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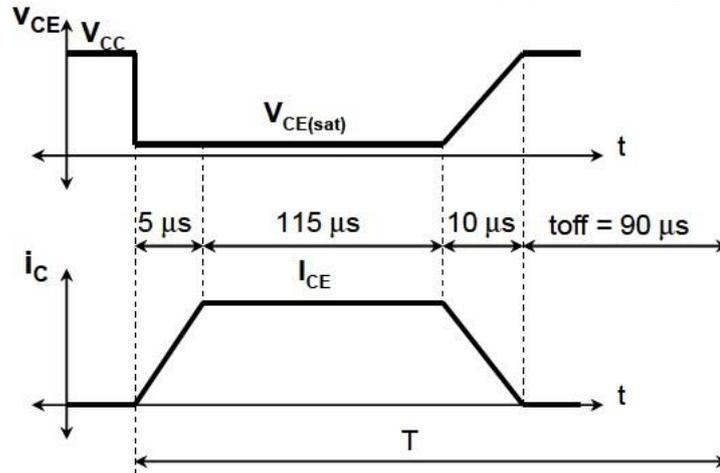
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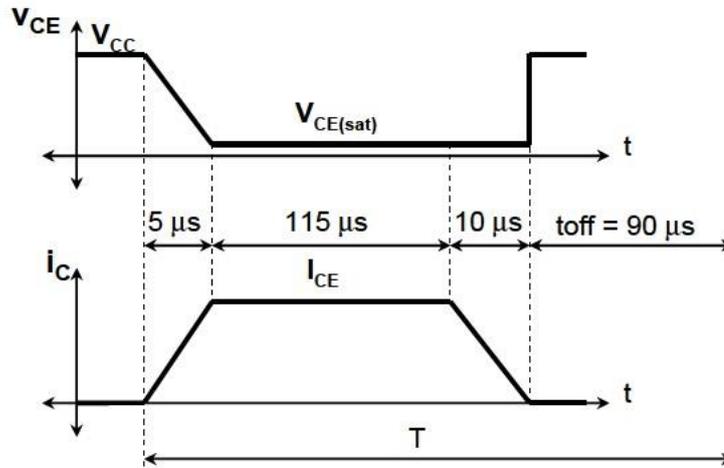
ECE 451 Power Electronics I

Tutorial questions – Chapters 1 & 2

1. The switching waveforms for a BJT with a turn-on snubber are shown below, where $V_{CC}=400$ V, $V_{CE(sat)} = 2.5$ V, and the collector current in the on-state is $I_{CE} = 80$ A. The collector leakage current is negligible ($I_{CEO} = 0$ A). Calculate the total average power dissipation.

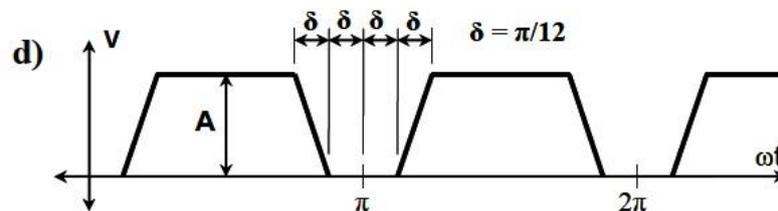
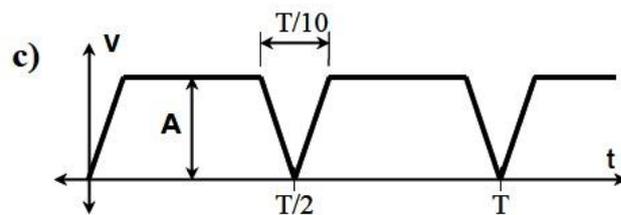
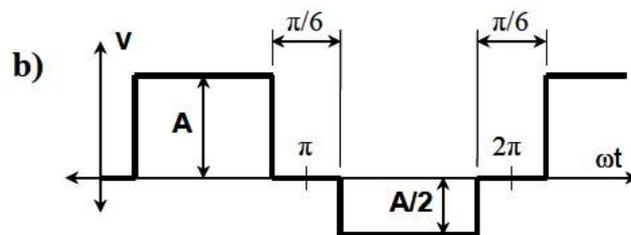
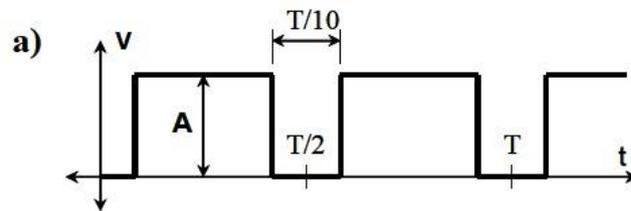


2. The switching waveforms for a BJT with a turn-off snubber are shown below. Use the same values as in the previous problem and calculate again the total average power dissipation.



3. A single-phase diode bridge rectifier must supply an average ripple free current of 12 A to a highly inductive load. If the rectifier is supplied from an ac source of 230 V_{rms}, determine:
- 3.1 the dc output voltage;
 - 3.2 the rms output voltage;
 - 3.3 the ac component of the output voltage;
 - 3.4 the rms output current (I_{rms});
 - 3.5 the the rms supply current (I_s);
 - 3.6 the apparent power of the transformer (S);

4. A single-phase diode rectifier is required to supply an average voltage of $V_{dc} = 216 \text{ V}$ to a highly inductive load at a ripple-free current of $I_{dc} = 14 \text{ A}$.
- 4.1 Determine the rms supply voltage (V_s) necessary to produce the required dc output voltage.
 - 4.2 Calculate the rms output current (I_{rms}).
 - 4.3 Find the rms current (I_r) through one diode.
 - 4.4 Determine the average dc current (I_{av}) through one diode.
 - 4.5 Find the PIV across one diode.
 - 4.6 Calculate the rms supply current (I_s).
 - 4.7 Find the apparent power of the transformer (S).
 - 4.8 Draw the waveforms of the output voltage, output current, supply current and the current through one of the diodes.
5. Determine the average (V_{av}), rms (V_{rms}), ac value (V_{ac}), form factor (FF), ripple factor (RF) and crest factor (CF) for the voltage waveforms below. Assume the values of $A = 20$ and $T = 50\mu\text{s}$.



