

# DESIGN OF SWITCHED MODE POWER SUPPLY

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## ABSTRACT

*This paper presents the design of SMPS. The fly back converter is taken in the design of SMPS. The simulation of the flyback converter using SIMULINK is presented and by varying its duty cycle various output voltages are obtained. The circuit for the open loop fly back converter is successfully tested in breadboard and it is implemented in veroboard. The circuit for the closed loop controlled flyback converter is then implemented in veroboard after its successful testing on breadboard. The output voltage is kept constant by using the closed loop controller for the fly back converter. It can be used successfully to step up the voltage.*

**Keywords – Flyback Converter, Hardware Implementation, Simulink, Smps**

## I. INTRODUCTION

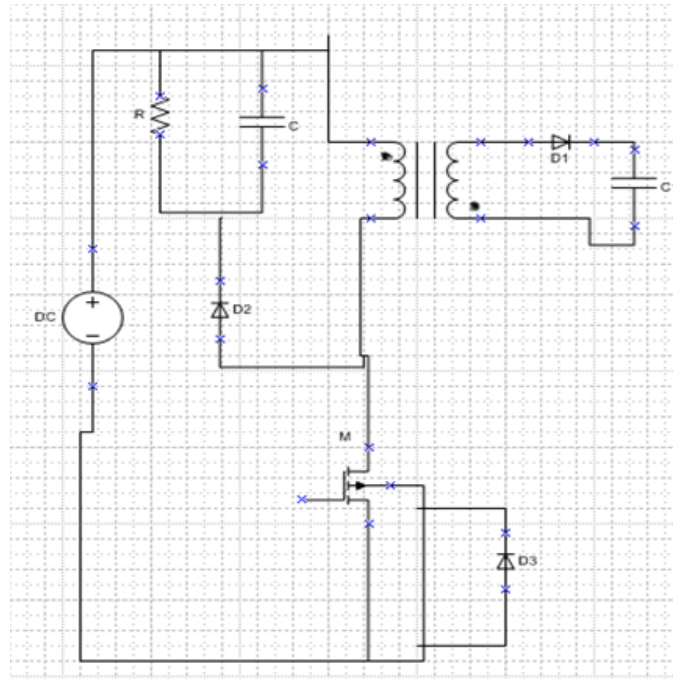
In today's world, the technology is on the peak of its advancement. Due to this advancement, there is an abundant need for smaller and lighter products. Consequently, it is very important that the power supply should be as small and light as possible. It should also be very efficient to the users and very flexible to the designers. Recent developments in semiconductors, integrated IC chips have made switched mode power supply very popular and indispensable choice in the power electronics field. The switch used is continuously turned "OFF" and "ON" at a very high frequency and that is the reason behind the name of "switched mode power supply". Due to its high efficiency, greater reliability and cost effectiveness, SMPS is becoming more and more popular over the linear power supply. By using SMPS an output voltage of desired magnitude can be obtained from any form of input voltage. Presently, SMPS annually produces 65% to 80% of the total power supply used. It has a wide range of applications from personal computers, televisions to various military equipments and industrial machineries.

In [1], a multilayered core-less step down transformer for high frequency SMPS is presented. The advantages of multilayered core transformer are discussed in it. In [2], the concept of switching function to design a flyback converter is presented. In [3], the high efficiency buck-boost converter with reduced average inductor current technique is described. In [4], operation of improved buck-boost circuit is presented. In [5], the operating principle and design of resonant switched mode converter are discussed. In [6], the design of closed loop voltage mode controlled PWM flyback converter is described. It is designed for CCM with integral lead controller. An improved flyback converter is presented in [7]. In [8], the design method of switched mode power supply is discussed.

In the present paper, the design of flyback converter is presented. The circuit diagram and operating principle of flyback converter are discussed in 2. The simulation model of the flyback converter and its output waveforms

are presented in 3. In 4, the feedback loop for designing closed loop controlled converter is described. The hardware implementation of flyback converter and various output waveforms are presented in 5.

## II. FLYBACK CONVERTER



**Fig 1: Circuit diagram of flyback converter**

Fig. 1 shows the circuit diagram of a flyback converter. It is a transformer-isolated converter. When the switch is on, the dot end of the primary becomes positive with respect to the non-dot end. The supply voltage is applied to the transformer primary. A corresponding voltage is induced in transformer secondary. The dot end of the secondary is positive with respect to the non dot end. So the diode in the secondary side becomes reverse biased and no current flows through the secondary winding. Thus the transformer behaves as an inductor. The current flows from the source through the transformer primary, switch and then back to source. The load current is supplied by the output capacitor.

