2- buck converter analysis report sample

Technology, Innovation

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Introduction

There are various methods that determine the existence of DC-DC voltage conversion. Each method has certain benefits and drawbacks based on the operating conditions and specifications, such as voltage conversion ratio range, the maximal output power, power conversion efficiency, number of components, power density, galvanic separation of input and output and many others. When designing a fully-integrated DC-DC converter, the specifications are relevant; however, some of them gain weight due to the emergence of restrictions. For instance, in the case of IC technology, the options and availability of the chip area are dominant factors in terms of production cost, which limit the value and quality factor of the passive components. The limitations have a significant impact on the choice of the conversion method. The current project discusses the different types of DC/DC converters and their connections as either series or parallel for the purpose of increasing the power. In addition to the advantages and disadvantages, the project mentions the applications for each converter and the underlying reasons. The report clarifies the idea of the final project in consideration to the research and objectives done in the first semester. Finally, the project also gives a brief description of the next semester plan.

2. DC- DC Converter Circuits

It is important to understand the background of the DC-DC converter before analyzing the four types, namely, Buck , Boost , buck-boost and Cuk converter. DC-Dc converter converts an unregulated dc input to a regulated dc output at a certain voltage level by variations in the time duty ratio of the switching. In the present time, there are several electrical and electronic devices energized by DC voltages rather than AC voltage, such as the computer system, which uses a low voltage DC voltage to power the mother board. Hence, the power engineer must rectify the AC to DC voltage and then covert the DC to different low voltage levels by DC/DC buck Converters. Moreover, some power applications require a higher amount of DC voltages, which is possible through the DC/DC boost converter. Others need both; however the current one requires a boost-buck converter.

2. 1. Step-Up Converter (Boost Converter)

2. 1. 1 OVERVIEW

Boost converter is one of the classic switched mode power supply circuit (SMPS), which uses any suitable DC source as a power supplier battery. The best example is the boost converter, which is a DC-DC CONVERTER that has an output voltage (V) greater than the input voltage (V). Sometimes, it also resembles a step-up converter as it steps up the voltage of the source since P = VI (while P is the power , I is the current and V is the voltage).

2. 1. 2Circuit analysis

- Step-up converter circuit

What is obvious from the boost circuit is that the circuit contains at least two semiconductors, namely diode and transistor. Furthermore, the energy storage elements, such as the capacitors and inductors include a filter made up of a capacitor, which decreases an output voltage ripple.

(b) Switching-on state

When it is in the " ON" state, current passes through the inductor to store the energy in the inductor and generate a magnetic field.

(c) Switching-off state

When the switch is open, current reduces due to higher impedance. The magnetic field previously created gets destroyed to maintain the current flow towards the load.

2. 1. 3Equations of step-up converter

The switch turns on and off periodically. The switching period is:

(Where TON and TOFF are the switch turn-on and off times, respectively, is the switching frequency and k is the switching duty ratio)

-Voltage on the inductor expression when the switch is ON is:

When the switch is OFF:

However, the rise in the current is equal to the fall in the current, which leads to the following equation:

Simplifying equation (3)

Input power = output power (For lossless system) So,

W= W

iV= IOVO

Substituting

2. 1. 4 Step-up converter V/I waveforms

Note that in this converter, the output current to the filter capacitor COUT equals ID, which is unsmooth. On the other hand, the input current is much smoother due to the inductor. It is in contrast to the Buck Converter, in which the opposite is true as the inductor is in series with the output. Thereby, it strongly influences the relative ease of smoothing the input and output DC voltages (i. e. the sizes of the capacitors).

2. 1. 5 output voltage ripple ;

Referring to fig2, peak - peak ripple can be calculated by the assumption of that all the ripple current of the diode current flows past the capacitor:-

2. 2. Step-Down Converter (Buck Converter)

2. 2. 1 OVERVIEW

Step down converter is belongs to the switched mode power family. In the Buck Converter, the output of the DC/DC converter is less than the input. It is clear that the idea of the buck converter depends on three key electrical components, which are Single Pole Double Throw (SPDT) switch, inductor, and capacitor.

2. 2. 2Circuit analysis

(a)Step-down converter circuit

Characteristics:

-andare very large

- Load current is constant

- Inductor’s current is continuous (steady state operation)

(b) Switching-on state (c) Switching-off state

2. 2. 3Equations of step-down converters:

As before,

TON = kTPandTOFF= (1-k)TP.

