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Observation and Calculation of Different Harmonics in Fly Back Converter

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***Abstracts*-----In order to avoid dangerous interactions between power and control part of the integrated circuit, it is necessary to control the rate of change of the power device voltage at turn-off. Accordingly, lossless passive Snubber was added to the conventional converter topology. The Snubber also limits the voltage spikes across the power device, due to the transformer leakage inductance, and reduces the electromagnetic noise generation. A basic review of the fly back switching topology will be presented with an emphasis on not-so-obvious design issues, such as effects of parasitic, fault protection, and EMI mitigation. Modeling and analysis will be demonstrated. The study involves analysis, circuit design, performance comparisons and implementation. The circuits are investigated by means of computer simulations. Operating principles and operating modes are studied along with design calculations. After applying prototypes in laboratory, the simulation results and theoretical analyses are confirmed.**

***Keywords*----SMPS, MOSFET, Snubber Resistance, Snubber circuit, fly back converter**

I. INTRODUCTION

Switch Mode Power Supply (SMPS) is the transformation of dc voltage from one level to another is accomplished by using dc-to-dc converter circuits. These circuit employ solid state devices (transistors, MOSFETS, etc.) which operate as a switch either completely off or completely on. Here since the power devices are not required to operate in their active region this mode of operation results in a lower power dissipation increased switching speeds higher voltage and current ratings and relatively lower cost of these devices are the factors that have contributed to the emergence of switching power suppliers.

Advantages of SMPS over linear power supply:

- In linear power supply the transistor operates in its active region incurring a significant power loss. So efficiency is in the range of 30-60%. But in SMPS it avoids operating in their active region so a significant reduction in power losses is achieved. This results in a higher energy efficiency in a 70-90% range.
- In linear power supply a low frequency transformer is required. Such transformers are larger in size and weight compared to high frequency transformers. In SMPS a high frequency isolation transformer is used so the size and weight of SMPS can be significantly reduced.

II. FLY BACK CONVERTER

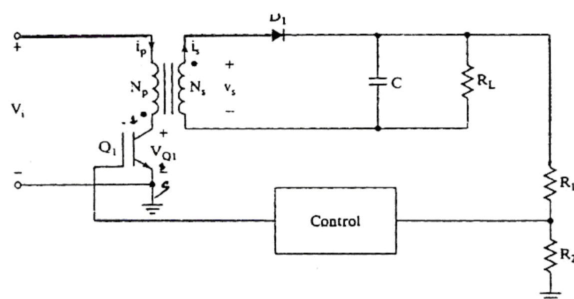

Figure:1 This is the circuit diagram of fly back converter.

There are two modes of operation.

(i) Mode 1 when Q_1 is turned on

(ii) Mode 2 when Q_2 is turned off.

Different Modes of operation

MODE-I

This mode begins when switch Q1 is turned on and it is valid for 0 < t < KT where K is the duty cycle ratio and T is the switching period.

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The voltage across the primary winding of the transformer is V_s. The primary current i_p starts to build up and stores energy in the primary winding. Due to opposite polarity arrangement between Input & Output winding of transformer diode D_1 is reversed biased. There is no energy transferred from the input to load R_1.

The primary current increases linearly is given by

$$i_p = \frac{V_s}{L_p} t$$

At the end of this mode at t = KT the peak primary current reaches a value to I_p (pk).

$$\text{So } i_p(pk) = i_p(t = KT)\frac{V_s KT}{L_p}$$

The peak secondary current I_{sc} ($_{pk}$) is

$$I_{sc}(pk) = \left(\frac{N_p}{N_s}\right) Ip(pk)$$

MODE – 2

This mode begins when switch Q_1 is turned off. Due to the opposite polarity diode D_1 on and charges the output capacitor C can also delivers current to R_L. The secondary current that decreases linearly is

$$i_p I_{sc}(pk) - \frac{V_o}{L_s} t$$

$$V_{Q1}(max) = V_s(max) + \frac{N_p}{N_s} V_o$$

V_{Q1} – Collector voltage

The peak primary current I_p ($_{pk}$) which is the same as the maximum collector current and the rms primary current.

I_c (max) of the power switch Q_1 is given by

$$I_c(max) = I_p(pk) = \frac{2p_i}{KV_s} = \frac{2P_o}{\eta V_s K}$$

Where Pi = Input Power

Po = Output Power

η = Efficiency

The following waveforms are the steady state waveforms under discontinuous mode of operation.