ECE 451 Power Electronics I

Tutorial questions – Controlled Rectifiers & Protection of Semiconductor Devices

1 A single-phase semiconverter is operated from a 240 V_{rms} supply. The highly inductive load current with an average value of $I_{dc} = 9$ A, is continuous with negligible ripple content. The delay angle is $\alpha = \pi/3$.

- 1.1 the dc output voltage;
- 1.2 the rms output voltage;
- 1.3 Determine the average dc current (I_{av}) through one thyristor. 14 Calculate the rms supply current (I_s).
- 1.4 Find the apparent power of the transformer (S).

2. A single-phase full-converter (thyristor controlled) has a load of $R = 3.14$ Ohms. The ac input supply voltage is a single-phase 220 V_{rms} / 50 Hz. The firing angle is $\alpha = 40^\circ$.

- 2.1 Find the dc output current (I_{dc}).
- 2.2 Determine the rms output voltage ($V_o(\text{rms})$).
- 2.3 Calculate the rms input current (I_s).

Find the input power factor

A three-phase rectifier is required to supply a rms voltage of $V_{rms} = 550$ V at a ripplefree current of $I_{rms} = 2000$ A. The rectifier is connected to the medium voltage supply via a Y-Y transformer ($a_{12} = 5:1$).

- 2.4 Determine secondary line-to-line voltage (VLL) necessary to produce the required rms output voltage.
- 2.5 Calculate the average output current (I_{dc}).
- 2.6 Find the rms current (I_r) through one diode.
- 2.7 Determine the average dc current (I_{av}) through one diode.
- 2.8 Find the PIV across one diode.
- 2.9 Calculate the rms phase secondary current (I_{ph}).
- 2.10 Find the apparent power of the transformer (S).
- 2.11 Determine the primary voltage (phase) of the transformer (V_p).

3. A three-phase full-converter (thyristor controlled) has a load of $R = 3.14$. The ac input supply voltage is a three-phase 380 V_{rms} / 50 Hz. The firing angle is $\alpha = 40^\circ$.

- 3.1 Find the dc output current (I_{dc}).
- 3.2 Determine the rms output voltage ($V_o(\text{rms})$).
- 3.3 Calculate the rms input current (I_s) considering the load current is continuously and ripple free.
- 3.4 Find the input power factor.

3.5

4. A three-phase supply of 440 V_{rms} / 60 Hz must supply DC power through a controlled rectifier to an industrial oven with a 15Ω element. The rectifier must supply a maximum DC current (I_{dc_max}) of 30 A and a minimum DC current (I_{dc_min}) of 20 A to the load.

- 4.1 Find the firing angles (α_{\max} and α_{\min}), for the prescribed minimum and maximum values of I_{dc} .
- 4.2 Determine the maximum possible rms thyristor current I_R .
- 4.3 Calculate the worst-case efficiency (η) and input power factor (PF) for $I_{dc_{\max}}$ and $I_{dc_{\min}}$.
- 4.4 What will be the minimum required power rating of the transformer for the specified load currents?

A parallel connected R C snubber protects a device against dv/dt .

- 4.5 Determine the value of R if the discharging current must be limited to 10 A and supply voltage is $V_s = 240$ V. (3)
- 4.6 Determine the dv/dt if $C_s = 0.1$ μ F. (3)
- 4.7 Calculate the power dissipated in the snubber resistor if the device operates at 1 Hz.

Consider that the power dissipated into a transistor device is 180 W and the thermal parameters of the device are $R_{th-jc} = 0.11$ K/W, $R_{th-cs} = 0.03$ K/W, $R_{th-sa} = 0.11$ K/W and the ambient temperature is 350C. Determine the junction temperature. [80 °C]

7. Calculate the thermal resistance for a heat sink used for a transistor with the power dissipated on it of 200W, $R_{th-jc} = 0.09$ K/W, $R_{th-cs} = 0.02$ K/W, the ambient temperature of 45°C and if the maximum allowable temperature of the junction is 95°C.

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8. A freewheeling diode is connected parallel on an inductive load of $L = 250$ μ H; the resistance is negligible ($R = 0$), the voltage source is $V_s = 200$ V
- 8.1 Calculate the value of the current after $t_1 = 100$ μ sec.
- 8.2 Determine the energy E stored in the inductor.
- A thyristor must control a DC load of $R = 10$ W and $L = 400$ mH that is supplied from $V_s = 360$ V. The latching current of the thyristor is $I_L = 75$ mA and the firing pulse width is 30msec.
- 8.3 If the thyristor is OFF find the parallel resistor R2 across the load in order to ensure the latching current after 30 msec.
- 8.4 Calculate the width of the pulse that ensures thyristor to stay ON with no other auxiliary resistor.

9. Two identical MOSFET's that share current equally are mounted on a common heat sink. The thermal resistances are as follows: Junction to Case: 1,2 °C/W; Case to Heat Sink: 0.3°C/W; Heat Sink to Ambient air: 0,75 °C/W; The maximum allowed junction temperature: 125 °C; Ambient air temperature: 25 °C
- Sketch the thermal equivalent circuit for the combination. (3)
- Determine the maximum power that can be safely dissipated by each device. (2)
- 9.1 Determine the heat sink temperature. (2)



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