JOURNAL OF SCIENTIFIC, TECHNOLOGY AND ENGINEERING RESEARCH
Bilim, Teknoloji ve Mühendislik Araştırmaları Dergisi, (2021) - 2(1): 32-45
ISSN : 2717-8404 *https://dergipark.org.tr/tr/pub/jster*

RESEARCH ARTICLE

DSTATCOM Based on Artificial Neural Networks and Particle Swarm Optimization for Voltage Profile Improvement

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HIGHLIGHTS

- *The distribution static synchronous compensator (DSTATCOM) is used with a developed control strategy*

GRAPHICAL ABSTRACT

The configuration parameters of DSTATCOM connected on power grid is shown in Figure A. the real and reactive power of DSTATCOM controlled by the inverter voltage magnitude V_c and the angle α difference between the bus voltage and the output voltage of the inverter. The controller of DSTATCOM is

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Keywords:

- DSTATCOM,
- Artificial Neural Networks,
- PI controller,
- Power Quality,
- Voltage Profile

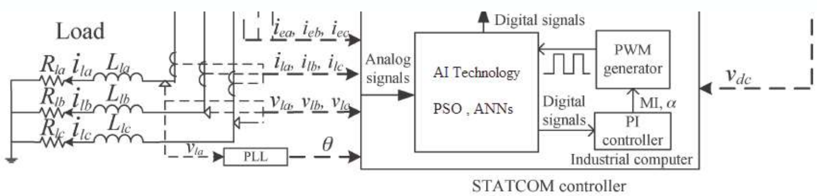

Figure A. DSTATCOM Configuration connected on power system

Article Info:

Received : 28.03.2021
Accepted : 07.05.2021
Published : 21.06.2021

DOI: 10.5281/zenodo.4742866

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- **Aim of Article:** *This study aims to design a DSTATCOM controller based on artificial intelligent (AI) techniques.*

Theory and Methodology: *The designed system is a controller based on artificial intelligent techniques. The proposed controller improves the voltage profile and eliminate the harmonic in the system as well as enhance the power quality.*

Findings and Results: *With the designed controller shown in Figure A, the efficient of using AI technique for tuning PI controller of DSTATCOM in order to improve the voltage profile on distribution system. The DSTATCOM with developed controller validated the importance of AI methods.*

Conclusion : *Using the proposed controller increase stability and reliability of power system and hence the network converts to smart network. The simulation results proved the efficient of suggested method for controlling DSTATCOM in order to improve voltage profile on distribution system.*

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Citation:

Zaro, F. Rashed, (2021). *DSTATCOM Based on Artificial Neural Networks and Particle Swarm Optimization for Voltage Profile Improvement,* Journal of Scientific Technology and Engineering Research, 2(1): 32-45. DOI**:** 10.5281/zenodo.4742866

Retracted

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PQ issue is voltage profile improvement with acceptable voltage harmonic distortion. It should be regulated to be within acceptable standard levels. In order to improve the voltage profile, the distribution static synchronous compensator (DSTATCOM) is used with a developed control strategy. In this research, DSTATCOM control is developed based on artificial intelligent (AI) using the artificial neural network (ANN), which depends on optimum values obtained by using particle swarm optimization (PSO). The results of the simulation proved the superiority and robustness of the proposed control strategy of DSTATCOM for improving the voltage profile on the distribution system. The validation of results has been done by MATLAB/Simulink software package.

Keywords: *DSTATCOM, Artificial Neural Networks, PI controller, Power Quality, Voltage Profile*

I. INTRODUCTION

The rapid increase in electrical power demand leads emerging use of renewable energy sources (RES) and distributed generations (DGs) in electrical grid. Emerging new resources of energy into the grid and connecting different types of loads such as nonlinear loads create different problems appears in current, voltage and/or frequency which causes error and malfunction of instrument and generally consider as power quality (PQ) problems [1].

Several studies are done regarding PQ issues using the benefits of huge developments in power electronics technologies, hence the network change from traditional network to smart network. Also, PQ may define as electrical constraints that allows an equipment function properly with high performance. According to these definitions of PQ, poor PQ will affect badly on the reliability and stability of electrical network as well as on sensitive loads connected to the end user of distribution bus. PQ is relating to the three main factors: voltage, current and frequency, all these factors should be remaining within their standard limits [2].

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The problems of PQ in the network caused by different reasons such as connecting nonlinear loads especially large motors in industrial applications, power electronics devices, switching capacitor banks and connected new electrical resources to the grid. Indeed, these disturbances effect on the performance and functionality of both distribution system and sensitive equipment. The smart grid (SG) technology opens a wide range for solving PQ problems. Family related to power electronics technologies called flexible alternating current transmission systems (FACTs) support SG system and provide solutions for PQ challenges. One application of FACTs family is called distribution static synchronous compensator (DSTATCOM), which is a shunt device connected with distribution bus. One of the main aspects of power system is voltage var control, so the voltage var

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system, unbalance conditions in the systems that caused by unbalanced loading and change the load and symmetrical and unsymmetrical faults, real and reactive power losses according to presence harmonic distortion low power factor (PF). Several FACTs devices are used to mitigate these PQ issues. Different control strategies used in DSTATCOM are sensitive to non-ideal supply conditions and load variation which needed careful design tuning controller for each specific insulation. Also, the cost of the system increases due to use special devices such as LCL filter. Other control strategies of DSTATCOM in literature needed complex control facilities and controllers, also needed additional supplementary components such as active filter. In addition, the controller may need additional delay time due the conversion from analogue to digital [4-5].

