iJRASET
International Journal For Research in Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH
IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 8 **Issue:** VIII **Month of publication:** August 2020

DOI: https://doi.org/10.22214/ijraset.2020.31125

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.429
Volume 8 Issue VIII Aug 2020- Available at www.ijraset.com

Design and Analysis of RSC-MLC Controlled DSTATCOM System

Zameer Ali Qazi[1], E. Ravi Teja[2]
[1]M.Tech Scholar, [2]Assistant Professor, Department of Electrical & Electronics Engineering, Bheema Institute of Technology & Science, Adoni, Kurnool Dist, A.P, India

Abstract: The appliances for energy distribution and generation are in demand due to the rapid increase in use of power electronics. The conventional devices offer reduced performance, paving the way for advanced compensated devices. So power quality (PQ) issues will occur in all electronics and electrical equipments when employed in distribution system. This issues results in currents distortion, voltage collapse and power losses. These power quality problems can be avoided with the use of Distribution Static Synchronous Compensator (DSTATCOM). In this paper, we propose the RSC-MLC controlled DSTATCOM to enhance the power quality. The proposed system is designed using MATLAB- SIMULINK and its performance is analyzed. The simulation results have been confirmed that DSTATCOM provides improvement in power quality.
Keywords: DC-link voltage, DSTATCOM, Power Quality, PV system, Reduced Switch Count Multi Level Converter (RSCMLC), Switching Losses.

I. INTRODUCTION

The prevalence of non-linear, inductive and unbalanced loads in the distribution system has resulted in many issues relating to power quality [1]. This is due to the rapid increase in the use of sensitive equipment in industrial, commercial, domestic and traction applications such as switched-mode power supplies, computers, refrigerators, televisions etc. Usage side demands regulated power supply that requires the use of electronic power converters. The generators generate a sinusoidal voltage so it distorts and unbalances the currents generated by these loads. It affects the voltage of the feeder and causes other loads that are attached to the same feeder to malfunction. A variety of design power devices (CPDs) were used to solve these problems[2-3]. Distribution Static Compensators (DSTATCOMs) are widely used out of these CPDs to alleviate current-based power quality issues including low power factor, unbalanced currents, and increased neutral current. Several DSTATCOM topologies and their architecture were protected, based on the requirement, in existing literature. Some traditional approaches are DSTATCOM with 4-legs and DSTATCOM with split-capacitor [4-5]. The topology of the 4-leg DSTATCOM uses one extra leg to have neutral current pathway. This includes the use of additional switches which lead to further losses from switching.

Split capacitor DSTATCOM suffers from capacitive voltage unbalance problem due to unequal charging of two capacitors at dc-link. In this paper to overcome issue of capacitive voltage unbalance problem a 3-leg Voltage Source Inverter (VSI) topology with neutral capacitor has been used, which overcomes these issues [6]. At the dc-link only one capacitor is used to avoid capacitor voltage unbalance. A neutral capacitor with small rated is used to provide neutral current compensation and hence this does not require extra leg with two more switches. But, in many topologies is maintained constant based upon the rated load conditions [7]. There is a change of occurrence of switching losses which is unnecessary at reduced loads.

The dc-link voltage can be decreased without affecting compensation at decreased loads to mitigate the switching losses associated with the Voltage Source Inverter (VSI). In [8], a variance in adaptive dc-link voltage was suggested using PI controller. However, due to PI controller behavior it suffers from slow transient response and leads to rippled dc-link voltage making it unreliable for rapidly changing loads. The proposed method uses Reduced Switch Count Multi Level Converter (RSC-MLC) to achieve the dc-link voltage regulation. Inverter switch gate pulses are operated using the faster and simpler Hysteresis Controller[9]. Using Instant Symmetrical Part Theory (ISCT), the gate pulses are derived to obtain the reference harmonic currents based on the load demand[8]. Such harmonic currents are used to find the dc-link voltage needed for the comparison. To achieve the required dc-link voltage level, the RSC-MLC is operated using the Pulse Width Modulation (PWM) technique. The speciality of this RSC-MLC topology is reduced voltage stress through switches at any operating environment, which contributes to reduced switching losses. Due to the growing use of traditional energy sources, there is an immense need to use non-conventional resources in as many applications as possible, as they are both widely available and non-polluting[9]. Solar energy is seen as one of the most common and potential source of energy to meet the demands. Using Photo Voltaic (PV) cells the solar energy is converted into electrical energy. Many analyzes have been carried out on the stability and performance of the integrated PV systems for different applications[10],[11],[12]. The suggested approach utilizes the PV panels to charge the RSC-MLC batteries.

Using the Perturb & Observe (P & O) algorithm, the optimal power point tracking (MPPT) is reached, and the output voltage of the PV panel is increased using the High Gain Boost Converter (HGBC)[13]. The photovoltaic panels generate full real power during the day. The batteries can then be charged, and real power can also be given. Due to insufficient irradiation, the PV panels can not deliver real power at night. In this case, the batteries will support the reactive power and harmonic compensation of the dc-link voltage. The real power can be intelligently shared based on irradiation and demand availability. Full description of the dc-link voltage variance using proposed RSC-MLC to achieve power quality improvement and actual power injection are discussed in detail below.

