overall block diagram

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3. BREAKER

Electrical Circuit Breaker is a switching device which can be operated manually as well as automatically for controlling and protection of electrical power system respectively. As the modern power system deals with huge currents, the special attention should be given during designing of circuit breaker to safe interruption of arc produced during the operation of circuit breaker. This was the basic definition of circuit breaker.

4. INVERTER

A power inverter, or inverter, is an electronic device or circuitry that changes direct current (DC) to alternating current (AC). The input voltage, output voltage and frequency, and overall power handling depend on the design of the specific device or circuitry. The inverter does not produce any power; the power is provided by the DC source.

5. VOLTAGE BALANCING CAPACITOR

Ideally when capacitors are placed in series the voltage across each capacitor should be distributed evenly across the capacitors. This does not always occur as intended due to the variations in the leakage currents of the capacitors. The variations in leakage current can lead to some of the capacitors having voltages across them that could exceed their voltage ratings.

II. INTERPRETATION OF THE DAMPING CHARACTERISTICS

In a conventional damping controller, such as a PSS on an electrical machine, changing the PSS gains usually retains the resonance frequencies near their original values but increases the damping. In contrast, when a STATCOM or STATCOM is included, the aforementioned are not only indicate improved damping, but also show a significant change in the resonant frequencies (eigen values) of the network. This section attempts to interpret this seemingly anomalous behavior.

- A method is presented to improve power system stability using STATCOM.
- Re-current neural network controllers damp oscillations in a power system.
- Training is based on back propagation with adaptive training parameters.
- Selection of effectiveness damping control signal carried out using SVD method
- A static VAR compensator (SVC) can also be used for voltage stability. However, a STATCOM has better characteristics than a SVC. When the system voltage drops sufficiently to force the STATCOM output current to its ceiling, its maximum reactive output current will not be affected by the voltage magnitude.
- Therefore, it exhibits constant current characteristics when the voltage is low under the limit. In contrast the SVC's reactive output is proportional to the square of the voltage magnitude. This makes the provided reactive power decrease.

1. BASIC MODEL OF STATCOM

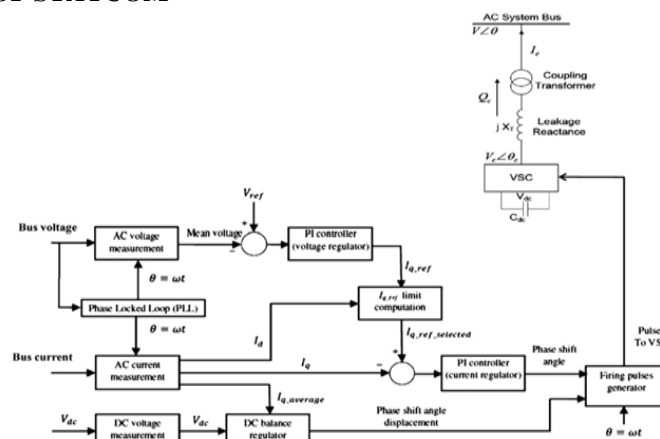


Fig 2. Basic model of STATCOM

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i. POWER GENERATION SOURCE

A power generation plant mainly consists of alternator runs with help of steam turbine. The steam is obtained from high pressure boilers.

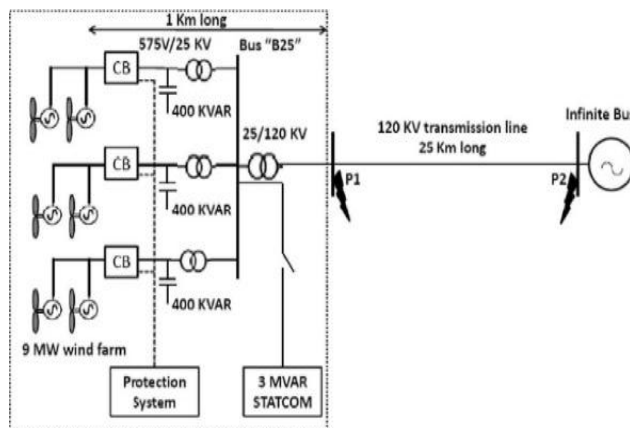


Fig 3. Single line diagram of the studied system

ii. PI- CONTROLLER

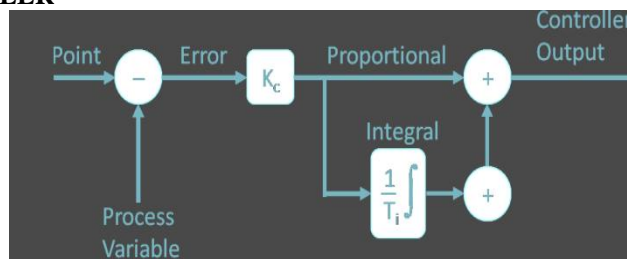


Fig 4. House model with PIcontroller

iii. PI CONTROL DEFINITION

$$u = K_p e \quad (1)$$

The definition of proportional feedback

Where

e= is the "error"