On the other side new proposed control strategies for DSTATCOM are implemented such as adaline based algorithm and direct method which depends mainly on position and magnitude control of output voltage. Although these methods are validated as efficient methods for controlling DSTATCOM, they are complex and expensive comparing with traditional methods. Different mathematical theories and physical models are used in analysis and implementing different control strategies of DSTATCOM. Instantaneous power theory, rotating reference frame (dq0), stationary reference frame, instantaneous reactive power (IRP) and Park's transformation are used to simplify the dynamic system equations [6-7].

Significant research has been concerned with FACTs devices and smart control compatible with renewable energy resources. Existing RES and DGs in power system create different challenges especially when these resources with high penetration levels. To deal with these challenges a SG technology is vital to manage the power flow generated by grid. Power generated from RES and the compensation power generated or absorbed by FACTs devices. Using SG technology leads to increase the reliability and stability

using ANNs as a technique for tuning controller of DSTATCOM, which its controller constants is selected optimally using PSO [14-17].

This paper introduces an AI technique specifically PSO and ANN used for design controller of DSTATCOM to enhance the profile of voltage on distribution electrical power system. section II introduces DSTATCOM configuration and design. Mathematical model of the proposed system is presented in Section III. In section IV the developed AI techniques and proposed optimization method are presented in details for constructing the developed controller for DSTATCOM. Section V presents the methodology which include the description of real distribution system as a case study. The simulation results of the proposed scenarios in this study and detailed discussion of all results for voltage events like sag and swell are showed in Section VI. Finally, the performance and efficiency and superiority of the proposed approach are summarized in section VII.

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II. DSTATCOM CONFIGURATION AND DESIGN

A. Principle and Operation of DSTATCOM

The circuit diagram of the equivalent model of DSTATCOM is shown in Fig.1 [6].

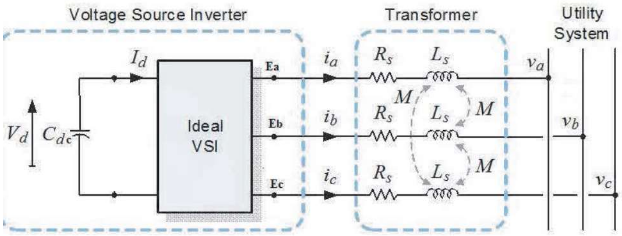

Figure 1: Equivalent model of DSTATCOM.

V_{out}: output voltage of the converter

I_{ac}: ac current flows through the reactance between the converter and ac system

The operation of DSTATCOM is summarized by three modes:

1. *Mode1*: when the output voltage V_{out} amplitude is greater than of the voltage of utility bus V_{ac}, in this condition the current flows from the converter to AC side of power system through the reactance and the DSTATCOM injects reactive power into the AC side of power system.
2. *Mode2*: when the V_{out} amplitude is less than of voltage at the utility bus, under this situation the current flows from the AC side of power system to the converter, DSTATCOM absorbs

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used in this study:

1. Square wave 48-step voltage waveform of four three level inverters is made using gate turn-off thyristor, on the other hand, to eliminate harmonics from the output voltage waveform special inter connection transformers are used.
2. PWM is used to convert DC input voltage to AC output voltage sinusoidal waveform, this inverter uses isolated gate bipolar transistor (IGBT).

The converter is connected to high voltage side of power system through the coupling shunt transformer. Fig. 2 shows the single line diagram of the simplified equivalent circuit of STATCOM.

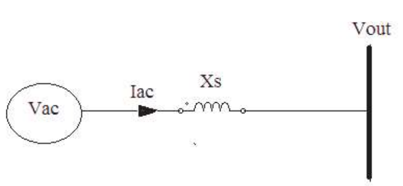

Figure 2: Equivalent circuit of DSTATCOM.

Where:

V_{ac}: ac voltage of the system

DSTATCOM to inject the required reactive current to the load. Fig. 3 shows the simplified scheme of control strategy of DSTATCOM [8].

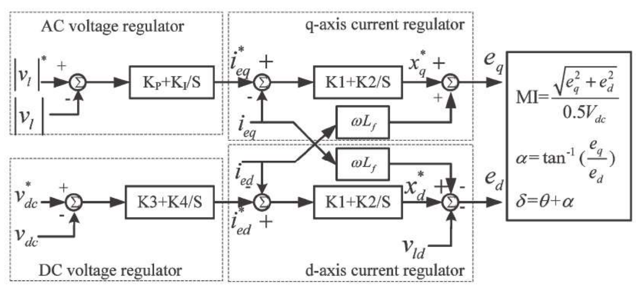

Figure 3: control strategy scheme of DSTATCOM

According to modulation index (MI) and phase angel α between the inverter voltage and line voltage PWM controls the output voltages for VSI. The PI controller of DSTATCOM controls the generating/absorbing the desired reactive power at the common coupling point in power system [11]. The goal of such control is to maintain constant voltage magnitude at PCC under system disturbances. Fig. 4 shows the controller input is an error signal which is the difference between the RMS reference voltage (1pu) and the RMS value of the

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terminal voltage measured. The PI controller process the error signal and generate the required drive angle to minimize the error to zero [15].

