International Journal of Applied Power Engineering (IJAPE)
Vol. 11, No. 1, March 2022, pp. 98~108
ISSN: 2252-8792, DOI: 10.11591/ijape.v11.i1.pp98-108

Implementation and study of fuzzy based KY boost converter for electric vehicle charging

Jalla Upendar, Sangem Ravi Kumar, Sapavath Sreenu, Bogimi Sirisha
Department of Electrical Engineering, Faculty of Engineering, Osmania University, Hyderabad, India

Article Info

Article history:

Received Dec 23, 2021
Revised Jan 28, 2022
Accepted Feb 13, 2022

Keywords:

Fuzzy logic controller
Electric vehicle
KY boost converter

ABSTRACT

Elecetric vehicle batteries require direct current (DC) current for charging; hence the circuit alternating current (AC) is converted to DC by a battery charger. Battery charger mostly consists of a rectifier and DC-DC converter with a controller built in to serve as a protective circuit. A harmonic source load is a type of electric car charger. During the AC-DC change over method, harmonic current is introduced into the power system, affecting power quality. In this study, a charging station consisting of buck boost and a charging station consisting a KY Boost converter were simulated. To maintain output voltage of DC-DC converters constant controller is used, the controller is either PI or fuzzy logic controller. So, four models are developed and simulated which are buck-boost converter controlled by proportional-integral (PI)-controller, KY-boost converter controlled by proportional integral-controller, buck boost converter controller fuzzy logic controller and KY boost-converter controlled by fuzzy logic controller. The total harmonic distortion (THD) of the four models is compared.

Corresponding Author:

Jalla Upendar
Department of Electrical Engineering, Faculty of Engineering, University College of Engineering (A)
Osmania University
Hyderabad, Telangana 500007, India
Email: dr.8500003210@gmail.com

1. INTRODUCTION

Electric vehicles will play a critical part in resolving energy shortages and environmental degradation issues since they emit less pollution and consume less energy. Electric vehicles are becoming more environmentally friendly than gasolinepowered vehicles, which is being pushed by automakers' desire to sell zero-emission automobiles. Electric vehicles provide roughly 60% more mileage for the same amount of raw energy, demonstrating outstanding energy conservation. Electric cars have the potential to enhance the energy structure, save energy, and reduce emissions [1]. As civilization progresses, more electric vehicles will become available to the general public, necessitating the installation of a massive number of charging points at the same instant. Electric vehicles are charged quickly and easily at home or at a charging station. Electric vehicles could be recharged during low-load periods, which occur frequently after midnight, reducing peak load and boosting valley load, resulting in increased power system efficiency. Large volumes of harmonic are produced while charging of electric vehicles due to the presence of converters, and if the harmonics is not regulated properly, it may cause huge damage to the power system [2]. Harmonic current in large quantities can increase system line loss, add to the problem of electric gear warming, cause control equipment failure, interrupt production or function, and possibly cause a huge shutdown [3]–[6].

2. PROPOSED METHOD

The block diagram of proposed model is in Figure 1. In this model power is taken at 11 KV and it is step down to 415 V and then to 120 V using two three phase transformers. The output of the 415 V/120 V transformer is given to "three phase-controlled thyristor bridge rectifiers". The DC out put is given to seven DC-DC converters. In this model either KY boost or the buck boost converter are being used. To control the load voltage of converter a controller is used. In this model either PI or fuzzy logic controller is used. So, four models are developed they are i) buck-boost converter controlled by "PI controller", ii) buck-boost-controlled by "fuzzy logic controller", iii) KY boost-controlled by "PI controller, and iv) KY boost controlled with "fuzzy logic controller". The Harmonics of Current generated by four different models are be examined.

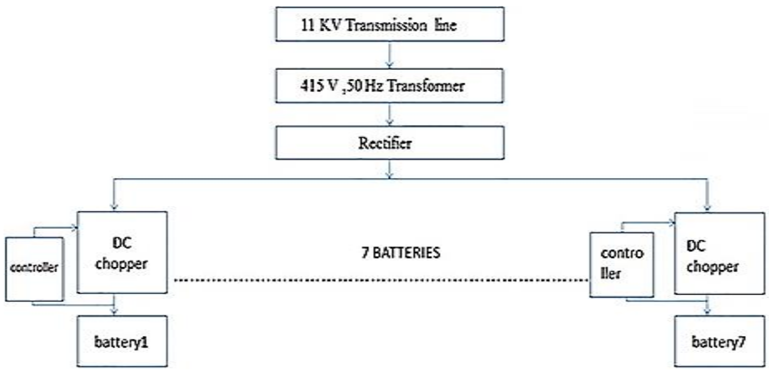


Figure 1. Proposed model block diagram

3. KY BOOST CONVERTER

Figure 2 displays the proposed "KY boost converter", which consists of a "KY –converter" and a "conventional SR-boost-converter". KY-boost converter Its made up of switches S_2, S1, the diode (D_b), the energy-transferring-capacitor (C_b), the load side inductor (L_o), and the load side capacitor (C_o) [7]–[9]. In addition, the KY converter's input is substituted with one buffer capacitor-C_m. In contrast, a conventional "SR-boost converter" made up of switches S_2 and S_1 and (L_i) the input-inductor. Furthermore, buffer capacitor (C_m) serves as a buffer here with the conventional SR boost converter and KY-converter, in other words, the buffer-capacitor (Cm) replaces output of conventional "SR boost-converter". One load resistor R_L [10] represents the output load.

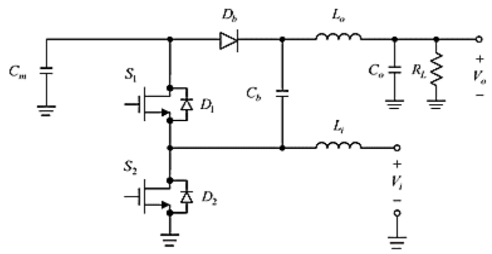


Figure 2. KY Boost converter

Some of the assumptions include the following: i) There is no delay between the power electronic switches; ii) There are zero voltage-drops at switch and diodes throughout on-period; iii) Currents-flowing in the inductors L_o and L_i were denoted as i_{Lo} and i_{Li}; and iv) the energy-transfer capacitor (C_b) which operates wih the principle of "charge pump",C_m is rapidly excited with V_{Cm} in the small time, lesser than the switching period T_s [11].

