Dynamic Performance Improvement of AFZ Converter with Improved Voltage Stability

Dr.D.Hemanand[1], Mr.Varatharaju[2],Dr.S.Gomathi[3],Mr.R.Manivannan[4], Dr.C.Naresh[5],Dr.S.Kannadhasan[6]

[1]*Professor, SA Engineering College, Chennai, Tamilnadu, India*
[2] *Professor, Electrical Section, University of Technology and Applied Science lbra.*
[3]*Associate Professor, St.Joseph's Institute of Technology, Chennai, Tamilnadu, India*
[4]*Assistant Professor, St.Joseph's Institute of Technology, Chennai, Tamilnadu, India*
[5]*Research Assistant, Chennai, Tamilnadu, India*
[6]*Associate Professor, Cheran College of Engineering, Karur, Tamilnadu, India*

d.hemanand@gmail.com[1], vmvraj@gmail.com[2], sgomathi411@gmail.com[3], manivannanr@stjosephstechnology.ac.in[4],c.naresh74@gmail.com[5], kannadhasan.ece@gmail.com

Abstract

The work is used to model and simulate a photovoltaic (PV)-based DC-DC Module Integrated Converter (MIC). It is proposed to use an autotransformer with type-Zeta resonant reset as a cascaded MIC. Due to its voltage raising capability, the AFZ converter is extremely versatile. It also uses a simplified autotransformer with only two windings, reducing complexity and power losses. It also has good dynamic performances, similar to those of the Forward converter. Resonant reset of the autotransformer type Zeta enables smooth transitions between modes.Time domain response of C Filter and Cascaded Filters (CF) arecompared. Experimental results validated.

Keywords:AFZ converter, PV cell, Autotransformer ,Filter, Cascaded Filter(CF), Dynamic Performance

1.INTRODUCTION

Renewable and green sources of energy are becoming more and more popular. One of the most important is photovoltaic energy. One of the biggest problems with high-power PV installations that are tied to the grid is that different PV panels on the same string reduce the amount of power that can be harvested. The word for this is "mismatching. This means that even when the sun is shining brightly and the weather is perfect, the power generated will be less. Connecting a DC-DC module integrated converter (MIC) to each PV panel is one of the most common ways to fix the mismatching problem. MICs are used, makes it possible to get the most power out of the installation, no matter how the other PV panels are working [1]–[2]. This MIC also controls the solar panel and makes sure it works at full power (MPP). The plans for this solution are called Distributed Maximum Power Point Tracking (DMPPT) [3]-[4] . Because of this, the MIC requirements for a flexible and profitable PV installation are low cost, high efficiency, and the ability to step up or step down the voltage.All of them achieve greater efficiency since the converter manages just a fraction of the energy, while the remainder is sent straight from the PV panel to the load. This sort of converters can obtain a maximum efficiency of 98 percent, as demonstrated in [5]. Other authors have achieved efficiencies of approximately 98 percent with full power processing topologies, but without the ability to perform both voltage step-down and step-up [6]-[20].

2.PROPOSED CONVERTER

This system introduces and thoroughly examines the AFZ with type-Zeta resonant converter, which aims to overcome the mismatching issue.Transitions between two major intervals are then investigated.

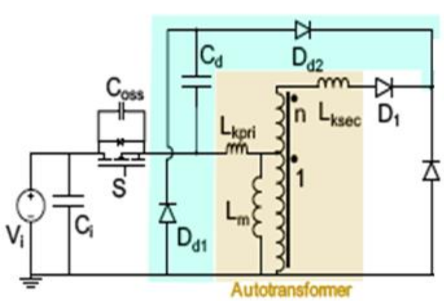

Fig 1Proposed diagram of AFZ Converter

t_{ON} (t_0 - t_1)

While the S is on, the converter uses an autotransformer to transfer power from the I/P to the O/P of the converter.L, Lm, Lkp, and Lks gain energy as a result of the current flow. High-frequency resonance By increasing the voltages of the capacitors, the energy transferred causes a voltage step.

t_{OFF1} ($t_2 – t_3$)

When the Lks delivers its energy to the Co and Cd and the ILkp equals theIm, t_{OFF1} subinterval begins.The S and D1 diode reach their maximum voltages at the end of this subinterval, when Imis zero amperes.

t_{OFF2} (t_3 - t_4)

The second part of the Type-Zeta resonant reset occurs during t_{OFF2}. The capacitors return the stored energy to the Lm.

