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Comparative Analysis and Performance of DSTATCOM Device using GSA and Cuckoo Search Control Algorithm

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Abstract: This paper presents a combination of voltage source converter and capacitor banks which is called as Static Compensator (STATCOM), Voltage Source Converter (VSC) based diversion connected Flexible AC Transmission System (FACTS) devices which improves the dynamic and static voltage control in transmission in addition with distribution system. It is a reactive power return device which can produce and absorb the reactive power. The power quality has ongoing to play an important role in electronic and electrical industries. A system concerning the power quality measurement is voltage flicker and harmonics. Normally DSTATCOM is connected in distribution system. Optimizing the parameters of a bio-inspired algorithm's naturally the main path to improve its performance. The distribution used in the displacement and creation of new solutions is also a factor to consider when enhancing its capacity. In this work, the efficiency of Gravitational Search Algorithm (GSA) and Cuckoo Search Algorithms (CSA) is investigated through MATLAB Simulink model. InThe IGBT is used as a power switch which has low switching loss and the turn off is very simple. In this paper THD is evaluated, disturbances obtained in the current waveforms are reduced by means of DSTATCOM. The distribution system with DSTATCOM and the control scheme used for power quality enhancement is simulated and validated.

Keywords: Static Compensator (STATCOM), Voltage Source Converter (VSC), Cuckoo Search Algorithms (CSA), Gravitational Search Algorithm (GSA).

I. INTRODUCTION

In recent times, power quality indices like flicker, harmonics and voltage fluctuations etc. are considered as most indispensable quantities to measure and analyse the power quality in uninterruptible process plants. Nonlinear loads are the source of harmonics when solid state devices controllers are used for converting AC power to feed to the electrical loads [1]. This Electric power generation and transmission is the multipart technique wherein many apparatuses of strength system are used to take full advantage of the output. Nowadays global strength is playing a vital function. So, it's far taken into consideration as a chief component for agriculture, railways, education, manufacturing and soon, for development of our financial system. The power which enables to drive active strength is known as reactive power [2]. In transmission system powers play a major role i.e. real power and reactive power. If any problem takes place in either transmission line or distribution line like sag, swell, skin impact, temperature effect, harmonics, flicker, noise etc. Then at that point power loss might be extra. DSTATCOM may be related inside the distribution system it'll be mitigated the electricity satisfactory issues [3]-[6]. DSTATCOM is a 'static voltage compensator' this is generally utilized in distribution line, connected in parallel. In this paper, it's far used for supply feeding with one give up i.e. handiest one client e.g. industry in which it will likely be the usage of one tapping, as a result very large amount of current might be there so, power loss could be very high. Some of the faults may additionally arise to reduce these to introduce STATCOM in transmission device [7]. DSTATCOM can have number of components while as compared to STATCOM. The fundamental objective of the undertaking is to satisfy the distribution masses in a device in which it cannot change the producing station for that the distribution load aspect DSTATCOM is brought. In this paper, the primary purpose is to place the DSTATCOM with a "distribution system", due to the fact it's far a lossless gadget. The power quality holds issues along with voltage flicker, sag, and in addition to harmonic ordinary and high-frequency clatter. Power electronic devices alternate voltage and modern-day waveforms in an electricity network, influencing electricity offerings and purchaser system. Harmonic voltages motive a lack of exactness in measuring gadgets and the damaged operation of relays and manipulate systems. "Electromagnetic noise"as a result of the noise of the high frequency electromagnetic waves (Harmonics) launched from strength-digital circuits, distresses 'electronic devices'used in business and enterprise' and often encourages interfering voltage in "communication strains. To mitigate the harmonics and high frequency losses

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in a distribution machine D-STATCOM is used [8]-[9]. STATCOM plays a main character in a distribution system whilst a power first-class trouble is occurred. If the supply is balanced then only the deliver will pass through the track, when the supply is unbalanced at that time only reactive power might be injected through the machine that is known as VAR compensation. In this assignment DSTATCOM is connected in distribution system to compensate the strength Satisfactory problems [10].

