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Analysis and simulation of a Flyback converter's open-loop and closed-loop control

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Abstract—In order to effectively convert and control electrical power, power electronic converters are essential. Low power applications are where it is most frequently employed. DC-DC converters are one type of power electronic converter that employ power electronic devices to change a DC voltage from one level to a different level as needed. In this study, a flyback converter's open and closed loop control are analysed and simulated. The primary goal of the work is to provide information on how flyback converters operate in low power applications like televisions, SMPs for computers, and chargers for mobile devices and cell phones, among others. This study compares the performance of closed loop and open loop PID controller controls for flyback converters. With a switching frequency of 100KHz, the circuit design is simulated in MATLAB/SIMULNK, and the results are then given.

Keywords—Flyback converter, PID controller, linear transformer, MOSFET I.

INTRODUCTION

Power electronics are primarily used to process and regulate the movement of electrical energy by delivering voltages and currents in a format that is most suited for user loads. Modern power electronic converters are complicated in a wide range of applications, including switched-mode power supplies, active power filters, motion control of electrical machines, renewable energy conversion systems, distributed power generation, FACTs, and automotive technology, among others [1].

An unregulated DC input voltage is fed into the chopper, which outputs a steady or regulated voltage. Power electrical circuits known as DC-DC converters, often known as choppers, change a DC voltage to a different voltage level. Electronic, linear, switched mode, magnetic, and capacitive converters are only a few of the many different types of conversion techniques that are accessible. Because DC cannot be easily ramped up or down using a transformer, DC-DC converters are needed. A transformer's DC equivalent is a DC-DC converter in many respects. They are simply meant to adjust the incoming energy's impedance level.

Fig1: Basic Block Diagram of Flyback converter with R load

Fig. 1 shows a flyback converter's basic block diagram. This paper implements a flyback converter for resistive loads in both open and closed loops. The flyback converter is most frequently employed in low power applications seen in everyday gadgets. [1]

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A. Basic topology of a flyback converter

SMPS circuits and other low power applications typically employ fly-back converters. In this instance, the input supply mains are isolated from the output voltage. The output of a flyback converter ranges from a few watts to about 100W. The Flyback converter circuits are discovered to be significantly simpler and easier to use than other circuits. This circuit can provide single or many isolated output voltages while operating over a wide range of input voltages. Flyback converters are more often employed even though they have lower efficiency when compared to other circuits due to their low cost, narrow range of output power, and simple circuit topology. The Flyback converters, which are frequently employed there, will be a controllable switch, similar to any power semiconductor switch, with a switching frequency that is typically in the range of 100 KHz, if we pay attention to them. [2]

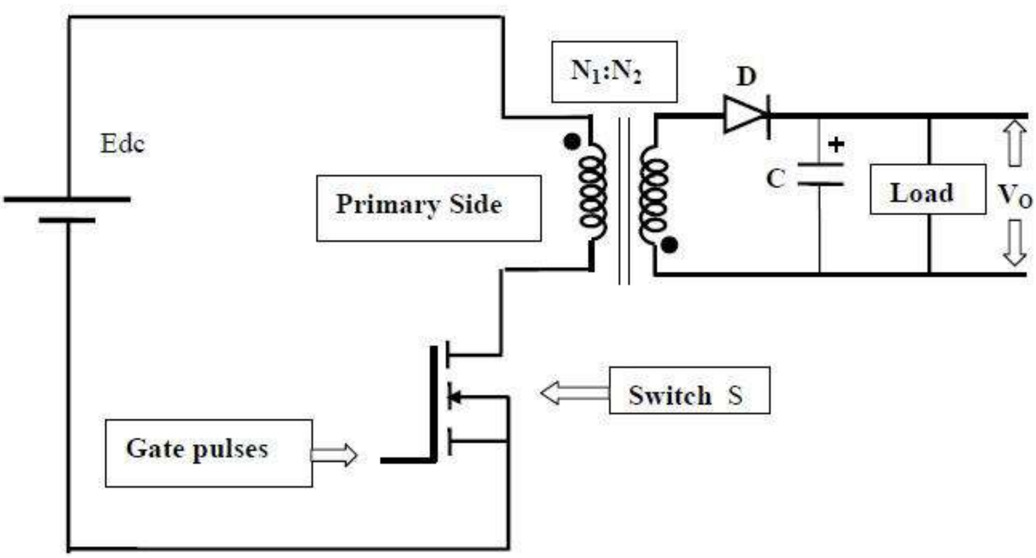

Fig2: Flyback converter

Fig. 2 depicts a flyback converter's basic structure. A switch, linear transformer, diode, and capacitor make up this device. The following details the many modes of operation:

Mode-1: (Switch is closed) As seen from the circuit diagram of Fig2., when switch S is closed or in ON condition, the input supply is connected to the primary winding of the transformer where the dot convention is connected to the positive side of the supply. During this operation, diode 'D' will be reverse biased. Because of this operation, primary winding will carry the current whereas secondary winding is nearly blocked as the diode 'D' is reverse biased. The transformer core will develop the flux and links with the winding all due to the primary side current. In mode-1, primary current raises linearly and input voltage appear across the primary winding. [14], [15].

Mode-2: (Switch is open) The operation in mode-1 is conducted for some time and the switch S is turned off or it is in open condition. Due to this condition, the current flow in the primary winding is broken and the voltage polarities across the winding is reversed. Because of the reversal of polarities diode 'D'is forward biased in the secondary circuit. Now, secondary winding starts conducting so that net MMF does not change. [3]

II. DESIGN PARAMETER OF A FLYBACK CONVERTER

The converter is designed for a supply voltage of Vs = 40V, output voltage of Vo = 40V, power = 40W, Resistive load, R = 40Ω with switching frequency = 100KHz.

Duty Ratio Calculation:

$N2 / N1 = Vo/Vs * (1-D)/D$ (1)

Taking turns ratio = 3, Substituting the values from given data we get Duty cycle = 35.71%.

Capacitor Calculation:

$\Delta Vo / Vo = D / RCf$ (2)

Substituting the values from given data we get Capacitor value = 17.85µF

III. OPEN LOOP SIMULATION OF A FLYBACK CONVERTER

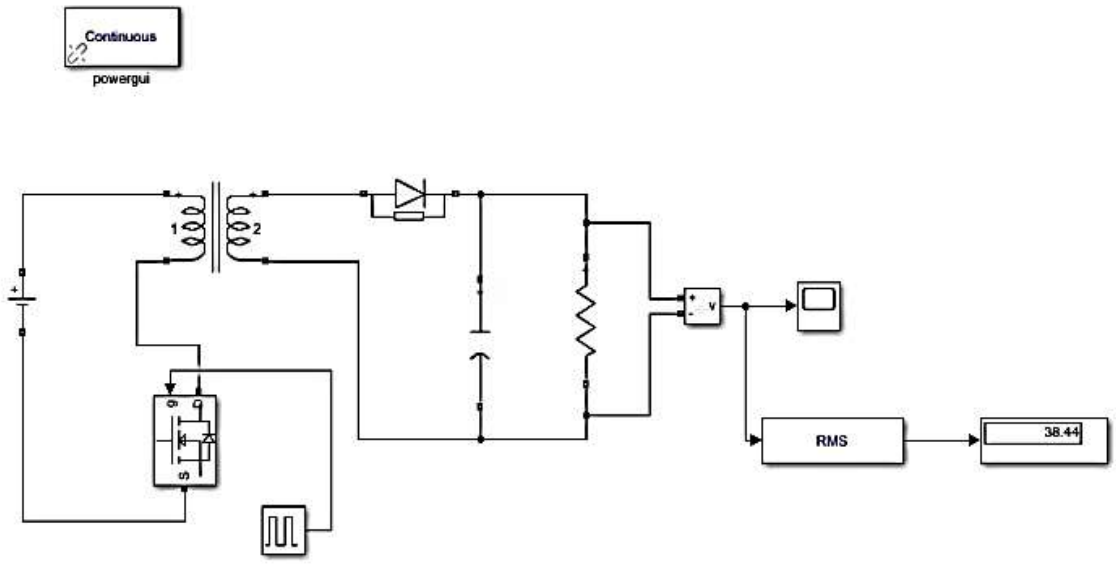

Fig3: Simulation of an open loop Flyback converter

Fly-back converter MATLAB simulation for open loop control is shown in fig3. When we execute the above the circuit, there will be fluctuation in the output because we assume the system to be under steady state condition i.e., constant input voltage and constant load. In order to rectify the above condition, closed loop control is necessary to give constant output voltage irrespective of the input voltage. [11],[12]

