# 3)

**a)** We know that average current through at steady state is zero.  
   
, → and   
, (100% efficiency assumed) →

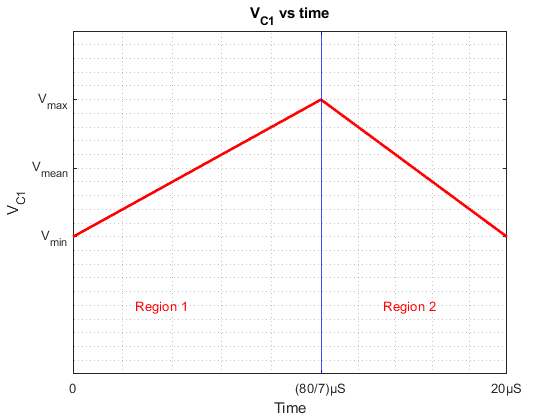
We know that , then for our values   
 ,   
   
We also know that our switching frequency is equal to 50Khz, this means that our period is equal to 20µS. Since we know that while the switch in conduction, capacitor supplies power to the load. This means that for capacitor is discharging.  
  


Figure 3.1 Capacitor voltage vs time graph  
  
Figure 3.1 shows the capacitor voltage in one period of switching, we know that mean capacitor voltage is equal to 12V.  
  
  
  
  
We also know that in region 1, switch is not in conduction and capacitor is charging. Moreover, in region 2, switch is in conduction and supplies power to the load.  
  
For the 2% voltage ripple, . This means that and   
  
Since this is first homework, we will make this calculation, first assuming that capacitor is discharging with constant current, then by assuming that current is not constant but converter is loaded with constant R load.  
  
If we assume constant discharge current of 2A then  
  
Solving this equation yields, C = 71.43µF.   
  
If we assume constant R load

Solving this differential equation,   
  
If we check for t=0, we can find that K=12.12V, then to satisfy the 0.24V voltage drop in 60/7µs our capacitor must be equal to 71.42µF. This means that constant current method is a good method. For the inductors, I will assume that while charging or charging inductor voltage is constant.   
  
For , we know that mean current is equal to mean input current which is 1.5A, if we assume 10% current ripple, this means that inductor current must fluctuate between 1.425A and 1.575A. Since it is clearly seen that while the switch is in conduction, the inductor current rises with the power of supply voltage, we can easily calculate the required inductance.

For the calculation of , if we assume that is large enough to keep the voltage constant, then we can say that mean current through is equal to mean output current. Moreover, it is clearly seen that while the switch is in conduction, inductor charges with the power of . If we assume that . We can calculate the required inductance for .

**B)** Since we know the mean current through , by assuming constant discharge current on . We can calculate the required capacitance for 10% ripple voltage. We know that mean voltage is equal to the input voltage, then for 10% ripple voltage change is equal to 1.6V.

**C)** Since the required capacitance value for is high for using all ceramic capacitor (it is not an economical solution), I will select an electrolytic capacitor and use it parallel with a ceramic capacitor. This will also help our electrolytic capacitor to handle high ripple current.

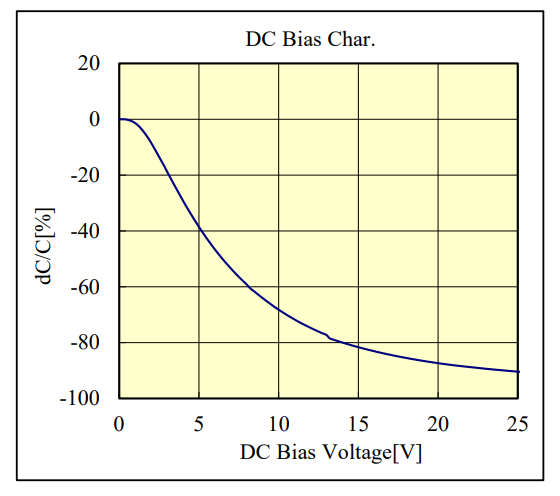
I will select an 68µF electrolytic capacitor and add ceramic capacitors for the complete it to 71.43µF. We know that capacitance of ceramic capacitors highly depends on the voltage across it. So, the exact required capacitance for the ceramic capacitors will depend on the selected series (given capacitance value is generally at 0V).