As a result, the converter is operated in two functional modes, switching-on time for the switches are (1-D, D), where D and (1-D) are the duty cycles of switch S_2 and S_1 respectively, duty-cycle (D) for switch S1. Furthermore, because all components are in perfect working order, the voltage at (C_m) roughly equals the voltage at (C_b).

- Mode 1: In Figure 3(a), S_2 is switched on while S_1 is switched off. In this situation, cathode (C_b) terminal is dragged to the ground potential, and D_b becomes forward-biased it begins to conduct. In this phase, the C_m is deenergized while the C_b is charged. As a result, the voltage at L_i is V_i, making L_i to magnetise, but

the voltage at L_o is V_o–V_{Cm}, making L_o to discharge. Furthermore, the current through C_o Becomes i_{Lo}–i_{RL}, but the current through Cm equals the addition of –i_{Cb} and –i_{Lo}. [12], [13].
- Mode2: S_2 is switched off and switch S_1 is switched-on as represented in Figure 3(b). Because S_1 was switched-on during present situation, D_b is swiched-off. C_m is energised in this mode, whereas C_b is denergised. As a consequence, the voltage at L_i was V_i-V_{cm} resulting in L_i is discharged, but the voltage at L_o was $2V_{Cm}$-V_0; resulting in L_o is magnetized. Furthermore, the current through C_o equals i_{Lo}-i_{RL}, but the current through C_m equals to i_{Li} –i_{Lo} [14].

As a result, "KY boost-converter" out-put to input voltage-ratio is:

$$\frac{Vo}{Vi} = \frac{2-D}{1-D}$$

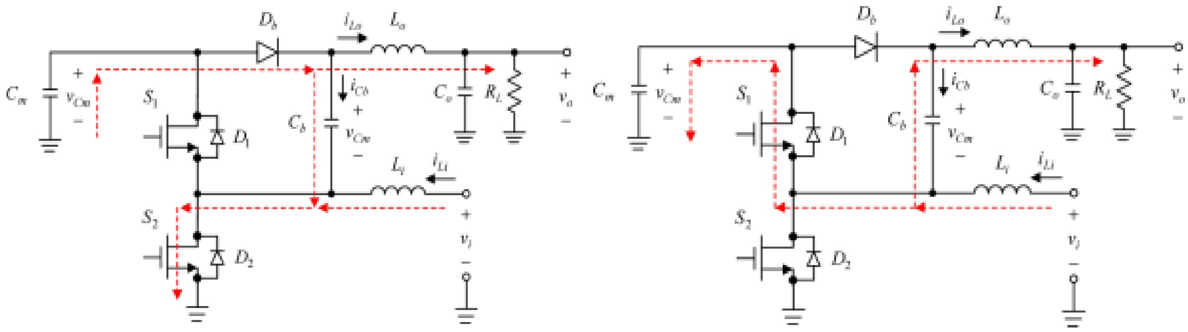


Figure 3. KY boost converter: (a) flow of power in mode 1 and (b) flow of power in mode 2

4. ELECTRIC VEHICLE

An electric vehicle is one that is propelled by electric motors and draws power from an onboard electric source. It is more durable and has a simpler mechanical design than a gasoline vehicle. Because it does not emit emissions like an internal combustion engine, it has a higher fuel economy than gasoline. However, the automobile industry is not yet fully committed to pure electric vehicles due to an issue with current battery technology. The battery is the most popular storage device used in electric vehicles for storing electric energy. It can store a lot of energy in a small amount of space and weight [15]–[18]. In this model Li-ion Battery with nominal voltage of 320 V is used as load at the out put of either "buck boost converter" or "KY-boost converter".

5. FUZZY LOGIC CONTROLLER

Rules defined by the linguistic variables are primarily responsible for fuzzy logic control. The model is controlled solely by simple mathematical computations. Despite the fact that it is based on basic mathematics. It has good performance in a control system, according to analysis. As a result, this strategy is one of the most popular. The greatest approaches accessible, as well as one that is easier to control a plant. A fuzzy-logic controller has three important blocks they are i) "fuzzification", ii) "fuzzy rule-base" and "interfacing", iii) "de-fuzzification".

In this model there are seven-member ship functions for inputs and outputs in this fuzzy-logic controller. The following are the member ship functions: negative huge (NH), negative moderate (NM), negative less (NL), zero (ZO), positive less (PL), positive moderate (PM), positive huge (PH).