t_{OFF3} (t_4 - t_5)

Because the Co and Lkp are orders of magnitude smaller than the Cd and Lm, they are ignored in the design.

t_{ON-T}(t_5 - t_6)

When the S is turned back on, the transition interval between the t_{OFF} and t_{ON}occurs,It is denoted by the symbol t_{ON-T}. The current flows through the S during this transition.

$$\Delta_m = \frac{Ts-0.5\,Tr}{Ts} = \frac{2.fr-fs}{2fr}$$

$$f_r = \frac{1}{2.\pi\sqrt{(L+Lk).(Cd+Co)}}$$

Table1: Switching Period Intervals

	Interval
ON	t_{on}
OFF-T	t_{off-T}
OFF	t_{off}
OFF1	t_{off1}
OFF2	t_{off2}
OFF3	t_{off3}
Re	$t_{off1}\,\&t_{off2}$
ON-T	t_{on-T}

Pmagnetic denotes magnetically processed power, whereas Pnmagnetic denotes unmagnetically processed power. Lmis not included because it has no effect on the energy delivered to theload.

$$P_{magnetic} = P_i.\frac{k}{1+k}$$

$$P_{n.magnetic} = P_i.\frac{1}{1+k}$$

4. SIMULATION RESULTS

AFZ converter circuit diagram Fig 3 depicts the use of C-Filter. Fig 4 depicts the I/P voltage, which is 15V. Fig 5 shows voltage across the R-load, which is 94V. Fig 6 shows the O/P voltage ripple, which is 7V.