This paper is organized as follows: in section II the related work is presented. Section III presents the proposed DSTATCOM and design using MATLAB SIMULINK., the simulation results is presented in section IV. Finally, conclusions are summarized in section V.

II. RELATED WORK

Papi Naidu Tentu et.al [14] in 2020 has been investigated the application of DSTATCOM for mircogrid to improve power quality. They designed the distributed system with different topology based DSTATCOM system to mitigate the issue of current and voltage related power quality.

Myneni H et al [15] in 2020 have been investigated use of hybrid DSTATCOM in distribution system for enhancement of power quality. They designed the system for improvement of performance.

Agrani Sharma et al [16] in 2018 have carried out the design and analysis of DSTATCOM for improving the power quality of distribution systems.

M. Hareesh, et al [17] in 2017 has investigated the improvement of power quality using split capacitor DSTATCOM with the use of dynamic DC voltage regulation.

Ghazanfar Shahgholian et al [18] in 2016 have carried out the design and analysis of DSTATCOM with sliding mode control strategy for employing in the distribution systems. This system can be used for improving voltage sag.

S. Mishra, et al [19] in 2016 have carried out the research for improvement of power quality with the use of Jaya optimization based Photovoltaic Fed DSTATCOM.

Elby Varghese K V et al [20] in 2016 have carried out the DSTATCOM systems design and analysis. Also they investigated the comparative analysis of various control algorithms.

Manpreet Singh et al [21] in 2015 have investigated the Role of DSTATCOM system with various fault conditions in distribution network.

K. Seetharamanjaneyulu et al[22] in 2014 have investigation of improving the power quality in distribution system by employing DSTATCOM with predictive ANN.

III. PROPOSED SYSTEM

A. Proposed DSTATCOM System using RSC-MLC

We propose a DSTATCOM system using RSC-MLC for improving power quality and injection of PV power with variable DC voltage control. The figure 1 shows the block diagram of proposed RSC-MLC controlled DSTATCOM. In this system a solar cells for generation of DC voltage and the high gain boost converter (HGBC) is employed to boost the PV panel output voltage to higher value and then feed to RSC-MLC.

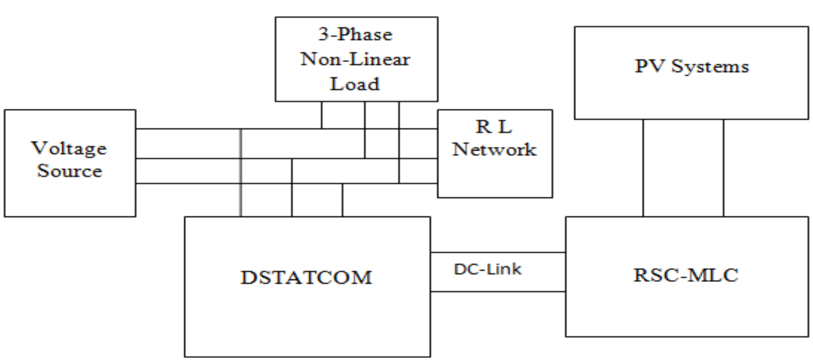
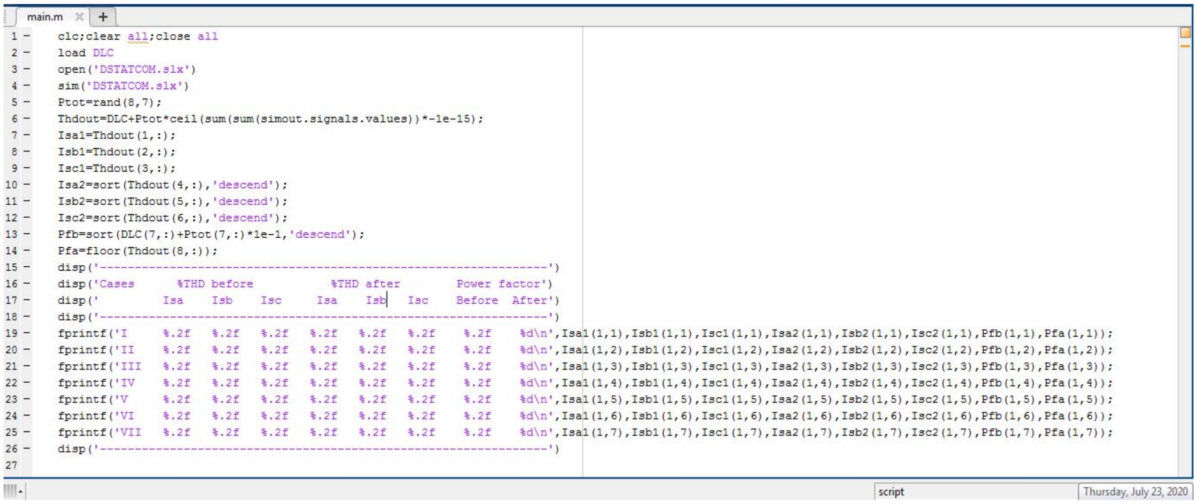