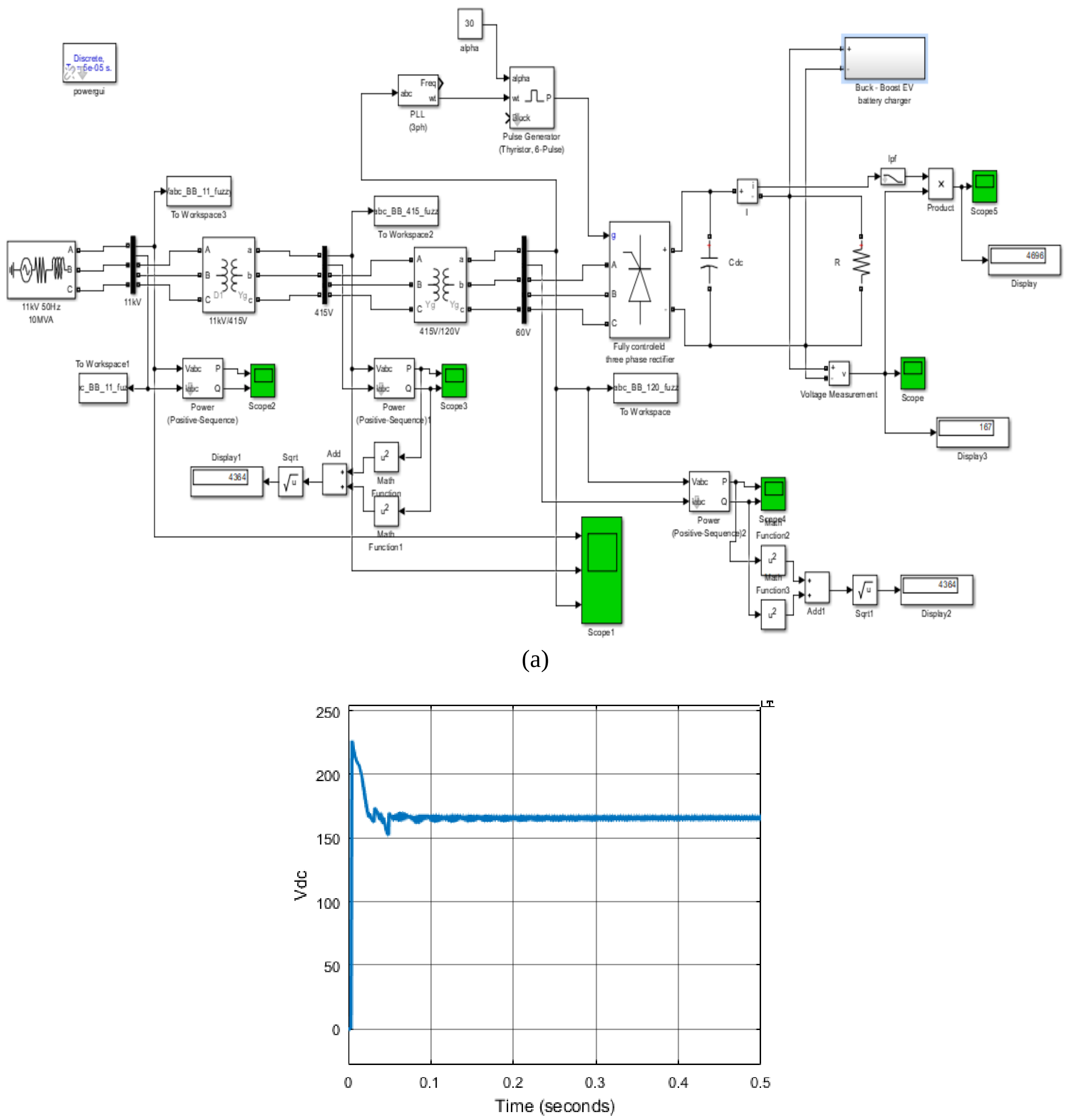
One input to the "fuzzy logic controller" given with error voltage that is difference in output voltage to reference voltage [19]–[27]. Second input is difference in error that is difference-between the present error voltages to previous-error voltage. Out-put the "fuzzy-logic" is "duty ratio". The "fuzzy-logic" works on the rule base. It has two in-puts and single out-put and seven membership-functions for each input, so total of 49 rules are obtained as shown in following Table 1. Where CE is difference in error voltage.

Table 1. Rule base for fuzzy logic controller

		ERROR VOLTAGE						
		NH	NM	NL	ZO	PL	PM	PH
CE	PH	ZO	PL	PM	PH	PH	PH	PH
	PM	NL	ZO	PL	PM	PH	PH	PH
	PL	NM	NL	ZO	PL	PM	PH	PH
	ZO	NH	NM	NL	ZO	PL	PM	PH
	NL	NH	NH	NM	NL	ZO	PL	PM
	NM	NH	NH	NH	NM	NL	ZO	PL
	NH	NH	NH	NH	NH	NM	NL	ZO

6. MATLAB/SIMULATION RESULTS

In this model up to the rectifier unit for all the four models is same. The rectifier is generating output voltage of 167 V. The MATLAB simulation of this model from AC source to output of rectifier is as shown in Figure 4(a) and output voltage across the rectifier is as shown in Figure 4(b).



(a)

(b)

Figure 4. The AC source to output of rectifier is (a) MATLAB simulation of proposed system and (b) output voltage across rectifier

6.1. Buck boost converter with PI controller

Output of “Three-phase thyristor bridge rectifier” was supplied to seven buck boost converter which is placed in parallel across the AC-DC rectifier. One of the Buck boost conveter connected to battery with proportional integral controller is shown in Figure 5(a). These seven buck-boost converters adjust the DC output voltage to feed the seven EV batteries. The controller used is PI controller.

The output voltage for three phase rectifier bridge rectifiers for firing angle α=30^0 is maintained at approximately at a constant value of 167.1 V. This 167.1 V this 167.1 V is utilized by seven buck boost converters. These buck boost converters operate in closed loop. That is the load voltage is subtracted from the reference voltage which is set to 350V.The error signal is the difference between set voltage and load voltage is given to PI controller. The duty ratio is produced by “PI controller “is given to PWM generator. The SOC characteristics, output voltage, output current characteristics of battery while charging are shown in Figure 5(b). The rectifier and the DC-DC converter are non-linear power electronic circuits, so current harmonics are induced in AC side. The current THD at 11 KV line is 26.49% is observed in Figure 5(c).

6.2. KY boost convetrer with PI controller

The output of “three phase thyristor bridge rectifiers” was given to seven KY Boost converters which are connected in parallel. One of the KY boost conveter connected to battery with Proportional integral controller is shown in Figure 6(a). These seven KY Boost converters adjust the DC out put voltage to feed the seven EV batteries. The SOC characteristics, output voltage, output current characteristics of Battery while charging are shown in Figure 6(b). The rectifier and the DC-DC converter are non-linear power electronic circuits, so current harmonics are induced in AC side. The current THD at 11 KV line is 17.43% is observed in Figure 6(c).

