International Journal of Scientific Research in Engineering and Management (IJSREM)
Volume: 05 Issue: 01 | Jan -2021 ISSN: 2582-3930

Simulation and Hardware Design of a Flyback Converter for Solar Energy Powered DC Loads

Patel Yogesh Girish[1], Mr. Sanjay Gothwal[2], Dr. Sanjay Jain[3]

M. Tech scholar, Asst. Professor,Professor

1. Department of electrical engineering Shri Satya Sai college of Engineering RKDP University Bhopal

---***---

Abstract -In the present day situation as the energy sources are becoming extinct to generate electricity, it has become a necessity to depend on the renewable energy sources to generate the power and convert it according to the type of appliances that are in use either AC or DC loads. This paper gives brief idea on the hardware implementation of the flyback converter.

***Key Words*:**Solar energy,Rectification, flyback converter, DC loads, MOSFET switch, Voltage Regulation, Converter efficiency

2. INTRODUCTION

The cost of limited conventional energy sources is rising rapidly. Besides the cost, the adverse impact on environment demands adopting of renewable energy. Noteworthy advantage of distributed energy sources such as solar PV systems is their capability to bestow sustainable electrical energy without harming environment. This becomes even more significant in areas where the conventional power grid has not penetrated. Being the distributed energy source it can be located near the loads. Utilization of solar energy has increased exponentially in last few years. Solar being the major renewable energy source in tropical countries like India necessitates research work for harvesting maximum power from it. The key to sustainable development is improvement in efficiency of harvesting renewable sources and effective use [1].

2. MOTIVATION AND OBJECTIVE

As the renewable energy sources are reliable and efficient in electricity generation, in the same way the use of DC loads makes a big deal in saving power in the individual households. So it is advantageous to use both the applications namely renewable energy source and DC appliances in order to get good efficiency and power saving both at the generation station and the household. In order to supply DC power from an AC source an SMPS converter is needed for rectification and voltage regulation [11].

Flyback topology is more famous among other SMPS converters due to its simple circuit and isolation between the input voltage and the output voltage. Its input may be a rectified DC voltage from AC mains supply or a direct DC input voltage. Its output power range can vary from different values to a maximum of 100W. Due to its simple circuitry and high efficiency for low power outputs it use has increased tremendously in areas requiring regulated low DC power outputs[8].

3. PRINCIPLE AND WORKING OF FLYBACK CNVERTER

In Figure.1 the circuit diagram of a fly-back converter is shown. Input supply to the SMPS circuit may be a rectified voltage from any AC supply. An isolation transformer is used to isolate the source side and the load side. As the SMPS circuit operates with high switching frequency, the input voltage even though is not regulated is considered regulated at the output side due to its high frequency response. Switching devices like MOSFET and IGBT are used for fast responses and to maintain constant output voltage [2].

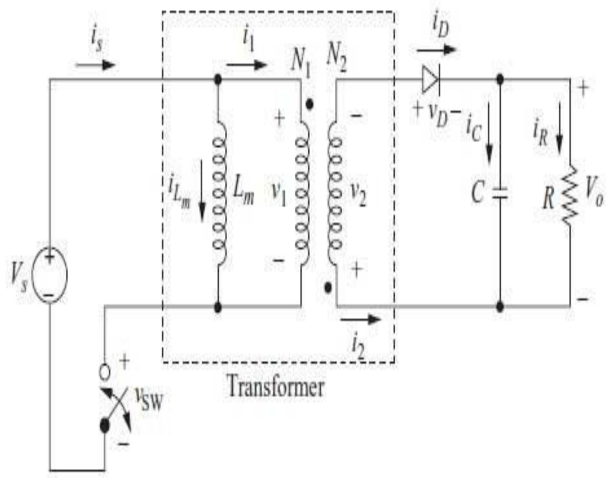


Figure 1: Basic Topology of Flyback Converter

A. *Analysis for the Switchopen*

When the switch opens (Fig. 2), as there is no return path for the current in the primary side the energy from the source side is transferred to the load side[10]. As the diode is forward biased this would be possible. The current on the secondary side is transferred to the load via the short circuited diode

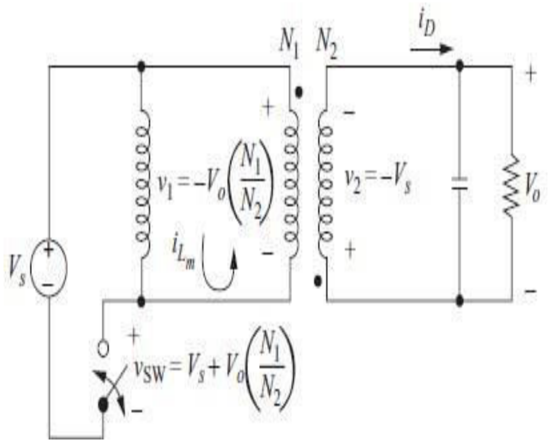


Figure 2: Circuit for switch open

A. Analysis for the switchclosed

When the switch is closed there is a return path for current in the primary side. The primary side inductor gets energized linearly [9]. But due to the reverse biased diode the secondary side inductor cannot be energized. So the current through it will be zero.

