Novel Optimization-Based FACTS Devices for Improving the Power Quality in Electrical Distribution Systems

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Abstract- I recommend using the paper presents the DSTATCOM and distributed generation (DG) into real-time imbalance distributed network such that profile of network has been enhanced and loss of line and imbalance of voltages like swells and sag has been lowered. By utilizing random placing of DSTATCOM and DG into the network, it causes maximal line losses and higher voltage that might result in weak-bus & to choose Monarch butterfly-optimization (MBO) weak bus has been determined. Moreover, the bus at which MBO has been minimal is chosen to be weak-bus. Furthermore, this projected model IEEE 57 & 33 bus real imbalanced distribution network has been considered as a fundamental case, and analysis of load flow has been carried out by utilizing software called MATLAB. Once the injection of DSTATCOM and DG has been done by appropriate planning, then the profile of voltage has been enhanced and the imbalance of voltage and losses of the line has been lowered. The projected system feasibility has been assured with single DGs that consist of array-fed solar PV as input of DC for DSTATCOM. Furthermore, DSTATCOM based on DG has been injected into weak-bus & to choose weak-bus PVR (positive voltage-ratio) has been defined. Bus, at which PVR has been minimal, has been chosen to be weak-bus.

Keywords: DG (Distributed Generation), Optimization, Power Quality, DSTATCOM, Monarch Butterfly Optimization (MBO), IEEE 33 & 57 Bus system, photovoltaic (PV), Power distribution network (PDN), Distribution network operators (DNO), Positive Voltage Ratio (PVR).

1. Introduction

Two types of switches have been presented in distribution systems, which are sectionalizing and tie [1]. Furthermore, by modifying the status of the switch among feeders, distribution network architecture would be changed and is called to be reconfiguration. In this, the significant aim of reconfiguration has been to lower the losses, enhance the reliability as well as stability, enhance the profile of voltage, & enhance the load in the network of distribution. This distribution network reconfiguration concept has been initially projected by [2] in the year 1975. Power systems that are restructured using the distributed energy resources generation incorporating photovoltaic (PV)[3], wind turbines, fuel-cells, and many more have been playing a prominent part due to their several benefits. The distributed energy resources generation benefits incorporate lowering of power loss, enhancement of PV & augment the network reliability. To attain the DG unit's benefits, choosing optimum capacity and locations became a significant issue. Several models have been projected by researchers for identifying the optimum capacity and placement of the DG units. Also, these models have been based often on heuristic algorithms and artificial intelligence. The work [4] projected the HS (Harmony search) algorithm based on a new model for allocating the units of DG optimally in the Power network for reducing the power loss and improvement of PV. The DFACT (distributed flexible AC transmission-model) devices have been utilized in distribution networks with diversified applications & controlling models to enhance the quality indices of power. The UPFC, DSTATCOM & DVR [5] have been utilized extensively by the DFACT components. To identify the gilt-edge location & ability of DFACT components has been considered the effect in distribution networks. Moreover, some of the researchers have projected several models for identifying the DFACT unit size and optimum location. The work [6] depicted a novel model based on the firefly algorithm for placing the DSTATCOM optimally in the distribution network.

The work [12] projected an updated BO (butterfly optimization) version called greedy technique and cross-over self-adaptive base MBO. Moreover, in this scheme, 2 enhancements have been projected for optimal exploitation potential and exploration. The projected crossover operators and greedy have been enhanced prominently by their ability of global searching. This strategy has been tested on distinct standard functions, which performed better as in [12] - [14]. According to the knowledge of researchers, the strategy has not yet been implemented for solving the optimum DER experimental setup issues of the PDNs. Moreover, in this manuscript, the MBO strategy has been introduced for solving DGs based on simultaneous renewable and integration issues of photovoltaic (PV) for the distributed networks. To solve this issue, MBO has been validated through solving a contemporary DG combination issue and identified that MBO has been performed well when compared with contemporary optimization models. For exhibiting the PV site effectiveness and system performance size, several test cases have been solved and formulated. This comparison exhibits that PV needs to be placed optimally rather than combined at the site of DG.

Problem Formulation: Formulation of problem: At the time of delivery of power, loss of power occurs at several phases, where the maximal loss of power occurs in the distribution networks. It has been relatively high when compared with transmission networks. Hence, the reduction of power loss has been among the initial aims of DNOs. Moreover, handling nominal voltages of nodes has been one of the priorities. Also, the above-stated aims could be optimized when a controllable and effective energy source or the components have been present in networks of power. The optimum DGs based on RES control along with changeable distribution networks demand has been a challenging issue. At the time of hours of light load, high generation of renewable energy has the possibility of causing the reverse flow of power into the grid upstream. Therefore, reverse flow of power has been designed conventionally, the significant grid could be deliberated as an aim at the time of RES deployment. The aims of the projected work incorporate minimal several losses of power, deviation of voltage backward power flow into a grid optimum RES base setup of PV and DGs simultaneously.