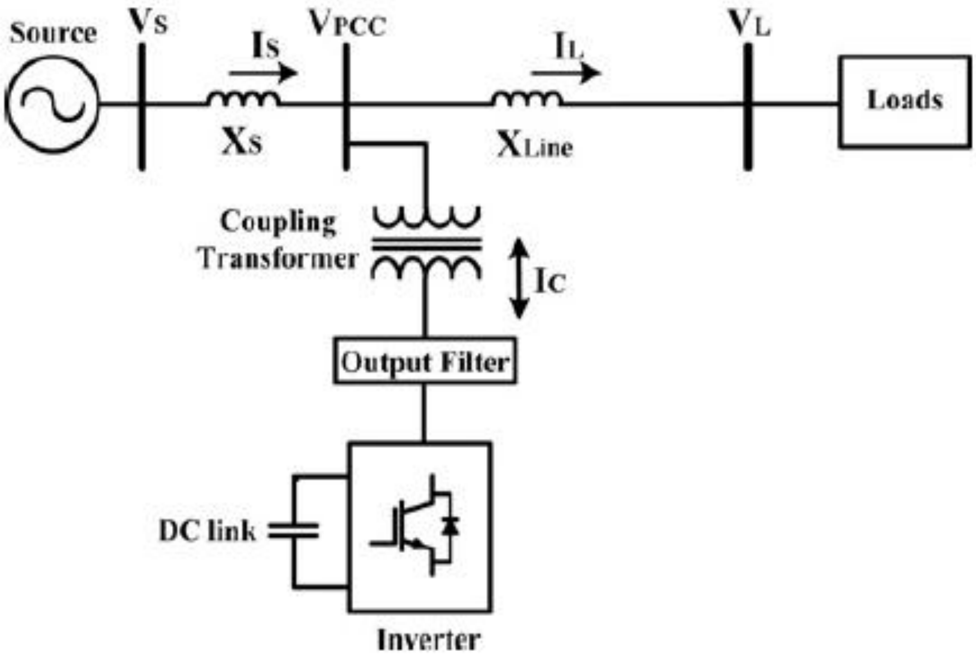

Figure1. DSTATCOM

A DSTATCOM is a fast-response, solid-state power controller that provides power quality improvements at the point of connection to the utility distribution feeder. It is the most important controller for distribution networks. It has been widely used to precisely regulate the system voltage and/or for load compensation. It can exchange both active and reactive powers with the distribution system by varying the amplitude and phase angle of the voltage of the VSC with respect to the PCC voltage, if an Energy Storage System (ESS) is included into the DC bus [11-13]. However, a capacitor-supported DSTATCOM is preferred for power quality improvement in the currents, such as reactive power compensation for unity power factor or voltage regulation at PCC, load balancing, and neutral current compensation.

II. PRINCIPLE OPERATION OF DSTATCOM

Current monitoring of energy efficiency issues is the key aim of DSTATCOM. DSTATCOMs counteract reactive power, unstable currents, neutral current, and harmonic distortion, which are the most frequent power quality dependent concerns. Within the AC transmission systems, DSTATCOM technology has now evolved a viable technology to provide reactive control, load handling and/or static current and resonance flow (if necessary). This grew with growth in terms of specific systems, control methods and solid-state devices over the past quarter century. On the basis of the demands and control technique, and the framework to be appropriately chosen, these tasks are accomplished independently or together. In general, DSTATCOM is classified into three groups, namely one-phase two-wire, three-phase three-wire and three-phase four-wire configuration, to satisfy the specifications of three types of customer charges for processing appliances. Since 1984 different approaches have been developed and investigated for diverse applications. Single phase DSTATCOMs are developed using both current source converters (CSC) with inductive power storage and power system (VSCs).

The main objective of DSTATCOMs is to alleviate the current-based power quality problems facing a manufacturing operation. A DSTATCOM alleviates most of the current performance issues such as elastic energy, unbalance, static flow, harmonics (if any) and adjustments inherent in the customer supply or otherwise in the scheme, and provides sinusoidal regulated supply constraints with its DC grid voltage power.

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A DSTATCOM, in particular, has a VSC connected to a DC cable and, as seen in Figures 2, its AC ends are typically linked in shunt over consumer charges or through the PCC. The VSC incorporates PWM power; thus, relatively small transient components are intended to minimize altering ripples. Usually the VSC is regulated in PWM current control technique to inject appropriate fluids into the system

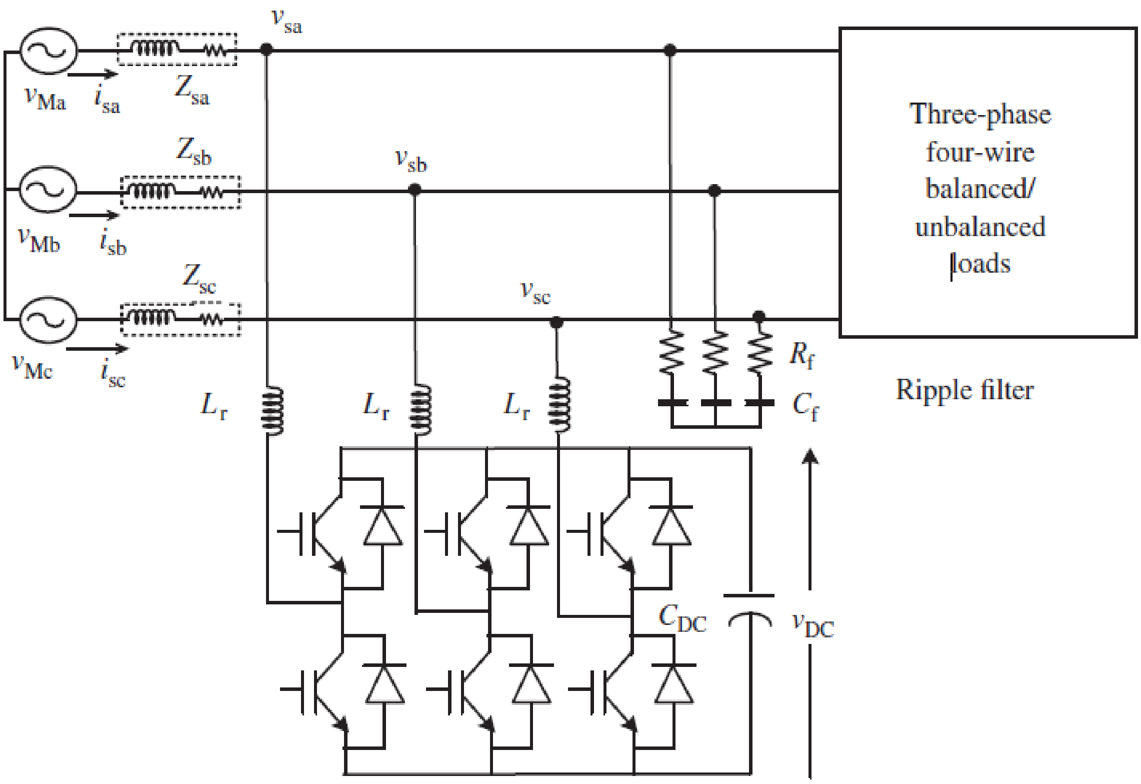

Fig 2: Block diagram of compensation by DSTATCOM

III. INSTANTANEOUS REACTIVE POWER THEORY (IRPT)

The IRPT-based control algorithm of DSTATCOMs is shown in Figure 3. Three-phase load currents and PCC voltages are sensed and used to calculate the instantaneous active and reactive powers. Three phase PCC voltages are sensed and processed through BPFs before their transformation to eliminate their ripple contents and are denoted as (vsa, vsb, vsc). A first-order Butterworth filter is used as a BPF [14].