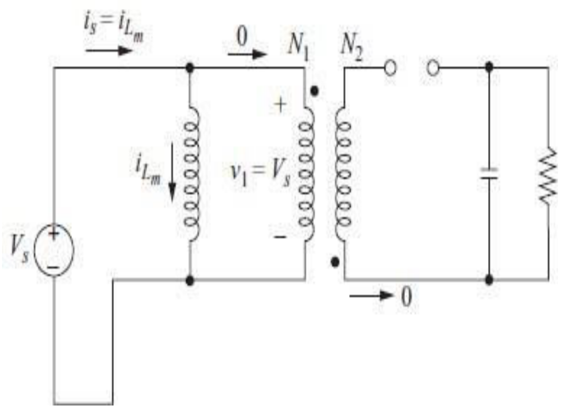


Figure 3: Circuit for switch closed

A. Matlab simulation block of flybackconverter

The Simulink model of the fly back converter used for solar energy powered DC loads is shown in figure 4. The AC power generated using the solar panels is first converted into DC power by the diode rectifier and then stepped down to lower voltage levels using the flyback converter.

Figure 4: Simulation block of Fly back converter

3. SIMULATION DESIGN AND RESULTS

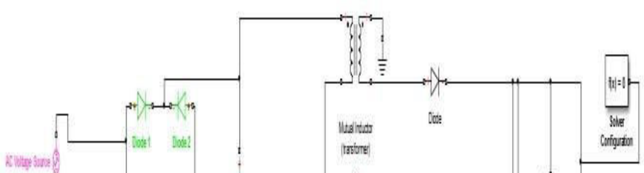
The flyback converter is to be designed for the requirements as tabulated below:

Parameter	Value
Input Volage	230V
Output Power	100W
Output Voltage	12V
Efficiency	85%

Table 1: Design specifications of the Flyback converter

After designing the flyback converter for the above given specifications the results obtained are as follows:

Figure 5 shows the waveforms of output power, output voltage and output current of the flyback transformer designed to meet the specifications tabulated in table



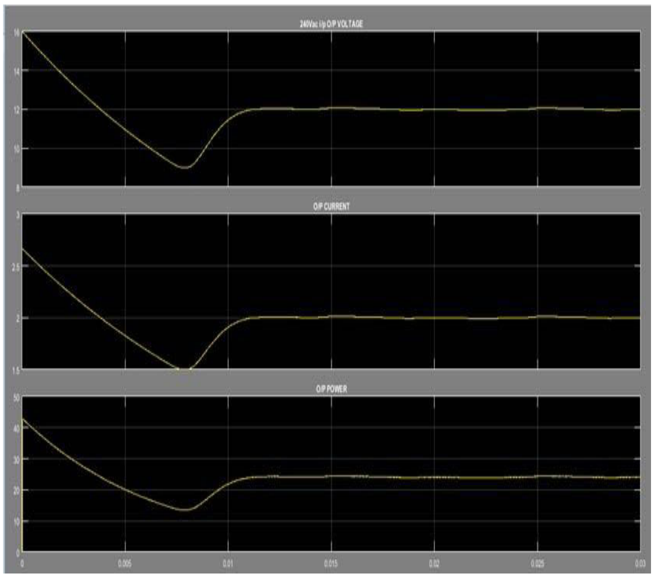


Figure 5: Resulting waveforms of output voltage, output current, output power of the simulink model of flyback converter respectively

4. DESIGN CALCULATIONS

The design calculations required for the hardware implementation of the flyback converter are included in this section. The EMI filter design is also briefly included[3][4].