2. Power Flow Equations

The following equations represent how power flows in a distribution network system

$$\begin{aligned} P_{k+1} &= P_k - P_{\text{loss},k} - P_{Lk+1} \\ &= P_k - \frac{R_k}{|V_k|^2}\left\{P_k^2 + \left(Q_k + Y_k|V_k|^2\right)^2\right\} - P_{Lk+1} \quad (1) \end{aligned}$$

$$\begin{aligned} Q_{k+1} &= Q_k - Q_{\text{loss},k} - Q_{Lk+1} \\ &= Q_k - \frac{X_k}{|V_k|^2}\left\{P_k^2 + \left(Q_k + Y_{k1}|V_k|^2\right)^2\right\} - Y_{k1}|V_k|^2 \\ &\quad - Y_{k2}|V_{k+1}|^2 - Q_{Lk+1} \end{aligned}$$

$$\begin{aligned} |V_{k+1}|^2 &= |V_k|^2 + \frac{R_k^2 + X_k^2}{|V_k|^2}\left(P_k^2 + Q_k^2\right) - 2\left(R_kP_k + X_kQ_k\right) \\ &= |V_k|^2 + \frac{R_k^2 + X_k^2}{|V_k|^2}\left(P_k^2 + \left(Q_k^2 + Y_k|V_k|^2\right)^2\right) \\ &\quad - 2\left(R_kP_k + X_k\left(Q_k + Y_k|V_k|^2\right)\right) \quad (2) \end{aligned}$$

Where

P_k : Useful Power flowing out from bus K

Q_k : Reactive power flow out from bus K

Y_k : shunt admittance at any bus k;

V_k : voltage amplitude at bus k.

Ploss,k : Actual power loss at bus k

Qloss,k :Reactive power loss at bus k

P_{Lk+1} : Real load power at bus k + 1

Q_{Lk+1} : Reactive load power at bus k + 1

R_k : Line section Resistance between buses k and k + 1

X_k : Line section Reactance between buses k and k + 1

The flow of load across general 2-port network interconnects buses j and I by a line of transmission has been exhibited in below fig1. Moreover, the below equations exhibit the network, which is under constant condition. The reactive and active power from bus i to j (P_{ij} & Q_{ij}) and j to i (P_{ji}& Q_{ji}) has been depicted in the following:

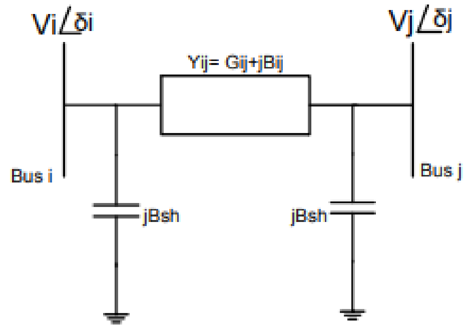

Fig.1. Two bus representations of the power system

$$P_{ij} = V_i^2 G_{ij} + V_iV_j(B_{ij}\sin\delta_{ji} - G_{ij}\cos\delta_{ji}) \quad (3)$$

$$Q_{ij} = -V_i^2(B_{ij} + B_{sh}) + V_iV_j(B_{ij}\cos\delta_{ji} + G_{ij}\sin\delta_{ji}) \quad (4)$$

$$P_{ji} = V_j^2 G_{ij} - V_iV_j(G_{ij}\cos\delta_{ji} + B_{ji}\sin\delta_{ji}) \quad (5)$$

$$Q_{ji} = -V_j^2(B_{ij} + B_{sh}) + V_iV_j(B_{ij}\cos\delta_{ji} - G_{ij}\sin\delta_{ji}) \quad (6)$$

Where

$$\delta_{ji} = \delta_j - \delta_i = -\delta_{ij} \quad (7)$$

The equation of power flow from 3-4 incorporates solving non-linear equations of algebraic sets. The reactive and active power has been a function of the magnitude of bus voltage V, angle (δ), susceptance (B), and transmission-conductance (G). The analysis of load flow has been performed with the assistance of MATLAB for solving this algebraic equation in a non-linear way. From eq, susceptance acts as a prominent part in enhancing the power flow of active and reactive in the bus. This DG design with the DSTATCOM deliberates the value of susceptance and depending on that, it might be either a power sink or power source. There could be an opportunity while it has been linked and having none of the power exchange.

P=f (V, B, G, δ) Q=g (V, B, G, δ)

3. Identification of Weak Bus

For distribution and transmission in the voltage stability of power system becomes an intricate issue due to some of the facts & these facts were:

- The heavy power transfer among some linked regions.
- Demand has been increasing continuously.
- The economic and environmental restriction results in an investment.
- The RES injection becomes maximum in both distribution and transmission systems.

