DC-DC Converter

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Contents

***Abstract*—This manual provides the design of a DC-DC Boost-Converter.**

1 Components

Component	Value	Quantity
Arduino Uno		1
Inductor	5 mH	1
Capacitor	10 uF	1
n-MOS	IRF 540	1
Jumper Wires	M-M	20
Diode		1
Gate Driver	TLP350	1

TABLE I

2 Circuit Operation

The boost converter blockdiagram and circuit is shown in Fig. 1 and Fig. 2.

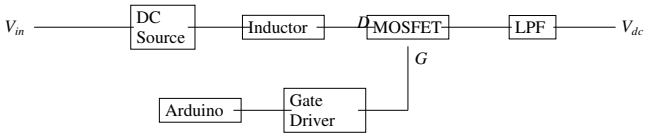

Fig. 1: Block Diagram

Problem 2.1. When the switch is ON, the circuit diagram is shown in Fig. 3. Express the voltage across inductor interms of V_s and V_o and current passing through the capacitor interms of I_L and I_o when swich is ON.

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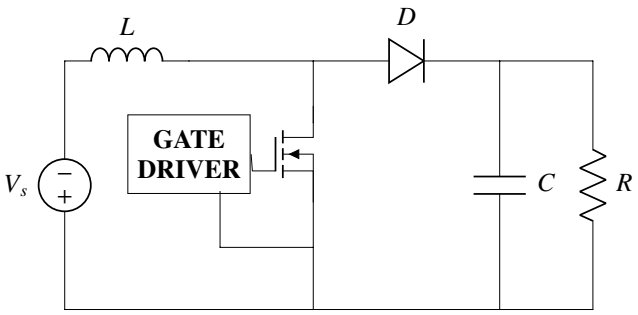

Fig. 2: DC-DC boost converter

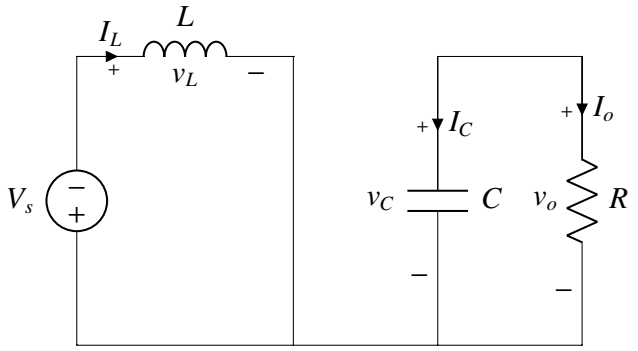

Fig. 3: Switch in ON state

Solution:

$$V_L(ON) = V_s$$
$$I_C(ON) + I_o = 0$$
$$I_C(ON) = -I_o$$

Problem 2.2. When the switch is OFF, the circuit diagram is shown in Fig. 4. Express the voltage across inductor interms of V_s and V_o and current passing through the capacitor interms of I_L and I_o when swich is OFF.

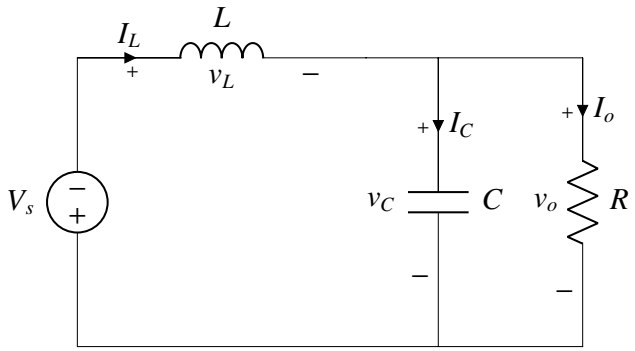

Fig. 4: Switch in OFF state

Solution:

$$V_L(OFF) = V_s - V_o$$
$$I_C(OFF) = I_L - I_o$$

Problem 2.3. Find V_o and I_o.