The required T(min) is derived based on the specifications of the maximum switching frequency at minimum line voltage and is represented as in equation (1).

$$\text{ToffNIN} = \frac{\text{KNin}}{FcwNAx} \qquad (1)$$

$$= 78.5\text{uS}$$

The turns ratio is calculated using the equation (2). Vf is the output diode forward voltage and Vauxillary is auxiliary forward voltage drop. D is the allowable duty cycle (0.68 approximately).

$$\text{Tratio} = \frac{D}{1-D}\frac{V_{DCN1n}}{V_{out} + V_F}$$

$$= 11.79$$

$$T_{ratio(ausisSary} = \frac{D}{1-D} * \frac{V_{DCN1n}}{V_{auxilarry} + V_{D\ auxilarry}}$$

$$= 11.79$$

Number of primary windings of the transformer is

$$\text{Npri} = \frac{L_{pri} I_{pri\,pk}}{B_{cat}\,AE_e}$$

$$= 105$$

Number of secondary windings of the transformer is

$$N_c = T_{ratio} * N_p$$

$$= 9$$

The output capacitor is selected on the basis of permissible ripple ΔVo= 80mV in the output and is determined by equation (6)

$$C_{out} = \frac{I_{out}(1-N1n)t_c}{\Delta V_0}$$

$$= 2.2 \text{ mF}$$

Thus, 3 capacitors of 1000uF value each are selected.

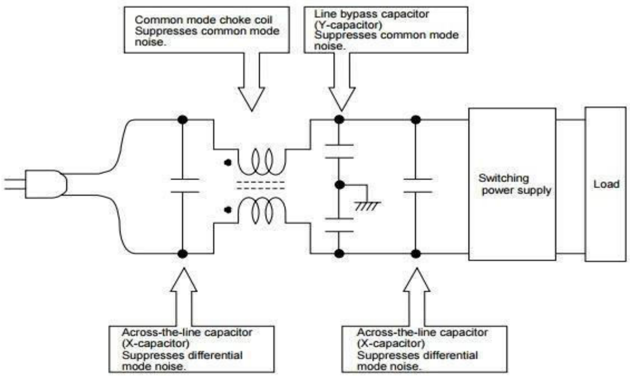


Figure 6: EMI filter circuit

The total noise suppression in a power supply line is depicted in the Figure 6. Capacitors are placed across thesupply ends and ground ends to avoid differential mode signal noises[7].

The order to avoid comman mode single noises comman mode choke coils are used that act as large inductances, thus avoiding the common mode currents. They suppress the common mode signal noises across those inductances without causing any distortions in the signal noises[5].

Another method is by using capacitances between the supply or ground lines and a metallic casing. Therefore the noise signal follows the path from the supply line to the capacitor to the metallic casing and then finally to the noise signal source

5. HARDWARE DESIGN AND RESULTS

.This section shows the Hardware and resulting waveforms of the converter

Figure 7: Hardware setup of the flyback converter

This setup includes an EMI filter to avoid harmonic distortion, a bridge rectifier for AC-DC conversion, snubber circuit for protecting the MOSFET switch, An LC filter to avoid ripple.

The converter specifications are given as follows:

Parameter	Value
Input voltage	230V
Output power	100W
Output voltage	12V
Efficiency	85%
Temperature	55 celsius

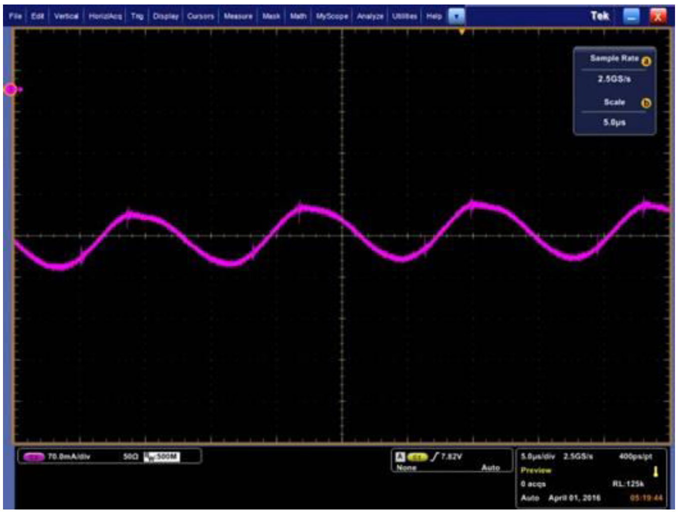


Figure 8: Input current waveform without any harmonic distortion

It is clearly observed from the input current waveform that there are no harmonics and the signal is a pure sine wave. This symmetry is achieved using the IC L6562 that not only does voltage regulation but also controls the total harmonic distortion at the input supply of the converter

Figure 9: MOSFET switch voltage at the primary side

Due to the presence of parasitic capacitance voltage hikes can be observed in the Switch voltage waveform in the figure 9.