K_p = Proportional gain

The definition of the integral feedback is

$$u = K_p e + K_i \int e d\tau \quad (3)$$

$$u = K_p e + \frac{1}{\tau_i} \int e d\tau \quad (4)$$

$$u = K_p \left(e + \frac{1}{\tau_N} \int e d\tau \right) \quad (5)$$

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iv. HOW TO TUNE THE PI-CONTROLLER

There are more ways to do that. A more or less automatic routine is presented in e) Ziegler-Nichols method.

III. AC GENERATOR

The definition of alternator is hidden in the name of this machine itself. An alternator is such a machine which produces alternation electricity. It is also known as synchronous generator.

I. POWER TRANSMISSION

Electrical power is generated at different generating stations. These generating stations are not necessarily situated at the load center.

2. 3PH AC VOLTAGE SOURCES

A Voltage source is a two terminal device which can maintain a fixed voltage. An ideal voltage source can maintain the fixed voltage independent of the load resistance or the output current.

3. HIGH VOLTAGE MEASUREMENT

High voltages can be measured in a variety of ways. Direct measurement of high voltages is possible up to about 200 kV, and several forms of voltmeters have been devised which can be connected directly across the test circuit.

4. HIGH CURRENT MEASUREMENT

A CT is an instrument transformer in which the secondary current is substantially proportional to primary current and differs in phase from it by ideally zero degree essential within normal working range.

IV. SINGLE BUS SYSTEM

Single Bus System is simplest and cheapest one. In this scheme all the feeders and transformer bay are connected to only one single bus as shown.

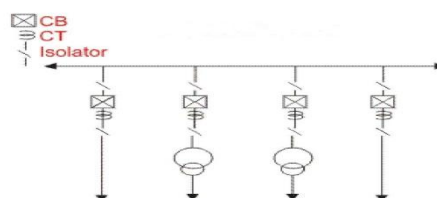


Fig 8. Single bussystem

V. DOUBLE BUS SYSTEM

In double bus bar system two identical bus bars are used in such a way that any outgoing or incoming feeder can be taken from any of the bus.

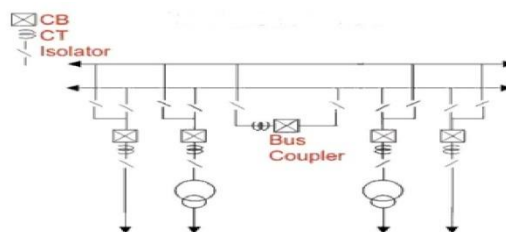


Fig 10. Double bus system

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Advantages of Double Bus System are

- Double Bus Bar Arrangement increases the flexibility of system.

VI. RELAYS

Relay is an electrically controllable switch widely used in industrial controls, automobiles and appliances. The relay allows the isolation of two separate sections of a system with two different voltage sources

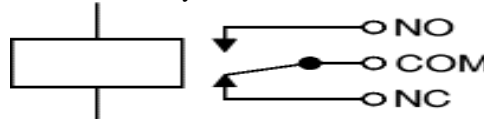
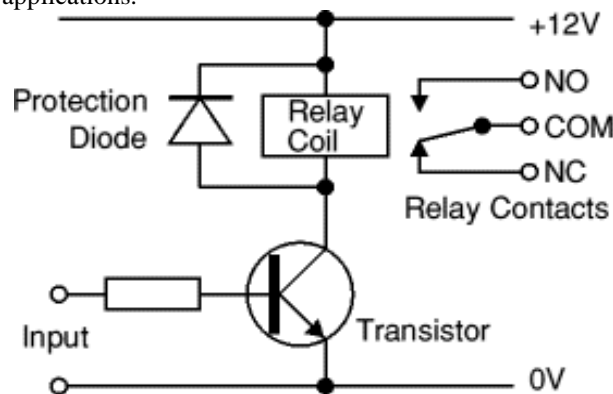