These three-phase filtered load voltages are transformed into two-phase α–β orthogonal co-ordinates (vα, vβ) as

$$\begin{bmatrix} Vs\alpha \\ Vs\beta \end{bmatrix} = \sqrt{\frac{2}{3}} \begin{bmatrix} 1 & \frac{-1}{2} & \frac{-1}{2} \\ 0 & \frac{\sqrt{3}}{2} & \frac{-\sqrt{3}}{2} \end{bmatrix} \begin{bmatrix} Vsa \\ Vsb \\ Vsc \end{bmatrix}$$

These three-phase filtered load current are transformed into two-phase α–β orthogonal coordinates (Iα, Iβ) as

$$\begin{bmatrix} Il\alpha \\ Il\beta \end{bmatrix} = \sqrt{\frac{2}{3}} \begin{bmatrix} 1 & \frac{-1}{2} & \frac{-1}{2} \\ 0 & \frac{\sqrt{3}}{2} & \frac{-\sqrt{3}}{2} \end{bmatrix} \begin{bmatrix} Ila \\ Ilb \\ Ilc \end{bmatrix}$$

The instantaneous active power pL and the instantaneous reactive power qL flowing into the load side are calculated from these two sets of expressions.

$$\begin{pmatrix} p_L \\ q_L \end{pmatrix} = \begin{pmatrix} v_\alpha & v_\beta \\ v_\beta & -v_\alpha \end{pmatrix} \begin{pmatrix} i_{L\alpha} \\ i_{L\beta} \end{pmatrix}.$$

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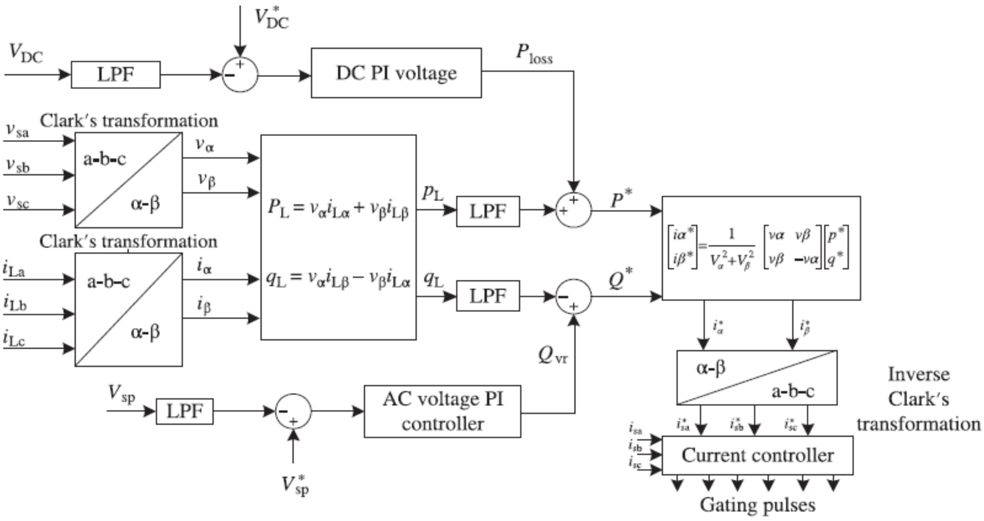

Figure 3: Instantaneous reactive power theory-based control algorithm of DSTATCOMs

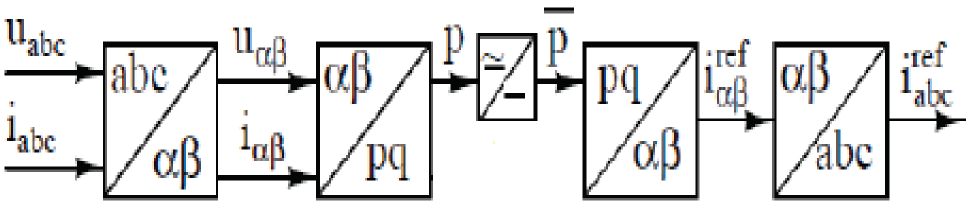

Figure 4: Block diagram of controlled current approach

Let $\widetilde{P_L}$ and $\overline{P_L}$ be the DC component and the P_L AC element, and let $\widetilde{Q_L}$ and $\overline{Q_L}$ be the DC component and the Q_L AC element, alternately.

$$p_L = \bar{p}_L + \tilde{p}_L, \quad q_L = \bar{q}_L + \tilde{q}_L$$

In these terms, the basic load power is transformed into pL and qL DC components and the distortion or negative sequence is transformed into ~pL and ~qL AC components. The effective and passive power parts of DC are obtained using two LPFs.
The reference current in two phase system is Type equation here. Isa* Isb* Isc* are the reference three-phase storage signals.

$$\begin{pmatrix} i_{sa}^* \\ i_{sb}^* \\ i_{sc}^* \end{pmatrix} = \sqrt{\frac{2}{3}} \begin{pmatrix} 1 & 0 \\ -\frac{1}{2} & \frac{\sqrt{3}}{2} \\ -\frac{1}{2} & -\frac{\sqrt{3}}{2} \end{pmatrix} \begin{pmatrix} v_\alpha & v_\beta \\ -v_\beta & v_\alpha \end{pmatrix}^{-1} \begin{pmatrix} p^* \\ q^* \end{pmatrix}$$

This IRPT-based control algorithm may easily be modified for the control on supply currents for indirect current control. In this case, for power factor correction mode of operation of the DSTATCOM, p* = PL + P_{loss} and q* = qL - qvr after the transformation from the α–β frame to the abc frame, three-phase transformed currents are reference supply currents and these must be compared with sensed supply currents in the PWM current controllers for indirect current control of the DSTATCOM. The term P_{loss} is an instantaneous active power necessary to adjust the voltage of the DC capacitor of the VSC used as a DSTATCOM to its reference value. In addition, qvr is instantaneous reactive power necessary to adjust the PCC voltage to its reference value, and PL and qL are the extracted load fundamental active and reactive power components, respectively. In the case of ZVR at PCC (voltage regulation mode of operation of the DSTATCOM), a PI voltage controller over the PCC voltage is used similarly to the above algorithms and its output is used to estimate p* and q* as p* = PL + P_{loss} and q* = qL - qvr . After the transformation, three-phase transformed currents are reference supply currents and these are compared with sensed supply currents as shown in figure for indirect current control of the DSTATCOM.

