Thứ ngày

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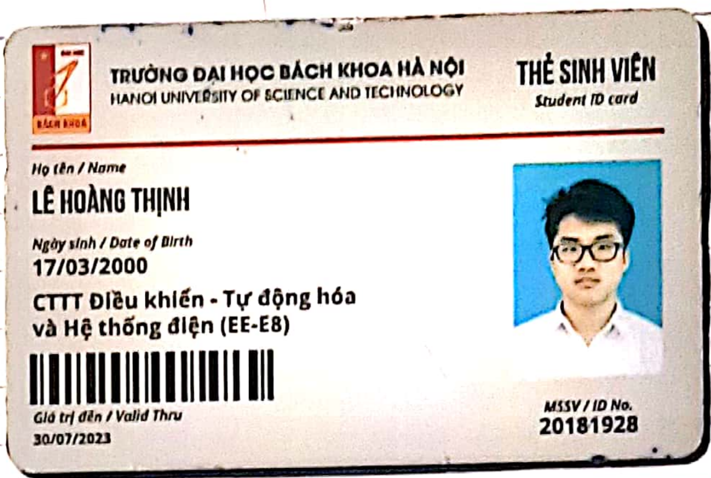
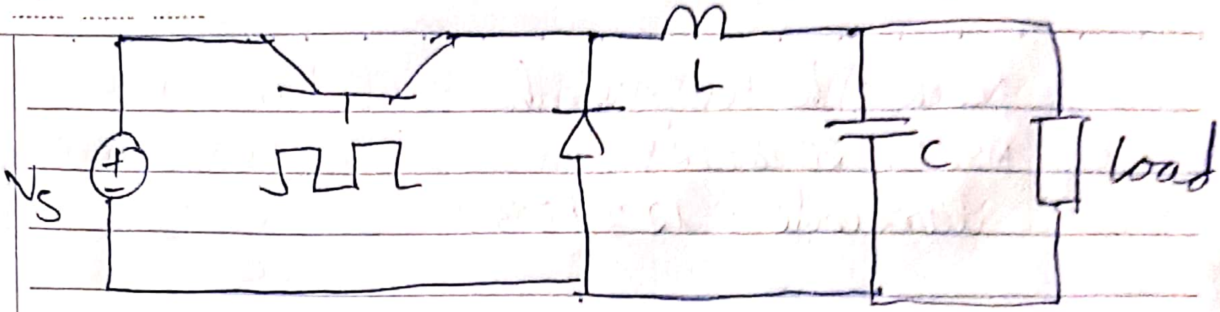


Đề 1

Question 1. High power frequency switching prefered in modern converter because it allows the use of a smaller inductor (and input and output filter capacitor). This is because the inductor size is primarily determined by the amount of ripple current allowed in a given switching regulator's specification. For a given inductance the ripple current decreases as the switching frequency increases and this will help reduces the size and the cost of power supply.

To reduce the loss switching loss, we can use Zero voltage switching or zero current switching

Question 2. ① Topology (choose $k_I = 3$; $k_u = 2$)



$D = \frac{V_{out}}{V_{in\,max}} = \frac{12}{\cancel{5}\,48 \cdot 1{,}15} = 0{,}22$

~~ΔI =~~ (+) Calculate inductor : (Choose $\Delta I\% = 30\%$)

$\Delta I = \frac{(V_{in.max} - V_{out})D}{f_s \cdot L}$

$\Rightarrow L = \frac{(V_{in.max} - V_{out})D}{f_s \cdot \cancel{\Delta} \cdot \Delta I} = \frac{(48 \cdot 1{,}15 - 12) \cdot 0{,}22}{100 \cdot 10^3 \cdot \frac{48}{12} \cdot 30\%}$

$= \cancel{11}\ \cancel{0{,}08\,(mH)}\ 0{,}08\,(mH)$

I_{avg} of inductor is : $I_{out} = 4\,(A)$

~~⇒ I peak of inductor is~~

So we choose inductor $\begin{cases} L = 0{,}08\,mH \\ I_{avg} = K_i \cdot 4 = 12\,(A) \end{cases}$

(+) choose capacitor :

$C_{out\,min} = \frac{\Delta I}{8 f_s \quad \Delta V_{out}} = \cancel{6{,}25}\ 3{,}125\ (MF)$

V_C reverse $= \cancel{48}\ 12 \cdot 1{,}04 = 12{,}48\,(V)$

Choose capacitor $\begin{cases} C = 3{,}5\,MF \\ K_u \cdot 12{,}5 = 25\,V \end{cases}$

(*) MOSFET :

