iJRASET
International Journal For Research in Applied Science and Engineering Technology



INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 10 **Issue:** V **Month of publication:** May 2022

DOI: https://doi.org/10.22214/ijraset.2022.43154

www.ijraset.com

Call: 08813907089 | E-mail ID: ijraset@gmail.com

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.538
Volume 10 Issue V May 2022- Available at www.ijraset.com

Performance Analysis of Buck Boost and Cuk converters for Solar PV Applications using PI Controller and Fuzzy Logic Controller

Huliraja, S.G Srivani
Department of Electrical and Electronics Engineering, RV College of Engineering, Bengaluru, Karnataka, India

Abstract: ***In this paper, analysis of DC-DC converters Buck-Boost and Cuk converter by using PI Controller and Fuzzy Logic controller. These converters are mainly used in solar PV applications and it is explained. In this paper mainly MATLAB/ Simulink software is used for the compare the performance of both. the design is mainly compared with the proportional integrated controller versus FLC. The main objective of this work to reduce the overshoot of these types of converters. The buck boost and cuk converter are simulated for different Loads and their output voltage is settle at desired voltage The performance of buck-boost and cuk converter are simulated using Matlab/Simulink and comparison study is performed. The complete control system has been developed analysed and validation by the simulation.***

Keywords: Buck-Boost Converter, Cuk Converter, MATLAB/ Simulink, Solar PV and Fuzzy Logic Converter.

I. INTRODUCTION

In recent year there has been an increasing in the development of DC-DC converter to improve the dynamic behaviour [1-2]. The performance of power converters is the choice of control methods. Frequency domain analog methods predominantly used are based on an equivalent linear small signal model of the converter and this model has restricted validity especially for systems with strong non-linearity. FLC is mostly used in industrial application and the main tool of FLC operation is membership function. It doesn't require any mathematical model for a system. The FLC provides a faster transient response [3-4]. Generally, DC-DC converters are used in DC motor drive applications, switched power supplies, marine cranes, electric cars, power factor correction applications and PWM based photovoltaic systems [1-3]. DC-DC converters are classified according to circuit topologies as buck converter, boost converter, buck-boost converter, SEPIC converter and Cuk converter etc. [3]. Buck and boost converter are the basic ones among those converters. The Cuk and buck-boost converter is obtained by the cascade connection of the buck and boost converter. There are many studies on the Cuk converter in the literature. By referring some authors, they designed a PI-controlled converter for photovoltaic panels. Fuzzy logic controllers' method was used to determine PI parameters.

A. Circuit Diagram

The input voltage is given to converter here the converter used are buck-boost and cuk converter. Then the converter output was given to load [7-8]. The output voltage is varied depending upon load whenever load change, gate pulse width is varied and given input signal to converter. Based on the ON- OFF time of converter switch, output voltage is varied and settles down for reference voltage. The Fig. 1. shows the block diagram of converter.

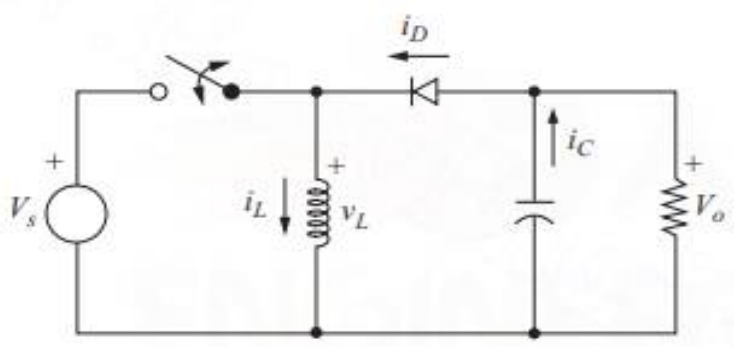


Fig.1 Buck- Boost converter

©IJRASET: All Rights are Reserved

For finding duty cycle, Inductor value and the below shown formulas are used

$$V_o = -V_s\left(\frac{D}{1-D}\right)$$

$$L_{\min} = \frac{(1-D)^2 R}{2f}$$

Note Inductor value is 1.25 times the Lmin.