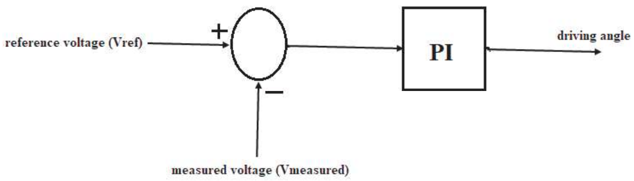

Figure 4: Direct PI control of DSTATCOM

III. MATHEMATICAL MODEL OF PROPOSED DSTATCOM

The study of control strategy of DSTATCOM is according to the simplified mathematical formulas because of DSTATCOM has nonlinear operation

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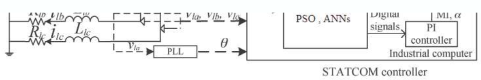

Figure 5: DSTATCOM Configuration connected on power system.

The real and reactive power of DSTATCOM controlled by the inverter voltage magnitude Vc and the angle α difference between the bus voltage and the output voltage of the inverter. The active and reactive power compensation of DSTATCOM is described by the equations (1) & (2), respectively [10]:

$$P = \frac{V_{Pcc} V_C \sin\alpha}{X} \tag{1}$$

$$Q = \frac{V_{Pcc}(V_{Pcc} - V_C \cos\alpha)}{X} \tag{2}$$

Where:

P: active Power.
Q: reactive Power
V_c: inverter Voltage
V_{pcc}: voltage at the point of common coupling
α: angle of V_{pcc} with respect to V_c
X: reactance of the branch and the transformer.

The controller of DSTATCOM is designed due to the dynamic equations of the system and according to the consideration that the system is linear system [8].

A. Load Model Mathematical Equations

As shown in Fig. 5 due to the explained configuration of the system, the three phase load voltages coordinates may written as:

$$\begin{pmatrix} V_{la} \\ V_{lb} \\ V_{lc} \end{pmatrix} = R_l \begin{pmatrix} i_{la} \\ i_{lb} \\ i_{lc} \end{pmatrix} + L_l \begin{pmatrix} i_{la} \\ i_{lb} \\ i_{lc} \end{pmatrix} \tag{3}$$

The rotating reference frame is described by

$$\begin{pmatrix} V_{ld} \\ V_{lq} \end{pmatrix} = R_l \begin{pmatrix} i_{ld} \\ i_{lq} \end{pmatrix} + L_l \frac{d}{dt} \begin{pmatrix} i_{ld} \\ i_{lq} \end{pmatrix} + L_l \begin{pmatrix} 0 & -w \\ w & 0 \end{pmatrix} \begin{pmatrix} i_{ld} \\ i_{lq} \end{pmatrix} \tag{5}$$

Where $\theta = \tan^{-1} \frac{V_{lq}}{V_{ld}}$

B. VSI AC-Side Model

The source voltage Vs and the inverter output voltage can be written as: respectively [23].

$$\begin{pmatrix} V_{sa} \\ V_{sb} \\ V_{sc} \end{pmatrix} = \frac{a_1}{L_l} \begin{pmatrix} i_{sa} \\ i_{sb} \\ i_{sc} \end{pmatrix} \frac{b_1}{L_l} \frac{d}{dt} \begin{pmatrix} i_{ea} \\ i_{eb} \\ i_{ec} \end{pmatrix} \frac{c_1}{L_l} \begin{pmatrix} i_{ea} \\ i_{eb} \\ i_{ec} \end{pmatrix} \frac{d_1}{L_l} \begin{pmatrix} e_a \\ e_b \\ e_c \end{pmatrix} \tag{6}$$

$$\begin{pmatrix} e_a \\ e_b \\ e_c \end{pmatrix} = \frac{a_2}{L_l} \begin{pmatrix} i_{sa} \\ i_{sb} \\ i_{sc} \end{pmatrix} + \frac{b_2}{L_l} \frac{d}{dt} \begin{pmatrix} i_{sa} \\ i_{sb} \\ i_{sc} \end{pmatrix} + \frac{c_2}{L_l} \begin{pmatrix} i_{ea} \\ i_{eb} \\ i_{ec} \end{pmatrix} + \frac{d_2}{L_l} \begin{pmatrix} V_{sa} \\ V_{sb} \\ V_{sc} \end{pmatrix} \tag{7}$$

where:

$$a_1 = (R_s L_l - R_l L_s)$$
$$b_1 = -(L_s L_f + L_s L_l + L_l L_f)$$
$$c_1 = -(R_f L_s + R_l L_s + R_f L_l)$$
$$d_1 = (L_s + L_l)$$

$$a_2 = -\left(R_s L_f + R_l L_f + R_s L_l\right)$$
$$b_2 = -(L_s L_f + L_l L_f + L_s L_l)$$
$$c_2 = \left(R_f L_l - R_l L_f\right)$$
$$d_2 = (L_f + L_l)$$

C. VSI DC-Side Model Equations

The power balance equation for VSI can be expressed as:

$$V_{dc} i_{dc} = \frac{3}{2}(e_d i_{ed} + e_q i_{eq}) \quad (8)$$

V_{dc} can be derived from a current balancing formula as:

$$\frac{d}{dt} V_{dc} = -\left(\frac{V_{dc}}{R_{dc} C_{dc}} + \frac{i_{dc}}{C_{dc}}\right) \quad (9)$$