$I_{avg} = I_{load} \cdot D = 4 \cdot \cancel{5}\ 0{,}22 = 0{,}88\,(A)$

$I_{peak} = I_{load} + \frac{1}{2}\Delta I = 4{,}6\,(A)$

$V_{peak} = V_{in\,max} = 48 \cdot 1,15 = 55,2\,(V)$

=> choose MOSFET $\begin{cases} V_{peak} = 111\,V \\ I_{avg} = 3\,A \\ I_{peak} = 4,6\,A \end{cases}$

⊕ Diode:

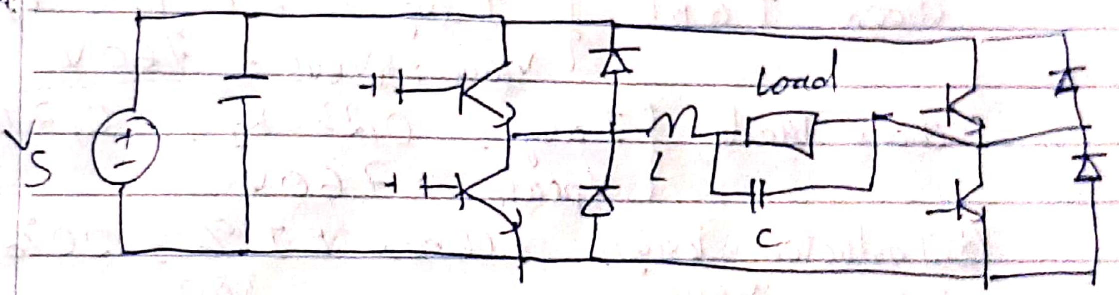
$I_{avg} = I_{load}\,(1 - D) = 3,12\,(A)$

$I_{peak} = I_{load} + \frac{1}{2}\Delta I = 4,6\,(A)$

$V_{peak} = V_{in.max} = 55,2\,(V)$

=> choose Diode $\begin{cases} V_{peak} = 111\,V \\ I_{avg} = 10\,A \\ I_{peak} = 4,6\,A \end{cases}$

Question 4: $K_I = 3;\ K_V = 2$



⊕ DC voltage calculation:

Choose $M_{max} = 0,9$ and drop voltage on the output filter to be about 10% of output voltage

$$\Rightarrow V_{BUS} = \frac{U_{OM}}{0,9} \cdot 1,1 = \frac{\cancel{220\sqrt{3}}\ 220\sqrt{2}}{0,9} \cdot 1,1$$

$$= \cancel{346} \approx 380\,V$$

⊕ calculate the amplitude of the output current I_{OM} (A)

RMS value: $I_o = \frac{S_o}{U_o} = \frac{1100}{220} = 5\,(A)$

Amplitude: $I_{OM} = 5 \cdot \sqrt{2} = 7,07\,(A)$

(*) IGBT and Diode calculation. (Choose $\cos\varphi = 0,8$)

~~IG~~ IGBT average current:

$$I_V = \cancel{\frac{1}{2\pi} \cdot (1+\cos\varphi)} \frac{1}{2\pi} \int_{\varphi}^{\pi} I_{OM} \sin(\theta - \varphi) d\theta$$

$$= \frac{1+\cos\varphi}{2\pi} I_{OM}$$

$$= 2,03\ (A)$$

Diode average current:

$$I_D = \frac{1}{2\pi} \int_0^{\varphi} I_{OM} \sin(\theta - \varphi) d\theta$$

$$= \frac{1-\cos\varphi}{2\pi} I_{OM} = 0,23\ (A)$$

Choose IGBT $\begin{cases} I_{avg} = 2,03 . K_I = 6,09 (A) \\ V_{peak} = K_u V_{BUS} = 760V \end{cases}$

Choose Diode $\begin{cases} I_{avg} = 0,23 . K_I = 0,7 (A) \\ V_{peak} = 760V \end{cases}$

(*) Inductor design (Choose $\Delta I\% = 20\%$)

$$L_i = \frac{V_{BUS}}{4 F_{SW} . \Delta I_{PP/max}} = \frac{380}{4 . 10^4 . 7,07 . 0,2}$$

$$= 6,72\ (mH)$$

Check drop voltage (less than 10 %)

Drop voltage $= w_s . L_i . I_o$

$= 100\pi . 6,72 . 10^{-3} . 5$

$= 10,56 (\sim 4,8\%\ V_{out})$

$I_{avg} = I_o = 5\ (A)$

Choose inductor $\begin{cases} L = 6,72\ mH \\ I_{avg} = 5 . K_I = 15 (A) \end{cases}$

(*) Capacitor:

Choose $w_{CL} = 0,1 w_{SW} = 2000\pi$.

$$C = \frac{1}{L . w_{CL}^2} = 3,77\ (\mu F)$$

Vpeak = Vout peak = 310 V

=> choose capacitor $\begin{cases} C = 3,77 \ \mu F \\ V_{peak} = k_u . 310 = 620 V \end{cases}$

(+) DC capacitor: worst loss = 0,5, ripple = 5%

$\Delta U_c = \frac{0,5 \ T_{SW}}{C} . I_c$

$\Rightarrow C = \frac{0,5 \ T_{SW}}{\Delta U_c} . I_{out\,max} = 18,6 (\mu F)$

$V_{peak} = V_{in\,p} = 380 V$

=> choose $\begin{cases} C = 18,6 \ \mu F \\ V_{peak} = k_u . 380 = 760 (V) \end{cases}$

Question 5: ~~(+) DC voltage calculation: VBUS~~

~~VBUS = choose m = 0,8~~

~~$U_0 = 150 e^{30°j}$~~

$U_0 = 150 e^{j30}$

$\Rightarrow U_0 = 129,9 + 75 j$

$\Rightarrow \begin{cases} U_\alpha = 129,9 \ V \\ U_\beta = 75 \cancel{,125} \ V \end{cases} \Rightarrow$ Sector 1

$T_1 = \frac{T_S}{2 V_{DC}} . (3 V_\alpha - \sqrt{3} V_\beta)$

$= \frac{1}{10^4 . 2 . 540} (3 . 129,9 - \sqrt{3} . \cancel{125}\ 75)$

$= 2,4 . 10^{-5}$

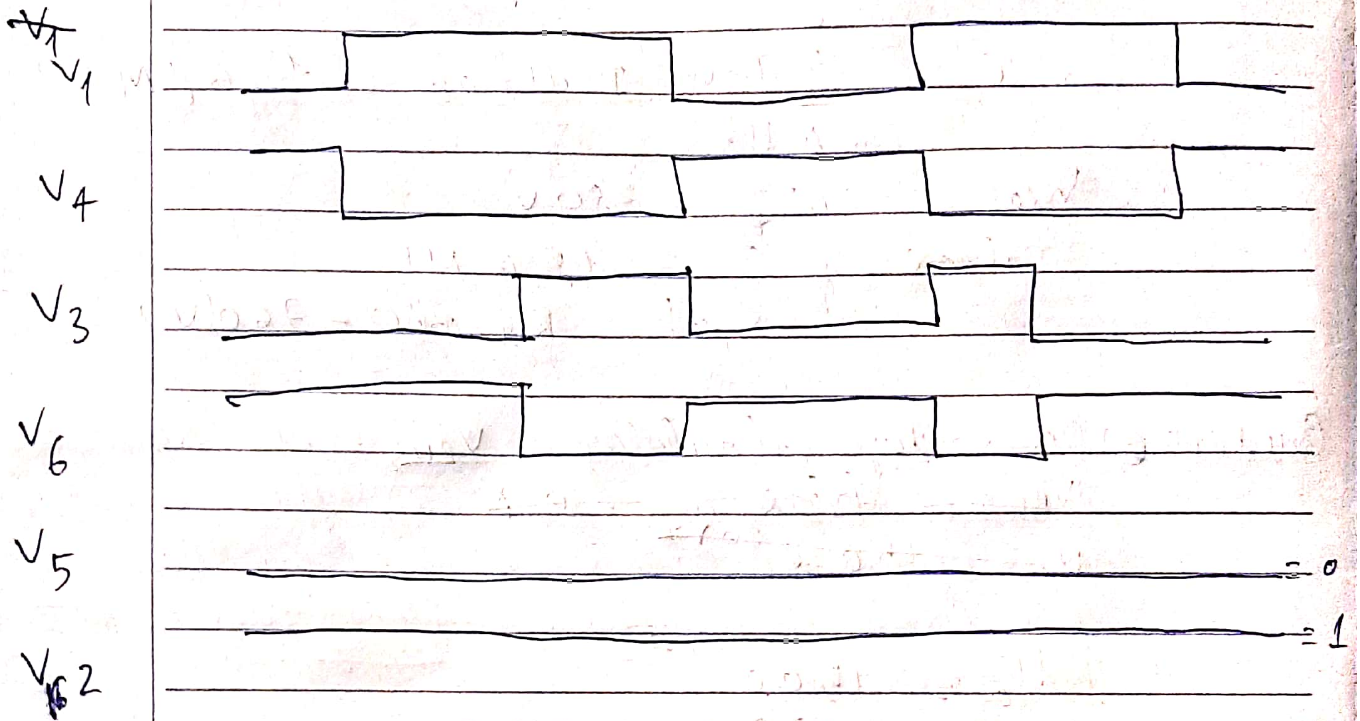
$T_2 = \frac{T_S}{V_{DC}} (\sqrt{3} V_\beta)$