$$\frac{\Delta V_o}{V_o} = \frac{D}{RCf}$$

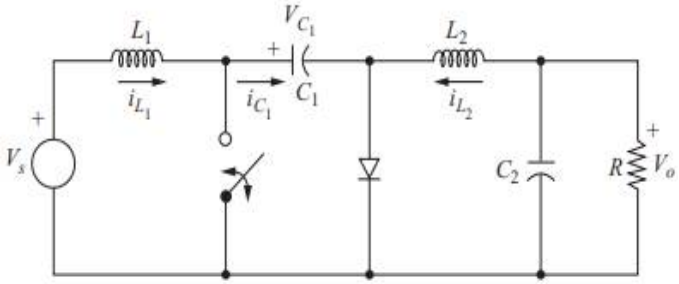


Fig.2 Cuk converter

Similarly, below shown formulas used for finding various components like Inductor, Capacitor and Duty cycle also.

$$V_o = -V_s\left(\frac{D}{1-D}\right)$$

The negative sign indicates a polarity reversal between output and input. Note that the components on the output (L2, C2, and R) are in the same configuration as the buck converter and that the inductor current has the same form as for the buck converter. Therefore, the ripple, or variation in output voltage, is the same as for the buck converter:

$$\frac{\Delta V_o}{V_o} = \frac{1-D}{8L_2C_2f^2}$$

$$\Delta v_{C_1} \approx \frac{V_o D}{RC_1 f}$$

$$L_{1,\min} = \frac{(1-D)^2 R}{2Df}$$

$$L_{2,\min} = \frac{(1-D)R}{2f}$$

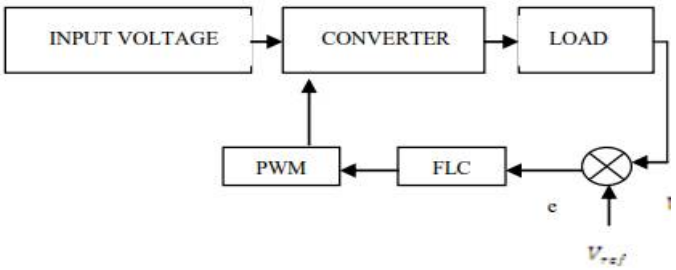


Fig.3 Block Diagram of FLC converter

II. PROPOSED FUZZY LOGIC CONTROLLER

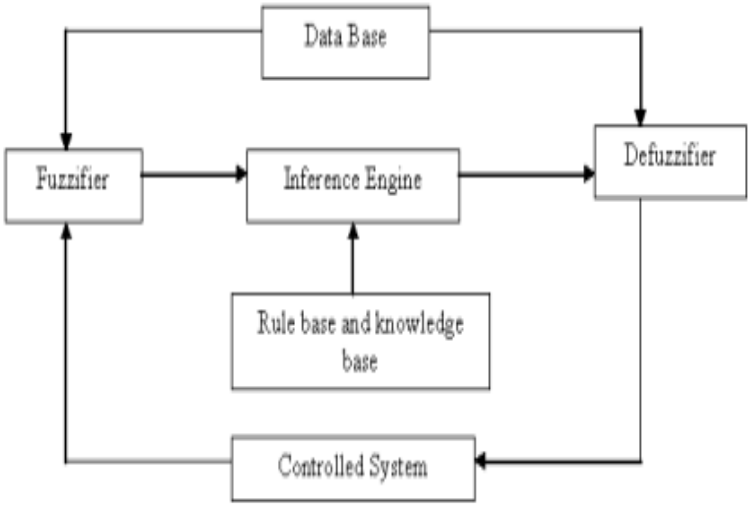


Fig.4 Proposed Fuzzy Logic Controller

With the aid of a design professional, Fuzzy logic controller improves conventional device design. With fuzzy logic, robust mathematical modelling in control processes can be greatly reduced. A human operator can monitor a process much more efficiently than a controller based on modern analytical techniques. In recent years FLC's implementation of fluid set theory has become popular. A fuzzy set is a subset of sets where only two separate values, 0 to 1, are inferred by the membership function (MF) values. The following is a fuzzy package. A fuzzy set A in discourse universe U is defined by a member function A(x) which at the interval of A measures member status [0, 1] and at that interval associates A(x) number with each element x of U. Fuzzy logic regulation is seen as actual physical structure and logic. 6 concerns all four of the main parts of (1) fuzzy source code, (2) knowledge base, (3) engine inference, and (4) difluence.

A. Fuzzification

Fuzzification can be defined as the conversion of a fuzzy set to a fuzzier set or crisp sets to a fuzzy set.

B. Knowledge Base (KB)

The basis of knowledge consists of the meanings and the control rules that describe when, how and why you apply the fuszy control rules, of the fuzzy MFs for the input and output variables. A database and language rules base are included in the framework. 1. The database serves as a reference for language control principles and pointless data processing. 2. The basic rule is structured to identify control goals and controls for domain experts through a set of language rules.

C. Inference Mechanism

Decision making on pen and paper using a set of fluid if then rules like:
IF X = A = Y = B = B = C. The linguistic values for x, y and z, a, b, and c represent two variables of input and one variable of power. It is a cornerstone of an FLC, capable of simulating human existence, including its decision making on the basis of furious logic and the rules of inference of furious logic. Generally speaking, fuzzy sets are mapped to a pair of outputs, the laws between the two systems.

D. Defuzzification

Defuzzification is used to measure linguistic dependent numerical values. In this study, the centre method was used. (1) A mapping scale that translates the input value range to the output variable set of values. (2) Difluence, an approach to differentiate between non-fuzzy control behaviour and a fluctuating control operation.

©IJRASET: All Rights are Reserved | SJ Impact Factor 7.538 | ISRA Journal Impact Factor 7.894 |

III. SIMULATION RESULTS

Table 1. CUK Converter Circuit Parameters

Input Voltage	12
Output voltage	-18
Inductor Values L1 and L2	100uF and 100uH
Capacitor values C1 and C2	150uF and 330uF
Switching Frequency	2kHz
Load resistance	20 ohm