Fig 13. circuit symbol of relay

OPERATION:

When current flows through the coil, a magnetic field is created around the coil i.e., the coil is energized. This causes the armature to be attracted to the coil. The armature's contact acts like a switch and closes or opens the circuit. When the coil is not energized, a spring pulls the armature to its normal state of open or closed. There are all types of relays for all kinds of applications.



voltage and current required to energize the coil. The voltage can vary from a few volts to 50 volts, while the current can be from a few milliamps to 20 milliamps. The relay has a minimum voltage, below which the coil will not be energized. This minimum voltage is called the "pull-in" voltage. There can be one or more contacts. i.e., different types like SPST (single pole single throw), SPDT (single pole double throw) and DPDT (double pole double throw) relay. The contacts can be normally open (NO) or normally closed (NC). In the NC type, the contacts are closed when the coil is not energized. In the NO type, the contacts are closed when the coil is energized.

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VII. SIMULATION DIAGRAM

New designs of power electronics systems or Power Systems are the norm due to new applications and lack of standardization in specifications is because of varying customer demands. Accurate simulation is necessary to minimize costly repetitions of designs and bread boarding and hence reduce the overall cost and the concept-to-production time.

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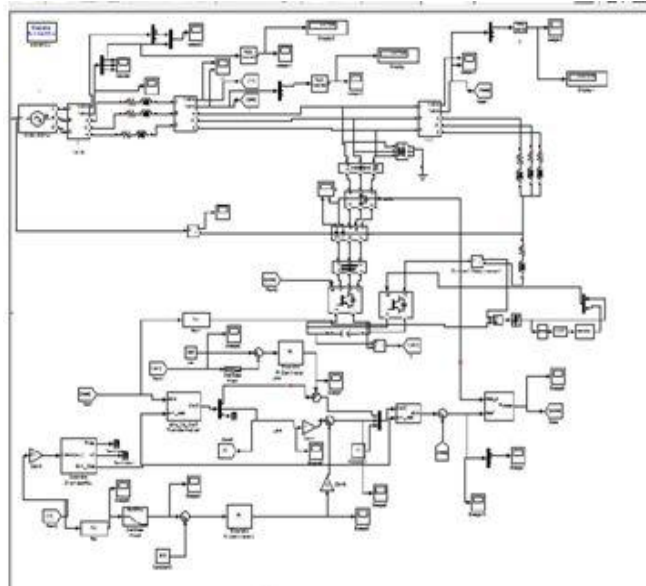


Fig 15 . Simulation diagram

OUTPUT WAVEFORM

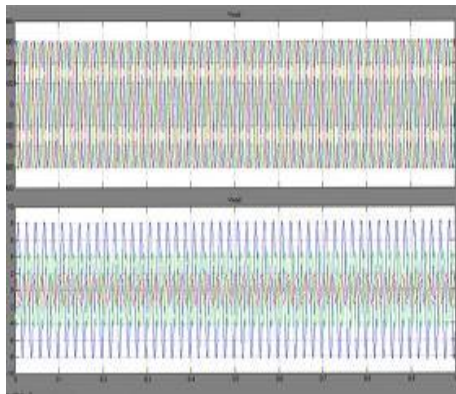


Fig 16. voltage waveform

Fig 17. Shows the distorted current waveform of a novel STATCOM model

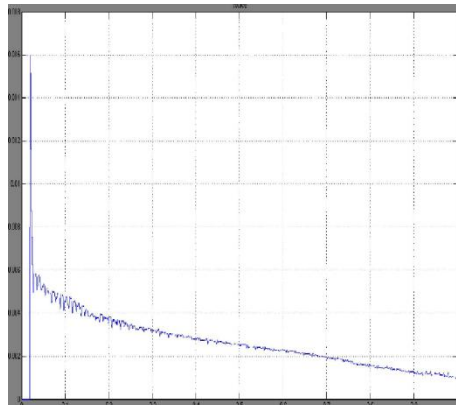


Fig 17. Current waveform

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VIII. CONCLUSION

A new STATCOM model for dynamic simulations of large scale power systems has been put forward in this paper whose modeling concepts do not rely on an equivalent voltage source but rather on the use of a complex phase-shifting transformer as its key element. The model solution is carried out using the PI Controlled tuned STATCOM Devices and this method which solves simultaneously the algebraic and differential equations at each time step. A comparative study was carried out to demonstrate that the main output variables and the number of iterations that the new model takes to converge at each time step is consistent with those of a STATCOM model based on conventional voltage source. This is in spite of the modeling approaches being fundamentally different. For instance, the inner active power losses are calculated in a quite different manner and the DC-bus representation in the new STATCOM leads to a much more flexible model. The latter is something that the equivalent voltage source-based model of the STATCOM definitely.

