*N. Bharat Mohan, et. al. International Journal of Engineering Research and Applications
www.ijera.com
ISSN: 2248-9622, Vol. 12, Issue 4, (Series-II) April 2022, pp. 58-64

RESEARCH ARTICLE OPEN ACCESS

A Simulation Modelfor Mitigationof Voltage Sag inthe Distribution Systemusing DSTATCOM

*N. Bharat Mohan[1], Dr. B. Rajagopal[1], Dr. D. Hari Krishna[1]
[1]Research Scholar, Dept of EE, Annamalai University, Tamilnadu, India
[2] Associate Professor, Dept of EE, Annamalai University, Tamilnadu, India
[3]Associate Professor, Dept of EEE, MVSR Engineering College, Hyderabad, Telangana, India

Abstract. The demand for meeting power quality is increasing daily from the industrial power consumers along with thetechnical advancements in industrial control processes and electric utilities. There are many issues present in the power quality among them, voltage sag is an important power quality issues. Voltage sags of short duration may not cause much harm other than cause a slight flickering of lights to a domestic and non-sensitive load. There are various kinds of FACTS equipment such as shunt-connected devices, series-connected devices, shunt-series-connected devices etc. Among various techniques one of the useful methods for controlling the voltage is to employ a DSTATCOM. A DSTATCOM is Distribution Static Synchronous shunt compensator which is used at distribution level for power compensation. In this paper a distribution line is considered in which a voltage sag is developed and it is mitigated using DSTATCOM.
Keywords: voltage sag, DSTATCOM, FACTS.

Date of Submission: 09-04-2022 Date of Acceptance: 26-04-2022

I. INTRODUCTİON

The wide spread use of non-linear power electronic devices and the occurrence of faults, pollute the relatively high-quality power from the generating stations. The pollution in power is not only due to utilities but also due to the industrial non-linear loads. So, power quality gets degraded due to the disturbances, occurring in the transmission as well as in the distribution sides. FACTS devices are employed on the transmission side to overcome the problems in power quality.The term FACTS include power electronics-based devices utilized in AC power transmission and distribution. With latest developments in power electronic systems, there are a lot of possibilities to decrease these troubles in the power system [3]. At present, devices with power semiconductor equipment usually known as active power system conditioners, active power filters etc., are designed for the power quality problems owing to active and adaptable solutions. FACTS are a proposal designed based on power electronic devices, which organizes the values of various electrical quantities. There are various kinds of FACTS equipment such as shunt-connected devices, series-connected devices and shunt-series-connected devices etc.

As per IEEE, FACTS are definedas "a power electronic based system and other static equipment that provide control of one or more AC transmission system parameters to improve controllability and power transfer capability" [2].

In a lossless power system, the expression for power flow, $P = \frac{V_1 V_2 \sin \alpha}{X}$

where V_1 and V_2 arethe bus voltage magnitude at both sending endreceiving end, α is angle between both the voltages and X is reactance of the line.

Hence it is evident that the real and reactive power can be handled in a transmission line by controlling the power flow arrangement [2].

II. STATİC SYNCHRONOUS COMPENSATOR (STATCOM)

Among the FACTS devices Static Synchronous Compensator (STATCOM) is shunt connected device which is developedas a static VAR compensator where controllable reactors are replaced withvoltage source converter (VSC) [6][12]. The working principle of STATCOM is that, the voltage source inverter creates a controllable AC voltage source behind a reactance,so thatthe voltage difference across the reactance produces an active and reactive power exchange between thetransmission line and STATCOM.It operates better than a synchronous condenser[5][13]. Among various techniques one of the useful methods for controlling the voltage is to

employ a DSTATCOM. DSTATCOM is a type of conventional power electronics equipment for supplying good quality power. A DSTATCOM is Distribution Static Synchronous Shunt Compensator which is used at distribution level for both the real and reactive power compensation.The schematic configuration of STATCOM is shown in Fig.1.

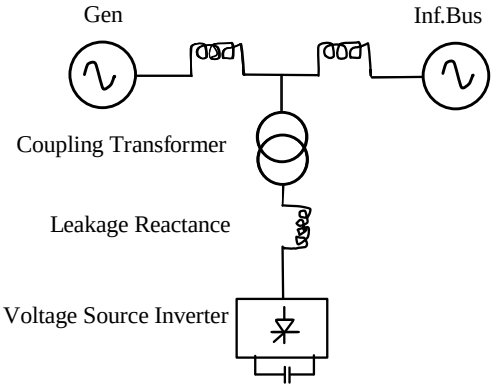

Fig.1. Schematic configuration of STATCOM

2.1 Basic Operation

At fundamental frequency,VSC changes an input dc voltage into an output three-phase voltage. A DC voltage source (capacitor or battery), a coupling transformerand VSC are the components of STATCOM. When a capacitor is utilized, the steady state power interchange between the device and AC system will be reactive powerandwhenthe battery is used power interchange will be active power[7][10].

