<u>Experiment 04:</u> Study of DC-DC Buck converter

Objective:

1) To study the condition of Buck Converter.
2) To comprehend the working principle of Buck Converter.
3) To study the behavior of Buck Converter.
4) To study the application of Buck Converter.

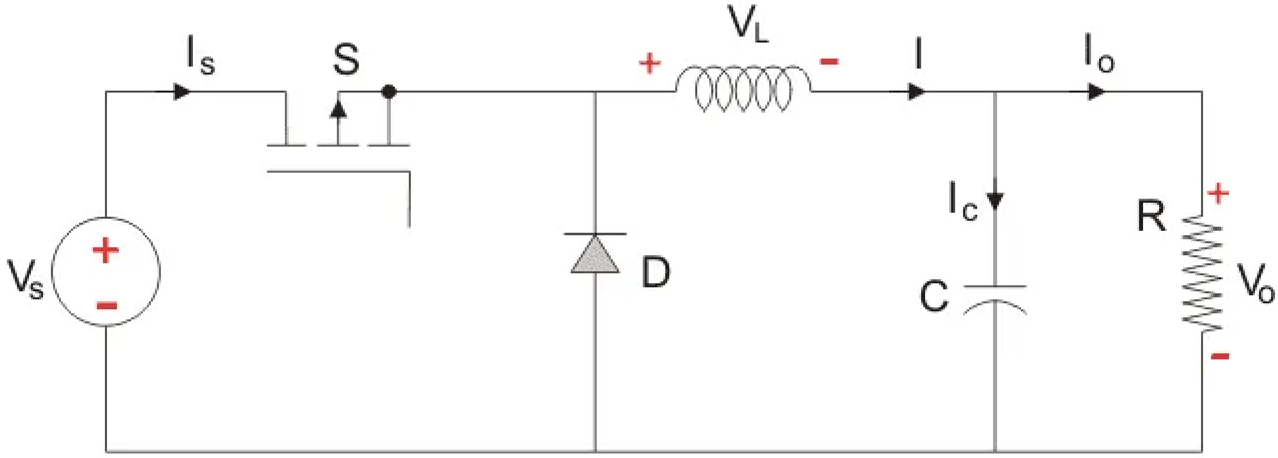


Fig.1 Power circuit diagram of Buck Converter

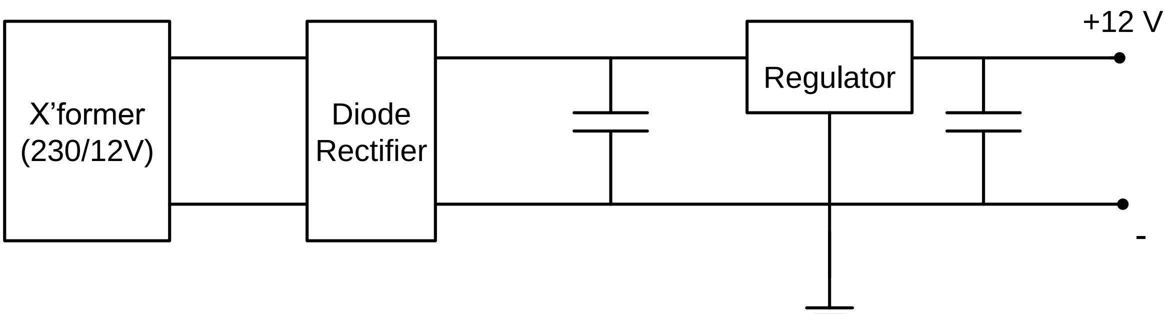


Fig.2

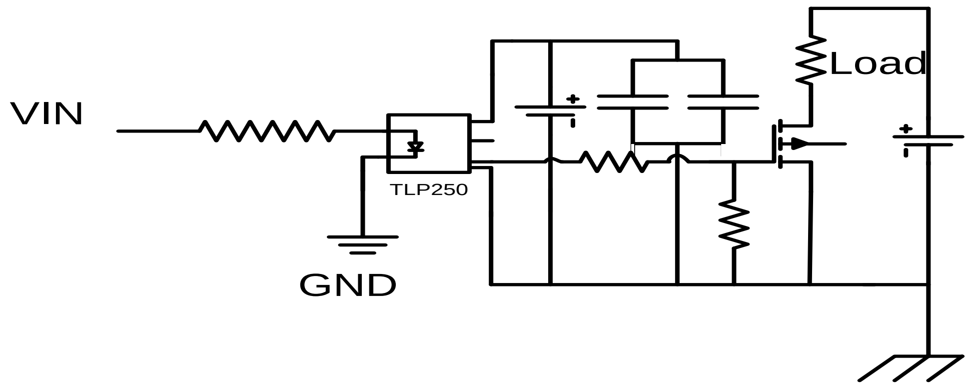


Fig.3 TLP 250 circuit for firing circuit isolation

Apparatus & Components Required:

S.NO	Equipment/Component name	Range	Quantity
1	DC voltage supply	0-50v	1
2	Inductor L		1
3	Capacitor C		1
4	Load Rheostat R	0 – 100 Ω	1
5	Diode	Fast Recovery Diode	1
6	MOSFET IRFP150	100 V, 29A	1
7	Arduino Mega board	2560	1
8	DSO	200mHz	1
9	Multimeter	Digital	1
10	optocoupler	TLP250	1

Introduction

A **buck converter** or **step-down voltage regulators**. It's a type of **DC-DC converter**, so it accomplishes the task using a few transistor switches and an inductor. A typical buck converter circuit is shown in the above image.

It's quite similar to a boost converter, but the placement of the inductor and transistor are switched. The switch shown in the above circuit will normally be a power electronics switch like MOSFET, IGBT or BJT. The switch will be switched (turned on and off) by using a PWM signal.

The **working of Buck converter** is slightly similar to that of PWM 'dimming'. We've all heard of lights being dimmed by a PWM signal. A small duty cycle means that the average voltage seen by the load is small and when the duty cycle is high the average voltage is high too.

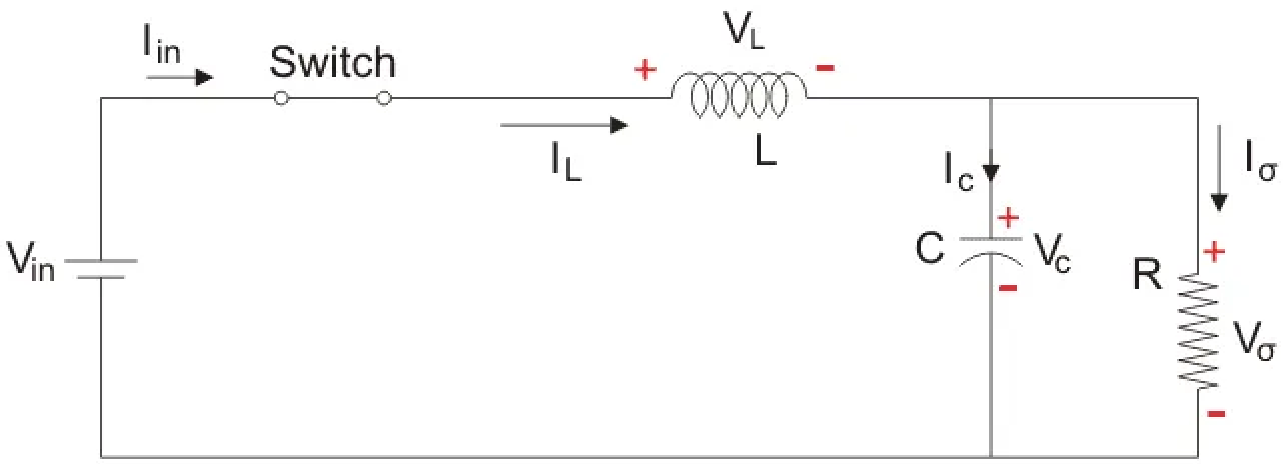
But average voltage is not what we need – a raw PWN signal oscillates between high voltage level and ground, something no delicate load (like the microcontroller) would like. Of course, connecting an RC filter to a square wave source renders the output clean. The voltage level of the filter depends on the duty cycle of the PWM signal – the higher the duty cycle the higher the output voltage.

Working of a Buck Converter

The working of a buck converter can be broken down into a few steps.