6.3. Buck boost converter controlled with fuzzy logic controller

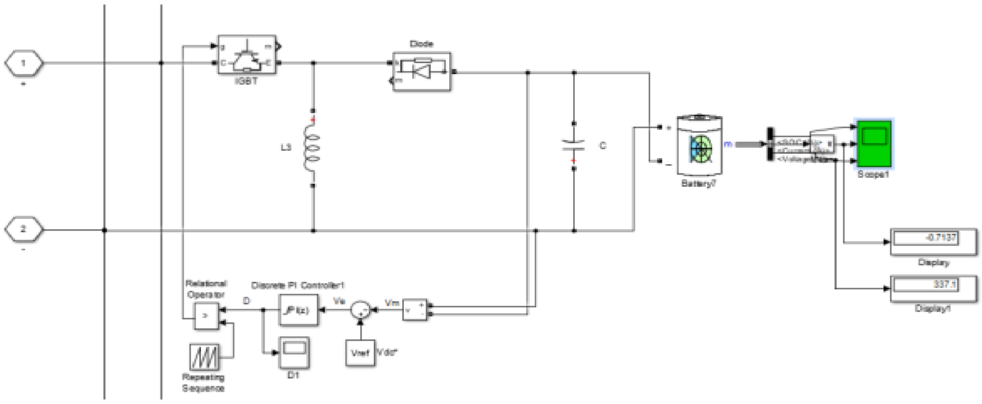
Output DC voltage of “Three-phase thyristor bridge rectifier” was given to seven buck boost converters which are connected in parallel. One of the Buck boost conveter connected to battery with fuzzy logic controller is shown in Figure 7(a). These seven buck boost converters adjust the DC out put voltage to feed the seven EV batteries. The buck boost controlled with “fuzzy-logic-controller”. The output voltage for three phase rectifier bridge rectifiers for firing angle α=30° is maintained at approximately at a constant value of 166.9 V. This 166.9 V is utilized by seven buck boost converters. These buck boost converters operate in closed-loop that is the out-put voltage is compared with set voltage which is set to 350 V. The error signal generated, that is difference between the set and output voltage is fed to “Fuzzy logic controller” and also the difference in error was also given as in-put to “fuzzy-logic controller”. Duty ratio is produced by fuzzy logic controller utilizing the rule base, for which switch has to be operated to make error voltage equal to zero. The duty ratio from Fuzzy logic controller out-put is given to drive “pulse width modulation generater”. The pulses are used to drive the switches to control the load voltage. So, result battery starts charging. The SOC characteristics, output voltage, output current characteristics of battery while charging are shown in Figure 7(b). The rectifier and the DC-DC converter are non-linear power electronic circuits, so current harmonics are induced in AC side. The current THD at 11 KV line is 22.00% is observed in Figure 7(c).

6.4. KY boost converter controlled with fuzzy logic controller

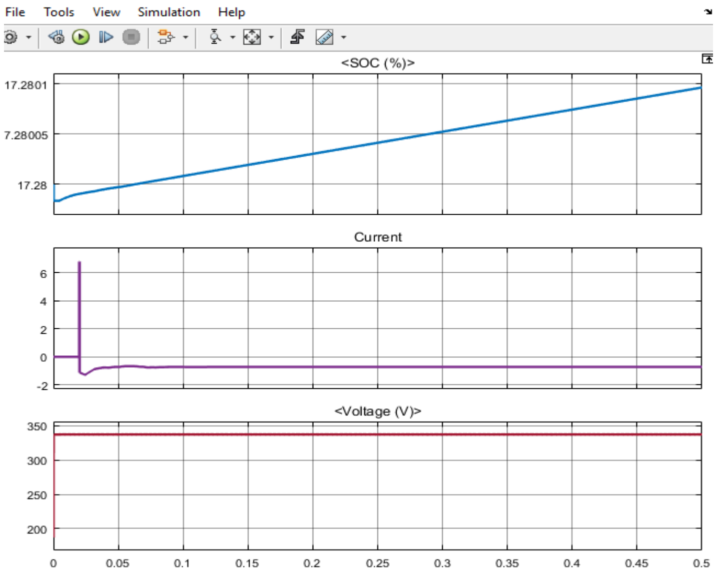
The output voltage of “three phase thyristor bridge rectifiers” was given to seven KY Boost converters which are connected in parallel. One of the KY boost conveter connected to battery with fuzzy logic controller is shown in Figure 8(a). These seven KY Boost converters adjust the DC out put voltage to feed the seven EV batteries. The KY Boost converter is operated by fuzzy logic controller. The SOC characteristics, output voltage, output current characteristics of battery while charging are shown in Figure 8(b). The rectifier and the DC-DC converter are non-linear power electronic circuits, so current harmonics are induced in AC side. The current THD at 11 KV line is 13.38% is observed in Figure 8(c). Table 2 represents the four different controllers current THD and power comparisons, among four controllers the KY boost converter with fuzzy logic controller has lower THD.

Table 2. THD power comparisons

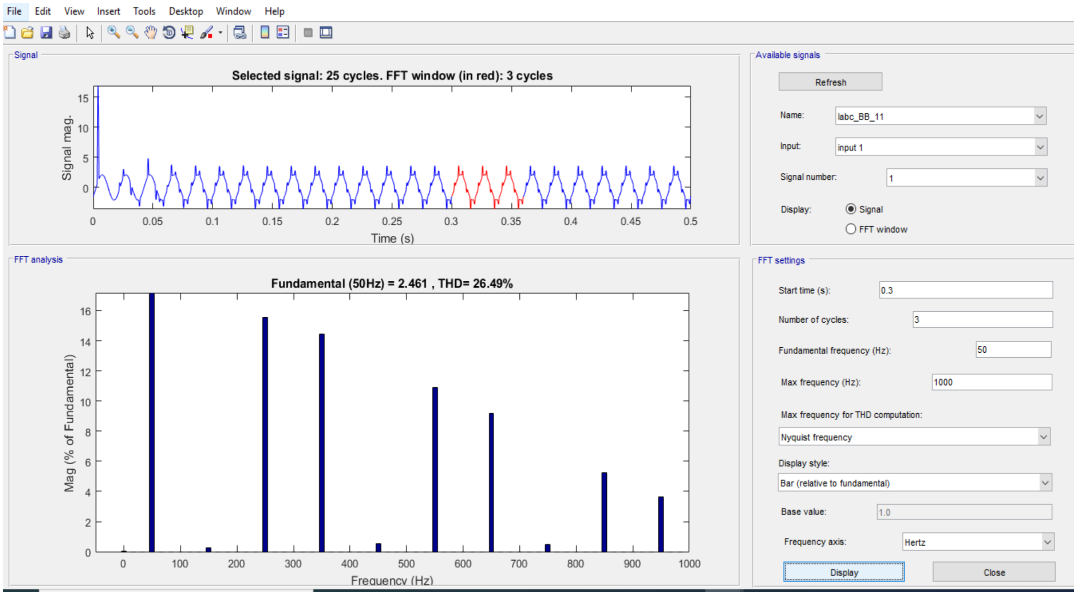
Converter with controller	Current THD at 11KV (%)	Power at the rectifier output (W)
Buck boost converter with PI controller	26.49	3482
KY boost converter with PI controller	17.43	4078
Buck boost converter with fuzzy logic controller	22.00	4222
KY boost converter with fuzzy logic controller	13.38	3826



