

# SSSC FACTS Device in Reactive Power Flow Solution

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**Abstract -** This paper describe the reactive power flow solution based BBO to amend the performance of the power system. Biogeography-based optimization is incorporating flexible AC transmission systems (FACTS). Static Synchronous Series Compensator (SSSC) is type of FACTS device used in this paper. In this BBO Store best parent solution and apply mutation and migration process on remaining parents to produce best fitted child sets. This paper define the problem of optimal power flow solution is very severe in modern interconnected transmission system the control of reactive and real power has to be fast to insure that the system remains stable under all condition of operation. The use of thyristor based controllers enable a transmission system to be flexible using SSSC FACTS is a series connected FACTS controller. The proposed BBO method gives better solution quality compared to particle swarm optimization with static synchronous series compensator facts device. The simulation results show that the proposed BBO algorithm is effective, fast and accurate in finding the optimal parameter settings for FACTS devices to solve OPF problems. BBO algorithm is tested on IEEE 14-bus with SSSC FACTS device gives better solution to enhance the system performance.

**Keywords-** Power system operation, FACTS, Biogeography based optimization, optimal power flow, SSSC Device.

## I. INTRODUCTION

The AC transmission system has different limits classified as stationary limits and dynamic limits. These inherent power system limits restrict the power deal, which guide to the beneath utilization of the active transmission resources. Conventionally, fixed or mechanically switched Series and series capacitors, reactors and synchronous generators were being used to solve much of the difficulty. Though, there are limitations as to the use of this conventional equipment. Wanted performance was not being able to attain efficiently. Wear and tear in the mechanical apparatus and sluggish response were the heart of the trouble. There was better requiring for the substitute technology made of solid state devices with quick response characteristics.

They require was extra fuelled by universal reformation of electric utilities, rising environmental and efficiency regulations and difficulty in realization authorize and accurate of technique for the construction of overhead transmission lines. This, jointly with the development of Thyristor switch (semiconductor gadget), opened the gate for the growth of power electronics devices known as Flexible AC Transmission Systems (FACTS) controllers. The path from historical Thyristor based FACTS controllers to present state of the skill voltage source converters based FACTS.

## II. STATIC SYNCHRONOUS SERIES COMPENSATOR (SSSC)

Static Synchronous Series Compensator (SSSC) is single of the main series FACTS devices. SSSC is a solid state voltage source inverter I insert an approximately sinusoidal voltage, of variable magnitude in series with the transmission line. The injected voltage is approximately in quadrature with the line current. A little part of the injected voltage, which is in phase with the line current, provides the losses in the inverter. Mainly of the injected voltage, which is in quadrature with the line current, emulates an inductive or a capacitive reactance in series with the transmission line. This emulated variable reactance, inserted by the injected voltage source, influences the electric power flow through the transmission line.

**Operating principle:-**

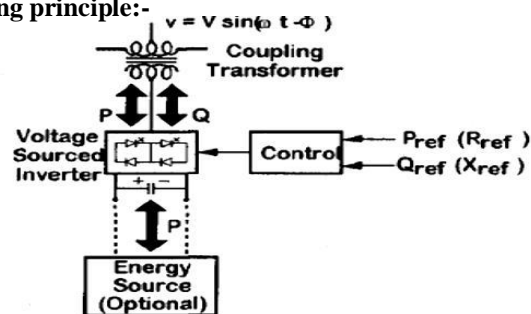


Fig.1 Block diagram of Stat Synchronous Series Compensator

### III. RESULT AND SIMULATION

Nominal Power ( $P_n$ ) – 3730 VA, Voltage (line -line) ( $V_n$ )– 338 Vrms, Frequency ( $F_n$ ) – 50 Hz , Stator Resistance ( $R_s$ ) – 1.115 ohm and Inductance ( $L_s$ )– 0.005974 H, Rotor Resistance ( $R_r$ )–1.083 ohm and Inductance ( $L_r$ )– 0.005974 H, Mutual Inductance ( $L_m$ )– 0.2037 H, Inertia (J) 0.02 Kgm<sup>2</sup> , Friction Factor (F) – 0.005752 N.M.S. , Pole Pair (p) – 2,  $L_c$ = 5mH,  $R_c$  = 0.1 $\Omega$ ,  $h_b$ =0.5A,  $C_1$ =5000F,  $R_l$  = 1000  $\Omega$ ,  $P$  = 0.43,  $I$  = 0.15,  $D$  = 0.