The exchange of the reactive power between converter and the AC system can be controlled by changing the three-phase output voltageamplitude, V_c of converter.

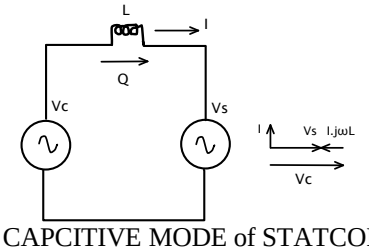

Fig.2. CAPCITIVE MODE of STATCOM with Phasor Diagram

Hence, whenever the amplitude of output voltage is greater than utility bus voltage V_s the current flows through the reactance from the converter to the AC systemand capacitive-reactive power is generated by converter and is in CAPACITIVE MODE as shown in Fig.2.

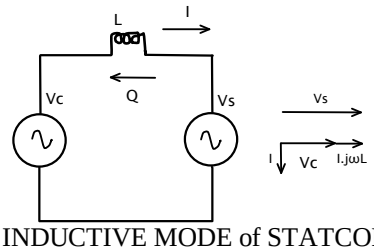

Fig.3. INDUCTIVE MODE of STATCOM with Phasor Diagram

Whenever the ouput voltage amplitude V_c is less than utility voltage V_s, then the current start flowing from AC system to the converter and the inductive reactive power from the AC system is absorbed by the converter, and is in INDUCTIVE MODE [7] as shown in Fig.3.

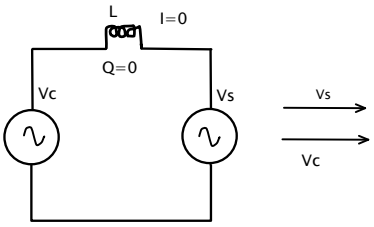

Fig.4. FLOATING MODE of STATCOM with Phasor Diagram

Now, when the output voltage amplitude $V_c$and AC system voltage are equal, there will be zero reactive power flow, then the STATCOM will operate in FLOATING MODE [7][8] as shown in Fig. 4.

III. VOLTAGE SAG

Voltage sags is research topic of immense interest as they interrupt the process of working equipment based on the precision. Voltage sags can beclassified as balanced or unbalanced based on the event or fault. The sag is balanced or symmetrical when the voltage in all phases correspond to each other and the phase angle is 120° otherwise, the sag is unsymmetrical or unbalanced. A symmetrical sag can be created bysymetrical fault i.e., three phase to ground fault or start of large motor.An unsymmetrical sags may be createdby unsymmetrical fault i.e.,L-G, L-L or L-L-G faults due to animal touching, accidents and different causes as well as sudden application of higher rating transformers [9][14][16].The industrial processes were controlled earlier using mechanical equipmentwith less sensitivity to voltage disturbances. But these days electronically controlled equipment such as adjustable speed drive (ASD) and PLC are more sensitive, which need a ripple free supply voltage.Fig.5 shows the classification of voltage variation based on time duration in power system[11] [15].

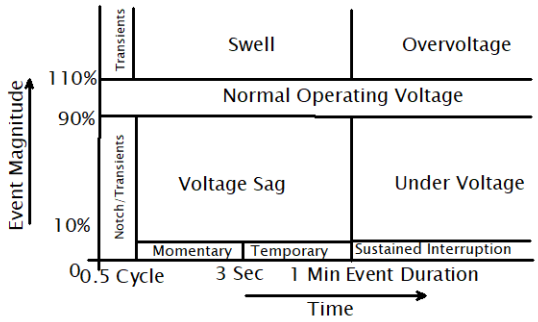

Fig.5. Classification of voltage sag and swell.

According to IEEE Std. 1159 (1995), sag magnitudes ranges from 10% to 90% of nominal voltage and sag durations from half- cycle to 1 minute[4][11]. The causes for voltage sag areSC fault in transmission lines,due to motor starting, opening and closing of circuit breakers and energizing a transformer etc. Various FACTS devices are used to avoid voltage sag problems[4][11].