The current i_{dc} can be expressed as:

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- *Design DC Bus Voltage*

The voltage DC link must be sufficient enough to obtain current compensation using the following equation can be calculated

$$V_{dc\,min} > \sqrt{2} V_{L-L(rms)} = \sqrt{2}\sqrt{3} V_{L-N(rms)} \quad (11)$$

- *Design DC Bus Capacitor*

According to the energy conservation principle, the C_{dc} may calculated by:

$$\frac{1}{2} C_{dc}[{V_{dc}}^2 - {V_{dc1}}^2] = 3\,k\,a\,V\,I\,t \quad (12)$$

Where:
V_{dc}: is the reference DC bus Voltage
V_{dc1}: is the minimum level of the DC bus voltage
a: is the over loading factor
V: is the phase voltage
I: is the phase current
t: is the time for which the DC bus voltage is to be recovered
k: factor for variation of energy during dynamics

- *Design AC Interfacing Inductor*

The selection of suitable filter depends on the ripple current icr-pp, switching frequency fs and DC bus voltage V_{dc} is given in Eq.13:

$$L_f = \frac{\sqrt{3}\, m\, V_{dc}}{12\, a\, f_s\, i_{cr-pp}} \quad (13)$$

Where *m* is modulation index.

- *Design Passive High Pass Ripple Filters*

To eliminate the high frequency noise from the voltage waveform at PCC in the power system the high pass filter is needed to do that, it could be calculated by the following formula:

$$R_f C_f = \frac{T_s}{\ldots} \quad (14)$$

technique is related to the main parts. One is guided by personal behavior (P_{best}) and the other part guided by social experience (G_{best}). The position of particle in search space is updated depends on these two parts [14]. The core equations of this technique are

$$V_{i,j}^{k+1} = w \times V_{i,j}^{k} + c_1 \times r_1 \times \left(P_{besti,j}^{k} - X_{i,j}^{k}\right)(15) + c_2 \times r_2 \times \left(G_{besti,j}^{k} - X_{i,j}^{k}\right) \quad (15)$$

$$X_{i,j}^{k+1} = X_{i,j}^{k} + V_{i,j}^{k+1} \quad (16)$$

Where $P_{besti,j}^{k}$ represent personal best j[th] component of i[th] individual, whereas G_{bestj}^{k} represents j[th] component of the best individual of population up to iteration k. The PSO search mechanism is multidimensional search space as shown in Fig. 6.

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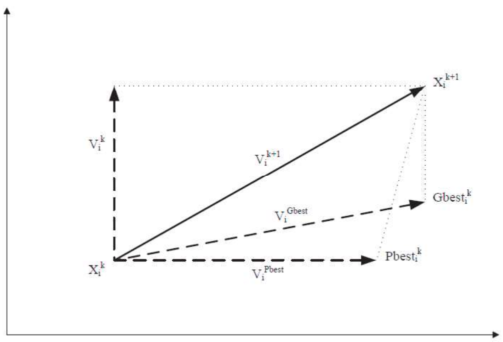

Figure 6: PSO mechanism search space

Fig..7 shows the considered steps of PSO technique in flowchart.

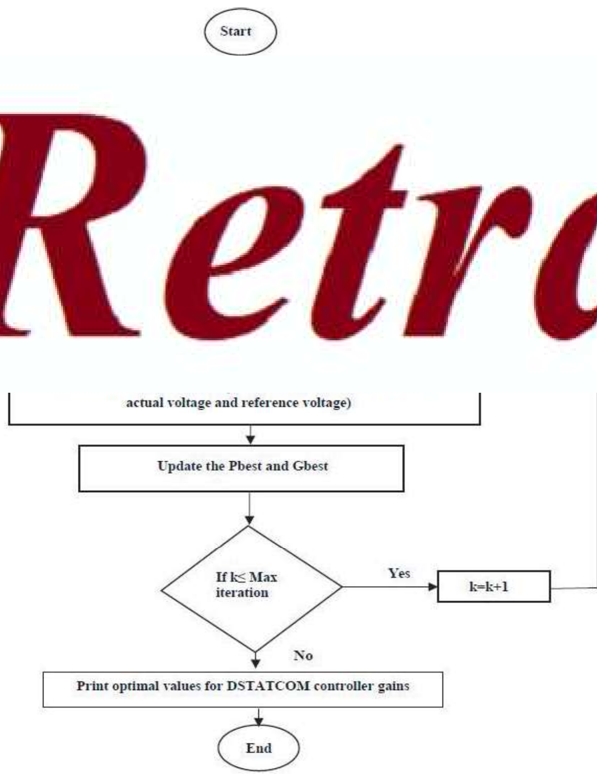

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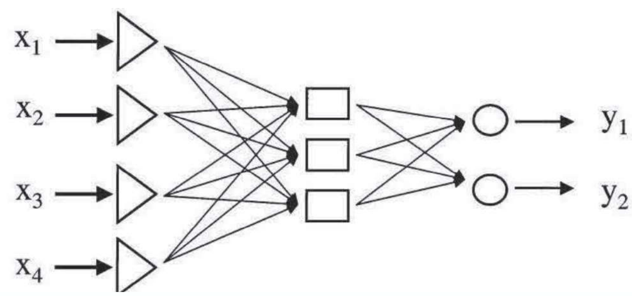
Figure 7: Flowchart of PSO algorithm