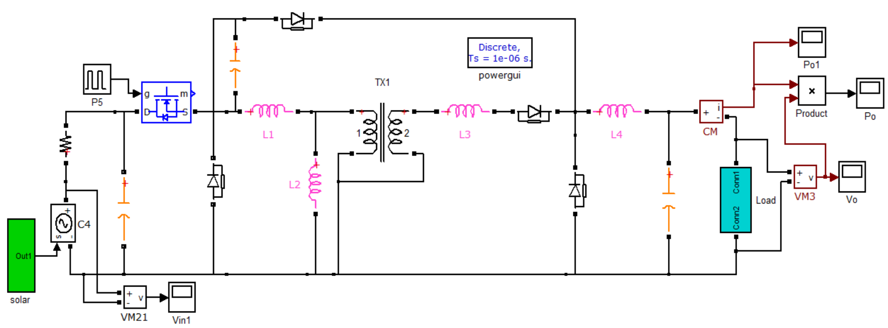

Fig 2. AFZ converter With C-Filter

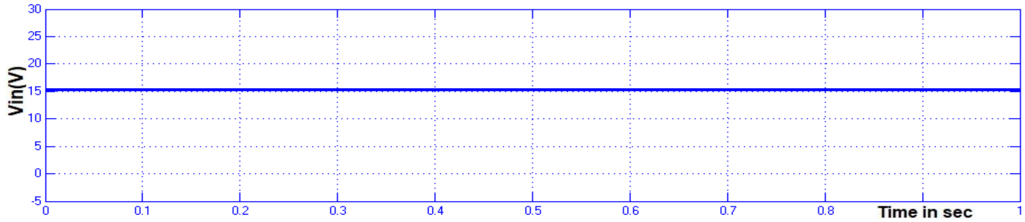

Fig 3. I/P voltage

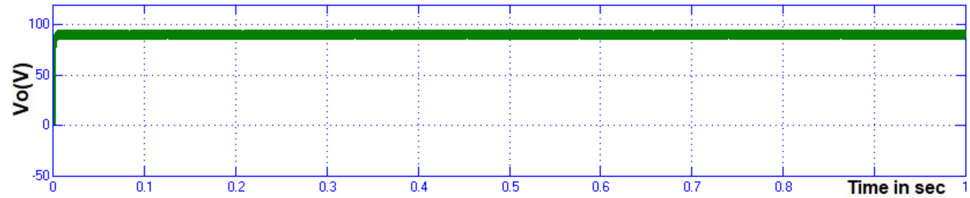

Fig 4. R-loadVoltage

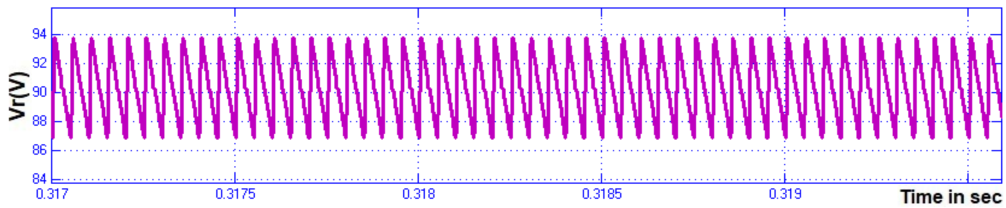

Fig 5.O/PVoltage Ripple

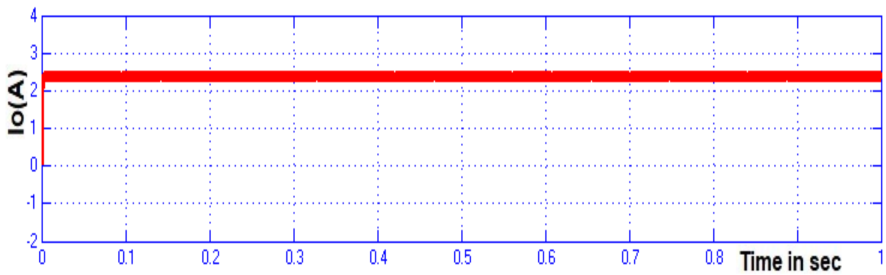

Fig 6. R load Current

Current through R load is shown in fig 7 and its value is 2.47A. O/P current ripple is shown in fig 8and its value is 1.7A. O/P power is shown in fig 9 and its value is 230W. O/Ppower ripple is shown in fig 10 and its value is 30W**.**