(a)

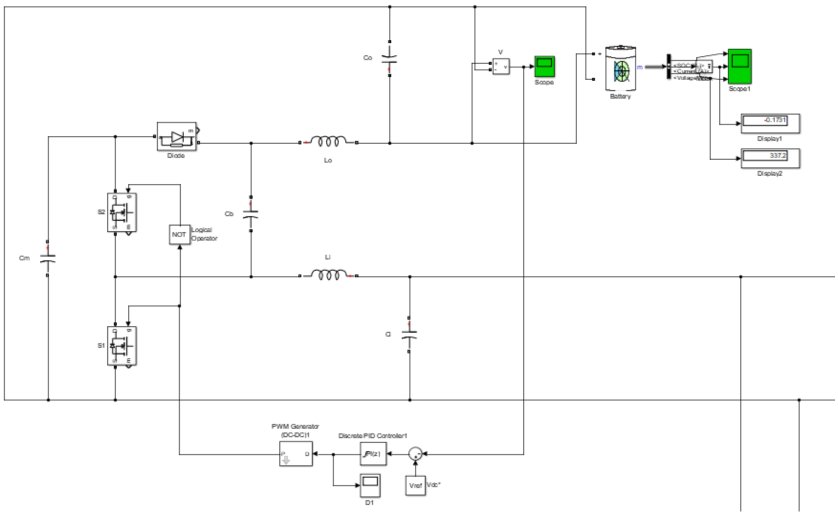


(b)

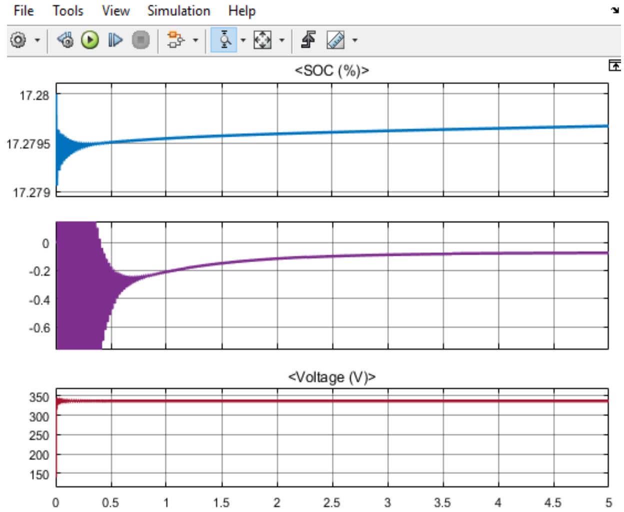


(c)

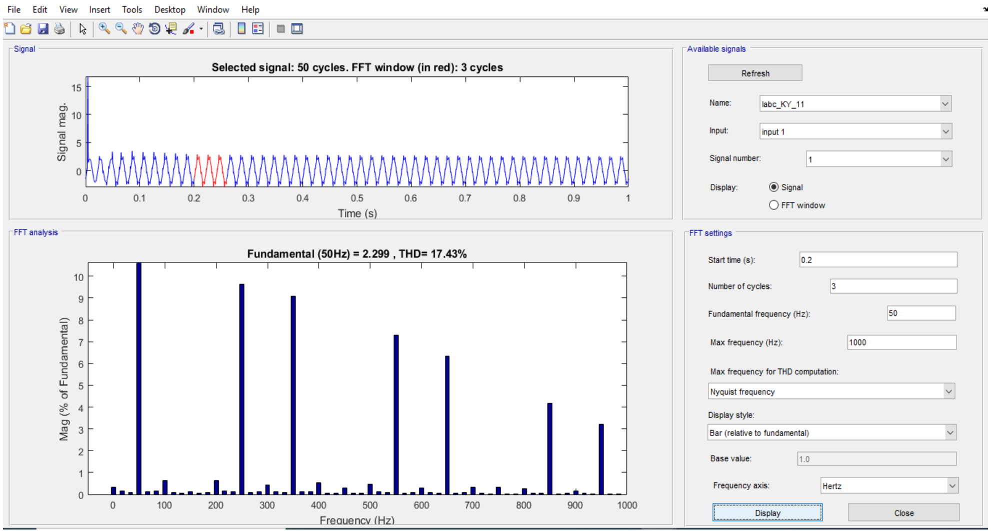
Figure 5. Simulink waveform of buck-boost converter with PI-controller: (a) closed-loop buck-boost converter controlled by PI controller, (b) SOC characteristics, output voltage, output current characteristics of battery and (c) current THD at 11 KV



(a)

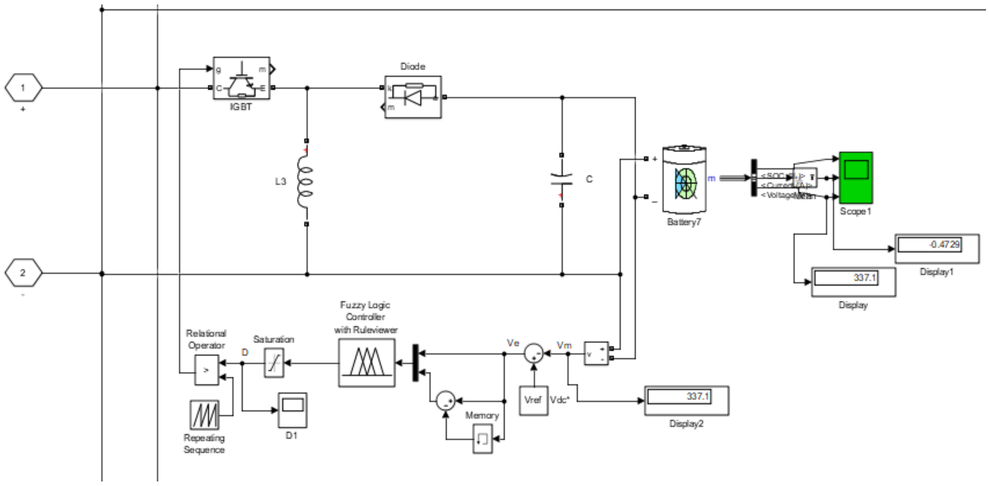


(b)