B. Artificial Neural Networks (ANNs)

Feed forward ANN is used to tune the controller of DSTATCOM in real time according to distribution bus voltage level. Fig. 8 shows the basic architecture of a feed forward of ANN consist of three layers architecture: input, hidden and output layer respectively. each node (neurons) in one layer is connected to each node in the next layer. The input nodes number in the input layer equals the number of inputs of the system, the number of output nodes in the output layer is the same number of outputs of the system. The number of hidden nodes in the middle layer is normally between the number of input nodes and the output nodes in the system. The number of hidden nodes is very important since both over fitting and under fitting will affect on the training results [15]-[16].



$$J = \sum_{1} e(i)^2 \quad (17)$$

Where N is the output neurons number, and $e(i)$ is instantaneous error between the actual and estimated value of the output.
The value of each neuron in the hidden layer *(y_j)* is given in terms of the input values x_i as shown in the following equation

$$y_j = \tanh(\sum w_{ij}\, x_i + b_j) \quad (18)$$

V. METHODOLOGY

A. Case Study

The work is applied on real network with data given by Jerusalem District Electricity Company (JDECO). The network is for Abu Mashaal zone in West Bank. The voltage on this network drops below the standard level (11kV) on distribution bus due the industrial nonlinear loads. The single line diagram of the given radial network is shown in Fig. 8.

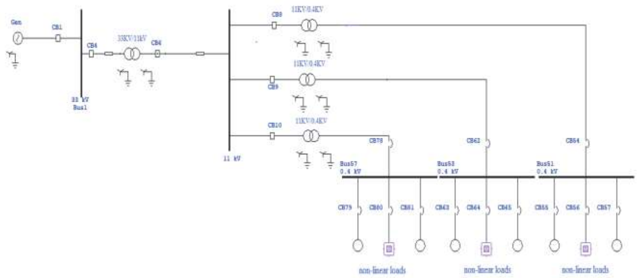


Figure 9: Single line diagram for radial network

Description of the system configuration is summarized in Table I.

Table I
Description of proposed distribution feeder

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Eq.14. The rated load connected on the end user of distribution system is 1MVA, Table II summarize the calculation values of DSTATCOM configuration.

Table II:
Values of DSTATCOM configuration

Parameter	Value
I_{rms}	1443.3A
V_{dc}	15556.3V
C_{dc}	16.665mF
L_f	31.42µH
C_r	1.8mF
R_r	0.0027Ω

C. MATLAB Model Simulation

Fig. 10 shows the overall power system for given case study with DSTATCOM connecting on 11kV distribution bus.

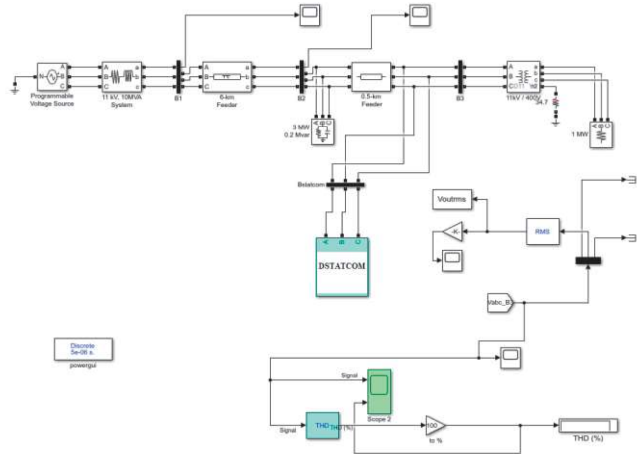

Figure 10: MATLAB Simulink simulation

Figure 11: Block diagram of closed loop control system.

The Fig. 12 shows the control strategy of DSTATCOM based on PLL.

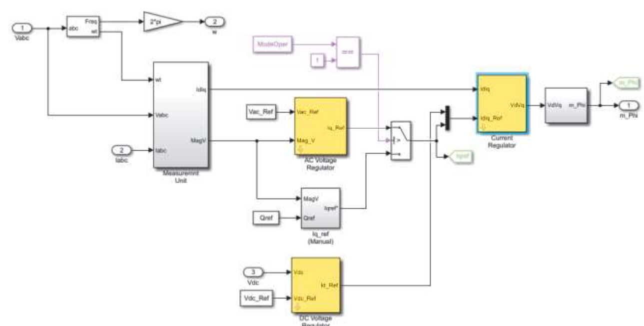

Figure 12: Control strategy for DSTATCOM [40]

D. Tuning DSTATCOM controller using ANNs and PSO

- *Employ PSO for optimum value of controller*

PSO algorithm is applied to find the optimum

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controller gains of DSTACOM (Vac regulator, Vdc regulator, and current regulator and PLL regulator). The algorithm parameters are selected as given in Table III.