$= \frac{1}{10^4 . 540} \sqrt{3} . 75 = \cancel{4,2}\ 2,4 . 10^{-5}$

$T_0 = T_S - T_1 - T_2 = \cancel{6,4}\ 5,2 \cdot 10^{-5}$ (s)

Pulse waveform:

$\frac{T_0}{4}$	$\frac{T_1}{2}$	$\frac{T_2}{2}$	$\frac{T_0}{4}$	$\frac{T_0}{4}$	$\frac{T_2}{2}$	$\frac{T_1}{2}$	$\frac{T_0}{4}$



Question 2: ⊛ Definition: Solid-state (Semiconductor relay) is a semiconductor device that can be used in place of a mechanical relay to switch electricity to a load in many applications. It is typical feature electrical isolution to several thousand volts between the control and load ~~sites~~ sides. It is quite common ~~cop~~ component nowadays but they are still quite expensive compared to their complexity

⊛ Topology:

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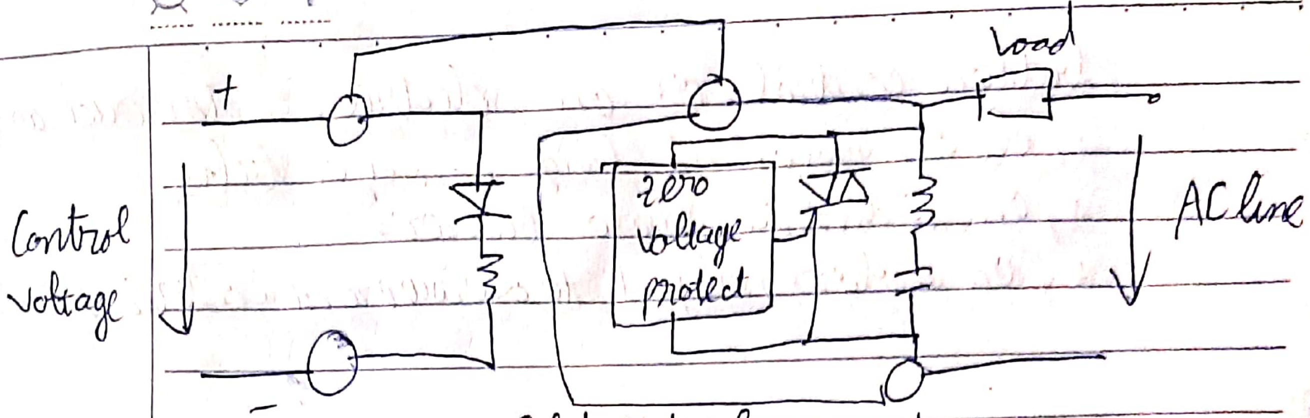
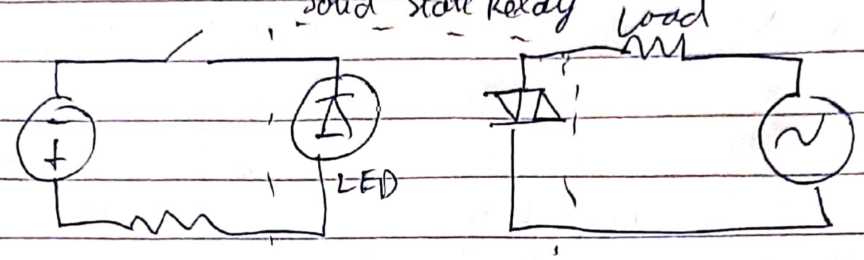


Solid State Relay



OPTO TRIAC

(*) Basic operation principle: It has the characteristics of being turned on when the voltage crosses zero and being turned off when the load current crosses zero. ~~When opto-coupler OPT is turned off, M1 turned on~~

(*) Advantage:

+, No mechanical moving parts

+, High switching ~~see~~ speed

+, High reliability

+, long operating life

+, High input output isolation

(*) Disadvantage:

+, output gets damaged quite easily by overvoltages

+, More expensive than normal relays

+, More sensitive to voltage transients

(*) Application:

~~It can be ~~ used~~:

It can be ~~us~~ used as with classic push

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button control or on electric-motor such as:
+, on the motor of large conveyor belts
+, on industrial motor blowers
+, on motors subject to overcurrent conditions