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IV. DESIGN OF THREE PHASE THREE WIRE D-STATCOM

DC BUS VOLTAGE SELECTION: The value of the VSC of D STATCOM's DC bus voltage should exceed twice the peak of the distribution system's phase voltage. The calculated capacitance value of DC is:

$$V_{DC} = 2\sqrt{2}V_{LL}/(\sqrt{3}\ m)$$

V_{LL} = AC line input voltage
V_{dc} = DC bus voltage
m = modulation indexThe value of dc bus voltage is calculated as 677.69V and it is taken as 700V.

DC BUS CAPACITOR SELECTION
During the transient period, the instantaneous energy available to the DSTATCOM decides how much capacitor value is used.

$$\frac{1}{2}C_{DC}(V_{DC}^2 - V_{DC1}^2) = k_1 3aIt$$

Where ,
V_{DC}:- Nominal DC voltage(equal to DC voltage(reference))
V_{DC1}:- DC bus minimum voltage level
a:- Overloading factor
V:- Phase voltage
I :- Phase current
t:- Time (value by which recovery of DC bus voltage is done)

AC INDUCTOR SELECTION
The equation can be given as:-

$$L_r = \sqrt{3}mV_{DC}/(12af_s I_{cr,pp})$$

Where,
L_r:- AC inductance
The value of AC inductor of voltage source converter depends on:-
a:- Overloading factor
$I_{cr,pp}$:- Current ripple
f_s:- Switching frequency
m:- Modulation index
V_{DC}:-Bus Voltage (DC)
The value of AC inductor is taken as 0.8mH

V. PI CONTROLLER

PI control systems, it is very important to obtain controller parameters that make the system stable. One of the methods used to obtain these parameters is the SBL method. The SBL method is a graphical method used to determine the controller parameters that make the control system stable. The choice of the suitable controller type is crucial to achieve the desired design criteria. In most applications, simple structured controllers are preferred. PID controllers are often preferred by the industry for reasons such as simple structure and robust performance characteristics. The optimization process can be defined as selecting the most appropriate one from the current situations. Simulink models have been developed for optimizations based on the integral performance criteria. The optimization process begins by entering initial values in controller parameters. When the smallest error value is reached, the optimization stops and the most suitable controller parameters are obtained

Now here to tuned the parameter of PI controller IAE, ISE and ITAE criteria are used.

1. $IAE = \int |e(t)|\, dt$
2. $ISE = \int e^2(t) dt$
3. $ITAE = \int t\, |e^2(t)|\, dt$

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VI. GRAVITATIONAL SEARCH ALGORITHM AND CUCKOO SEARCH ALGORITHM

In this paper, Gravitational Search Algorithm (GSA) approach is proposed, to improve voltage profile and voltage stability by solving StatCom placement and sizing problem. GSA was efficiently tested on SVC Allocation problem [15] and found that GSA provides high quality optimal solution compare to CSA. GSA approach was also applied for other power system engineering problems for example, reactive power dispatch problem [16-17], optimal power flow and others. GSA provided good solutions for the above problems, in compare to c1assical optimization techniques and it is also reduced the computational work. To be specific, the original GSA algorithm is formed by these steps: initialization, calculate the gravitational forces, calculate the acceleration and velocity, update the position of the solution. These steps are described as follows, respectively. To start with, the masses are randomly generated in the solution space. Each mass presents a solution which is

$$\mathbf{x}_i = \left(x_{i,1}, x_{i,2}, \cdots, x_{i,D}\right) \ \ i = 1,2 \cdots, NP$$

where NP is the number of solutions. Each solution xi is a D-dimensional vector.
The gravitational force between the masses is determined by the following formula [10].

$$F_{i,j}^{g} = G^{g} \frac{M_i^g \times M_j^g}{R_{i,j}^{g} + \varepsilon} \left(x_j^g - x_i^g\right)$$

where M_i^g and M_j^g are the mass of the solution *i* and the solution *j* at generation *g*, respectively. ε is a small constant and $R_{i,j}^g$ is the Euclidian distance between two masses *i* and *j*.

In operations research, cuckoo search is an optimization algorithm developed by Xin-she Yang and Suash Deb in 2009. It was inspired by the obligate brood parasitism of some cuckoo species by laying their eggs in the nests of other host birds (of other species) [18]. Some host birds can engage direct conflict with the intruding cuckoos. For example, if a host bird discovers the eggs are not their own, it will either throw these alien eggs away or simply abandon its nest and build a new nest elsewhere. Some cuckoo species such as the New World brood-parasitic Tapera have evolved in such a way that female parasitic cuckoos are often very specialized in the mimicry in colors and pattern of the eggs of a few chosen host species. Cuckoo search idealized such breeding behavior, and thus can be applied for various optimization problems.