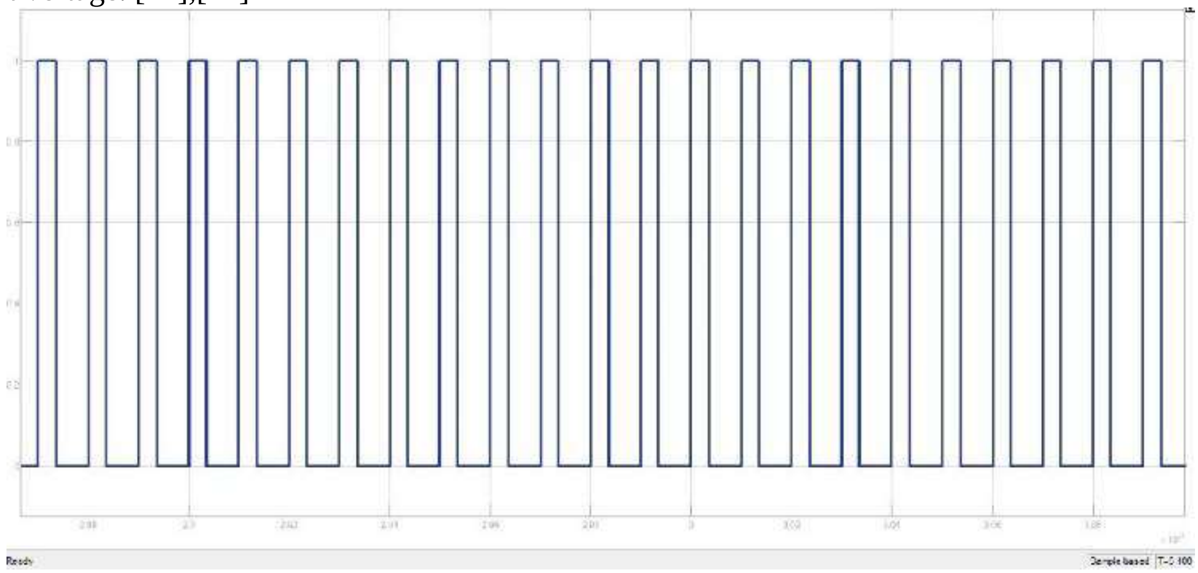

Fig4: Pulse generation in case of an open loop Flyback converter

Fig 4 represents the pulse generated for the MOSFET switch in MATLAB. Duty cycle is 35.71%.