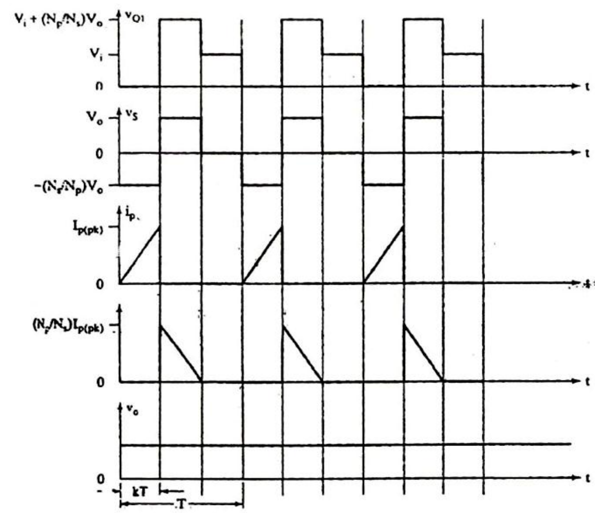

Figure2: Waveforms of Fly back Converter at discontinuous mode of operation

III. PROTECTION SNUBBER

The function of a snubber circuit is to reduce the electrical stresses placed on a device during switching by a power electronics converter to levels that are within the electrical ratings of the device. More explicitly a snubber circuit reduces the switching stresses to safe levels by :

1. Limiting voltages applied to devices during turn-off transients.
2. Limiting device currents during turn-on transients.
3. Limiting the rate of rise of (di/dt) current through devices at device turn-on.
4. Limiting the rate of rise (dv/dt) of voltage across devices during turn off.

Need for snubbers with Transistors:

Snubber circuits are used to protect the transistors by improving their switching trajectory, there are three basic types of snubbers.

1. Turn off snubbers.
2. Turn-on snubbers.
3. Over voltage snubbers.

Turn –off Snubber:

To avoid the problems at turn-off the voltage of a turn-off snubbers is to provide a zero voltage across the transistor while the current turns off.

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This can be approached by connecting A RCD network across the BJT. Prior to turn off the transistor current is Io and the transistor voltage is essentially zero. At turn off in the presence of this snubber the transistor current is decreases with a constant di/dt and (I_o – i_c) flows into the capacitor through the snubber diode Ds. Therefore for a current fall time of t_{fi} the capacitor current is i_{cs} = Iot/t_n O < t < t_n