Cuckoo search (CS) uses the following representations: Each egg in a nest represents a solution, and a cuckoo egg represents a new solution. The aim is to use the new and potentially better solutions (cuckoos) to replace a not-so-good solution in the nests. In the simplest form, each nest has one egg [19]. The algorithm can be extended to more complicated cases in which each nest has multiple eggs representing a set of solutions.
CS is based on three idealized rules:

1. Each cuckoo lays one egg at a time, and dumps its egg in a randomly chosen nest;
2. The best nests with high quality of eggs will carry over to the next generation;
3. The number of available hosts nests is fixed, and the egg laid by a cuckoo is discovered by the host bird with a probability {\display style p_{a}\in (0,1)} In this case, the host bird can throw the egg away/abandon the nest, and build a completely new nest.

VII. BLOCK DIAGRAM OF DSTATCOM AND RESULTS

The system is simulated under nonlinear load configuration for which the approach of PI controller based DSTATCOM. The main objective is to minimize the odd harmonic components using Cuckoo search Algorithm technique and Gravitational search Algorithm.

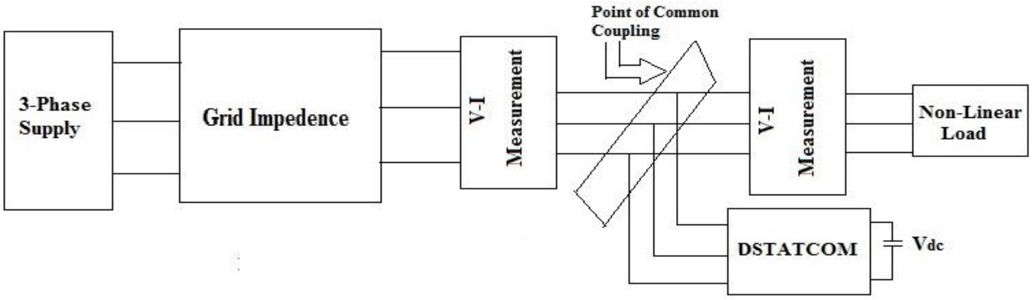

Figure 5: Block diagram of proposed model system

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The above simulation can be performed under three criteria i.e. IAE, ISE and ITAE. From Table 2 it is clear that criteria ISE gives minimum THD as compare to IAE and ITAE.

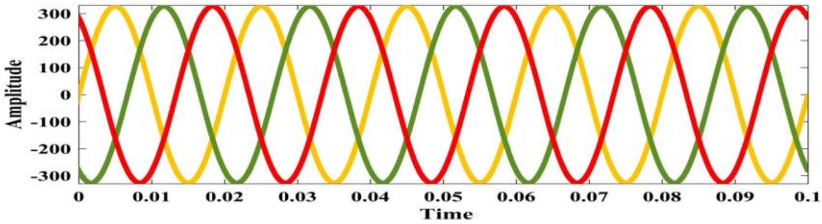

Figure 6: Waveform of source voltage.

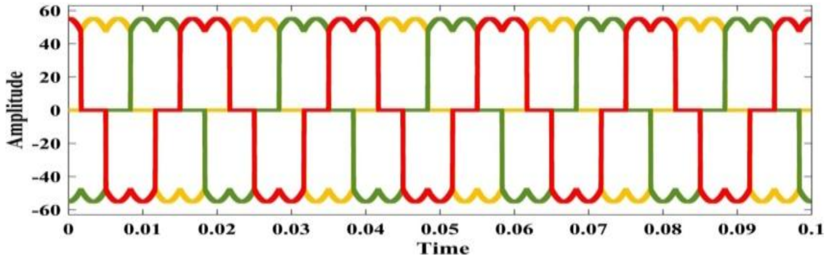

Figure 7: Waveform of source current without filter.