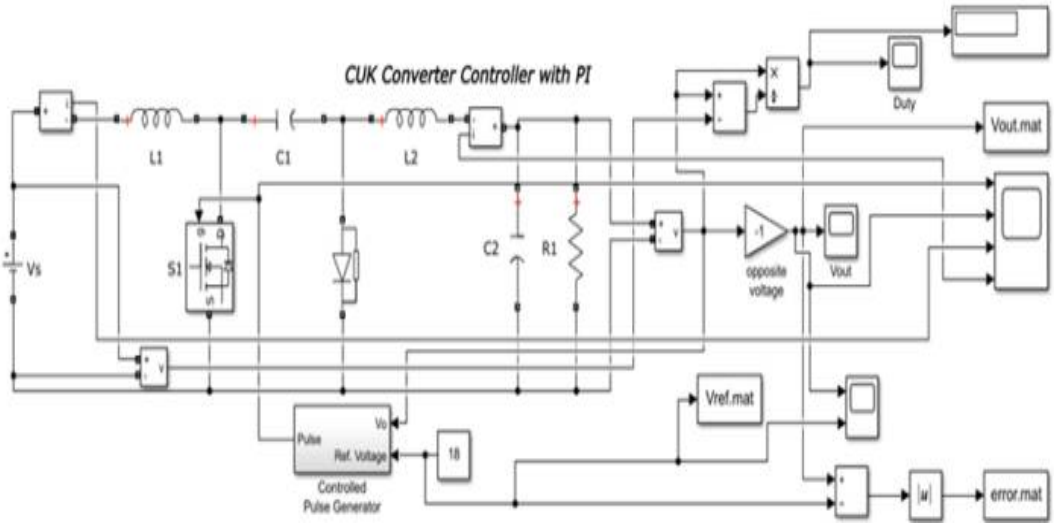


Fig 5. Cuk converter simulation model controlled by PI controller

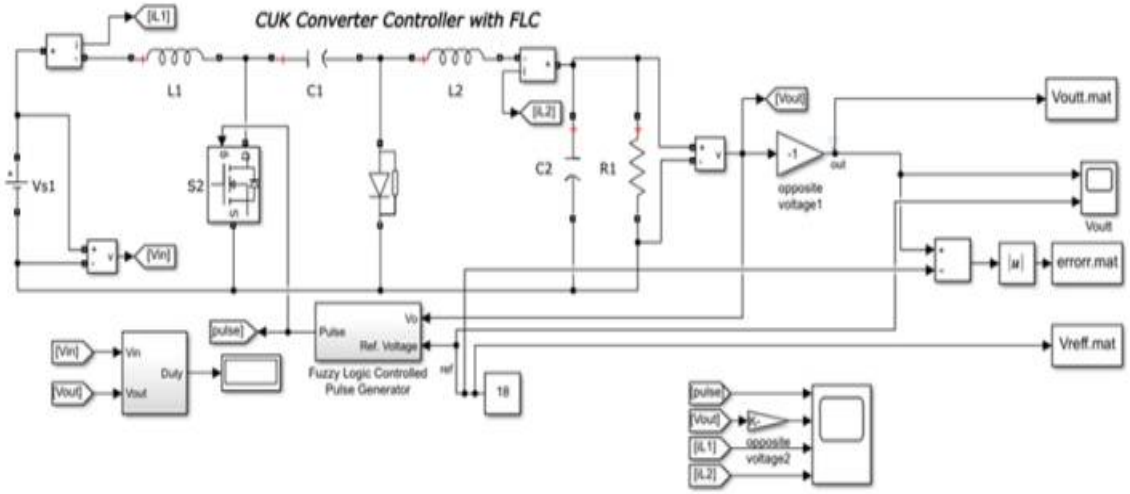


Fig.6 Cuk converter simulation model controlled by FL controller

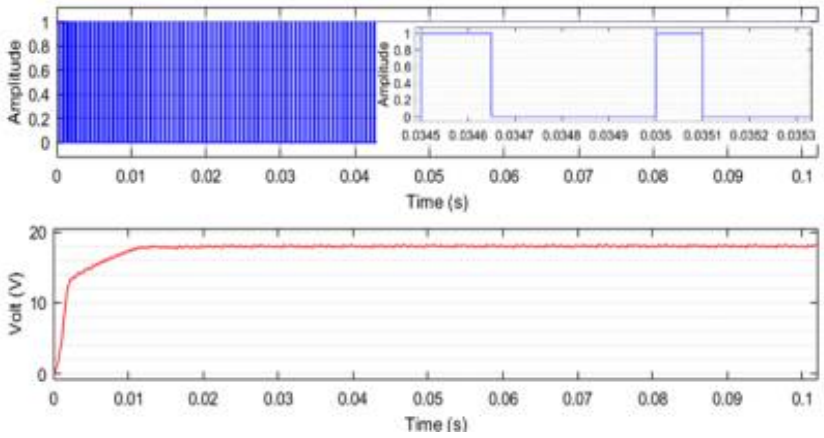


Fig.7. Change of output voltage and duty period with PI controller

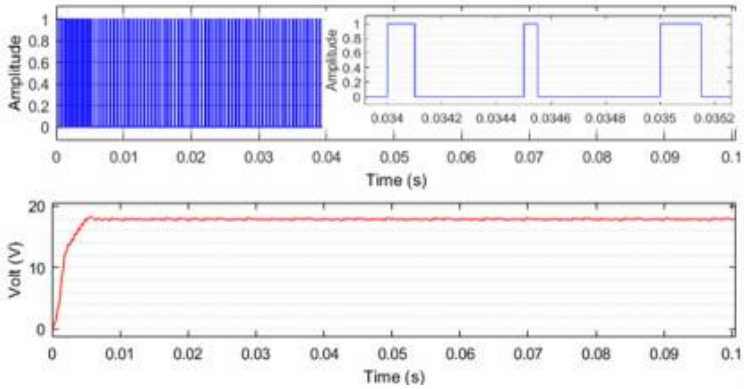


Fig.8. Change of output voltage and duty period with FL controller

The change of output voltage and duty period with PI controller is applied to Cuk converter and shown in Fig 7 and the change of output