RESEARCH PAPER | Engineering | Volume : 3 | Issue : 8 | Aug 2013 | ISSN - 2249-555X

A Novel Bats Echolocation Logic Controller for Statcom to Improve Voltage Stability in Two Area Power System

KEYWORDS: STATCOM, FACTS, Bats Echolocation logic controller, Kundur's two area system

G. Kumaravel
Research Scholar, Sathyabama University, Chennai, India

C. Kumar
Director-Academic, SKP Engineering College, Tiruvannamalai, India

ABSTRACT *A Static Synchronous Compensator (STATCOM) is a Flexible AC Transmission System (FACTS) device which is mainly used to provide voltage support at point of common coupling (PCC) in a power system. This paper presents a design of Bats Echolocation Logic Controller of STATCOM which is connected in Kundur's two area power system. It provides better voltage support at point of common coupling (PCC).it also improves voltage profile of the other areas under long-term disturbances. The effectiveness of the proposed controller is evaluated by MATLAB/ Simulink tool. The simulation results are shown that the proposed controller improves voltage profile of whole system and better voltage regulation at point of common coupling.*

I. INTRODUCTION
Ever increase in demand of electricity push the power system planners to deliver the effective power by existing network at its maximum usable capacity. Flexible AC Transmission System (FACTS) device opens up new area for planners to control the power flow through a transmission line to enhance its usable capacity [1] & [2]. the recent developments in power electronics devices leads to Voltage Source Converter (VSC) based FACTS devices as a best reactive power compensators. Static Synchronous Compensator (STATCOM) is one of the typical FACTS device used to alleviate small and large transient disturbances in the power system [3]-[6].

This paper focuses on a design of a STATCOM to alleviate the large transient disturbances in a Kundur's two area system. It is a test system referred by Prabha Kundur in the text book "Power system stability and control" [7]. In this paper,Bats Echolocation logic based controller is implemented as a supplement controller for PI controller of STATCOM. It is used to tune the PI controller gains according to the system loading condition. In olden days, fixed gain PI controllers are used for STATCOM.These types of STATCOM perform very well in nominal load. If the load changes drastically, it's performance is gradually reduced. in order to overcome that a lot self tuning PI controlling methods are developed like Fuzzy logic controller, Artificial Neural Network and Genetic algorithm[8]-[14].

This paper is organized as follows, section II, presents a basic principle of STATCOM. Section III presents kundur's two area system with STATCOM, Section IV presents a analogy of Bats Echolocation logic Controller. Section V presents a step by step procedure of Bats Echolocation logic controller. Section VI presents simulation results.

II. BASIC PRINCIPLE OF STATCOM
Fig.1 shows the Voltage Source Converter (VSC) with DC coupling capacitor connected with system through coupling transformer. The VSC acts as a controllable voltage source, depending on its magnitude, reactive power exchange between STATCOM and system takes place through leakage reactance of the coupling transformer. when the VSI voltage is greater than system voltage,then the STATCOM deliver the reactive power to the system and vice versa[1] & [15].

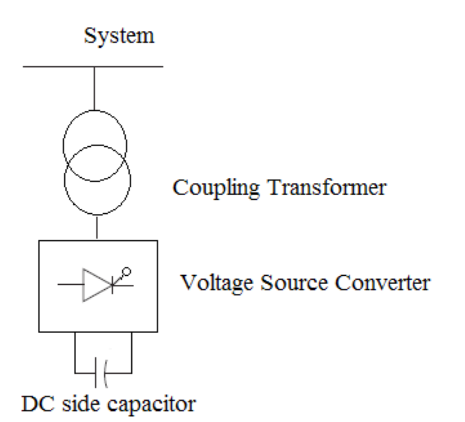

Fig.1 Basic principle of STATCOM

III. KUNDUR'S TWO AREA SYSTEM WITH STATCOM
The fig. 2 shows the Kundur's two area system with STATCOM. It has two areas connected by weak tie between buses 7 and 9. Each area has two generators with a rating 900 MVA and voltage as 20 kV [7]. In this paper the STATCOM is connected at bus 7 to improve the long – term stability of the system caused by drastic changes in load 7.

IV. ANALOGY OF BATS ECHOLOCATION LOGIC CONTROLLER
While hunting airborne targets, Bats emit ultrasonic sound bursts at the rate of 10Hz. the duration of the each burst is in the order of 5 to 20ms.These sounds are synchronized with wing beats. Once the Bats found the target or prey. It increases the frequency of the ultrasonic sound bursts and also duration of the bursts. Experts found that frequency is in the order of 200Hz and duration in the order of milliseconds. This is because, to avoid overlap and echo of the reflected sounds [16]-[17]. This behavior of the Bats is mimicked as a bats Echolocation logic controller. The table I give the analogy between Bats Echolocation systems to Bats Echolocation logic controller.