When transmission line loading is enhanced, then it could be related to breakdown issues of voltage in the system of power and such conditions would be raised when the power of reactive supply has been not adequate and power transmission over the long-distances. The breakdown of voltage occurred because of their uncontrollable levels of voltage in the system, which causes the blackouts. Moreover, in this projected model IEEE 57 bus real imbalanced distribution system has been considered as base-case that has been exhibited in fig-2. Also, this imbalanced distribution network comprises several stages, which are single, 2, and 3 stages. When DGs have been randomly injected in any bus causing over-voltage, maximum losses of line fail the system. For enhancing the profile of voltage and minimal losses of across-line and imbalance of voltage, some of the weak-bus has been chosen for the injection of DG. For bus selection in this model, 3 aspects have been deliberated: breakdown of voltage, no voltage of load, and the ratio of positive voltage. The ratio of positive voltage has been voltage breakdown ratio towards none voltage of the load. Equation 8 depicts PVR's mathematical form.

$$PVR = V_b / V_0 \quad (8)$$

The notations V_b depict voltage breakdown as well V0 depict no voltage of the load. The PVR equation has been identified for every bus. Bus, at which PVR has been low, where the bus has been deliberated as DG and weak-bus would be injected at bus weak only such that profile of voltage has been enhanced, reduced of line-loss and imbalance of voltage has been lowered.

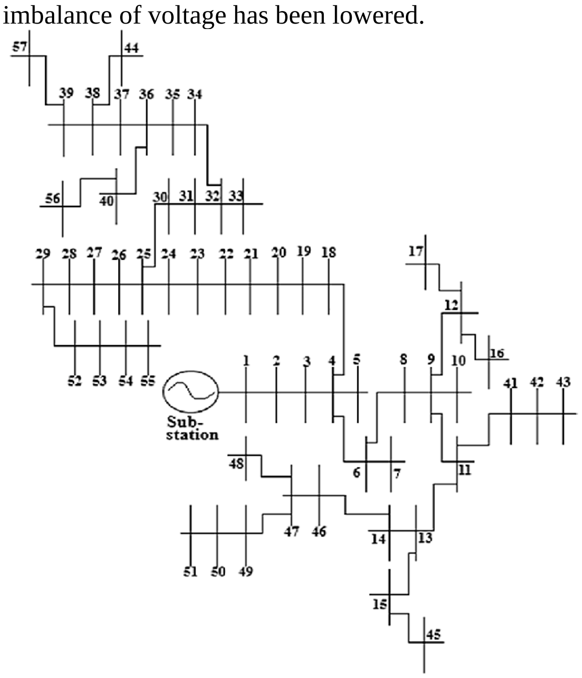

Fig 2: IEEE 57 Bus Radial Distribution Systems

4. Distributed Generation

Currently, enhancing electricity demand all over the world might result in a prominent fascination towards DG. The sources of alternative energy, which has been DG depending on energy sources that are renewable such as wind energy, sources of solar energy, and photo-voltaic. Moreover, these sources of energy were now present to a huge extent such that they could be available easily. DG is having numerous benefits, which means that it could not produce any type of pollution, harmful gases. At that time, when there is an increase in the electricity demands, DG also assists in offering power backup. The DG injection in network distribution has been adaptable and it assists in enhancing the profile of voltage, lowering the line losses & imbalance of voltage that also lowers the number of voltage regulators and capacitors in the network. To attain maximal advantage from DG appropriate planning has been required for placement of DG in real-imbalance network distribution.

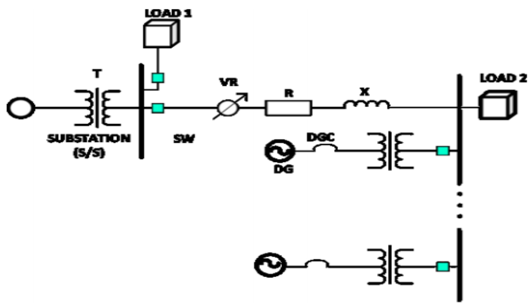

Fig 3: Modeling of DG with the distribution system

DSTATCOM

In a distribution network, DSTATCOM indicates a static compensator, which is a fixed synchronous compensator such as a shunt component, which controls the voltage system by taking off to and fro reactive power assistance significantly. The DSTATCOM consists of a voltage source converter (VSC), a coupling reactor set, and a controller as shown in figure 4. It has a unique function of voltage control of the bus by absorbing or generating reactive powers towards the network. Variance in voltage among this reactance would lead to reactive and active movement all over the power system and DSTATCOM. The issue of voltage quality becomes a concern when at a common point of coupling. DSTATCOM has been related to the network of power. For voltages and currents comparison regarding signal reference, voltage and current measurement have been needed that has been fed into the controller. Also, feedback control has been performed then by the controller & produces the outcome as a set of switching signals in respect to operating the converter's power.