At the end of the ON time, the magnetizing current in the transformer continues to flow through the primary winding. Due to this current, the dot end of the transformer becomes negative with respect to the non dot end. The energy stored in the primary winding is transferred to the secondary winding. The diode in the secondary side becomes forward biased and current flows from the secondary winding to the load. The output capacitor gets charged.

### III. SIMULINK MODEL OF FLYBACK CONVERTER AND ITS OUTPUT WAVEFORMS

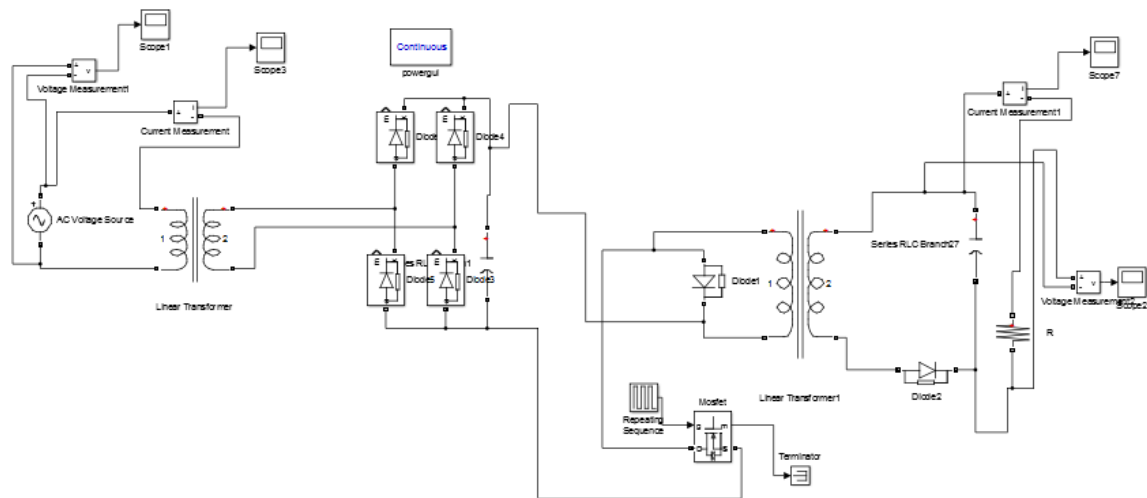