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Vo = 38.44 Volts

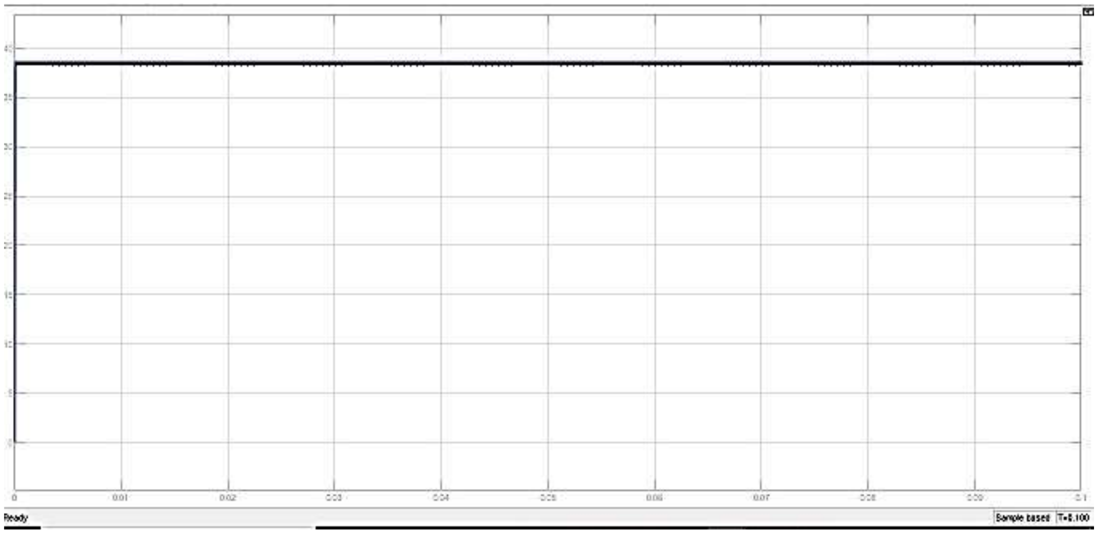

Fig5: Voltage response of open loop Flyback converter

The output waveform shows a lot of variations when we zoom and check for the errors. To overcome this situation we add a controller in the closed loop.[13]

Table1: Input Vs output voltage variation in case of an open loop Flyback converter

SL.No.	Input voltage	Output voltage
1	24	38.44
2	28	44.98
3	32	51.52
4	36	58.05
5	40	64.59
6	44	71.13

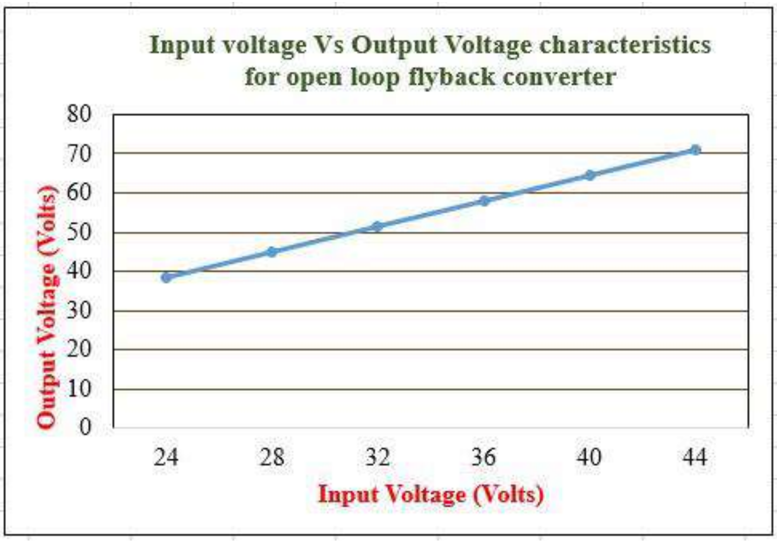

Fig6: Graphical representation of Voltage variation of open loop Flyback converter

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Fig 6 represents graphical interpretation of output voltage versus the input voltage. We can observe that since it is an open loop system, both vary in direct proportion. Irrespective of input voltage if we want to keep output voltage constant then we can go for closed loop system.

IV. CLOSED LOOP SIMULATION OF A FLYBACK CONVERTER

It takes a lot of work to start off with a stable waveform that is spike-free in practically all open loop systems. Additionally, a mistake will be made in relation to the input that we give. It is necessary to treat this condition. To do this, we employ a feedback mechanism that allows us to apply any control strategy to create a feedback control loop and, to the greatest extent feasible, provide an output that is error-free. The PID controller is used in this study as a feedback control mechanism among other control techniques such as P, PI, PID, Fuzzy, etc. The optimum controller for industrial applications is the PID Controller. The closed loop controller is once more used, but only for switching frequencies up to 100 kHz. [5],[9],[10]