voltage and duty period with FL controller is presented in Fig 8. In addition, if the PI controller is applied, the output voltage error graph is shown in Fig 9. Similarly, the error plot of the voltage at the converter output in FL controller is shown in Fig 10. A visual comparison of the output voltages obtained when both controllers are applied to the Cuk converter circuit is presented in Fig 11.

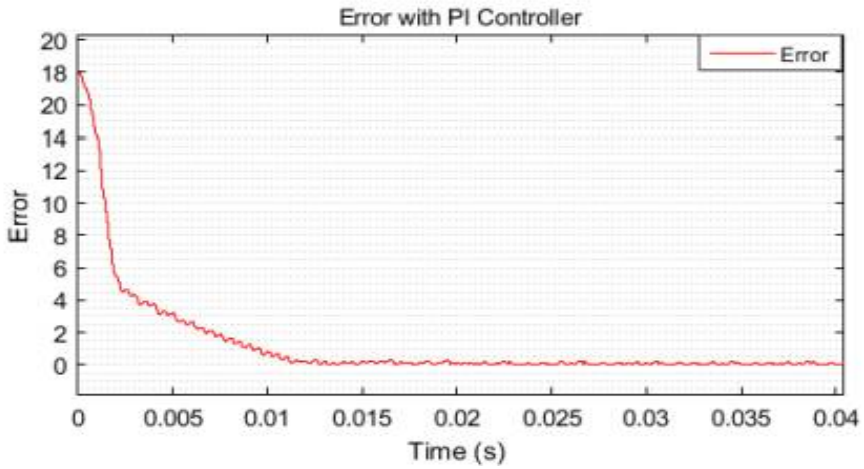


Fig.9. Error with PI Collector

©IJRASET: All Rights are Reserved | SJ Impact Factor 7.538 | ISRA Journal Impact Factor 7.894 |