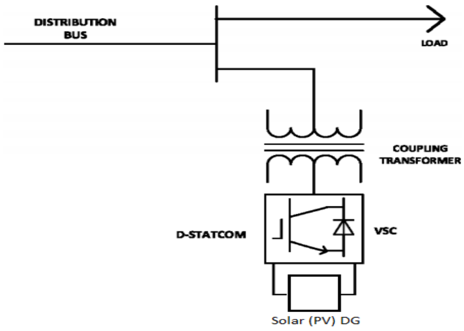

Fig 4: DG based DSTATCOM connected with IEEE 33 & 57 distribution bus

5. Monarch Butterfly Optimization (MBO)

The MBO strategy has been proposed by and inspired by monarch butterflies immigration behaviors of north-America [12]. This monarch swarm emigrates the butterfly from territory 1-2 in April month & territory 2-1 in September month. At the time of emigration, they place generating offspring that substitute their parents in swarms. Also, this MBO model comprises 2 updated operators called butterfly adjustment and migration operator. This model keeps operating until the criteria of operation have been attained. This model has been projected on various standard functions. Moreover, it has been perceived that the standard MBO version exhibits some technical confines such as average fitness and standard deviation, for intricate standard functions as [13]. To overcome such limitations, the author proposed an improved BO version called MBO. To update basic BO, MBO has been deployed into 2 operators. Initially, it projected an enhanced operator of a crossover called SAC (Self-adaptive crossover-operator) for combining the operator of the butterfly adjustment, for enhancing the monarch flutter diversity mainly at the time of search ultimate level. SAC could be utilized to swarm complete information effectively. Next, the greedy operator has been implanted by an objective for accepting such offspring that has an effective solution when compared with parents.

5.1 Migration operators

The monarch swarm population in subpopulation 1 (NP1), Territory 1 has been determined to be ceil (pr*NP). Identically, for the second territory, 2 (NP2) subpopulations could be computed in the form of NP-NP1. Further, NP has been an amount of overall monarch population of butterflies in both areas, pr has been the monarch butterfly ratio in the first territory towards the overall population. Also, the mathematical architecture of the immigration procedure has been formulated in the following way:

$$Z_{x,k}^{t+1} = Z^t_{r1,k} \tag{9}$$

Where, the notation Zx,kt+1 depicts Zx of the Kth component in production t+1 iteration. Simultaneously, Kt, Z_{rl} depicts Z_{rl} kt component for current generation t. Also, rl has chosen the butterfly randomly from the NP1(subpopulation1). When $r \leq pr$, then Z_x,kt+1 value has been determined by the (9) or else (11). r value has been determined in the form of

$$r = rand*pari \tag{10}$$

Pari has been a migration operator usually equivalent to 1.2 as in [11] & rand has been termed to be random-number.

$$Z_{x,k}^{t+1} = Z^t_{r2,k} \tag{11}$$

5.2 Butterfly adjustment operator (BAO)

The remaining butterfly components have been upgraded by the BAO. When the generated value in random is lower than pr, then the Zy,kt+1 has been upgraded by (12) or else (13).

$$Z_{y,k}^{t+1} = Z^t_{best,k} \tag{12}$$

The notation Zy,kt+1 depicts the Zy component of kth in t+1 generation. Identically, kt, Zbest depicts the kth device of suitable butterfly Zbest for current t generation.

$$Z_{y,k}^{t+1} = Z^t_{r3,k} \tag{13}$$

$$Z_{y,k}^{t+1} = Z_{y,k}^{t=1} + \alpha\,(dZ_k - 0.5) \tag{14}$$

In the eq (14), BAR depicts the butterfly adjustment rate & Zd has been the step size of butterfly walk y, which could be produced by dZ=levy (Z_y^t) Levy flight. Moreover, α has been weighting aspect, defined to be

$$\alpha = W_{max}/t^2 \tag{15}$$

5.3 The Basic Steps of MBO

Step 1: Prepare random but adaptable monarch swarm population of butterfly NP, further then segment into NP2, NP1 and set the aspects of the algorithm like BAR, the maximal amount of iterations, Wmax.

Step 2: Compute every monarch butterfly fitness value individual population.

Step 3: arrange the individual butterflies as per their values of fitness and segment them into 2 populations NP1 & NP2 for territories 1 & 2 in respective order.

Step 4: Territory 1 population NP1 generates offspring through modified migration through greedy operators. Identically, territory 2 population NP2 generates novel generation by changing the operator of adjusting butterfly algorithms with greedy and adaptive crossover scheme operators.

Step 5: implement a correction algorithm for correcting impossible individuals' butterflies, when any.