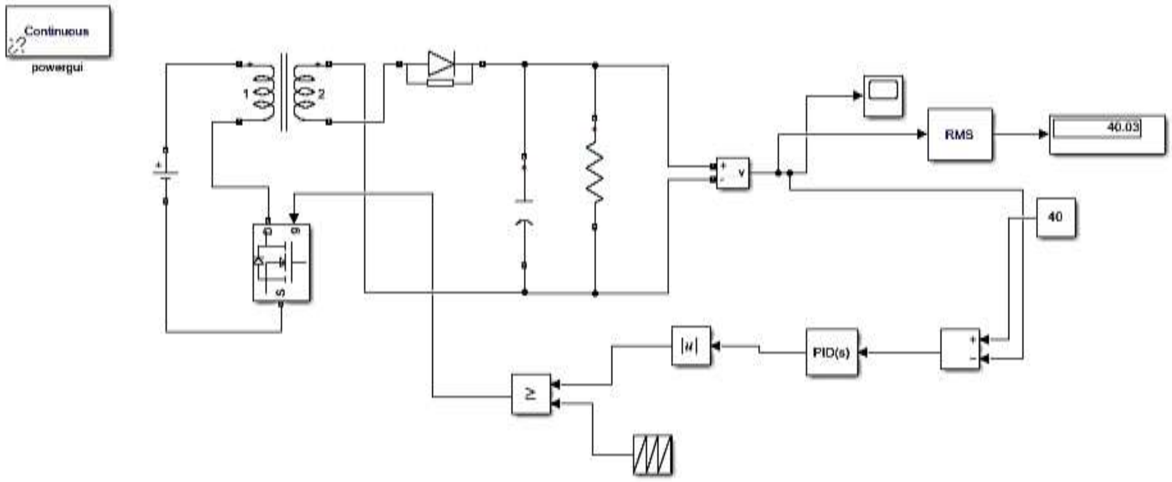

Fig7: Simulation of a closed loop Flyback converter by means of PID Controller

Using a PID controller, Fig. 7 shows a MATLAB simulation of a closed-loop Flyback converter. A sub tractor receives the output voltage, which is then connected to a PID controller with a reference voltage of 40V. The larger than or equal relational operator, whose output is provided as a pulse to the gate of the MOSFET switch, receives the absolute value of the input from the PID controller and compares it with a repeating sequence. [4]

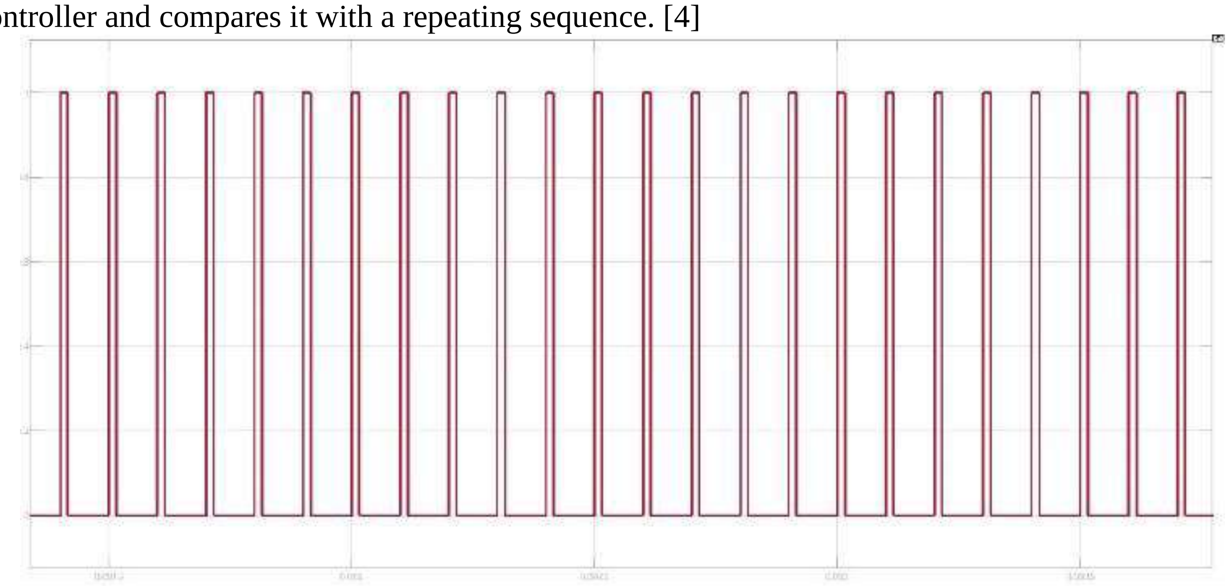

Fig8: Pulse generation output in case of a closed loop Flyback converter

Fig 8 represents the pulse-generated output in case of closed loop flyback converter system with a duty cycle of 35.71%.