IV. PROPOSED MODEL

The MATLAB simulation model shown in Fig.6 consists of 11 kV voltage source with feeder 11kV bus, 11/.4kV transformer, 0.4 kV bus and of R-L load. The specifications of R-L load are 10kW and 100var.

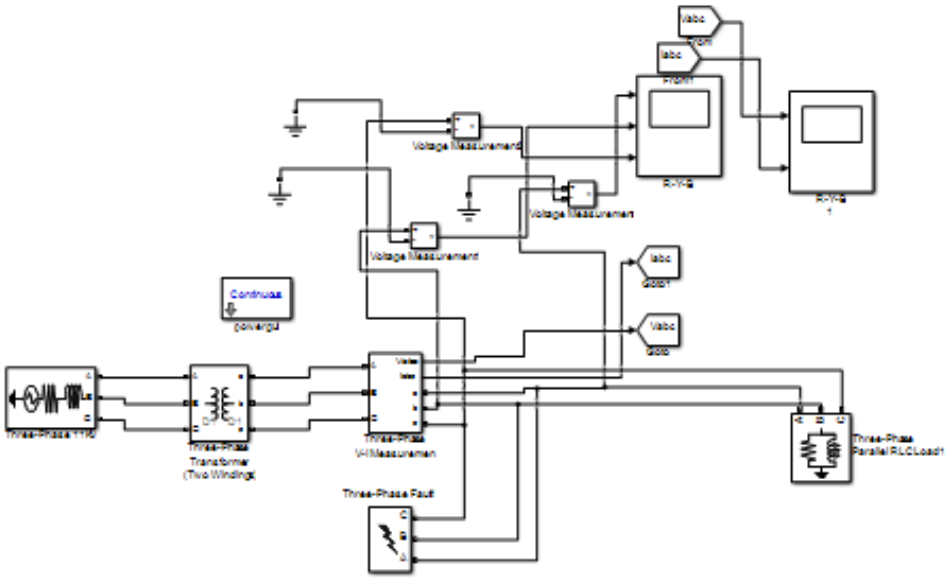

Fig.6. A distribution line model with RL Load and three phase fault.

In a distribution system a voltage sag is created using three-phase faultwith a fault duration of0.1-0.3 seconds near the load and the simulation result of three phase voltage waveform with voltage sag is observed in Fig.7. İn the Fig. 8 the voltage sag effect in each phase is clearly shown along with THD in Fig.9. The voltage sag problem is reduced using DSTATCOM