Table III.
Parameters of PSO algorithm

Parameter	Size
Population size	N=50
Accelerated factors	C_1=1, C_2=1.5
Inertia	w=1.2
Number of iterations	i=100
Upper limits for controller gains	[10 3500 10 20 5 1500 1500 3000]
Lower limits for controller gains	[0.01 10 0.0001 0.01 1 100 10 10]

The objective function is minimization of root mean square error (RMSE) between the actual measured voltage and reference voltage (1pu). The RMSE and the objective function are given in Eq.20 and Eq.21

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[illegible]
and n: number of samples.
MATLAB code is written for the objective function and the PSO algorithm is running for voltage profile improvement. Sag and swell events are created in order to obtain controller gains for deviation of voltage from 1pu. The simulation is running for every deviation of (0.05pu) from extreme swell to extreme sag. At every case of sag and swell event the percentage error is calculated as well the THD.

- *Employ ANNs for control DSTATCOM*

ANN is proposed as AI method used for controlling DSTATCOM. The environment of ANN controller has made them a wide area of interest among researches in extensive field, due ANN can proficiently learn the unknown continuously varying environment and act accordingly. The results from PSO for wide range of sag and swell events (0.7-1.3) processed and nearly 70% of these data considered as a data base for ANNs training process. Then the results of ANNs provides real time to control DSTATCOM. The learning process of ANN is developed in MATLAB, aided by the toolbox neural network. For this study eight networks are defined in MATLAB code in order to applied the ANNs algorithm for learning and find the best optimal value of controllers gains according to disturbance voltage level, the networks are defined as shown in Table IV.

Table IV
Define networks in ANN algorithm

ANNs	Controller gain
Network1	$V_{ac}(k_p)$
Network2	$V_{ac}(k_i)$
Network3	$V_{dc}(k_p)$
Network4	$V_{dc}(k_i)$
Network5	$i(k_p)$
Network6	$i(k_i)$
Network7	$PLL(k_p)$
Network8	$PPL(k_i)$

- Building the network.
- Training the network.
- Testing the network by used the targets output in simulation model.

Fig.13 describe the Basic flowchart for designing ANN Model.

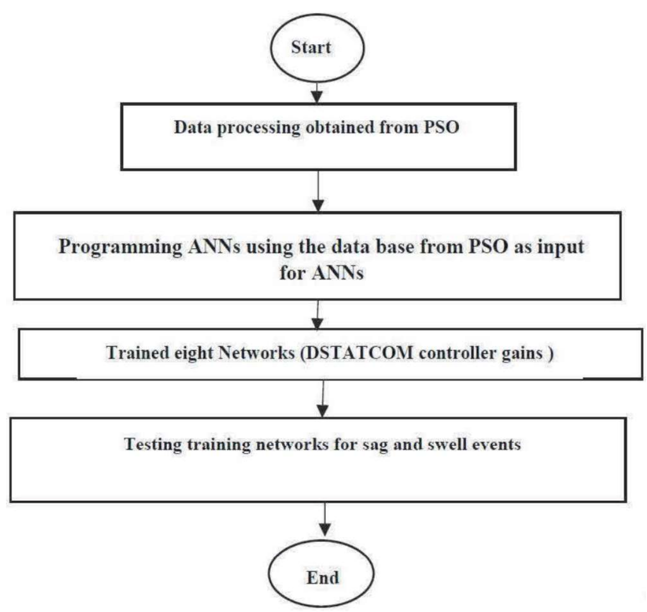

Figure 13: Basic flowchart for designing ANNs model

VI. RESULTS AND DISCUSSION

A. Creation of Sag and Swell Events on Distribution Bus

A wide range of extreme sag (0.7pu) and extreme swell (1.3pu) are created on distributed bus. This may represent the different disturbances occur on distribution system such as faults or over voltage due switching capacitor bank and other electrical disturbance may occur. Fig.s 14 and 15 show the extreme sag and extreme swell respectively.

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Figure 15: Extreme swell event 1.3pu

These events are simulated by network model using MATLAB/Simulink. The deviation of voltage on distribution bus is considered to be around 0.05 pu. DSTATCOM controller gains are obtained for each created event using PSO algorithm as well as the percentage error is also calculated according to the objective function of the optimization function. Table V and Table VI shows the results of DSTATCOM controller gains for the main steps selected from the data base obtained by PSO disturbances of swell and sag voltage events respectively.

Table V.
Optimal values of DSTATCOM controller gains during main steps of swell events using PSO

Event	1.3pu	1.25pu	1.20pu	1.15pu	1.10pu
$V_{ac}(k_p)$	10	7.43	3.82	10	10
$V_{ac}(k_i)$	10	3500	198	10	10
$V_{dc}(k_p)$	10	1e-4	6.22	10	10
$V_{dc}(k_i)$	20	12.3	15.5	1e-2	20
$i(k_p)$	2.75	2.17	2.05	5	5
$i(k_i)$	415	1500	436	1280	1500
$PLL(k_p)$	1170	1500	1380	1500	1800
$PPL(k_i)$	3000	10	2640	3000	3000
Error%	4	4.58	5.457	8.86	5.925

Table VI:
Optimal values of DSTATCOM controller gains during main steps of sag events using PSO

Event	0.9pu	0.85pu	0.80pu	0.75pu	0.70pu

B. Selection of Controller Gains Using PSO

The controller gains of DSTATCOM are selected and optimized according to the objective function which is minimization the RMSE between the measured bus voltage and the reference value (1pu). The sag events via error are drawn as in Fig. 16, while the swell events via error drawn in Fig. 17. From the charts of sag and swell via percentage error, it clear that the worst case of error is below 10% which acceptable referring to IEEE Standards.