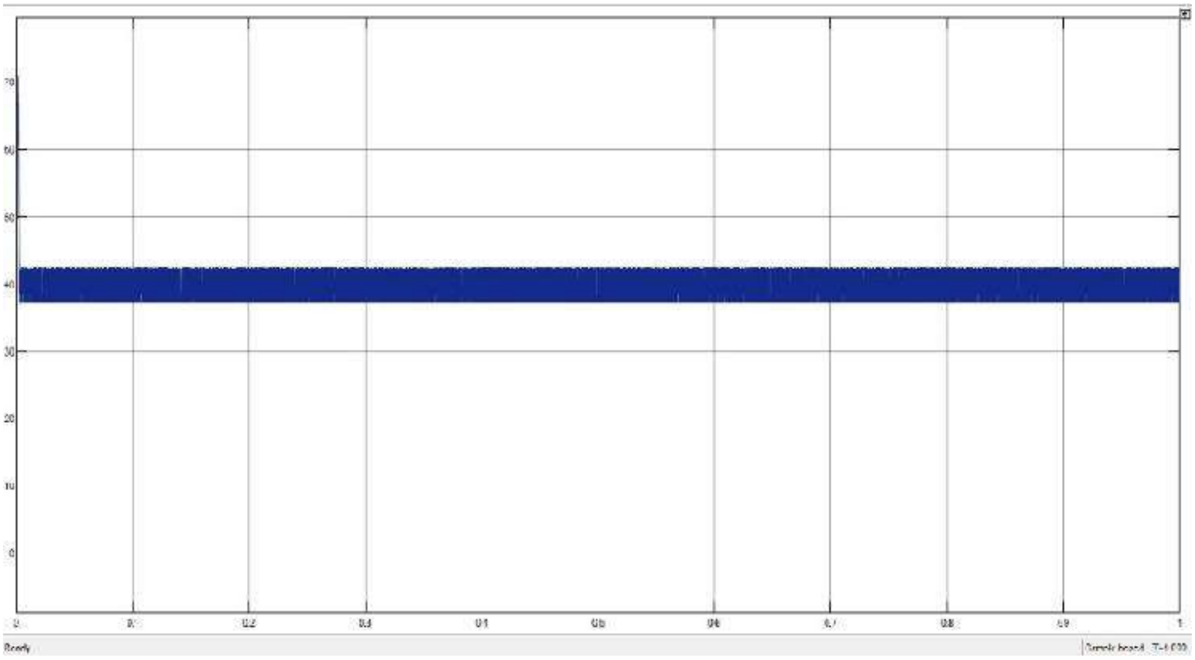

Fig9: Voltage response of a closed loop Flyback converter using a PID Controller

In both the open and closed loop controllers of MATLAB Simulink, a flyback converter is designed as a counterfeit. PID Controller is used to implement closed loop control using an input voltage of 24V. P & D are maintained at zero when it is set to integral part. Gate pulses are delivered as output to the MOSFET gate switch. Here, we can see that for a 24V input, closed loop control results in an output voltage that is almost exactly equal to 40.03V while minimising error compared to open loop control. If we look at the output voltage waveform, the ripple is still quite significant, but it may be decreased by applying the right capacitor values. [6],[7],[8]

V. CONCLUSION

The MATLAB Simulink model is used to analyse and simulate the control of an open and closed loop Flyback converter, as shown in the above pictures. First, we conducted an open loop study and found that the output voltage fluctuates linearly with the input voltage while maintaining a constant duty cycle. These results don't really help much because they cause a lot of ripple and output inaccuracy. To remedy this, a Flyback converter's closed loop control was implemented using a PID controller, eliminating all the drawbacks of the open loop control method. The aforementioned figures display the tabular and graphic findings for both open and closed loop Flyback converters. We can infer from the analysis that Flyback converters work well for a variety of low power applications in addition to helping to isolate the core component from the output.