Fig 2: SIMULINK model of flyback converter

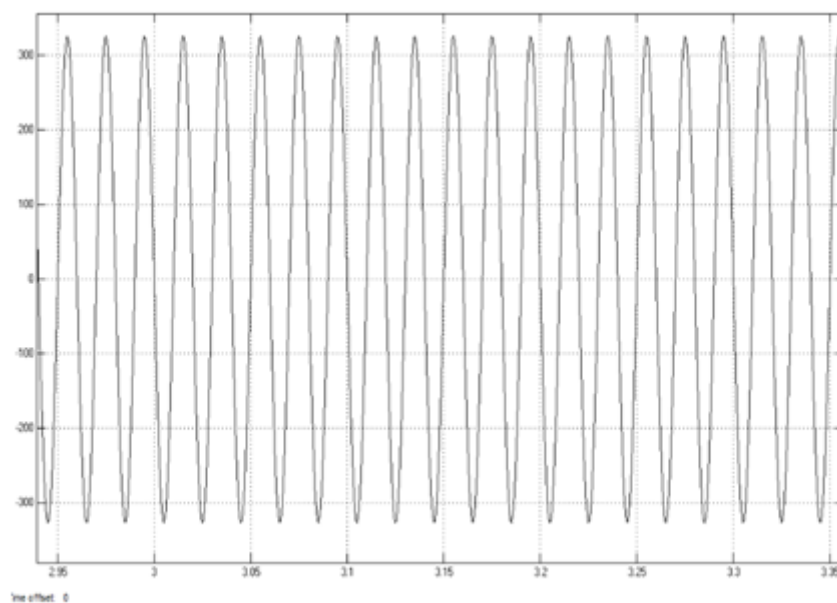
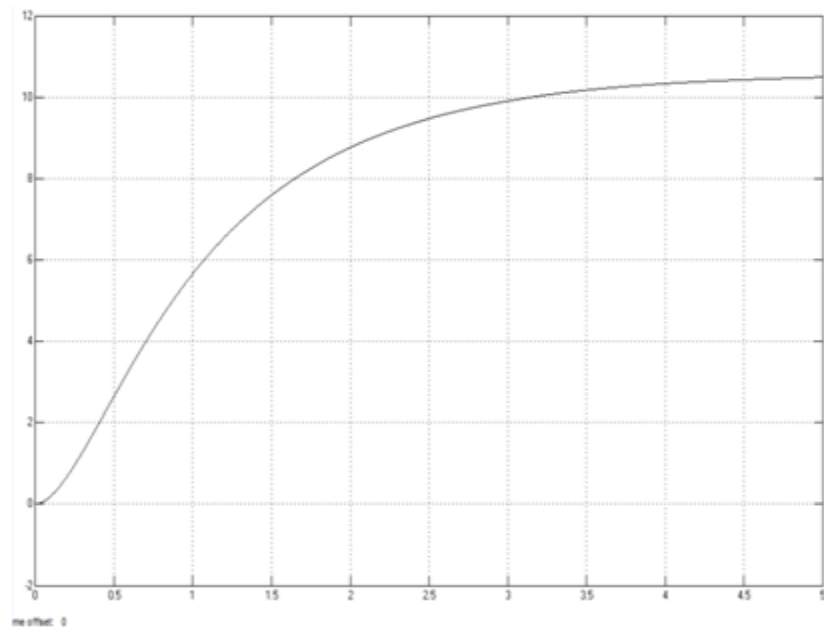
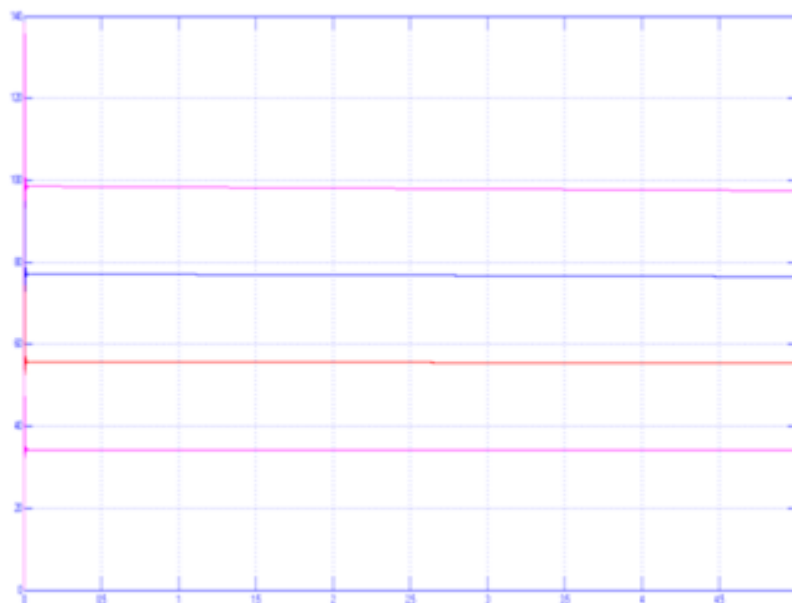


Fig 3: Input Voltage Waveform

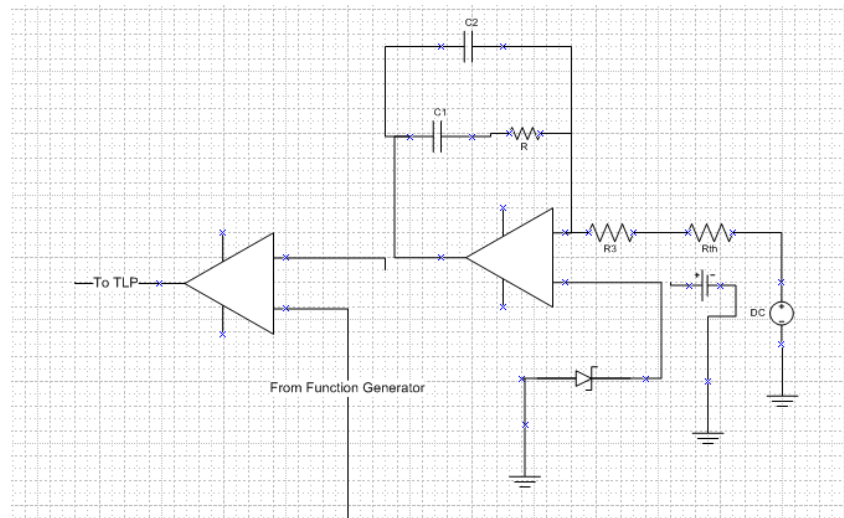


**Fig 4: Output Voltage Waveform**



**Fig 5: Variation of Output Voltage by varying the duty cycle**

#### IV. DESIGN OF THE FEEDBACK LOOP



**Fig 6: The circuit diagram for the feedback loop**

From the bode plot, the corner frequencies obtained are – 10Hz and 36.345 KHz.