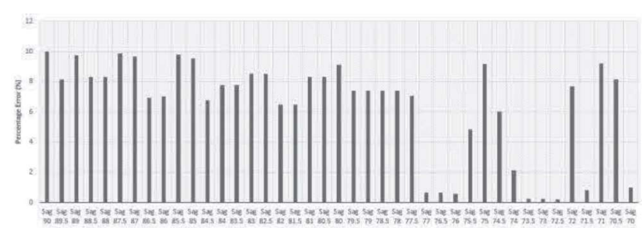

Figure 16: Sag events via error%

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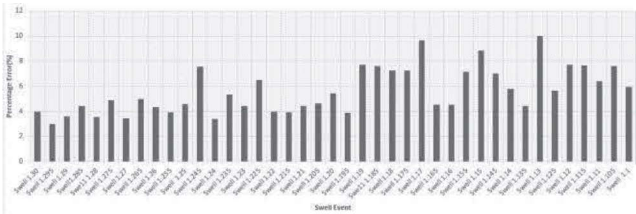

Figure 17: Swell events via error%

C. Control DSTATCOM using ANNs

PSO is used as a tool to obtain the optimum values of controller gains. Then data processing is done and nearly 70% of these data is used to train eight networks that control DSTATCOM as mention in Table 4. Values for controller gains is applied to ANNs in

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VII. The R value is an indication of the relationship between outputs and targets.

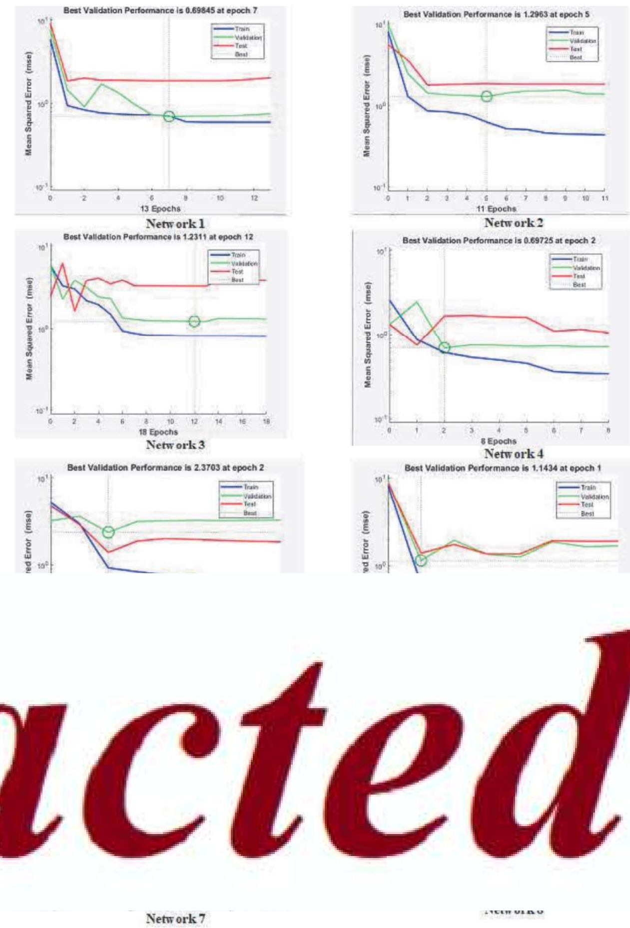
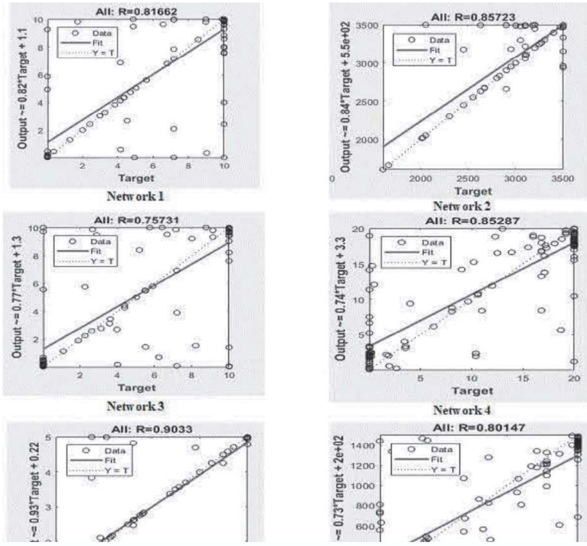


Figure 18: Training validation and test curves for neural networks

Table VII.
Evaluation of MSE and fitting function R for eight neural networks

Neural Network	MSE	R
Network1	0.69845	0.81662
Network2	1.2963	0.85723
Network3	1.2311	0.75731
Network4	0.69725	0.85287
Network5	2.3703	0.81662
Network6	1.1434	0.85723
Network7	1.3516	0.75731
Network8	3.8998	0.85287