REFERENCES

[1] Tue T. Vu; Seamus O'Driscoll; John V. Ringwood, “Control oriented modelling and simulation of a variable frequency efficiency-optimized flyback converter,” 2014 IEEE Conference on Control Applications (CCA),ISBN:978-1-4799-7409-2,ISSN: 1085-1992, 8- 10 Oct. 2014,DOI: 10.1109/CCA.2014.6981551, IEEE
[2] A. Palamalai VIJAYAKUMAR, Ramakrishnan DEVIClerk Maxwell, “Simulation and experimental results for the closed loop-controlled dc to dc forward converter”, Acta Electrotechnica

et Informatica, Vol. 17, No. 2, 2017, 23–29, DOI: 10.15546/aeei-2017-0012, ISSN 1338-3957, Pg: 23-29.
[3] Bhagvan Patil, Pradeep Kumar, "Performance analysis of a flyback converter," IJIRSET, DOI:10.15680/IJIRSET.2016.0505636, ISSN(Online): 2319-8753, Vol. 5, Special Issue 9, May 2016, Pg: 820- 825.
[4] Nisha Kasundra, Ankit Kumar "Design & Simulation of Flyback Converter in MATLAB using PID Controller," JAREEIE, DOI:10.15662/IJAREEIE.2016.0502057, ISSN(Online) : 2278 – 8875, Vol. 5, Issue 2, February 2016, Pg: 960-965.
[5] Tandel Jaykumar S, "Closed loop modeling of flyback converter for speed control of separately excited DC motor", IJAERD, Volume 1,Issue 3, April 2014, e-ISSN: 2348 - 4470 , print-ISSN:2348-6406, Pg:1-10
[6] Ferudun gokcegoz, Erdem Akboy, Hulya Obdan, "Analysis and design of a Flyback converter for universal input and wide load ranges", Research gate article, ELECTRICA 2021; 21: 235-241, DOI: 10.5152/electrica.2021.20092, Istanbul university
[7] Xiangjun Zhang, Hankui Liu, Dianguo Xu, "Analysis and design of the flyback transformer", December 2003, DOI:10.1109/IECON.2003.1280070, IEEE Xplore, Conference: Industrial Electronics Society, 2003. IECON '03. The 29th Annual Conference of the IEEE, Volume: 1
[8] Gourab das, Kamal Krishna mandal, Meenakshi de, "Analysis of flyback converter design using PV-based MOSFET switching", January 2020, International Journal of Nanoparticles 12(4):289, DOI:10.1504/IJNP.2020.112400
[9] Tze-yee ho, mu-song chen, chih hsein lin, chen wen chang, "The design of a flyback converter based on simulation", DOI:10.1109/ICECC.2011.6067588, Conference: Electronics, Communications and Control (ICECC), 2011
[10] Alireza Goudarzian, Adel Khosravi, HeidarAli Raeisi, "Modeling, design and control of a modified flyback converter with ability of right-half-plane zero alleviation in continuous conduction mode", Engineering Science and Technology, an International Journal, Volume 26, February 2022, 101007, https://doi.org/10.1016/j.jestch.2021.05.011
[11] Swati Kunkolkar, V.N Shet, "Flyback Converter Design and Simulation", International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering, Vol. 6, Issue 5, May 2017, ISSN (Online): 2278 – 8875
[12] Ali Mamizadeh, Bestoon Ahmed Mustafa, Naci Genç, "PLANAR FLYBACK TRANSFORMER DESIGN FOR PV POWERED LED ILLUMINATION", Vol 11, No 1 (2021), IJRER, DOI (PDF): https://doi.org/10.20508/ijrer.v11i1.11695.g8155
[13] Siyang Zhao, Junming Zhang, Yang Shi, â€oeA Low cost, low power flyback converter with a simple transformer,â€ 2012 IEEE 7th International Power Electronics and Motion Control Conference - ECCE Asia
[14] Park.J.H, Ahn.J.Y,ChoB.H, and Yu.G.J,(2006),‖Dualmodule- Based Maximum Power Tracking Control of Photovoltaic Systems‖IEEE Trans.Power Electron., vol. 53, no. 4, pp. 1036–1047
[15] Hinal shah, raj shah, "DESIGN OF FLYBACK CONVERTER WITH POST REGULATOR (TWO OUTPUTS, 8 W)", International Journal of Application or Innovation in Engineering & Management (IJAIEM) Web Site: www.ijaiem.org Email: editor@ijaiem.org Volume 7, Issue 9, September 2018, ISSN 2319 - 4847