TABLE I
ANALOGY BETWEEN BATS ECHOLOCATION LOGIC

Volume : 3 | Issue : 8 | Aug 2013 | ISSN - 2249-555X

CONTROLLER AND BATS ECHOLOCATION SYSTEM

Sl. No.	Bats Echolocation System	Bats Echolocation logic Controller
i	Bats emits low frequency high duration ultrasonic sound burst while navigation in space	This controller makes almost no changes in PI controller gains when the system is in stable condition.
ii	When the target is nearer, bats emit high frequency low duration sound bursts in the direction of the target.	This controller updates PI controller gains when long –term disturbance occur in the system.
iii	when the target is nearer, The bats emits high frequency sound bursts in order to avoid overlapping and echo of reflected signal.	This controller updates the PI controller gains depending on the error which is caused due to long - term disturbances in the system.

V. BATS ECHOLOCATION LOGIC CONTROLLER

The step by step procedure of Bats Echolocation logic controller is given as follows.

Step 1: Measure the voltage and current at point of common coupling (at bus 7).

Step 2: Estimate the approximate impedance. It is estimated by dividing the voltage at point of common coupling by current. It reflects the condition of system at point of common coupling.

Step 3: if the variation of this impedance is within 1%, then the PI controller gains are intact.

Step 4: if the variation is more than 1%. Then the PI controller gains are updated as

$K_p^{new}, K_i^{new} = K_p + x \, delK_p, K_i + xdel \, K_i$ (1)

Here x is the parameter which is depends on the rate of change of the estimated impedance.

Step 5: Check, voltage at bus 7,if $V_7 \sim V_7^{ref} \geq 0.001$,then,

$K_p^{final}, K_i^{final} = K_p^{new}, K_i^{new}$ (2)

Step 6: $V_7 \sim V_7^{ref} < 0.001$, then the step 4 to step 5 are repeated.

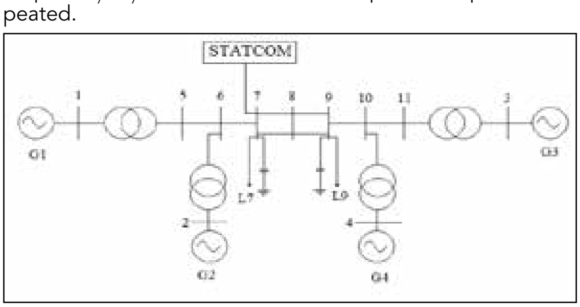

Fig.2 Kundur's two area system with STATCOM

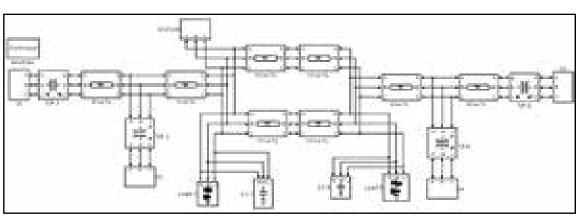

Fig.3 SIMULINK model of Kundur's two area system with STATCOM

VI. SIMULATION RESULTS

To demonstrate the effectiveness of the proposed controller, The MATLAB/SIMULINK model of the kundur's two area system with STATCOM is analyzed. The model is shown in fig.3.

The parameters considered for Kundur's two area system with STATCOM is represented in Table 2.

TABLE 2
SYSTEM PARAMETERS

Kundur' two area system	
Number of generators	4
Number of buses	11
Number of loads	2
Generators' rating	900MVA,20kV
Transformers' rating	900MVA,20/230kV,R12=0(p.u) & X12=0.15(p.u)
Shunt impedances	-200MVAR(at bus 7) &-350MVAR(at bus at 9)
Loads	P=967W,Q=100VAR(at bus 7) & P=1767W, Q=100VAR (at bus 9)
Transmission line parameters	R=0.0001(p.u) ,X=0.01(p.u) & B=0.00175(p.u)
STATCOM	
Voltage Source Inverter	7 level Cascaded Multilevel Inverter
DC link Capacitors' value	0.001 Farads
Initial PI controller gains	K_p=0.1,K_i=0.01

The simulation results are shows that the voltage profile at bus 7 and other buses are improved. The voltages at buses 1,2,3,4 and 7 in Kundur,s two area system after long-term disturbance, are given in table 3.the bus voltages are represented in per unit system with base voltage as 20kV and 900 MVA rating.