#### 1. Performance of D-SSSC for Harmonics Elimination of linear Load

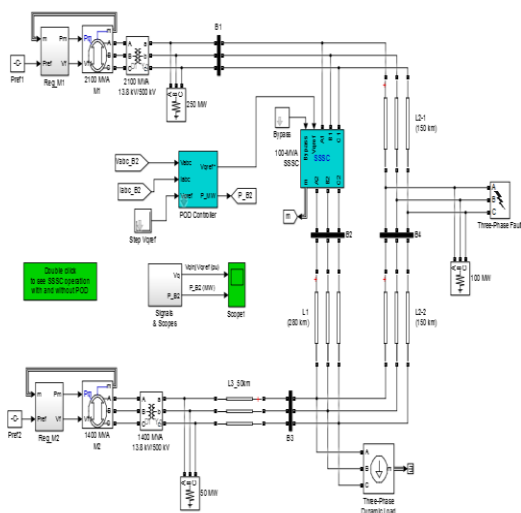


Fig.2 Simulated System of D-SSSC for Harmonics Elimination of linear Load.

#### 2. Simulated design of Control Strategies for System.

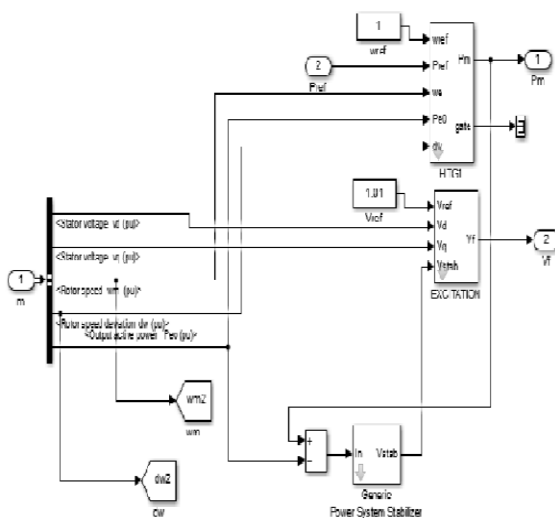


Fig. 3 Simulated design of Control Strategies for System.