Assuming feedback current 100mA, the components required for the design of feedback loop are-

- $R_{th} = 20\Omega$ ,
- $R_3 = 3.3\text{ K}\Omega$ ,
- $R = 33\text{ K}\Omega$ ,
- $C_1 = 50\mu\text{F}$ ,
- $C_2 = 0.01\mu\text{F}$

#### V. HARDWARE DESIGN AND IMPLEMENTATION OF FLYBACK CONVERTER

Components required for the design of hardware:

- Microcontroller ATMEGA 328
- Power MOSFET (IRF640:  $V_{DS} = 200$  Volts,  $V_{GS} = 2-4$  Volts,  $I_D = 250\mu\text{A}$  )
- Optocoupler (TLP250: Isolation Voltage = 10-35 Volts, Current = 0.02 Amps)
- Diode (IN4007S: Voltage = 50-1000 Volts, Current = 1Amps)
- OP-AMP 741
- Transformer ( $V_p = 40$  Volts,  $V_s = 240$  Volts)
- NPN Transistor (BC547)
- PNP Transistor (C557B)
- Resistances (100 $\Omega$ , 20 $\Omega$ , 1K $\Omega$ , 3.3K $\Omega$ , 33K $\Omega$ , 4.7K $\Omega$ )
- Capacitances (250 $\mu\text{F}$ , 47 $\mu\text{F}$ , 0.1 $\mu\text{F}$ , 0.01 $\mu\text{F}$ )

The circuit for the flyback converter is first successfully tested on breadboard and then it is implemented in veroboard. In case of open loop circuit, microcontroller is used to generate the firing pulses. Power MOSFET is used as the switch. Transistors are used for the gate driver circuit of the power MOSFET. OP-AMPS are used in

the feedback loop as comparator and error amplifier. In the comparator, the triangular pulse is provided with the help of a function generator. By using PWM control, the value of the output voltage is kept constant. Input voltage of the converter is set as 5 volts and it is designed to get an output voltage of 12 volts.