Figure 1 Block diagram of RSC-MLC controlled DSTATCOM

Further the RSC-MLC employed with DC voltage supply is utilized for variation of dc-link voltage. The perturb and observe (P&O) algorithm is used for maximum power point tracking (MPPT) of PV panels. This proposed method will optimize the dc-link voltage of DSTATCOM on the basis of requirement of load compensation by utilizing RSC-MLC with PV system integration. The benefits of proposed system are: it is capable for compensating reactive power, unbalance and harmonics demanded by three phase unbalanced and non-linear loads connected to the distribution side, leading to improvement of power quality. It is also capable of providing real power support to the load and thus prevents source from getting over loaded whenever required. During off-peak loads, the dc-link voltage can be brought down to a lower value, which will reduce the voltage-stress across switches of inverter and minimizes the switching losses.

B. *Proposed System Design using MATLAB-SIMULINK*

The proposed RSC-MLC controlled DSTATCOM system is designed using MATLAB- SIMULINK and its performances are analyzed. The figure 2 and figure 3 shows the MATLAB code and SIMULINK design for the proposed system



```
clc;clear all;close all
load DLC
open('DSTATCOM.slx')
sim('DSTATCOM.slx')
Ptot=rand(8,7);
Thdout=DLC+Ptot*ceil(sum(sum(simout.signals.values))*-1e-15);
Isa1=Thdout(1,:);
Isb1=Thdout(2,:);
Isc1=Thdout(3,:);
Isa2=sort(Thdout(4,:),'descend');
Isb2=sort(Thdout(5,:),'descend');
Isc2=sort(Thdout(6,:),'descend');
Pfb=sort(DLC(7,:)+Ptot(7,:)*1e-1,'descend');
Pfa=floor(Thdout(8,:));
disp('-----------------------------------------------------------------')
disp('Cases      %THD before            %THD after         Power factor')
disp('           Isa    Isb    Isc     Isa    Isb    Isc    Before  After')
disp('-----------------------------------------------------------------')
fprintf('I     %.2f   %.2f   %.2f   %.2f   %.2f   %.2f    %.2f     %d\n',Isa1(1,1),Isb1(1,1),Isc1(1,1),Isa2(1,1),Isb2(1,1),Isc2(1,1),Pfb(1,1),Pfa(1,1));
fprintf('II    %.2f   %.2f   %.2f   %.2f   %.2f   %.2f    %.2f     %d\n',Isa1(1,2),Isb1(1,2),Isc1(1,2),Isa2(1,2),Isb2(1,2),Isc2(1,2),Pfb(1,2),Pfa(1,2));
fprintf('III   %.2f   %.2f   %.2f   %.2f   %.2f   %.2f    %.2f     %d\n',Isa1(1,3),Isb1(1,3),Isc1(1,3),Isa2(1,3),Isb2(1,3),Isc2(1,3),Pfb(1,3),Pfa(1,3));
fprintf('IV    %.2f   %.2f   %.2f   %.2f   %.2f   %.2f    %.2f     %d\n',Isa1(1,4),Isb1(1,4),Isc1(1,4),Isa2(1,4),Isb2(1,4),Isc2(1,4),Pfb(1,4),Pfa(1,4));
fprintf('V     %.2f   %.2f   %.2f   %.2f   %.2f   %.2f    %.2f     %d\n',Isa1(1,5),Isb1(1,5),Isc1(1,5),Isa2(1,5),Isb2(1,5),Isc2(1,5),Pfb(1,5),Pfa(1,5));
fprintf('VI    %.2f   %.2f   %.2f   %.2f   %.2f   %.2f    %.2f     %d\n',Isa1(1,6),Isb1(1,6),Isc1(1,6),Isa2(1,6),Isb2(1,6),Isc2(1,6),Pfb(1,6),Pfa(1,6));
fprintf('VII   %.2f   %.2f   %.2f   %.2f   %.2f   %.2f    %.2f     %d\n',Isa1(1,7),Isb1(1,7),Isc1(1,7),Isa2(1,7),Isb2(1,7),Isc2(1,7),Pfb(1,7),Pfa(1,7));
disp('-----------------------------------------------------------------')
```

