Simulation of Multi output Fly back Converter with Integrated Auxiliary Buck Converter with reduced components

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Abstract— The fly back converter has been widely used for multi outputs due to the simple structure and low cost in low-power applications. This paper presents a new multi output converter. It consists of a half-bridge inverter with boost converter in primary side and a fly back rectifier that is integrated with an auxiliary buck converter in secondary side. The boost converter is used to generate high voltage dc from Low voltage PV cells. The primary switches control the main output voltage and the secondary synchronous switches control the auxiliary output voltage. The main advantages of the proposed converter are that the transformer size can be reduced due to the less magnetizing offset current, all the power switches including synchronous ones can achieve the zero-voltage switching (ZVS) and it has no output cross regulation problems. The circuit is simulated using MATLAB. The performance is verified with simulation results.

Keyword- Boost converter, fly back converter, inverter, zero voltage switching and buck converter

I. INTRODUCTION

Photovoltaic (PV) power-generation systems are becoming increasingly very important and prevalent in distribution generation systems. PV energy is limitless and pollution free environment source. A serial connection of multiple solar cell combination gives higher dc-link voltage for main electricity through a dc–ac inverter [1]-[2]. The solar cell has nonlinear *V –I* and *P–V* characteristics. It depends on the irradiance, the operating temperature and load condition of the cell. Unfortunately, once there is a partial shadow on some solar panels, the system's energy yield becomes significantly reduced [3].To avoid more solar cells and reduce the size and cost of the system to develop some step up chopper based dc-dc converter after solar cells. [4] .These converter is used to give constant output voltage. Therefore, the dc–dc converter for a PV system has to control the variation of the maximum power point of the solar cell output. In other words, modulation of the duty ratio of the boost converter controls maximum power point tracking (MPPT) [4] - [5].

Many industrial equipment need multi output power supplies but the voltage values can be different. Therefore, the manufacturer could use the same product for different customers if the output power ratings and voltages can have some adjustment capability. Recently, switch-mode power supplies has become smaller and lighter, because the switching frequency has increased. Due to load and climate changes, planetary efforts are conducted toward energy saving by increasing the equipment efficiency.

Especially the high efficiency not only under full-load conditions but also under light-load conditions is required in many applications such as personal computer, display devices, and so on [6]-[7]. Also, system requirements often dictate the need for most switching power supplies to provide regulated and isolated multiple outputs. The fly back converter has been widely used for multi outputs due to the simple circuit and low cost in low-power applications.

Fly back converter has single switch so it has high voltage stress of the primary side switch, more power loss due to Leakage inductance and EMI problem. [8]–[9]. To overcome these drawbacks, half-bridge inverter can be a good solution. Especially, as the gate signals of two switches are operated in asymmetrical method, the main switch not only has less-voltage stress of the input voltage, but also can easily achieve zero-voltage switching (ZVS) using the transformer leakage inductance [10]–[17]. Some multi output topology has multi winding transformer for multi output or parallel connection of rectifier (multi ups). In this case the transformer size is large and increases the semi conductor devices. Similarly output voltage regulation also is difficult in this method. In this paper, a new isolated multi output dc/dc converter is proposed. The proposed converter is based on the half-bridge fly back converter for the main output and buck converters for the auxiliary outputs[18]. The buck converter is integrated with the secondary fly back rectifier. This integration makes simple structure, and lower transformer size, and ZVS of all the switches are achieved by gate control without additional components. In addition, cross regulation problems among the outputs do not occur.

II. PROPOSED CONVERTER DESCRIPTION

A. *Operating principle*

Fig. 1 shows the conventional converter circuit diagram. Fig. 1(a) shows the conventional half-bridge based fly back converter for main output *VO*2 and auxiliary buck converter for auxiliary output *VO*1. The half-bridge inverter can achieve the ZVS of the primary side switches using asymmetric gate control. The secondary fly back synchronous switch *QF* is used instead of a diode for less conduction loss. *VO*1 is made from *VO*2 through the buck converter, assuming that *VO*1 is lower than *VO*2.

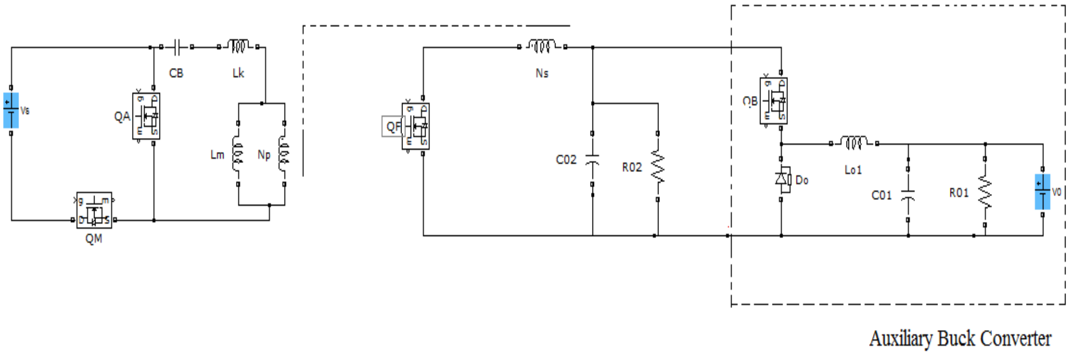


Fig. 1(a). Circuit diagrams of the Conventional half-bridge fly back converter with auxiliary buck converter.

Fig. 1(b) shows the derivation of proposed secondary side. The switch *QB* and diode *DB* of the buck converter are integrated with *QF* , and it is divided into two synchronous switches *QS*1 and *QS*2 . These two switches provide the current path for the main output as usual. Also, *QS*2 and *QS*1 offer the powering and freewheeling path for auxiliary output, respectively. This multifunction is the result from the gate signal controls of these switches, which will be analyzed in the following section.

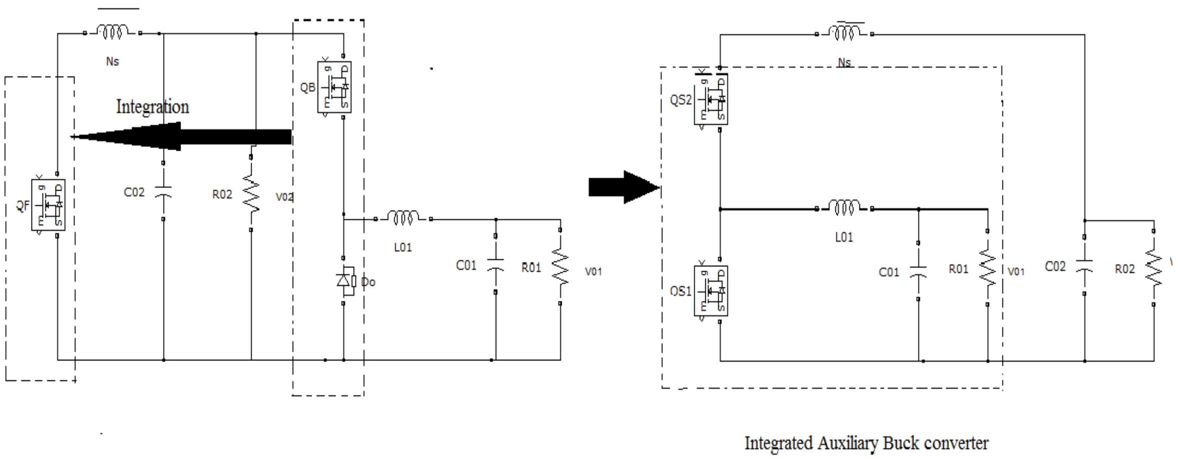
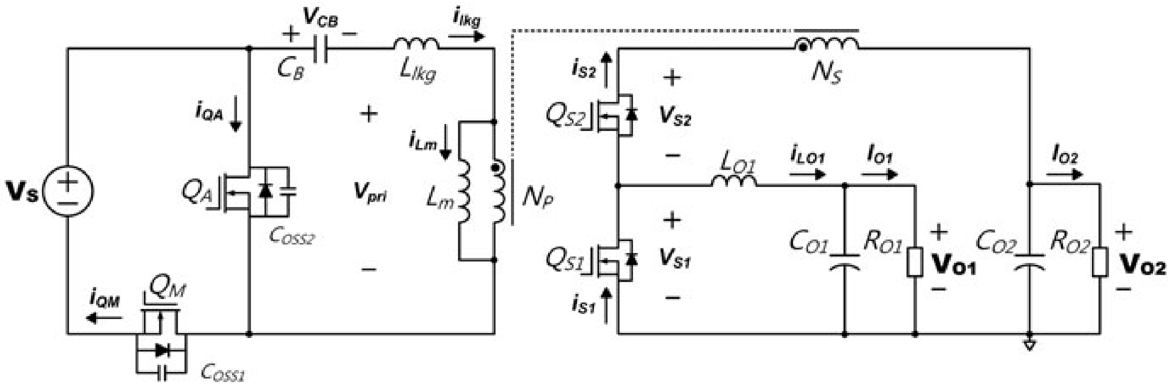


Fig. 1(b). Circuit diagrams of the Conventional half-bridge fly back converter with integrated auxiliary buck converter.



(c)

Fig. 2 circuit diagram for proposed converter

Fig. 2 shows the proposed circuit diagram of fly back converter with two outputs. It consists of boost converter fed half-bridge inverter; fly back converter based two outputs. Fig. 3 shows the timing diagrams of the proposed converter in the steady state. Each switching period is divided into six modes and their operational modes are shown in Fig. 4. The main switch *QM* is operated in a duty ratio of k, and the auxiliary switch *QA* is operated complementary to the main switch *QM* . The secondary switch *QS*2 is turned ON simultaneously with *QA,* and *QS*1 is turned ON after *QS*2 is turned OFF. The main and auxiliary output can be regulated by controlling the duty ratios *D* and *DS,* respectively, where *D* is the duty ratio of the main switch *QM* , and *DS* is the duty ratio of the overlap interval of *QM* and *QS*2 . In order to illustrate the steady-state operation, several assumptions are made as follows:

1) All parasitic components are neglected;

2) The parasitic capacitances *COSS*1 and *COSS*2 of the primary switches are the same capacitance of *COSS;*

3) The output voltages *VO*1 and *VO*2 and blocking capacitor voltage *VCB* are constant during a switching cycle;

4) The transformer turns ratio *n = NP /NS.*

1) Mode 1 [t0–t1]

Mode 1 starts when the leakage current ilkg (t) reaches iLm(t) + iLO1 (t)/n. the current flow in the primary side through Vs-Likg-Lm-Cb-Qm. transformer, so the magnetizing current iLm(t) is linearly increased. In the secondary side, the output inductor current iLO1 (t) flows through the switch QS2 and the auxiliary output is in powering mode.

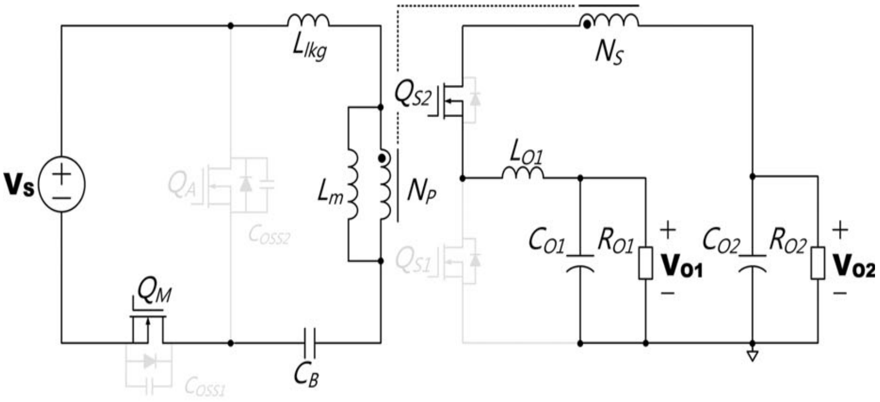


Fig. 3 Mode-1

2) Mode 2 [t1–t2]

During this mode, *QS*2 is turned OFF. *iLO*1 (*t*) flows through *QS*1, so the auxiliary output enters into the freewheeling mode. *iLO*1 (*t*) is not reflected to the primary side.

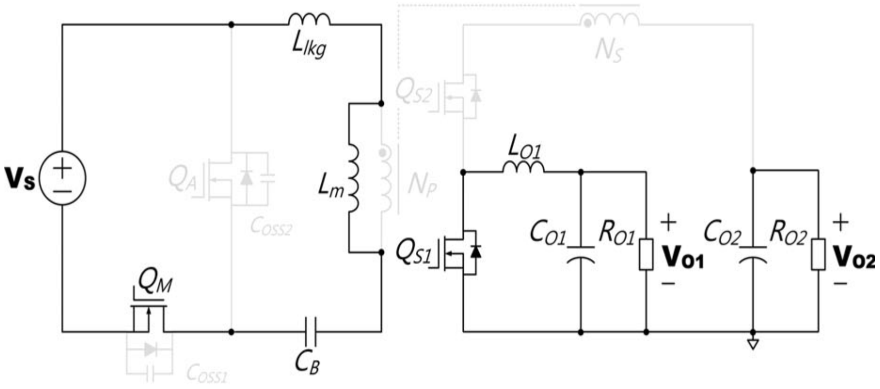


Fig.3.b Mode-2

3) Mode 3 [t2–t3]

During Mode 3 the main switch *QM* is turned OFF. It assumes that *ilkg* (*t*) is constant during this mode. Therefore, *COSS2 and COSS*1 *are linearly discharged and charged by ilkg* (*t*), respectively. In the output side, the voltage of *QS*2 is also decreased. When the primary voltage reaches −*VCB*, the ZVS of the switches *QA* and *QS*2 can be achieved.

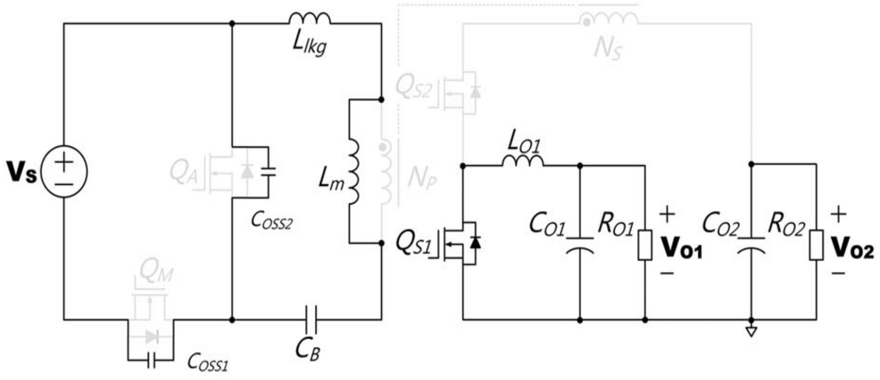


Fig.3. c Mode-3

4) Mode 4 [t3–t4]

During Mode 4 *QA* and *QS*2 are turned ON with ZVS. The power is transferred from the primary side to the secondary side main output *VO*2. The voltage across the leakage inductance is the difference between the voltage reflected from the secondary side, *nVO*2 and the primary side blocking capacitor voltage, *VCB*. The secondary side transformer current is *n*(*iLm*(*t*) − *ilkg* (*t*)) and the auxiliary output is still in freewheeling mode.

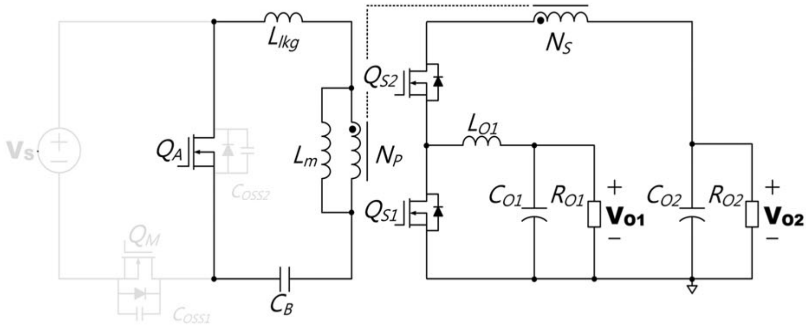


Fig 3. d Mode-4

5) Mode 5 [t4–t5]

During mode 5, *QA* is turned OFF. *COSS*1 and *COSS*2 are resonated with *Llkg* , and discharged and charged by *ilkg* (*t*), respectively. In secondary side, *QS*2 is still on state.

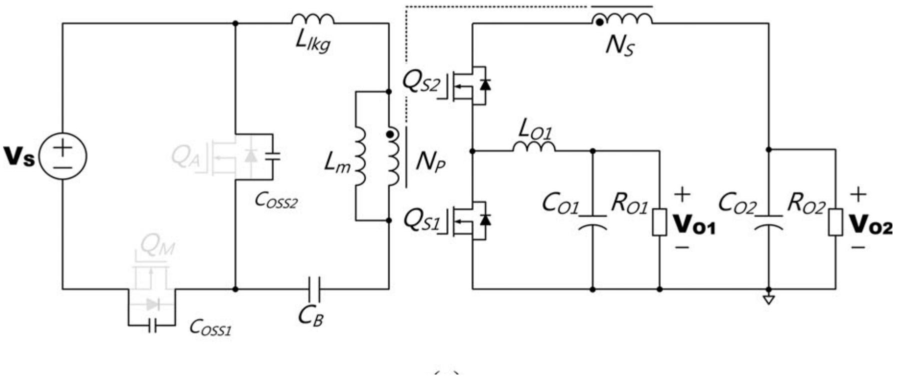


Fig 3. e Mode-5

6) Mode 6 [t5–t6]

During Mode 6, *QM* is turned ON with ZVS. $(VS - VCB) + nVO2$ is applied to the leakage inductance, so the leakage current *ilkg* (*t*) is rapidly increased. When *ilkg* (*t*) reaches to *iLm*(*t*) + *iLO*1 (*t*)*/n*, this mode ends.

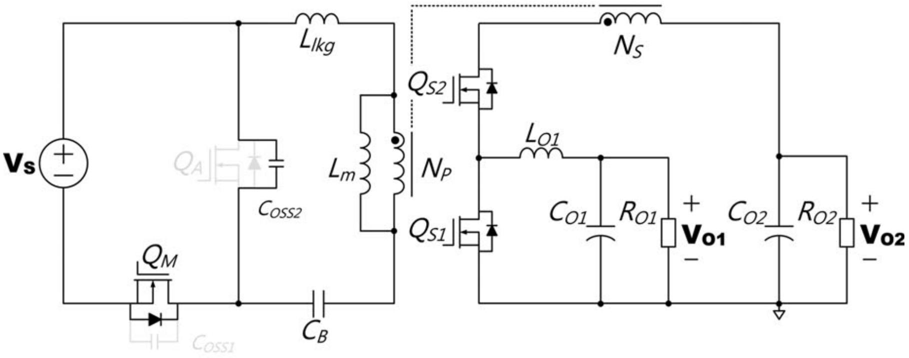


Fig 3. f Mode-6

Figure 3 various modes of operation

III. SIMULATION RESULTS

The simulation is carried out in Matlab/Simulink environment. The conventional and proposed circuits are shown in Figure 1 and figure 4. The proposed circuit consists of Dc source/PV cell, boost converter, half bridge inverter based fly back buck converter. Figure 5 shows the Switching Pulse, Current Through and Voltage across the boost Switch S. Figure 6 and 7 shows the Switching Pulse, Current Through and Voltage across the Switch Qs1 and Qs2. Figure 8 and 9 shows the Switching Pulse, Current Through and Voltage across the Switch Qa and Qm. Figure 10 shows the Current waveform through inductor Lk , Lm and Lo. Figure 11 shows the Output current and voltage waveform for output1. Figure 12 shows the Output current and voltage waveform for output2. Figure 13 and 14 shows the relationship between input voltage, output voltage and power.

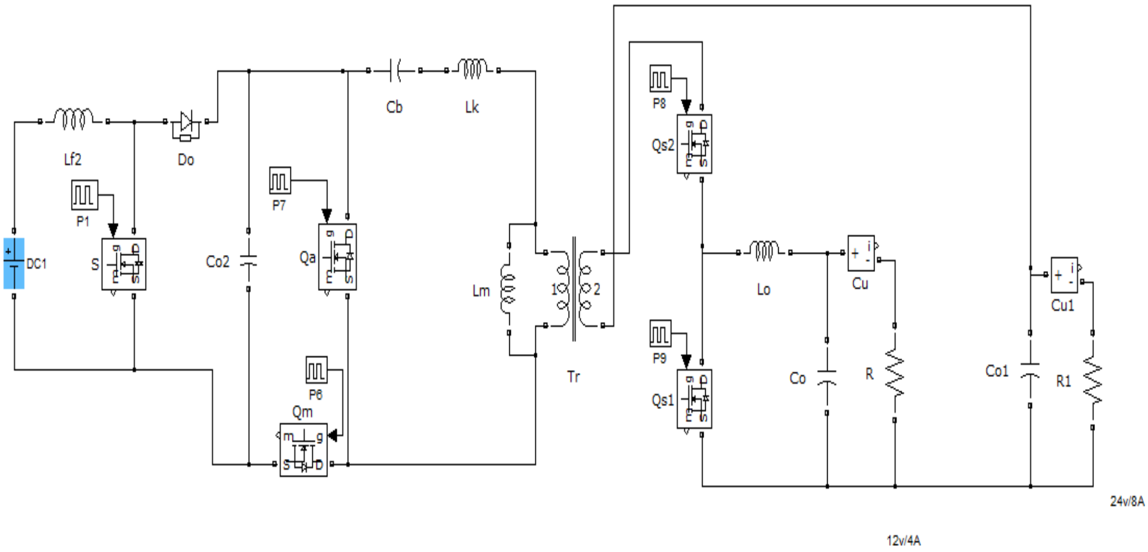


Fig 4. Proposed Circuit diagram

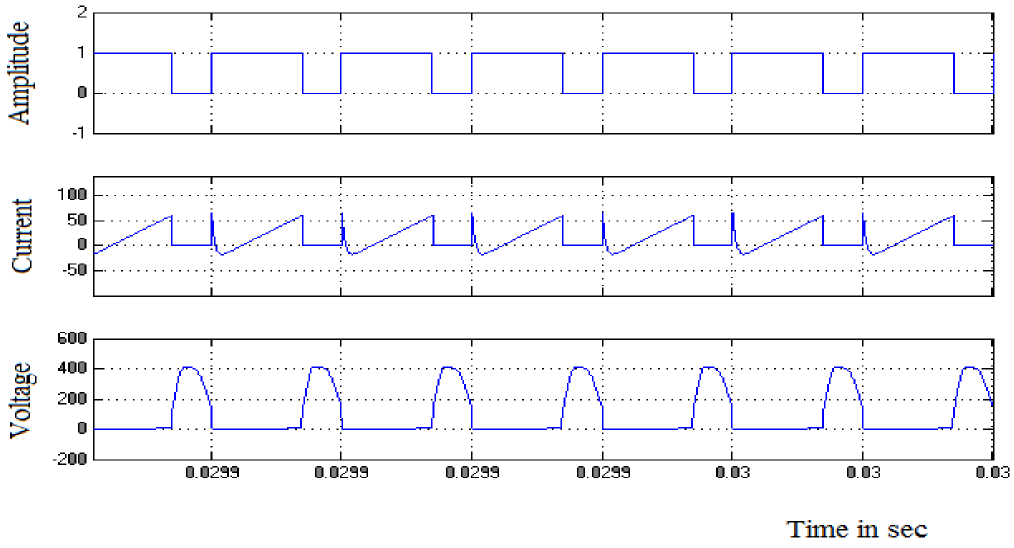


Fig. 5 Switching Pulse, Current Through and Voltage across the Switch S

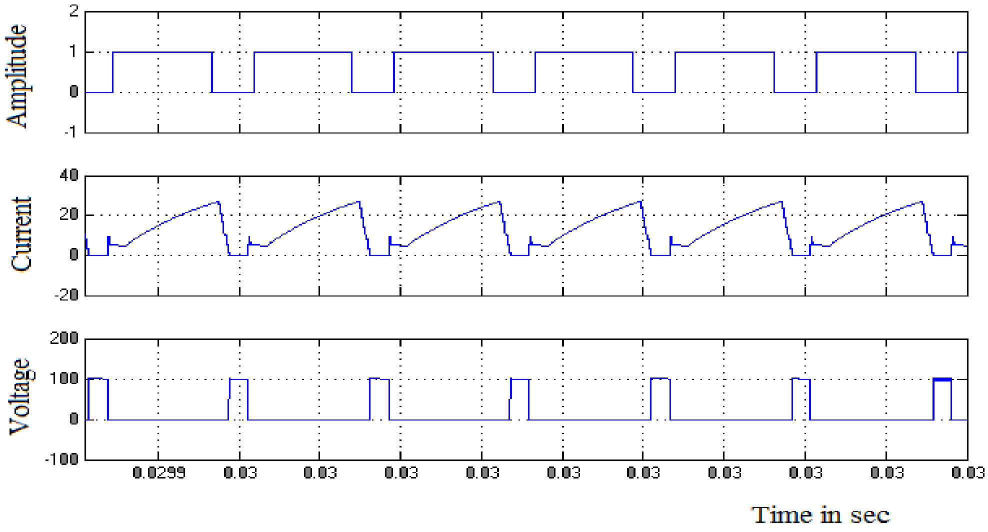


Fig.6 Switching Pulse, Current Through and Voltage across the Switch QS1

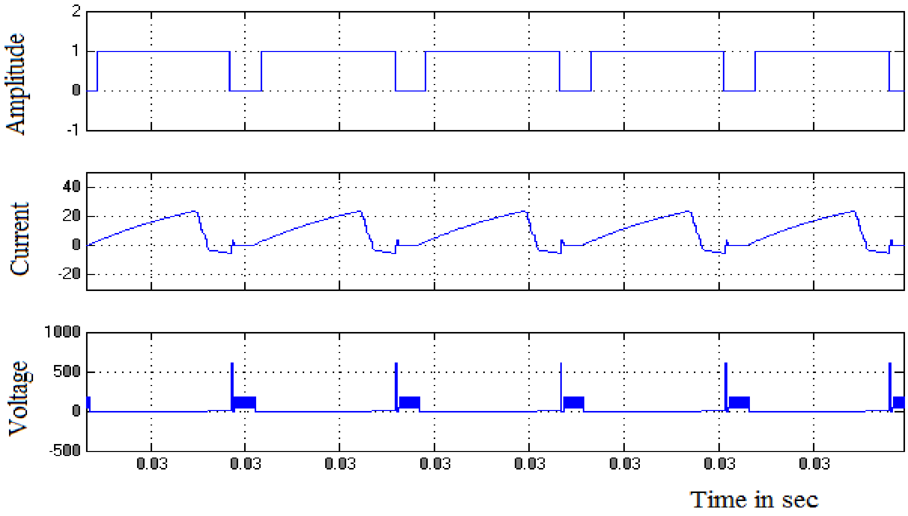


Fig.7 Switching Pulse, Current Through and Voltage across the Switch QS2

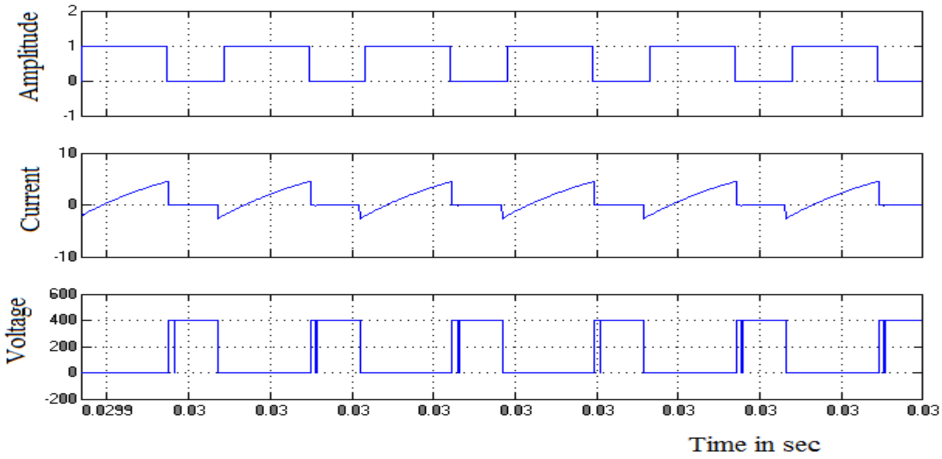


Fig.8 Switching Pulse, Current Through and Voltage across the Switch Qa

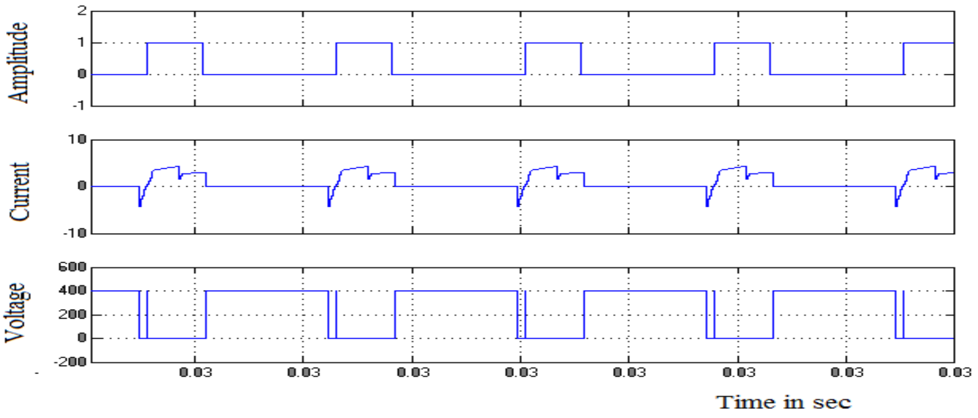


Fig.9 Switching Pulse, Current Through and Voltage across the Switch Qm

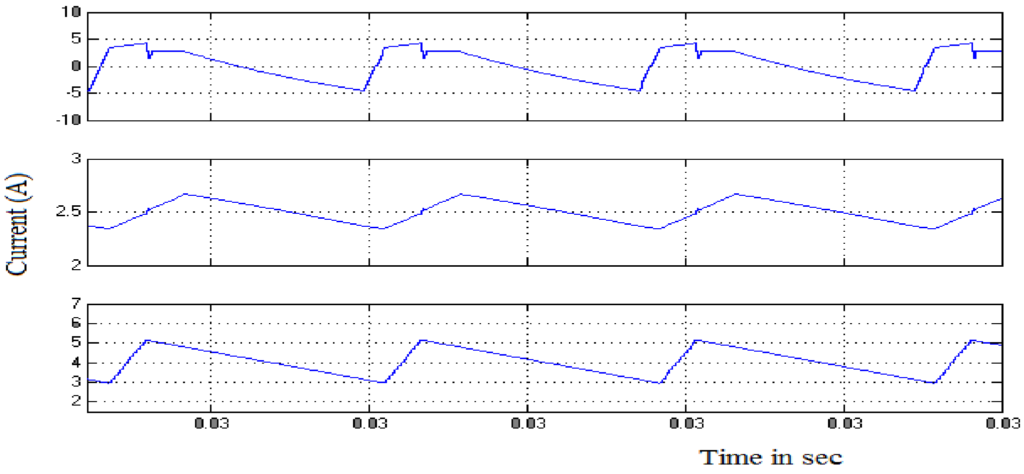


Fig.10 Current through inductor Lk , Lm and Lo

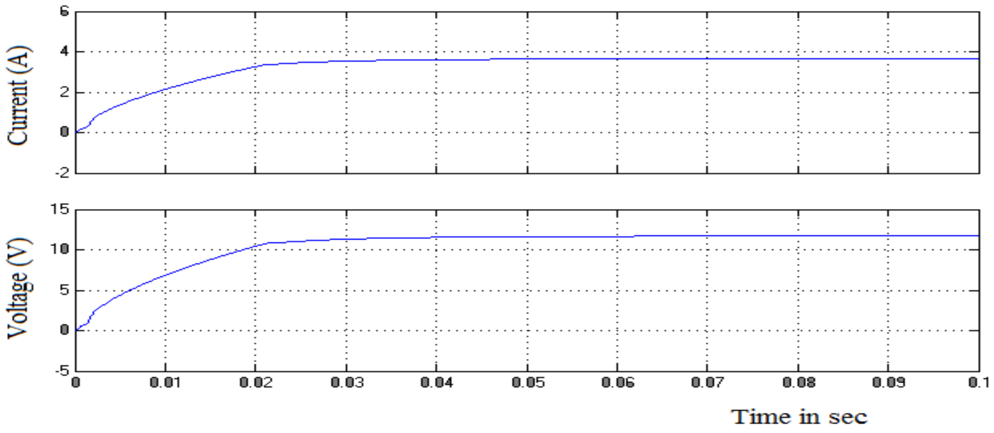


Fig.11 Output current and voltage 1

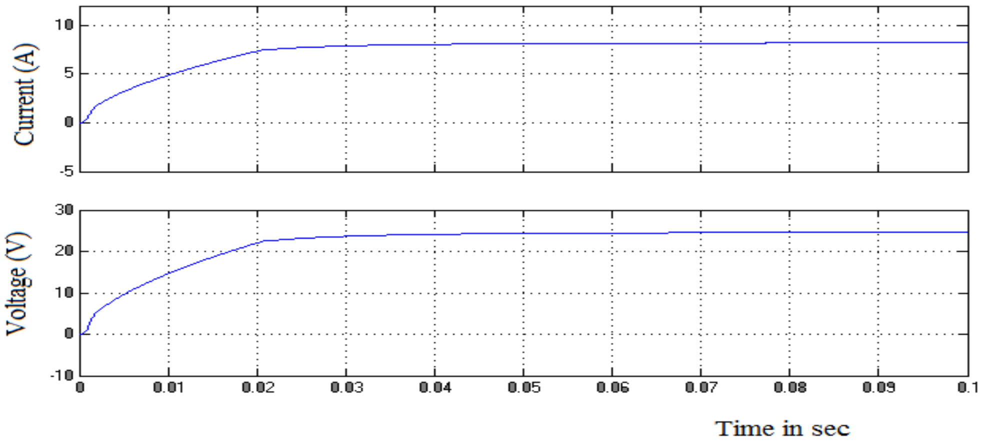


Fig.12 Output current and voltage 2

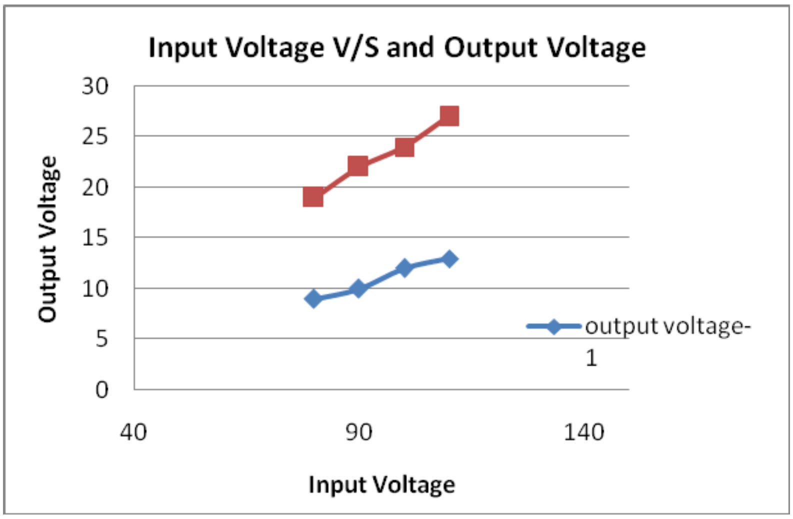


Fig.13 Input Voltage V/S Output Voltage Graph

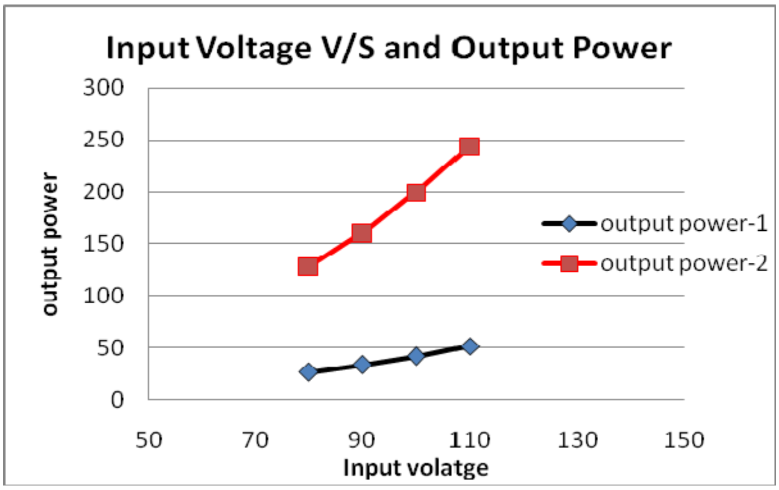


Fig.14 Input Voltage V/S Output power Graph

TABLE 1
INPUT AND OUTPUT PARAMETER

Parameters	Value
Input volatge (V)	100
Boost converter output (V)	200
Output voltage1 (V)	12
Output voltage2 (V)	24
Output power1 (W)	42
Output power2 (W)	200

The proposed system has soft switching across all switches which is evident from the graph.

It is observed from the simulation results that the voltage across the switches is zero when they are turned on and off. Therefore zero voltage switching is achieved due to which switching losses are alleviated.

IV. CONCLUSION

A boost converter based multi output fly back buck converter was proposed in this paper which requires multiple outputs. The boost converter helps in producing low voltage dc to high voltage Dc. Fly back based multi output buck converter produce multiple output voltage without any voltage disturbance and less loss. Due to zero voltage switching of all the switches, the proposed system has less switching losses. The proposed converter is more efficient for the multiple outputs generating system.

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