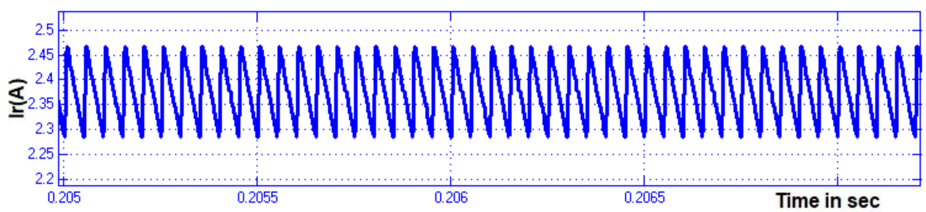

Fig 7. O/Pcurrent Ripple

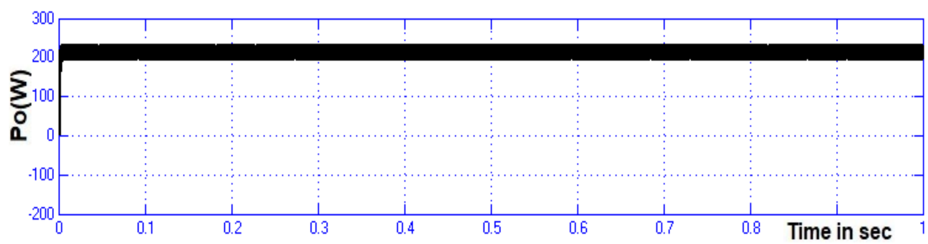

Fig 8. O/P power

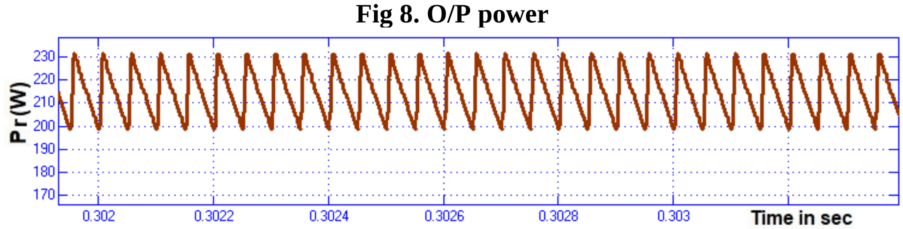

Fig 9. O/P ripple

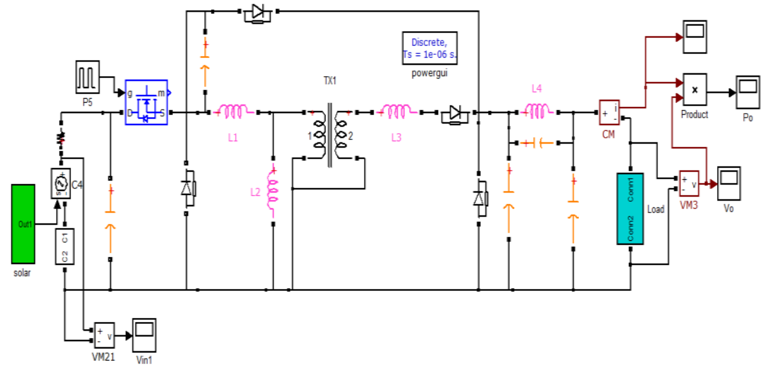

Fig 10. AFZ converter With Cascaded-Filter

AFZ converter With CF is shown in fig 11. The I/P voltage is shown in fig 12 and its value is 15V. Voltage across R-load is shown in fig 13 and its value is 94V. O/P voltage ripple is shown in fig 14 and its value is 0.03V.

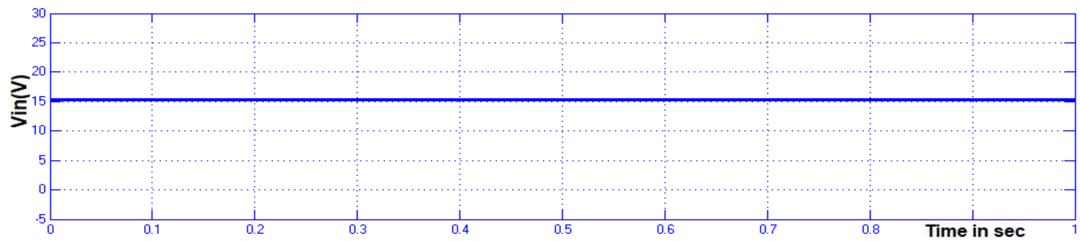

Fig 11. I/P voltage

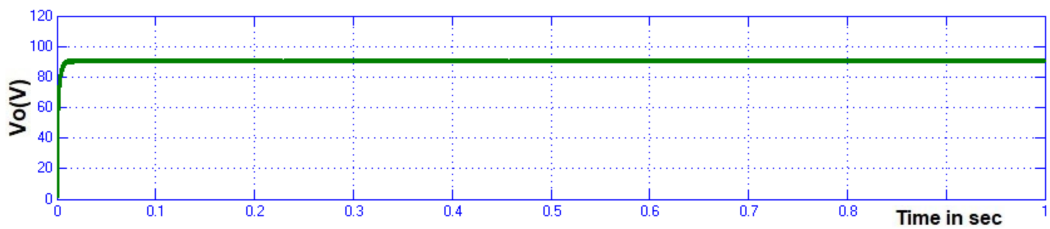

Fig 12. R-load Voltage

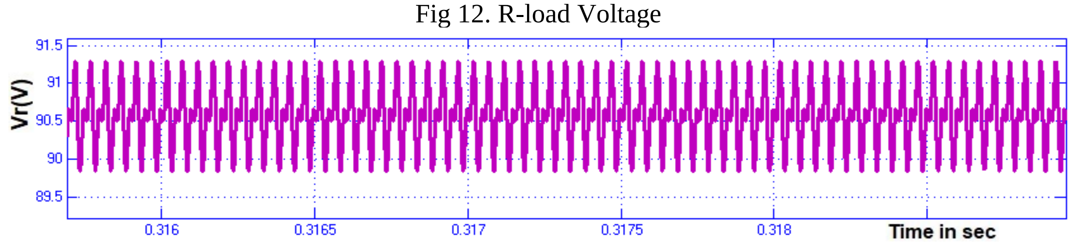

Fig 13. O/PVr

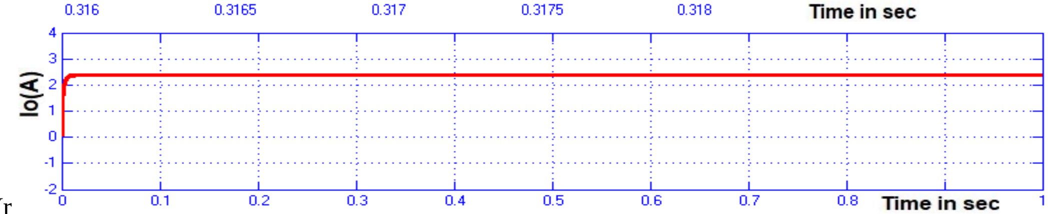

Fig 14. R load Current

Current through R load is shown in fig 15 and its value is 2.47A. O/P current ripple is shown in fig 16 and its value is 0.03A. O/P power is shown in fig 17 and its value is 230W. O/P power ripple is shown in fig 18 and its value is 6W.