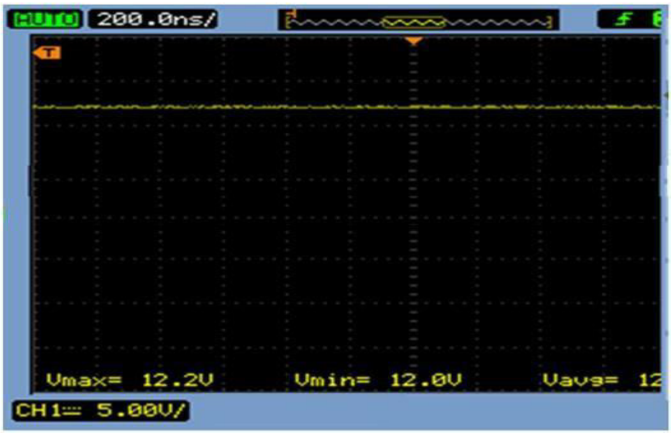
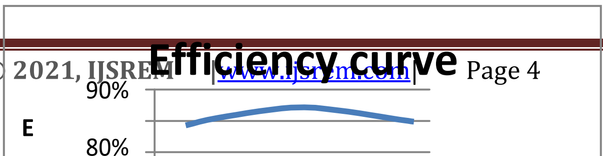


Figure 10: Output voltage waveform of the converter

A constant output voltage of 12V is achieved with very negligible output ripple voltage. The voltage remained constant irrespective of the load variations.

The efficiency of the flyback converter for different load conditions is calculated. A graph is drawn with load value and efficiency as the coordinates. Figure 11 shows the efficiency curve of the flyback converter. It is observed that irrespective of the load value the flyback converter maintained its efficiency in the range of 80% to 85%.



International Journal of Scientific Research in Engineering and Management (IJSREM)
Volume: 05 Issue: 01 | Jan -2021 ISSN: 2582-3930

Figure 11: Efficiency curve of the converter

Conclusion

The basic working of the converter, its design procedure, the simulation block and its results are mentioned in this paper. The simulation results are used to further carry out this project to hardware level. This flyback converter is mainly intended to be used in the household and rural areas where mostly DC appliances are in use.

The Hardware setup of the converter at different loads exhibits different efficiency values but is seen that it maintains efficiency more than 80 percent. A high efficiency converter is designed and the ripple free power is supplied to the loads.

REFERENCES

1. G.Boyle, “Renewable Energy, Power for a sustainable future”, Oxford University Press in association with the Open University, second edition, 2004.

[2]. Rakesh Maurya1, PunnaiahGunturu& Shaikh Mo,’” Simulation and Design of an Integrated Fly Back Converter for Uninterruptible Power Supply”,IEEE Trans, Vol 3,2010.

[3]. W. Tang, Y. Jiang, G. C. Hua, and F. C. Lee,” Power Factor Correction
With Flyback Converter Employing Charge Control”, IEEE Trans, 1993.

[4].K.Umamaheswari , V. Venkatachalam “Single Phase Converters for Power Factor Correction with Tight Output Voltage Regulation” International Journal of Emerging Technology and Advanced Engineering , Volume 3, Issue 2, February 2013

[5]. Y. M. Liu and L.K.Chang, “Single-stage soft-switching AC–DC converter with input current shaping for universal line applications,” IEEE Trans. and.Electron.,vol.56, no.2, pp.467–479, Feb.2009.

[6].Tzuen-LihChern ,Li-Hsiang ,Liu Ping-Lung Pan ,Yi-Jie Lee” Single- Stage Flyback Converter for Constant Current Output LED Driver with Power Factor Correction”, IEEE Trans. and.Electron.,vol.56, no.2, pp.467–479, Feb.2009.

[7].Himanshu K Patel ”Flyback Power Supply EMI Signature and Suppression Techniques”, IEEE Trans. and.Electron.,vol.56, no.2 , Feb 2009.

[8]L.Umanand, “Power Electronics Essentials and Applications”, Wiley India Pvt. Ltd,

[9] Daniel. W. Hart, “Power Electronics”, The McGraw-Hill Company, 3rd edition, 2010.

[10] Ned Mohan, Tore M. Undeland and William P. Robbins, “Power Electronics Converters, Applications, and Design”, John Wiley and sons, 3rd Wiley India edition, 2012.

[11] Zhang H J. “Basic Concepts of Linear Regulator and Switching Mode Power Supplies”,Linear Technology, Application note 140, Oct 2013.

[12] “Switch-Mode Power Supply” Reference Manual by On Semiconductor, rev. 4, April2014.