#### 3. Performance of SSSC for Harmonics Elimination of Nonlinear Load

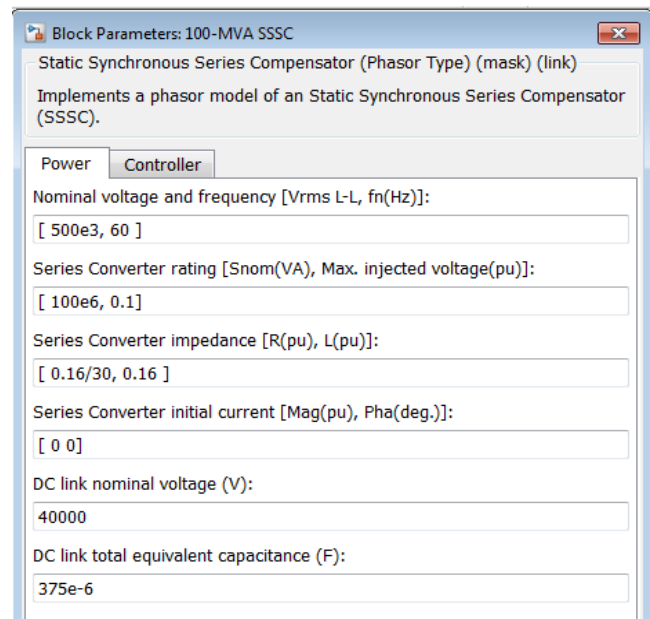


Fig. 4 Simulated System of SSSC for Harmonics Elimination of Nonlinear Load

#### 4. Performance of D-SSSC for Harmonics Elimination of Induction Motor Load:- Simulation Results:- For Linear Load:-

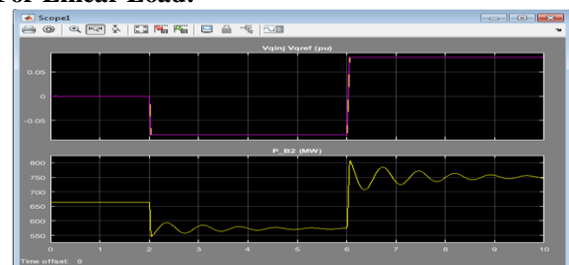


Fig.5 Source voltage ( $V_s$ )

Fig. 5 shows the source voltage ( $V_s$ ) of the linear load of SSSC system. And fig. 7.6 shows the load current of the linear load ( $I_L$ ) of the SSSC system.

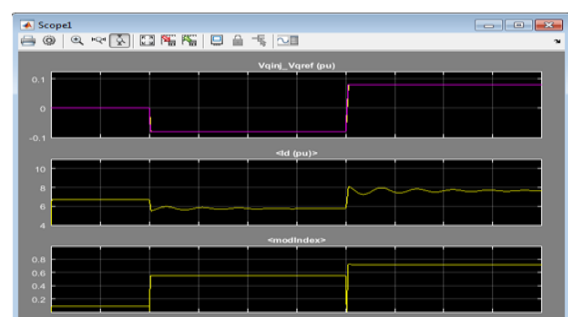


Fig.6 Load Current ( $I_L$ )

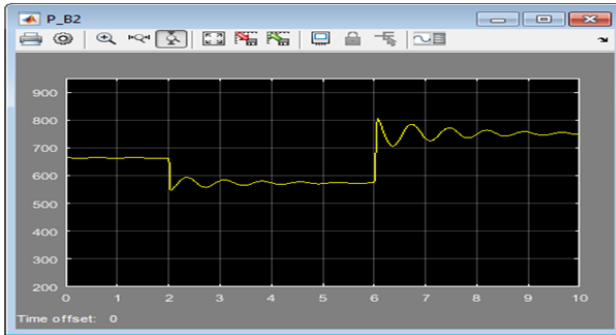


Fig.7 Compensating Current ( $I_c$ ).

Fig. 7 shows the Compensating Current ( $I_c$ ) of the linear load of D-SSSC system. And fig. 3.7 shows the Gating pulse ( $I_g$ ) of the linear load of the D-SSSC system

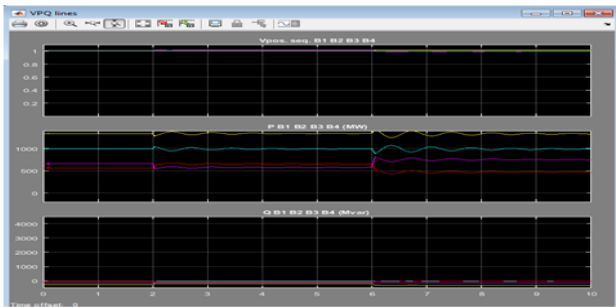


Fig.8 Gate Pulse ( $I_g$ ).