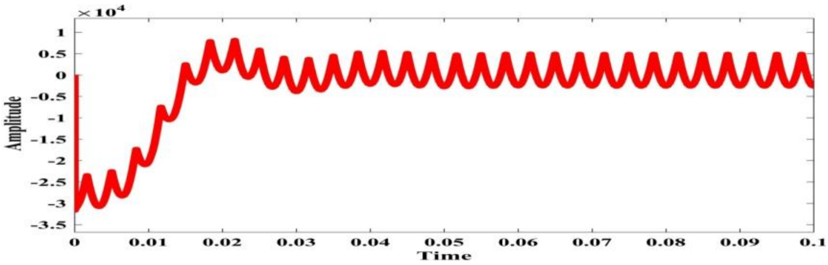

Figure 8: Waveform of P-Loss and Active power loss

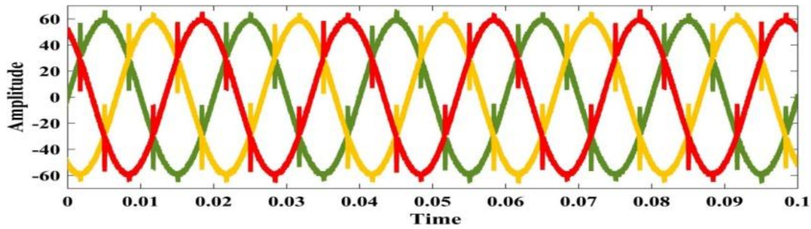

Figure 9: Waveform of source current with DSTATCOM

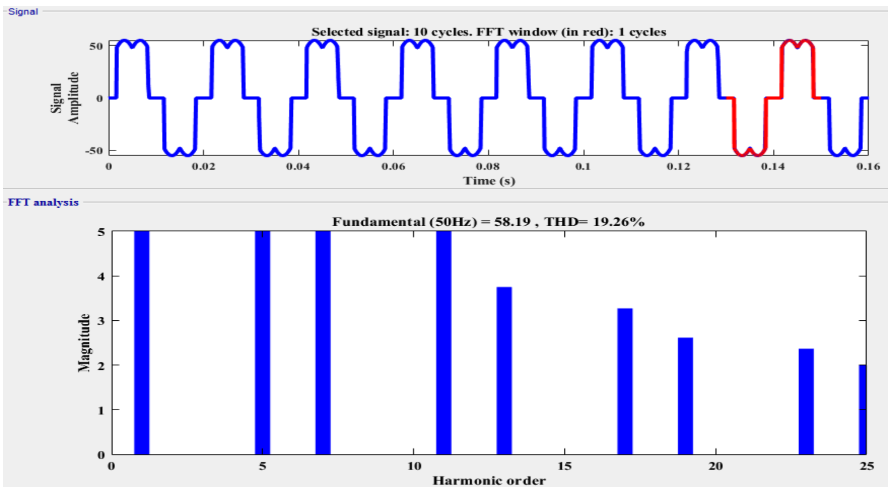

Figure 10: FFT analysis of source current without filter

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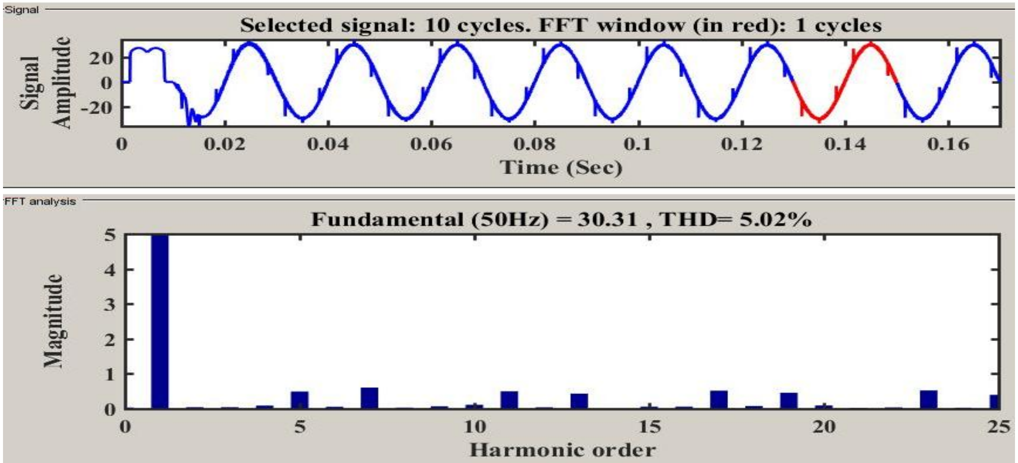

Figure 11: FFT analysis of Source current via Cuckoo Search (ISE Criteria)

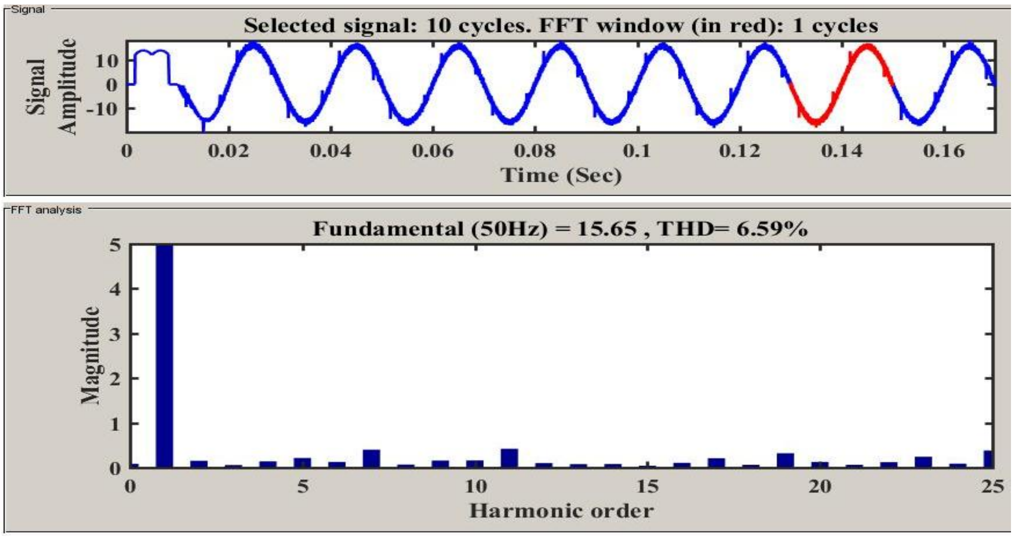

Figure 11: FFT analysis of Source current via Cuckoo Search (ITAE Criteria)

