J. U. S. T.
EE 532 Power Electronics
Final Exam 27.1.2004

Problem 1: (20 marks)

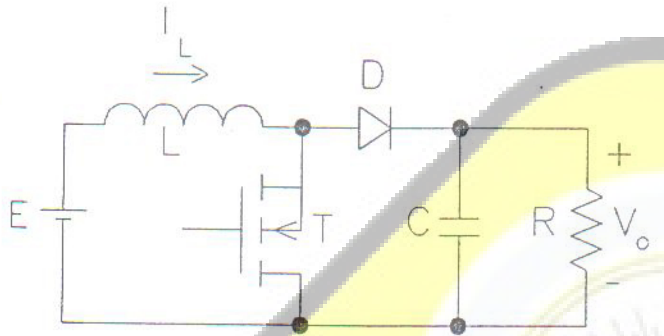
The boost dc-dc converter shown has the following parameters:

$E = 48$ V, duty ratio $= 0.6$, $L = 720\ \mu$H, $C = 10\ \mu$F, switching frequency $= 50$ kHz, and $R = 30\ \Omega$.

(i) At steady-state, assuming ideal components calculate: (a) output voltage V_o, (b) inductor current ripple ΔI_L, (c) output voltage ripple ΔV_o.

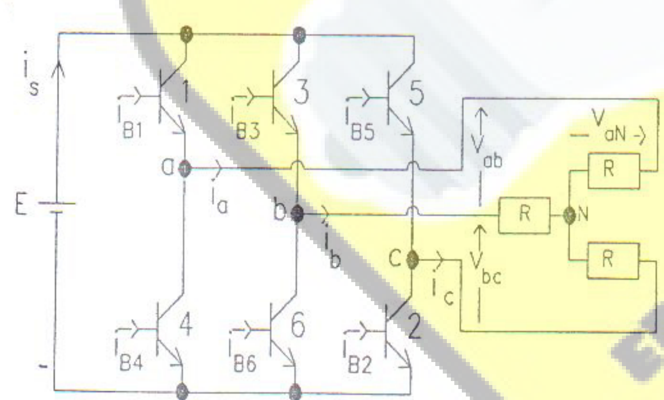
(ii) What is the minimum inductance that should be used to ensure that the converter works in the continuous current conduction mode?

(iii) If the transistor switching losses is to be calculated, estimate these losses assuming that the transistor has $(t_{on})_{sw} = (t_{off})_{sw} = 100$ nsec.



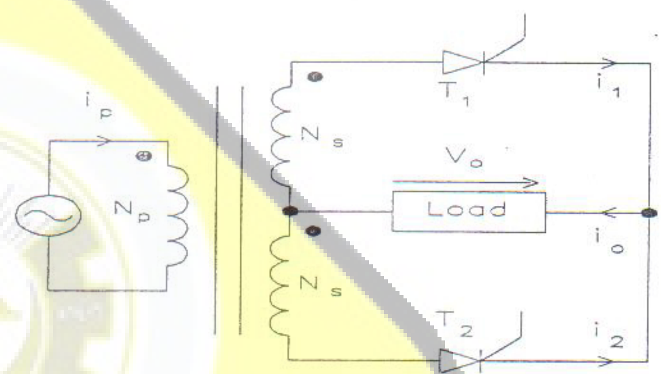
Problem 2: (25 marks)

The inverter circuit shown is operated with 180° firing. $E = 180$ V, $R = 10\ \Omega$, and the devices are assumed ideal, determine: (a) the peak voltage across the transistors while not conducting, (b) the rms current ratings of the transistors, (c) the power delivered to the load, (d) the current generated by the source i_s