Step 6: upgrade the effective individual butterfly when a better individual is identified.

Step 8: Iterate steps 2-6 until the maximal amount of stopping criteria or iterations has been achieved.

5.4 Optimal Deployment & Management of PV DSTATCOM By Using MBO

The projected DSTATCOM and DGs integration issues have been formulated in the form of non-convex, non-linear, bi-level, and mixed-integer optimization issues. The issue has several variables that have been optimized in 2 phases. DER variables planning in level-1 have been optimized like nodes of DER and their sizes. Individual butterfly architecture has been utilized in these levels as shown in fig 1. Moreover, it comprises the DER node's information and their corresponding sizes. The operational variables for every hour have been optimized in level 2, as it incorporates optimum BESS dispatch and DG(RESS)[19] is shown in fig 5. This level outcome has been forwarded back towards level 1 at every level 1 iteration.

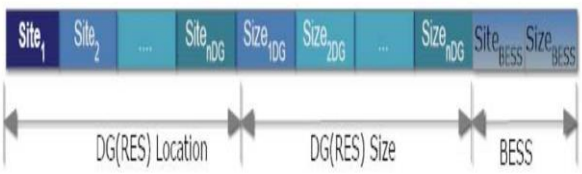

Fig 5: The structure of individuals used in MBO for DG's and BESS[20] deployment (Level-1).

The section comprises MBO implementation in RES-based DG's for optimal management and deployment [23].

6. Result and Discussion

Load flow has been performed when only 1 source of generator has been interconnected towards 1st bus & profile of voltage amplitude has been cataloged that is exhibited in the figure.6 and identified overall 5 buses such as 29, 30, 31, 32, as well as 33, which are under the range of voltage as per the standard of Indian, where bus 33 number has been the weakest bus & some of the buses were at the crucial circumstance. For enhancing the magnitude of voltage, we linked DG by the DSTATCOM for the bus & noticed that the magnitude profile of voltage has been enhanced while it has been connected with bus 13 as exhibited in fig 6. This DSTATCOM has been located at every location of the bus and dynamic generation of power in Pu & generation of reactive power in the Pu has been recorded with the assistance of MATLAB flow features. As per MBO, bus no 12 has been an optimal location for the DSTATCOM & per MBO.