For 68uF electrolytic capacitor, I am selecting 25ZLJ68M5X11 from Rubycon. Specifications of it for 50Khz can be seen in the table below.

|  |  |
| --- | --- |
| Capacitance | 68µF |
| Voltage rating | 25V |
| Impedance at ~50Khz | 0.4Ω |
| Rated ripple current ~50Khz | 450mA |

Table 3.1 Selected electrolytic capacitor

For the ceramic capacitors Taiyo Yuden is selected as manufacturer, it is known that capacitance value will reduce with increased voltage. Even though we know that we will lose most of capacitance if we select 25V rated capacitor, for simplicity I am directly selecting an 25V voltage and by looking the DC bias characteristics I am selecting a 10uF 25V rated 0805 package capacitor coded as MSAST21GBB5106MTNA01 (previously TMK212BBJ106MG-T) its DC bias characteristics can be seen below.

  
Figure 3.2 DC bias characteristics for selected ceramic capacitor

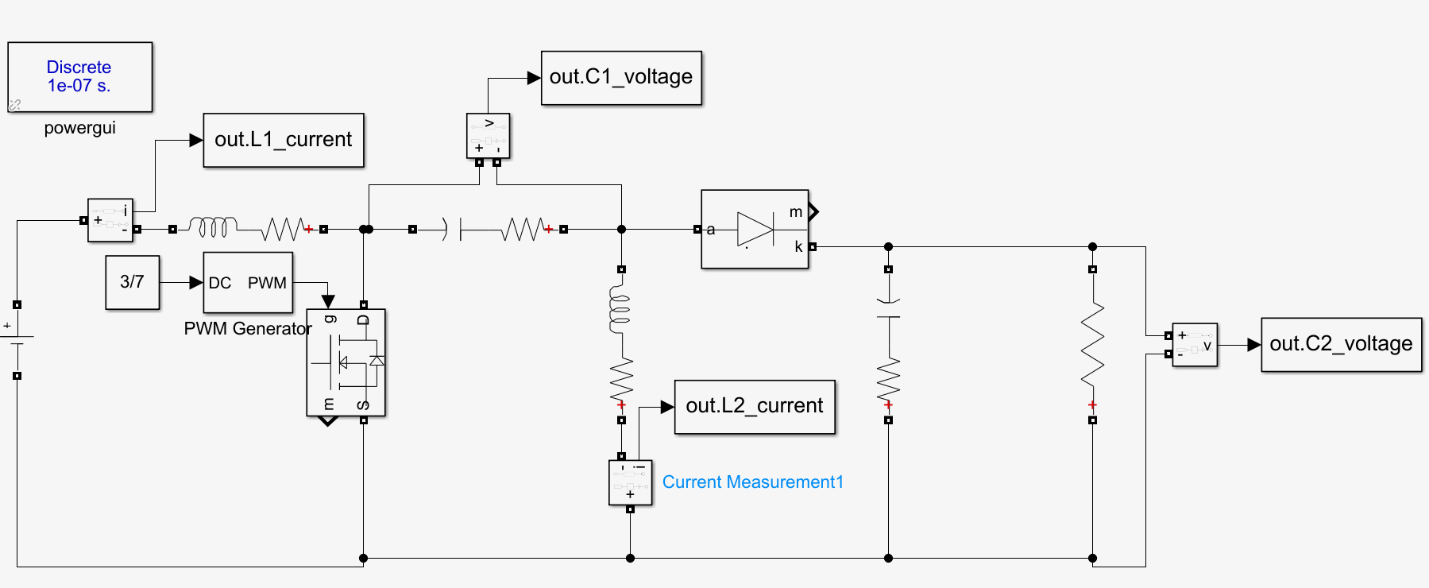
Dc bias value for every voltage value can be seen from the manufacturer’s web site, for 12V bias loss in capacitance is equal to -74.73% this means that our capacitance at steady state will equal to 2.527µF.   
Then by simplicity we can use two of them in parallel.  
  
Final   
  
 For the , required capacitance value can be satisfied by using only ceramic capacitors, but it will require a lot of them in parallel. Since we don’t have a restrictions about it, I will do it. So if we use the same ceramic capacitor at 16V, capacitance value will be equal to 1.69µF, we can use it by paralleling seven of them.  
  
Final . Using the same capacitor again better for mass production.  
  
I will continue with the selection of inductors and start with the L1. Required minimum inductance value is 914µH and I will ignore the saturation effect on this part and look for inductors which have higher saturation current than 1.575A

For the L1, AIRD-03-102K from Abracon LLC, satisfies those conditions. It has 1mH inductance value and 2A saturation current.   
  
After repeating the same procedure for L2, DC1050R-824K from API Delevan Inc., can be used for L2. It has 820µH inductance and 2.5A saturation current.