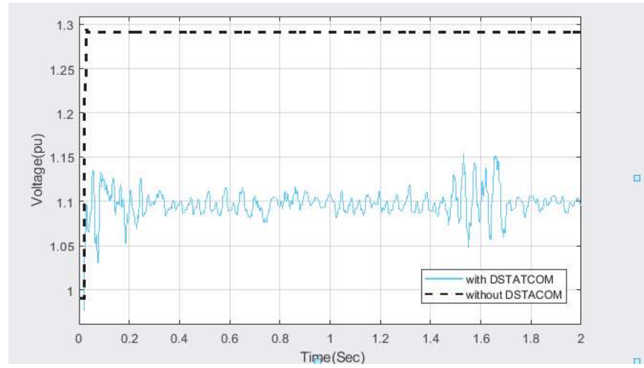


Figure 19: Effect of DSTATCOM on Voltage profile during extreme swell event**.**

Fig. 21 shows the effect of DSTATCOM on improving

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Figure 19: Estimation and fitting for neural networks

D. *Effect of ANNs Controller on Performance of DSTATCOM for Improve the Voltage Profile*

ANN logarithm is used for practice the controller and select the its gains constants according to activations elements. The algorithm is employed using nearly 70% of data obtained from PSO. Table VIII shows the results and controller gains for extreme swell and extreme sag by using developed controller of DSTATCOM.

Table VIII:
Voltage profile improvement using developed DSTATCOM controller

Event	Voltage profile improvement	THD%
Extreme swell (1.3pu)	1.02pu	3.26
Extreme sag (0.7pu)	1.07pu	9.23

Fig. 20 shows the effect of DSTATCOM on improving the voltage profile of the system at PCC during voltage swell event with acceptable range according to IEEE Std.1159.

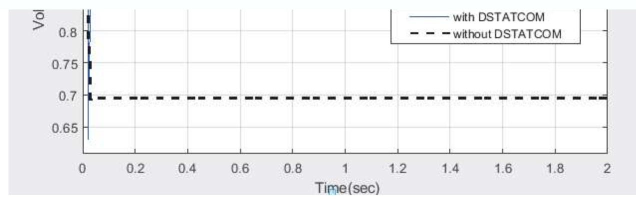

Figure 20: Voltage profile improvement for extreme sag event.

The proposed technique ANN with PSO is an effective technique to control DSTATCOM for voltage profile improvement on distribution system for the goal of real time control rather than traditional off line control. Also, the controller is examined for improving the voltage profile for continuous extreme sag and extreme swell, the results proved the robust and efficient of developed controller as shown in Fig.s 22 and 23 for rms voltage and phase voltage respectively.

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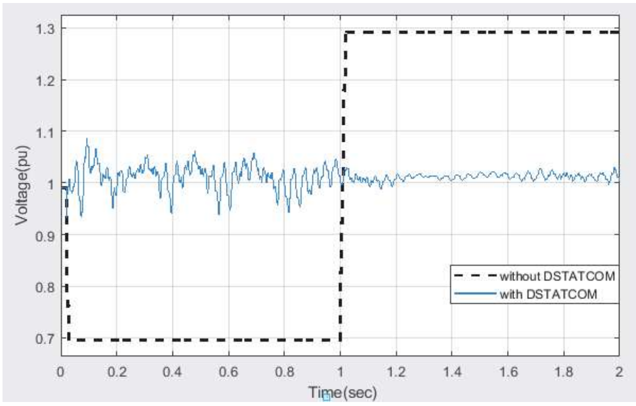

Figure 21: Effect of developed DSTATCOM controller using AI on rms voltage profile**.**

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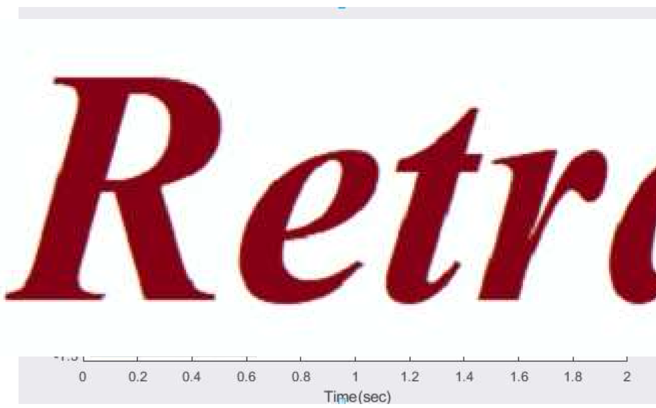

Figure 22: Effect of developed DSTATCOM controller using AI on instantaneous voltage profile**.**

VII. CONCLUSIONS

The results proved the importance of using AI in controller design of DSTATCOM, the voltage profile is improved during voltage events mainly sag and swell events in real time. The PSO is used as a tool for obtained the optimum values of DSTATCOM controller gains and then ANN is used as AI technique for real time control of DSTATCOM. The work proved the efficient of using ANN as AI technique for tuning PI controller of DSTATCOM in order to improve the voltage profile on distribution system. The DSTATCOM with developed controller validated the importance of AI methods such as ANN. Using such this developed controller may increase stability and reliability of power system and hence the network converts to smart network. Developed controller using ANN supports DSTATCOM with robust tuning system, since its responds to different real time voltage disturbances that may occur in distribution system with efficient enhancement for voltage profile compared with conventional control strategies. The simulation results proved the efficient of suggested method for controlling DSTATCOM in order to improve voltage profile on distribution system.

CONFLICTS OF INTEREST

There is no conflict of interest.

RESEARCH AND PUBLICATION ETHICS

The authors declare that this article does not require ethics committee approval or any special permission.

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