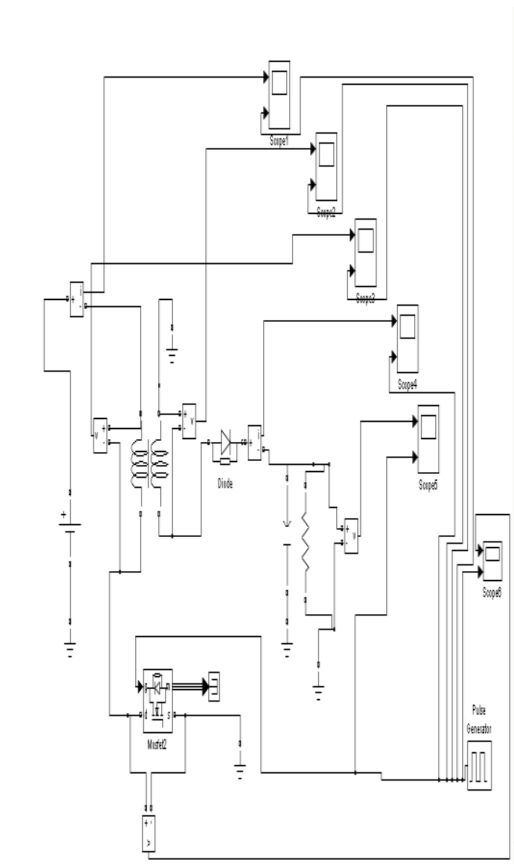

Figure:3 Simulation diagram for fly back converter without snubber

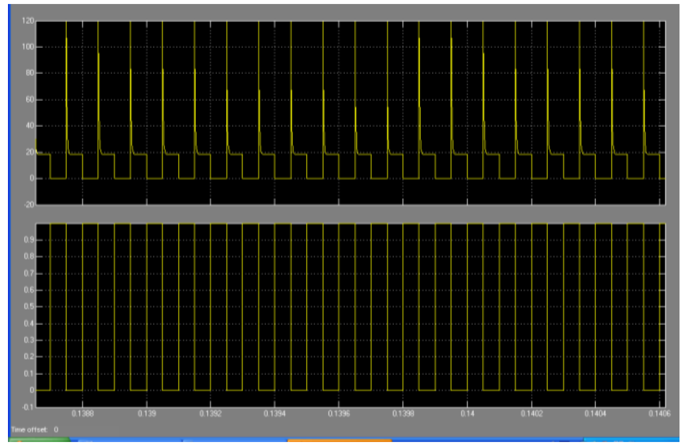

Figure 4: V_{sw} & I_G(Gate pulse)

1. The switch voltage is found to be around 20 volt
2. Due to the absent of snubber circuit the voltage spike is high up to 120 volt.

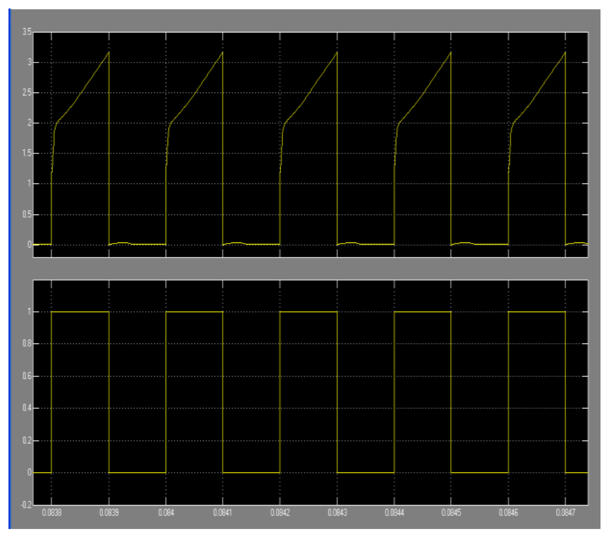

Figure 5: I_P & I_G (Gate pulse)(without snubber)The primary current is found to be 1.5 amp.

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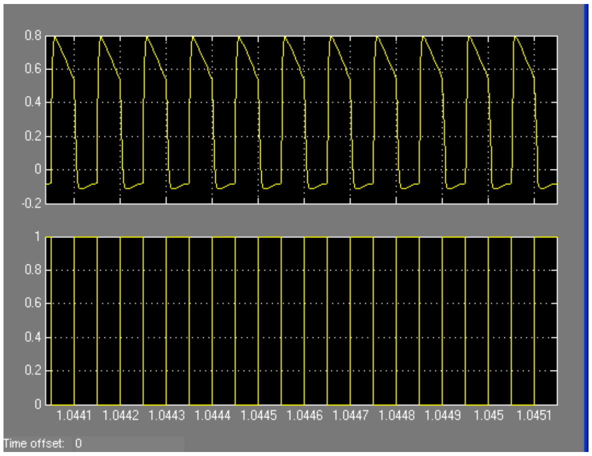

Figure 6: I_S&I_G (Gate pulse)(without snubber)The secondary current is found to be 0.5 amp.

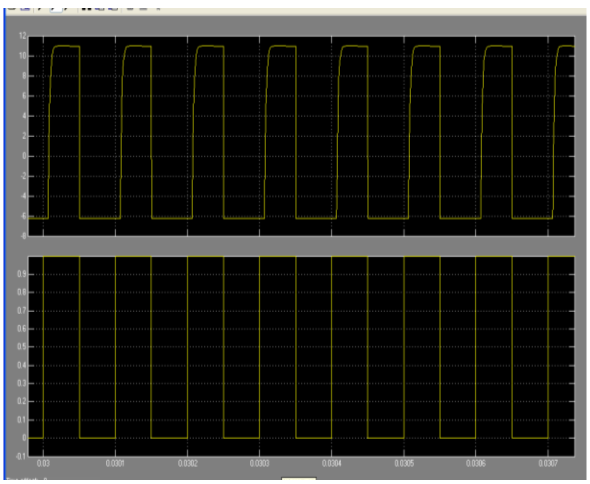

Figure 7: V_2 & I_G (Gate pulse)(with out snubber)