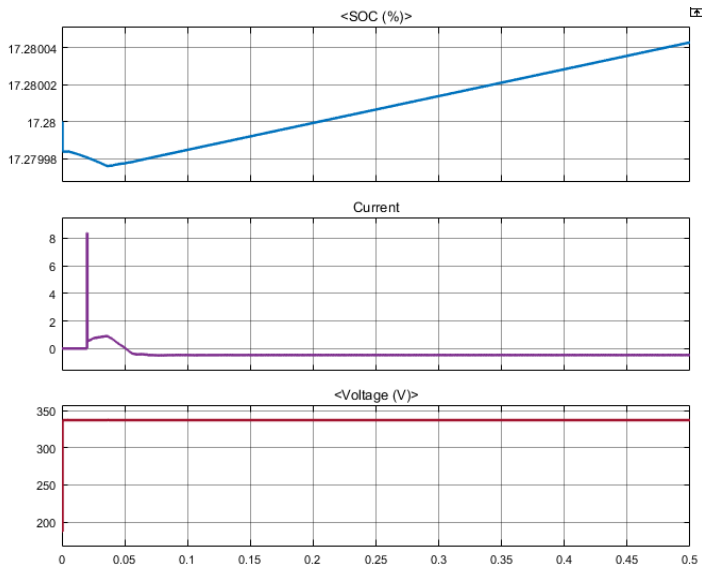


(c)

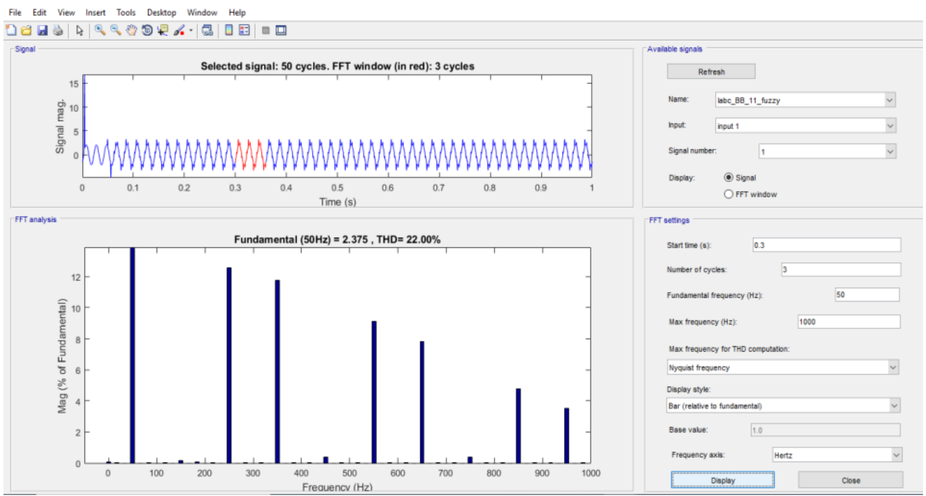
Figure 6. Simulink waveform of KY boost converter with PI-controller (a) closed-loop KY Boost converter controlled by PI controller, (b) SOC characteristics, output voltage, output current characteristics of battery and (c) current THD at 11 KV



(a)

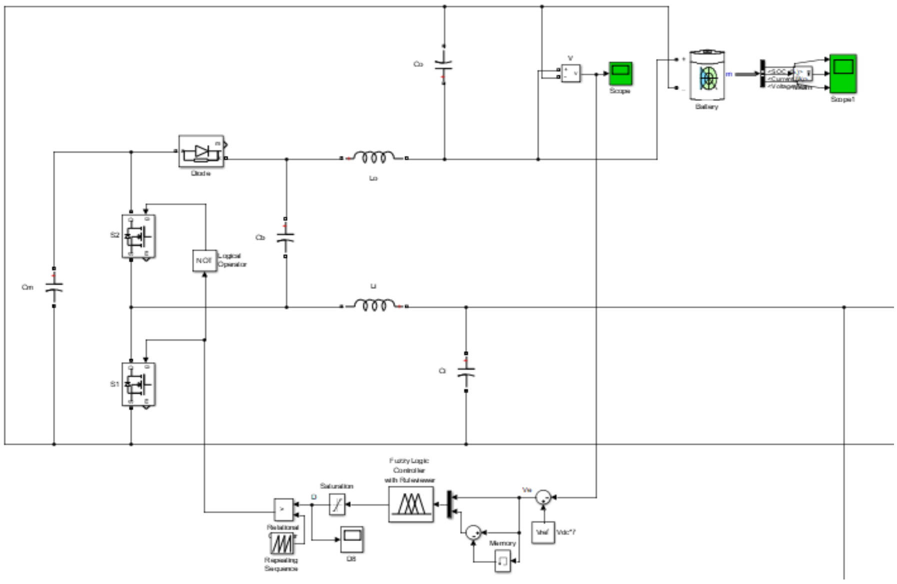


(b)

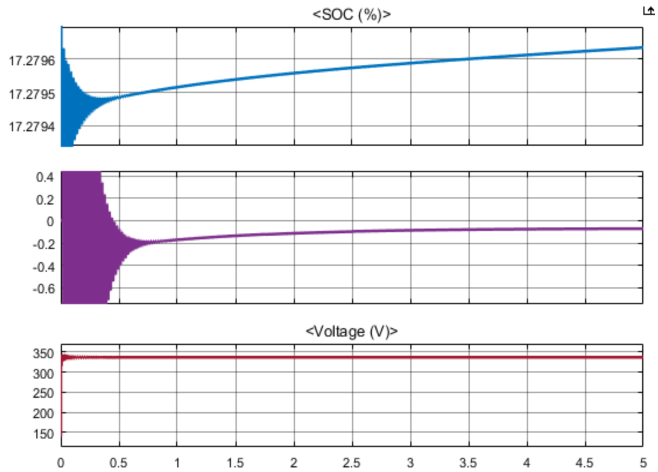


(c)