Figure 2 MATLAB code for RSC-MLC controlled DSTATCOM

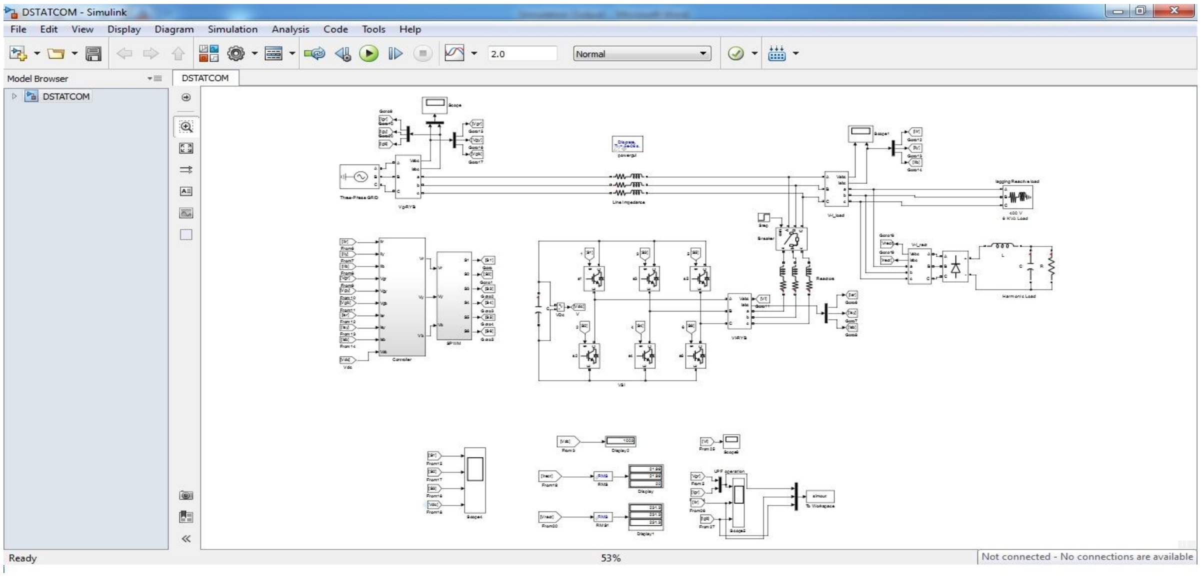


Figure 3 SIMULINK design of RSC-MLC controlled DSTATCOM

The circuit of proposed DSTATCOM have been design using the blocks available in SIMULINK tool. Every block is taken from libraries and drawn the diagram and interconnections are made. Then the design is saved.. This design circuit is further simulated to know the flow of various current and voltages and also power.

IV. SIMULATION RESULTS AND DISCUSSION

The simulation results are shown in terms of snapshots of execution results of designed proposed system from figure 4 to figure 8. To validate the effectiveness of proposed system the simulation analysis are carried out on SIMULINK platform with the use of system parameters like grid voltage/phase of 400V,50Hz , maximum dc-link voltage of 1100 V and hysteresis band of ±0.8A.

Table 1: %THD of source current and source side power factor before and after compensation under various load conditions.

Cases	%THD before			%THD after			Power factor	
	Isa	Isb	Isc	Isa	Isb	Isc	Before	After
I	26.81	26.91	26.13	4.91	4.63	4.10	0.98	1
II	24.96	24.96	24.16	2.97	2.96	2.49	0.98	1
III	16.42	16.92	16.79	2.96	1.69	2.04	0.97	1
IV	11.68	12.76	11.74	1.82	1.66	1.49	0.93	1
V	13.28	14.05	13.10	1.80	1.66	1.32	0.90	1
VI	13.44	14.38	13.77	1.68	1.66	1.17	0.84	1
VII	13.71	14.75	13.28	1.39	1.19	1.16	0.81	1

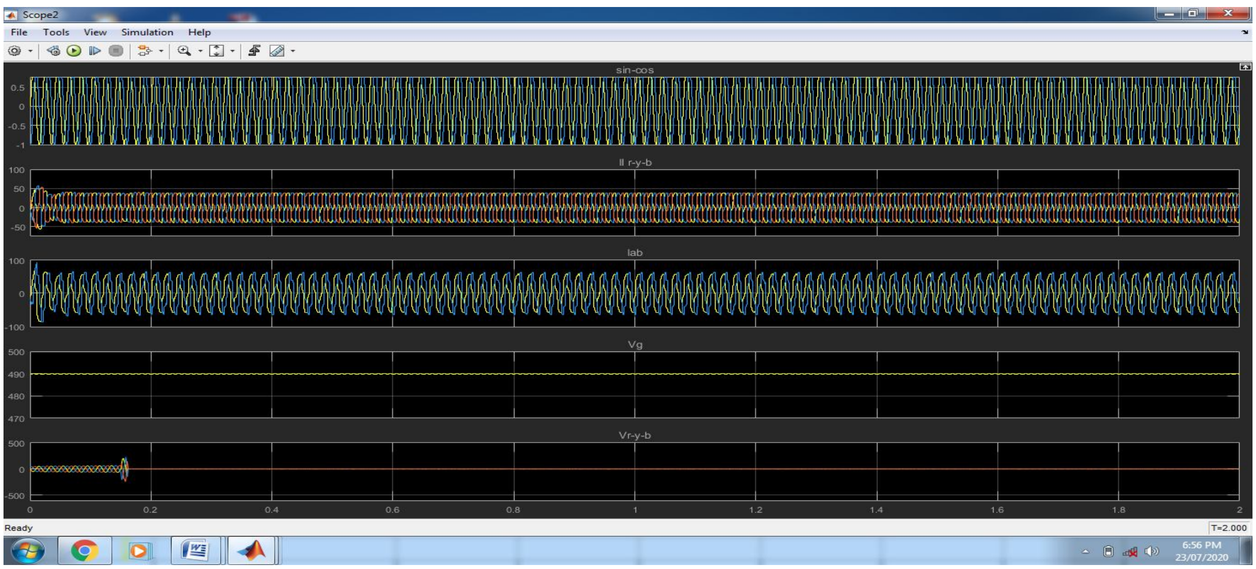


Figure 4 Output scope graphs for simulation data, distributed data, PCC voltage and distributed voltages