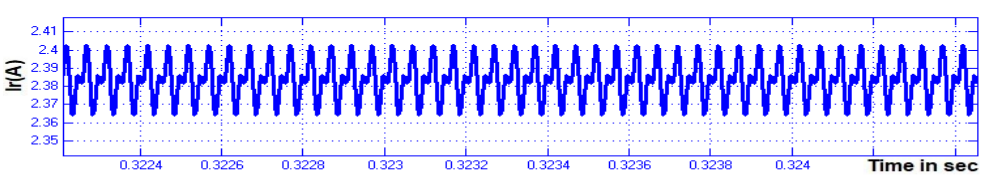

Fig 15. O/PIr

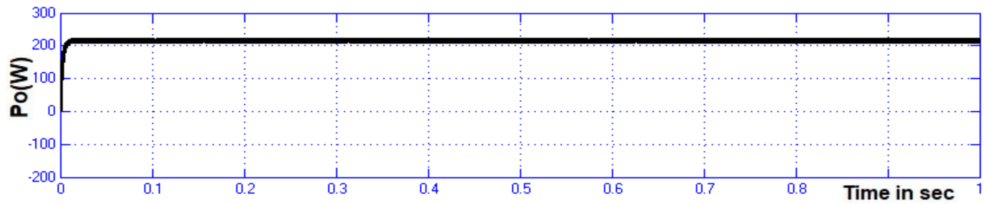

Fig 16. O/P power

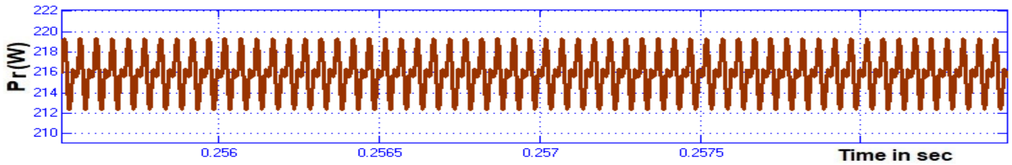

Fig 18. O/PPr

Table-2

Comparison of Parameters

AFZ Converter	Vor(V)	Ior(V)	Por(W)
C-Filter	7	0.17	30
Cascaded Filter	1.5	0.03	6

Table-3

Comparison Time Domain specifications

	tr (s)	tp (s)	ts (s)	Es (V)
C-Filter	0.52	0.67	1.14	1.82
Cascaded Filter	0.48	0.58	0.80	1.23

4.CONCLUSION

AFZ converter with C-Filter system is simulated. Circuit diagram of AFZ converter with Cascaded Filter is simulated. Above systems are compared. From Table 2 Output voltage ripple is reduced from 7V to 1.5 V by using AFZ converter with Cascaded Filter system. Output ripple current is reduced from 0.17A to 0.03A by using AFZ converter with Cascaded Filter system. Output power ripple is reduced from 30W to 6W by using AFZ converter with Cascaded Filter system. Hence the AFZ converter with CF system has better performance than AFZ converter with C-Filter system. From Table 3 Parameters observation settling time reduced from1.14S to 0.80S and Steady state Error decreased to1.23.

5.REFERENCE

1. M.A.Al-Saffar, -E.H.Ismail and-A.J.Sabzali, "High efficiency quadratic boost converter," *2012 -Twenty-Seventh-Annual-IEEE-Applied-Power-Electronics-Confe..,and -Exposition (APEC)*, -Orlando, FL, -2012, pp-1245-1252.
2. R. V. Babu, P. M. Kumar and G.S.Rao, "-Design&-modeling-of-fuel-cell-powered quadratic-Boost-converter-based-multi-level-inverter," *-2017 –Innovations-in Power-and Advanced-Computing-Technologies-(i-PACT)*, -Vellore, -2017, pp-1-6.
3. J. D. Navamani, J. M. Raj, K. Vijayakumar and A. Lavanya, "-Analysis-of-modified –quadratic-DC-DC boost converter," *2017 International-Confe.., on Inventive-Systems &Control-(ICISC)*, Coimbatore, 2017, pp. 1-5.
4. PingYang,-JianpingXu,-GuohuaZhou and-ShiyuZhang, "A-new-quadratic-boost converter-with-high-voltage-step-up-ratio-and-reduced-voltage-stress," *Pro..,of The-7th-International-P.E&Motio- Control-Conference*, Harbin, 2012, pp. 1164-1168.
5. S. Zhang, J. Xu and P. Yang, "-A-single-switch-high-gain-quadratic-boost-converter based-on voltage-lift-technique," *2012 10th International-Power &-Energy-Conference (IPEC)*, Ho Chi Minh City, 2012, pp. 71-75