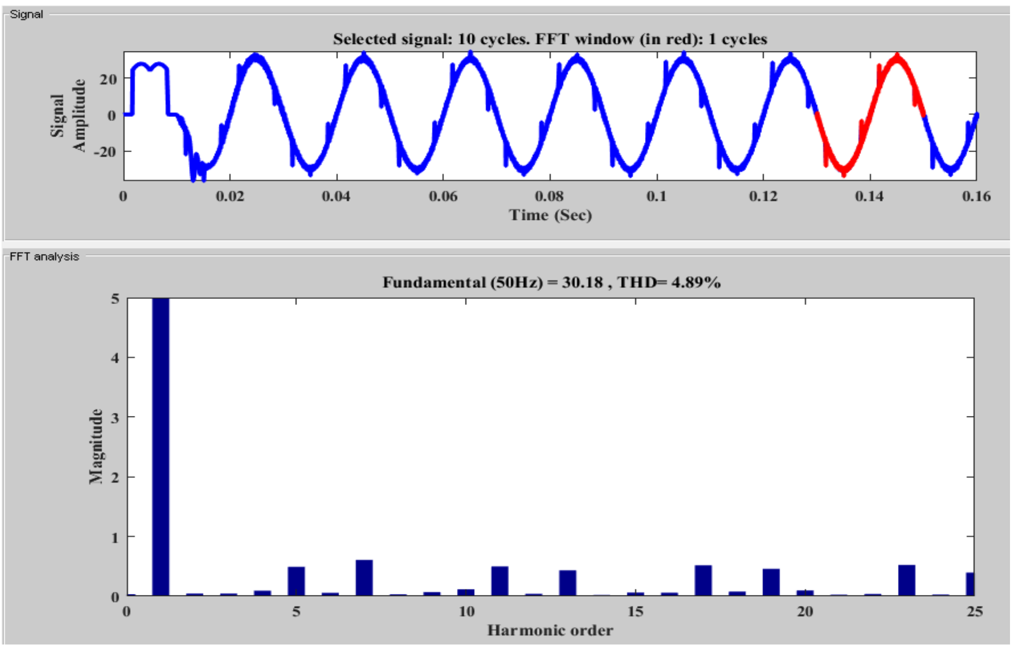

Figure 13: FFT analysis of Source current via Gravitational Search (ISE Criteria)

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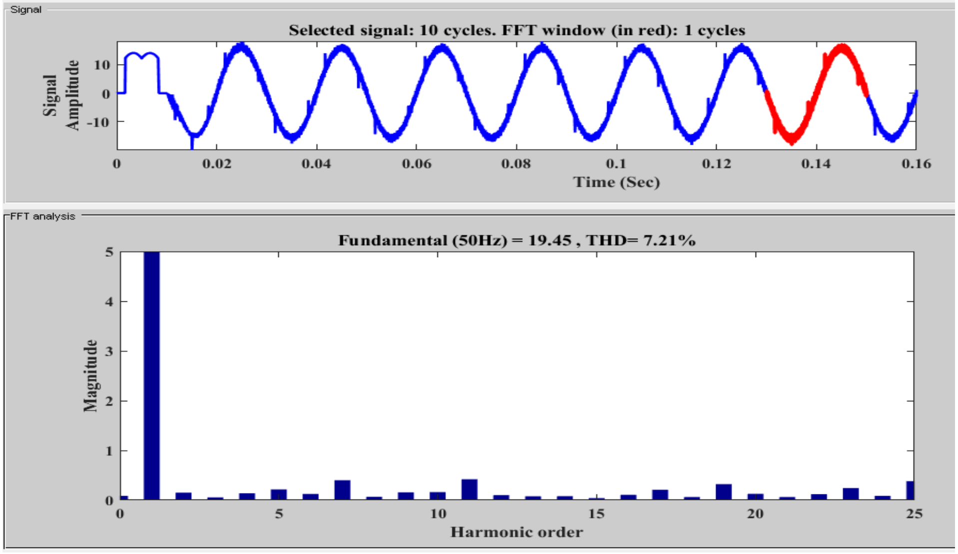

Figure 14: FFT analysis of Source current via Gravitational Search (IAE Criteria)

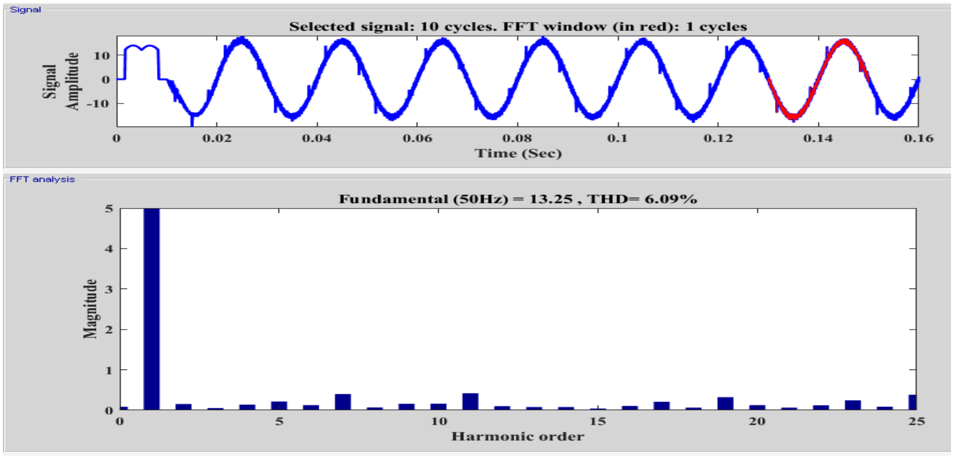

Figure 15: FFT analysis of Source current via Gravitational Search (ITAE Criteria)

Table 1: Cuckoo Search Algorithm Parameter

GSA Parameter	IAE	ISE	ITAE
P	62.36	41.32	82.59
I	48.35	40.19	52.47
Kp	22.29	71.32	82.32
Ki	23. 52	47. 14	84.39
CURRENTTHD (%)	**8.05**	**5.02**	**6.59**

Table 1 shows the whole parameter value which we have taken a run a whole matlab model during a whole matlab simulation period. From Table. 1 it is clear that the current THD will be simultaneously reduced in the ISE criteria as compared to the other criteria i.e IAE and ITAE.

Table 2: Gravitational Search Algorithm Parameter

GSA Parameter	IAE	ISE	ITAE
P	62.89	52.14	79.55
I	25.52	40.15	62.37
Kp	41.91	55.24	68.22
Ki	43. 52	49. 15	72.25
CURRENTTHD (%)	**7.21**	**4.89**	**6.09**

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Table 2 shows the whole parameter value which we have taken a run a whole matlab model during a whole MATLAB simulation period. From Table. 2 it is clear that the current THD will be simultaneously reduced in the ISE criteria as compared to the other criteria i.e IAE and ITAE.P, I, Kp and Ki are the simulation PI Controller parameter which can be optimized by the help of Cuckoo Search Algorithm optimization techniques and Gravitational Search Algorithm optimization techniques.