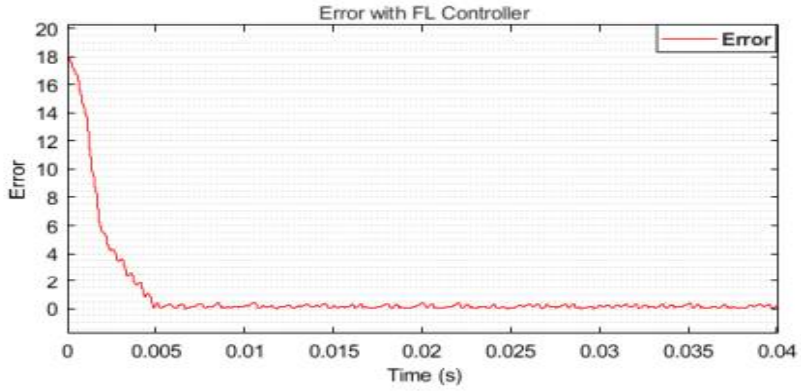


Fig.10 Error with FLC Controller

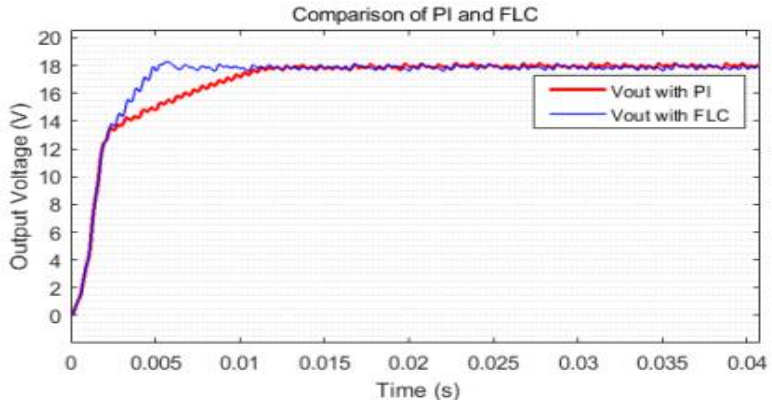


Fig.11. Comparison of PI and FLC Controller

Table 2. Comparison of PI and FLC

Controller	PI	FLC
Error RMSE	0.7422	0.7235
Rise Time (ms)	6.55	3.6
Settling Time (ms)	10	5

In Fig 7, it was observed that the Cuk converter output voltage reached a reference value of 18V after 10 ms without overshoot. In Fig 8, it is observed that the Cuk converter output voltage reaches a reference value of 18V after 5 ms. In Fig 9, it was observed that the error reached 0 after 10 msec when the PI control method was applied and when the FL control method was applied in Fig 15 the error reached 0 after 5 msec. In Fig 11, it is observed that FL control method gives better results than PI control method.

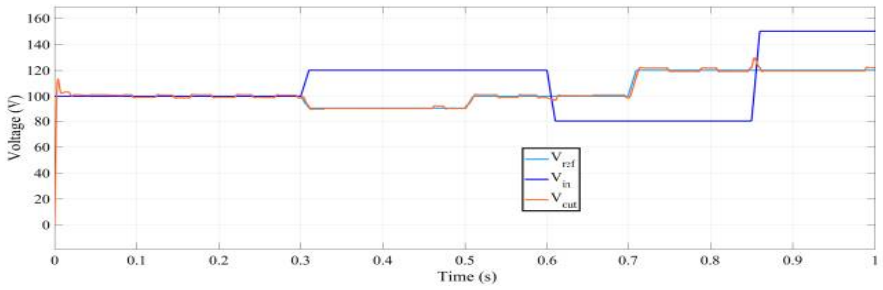


Fig. 12. The waveform of output voltage with PI controller

©IJRASET: All Rights are Reserved | SJ Impact Factor 7.538 | ISRA Journal Impact Factor 7.894 |

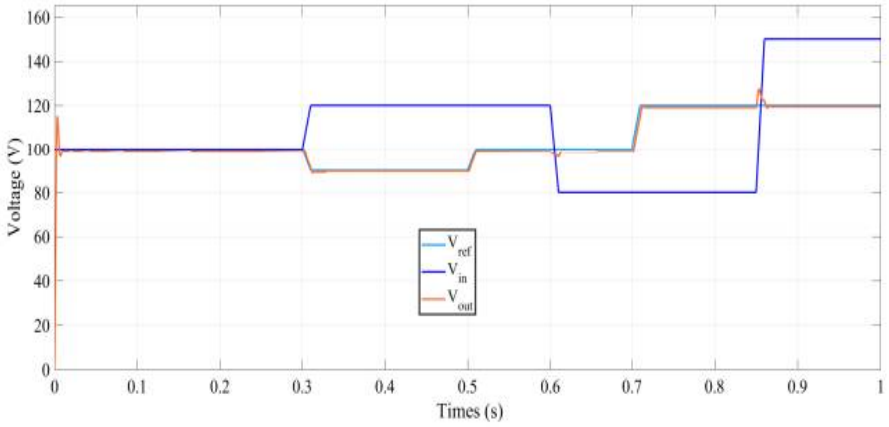


Fig.13. The waveform of output voltage with FLC controller

Table 3. Comparison of Buck-Boost FLC and PI Controllers

Operation State	Parameters	FLC	PI	Unit
Start-up	Settling time	10	20	ms
	Overshoot	08	08	%
Output voltage decrease	Settling time	10	15	ms
	Peak error	97	95	V
Output voltage increase	Settling time	10	15	ms
	Peak error	125	130	V

