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DESIGN OF FLYBACK CONVERTER WITH POST REGULATOR (TWO OUTPUTS, 8 W)

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ABSTRACT

DC-DC converter is the essential part of any satellite for providing power to high definition cameras and sensitive sensors and other small devices. These devices require constant low dc voltage and varying load current which can be provided by isolated DC-DC topologies. Some ICs are also available which can provide the required constant low voltage but they are cost effective. So the paper includes the design and Simulation of Flyback converter (Two Outputs, 8W). Design calculations of Flyback converter presented in this paper. Design is also simulated in PSPICE simulator with a switching frequency of 150KHz. Simulation results of close loop and open loop are also presented and discussed

Keywords: Flyback Converter, Isolated Buck – Boost Converter, PSpice Simulator, Multiple Output Converter, DC – DC Converter, Post Regulation, Closed Loop

1. INTRODUCTION

Power electronics use has increased a lot over the past few decades. One of the major applications of power electronics is the dc-dc conversion. We can differentiate this application into two different types.

- DC-DC converter with an input of direct source
- Use of DC-DC converter when the input is alternating source

Switched mode power supplies with PWM techniques become an essential component of many industrial, military, communication, automobile, computer, space applications and also in consumer products where good efficiency, light weight, low cost and small size are of major concern. In addition to these, some switched mode power supplies requires electrical isolation between source and load.

The Flyback converter is used in both AC to DC and DC to DC conversion with galvanic isolation between the input and any outputs. The Flyback converter is a buck-boost converter with the inductor split to form a transformer, so that the voltage ratios are multiplied with an additional advantage of isolation. When driving for example a plasma lamp or a voltage multiplier the rectifying diode of the boost converter is left out and the device is called a Flyback transformer.

Flyback converter is the most commonly used SMPS circuit for low output power applications where the output voltage needs to be isolated from the input main supply. The output power of fly-back type SMPS circuits may vary from few watts to less than 100 watts. The overall circuit topology of this converter is considerably simpler than other SMPS circuits. Input to the circuit is generally unregulated dc voltage obtained by rectifying the utility ac voltage followed by a simple capacitor filter.

The circuit can offer single or multiple isolated output voltages and can operate over wide range of input voltage variation. In respect of energy-efficiency, Flyback power supplies are inferior to many other SMPS circuits but it's simple topology and low cost makes it popular in low output power. [2] [4]

2. CIRCUIT DESCRIPTION

Circuit shown in figure 1 operates in similar manner to the buck-boost converter, but here inductor has a secondary winding. An isolation transformer is used which acts like a coupled inductor. An ideal transformer directly couples' energy between the Primary and secondary circuit and does not store energy. In this circuit an air gap is required, as primary energy stored in the device.

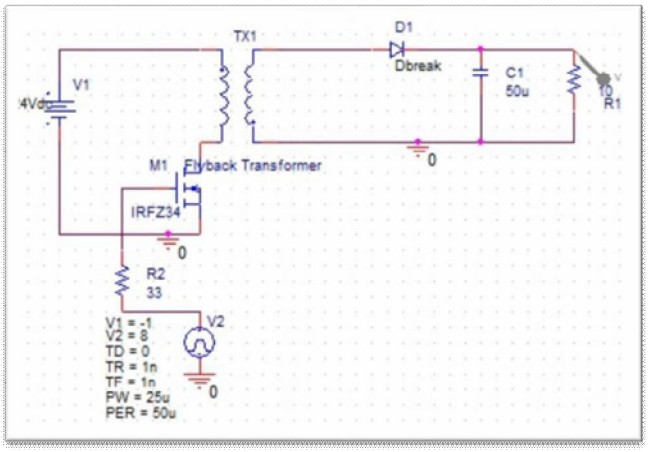

Figure 1 Circuit diagram of Flyback converter

During On period, current builds up in the primary winding, storing energy in the inductor. Since secondary has opposite polarity so diode is reversed biased during on period. During off period, volt-ampere is transferred to secondary which conduct the diode in forward bias and hence energy is released to the load. [3]

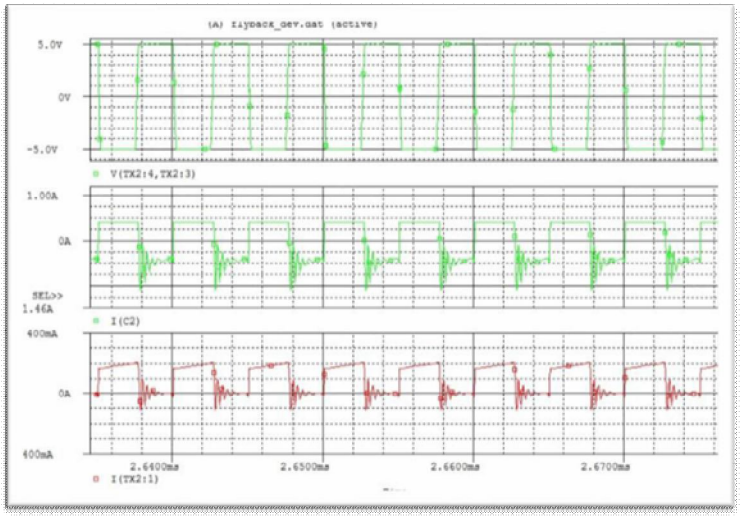

Figure2 Output results of Flyback converter

Here above figure 2 indicate the ideal output waveforms of the Ideal Flyback converter in the Pspice simulator.The Flyback converter is mostly used in discontinuous mode due to