6. Kuo, J.K.. "-An-integrated-simulation-model-for-PEM-fuel cell-power-ystems-with-a buck-DC –DC converter", -Internati..,-Jour.., of Hydrogen-Energy, vol.36, no.18, pp.11846-11855, September 2011.
7. T. R. Choudhury and B.Nayak, "-Comparison &-analysis of-cascaded &-Quadratic-Boost- -Converter," *2015 IEEE-Power,-Communication & Information-Technology Conference (PCITC)*, Bhubaneswar, 2015, pp. 78-83.
8. V.Vijayakumar, -R.Divya, and -A.Vivek, "-Sliding-mode-controlled-quadratic-boost -converter",-in-IEEE-Intern..,-Conf.., on-Computation-of-Power, -Energy, -Information and-Communication ,2014 ,.pp. 189-193.
9. A. Rico, et al, "Power Injection Control System and Experimental Model based on Manufacturer Characteristic Curves for a Photovoltaic Generation System", in 2007 Compatibility in Power Electronics, CPE'07, Digital object Identifier:10.1109/CPE.2007.4296501, pp. 1-7
10. Femia, N.; Lisi, G.; Petrone, G.; Spagnuolo, G.; Vitelli, M. "Distributed Maximum Power Point Tracking of Photovoltaic Arrays: Novel Approach and System Analysis" Industrial Electronics, IEEE Transactions on Volume: 55 , Issue: 7 DOI: 10.1109/TIE.2008.924035 Publication Year: 2008, Page(s): 2610 - 2621
11. G. R. Walker and P. C. Sernia, "Cascaded DC/DC Converter Connection of Photovoltaic Modules," IEEE Trans. Power Electron., vol. 19, no. 4, pp. 1130–1139, 2004.10.1109/TEC.2006.874230, pp. 439-449.
12. A. Elasser, et al., "A Comparative Study of Central and Distributed MPPT Architectures for Megawatt Utility and Large Scale Commercial Photovoltaic Plants", in the 36th Annual Conference on IEEE Industrial Electronics Society (IECON) 2010, Digital Object Identifier: 10.1109/IECON.2010.5675108.347797, pp. 2753-2758
13. S. Poshtkouhi, V. Palaniappan, O. Trescases, "A General Approach for Quantifying the Benefit of Distributed Power Electronics for Fine Grained MPPT in Photovoltaic Applications Using 3-D Modeling", IEEE Transactions in Power Electronics 2012. Volume:27, Issue:11, Digital Object Identifier: 10.1109/TPEL.2011.2173353, pp. 4656-4666
14. Bratcu, et al., "Power Optimization Strategy for Cascaded DC-DC Converter Architectures of Photovoltaic Modules", in IEEE International Conference on Industrial Technology, 2009. ICIT 2009. Digital Object Identifier:10.1109/ICIT.2009.4939559, pp.1-8
15. Gomathi, S, "Enhancement of Modified Multiport Boost Converter for Hybrid System"International Conference on Innovative Computing,Intelligent Communication and Smart Electrical systems,Sep2021.
16. R.M. Button, "An advanced photovoltaic array regulator module", in the Proceedings of the 31st Intersociety Energy Conversion Engineering Conference, 1996, IECEC'96. Volume:1, Digital Object Identifier: 10.1109/IECEC.1996.552937, pp. 519-524
17. H. Kim, et al., "A highly efficient PV system using a series connection of DC-DC converter output with a photovoltaic panel", Original Research Article Renewable Energy, Volume 34, Issue 11, November 2009, Pages 2432-2436
18. Gomathi, S , "PFC Based Three Stage Interleaved Boost Converter For Renewable Energy System" 6th International Conference on Trends in Electronics and Informatics (ICOEI) April 2022.pp.289 – 295.
19. Gomathi, S Suganyadevi, MV, "Active Bridges based Bidirectional DC-DC converter for Solar PV application," International conference on smart Electronics and Communication (ICOSEC 2020) September 2020.pp1087-1094.
20. Gomathi, S, "Steady State Analysis of Wireless Power Transfer based LCC-C Resonant Converter" 6th International Conference on Trends in Electronics and Informatics (ICOEI) April 2022.pp.386 – 391.