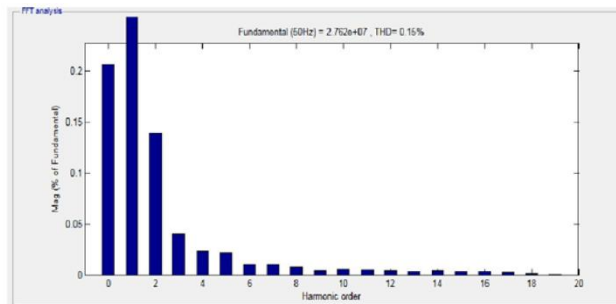


Fig.9  $I_s$  Harmonics Spectrum.

Fig. 8 shows the FFT analysis of source current ( $I_s$ ) of the linear load of D-SSSC system. And fig. 9 shows the FFT analysis of load current ( $I_L$ ) of the linear load of the D-SSSC system.

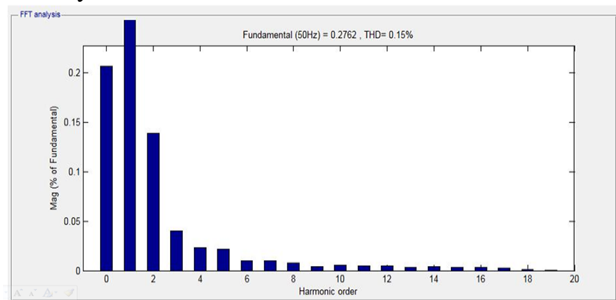


Fig.10  $I_L$  Harmonics Spectrum

## 5. For Non Linear Load:-

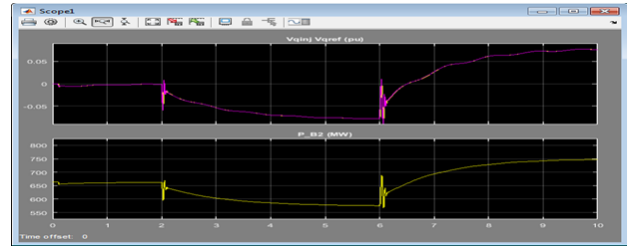


Fig.11 Source voltage ( $V_s$ ).

Fig. 11 shows the source voltage ( $I_s$ ) of the nonlinear load of SSSC system. And fig.12 shows the load current of the nonlinear load ( $I_L$ ) of the SSSC system.

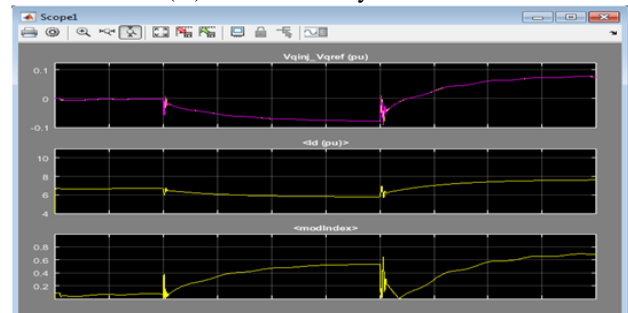


Fig.12 Load Current ( $I_L$ ).

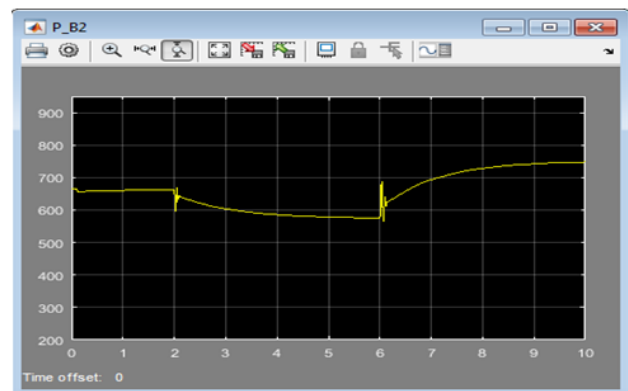


Fig.3.12 Compensating Current ( $I_c$ ).

Fig.12 shows the Compensating Current ( $I_c$ ) of the non linear load of SSSC system. And fig. 13shows the Gating pulse ( $I_g$ ) of the non linear load of the SSSC system.