- Smaller inductor required
- Better closed loop response

The disadvantages of discontinuous mode operation are:

- High peak transistor current
- Large filter capacitor

3. DESIGN CALCULATION

Design Specifications:

Input voltage range (Vg) = 28-42Volts

Nominal value of input voltage = 35V

Auxiliary voltage (Vaux) = 12volts at 0.16 A

Maximum duty cycle (Dmax) = 0.45

Output voltage (V_{O1}) = 14 volts at 0.25 A

Output voltage (V_{O2}) = 5 volts at 0.5 A

Switching frequency (Fs) = 150 kHz

Time Period (T_P) = 6.66 µs

Time On (T_{On}) = 2.99 µs

Efficiency = 75% (Estimated)

Here in this converter we use mpp toroid core.

- Dc transfers function of Flyback Converter:
  - *Vo = (N*D/(1-D)) *TP*
- Output Power:
  - Pout = 14(0.25) +5(0.5) +12(0.160) = **7.92W**
- Primary inductions :
  - $L_{Pri} = (V_{In\ (Low)} * D * T_P) / I_{Pk}$ = **54µH**
- Primary Turns [1]
  - $N_{Pri} = ((L * 10^3) / A_L) \wedge (1/2)$
- Secondary turns
  - $N_{Sec} = (N_{Pri} * (V_O + V_D) * (1-D) / (V_{In} * D))$
  - $N_{Sec\ (5V)}$ = **6 Turns**
  - $N_{Sec\ (14V)}$ = **15 Turns**
  - $N_{Sec\ (12V)}$ = **13 Turns**
- Secondary Inductance
- $L_{Sec} = (L_{Pri} / (N_{Pri} / N_{Sec})^2)$
  - $L_{Sec\ (5V)}$ = **4 µH**
  - $L_{Sec\ (14V)}$ = **25 µH**
  - $L_{Sec\ (12V)}$ = **18.85 µH**

4. CIRCUIT SIMULATION

Pspice technology offers mixed-signal simulation and system-level analysis capabilities across different levels of abstraction across low- to high-power applications, including electric vehicles to data centres, to wearables, renewable, and the power grid. Known for its accuracy and high performance in power supply simulation technology as well as the ability to integrate with OrCAD capture and Allegro solution, PSpice simulation program makes power supply analysis simple.

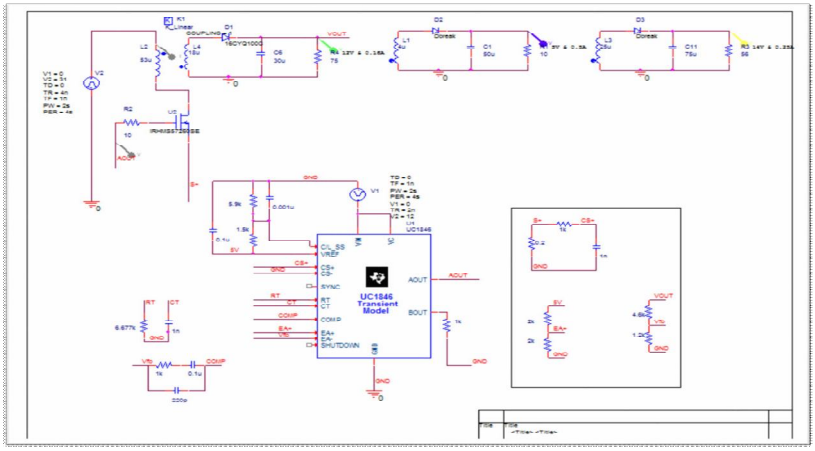

FIGURE3 CLOSE LOOP SIMULATION WITH UC 1846

To Design, simulate and analyze the circuit we have used PSpice software. PSpice have made simulating switching

regulators extremely fast, allowing the user to view waveforms for most switching regulators in just a few minutes.
Here above figure 3 indicate the close loop simulation with UC 1846 in Pspice simulator with multiple outputs as required in design calculation. Above fig also contain the post regulator IC – UC1846 in simulation to regulate the output voltage as well as current.

5.