IV. COMPARISON OF SIMULATION RESULTS OF THE BUCK-BOOST CONVERTER USING FLC AND PI

We can compare the responses of the converter reported in Fig. 12 and with Fig. 13, obtained using PI and FL controller, respectively: In particular, the FLC settling time was 10 ms less than PI at the nominal voltage of 100 V. Moreover, there was very little different overshoot at nominal input voltage using FLC during start up transient response, while there was high overshoot with PI with respect to an input voltage change. Additionally, a comparison between the voltage transient in Fig. 12 (FLC) and Fig. 13 (PI control) can be analysed when the load voltage decreased 10% (from 100 to 90 V): from the reported results, FLC method occurred to show a shorter settling time. Moreover, the maximum over-voltage resulted by the traditional PI application was greater than the related FLC error. In particular, the output voltage response presented oscillation with PI control during operation, while, in case of the FLC, the output voltage presented a good stability during operation. When the load voltage increased to 120 V, again a lower settling time was obtained by means of FLC with respect to PI control.

Table 3 compares the performance of FLC and PI control for the proposed DC/DC converter with respect to input voltage, considering the respective transient responses. By this comparison, the FLC results to have a transient response faster than PI, with negligible differences on overshoot during start up; additionally, load transient response is more stable. The reported results show the advantages of FL controller in terms of robustness versus input voltage and load variations with respect to linear PI controller.