REFERENCES

- [1] N. G. Hingorani and L. Gyugyi, *Understanding FACTS: Concepts and Technology of Flexible AC Transmission Systems*. New York, NY, USA: Wiley-IEEE Press, 1999.
- [2] E. Acha, C. R. Fuerte-Esquivel, H. Ambriz-Perez, and C. Angeles-Camacho, *FACTS Modeling and Simulation in Power Networks*. New York, NY, USA: Wiley, 2005.
- [3] C. A. Cañizares, "Power flow and transient stability models of FACTS controllers for voltage and angle stability studies," in *Proc. IEEE PES Winter Meeting 2000*, 2000, vol. 2, pp. 1447–1454.
- [4] C.Nagarajan and M.Madheswaran - 'Performance Analysis of LCL-T Resonant Converter with Fuzzy/PID Using State Space Analysis'- Springer, *Electrical Engineering*, Vol.93, March 2011.
- [5] C.Nagarajan and M.Madheswaran, *Stability Analysis of Series Parallel Resonant Converter with Fuzzy Logic Controller Using State Space Techniques*, Taylor & Francis, *Electric Power Components and Systems*, Vol.39 (8), pp.780-793, 2011.
- [6] C.Nagarajan and M.Madheswaran - 'Experimental verification and stability state space analysis of CLL-T Series Parallel Resonant Converter' - *Journal of ELECTRICAL ENGINEERING*, Vol.63 (6), pp.365-372, Dec.2012.
- [7] C.Nagarajan and M.Madheswaran - 'Analysis and Implementation of LLC-T Series Parallel Resonant Converter with Fuzzy controller'- *International Journal of Engineering Science and Technology (IJEST)*, *Applied Power Electronics and Intelligent Motion Control*. Vol.2 (10), pp 35-43, December 2010
- [8] C.Nagarajan and M.Madheswaran - 'Performance Estimation of LCL-T Resonant Converter with Fuzzy / PID Controller' - *International Journal of Computer and Electronic Engineering (IJCEE)*, Vol.2 (3), pp.534-542, June 2010
- [9] C. Nagarajan, M.Madheswaran and D.Ramasubramanian- 'Development of DSP based Robust Control Method for General Resonant Converter Topologies using Transfer Function Model' - *Acta Electrotechnica et Informatica Journal* , Vol.13 (2), pp.18-31, April-June.2013
- [10] C.Nagarajan and M.Madheswaran - 'DSP Based Fuzzy Controller for Series Parallel Resonant converter' - Springer, *Frontiers of Electrical and Electronic Engineering*, Vol. 7(4), pp. 438-446, Dec.12.
- [11] C.Nagarajan and M.Madheswaran - 'Experimental Study and steady state stability analysis of CLL-T Series Parallel Resonant Converter with Fuzzy controller using State Space Analysis' - *Iranian Journal of Electrical & Electronic Engineering*, Vol.8 (3), pp.259-267, September 2012.
- [12] E. Barrios-Martinez, C. Angeles-Camacho, E. Acha, and M. A. Olguin- Becerril, "Dynamic phase-domain modelling and simulation of STATCOM in large-scale power systems," in *Proc. IEEE Power TechConf. 2009*, Bucharest, Romania, 2009, pp. 1–9.
- [13] [5] S. F. Faisal, A. H. M. A. Rahim, and J. M. Bakhshwain, "A robust STATCOM controller for a multi-machine power system using particle swarm optimization and loop-shaping," *Int. J. Elect. Commun. Syst.Eng.*, pp. 64–70, 2007.
- [14] G. Shahgholian, M. Mahdavian, A. Etesami, S. Moalem, and M. Jabbari, "Improvement of dynamic behavior and system stability by using STATCOM," in *Proc. IEEE Int. Symp. Industrial Electronics*, 2011, pp.
- [15] M. Mahdavian and G. Shahgholian, "Effect of STATCOM on enhancing power system dynamic stability," in *Proc. IEEE Int. Conf. Elect. Eng., Comput., Telecomm., and Inf. Technol. (ECTI)*, 2011,