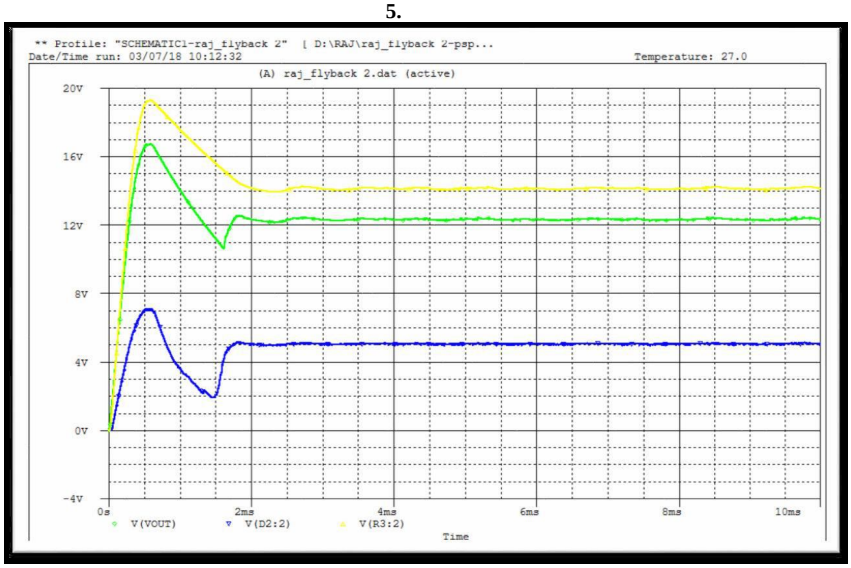

FIGURE4 OUTPUT WAVEFORM OF CLOSED LOOP FLYBACK CONVERTER

In the above figure 4 shown the output waveform of closed loop of the designed Flyback converter, this waveform is at 28V but it will maintain at input voltage of 35 V and 42 V.

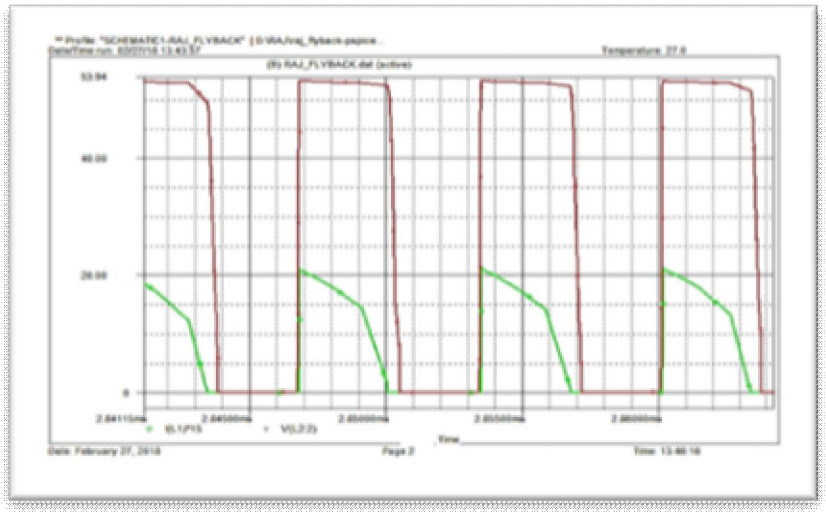

FIGURE5 INDUCTOR CURRENT AND DUTY CYCLE WAVEFORM

Table 1: Margin specifications

Margin	A4 Paper	US Letter Paper
Left	18.5 mm	14.5 mm (0.58 in)
Right	18mm	13 mm (0.51 in)

5. RESULT AND DISCUSSION

Isolated Buck- Boost converter also known as Flyback converter is simulated in Pspice. The line regulation found was poor, so in order to improve the regulation, IC UC-1846 is used as a post regulator.

Table 1: Open loop Line regulation voltage

Vin (v)	Vo1 (v)	Io1 (A)	Vo2 (v)	Io2 (A)	Vo3 (v)	Io3 (A)
28	14	0.245	5	0.49	12	0.158
35	15.37	0.292	6.97	0.515	14.9	0.161
42	18.7	0.326	7.93	0.57	16.22	0.172

Table 2: Close loop Line regulation voltage

Vin (volts)	Vout1 (volts)	Iout1 (Amp)	Vout2 (volts)	Iout2 (Amp)	Vout3 (volt)	Iout3 (Amp)
28	14	0.245	5	0.49	12	0.158
35	13.7	0.242	5.17	0.495	12.29	0.159
42	13.47	0.246	5.43	0.50	12.72	0.161

Hence, complete design of Flyback Converter employing IC UC-1846 is done and implemented. The results obtained are satisfactory. Worst case Line regulation at 28 Volt input. However, load and line regulation obtained above 30 Volt input is found good.

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