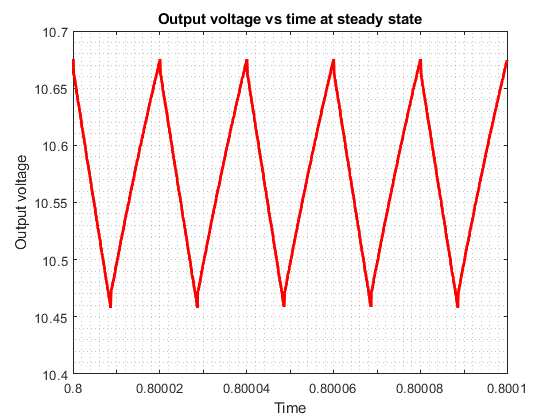
Since our currents are quite low for a discrete mosfet, I will directly search for a mosfet. RQ3G100GNTB from Rohm Semiconductor. It has the enough voltage and current ratings for our converter.

Our last component is diode, SS5P4-M3/86A from Vishay General Semiconductor - Diodes Division selected.

|  |  |  |  |
| --- | --- | --- | --- |
| Component | Product | Price | Amount |
| L1 | **AIRD-03-102K** | **$6.07** | **1** |
| L2 | **DC1050R-824K** | **$7.37** | **1** |
| C1 | **MSAST21GBB5106MTNA01** | **$0.21** | **7** |
| C2 ceramic | **MSAST21GBB5106MTNA01** | **$0.21** | **2** |
| C2 | **25ZLJ68M5X11** | **$0.28** | **1** |
| MOSFET | **RQ3G100GNTB** | **$0.49** | **1** |
| Diode | **SS5P4-M3/86A** | **$0.67** | **1** |
|  |  | Total Price | $16.77 |

**D)  
  
**Figure 3.3 Simulation model for SEPIC converter

Firstly, while calculating our duty cycle we didn’t include voltage drop due to diode. Moreover, we neglect the resistance of the inductors, ESR of capacitors. Due to those differences, our results will be different than our idealized solutions.

  
Figure 3.4 Output voltage vs Time

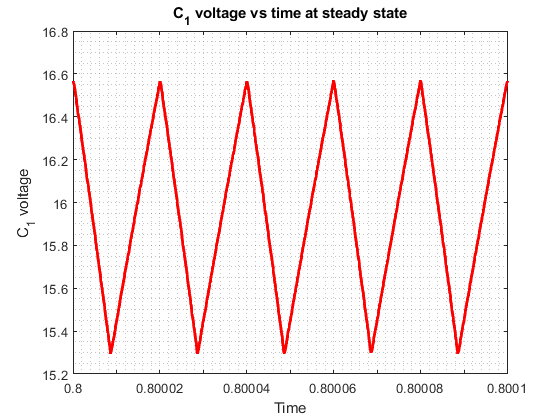
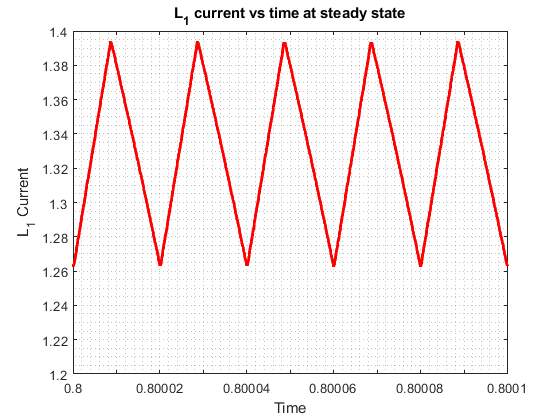


Figure 3.5 C1 voltage vs time

  
Figure 3.6 L1 current vs time

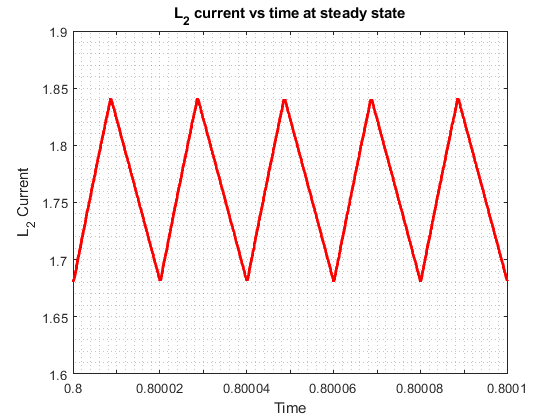
  
Figure 3.7 L2 current vs time

Figure 3.4, 3.5, 3.6, 3.7 shows the required plots. It is clear that output voltage is less than required, however this can be fixed easily with closed loop control. Moreover, output voltage ripple value is required is less than 2%, for the 12V output this is equal to 0.24V ripple, this is satisfied, however our output voltage is different and for the current value the ripple value 0.21V with mean voltage of 10.57V, this means that our ripple value is at the limit. The assumptions for the C1, L1 and L2 is satisfied.