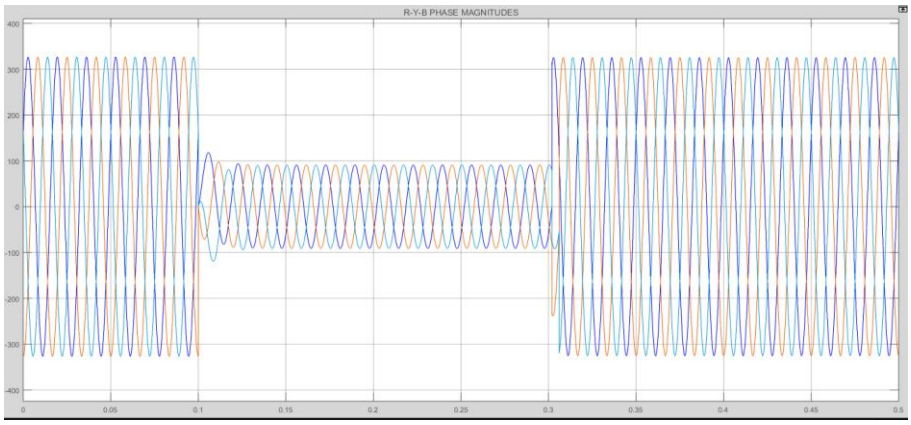

Fig.7. Three phasevoltage waveform with voltage sag

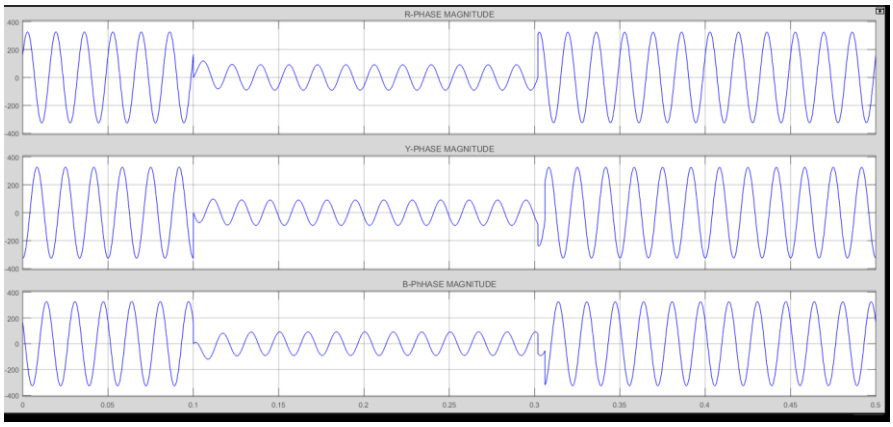

Fig.8. voltage sag waveform in individual phases from 0.1 to 0.3 sec

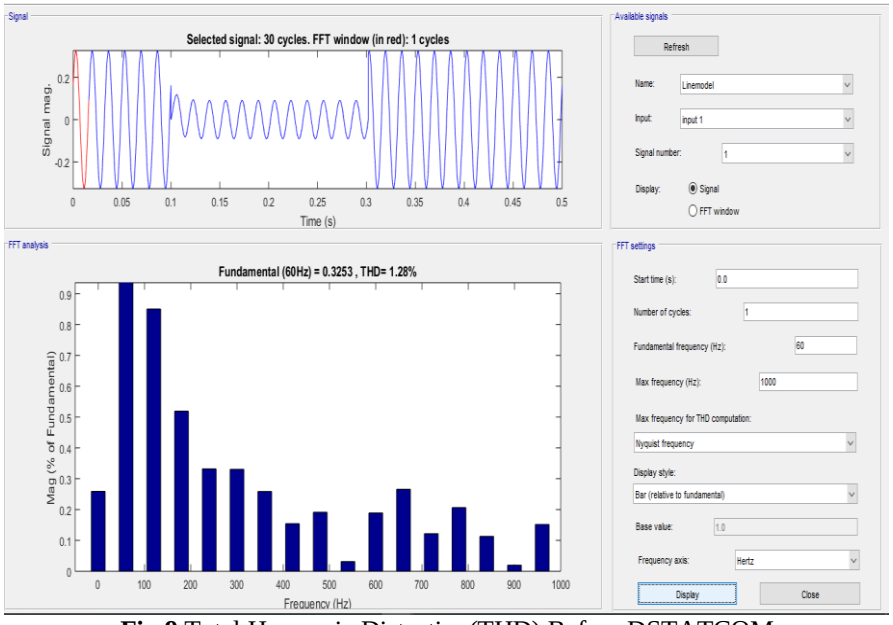

Fig.9.Total Harmonic Distortion(THD) Before DSTATCOM

A simulation model of a distribution line with DSTATCOM to reduce the voltage sag problemdue to three phase fault is shown in Fig. 10.