VIII. CONCLUSION

In this paper, GSA and CSA control algorithms for a three phase three wire DSTATCOM for power quality improvement are discussed. The main purpose of this DSTATCOM is to compensate reactive power, harmonic load and to balance the source currents. The various control algorithms are instantaneous reactive power (IRP) theory are used to generate reference current. DSTATCOM provides reactive power required by the load and therefore the source current remains at unity power factor.

REFERENCES

[1]. A. P. Vishwakarma and K. Milan Singh, "Comparative Analysis of Adaptive PI Controller for Current Harmonic Mitigation," 2020 International Conference on Computational Performance Evaluation (ComPE), Shillong, India, July 2020.
[2]. Bhim Singh, Kamal Al-Haddad, “A Review of Active Filters for Power Quality Improvement”, IEEE Transactions On Industrial Electronics, VOL. 46, NO. 5, October 1999.
[3]. B. Singh and J. Solanki, "A Comparative Study of Control Algorithms for DSTATCOM for Load Compensation," *2006 IEEE International Conference on Industrial Technology*, Mumbai, 2006, pp. 1492-1497.
[4]. BhimSingh, JitendraSolanki “A Comparison of Control Algorithms for DSTATCOM” IEEETransactions On Industrial Electronics, Vol. 56, No. 7, July 2009.
[5]. Bhim Singh, , P. Jayaprakash, D. P. Kothari, Ambrish Chandra, Kamal Al Haddad, “Comprehensive Study of DSTATCOM Configurations” 854 IEEE Transactions On Industrial Informatics, VOL. 10, NO. 2, May 2014.
[6]. D. Nair, M. Raveendran, A. Nambiar, N. P. Mohan and S. Sampath, "Mitigation of power quality issues using DSTATCOM," *2012 International Conference on Emerging Trends in Electrical Engineering and Energy Management (ICETEEEM)*, Chennai, 2012, pp. 65-69.
[7]. V. M. Awasth and V. A. Huchche, "Reactive power compensation using D-STATCOM," *2016 International Conference on Energy Efficient Technologies for Sustainability (ICEETS)*,Nagercoil, 2016, pp. 583-585.
[8]. A. Sode-Yome, N. Mithulananthan and K. Y. Lee, "A Comprehensive Comparison of FACTS Devices for Enhancing Static Voltage Stability," *2007 IEEE Power Engineering Society General Meeting*, Tampa, FL, 2007, pp. 1-8.
[9]. Mohammed BarghiLatran, AhmetTeke, YelizYoldaş “Mitigation of power quality problems using distribution static synchronous compensator a comprehensive review” ISSN 1755-4535,2015.
[10]. D. Nair, M. Raveendran, A. Nambiar, N. P. Mohan and S. Sampath, "Mitigation of power quality issues using DSTATCOM," *2012 International Conference on Emerging Trends in Electrical Engineering and Energy Management (ICETEEEM)*, Chennai, 2012, pp. 65-69.
[11]. Ambrish Chandra Bhim Singh, B. N. Singh,and Kamal Al-Haddad, “An Improved Control Algorithm of Shunt Active Filter for Voltage Regulation, Harmonic Elimination, Power-Factor Correction, and Balancing of Nonlinear Loads”, IEEE TRANSACTIONS ON POWER ELECTRONICS, VOL. 15, NO. 3, MAY 2000.
[12]. AnantNaik, UdaykumarYaragatti “Comparison of Three Popular Control Strategies Used in Shunt Active Power Filters” Asia Pacific Conference on Postgraduate Research in Microelectronics & Electronics (PRIMEASIA) 2012.
[13]. GunjanVarshney, D.S. Chauhan ,M.P. Dave “Performance Analysis of Photovoltaic based DSTATCOM using SRF and IRP Control Theory” 2015 1st International Conference on Next Generation Computing Technologies (NGCT-2015) Dehradun, India, 4-5 September 2015.
[14]. M. F. Shousha, S. A. Zaid and O. A. Mahgoub, "Better performance for shunt active power filters," 2011 International Conference on Clean Electrical Power (ICCEP), Ischia, 2011, pp. 56-62.
[15]. P.Rao, M.L.Crow and Z.Yang, "STATCOM control for power system voltage control applications," in IEEE Transactions on Power Delivery, vol. 15, no. 4, pp. 1311-1317, Oct.2000.
[16]. Y. Xu and F. Li, "Adaptive PI control of STATCOM for voltage regulation," 2014 IEEE PES General Meeting | Conference & Exposition, National Harbor, MD, 2014, pp. 1-1.
[17]. A. Ahirwar and A. Singh, "Performance of DSTATCOM control with Instantaneous Reactive Power Theory under ideal and polluted grid," 2016 Second International Innovative Applications of Computational Intelligence on Power, Energy and Controls with their Impact on Humanity (CIPECH), Ghaziabad, 2016, pp. 129-133.
[18]. P. Rao, M. L. Crow and Z. Yang, "STATCOM control for power system voltage control applications," in IEEE Transactions on Power Delivery, vol. 15, no. 4, pp. 1311-1317, Oct. 2000.
[19]. S. R. Arya, B. Singh, R. Niwas, A. Chandra and K. Al-Haddad, "Power quality enhancement using DSTATCOM in distributed power generation system," 2014 IEEE International Conference on Power Electronics, Drives and Energy Systems (PEDES), Mumbai, 2014, pp. 1-6.
[20]. A. Sode-Yome, N. Mithulananthan and K. Y. Lee, "A Comprehensive Comparison of FACTS Devices for Enhancing Static Voltage Stability," 2007 IEEE Power Engineering Society General Meeting, Tampa, FL, 2007, pp. 1-8.
[21]. N. Raveendra, V. Madhusudhan and A. J. Laxmi, "PI and fuzzy controlled D-STATCOM based on power quality theory," 2017 International Conference on Energy, Communication, Data Analytics and Soft Computing (ICECDS), Chennai, 2017, pp. 357-362