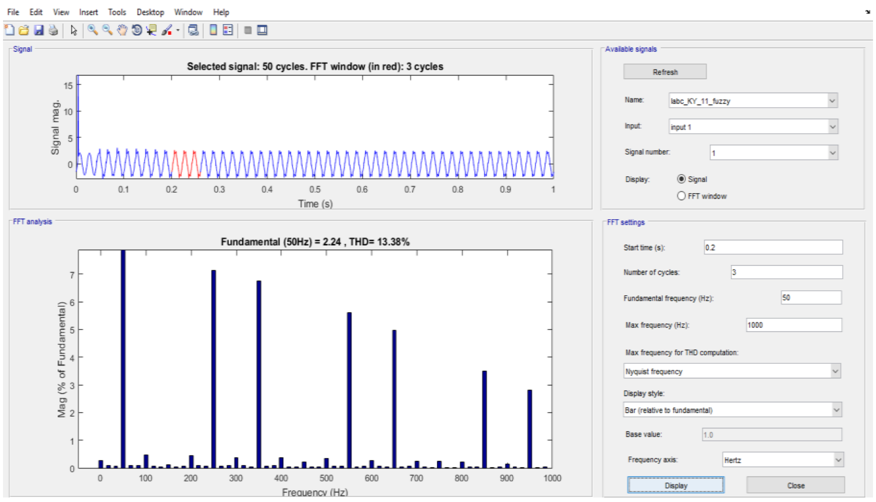
Figure 7. Simulink waveform of buck-boost converter with fuzzy-logic controller: (a) closed-loop buck-boost converter controlled by fuzzy logic controller, (b) SOC characteristics, output voltage, output current characteristics of battery and (c) current THD at 11 KV



(a)



(b)



(c)

Figure 8. Simulink waveform of KY-boost converter with fuzzy-logic controller: (a) closed-loop buck-boost converter controlled by PI controller, (b) SOC characteristics, output voltage, output current characteristics of battery and (c) current THD at 11 KV

7. CONCLUSIONS AND FUTURE SCOPE

By comparing the four charges THD with the charger with KY boost-converter controlled with "fuzzy-logic controller" has lowest harmonic contamination in terms of voltage and current so it is better to have charger with KY Boost-converter controlled with "fuzzy logic controller" out of four charges. The harmonics can be effectively reduced by designing compensating equipments, so that these compensators will supply harmonics and the grid will supply only the fundamental current.

REFERENCES

[1] W. Yang, J. Wang, Z. Zhang, and Y. Gao, "Simulation of electric vehicle charging station and harmonic treatment," in *2012 International Conference on Systems and Informatics (ICSAI2012)*, May 2012, pp. 609–613, doi: 10.1109/ICSAI.2012.6223071.

[2] A. Megha, N. Mahendran, and R. Elizabeth, "Analysis of Harmonic Contamination in Electrical Grid due to Electric Vehicle Charging," in *2020 Third International Conference on Smart Systems and Inventive Technology (ICSSIT)*, Aug. 2020, pp. 608–614, doi: 10.1109/ICSSIT48917.2020.9214096.

[3] K. I. Hwu and Y. T. Yau, "A KY Boost Converter," in *2009 Twenty-Fourth Annual IEEE Applied Power Electronics Conference and Exposition*, Feb. 2009, pp. 1417–1420, doi: 10.1109/APEC.2009.4802851.

[4] R. Vinayakumar, M. Alazab, K. P. Soman, P. Poornachandran, A. Al-Nemrat, and S. Venkatraman, "Deep Learning Approach for Intelligent Intrusion Detection System," *IEEE Access*, vol. 7, pp. 41525–41550, 2019, doi: 10.1109/ACCESS.2019.2895334.

[5] K. Sivaraman, R. M. V. Krishnan, B. Sundarraj, and S. Sri Gowthem, "Network failure detection and diagnosis by analyzing syslog and SNS data: Applying big data analysis to network operations," *Int. J. Innov. Technol. Explor. Eng.*, vol. 8, no. 9 Special Issue 3, pp. 883–887, 2019, doi: 10.35940/ijitee.I3187.0789S319.

[6] A. D. Dwivedi, G. Srivastava, S. Dhar, and R. Singh, "A decentralized privacy-preserving healthcare blockchain for IoT," *Sensors*, vol. 19, no. 2, pp. 1–17, 2019, doi: 10.3390/s19020326.

[7] F. Al-Turjman, H. Zahmatkesh, and L. Mostarda, "Quantifying Uncertainty in Internet of Medical Things and Big-Data Services Using Intelligence and Deep Learning," *IEEE Access*, vol. 7, pp. 115749–115759, 2019, doi: 10.1109/ACCESS.2019.2931637.

[8] S. Kumar and M. Singh, "Big data analytics for healthcare industry: impact, applications, and tools," *Big Data Min. Anal.*, vol. 2, no. 1, pp. 48–57, Mar. 2019, doi: 10.26599/BDMA.2018.9020031.

[9] L.-M. Ang, K. P. Seng, G. K. Ijemaru, and A. M. Zungeru, "Deployment of IoV for Smart Cities: Applications, Architecture, and Challenges," *IEEE Access*, vol. 7, pp. 6473–6492, 2019, doi: 10.1109/ACCESS.2018.2887076.

[10] B. P. L. Lau *et al.*, "A survey of data fusion in smart city applications," *Inf. Fusion*, vol. 52, pp. 357–374, Dec. 2019, doi: 10.1016/j.inffus.2019.05.004.

[11] S. Kumar Ajmeera, B. Balu, and S. Sreenu, "A Novel Reduced Capacitance with Quasi-Z-Source Inverter for RES Application," *Pramana Res. J.*, vol. 9, no. 6, pp. 1279–1291, 2019.

[12] Y. Wu *et al.*, "Large scale incremental learning," *Proc. IEEE Comput. Soc. Conf. Comput. Vis. Pattern Recognit.*, vol. 2019-June, pp. 374–382, 2019, doi: 10.1109/CVPR.2019.00046.

[13] A. Mosavi, S. Shamshirband, E. Salwana, K. Chau, and J. H. M. Tah, "Prediction of multi-inputs bubble column reactor using a novel hybrid model of computational fluid dynamics and machine learning," *Eng. Appl. Comput. Fluid Mech.*, vol. 13, no. 1, pp. 482–492, 2019, doi: 10.1080/19942060.2019.1613448.