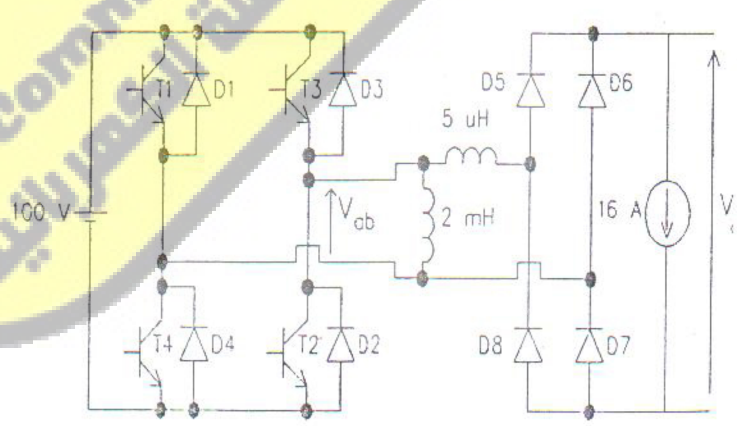
Problem 3: (35 marks)

The circuit shown below is supplied by a 220 V (rms) at 50 Hz. The step-up transformer has identical secondary windings with a turns ratio $N_s/N_p = 6.4$. The load is highly inductive, and consists of an inductance $L = 0.5$ H in series with a resistance $R = 3\ \Omega$. The steady state load current is 400 A dc. Assuming ideal devices and neglecting the effect of source inductance: (a) calculate the value of the thyristors firing angle (α) that produces the required load current, (b) what is the frequency of the output voltage ripple? (c) determine the peak reverse voltage (PRV), and the rms current ratings of the thyristors, (d) calculate the supply rms current, (e) determine the input power factor, distortion factor, and displacement factor of the supply current, (f) without any external circuitry added, how, and what is the shortest time to reduce the load current from its steady-state value to zero?



Problem 4: (20 marks)

For the circuit shown below, the inverter works at a switching frequency of 10 kHz, and its output V_{ab} is a symmetrical square wave. Assuming ideal semiconductor devices: (a) Derive an expression for the output voltage V_o, (b) determine the voltage and average current ratings of the semiconductor devices.



J.U.S.T.
EE524 Power Electronics
Final Exam 29.1.2001

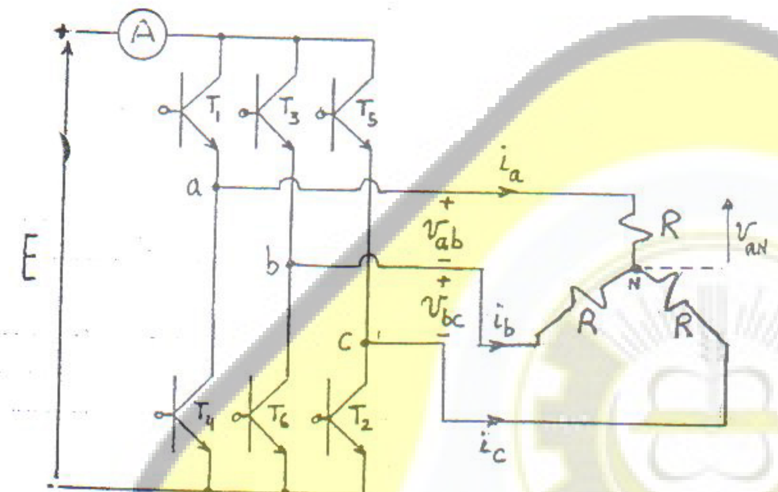
Problem 1 : *(20 pts.)*

The 3-phase inverter circuit shown below is operated with 180° firing. E = 180 V, R = 10 Ω . Assuming ideal components, determine:

(a) the rms load current and the required rms current rating of the transistors.

(b) the average power delivered to the load.

(c) the AC ammeter reading. Assume that the ammeter has an extremely low resistance.



Problem 2 : *(20 pts.)*

A highly inductive dc load requires 10 A at 75 V from a 220 V (rms), 50 Hz supply. Give design details for this requirement using a bi-phase rectifier circuit which employs ideal diodes and transformer. Specify:

(a) devices PRV, and I_{rms} .

(b) transformer KVA .

