Personal Contribution to 2015 Student EMC Hardware Design Competition

EECE 675
Test-2 Report
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Acknowledgement:

We are really grateful since we managed to complete our *EMC Student Hardware Design Project* within the time given by our professor *Dr.Hedema*. This project cannot be completed without the effort and co-operation from our group members. We sincerely express our gratitude to our professor for the guidance and encouragement in finishing this project successfully and also for the support and willingness to spend time with us to fill in the questionnaires.

Introduction:

To design and study a step-down power supply (DC/DC converter) as per the technical specifications of 2015 Student EMC hardware Design Competition.

Personal Contribution:

I am intended to design a step-down power supply (DC/DC converter) with an efficient output filter which in turn produces an output voltage of 3.3v with a very low A.C ripple voltage.

Design Procedure:

a) Firstly, I used the following schematic as reference (Figure 1)

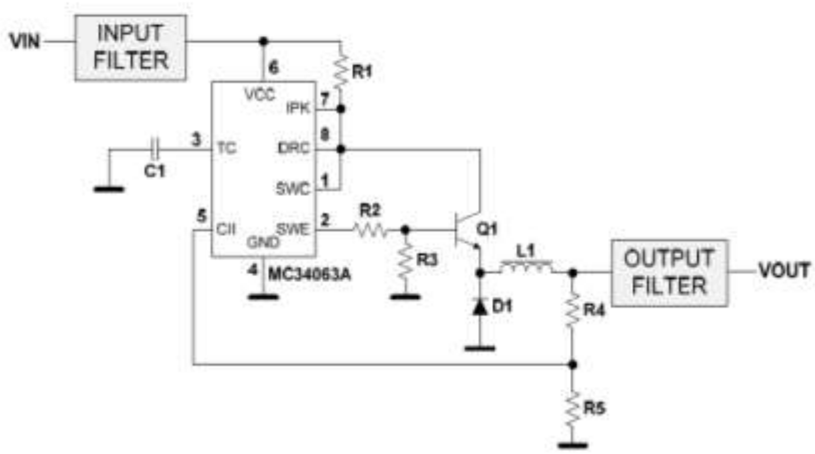


Figure 1

The above circuit design uses **$V_{in\,(min)}$** 6V, **$V_{in\,(max)}$** 12V, **V_{sat}** 0.5V, **F_{min}** 40 KHz, and **V_{out}** 3.3v in the following formulae [1]:

$$\frac{Ton}{Toff} = \frac{Vout + Vfd1 + Vfd2}{Vin\,min - Vsatq1 - Vsatq2}$$

$$Ton\,max + Toff = \frac{1}{fmin}$$

$$Ct = 4.0x10^{-5}\,Ton\,max$$

$$Lmin = \frac{Vinmin - Vsatq1 - Vsatq2}{Ipk\ switch}\ Ton$$

$$Vout = 1.25\left(1 + \frac{R2}{R1}\right)$$

$$R1 = \frac{0.3}{Ipk\ switch}$$

Upon solving the above formulae, I figured out the following components and their values:

- **MC34063A**, an easy-to-use IC for DC/DC switching voltage regulator applications which gives a fixed output voltage of 3.3V for input of 6-12V DC.
- **R_1** (0.47 Ohm), **R_2** (15 Ohm), and **R_3** (300 Ohm) where R_1, R_2, R3 are the base and emitter resistors which maintain the saturation and cut-off voltage levels for transistor Q_1.
- **R_4** (2.2 KOhm) and **R_5** (1.3 KOhm) are the resistors which satisfy the IC's output voltage required ratio and the saturation voltage levels of the transistor.
- A timing capacitor **C_t** (680pF) is used to set the IC's frequency, period, time, duration, and duty cycle.
- A BJT NPN transistor **Q_1** is used for good switching speed.
- A Schottky Diode **D_1** is used in order to provide best performance when different design load currents are selected.

b) Next, I designed a second order damped output filter (Figure 2) for the DC/DC converter switching supply which brings out the lowest A.C ripple voltage.

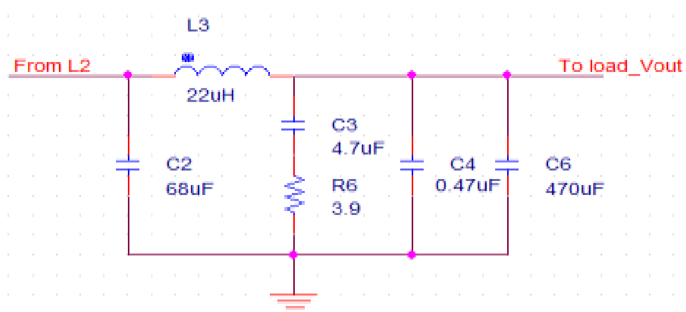
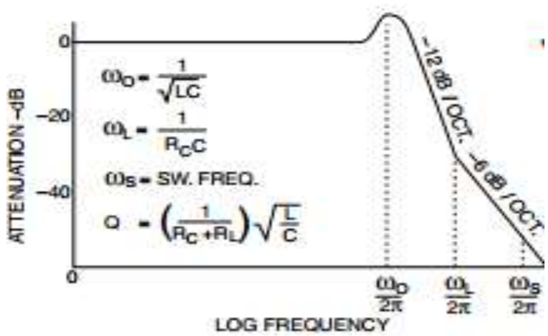


Figure 2

The above circuit design uses cut-off frequency (**f_0**) 10 KHz, limiting frequency (**f_L**) 20-30 KHz, and switching frequency (**f_s**) 50 KHz. Upon choosing **L** (22 uH), the capacitors **C_3** (4.7 uF), **C_4** (0.47 uF), **C_6** (470 uF) are computed from the following formulae:



The switching frequency (**f_s**) of 50 KHz is determined by the capacitor **C_3** and the inductor **L**. Capacitors **C_4** and **C_6** are used to compensate for the zero due to the capacitor's ESR and hence improve high frequency rejection. An output capacitor **C_2** (68 uF) is used for low output ripple voltage and good stability. It filters the output and provides regular loop stability. The low ESR of the output capacitor and the peak-to peak value of the inductor ripple current are the two main factors which contribute to low output voltage ripple.

In addition, a second order damped filter provides better attenuation as a function of frequency and reduces common mode output noise. They are also more forgiving to imperfect layouts because of the inductor in series with the circuit.

Team Contribution:

We together as a team decided the design layout, components placement and the type of PCB to be used. By using adequate amount of flux and solder, we soldered the IC and the filters on PCB. Also, we tested our design over the range of 150KHz to 30MHz using a digital spectrum analyzer to measure the input noise and a digital oscilloscope to measure output ripple voltage.

EMC Techniques learned:

- Grounding technique (chapter 3, [2]): To ensure that each stage of the system operates with the same zero potential**.**
- General purpose board layout (chapter 16, [2]): Rapidly switching currents associated with wiring Inductance, stray capacitance, and parasitic inductance of the general purpose circuit board traces can generate voltage transients which can in turn produce electromagnetic interferences (EMI) and affect the desired operation. In order to minimize the inductance and ground loops, the length of the leads of the components should be kept as short as possible.
- Component Placing Technique (chapter 16, chapter 17 [2]): Taking loop currents and parasitic stray capacitance into consideration, placing components as close as possible on PCB layout is preferred.