When S (switch) is on the voltage across the inductor, the equation is :

When S is OFF fig 4:

In the steady state, the fall and rise in the current must be equal.

So,

It leads to the following equation :

For losses system,

Input power = output power

=

=

Therefore,

The magnitude of the current ripple (from equations (1) and (2))

2. 2. 3 Step-up converter V/I waveforms

2. 2. 5 output voltage ripple ;

Referring to fig 6, the output voltage ripple is,

Using equation (6) (Assuming i ripple flows via capacitor and average i through the resistor)

(ΔQ= charge)

Then

(Switching frequency fs = 1/TP and fc = 1/2(LC)).

2. 3Buck-boost converter

2. 3. 1overview

Buck-boost converter is a type of DC-DC converter, which has a magnitude of an output voltage either greater or lesser than the input voltage. Pulsed input current requires the input filter.

2. 3. 2Circuit analysis;

(a) Buck-boost converter circuit

Characteristics:

- Output voltage changes from 0 to continuously.

- For buck converter, the range of the output voltage is from 0 to .

- For the boost converter, the range of the output voltage is from to.

- On-state:-

- When the switch is in the closed state, the input voltage source connects directly to the inductor, while the capacitors supply energy to the load resistor.

- When the diode is OFF, no current passes through the diode as shown in fig 8.

- OFF state

- In this case, the inductor is connected to both, output load and capacitor.

- When the diode is On, the inductor supplies the current to the load via diode.

2. 3. 3Equations of buck-boost converter

1-During the on state,

The rate of change in the inductor current is,

(D is duty cycle)

2-During the Off-state

ΔIon + ΔIoff = 0

So Vo / Vs = (D/1-D)

2. 4CUK converter

2. 4. 1Overview

Switch Mode Power Supply topologies follow a set of rules. Though there are a very large number of converters, there are minor variations of a group of basic DC-DC converters, which depend on a set of rules. Many consider the basic group, which consists of the three converters, namely, BUCK, BOOST and BUCK-BOOST converters. The CUK, which is essentially a BOOST-BUCK converter, is not the basic converter due to its variations, which include the SEPIC and zeta converters.

- cuk converter circuit

(b)When the switch is ON,

==

(Δ)= (charging)

== (Δ)= (is charging)

(b)When switch is OFF,

VL1= V1 – Vc = L di/dt

((V1-Vc) toff)/L1 = (Δi1)off

Vo = - L1 di2/dt(L1 discharging)

(Δi2)off = - Vo = -(Vo X (toff)) / L2 (L2 discharging)

(Δi1)on + (Δi1)off = 0

((V1 – Vc)/L1) + ((V1 ton)/L1)= 0

(V1 – Vc)(1-k)Tp + v1 kTp = 0

$(V1 – V1)(1-k) +(v1k)= 0$

$V1(1-k)+ V1k - V1(1-k)= 0$

$V1= Vc(1-k)$

$Vc = V1 / (1-k)$

$((Vc – Vo)ton) + Vo (toff) = 0$

L2 L2

$(Vc – Vo)K – Vo(1-K)= 0$

$VcK –VoK- Vo(1-K) = 0$

$Vc = Vo / K$

$Vo/K = V1/ (1-K)$

=

3. 0 Overview on Series Connection of DC-DC Converters

Many applications employ a number of power converters with a lower power rating instead of a single power converter in order to bring performance improvements and/or reduce the cost. For example, paralleling of power converters is a widely used approach in today's high-efficiency, high power density applications as it makes it possible to implement redundancy and improve the partial-load efficiency by employing power management. Similarly, in applications with a relatively high input voltage, instead of a single converter, a number of converters connect their inputs in series and outputs in parallel. Series connection of converters' inputs makes it possible to use the converters designed with lower-voltage-rated components, which are typically more efficient and less expensive than the high-voltage-rated counterparts. For example, in applications where a front end provides high-voltage to the downstream dc/dc converters, it is a common practice to use series connection of lower-voltage-rated energy-storage capacitors at the output of the front end and connect dc/dc converters directly across them, as illustrated in Fig. 1. In the connection of the converters in Fig10. 1, it is possible to maintain the balance of the input voltages, i. e., the balance of the capacitor voltages if the converters are identical and capacitors C1 and C2 have the same characteristics. Otherwise, the input voltages of the two converters differ depending on the mismatch of the two converters and capacitors. To prevent the input voltage imbalance from exceeding a permissible range, one must implement a voltage-balancing control.

5. 0 Conclusions & Work Plan for Second Semester