Fig.3.13 Gate Pulse ( $I_g$ )

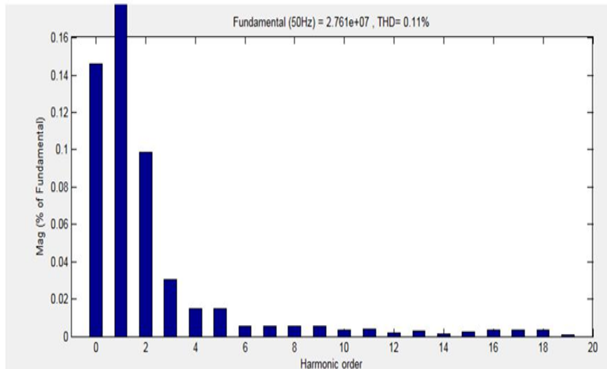


Fig.14  $I_s$  Harmonics Spectrum.

Fig.14 shows the FFT analysis of source current ( $I_s$ ) of the non linear load of D-SSSC system. And fig. 3.15 shows the FFT analysis of load current ( $I_L$ ) of the non linear load of the D-SSSC system.

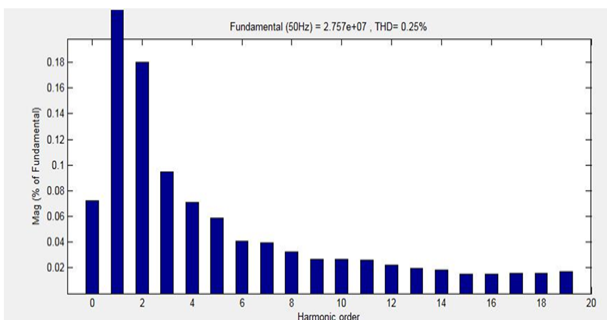


Fig.15  $I_L$  Harmonics Spectrum.

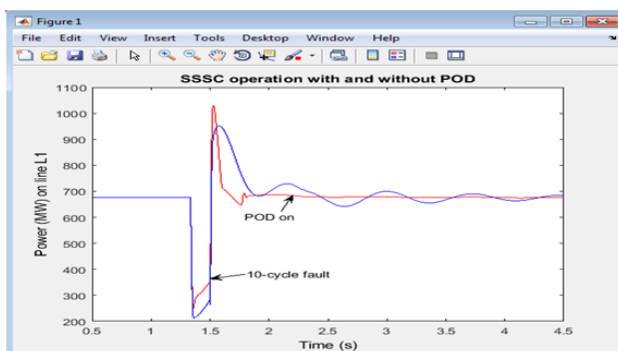


Fig.16  $I_s$  Harmonics Spectrum.

Fig. 16 shows the FFT analysis of source current ( $I_s$ ) of the nonlinear load of SSSC system. And fig. 3.17 shows the FFT analysis of load current ( $I_L$ ) of the nonlinear load of the SSSC system.

Table 1 Comparative analysis of OSCILLATION through Compensated and Uncompensated system

Types of Load	OSCILLATION % Without Compensation		OSCILLATION % With Compensation	
	$i_s$	$i_L$	$i_s$	$i_L$
Linear Load	3.21	3.21	0.15	0.15
Non Linear Load	25.34	25.34	0.11	0.25
Induction Motor Load	26.86	26.86	0.21	2.58

## IV. CONCLUSION

- A model of SSSC has been developed in MATLAB environment using Power System Block-set. The performance of the developed model is tested under a wide variety of loading conditions.
- It is found that SSSC is capable of minimizing the harmonics and reactive power compensation.
- Indirect current control technique has been applied over the sensed and reference supply currents for SSSC and it has been found to be a simple technique. Only one PI controller is required to regulate terminal voltage and thus reduces computation effort.
- The control algorithm of the SSSC is flexible and has been tested for power quality improvement for linear as well as nonlinear and Induction motor loads.
- D-SSSC is able to reduce harmonics in voltage at PCC and supply currents to less than 5% IEEE 519 standards. SSSC reduces harmonics in load current to a large extent and provides quality power.