### 5.1 Breadboard Testing Circuit of Flyback Converter

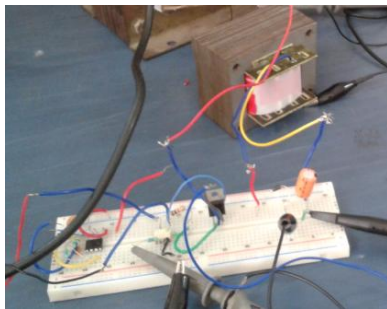


Fig7: Breadboard Testing of Open loop Power Circuit

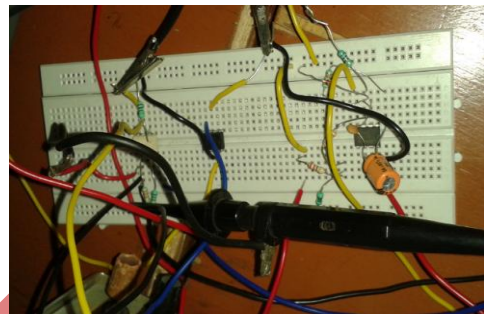


Fig 8: Breadboard Testing of Feedback Loop

### 5.2 Implementation of the circuit in veroboard

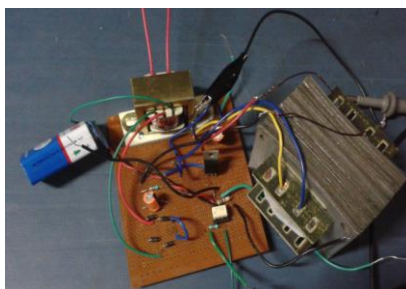


Fig 9: Open loop power circuit in veroboard

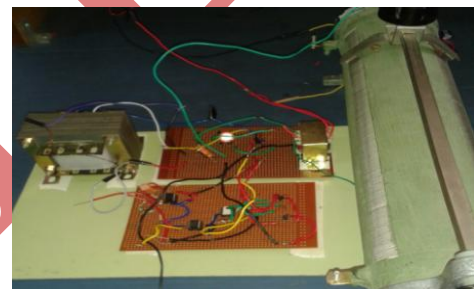


Fig 10: Complete Setup of Hardware

### 5.3 Output Waveforms of the Hardware

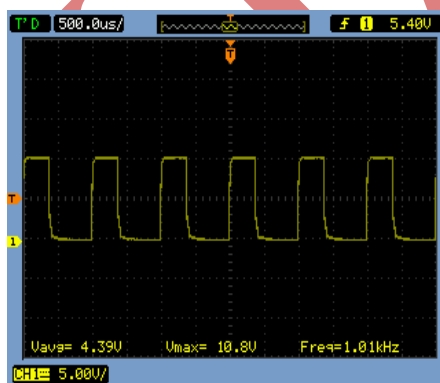


Fig 11: TLP Pulse

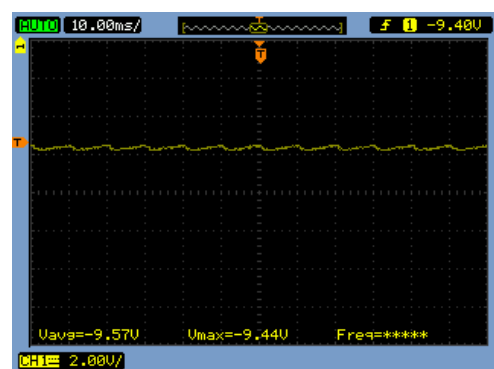


Fig 12: Output Voltage of the bridge rectifier

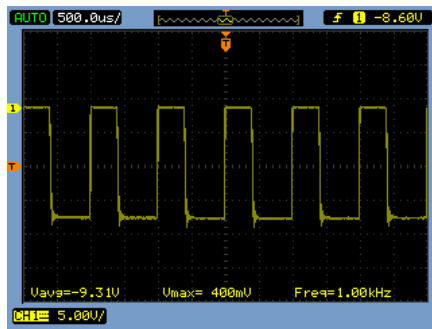


Fig 13: Pulse across the MOSFET

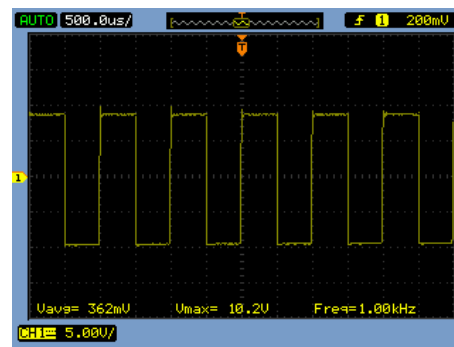


Fig 14: Output across the primary winding



Fig 15: Output across the secondary winding

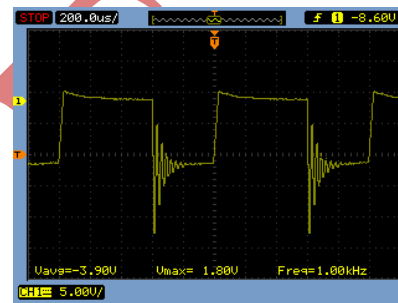


Fig 16: Pulse across the diode

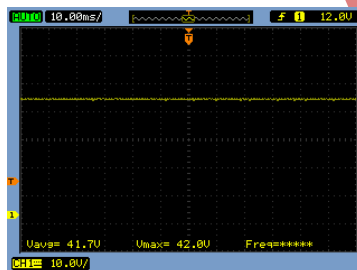


Fig 17: Output voltage waveform of open loop circuit

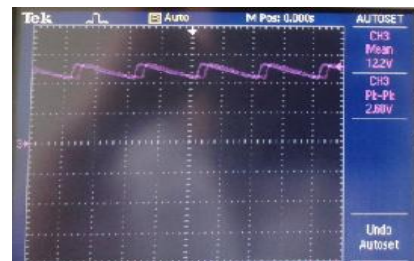


Fig 18: Output voltage waveform of closed loop circuit

## VI. CONCLUSION

This paper presents the simulation, design and hardware implementation of switched mode power supply. A flyback converter based SMPS is designed and implemented using power MOSFET, diode, bridge rectifier, transformer, PI controller. This SMPS can be used in power electronics lab to step up the voltage. It can give fixed or constant desired output voltage. When the output voltage of the converter is still far away from the target output, more power will be applied to the converter to drive it towards the target output value and in this case, the width of the pulse will be higher to reach the target value. When the output voltage of the converter is



getting nearer to the target value, the power must be reduced and in this case, the width of the pulse is low to reach the target value.

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