- The secondary voltage is found to be around 12volt.
- The primary voltage referred to secondary is found to be 6volt

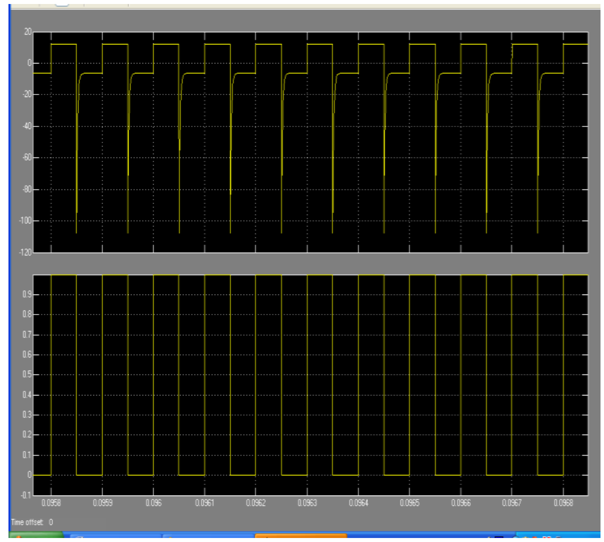

Figure 8:$V_P$versus I_G (Gate pulse)(without snubber)

- The primary voltage is found to be 12 volt.
- The secondary voltage referred to primary is found to be 8 volt.
- The spike voltage is found to be 110 volt.

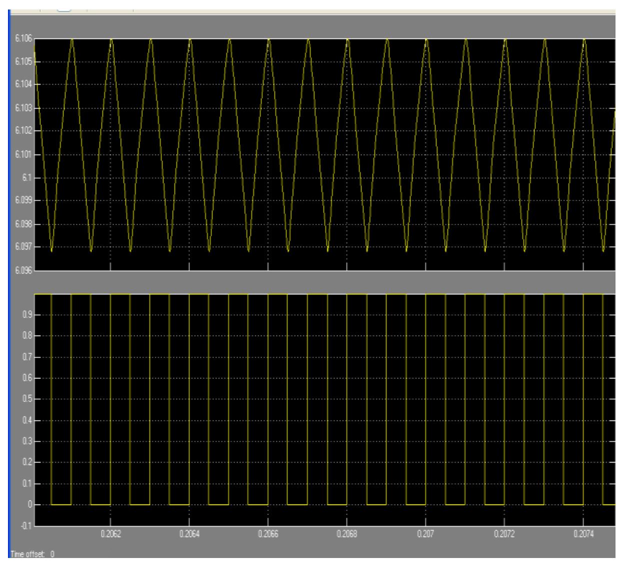

Figure 9: V_0 versus I_G (Gate pulse)(with out snubber)The output voltage is found to be around 6 volt.

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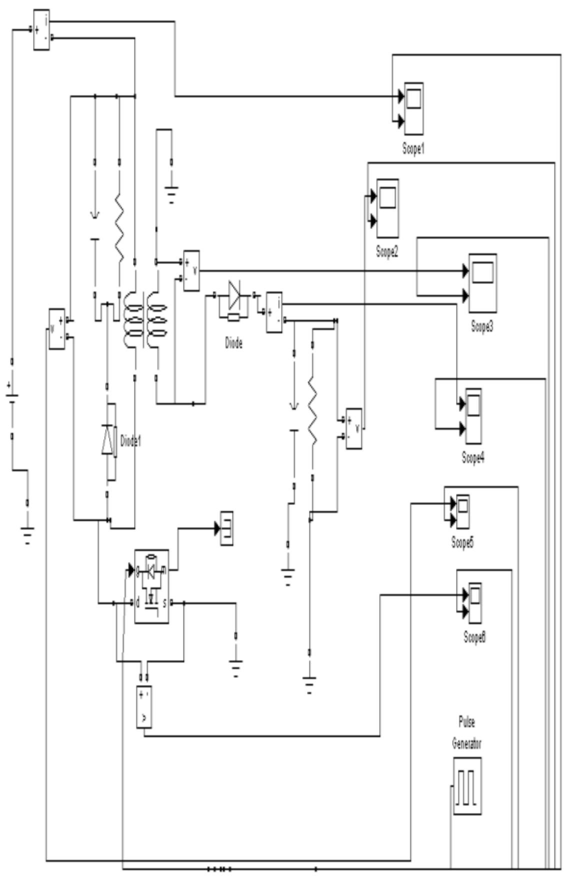

Figure 10: Simulation diagram for Fly back converter with snubber

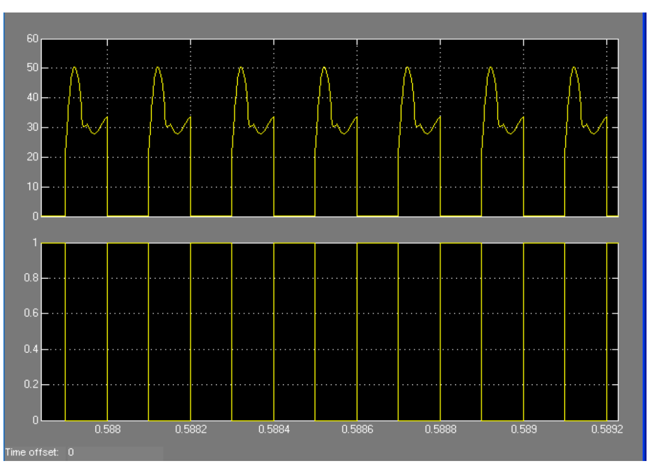

Figure 11: Vsw & Gate-pulse(with snubber)

- The switch voltage is around 30 volt.
- An extra spike voltage of around 30 volt is developed across switch.
- By utilization of snubber circuit the spike voltage satisfactory reduced.

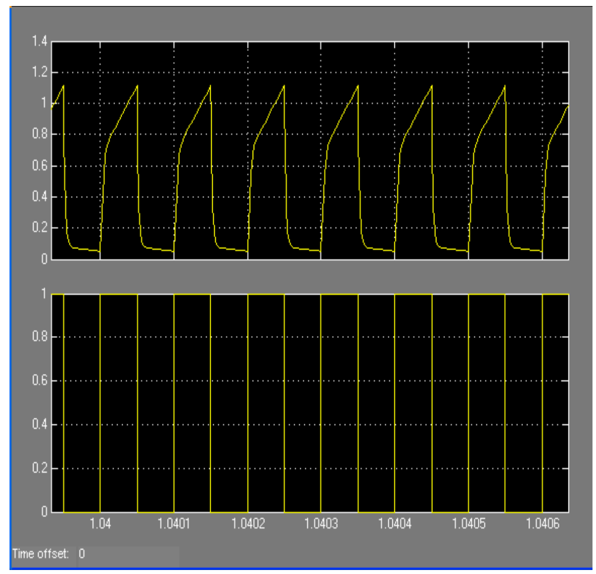

Figure 12: Ip &Gate pulse(with snubber)The primary current is found to be around 0.6 amp.

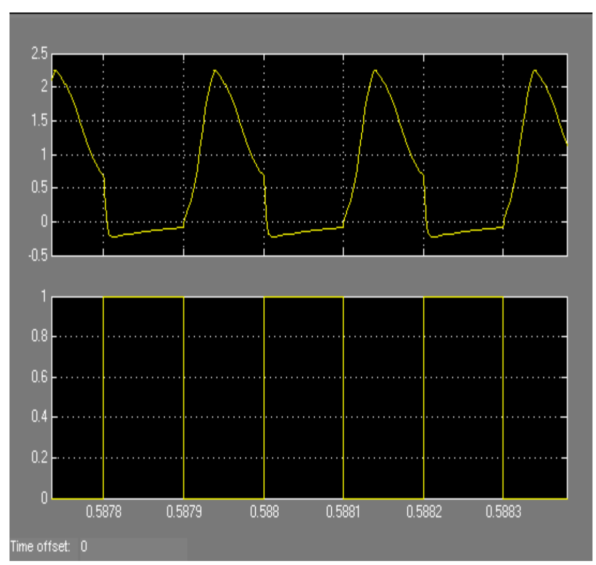

Figure 13: I_2 versus I_G (Gate pulse)(wth snubber)The secondary current is around 1.5 amp.

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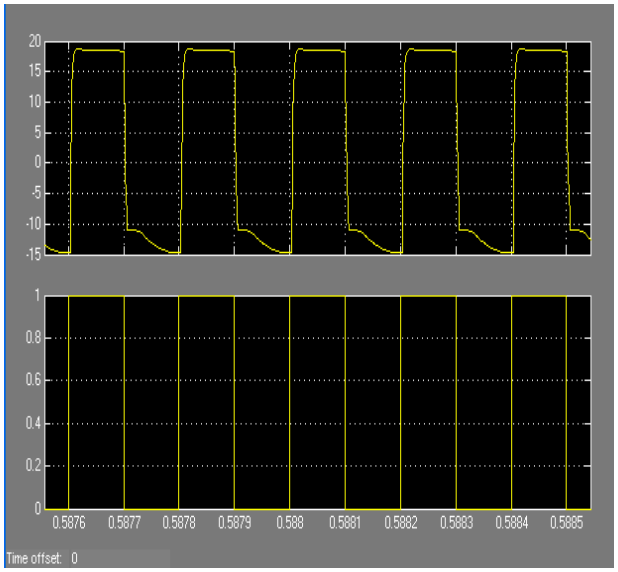

Figure 14: V_2 versus I_G (Gate pulse)

- The secondary voltage is found to be 18 volt.
- The primary voltage referred to secondary is around 10 volt.

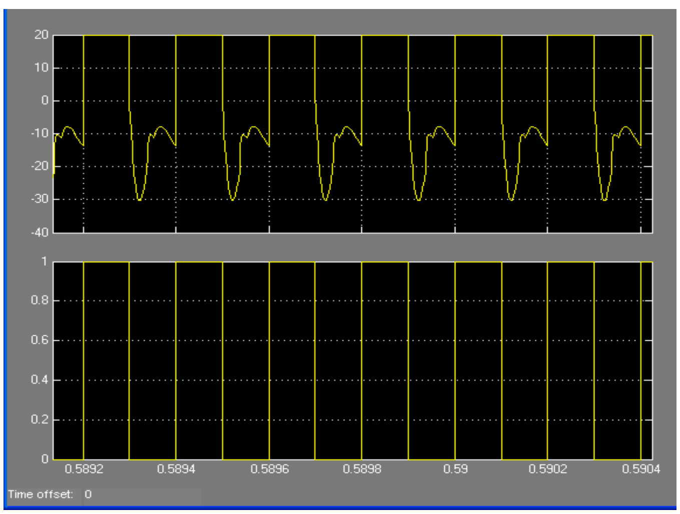

Figure 15: V_p & I_G (gate pulse) (with snubber)

- The primary voltage is around 20 volt, the secondary voltage referred to Primary is 10 volt.
- A spike of around 20 volt is developed at primary.

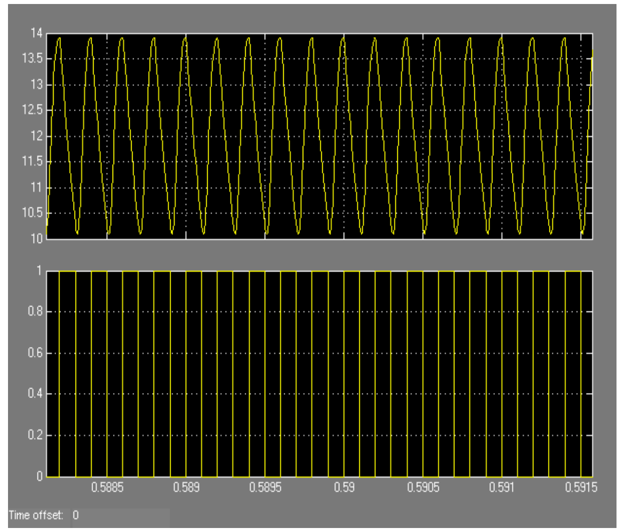

Figure 16.: V_0 & I_G (gate current)Output voltage is found to be 12 volt.

IV. Comparison Study

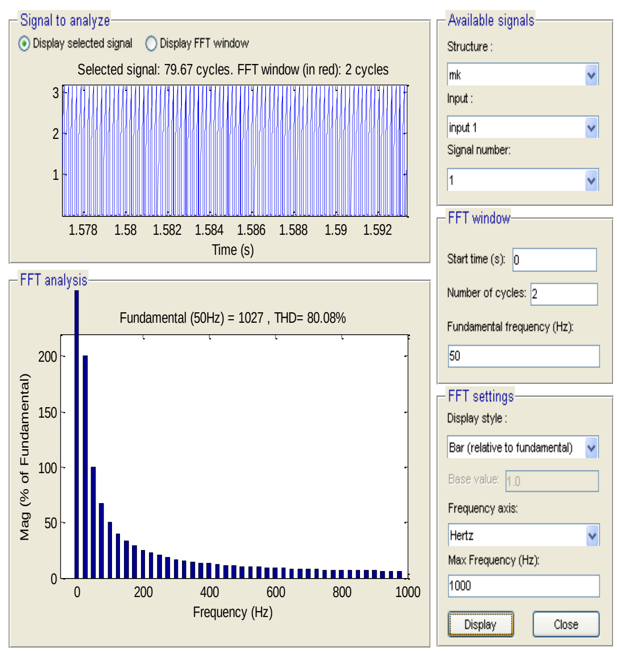

Figure 17.. shows harmonic order of input current .(with out snubber)

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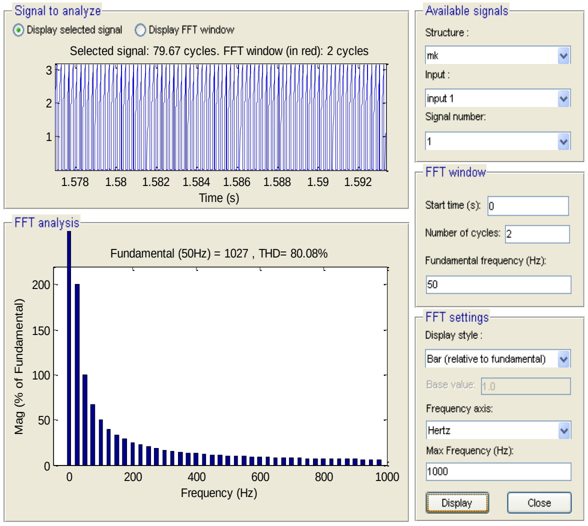

Figure 18 shows bar diagram of harmonic order of input current. (With snubber)

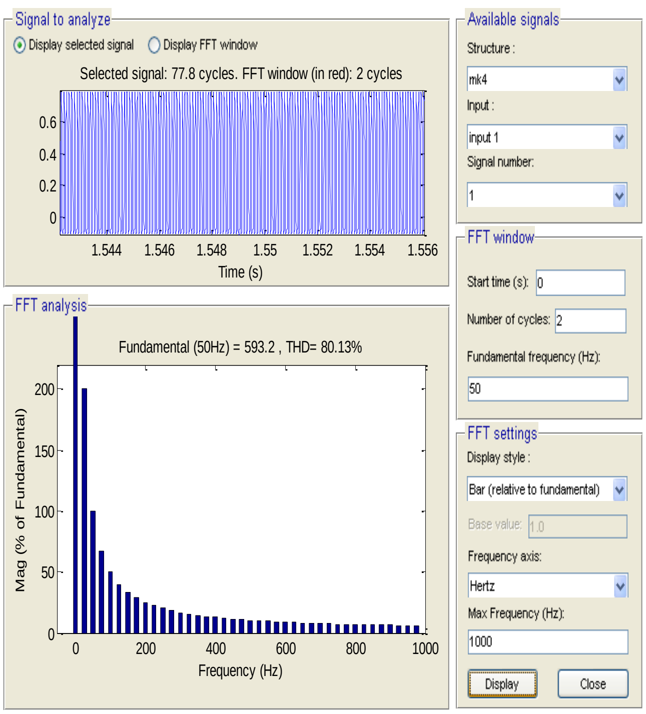

Figure 19: shows the harmonic content in secondary current(without snubber)

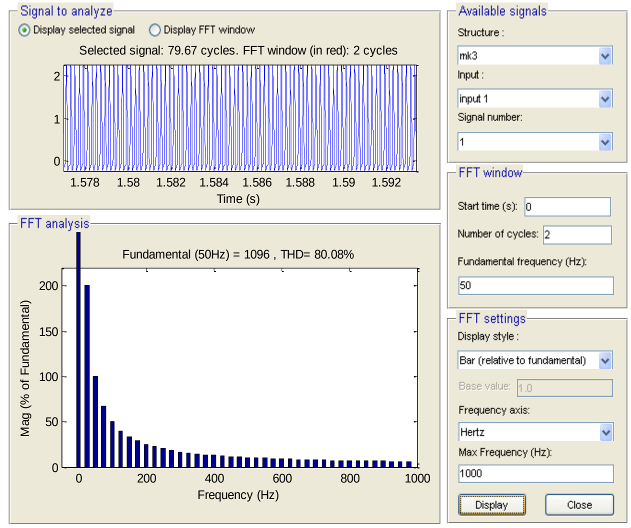

Figure 20: shows the harmonic content in secondary current(with snubber)

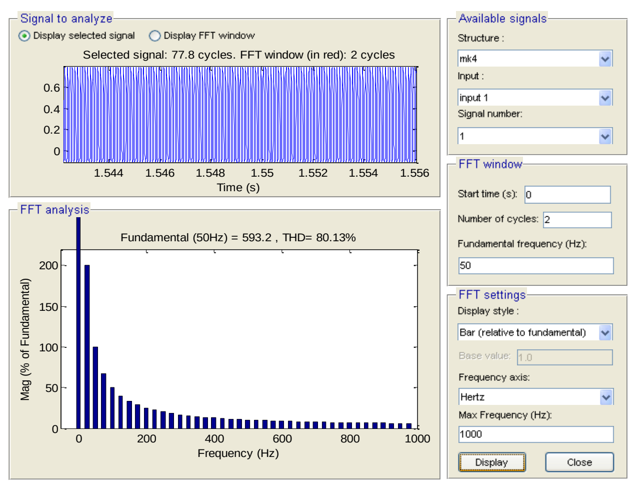

Figure 21.shows the harmonic content in secondary current (without Snubber)

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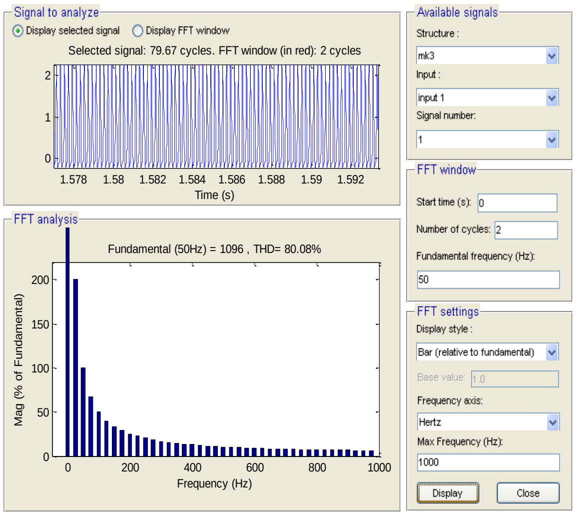

Figure 22shows the harmonic content in secondary current (with Snubber)

V. Result & Comparision

- During simulation of Fly back converter with snubber & without snubber the primary & secondary current contain harmonics.
- In both the cases there was harmonics which can be removed by a suitable filter circuit.
- From the simulation study we found the switch stress is around 120v without snubber circuit, where as by using snubber circuit the stress was reduced upto 40 v.

Without Snubber	with Snubber
V_{IN} =12v	**V_{IN}=12v**
V_{OUT}=6v	**V_{OUT}=13v**
I_1 =1.5a	**I_1=1.5a**
I_2=0.5a	**I_2=1.2a**
V_{SW} =110v	**V_{SW}=50v**

VI. Conclusion

Aim of the thesis is to simulate and hardware design of fly back converter. Accordingly simulation has done with fly back converter without snubber and fly back converter with snubber. The Result found that during simulation of fly back converter with snubber gives better output voltage and current and voltage stress across the switch is also less.

Fly back converter with unique configuration aimed to increase the efficiency and performance of standard fly back converters. The proposed configuration integrates DC-DC stage and PFC stage of a fly back converter and provides power conversion in one stage. The proposed converter designed for 90 Watts. This power levels need more attention in design and similar commercial products in this power level is high cost devices. The proposed converter reduces the component count, the size and cost of the converter. In this thesis, analytical solutions approved the operation system of the converter, however the simulations and experimental verifications showed that performance could not give proposed performance values of the research. The research suggests several different values for passive elements and finally some limits are defined for these parameters.

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