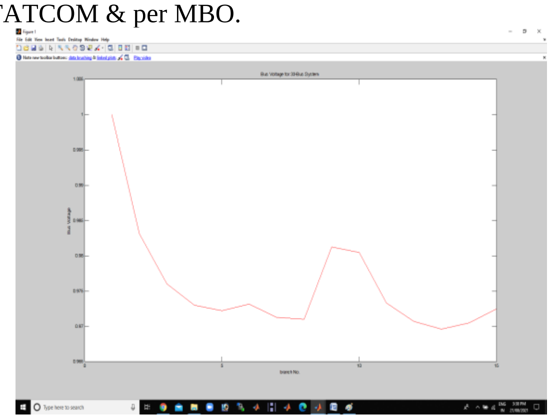

Fig 6 :voltage magnitude profile of 33 bus system with MBO

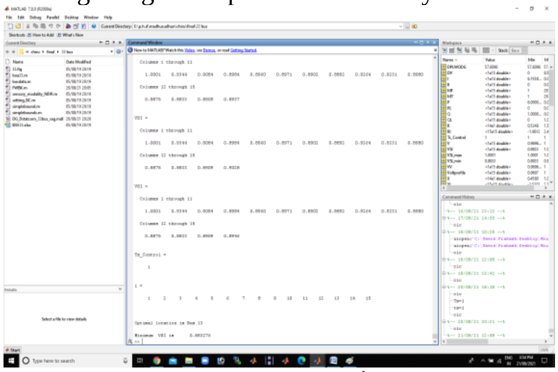

Fig 7: For IEEE 33 bus system 13th bus is the optimal location traced by MBO

Table I. Power Flow Comparıson Wıth D-Statcom And Wıthout D-Statcom Connectıon

Bus no.(i-j)	*Power flow without compensator*				*Power flow with compensator at 13th bus*			
	P_{ij}(p.u.)	Q_{ij}(p.u.)	P_{ji}(p.u.)	Q_{ji}(p.u.)	P_{ij}(p.u.)	Q_{ij}(p.u.)	P_{ji}(p.u.)	Q_{ji}(p.u.)
1-2	0.03911	-0.00511	0.03899	-0.00417	0.04131	-0.01942	0.04116	-0.01850
2-3	0.03437	-0.00242	0.03389	-0.00169	0.03654	-0.01675	0.03589	-0.01610
3-4	0.02357	-0.00382	0.02340	-0.00295	0.02557	-0.01821	0.02527	-0.01740
4-5	0.02220	-0.00375	0.02203	-0.00288	0.02407	-0.01820	0.02378	-0.01739
5-6	0.02143	-0.00318	0.02109	-0.00255	0.02318	-0.01769	0.02259	-0.01725
6-7	0.01106	-0.00539	0.01103	-0.00456	0.01256	-0.01987	0.01247	-0.01921
7-8	0.00903	-0.00556	0.00896	-0.00467	0.01047	-0.02021	0.01017	-0.01936
8-9	0.00696	-0.00567	0.00689	-0.00481	0.00817	-0.02036	0.00776	-0.01969
9-10	0.00629	-0.00501	0.00624	-0.00415	0.00716	-0.01989	0.00677	-0.01919
10-11	0.00564	-0.00435	0.00563	-0.00346	0.00617	-0.01939	0.00611	-0.01844
11-12	0.00518	-0.00376	0.00516	-0.00287	0.00566	-0.01874	0.00554	-0.01780
12-13	0.00456	-0.00322	0.00453	-0.00235	0.00494	-0.01815	0.00453	-0.01749
13-14	0.00393	-0.00270	0.00392	-0.00183	0.00393	-0.00327	0.00392	-0.00228
14-15	0.00272	-0.00263	0.00271	-0.00175	0.00272	-0.00308	0.00271	-0.00209
15-16	0.00211	-0.00185	0.00210	-0.00096	0.00211	-0.00219	0.00210	-0.00119
16-17	0.00150	-0.00116	0.00150	-0.00028	0.00150	-0.00139	0.00150	-0.00040
17-18	0.00090	-0.00048	0.00090	0.00040	0.00090	-0.00060	0.00090	0.00040
18-19	0.00361	-0.00136	0.00362	-0.00235	0.00361	-0.00136	0.00362	-0.00235
19-20	0.00271	-0.00176	0.00270	-0.00078	0.00271	-0.00176	0.00270	-0.00078
20-21	0.00180	-0.00118	0.00180	-0.00019	0.00180	-0.00118	0.00180	-0.00019
21-22	0.00090	-0.00059	0.00090	0.00040	0.00090	-0.00059	0.00090	0.00040
22-23	0.00941	0.00173	0.00938	0.00267	0.00941	0.00171	0.00938	0.00266
23-24	0.00848	0.00217	0.00842	0.00307	0.00848	0.00216	0.00842	0.00307
24-25	0.00422	0.00107	0.00420	0.00200	0.00422	0.00107	0.00420	0.00200
25-26	0.00942	0.00355	0.00944	0.00265	0.00941	0.00335	0.00943	0.00242
26-27	0.00882	0.00330	0.00880	0.00420	0.00881	0.00310	0.00879	0.00403
27-28	0.00820	0.00395	0.00811	0.00477	0.00819	0.00378	0.00811	0.00463
28-29	0.00751	0.00457	0.00745	0.00540	0.00751	0.00443	0.00745	0.00529
29-30	0.00625	0.00470	0.00622	0.00555	0.00625	0.00459	0.00622	0.00547
30-31	0.00422	-0.00045	0.00420	0.00039	0.00422	-0.00053	0.00420	0.00034
31-32	0.00270	-0.00031	0.00270	0.00055	0.00270	-0.00036	0.00270	0.00052
32-33	0.00060	-0.00045	0.00060	0.00040	0.00060	-0.00048	0.00060	0.00040

In the table it is observed for IEEE 33 bus system 13^{th} bus is the optimal location traced by MBO

To enhance the magnitude of voltage, in 57 bus systems of IEEE we linked MBO towards the bus and noticed that, profile magnitude of voltage has been more enhanced while linked at bus 30 as exhibited in fig 8. This DSTATCOM has been located at every location of the bus and dynamic generation of power in Pu & generation of reactive power in the Pu has been cataloged with the assistance of MATLAB flow features. Appropriate usage of DSTATCOM has been understood by the entire generation of power. According to MBO, being under MBO 30th, bus no 12 is a gilt-edge location for DSTATCOM. Therefore, compensator placement will be either 30th or 31^{st} bus. The accurate usage of DSTATCOM can be measured by universally generated power in the system. It is traced in MBO that projects the real improvement and reactive power flows. This data is observed when DSTATCOM is situated at the 30th bus with the support of the extension of power flow in MATLAB.