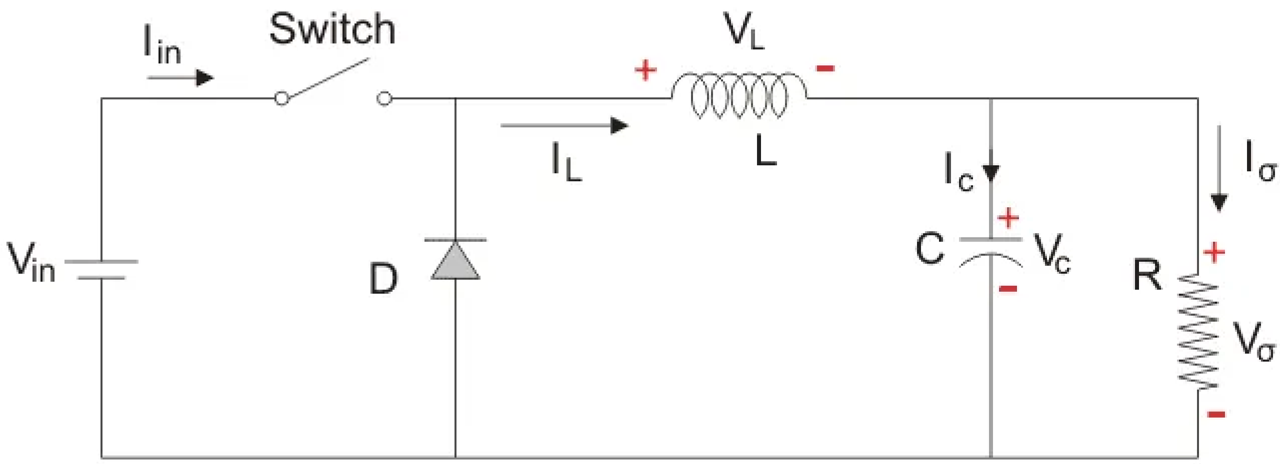
Mode I : Switch is ON, Diode is OFF:

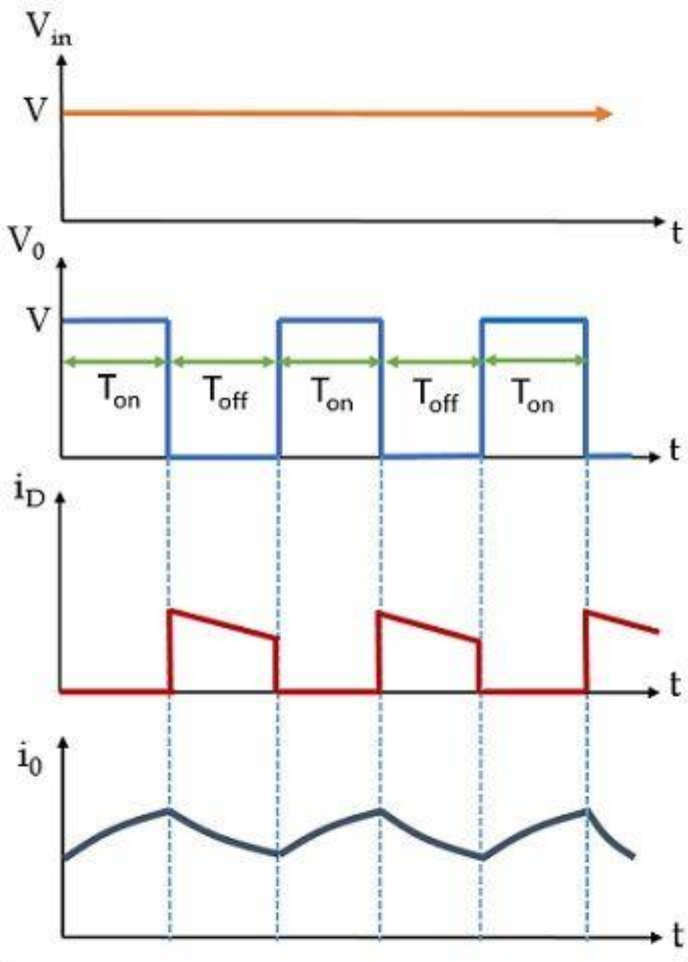
The switch turns on and lets current flow to the output capacitor, charging it up. Since the voltage across the capacitor cannot rise instantly, and since the inductor limits the charging current, the voltage across the cap during the switching cycle is not the full voltage of the power source.



Mode II: Switch is OFF, Diode is ON:

The switch now turns off. Since the current in an inductor cannot change suddenly, the inductor creates a voltage across it. This voltage is allowed to charge the capacitor and power the load through the diode when the switch is turned off, maintaining current output current throughout the switching cycle.





Waveform Representation

Procedure:

1) The circuit as shown in diagram in fig.1
2) Design a driver circuit and required Power supply of +12 v for driver circuit on the breadboard as shown in fig 2 & fig 3 and check the biasing of TLP250 IC for biasing.