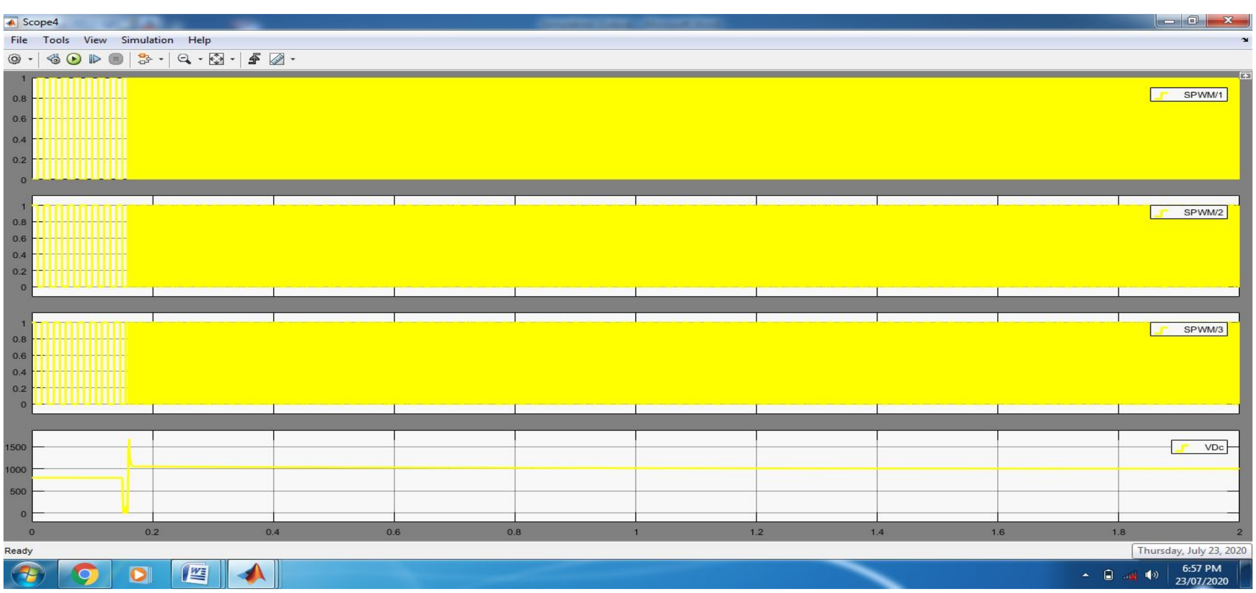


Figure 5 Output scope graphs for three different SPWM and respective voltage

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.429
Volume 8 Issue VIII Aug 2020- Available at www.ijraset.com