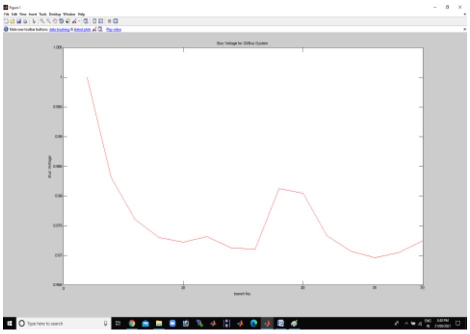

Fig.8: voltage magnitude profile of 57 bus system with MBO

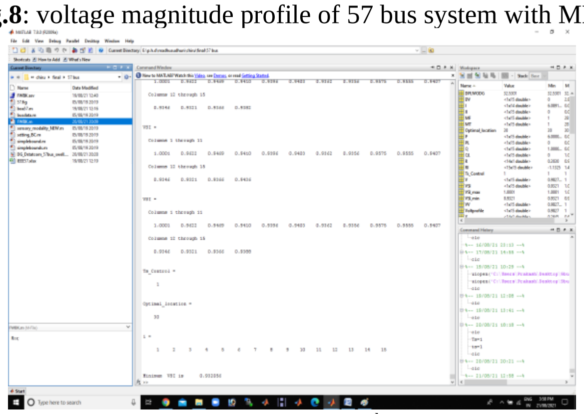

Fig 9: For IEEE 57 bus system 30^{th} bus is the optimal location traced by MBO

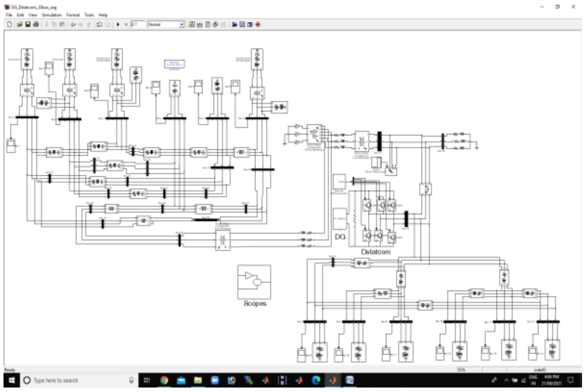

Fig 10: A simulation model of IEEE 33 Bus system with DG connected DSTATCOM

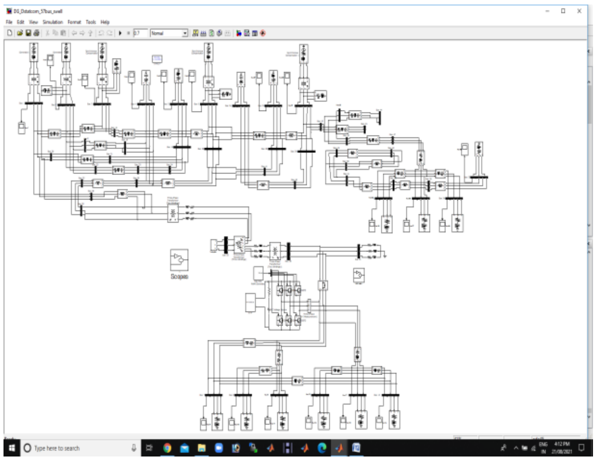

Fig 11: A simulation model of IEEE 57 Bus system with DG connected DSTATCOM

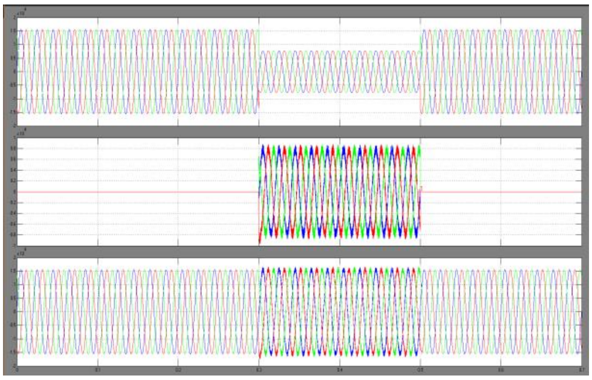

Fig 12: Voltage profile (Vabc): Sag voltage, DG based DSTATCOM injected voltage, Compensated Voltage at load

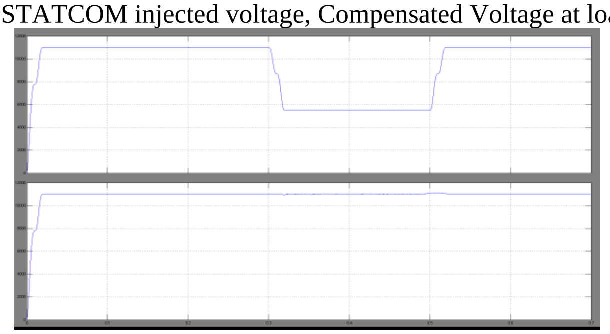

Fig 13: Voltage profile (Vrms): Before & After compensation (Sag)