Solution: From Volt-sec Balance

$$V_L(ON)T_{ON} + V_L(OFF)T_{OFF} = 0$$
$$V_sDT - (V_s - V_o)(1-D)T = 0$$
$$V_o = \frac{V_s}{(1-D)}$$

Where D is Duty cycle

From Amp-sec Balance

$$-I_oDT + (I_L - I_o)(1-D)T = 0$$
$$I_o = \frac{I_L}{(1-D)}$$

Problem 2.4. Express L interms of D,V_s, $f = \frac{1}{T}$ and ΔI_L.
Where ΔI_L is Ripple in the inductor current i.e maximum change in the inductor current from ON state to OFF state .

Solution:

$$V_L(ON) = V_s$$
$$L\frac{di_{ON}}{dt_{ON}} = V_s$$
$$L\frac{\Delta I_L}{DT} = V_s$$
$$L = \frac{DV_s}{\Delta I_L f} \tag{2.4.1}$$

Problem 2.5. Express C interms of I_o,D,ΔV_o and $f = \frac{1}{T}$.

Solution: $\Delta V_C = \Delta V_o$
During ON state, $I_C = -I_o$

$$C\frac{dV_C}{dt_{ON}} = -I_o$$
$$\int_{V_{max}}^{V_{min}} dV_C = \int_0^{DT} \frac{-I_o}{C} dt$$
$$V_{min} - V_{max} = \frac{-I_o}{C}DT$$
$$-\Delta V_o = \frac{-DI_o}{Cf}$$
$$C = \frac{DI_o}{f\Delta V_o} \tag{2.5.1}$$

Problem 2.6. Assume,
Input Voltage (V_s) = 5V
Output Voltage (V_o) = 10V
ΔI_L = 5% of I_L
ΔV_o = 7% of V_o
Let $R = 10\Omega$ (for $I_o = 1A$)
Calculate L and C.

3 Circuit Assembly

Problem 3.1. Assemble the Boost converter circuit according to Figs. 2, 5 and Table II.

TLP350	1	2	3	4	5	6	7	8
ARDUINO	NA	13	GND	NA			NA	
					-5 V	10 Ω		12 V
MOSFET					S	G		

TABLE II: Pin Connections

Problem 3.2. Program the arduino to generate a square wave with *Duty Cycle* $D = 0.5$ and frequency $f = 5KHz$.

Solution:

```
void setup(){
  pinMode(13,OUTPUT);

}

void loop(){
  digitalWrite(13,LOW);
  delayMicroseconds(100);
  digitalWrite(13,HIGH);
  delayMicroseconds(100);
```

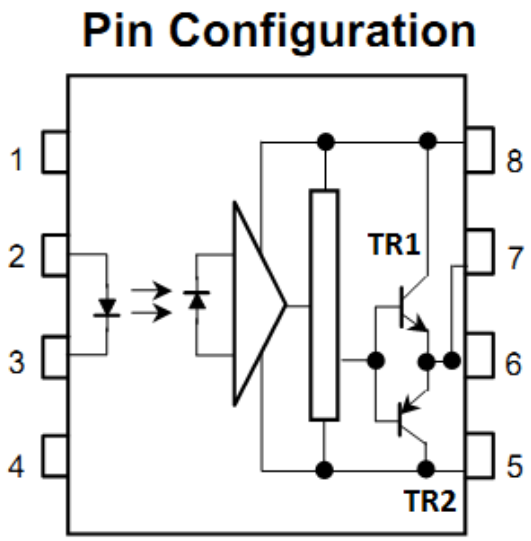
Pin Configuration
1
2
3
4
8
7
6
5
TR1
TR2
1 : N.C.
2 : Anode
3 : Cathode
4 : N.C.
5 : GND
6 : V_O (Output)
7 : V_O
8 : V_{CC}

Fig. 5: TLP350

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