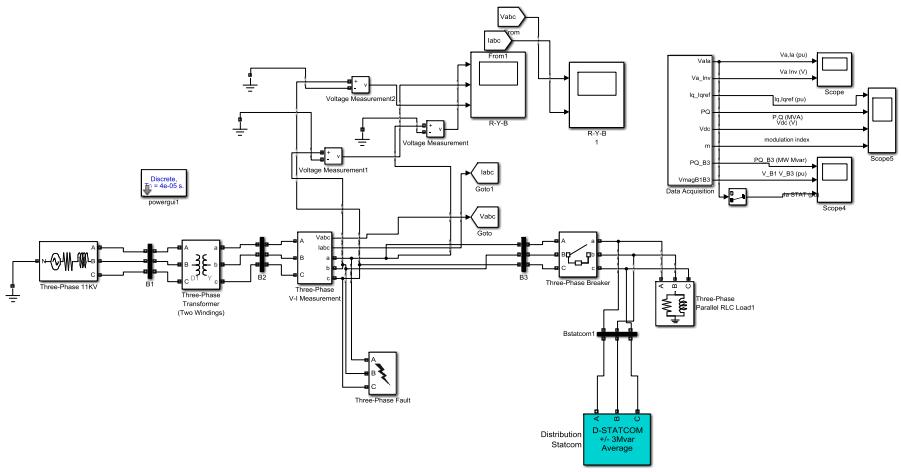

Fig.10. Simulation model of distribution line with DSTATCOM

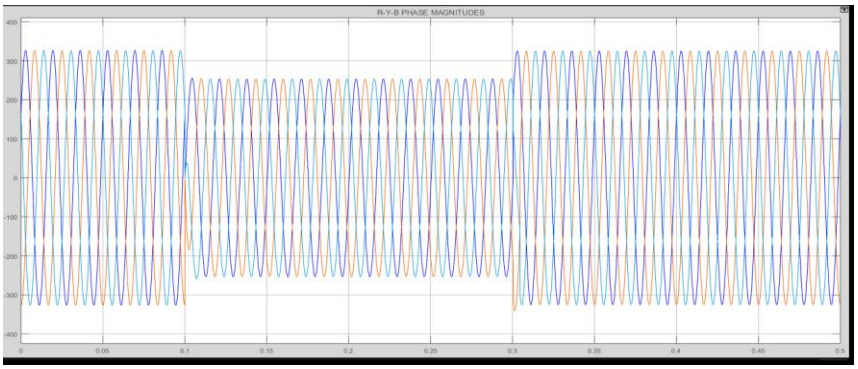

Fig11. Three phase voltage waveforms using DSTATCOM

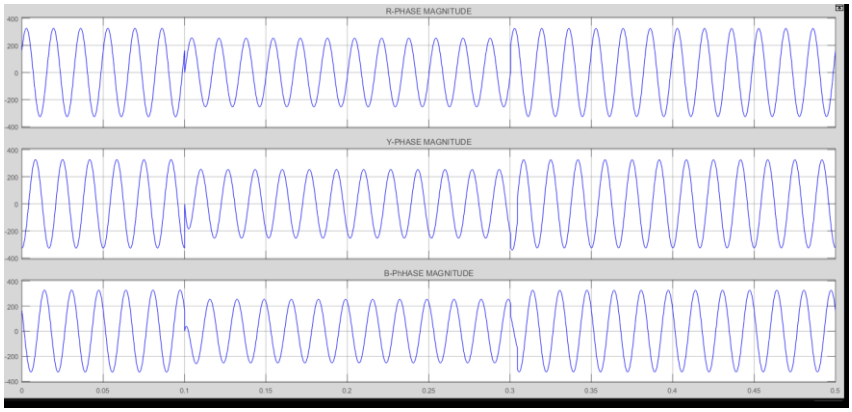

Fig.12. R,Y,B phase voltage individual waveforms using DSTATCOM

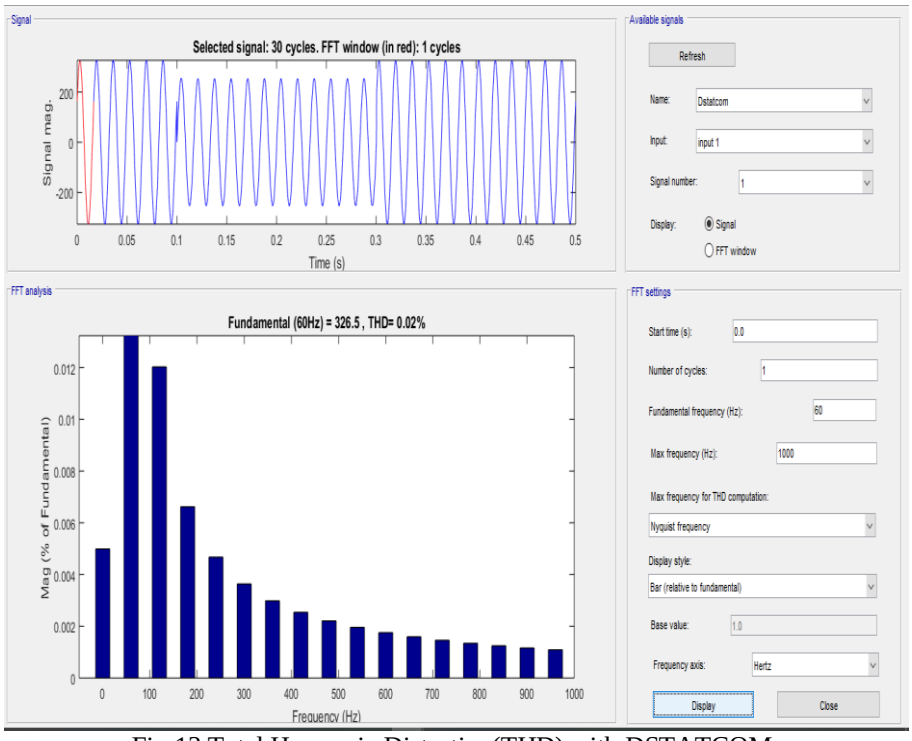

Fig.13.Total Harmonic Distortion(THD) with DSTATCOM.