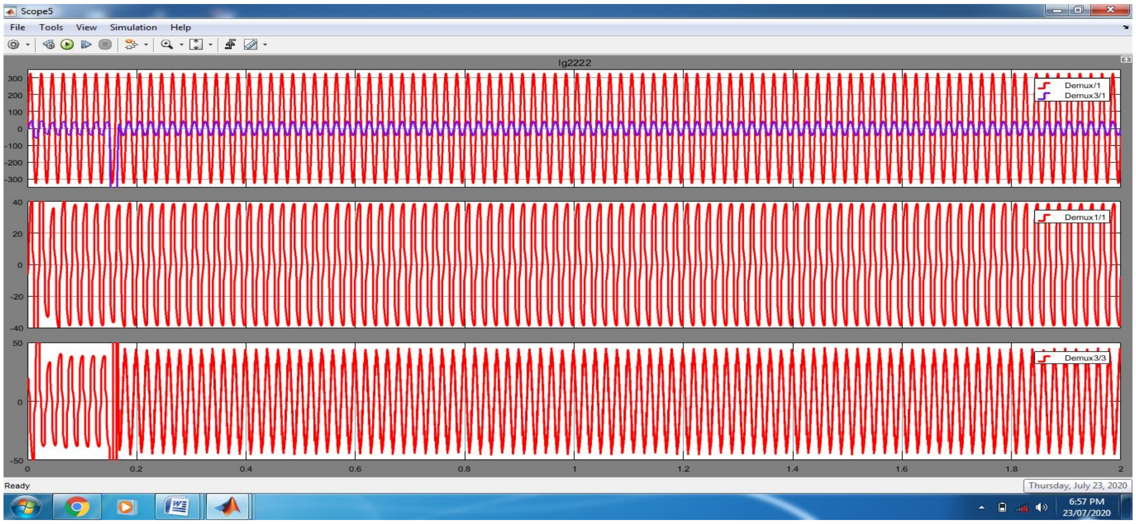


Figure 6 Output scope graphs for de-multiplexer for different power injections

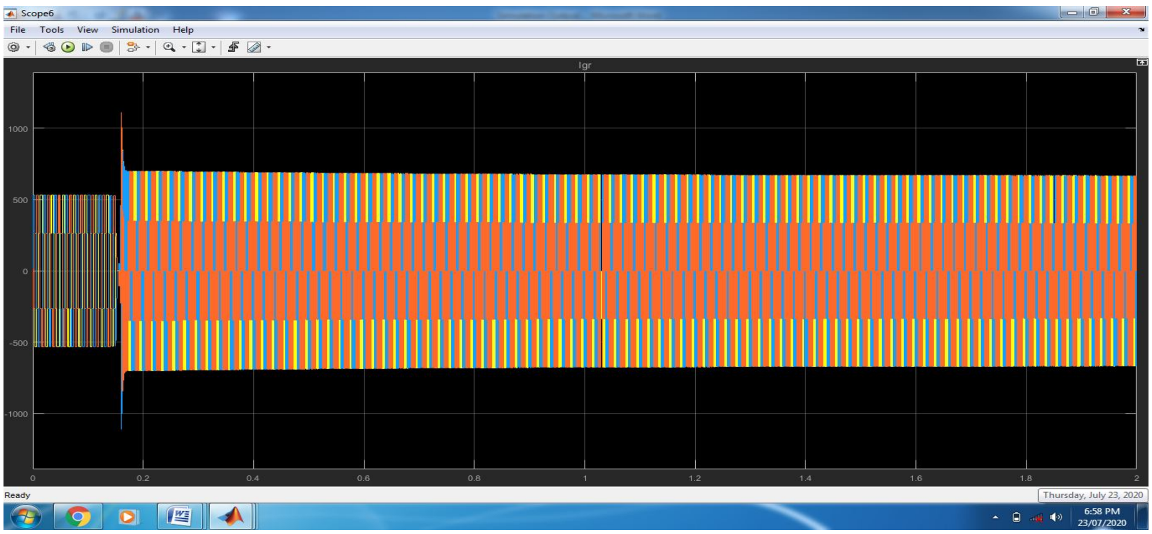


Figure 7 Output scope graphs for without real power injection

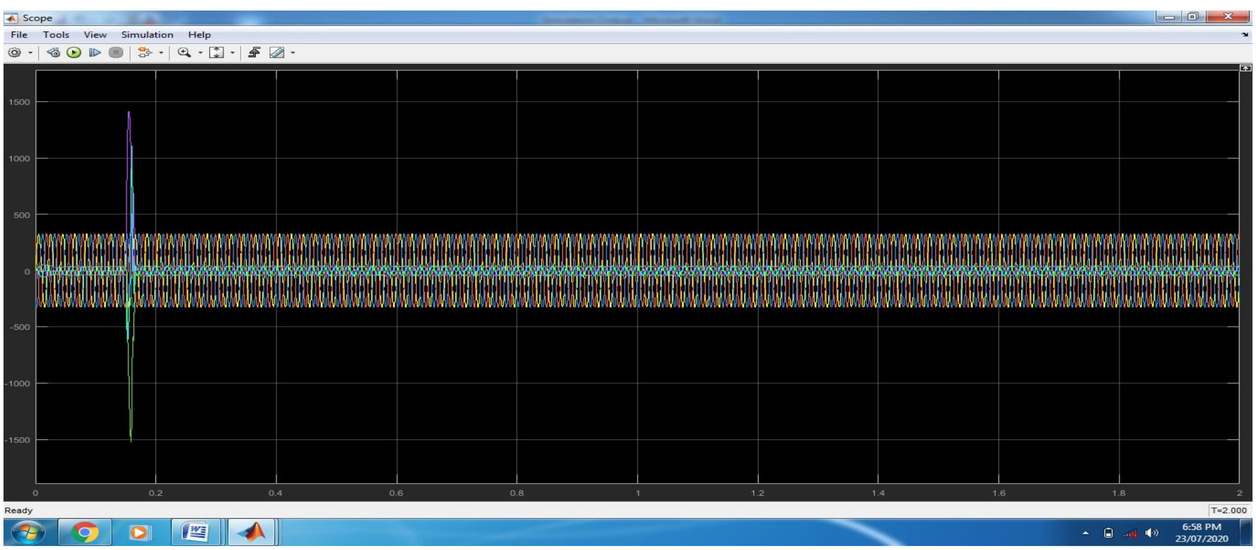


Figure 8 Output scope graphs for with real power injection

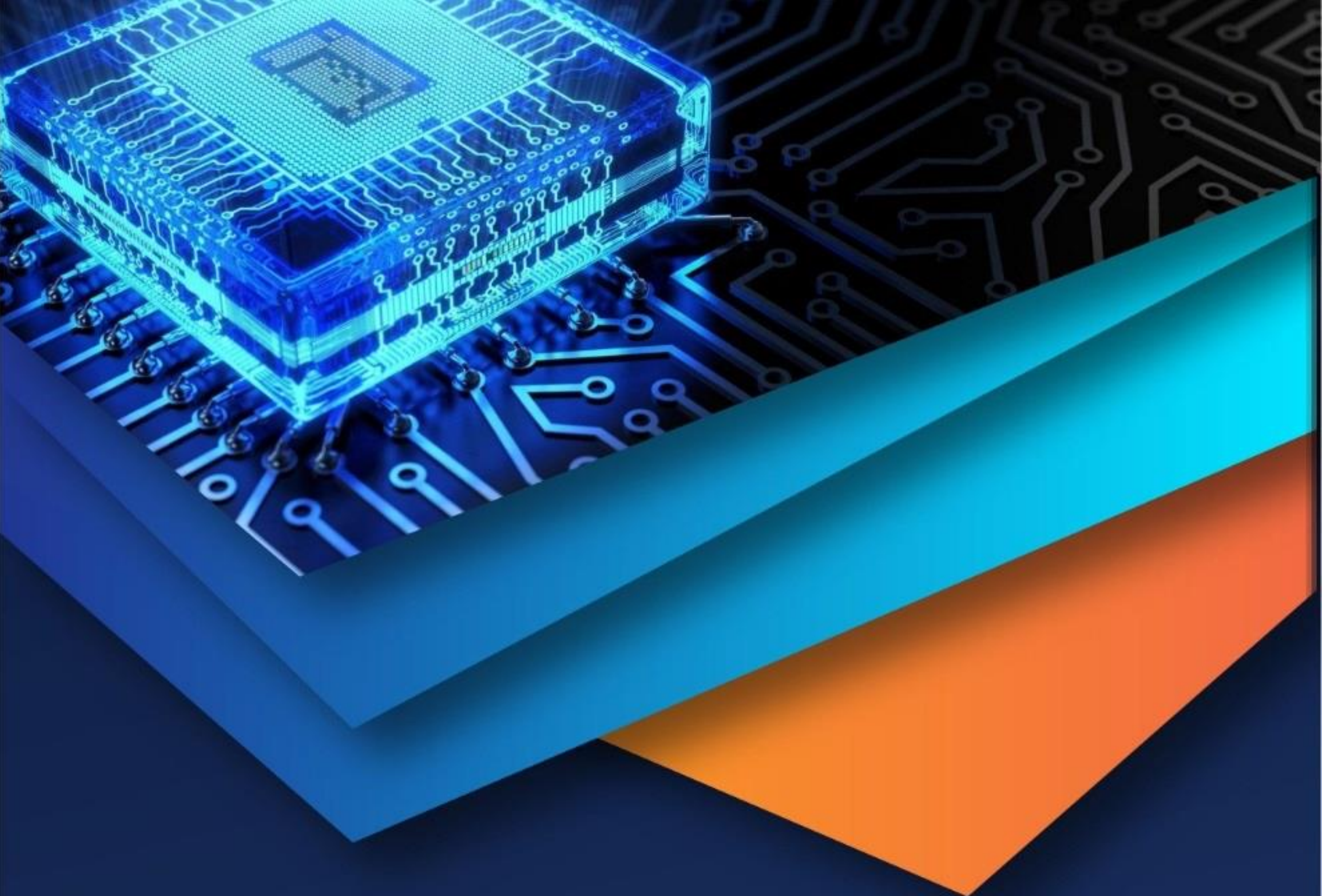
V. CONCLUSION AND FUTURE WORK

The design of DSTATCOM is successfully carried out and also its analysis is performed to verify the ability for power quality improvement. It can be observed from MATLAB SIMULINK simulation results that compensation for reactive power and harmonics has been achieved effectively. The source current is smooth, sinusoidal, distortion-free with enhanced factor of strength. After compensation the percentage of THD decreased significantly. In addition, due to reduced dc-link voltage at lower loads, voltage stress across switches has been reduced, and switching losses are greatly decreased, increasing DSTATCOM 's lifespan and performance. Therefore it can be a good alternative for improving power quality and supporting the load with real electricity.

Future works are the proposed DSTATCOM can be implemented using VHDL and simulated using Xilinx tool, the DSTATCOM can be controlled to function as an active filter and also the controller for the DSTATCOM can be implemented using fuzzy logic or artificial neural networks.