3) Connect the output of the driver circuit to the g and s terminal of MOSFET/Switch.
4) Turn on the DC Supply and Driver Circuit Power.
5) Set the Input of dc supply at a fixed value at a specific value of duty cycle, and observe the fix required waveform in the DSO as shown in fig.6.
6) Note Down the reading in the observation table. Keep the input voltage fix for different value of duty cycle.

OBSERVATIONS: -

Sl. No.	Input Volatge V_{in}	Input Current I_{in}	Output Volatge V_o	Output Current I_o	Duty Cycle D	η
1						
2						
3						
4						
5						

PRECAUTIONS: -

1. Components used in the circuit for conducting the experiment should be checked and tested thoroughly, before connecting them in the circuit.
2. Confirm that you have connected the input and output terminals correctly to source and load.
3. Have your circuit checked by your Lab Instructor.

RESULTS: -

1. Study the working principles of a Buck Converter.
2. Observe the various wave forms.
3. Note down the values of Input Voltage V_{in}, Input Current I_{in}, Output Voltage Vo, and Output Current Io by varying load resistance and Duty Cycle D.
4. Compare the theoretical results with practical results.
5. Effect of change in duty cycle on output voltage for line & load regulation.

<u>Experiment 05:</u> Study of DC-DC Boost converter

Objective:

1) To study the condition of Boost Converter.
2) To comprehend the working principle of Boost Converter.
3) To study the behavior of Boost Converter.
4) To study the application of Boost Converter.