[14] V. Palanisamy and R. Thirunavukarasu, "Implications of big data analytics in developing healthcare frameworks – A review," *J. King Saud Univ. - Comput. Inf. Sci.*, vol. 31, no. 4, pp. 415–425, Oct. 2019, doi: 10.1016/j.jksuci.2017.12.007.

[15] J. Sadowski, "When data is capital: Datafication, accumulation, and extraction," *Big Data Soc.*, vol. 6, no. 1, pp. 1–12, 2019, doi: 10.1177/2053951718820549.

[16] J. R. Saura, B. R. Herraez, and A. Reyes-Menendez, "Comparing a traditional approach for financial brand communication analysis with a big data analytics technique," *IEEE Access*, vol. 7, pp. 37100–37108, 2019, doi: 10.1109/ACCESS.2019.2905301.

[17] D. Nallaperuma *et al.*, "Online Incremental Machine Learning Platform for Big Data-Driven Smart Traffic Management," *IEEE Trans. Intell. Transp. Syst.*, vol. 20, no. 12, pp. 4679–4690, 2019, doi: 10.1109/TITS.2019.2924883.

[18] S. Schulz, M. Becker, M. R. Groseclose, S. Schadt, and C. Hopf, "Advanced MALDI mass spectrometry imaging in pharmaceutical research and drug development," *Curr. Opin. Biotechnol.*, vol. 55, pp. 51–59, Feb. 2019, doi: 10.1016/j.copbio.2018.08.003.

[19] C. Shang and F. You, "Data Analytics and Machine Learning for Smart Process Manufacturing: Recent Advances and Perspectives in the Big Data Era," *Engineering*, vol. 5, no. 6, pp. 1010–1016, 2019, doi: 10.1016/j.eng.2019.01.019.

[20] Y. Yu, M. Li, L. Liu, Y. Li, and J. Wang, "Clinical big data and deep learning: Applications, challenges, and future outlooks," *Big Data Min. Anal.*, vol. 2, no. 4, pp. 288–305, 2019, doi: 10.26599/BDMA.2019.9020007.

[21] M. Huang, W. Liu, T. Wang, H. Song, X. Li, and A. Liu, "A queuing delay utilization scheme for on-path service aggregation in services-oriented computing networks," *IEEE Access*, vol. 7, pp. 23816–23833, 2019, doi: 10.1109/ACCESS.2019.2899402.

[22] G. Xu, Y. Shi, X. Sun, and W. Shen, "Internet of Things in Marine Environment Monitoring: A Review," *Sensors*, vol. 19, no. 7, p. 1711, Apr. 2019, doi: 10.3390/s19071711.

[23] M. Aqib, R. Mehmood, A. Alzahrani, I. Katib, A. Albeshri, and S. M. Altowaijri, "Smarter Traffic Prediction Using Big Data, In-Memory Computing, Deep Learning and GPUs," *Sensors*, vol. 19, no. 9, p. 2206, May 2019, doi: 10.3390/s19092206.

[24] S. Leonelli and N. Tempini, *Data Journeys in the Sciences*. Springer.

[25] N. Stylos and J. Zwiegelaar, "Big Data as a Game Changer: How Does It Shape Business Intelligence Within a Tourism and Hospitality Industry Context?," in *Big Data and Innovation in Tourism, Travel, and Hospitality*, Singapore: Springer, 2019, pp. 163–181.

[26] B. Balu, S. K. Ajmeera, and S. Sreenu, "Comparative Study of Various PWM methodologies for Grid connected Inverter for RES Application," *Pramana Res. J.*, vol. 9, no. 6, pp. 1267–1271, 2019, doi: 10.32968/PRJ.2249-2976.

[27] Q. Song, H. Ge, J. Caverlee, and X. Hu, "Tensor Completion Algorithms in Big Data Analytics," *ACM Trans. Knowl. Discov. Data*, vol. 13, no. 1, pp. 1–48, Jan. 2019, doi: 10.1145/3278607.

BIOGRAPHIES OF AUTHORS

Jalla Upendar he has an Assistant Professor at the Department of Electrical Engineering, University college of Engineering, Osmania university, Hyderabad, India, where he has been a faculty member since 2013. From 2010-2013, he was also the Senior Engineer-Power Electronics Team Development, General Electric (GE Power Conversion) (CVT EDC Private Limited) Chennai-32, India (and in UK, France), And completed his Doctor of Philosophy (Ph.D.) in Electrical Engineering from Indian Institute of Technology (IIT), Roorkee, India. His research interests are primarily in the area of intelligent approach for fault classification of power transmission systems, where he is the author/co-author of over 30 research publications. He can be contacted at email: dr.8500003210@gmail.com.

Sangem Ravi Kumar he is PG scholar at the Department of Electrical Engineering, University college of Engineering, Osmania university, Hyderabad, India, And He received Bachelor of Technology (B.Tech) in Electrical and Electronics Engineering, at Gugu Nanak Institute of Technology in 2018. He can be contacted at email: sangem.ravi11@gmail.com.

Sapavath Sreenu he has Research scholar at the Department of Electrical Engineering, University college of Engineering, Osmania university, Hyderabad, India. He received Master of Technology (M.Tech) in Power Electronics and Electrical Drives (PE&ED) from Anurag Engineering College (Autonomous), Kodad, India. And He received Bachelor of Technology (B.Tech) in Electrical and Electronics Engineering, SRREC, Karepally, India. He can be contacted at email: sreenu274@gmail.com.

Bogimi Sirisha she holds a B.E. in Electrical Engineering from Osmania University, M. Tech Power Eelectronics from JNTUH in 2003, and a Ph.D. degree from Osmania University 2018. She has over 16 years of experience in research and teaching and is currently employed as an Associate Professor in Electrical Department, Engineering College, Osmania University, Hyderabad INDIA. She has published various articles in international and national journal publications and conferences. Multilevel inverters, power electronics and drives, renewable energy applications and special electrical machines are among her research interests. Osmania University awarded her a Ph.D. in the field of multilevel inverters. Shee can be contacted at email: sirishab@osmania.ac.in.