## V. FUTURE IMPLICATIONS

- The simulation has been carried out in MATLAB/SIMULINK environment and power factor is unity for supply voltage and current.
  - To analyze the effect of non-linear loads, linear loads and Motor loads on Distribution system when feeding a generation with wind and solar.
  - Modelling of reactive power theory and compare results with ICCT.
  - To Study and Simulation of Fuzzy and ANN based controller on behalf of PI controller.
- In a future work, the obtained simulation results will be compared with experimental results, to be measured in a developed D-SSSC prototype.

## REFERENCES

- N.G. Hingorani and L. Gyugyi, (2001) Understanding FACTS, Delhi: Standard Publishers.
- Bhim Singh, A. Adya, A.P. Mittal and J.R.P Gupta, "Application of Battery Energy Operated System to Isolated Power Distribution Systems" Proc. Of IEEE PEDC 2007 pp.526-532.

- [3].B. Singh, J. Solanki, A. Chandra, "Adaline Based Control Of Battery Energy Storage System For Diesel Generator Set," Proc. Of Ieee Power India Conference, April 2006, Pp.5.
- [4].B. Singh, J. Solanki, A. Chandra, K. Al-Haddad, "A Solid State Compensator With Energy Storage For Isolated Diesel Generator Set," Proc. Of Ieee International Symposium On Industrial Electronics, Vol.3, July 2006, Pp. 1774-1778.
- [5].Dipesh. M .Patel, Dattesh Y. Joshi, Sameer H. Patel, Hiren S. Parmar "Operation Of D-Sssc For Voltage Control In Distribution Networks With A New Control Strategy"
- [6].Proc. Of National Conference On Recent Trends In Engineering & Technology, 13th & 14th May-2011, B.V.M. Engineering College, V.V.Nagar,Gujarat, India
- [7].A Real And Reactive Power Control Approach F Or Battery Energy Storage System, C. E. Lin
- [8].Y. S. Shiao C. L. Huang Senior Member P. S. Sung, Proc. Of " Transactions On Power Systems, Vol. 7, No. 3, August 1992.
- [9].Design And Commissioning Of A 5 Mva, 2.5 Mwh Battery Energy Storage System, N.W. Miller (Sm), R.S. Zrebiec (Nm), G. Hunt (Nm), Page No. 339-345.
- [10]. Using Battery Energy Storags System In A Deregulated Environment To Improve Power System Performance, K.K. Leung And D. Sutanto, Proc. Of International Conference On Electric Utility Deregulation And Restructuring And Power Technologies 2000, City University, London, 4-7 April 2000. P.N. 614-619.
- [11]. Veeraiah kumbha, N. Sumathi "Power Quality Improvement Of Distribution Lines Using D-Sssc Under Various Loading Conditions", ,Prpc. Of International Journal Of Modern Engineering Research (Ijmer) Www.Ijmer.Com Vol. 2, Issue. 5, Sep.-Oct. 2012 Pp-3451-3457 Issn: 2249-6645
- [12]. Ghazan far shah gholian, Mehdimahdavian,Afsh Netesami, Sepehrmoalem, Masoudjabbari
- [13]. "Improvement Of Dynamic Behavior And System Stability By Using Sssc"
- [14]. A. Ghosh, And G. Ledwich, Power Quality Enhancement Using Custom Power Devices, London: Kluwer Academic Publishers, 2002.
- [15]. T.J.E Miller, Reactive Power Control In Electric Systems, Toronto, Ontario, Canada: Wiley Publications, 1982.
- [16]. R.M. Mathur, Static Compensators For Reactive Power Control, Winnipeg, Canada, Contexts Publications,1984.