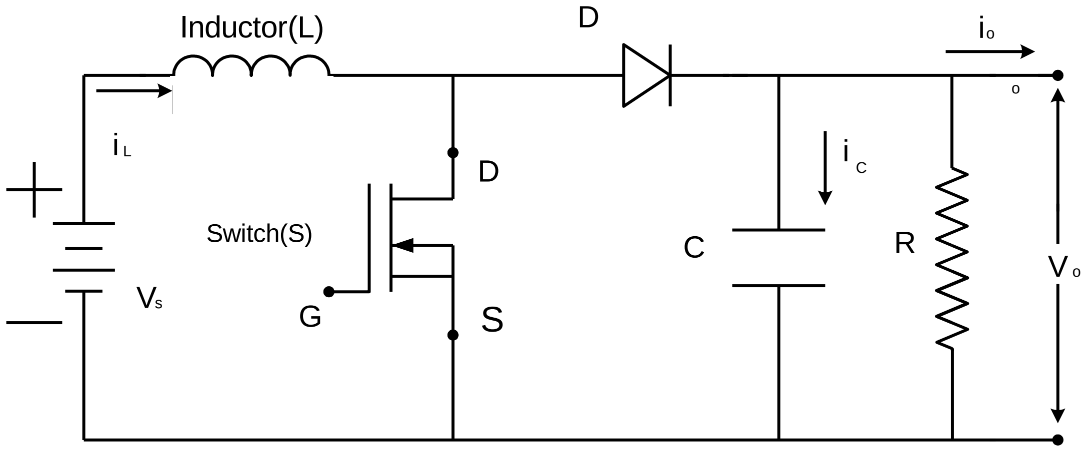


Fig.1 Power circuit diagram of Boost Converter

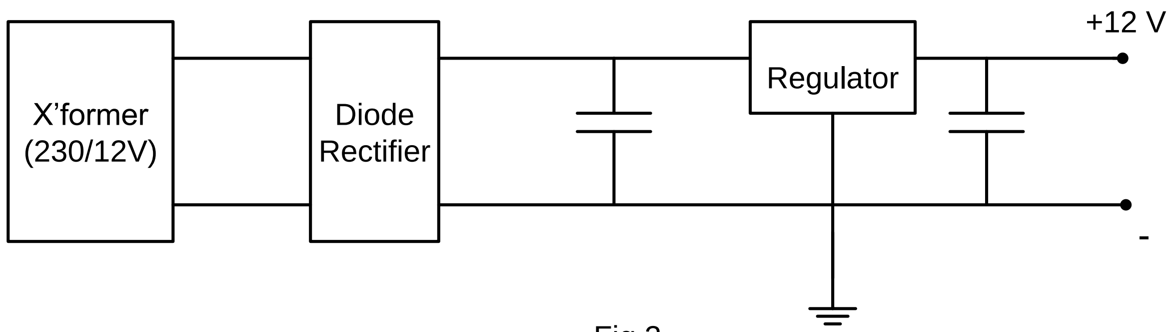


Fig.2

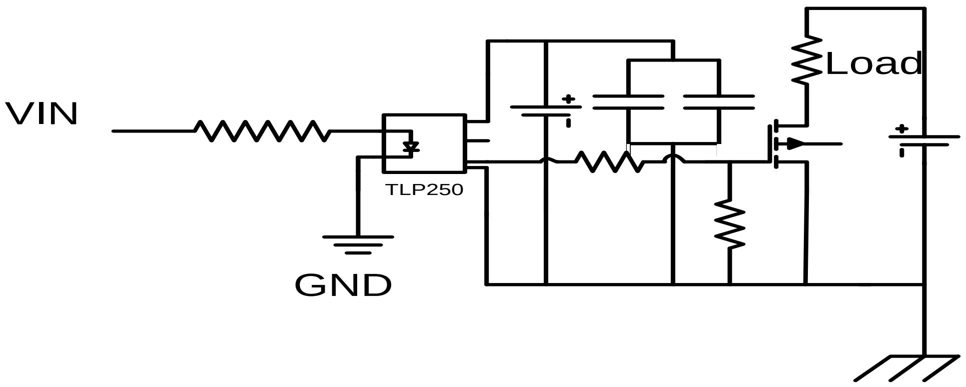


Fig.3 TLP 250 circuit for firing circuit isolation

Apparatus & Components Required:

S.NO	Equipment/Component name	Range	Quantity
1	DC voltage supply	0-50v	1
2	Inductor L		1
3	Capacitor C		1
4	Load Rheostat R	0 – 100 Ω	1
5	Diode	Fast Recovery Diode	1
6	MOSFET IRFP150	100 V, 29A	1
7	Arduino Mega board	2560	1
8	DSO	200mHz	1
9	Multimeter	Digital	1
10	optocoupler	TLP250	1

Introduction:

A boost converter (step-up converter) is a DC-to-DC power converter that steps up voltage (while stepping down current) from its input (supply) to its output (load). It is a class of switched-mode power supply (SMPS) containing at least two semiconductors (a diode and a switch) and at least one energy storage element: a capacitor, inductor, or the two in combination. To reduce voltage ripple, filters made of capacitors are normally added to such a converter's output. Power for the boost converter can come from any suitable DC sources, such as batteries, solar panels, rectifiers and DC generators. A process that changes one DC voltage to a different DC voltage is called DC to DC conversion. A boost converter is a DC to DC converter with an output voltage greater than the source voltage.

A schematic of a boost power stage is shown in Fig.1. The function of boost converter can be divided into two modes, Mode 1 and Mode 2. Mode 1 begins when MOSFET S is switched on at time t=0. The input current rises and flows through inductor L and MOSFET S.

Mode 1 : When the switch is closed, current flows through the inductor in clockwise direction and the inductor stores some energy by generating a magnetic field. Polarity of the left side of the inductor is positive. Fig.2 shows the Mode 1 of Boost Converter in turn-on state.

Mode 2 : When the switch is opened, current will be reduced as the impedance is higher. The magnetic field previously created will be destroyed to maintain the current towards the load. Thus the polarity will be reversed (means left side of inductor will be negative now). As a result, two sources will be in series causing a higher voltage to charge the capacitor through the diode D. Fig.3 shows the Mode 2 of Boost Converter in turn-off state.