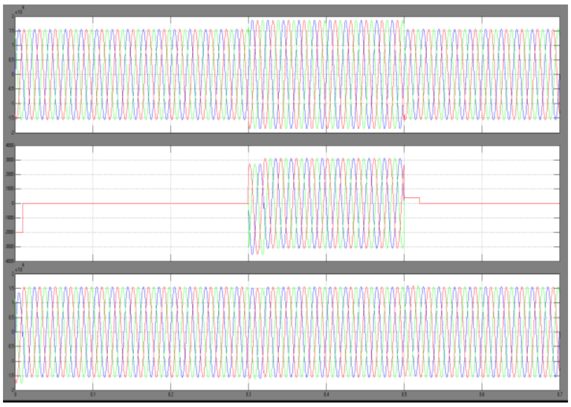

Fig 14: Voltage profile (Vabc): Swell voltage, DG based DSTATCOM injected voltage, Compensated Voltage at load

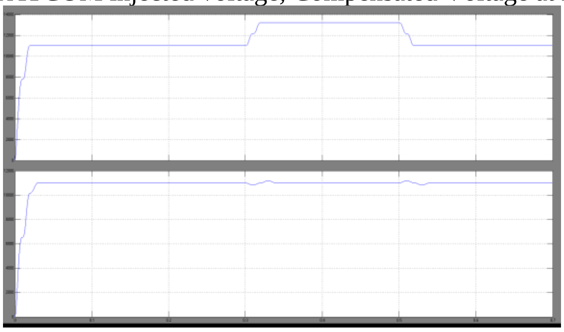

Fig 15: Voltage profile (Vrms): Before & After compensation (Swell)

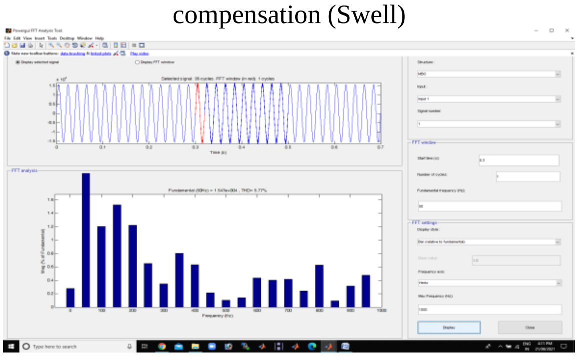

Fig 16: Total harmonic distortion of DG connected DSTATCOM i,e. T.H.D = 5.77%

Table 2 Simulation Parameters Used in DG based DSTATCOM Configuration

Configuration	parameters	Notation Value
Supply voltage	vs	230V (rms)/phase
DC link voltage as reference	vdc(ref)	600V DC
P- controller	Kpa	0.01
DC link capacitor	Cdc	2000µF
Inductance of Compensator	Lc	1.5mH
System frequency	fs	50Hz
Resistance at Source	Rs	0.5Ω
Inductance at Load	Ll	20mH
Compensator resistance	Rc	0.25Ω
Inductance at Source	Ls	2mH
Load resistance	Rl	10Ω
I-controller at DC side	Kia	0.05
I-controller at AC side	Kir	1.1
P-controller at AC	Kpr	0.2
P-controller at DC	Kpa	0.01

Table 3. Obtained comparative results by using the MB Optimization technique

Optimal size and location of DG	359.4 kW at bus 8 2250.7 at bus 57
Optimal size and location of D-STATCOM	692.1 kVAr at bus 8 1079.8 kVAr at bus 57
Loss reduction (%)	89.88
Optimum power loss (kW)	31.94

CONCLUSION

In this paper, the new technology was introduced as a Monarch Butterfly Algorithm which will be observed as the best algorithm that gives one of the good results when with that of heuristic algorithms currently used in the classification of OPF on IEEE 33& 57-bus test system. All the possible optimal locations are verified by the new MBO algorithm and found to be a very perfect algorithm. At the 13^{th} bus, the possible optimal location is traced and confirmed and similarly for IEEE 57 bus system the optimal place for installing the DG base designed DSTATCOM is at the 30^{th} bus. The DG base designed DSTATCOM will work on the real unbalanced distribution network which causes the performance improvement accurately. This method has successfully done before introducing DG & DSTATCOM involvement in a distribution network to get the accurate efficiency which will improve the performance of the network. DG and DSTATCOM injection at weak buses cause ratio of PVR is going to be minimized. At the stage of loaded condition, the voltage amplitude and phase sequence are different and it is treated as the unbalanced voltage condition which will occur in real-time distributed systems. In this case, the proposed system is more beneficial to the real-time distributed network. So in this paper, the proposed algorithm for an IEEE 33 & 57 bus practical imbalanced Power network is considered as a base case & the analysis of the load flow concept is designed and developed by using MATLAB software. It is also concluded after injecting DG and DSTATCOM by suitable arrangement, that voltage performance is improved and voltage disturbances like sag & swell, Vrms, line losses are reduced considerably. The value of the total harmonic distortion is also minimized up to 5.77%

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