TABLE 3
VOLTAGE PROFILE OF KUNDUR'S TWO AREA SYSTEM WITHOUT STATCOM AT BUS 7

Bus Number	Voltage magnitude (p.u)	Voltage phase angle (deg)
1	1.03	0
2	0.9471	-0.41
3	0.9438	-0.42
4	0.9671	-0.47
7	0.9321	-0.62

TABLE 4
VOLTAGE PROFILE OF KUNDUR'S TWO AREA SYSTEM WITH STATCOM AT BUS 7

Bus Number	Voltage magnitude (p.u)	Voltage phase angle (deg)
1	1.03	0
2	0.9821	-0.46
3	0.9442	-0.41
4	0.9721	-0.48
7	1	-0.74

Table 4 shows that the connection of STATCOM at bus 7 improves voltage profile at buses very nearer to the point of common coupling. Bus 7 is in Point of Common Coupling. so it attains its value 1p.u and nearer bus 2 attains its value as 0.9821.the buses far away from STATCOM attains only little bit improvement in its voltage profiles(bus 3 &4).so the results shows that the STATCOM is best suited to improve the voltage profile at localized applications.

VII. CONCLUSION

In this paper, Bats Echolocation logic controller is proposed

Volume : 3 | Issue : 8 | Aug 2013 | ISSN - 2249-555X

for STATCOM which is connected at bus 7 in Kundur's two area system. Based on the estimated impedance at bus 7, The Bats Echolocation logic controller updated the PI controller gains. The simulation results are show that STATCOM is best suited to improve the voltage profile for localized area in the given power system network.

REFERENCE

[1] N.G.Hingorani and L.Gyugi (2000), "Understanding FACTS". New York, IEEE Press. | [2] T.J.E.Miller, Ed. (1982), "Reactive Power Control in Electric Systems" New York, Wiley. | [3] P. Rao, M.L. Crow and Z. Yang (2000), "STATCOM control for system voltage control applications," IEEE Transaction on Power Delivery,1311-1317. | [4] K.R. Padiyar and A.L. Devi (1994), "Control and simulation of static condenser", /Ninth Annual Applied Power Electronics Conference and Exposition, 826-/831. | [5] M. S. El-Moursi and A. M. Sharaf (2005), "Voltage stabilization and reactive compensation using decoupled controllers for the STATCOM and SSSC," IEEE Transaction on Power System,1985–1997. | [6] M. Routimo, M. Salo, and H. Tuusa (2007), "Comparison of voltage-source and current-source shunt active power filters," IEEE Transaction on Power Electronics,636–643. | [7] Prabha Kundur (1994), "Power System Stability and Control", The EPRI Power System Engineering Series, McGraw-Hill. | [8] Chien-Hung Liu,Yuan-Yih Hsu (2010), "Design of a Self-Tuning PI Controller for a STATCOM Using Particle Swarm Optimization," IEEE transaction on Industrial Electronics, vol. 57, no. 2.. | [9] Boniface H.K.Chia,Morris.S.and,Dash.P.K. (2003), "A feedback Linearization Based Fuzzy-Neuro Controller for current Source Inverter based STATCOM," Power Engineering Conference,172–179. | [10] G.Kumaravel and C.Kumar (2011), "Design of Self tuning PI Controller for STATCOM using Bats Echolocation Algorithm," European Journal of Scientific Research,Vol.54, No.3,473-483. | [11] G.Kumaravel and C.Kumar (2012), "Design of Self Tuning PI Controller for STATCOM using Bats Echolocation Algorithm based Neural Controller,"IEEE International Conference on Advananced .Engineering Science. and Management,276-281. | [12] S. Panda, N. P. Padhy and R. N. Patel (2007), "Application of Genetic Algorithm for FACTS-Based Controller Design," International Journal of. Computer Information and Sysem, Science and Engineering, vol. 1, No. 1,40-47. | [13] Valderrábano, A. and J.M. Ramirez (2010), "STATCOM regulation by a fuzzy segmented PI controller," Electronics Power System and Research,707-715. | [14] S. Mohagheghi et al.(2003), "Adaptive critic design based neurocontroller for a STATCOM connected to a power system," in Proceeding of IEEE IAS,749–754. | [15] P. Rao, M. L. Crow, and Z. Yang (2000), "STATCOM control for power system voltage control applications," IEEE Transaction of Power Delivery,1311–1317. | [16] Simmons JA and Stein RA (1980), "Acoustic imaging in bat sonar:echolocation signals and the evolution of echolocation," Journal of Comp Physiology,61–84. | [17] Rayner JMV (1991), "Complexity in a coupled system: flight, echolocation and evolution in bats. In: Schmidt-Kittler, Vogel K (eds) Constructional morphology and evolution," Springer,Berlin Heidelberg New York,173–191 |