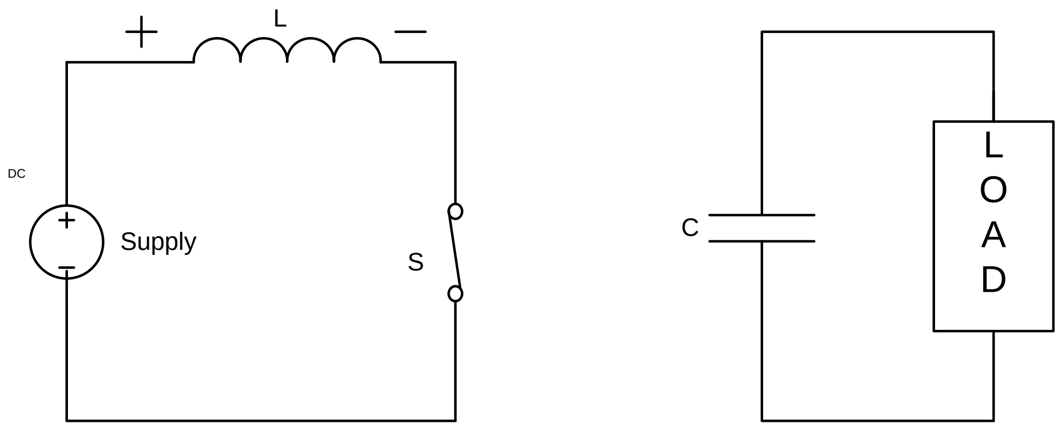


Fig.4 Mode 1 ON state

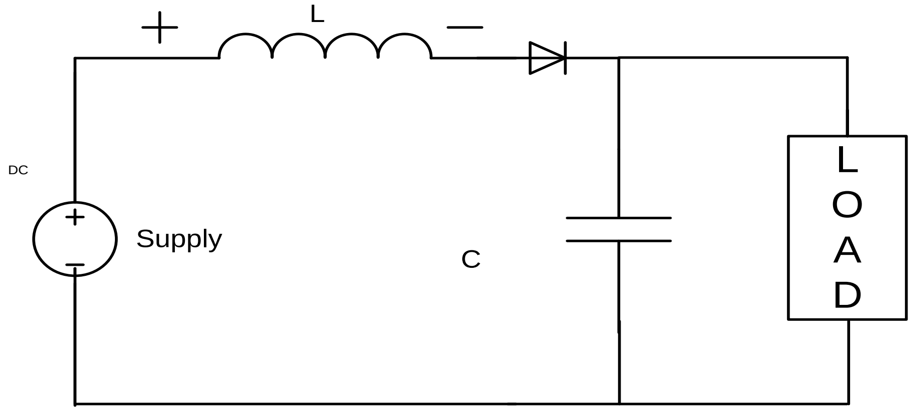


Fig.5 Mode 2 OFF state

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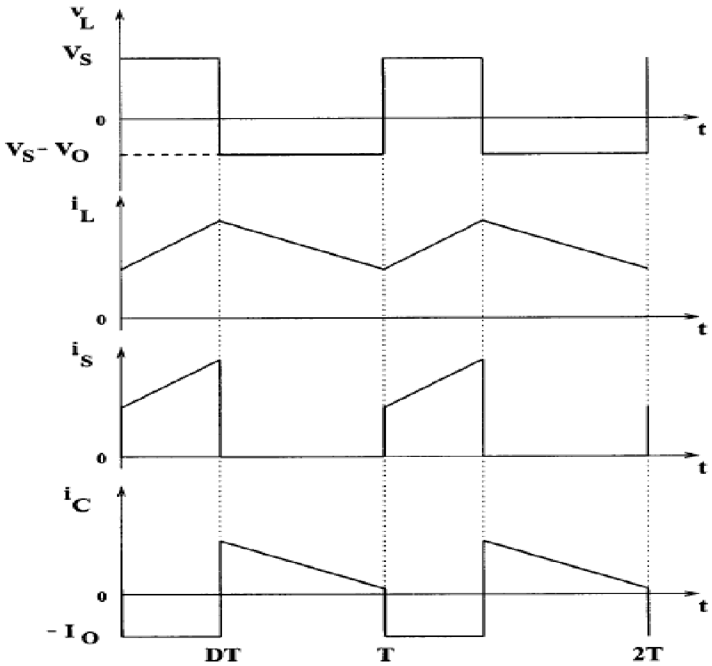

(Vs-Source Voltage ,Vo-Load Voltage ,Vl-inductor voltage)

(Is= Source Current, Io=Load Current, IL-Inductor Current)

Fig. 6. Waveform of Boost Converter

Calculation of Inductor and Capacitor

Using Faraday's law for the boost inductor
$Vs = (\mathrm{Vo} - \mathrm{Vs})(1 - \mathrm{D})\mathrm{T}$ From which the dc voltage transfer function turns out to be

$$\frac{Vo}{Vs} = \frac{1}{1 - D}$$

As the name of the converter suggests, the output voltage is always greater than the input voltage. The boost converter operates in the CCM for L > L_b where

$$\mathrm{L}_b = \frac{(1 - D)^2 DR}{(10 - 15\%)ripple\ current\ x\ f}$$

The current supplied to the output RC circuit is discontinuous. Thus, a larger filter capacitor is required in comparison to that in the buck-derived converters to limit the output voltage ripple. The filter capacitor must provide the output dc current to the load when the diode D is off. The minimum value of the filter capacitance that results in the voltage ripple V_r is given by

$$C_{min} = \frac{1 - D}{2\,Rf(1-2)\%\ of\ ripple\ voltage}$$

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