From the Fig.11,Fig.12 and Fig.13 it is clear that by using DSTATCOM for distribution system the voltage sag is reduced and voltage waveform has improved. From above simulation results it is evident that the voltage sag has improved using DSTATCOM.

V. CONCLUSİON

When ever the industrial economic aspects are considered the voltage sag problems are significant among power quality issues. So the necessity of sag mitigation is very high.DSTATCOM is one of the custompower devices which has been chosen in this paper for mitigation of voltage sag.The results obtained from the MATLAB model of distribution line with and without DSTATCOM show that voltage sag can be minimized adequately.

VI. FUTURE SCOPE

Most of the times transmission line face problems like voltage sag, which can be avoided by using DSTATCOM. The model can be extended with off-shore wind turbine due to the advantage of high power. DSTATCOM can be replaced with UPQC for better power control. The control structure can be enhanced with the implementation of fuzzy logic control.

REFERENCES

[1]. R.C. Dugan, M.F. McGranaghan, and H.W.Beaty,Electric Power Systems Quality, McGraw-Hill, Nov (1996)
[2]. A.A. Edris, Chair, Proposed Terms and Definitions for Flexible AC Transmission Systems (FACTS), IEEE Transactions on Power Delivery, Vol. 12, No. 4, October (1997)
[3]. N.G .Hingorani and L. Gyugyi, Understanding FACTS - Concepts and Technology of Flexible AC Transmission Systems, IEEE Press (2000)
[4]. R. Mohan and R. K. Varma, Thyristor-Based FACTS Controllers for Electrical Transmission Systems. Piscataway, NJ: IEEE Press (2002)
[5]. S. Elango, Dr. E.Chandra Sekaran, Mitigation of voltage sag using Distribution Static Compensator,IEEEJuly (2011)
[6]. Hirak K. Shah, P.N. Kapil, and M.T.Shah, Simulation & Analysis of Distribution Static Compensator (D-STATCOM),IEEE PressDec (2011)
[7]. Gishin Jacob George, Rakesh R., Dr. M. Kowsalya, Modeling of STATCOM under Different Loading Conditions,IEEEJan (2012)
[8]. K.R.Sujal, !.Jacob RagJend2, Power Quality Improvement in Grid Connected Wind Energy System Using STATCOM,IEEEMay (2012)
[9]. Wu Zhu, Wei-Ya Ma, Yuan Gui, Hua-Fu Zhang,Modelling and Simulation of PQ Disturbance Based on Matlab,IEEEJuly (2012)
[10]. Mr.Sharad S.Pawar, Mr.A.P.Deshpande, Mrs.Meera Murali, Modelling and Simulation of DSTATCOM for Power Quality Improvement in Distribution System Using MATLAB Simulink Tool,IEEENov (2015)
[11]. Shweta Singh, Vivekanand Rai, Awadhesh Kumar, Kishan Bhusan Sahay Simulation and Comparison of DVR and D-STATCOM for Voltage Sag Mitigation,IEEEMarch (2016)
[12]. Sachin Karare, Vijay M. Harne, Modelling and Simulation of Improved Operation ofD-STATCOM in Distribution System for Power Quality Improvement using MATLAB Simulink tool, IEEEApril(2017)
[13]. Sapna Sakvaya1, Shuchi Shah2 and Virendra Jain3,Simulation and Design of D-STATCOM to Mitigate Power Quality Problems using Synchronous Reference Frame with Feeding Wide Variety of Static and Dynamic Loads, IEEEJune(2017)
[14]. V.Kavitha, K.Subramanian, Modelling and Simulation of Power Quality Disturbance using MATLAB/SIMULINK, IEEEMarch(2019)
[15]. R.Gidd,A.D.Gore,S.B.Jodhale,O.V.Kadekar, M.P.Thakre,Modelling, Analysis and performance of a DSTATCOM for Voltage Sag Mitigation in Distribution Network,IEEE April (2019)
[16]. Ms.Minakshi V.Bhakkad, Prof.B.T.Deshmukh, Generation of Voltage Sag for different loads and conditions using MATLAB SIMULINK, IEEEDec(2019)
[17]. Rodney H.G.Tan and Vigna K.Ramachandramurthy, A Comprehensive Modeling and simulation of power quality disturbances using MATLAB/SIMULINK.

*N. Bharat Mohan, et. al. "A Simulation Modelfor Mitigationof Voltage Sag inthe Distribution Systemusing DSTATCOM." *International Journal of Engineering Research and Applications (IJERA)*, vol.12 (04), 2022, pp 58-64.