REFERENCES

[1] J. Arrillaga, N. R. Watson, "Power system harmonics," John Wiley and Sons, 2004.
[2] A. Ghosh A, G. Ledwich, "Power Quality Enhancement using Custom Power Devices," Springer Science and Business Media, 2012.
[3] M. H. J. Bollen, "Understanding Power Quality Problems: Voltage Sags and Interruptions," Wiley - IEEE press, Piscataway, NJ, USA, 2002 .
[4] B. Singh, S. R. Arya, C. Jain, S. Goel, "Implementation of Four-leg Distribution Static Compensator," IET Gener. Transm. Distrib., vol. 8, no. 6, pp. 1127-1139, Jun.2014.
[5] R. P. Tondare, S. P. Gawande, M. R. Ramteke, "Modeling of Split Capacitor Based DSTATCOM and Voltage Balancing Scheme for Load Compensation," International Conference on Emerging Trends in Communication, Control, Signal Processing and Computing Applications (C2SPCA), Bangalore, pp. 1-6, 2013.
[6] M. V. Manoj Kumar, M. K. Mishra, "Three-leg Inverter-based Distribution Static Compensator Topology for Compensating Unbalanced and NonlinearLoads," IET Power Electron., vol. 8, no. 11, pp. 2076-2084, Nov. 2015.
[7] B. Singh, P. Jayaprakash, D. Kothari, "A T-Connected Transformer and Three-leg VSC Based DSTATCOM for Power Quality Improvement," IEEE Trans. Power Electron., vol. 23, no. 6, pp. 2710-2718, Nov. 2008.
[8] B. Singh, A. Chandra, K. Al-Haddad, "Power quality: problems and mitigation techniques," John Wiley & Sons Ltd., United Kingdom, Dec. 2014.
[9] T. B. Johansson, "Renewable energy: sources for fuels and electricity," Island press, California, 1993.
[10] L. Wang, Q. S. Vo, A. V. Prokhorov, "Dynamic Stability Analysis of a Hybrid Wave and Photovoltaic Power Generation System Integrated Into a Distribution Power Grid," IEEE Trans. Sustain. Energy, vol. 8, no. 1, pp. 404-413, Jan. 2017.
[11] S. Mishra, P. K. Ray, "Power Quality Improvement using Photovoltaic Fed DSTATCOM Based on JAYA Optimization," IEEE Trans. Sustain. Energy, vol. 7, no. 4, pp. 1672-1680, Oct. 2016.
[12] R. K. Varma, R. Salehi, "SSR Mitigation with a New Control of PV Solar Farm as STATCOM (PV-STATCOM)" IEEE Trans. Sustain. Energy, vol. 8, no. 4, pp. 1473-1483, Oct. 2017.
[13] N. R. Tummuru, M. K. Mishra, S. Srinivas, "Multifunctional VSC Controlled Microgrid Using Instantaneous Symmetrical Components Theory," IEEE Trans. Sustain. Energy, vol. 5, no. 1, pp. 313-322, Jan. 2014.
[14] Papi Naidu Tentu, Dhannana Vara Arundhathi, Kandi Purushotham, Gundu Sudha Rani , Barla Sowmya, " Power Quality Improvement using DSTATCOM for Microgrid Applications", International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056 Vol: 07, issue: 06, pp: 423-4243, Jun. 2020.
[15] Myneni H, Ganjikunta SK, Dharmavarapu S. "Power Quality Enhancement by Hybrid DSTATCOM with Improved Performance in Distribution System,. *Int Trans Electr Energ Syst*.; 30, pp:1-18,2020
[16] Agrani Sharma, Anil S. Thosar "Distribution System Power Quality Improvement Using D-STATCOM Journal of Advanced Research in Power Electronics & Power Systems Vol: 5, Issue 3&4, Pg. No. 14-20, 2018
[17] M. Hareesh, G. Siva Kumar, D. Sreenivasarao, "Dynamic DC Voltage Regulation of Split-Capacitor DSTATCOM for Power Quality Improvement," IET Gener. Transm. Distrib., vol. 11, no. 17, pp. 4373-4383, Dec. 2017.
[18] Ghazanfar Shahgholian and Zahra Azimi "Analysis and Design of a DSTATCOM Based on Sliding Mode Control Strategy for Improvement of Voltage Sag in Distribution Systems", Electronics MDPI journal, 5, 41, pp: 1-12,2016.
[19] S. Mishra, P. K. Ray, "Power Quality Improvement using Photovoltaic Fed DSTATCOM Based on JAYA Optimization," IEEE Trans. Sustain. Energy, vol. 7, no. 4, pp. 1672-1680, Oct. 2016
[20] Elby Varghese K V, Jayaprakash P, "Design and Analysis of DSTATCOM and Comparison of Various Control Algorithms", International Journal of Innovative Research in Electrical, Electronics, Instrumentation and Control Engineering Vol. 3, Special Issue 1, Feb. 2016.
[21] Manpreet Singh, Jaspreet Kaur, "Role of DSTATCOM in Distribution Network under Various Fault Conditions", International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering Vol. 4, Issue 7, Jul. 2015
[22] K. Seetharamanjaneyulu and G.Nagaraju,"Power Quality Improvement in Distribution System by using DSTATCOM with Predictive ANN",International Journal of Innovative Science, Engineering & Technology, Vol. 1 Issue 9, Nov. 2014



10.22214/IJRASET

45.98

IMPACT FACTOR: 7.129

IMPACT FACTOR: 7.429

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY