DESIGN AND SIMULATION OF DC-DC CONVERTERS

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Abstract:- In particular this research paper focuses especially on the design and simulation of dc-dc converters. It contains the theoretical derivations and parameters equations with design and examples. Simulation results for buck, boost and buck-boost converters are shown with the chance of different input values. In this work we have analysed the equation of a buck, boost and buckboost converters and proposed the design components and simulation of these converters. Changing the input parameters like inductance, capacitance and switching frequency in order to observe the changes in output voltage has been added with simulation graph. These parameters and their equations should be well understood before designing buck or boost or buckboost converters. Simulation procedures in Orcad are also added in this paper. We have achieved performance parameter equations for these three regulators. It was completed the design and investigation of these three converters through mathematical examples and have generated the circuits for simulating buck, boost and buck boost converters. And also have attained different output voltage curve with the change of input parameters. The output graphs for all the converters are well fitted.

Key Words: Converters, Simulation, mathworks, matlab Power Regulator, Switching Matrix.

I. INTRODUCTION

For the control and use of electric power or power conditioning, the conversion of electric power into another form to another is necessary and the switching characteristics of the power devices permit these conversions. The static power converters perform these functions of power conversions. A converter may be considered as a switching matrix. As the portable electronics industry progressed over the years, different requirements evolved such as more battery lifetime, cheap and small systems, brighter, full colour displays and cell phones having a better life time. A continually increasing demand from power systems has placed power consumption at a premium. To carry on with these demands engineers have worked towards developing efficient conversion techniques and also have resulted in the subsequent formal growth of an interdisciplinary field of Power Electronics. However it comes as no surprise that this new field has offered challenges owing to the unique combination of two major disciplines of electrical engineering: electronics and power. Commonly speaking the use of a swift or switches for the rationale of power conversion can be regarded as an SMPS (Switch Mode Power Supply).A dc-dc converter can be considered as dc equivalent to an ac transformer with a continuously variable turn's ratio.

II. APPLICATION OF DC-DC CONVERTERS

In many industrial applications, it is required to convert a fixed-voltage dc source into a variable-voltage dc source. A dc-dc converter converts directly from dc to dc and is simply known as a dc converter. A dc converter can be considered as dc equivalent to an ac transformer with a continuously turns ratio. Similarly like a transformer, it can step down or step up a dc voltage source.
The dc-dc converters are widely used for traction motor control in electronic and dynamic automobiles, trolley cars, marine hoists, forklift trucks, and mine haulers. They provide smooth acceleration control, high efficiency, and fast dynamic response. DC-DC converters can be used in regenerative braking of dc motors to return energy back into the supply, than this feature results in energy savings for transportation systems with frequent stops and are mainly used in trains and trolley buses.

III. OTHER PATTERNS

Regulation of this converter can be achieved by various switching techniques by pulse width modulation technique. The drivers used for switching are:-

- IGBT
- BJT
- MOSFET

IV. DIFFERENT TYPES OF REGULATOR

- Buck Regulator
- Boost Regulator
- Buck-Boost Regulator
- Cuk Regulator

V. THEORY OF DIFFERENT CONVERTERS

A buck converter is a step down dc-dc converter consisting primarily of inductor and two switches (generally a transistor switch and diode) for controlling inductor. It fluctuates between connection of induction to source voltage to mount up energy in inductor and then discharging the inductor's energy to the load. When the switch pictured above is closed (i.e., ON state), the potential across the inductor is VL= Vi- Vo. The current flowing through inductor linearly rises.The diode doesn't allow current to flow through it, since it is reverse-biased by voltage. For Off case (i.e., when switch pictured above is opened), diode is forward biased and voltage is VL= - Vo (neglecting drop across diode) across inductor. The inductor current which was rising in ON case now decreases.

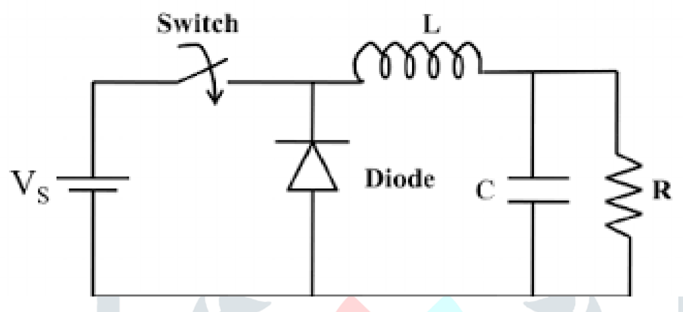


Fig 1

VI. IDEAL CIRCUIT

In a buck converter, the average output Va is less than the input voltage, Vs. The circuit diagram of a buck regulator has shown below and this is like a step-down converter.

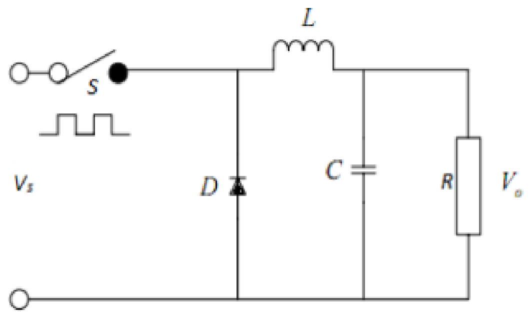
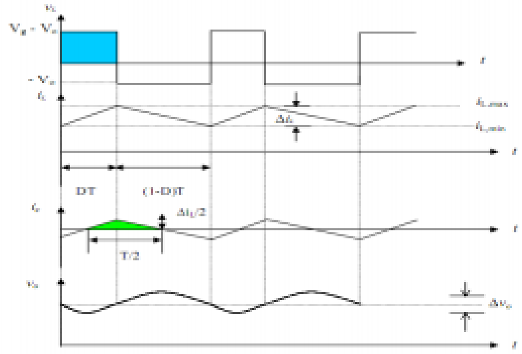


Fig 2

VII. WAVEFORM AND GRAPH

The waveforms for voltage and current are shown in for continuous load current assuming that the current rises or falls linearly. For a constant current flow in the inductor L, it is assumed that the current rises and falls linearly. In practical circuits, the switch has a finite, nonlinear resistance. Its effect can generally be negligible in the most applications depending on the switching frequency, filter inductance, and capacitance, the inductor current could be discontinuous.



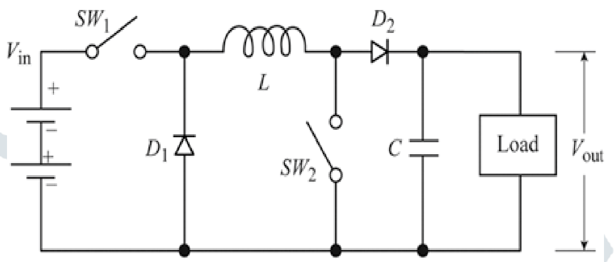


Fig 3

VIII. BUCK BOOST CONVERTER

A buck-boost converter provides an output voltage that may be less than or greater than the input voltage hence the name "buck-boost"; the output voltage polarity is opposite to that of the input voltage. This converter is also known as inverting regulator .It is shown in figure 1.

The circuit operation divided into two modes. During mode 1, transistor Q1 is turned on and the diode Dm is reversed biased. The input current, which rises, flows through inductor L and transistor Q1. During mode 2, transistor Q1 is switched off and the current, which was flowing through inductor L, would flow through L, C, Dm, and the load. The energy stored in inductor L would be transferred to the load and inductor current would fall until transistor Q1 is switched on again in the next cycle. The equivalent circuits for the modes are shown. The waveforms for steady-state voltages and currents of the buck-boost regulator are shown in diagram 8 for a continuous load current.

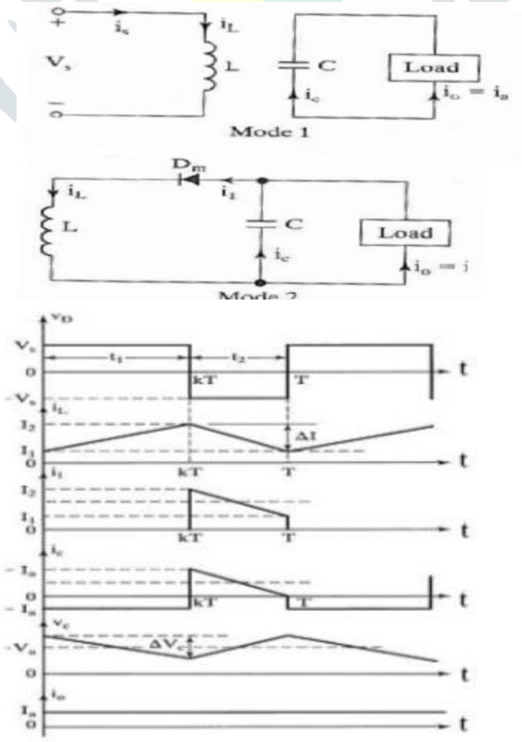


Fig 4

IX. DESIGN ANALYSIS OF DC-DC CONVERTERS

Performance Parameters
There are quantities of vital performance parameters which decide the output characteristics of the dc-dc converters. These parameters should be well understood before designing an ideal dc-dc converter.

X. RANGE OF OPERATING FREQUENCIES AND CHARACTERISTICS.

The operating frequency determines the performance of the switch. Switching frequency selection is normally determined by efficiency requirements.There is now a rising trend in research work and new power supply designs in increasing the switching frequencies. The higher is the switching frequency, the smaller the physical size and component value.
At higher frequencies the switching losses in the MOSFET increase, and therefore reduce the overall efficiency of the circuit.
At lower frequencies the required output capacitance and inductor size increases, and the volumetric efficiency of the supply degrades.
The trade-off between size and efficiency has to be evaluated very carefully.

XI. SIMULATION

• Simulation has taken up to 7.0 ms.
•Output voltage becomes peak at 1.2 ms and at 14.8 volts.
•Output current becomes peak at 0.6 ms and at 14.4 volts.
•[5]Current and voltage don’t reach from zero to the peak during same time. In steady state positions the current falls more than the voltage. Better the ripple current better the performance which depends on circuit parameters.
Output current and voltage waveform of buck boost converter.
Output ripple current waveform of buck boost converter
•Simulation has taken up to 1.1 s.
•Output voltage becomes peak at 1.3ms and at 14.6 volts.
•Output current becomes peak at 0.5 ms and at 14.5 volts.
•Current and voltage don’t reach from zero to the peak during same time.
•In steady state positions the current falls more than the voltage.
•Better the ripple current better the performance which depends on circuit parameters.
Current and voltage waveform of buck boost

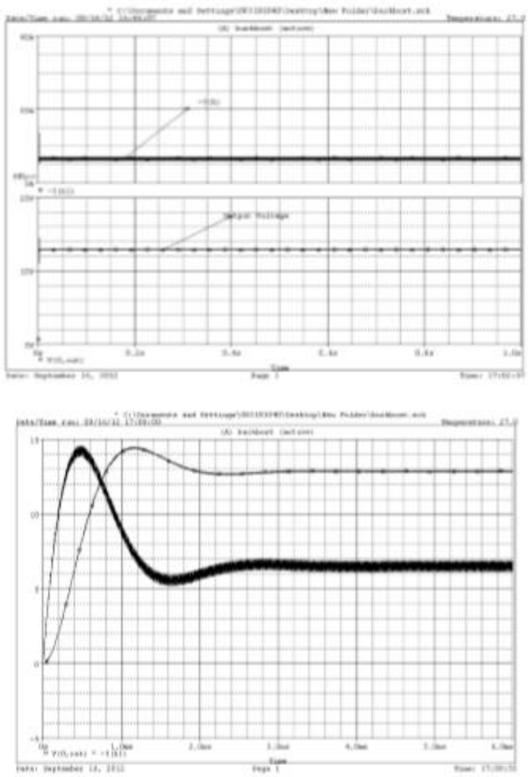


Fig 5

ADVANTAGES

•Step-up and step-down of voltage is possible with minimum component count. (Cuk, Sepic, Zeta uses almost double component count)
•Less costly compared to most of the other converters if compromised performance is desired for a low cost.
•Input current and charging current of the output capacitor is discontinuous resulting in larger filter size and more EMI issues.

DISADVANTAGES

•The output is inverted which introduces complexity in the sensing and feedback circuit. The sensed voltage is negative so an inverting opamp is required for feedback and closed loop control.
•The efficiency is poor for high gain i.e. very small or large duty cycle. Therefore, high gain operation cannot be achieved with this converter. efficiency can be as poor as 60% for a duty cycle of 0.7 or 0.3. Whereas it has 90% efficiency for duty cycle of 0.5.

CONCLUSIONS

From the simulation results it is found that in case of the buck, boost and buck-boost converters, the desired output voltages can be obtained by selecting proper values of inductor, capacitor and switching frequency. All of these individual theories were difficult for anyone to grasp primarily and putting them collectively in the simulator which was extremely puzzling. But it has been
done most excellent to formulate an outstanding scheme dissertation with affluent in its contest. At each stage, targets were set to acquire the necessary skills to meet the criteria of the research and design the circuits for implementation into the software simulation. This research gives the opportunity to study new skills and raise valuable knowledge in circuit designing and problem solving skills which has greatly enriched knowledge and understanding through the erudition route which may help one in for the further progression.

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