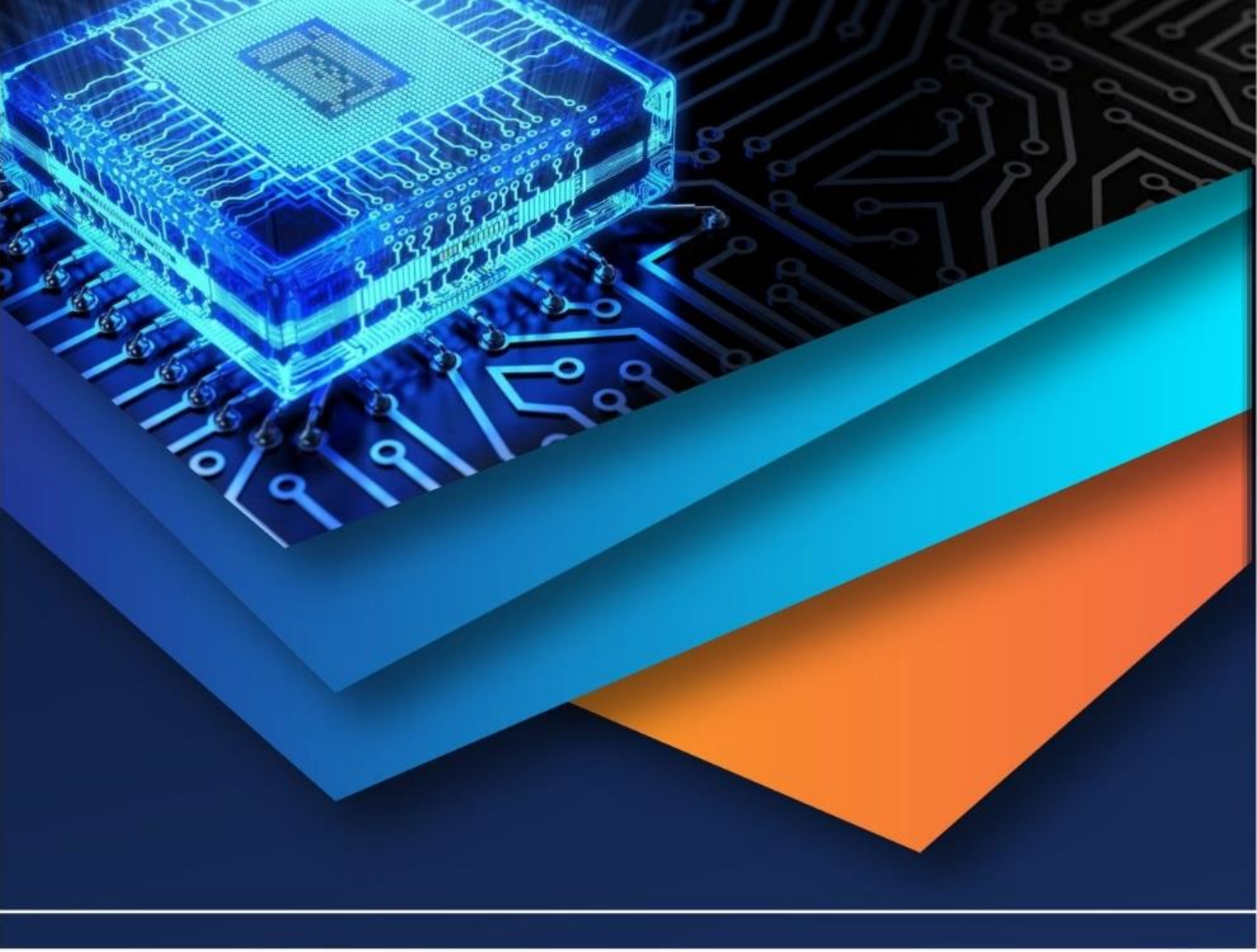
REFERENCES

[1] D. J. Arent, A. Wise, and R. Gelman, "The status and prospects of renewable energy for combating global warming," Energy Economics, vol. 33, no. 4, pp. 584–593, 2011.
[2] R. Adib, H. Murdock, F. Appavou, A. Brown, B. Epp, A. Leidreiter, C. Lins, H. Murdock, E. Musolino, K. Petrichenko et al., "Renewables 2016 global status report," Global Status Report RENEWABLE ENERGY POLICY NETWORK FOR THE 21st CENTURY (REN21), 2016.
[3] F. Grimaccia, M. Mussetta, and R. Zich, "Neuro-fuzzy predictive model for pv energy production based on weather forecast," in Fuzzy Systems (FUZZ), 2011 IEEE International Conference on, 2011, pp. 2454–2457.
[4] J. M. Alonso, J. Vina, D. G. Vaquero, G. Mart ˜ ´ınez, and R. Osorio, "Analysis and design of the integrated double buck–boost converter as a high- power-factor driver for power-led lamps," IEEE Transactions on Industrial Electronics, vol. 59, no. 4, pp. 1689–1697, 2012.
[5] H. M. Mahery and E. Babaei, "Mathematical modeling of buck–boost dc–dc converter and investigation of converter elements on transient and steady state responses," International Journal of Electrical Power & Energy Systems, vol. 44, no. 1, pp. 949–963, 2013.

©IJRASET: All Rights are Reserved | SJ Impact Factor 7.538 | ISRA Journal Impact Factor 7.894 |

[6] M. Ramasamy and S. Thangavel, "Photovoltaic based dynamic voltage restorer with power saver capability using pi controller," International Journal of Electrical Power & Energy Systems, vol. 36, no. 1, pp. 51–59,
[7] Mohan, N., Undeland, T. M., & Robbins, W. P. (2003). Power electronics: converters, applications, and design. John wiley & sons.
[8] Rashid M. H, R. (2015). Power Electronics Devices, Circuits and Applications. London: Pearson Education.
[9] Gupta, Yelamarthi & P, Sri. (2014). Analysis and Design of CUK Converter using PI Controller for PV Application. International Journal for Scientific Research & Technology. 2. 2321-613

©IJRASET: All Rights are Reserved | SJ Impact Factor 7.538 | ISRA Journal Impact Factor 7.894 |



10.22214/IJRASET

45.98

IMPACT FACTOR: 7.129

IMPACT FACTOR: 7.429

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Call : 08813907089 (24*7 Support on Whatsapp)