(c) power factor of the supply current

Problem 3 : *(20 pts.)*

A 3-phase thyristor-controlled bridge rectifier is used to control the magnetic field of a certain load. The load can be modelled as a series combination of L = 0.5 H, and R = 2.5 Ω. The 50 Hz supply has a peak phase voltage of 2000 V. Assuming a steady-state dc load current of 400 A, calculate the firing angle (α) that produces this current and then the power factor of the supply current. How quickly can the load current be brought to zero from the steady-state value? Neglect the effect of source inductance, and drop on the devices.

Problem 4 : *(20 pts.)*

It is desired to use a boost-based DC-DC converter to produce 200 V from a 50 V DC source. The resistive load range varies from 50 Ω to 100 Ω , and the switching frequency is at 50 kHz. Assuming ideal devices, and neglecting circuit losses:

(a) determine the minimum size of output filter inductor required to keep the converter in the continuous conduction mode.

(b) determine the minimum size of output filter capacitor required to keep the maximum peak-to-peak output voltage ripple at 1% of the output voltage.

(c) specify the type and ratings of the power semiconductor devices.

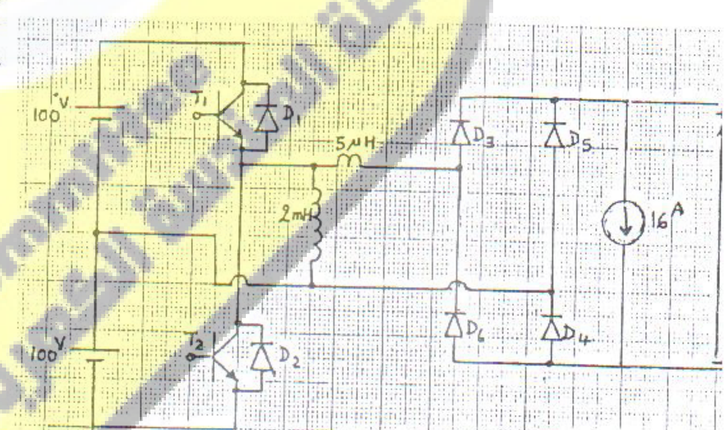
Problem 5 : *(20 pts.)*

For the converter circuit shown below each transistor conducts for 50% of the cycle. The switching frequency is 20 kHz. Assuming ideal semiconductor devices:

(a) derive an expression for the output voltage V_o .

(b) determine the voltage rating of the semiconductor devices.

(c) determine the average current rating of the semiconductor devices.



J.U.S.T.
EE524 Power Electronics
Final Exam 24.1.2000

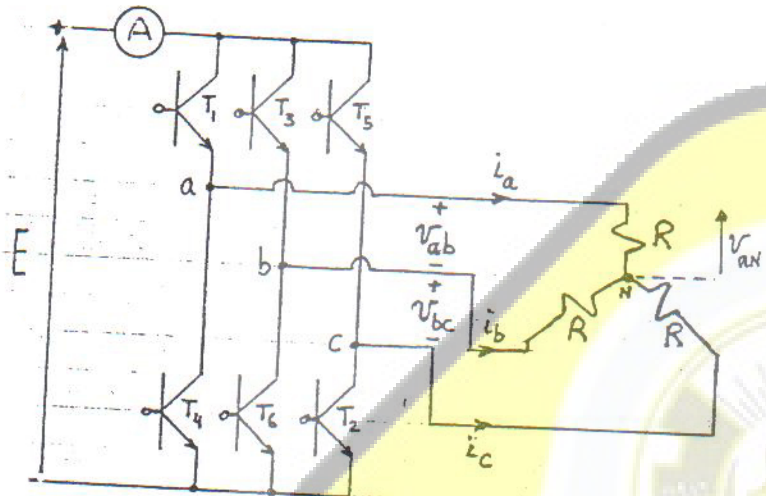
Problem 1 : *(15 pts.)*

The inverter circuit shown below is operated with 180° firing. E = 180 V, R = 10 Ω . Assuming ideal components, determine:

(a) the peak voltage and rms current ratings of the transistors.

(b) load power.

(c) the AC ammeter reading. Assume that the ammeter has an extremely low resistance.



Problem 2 : *(20 pts.)*

A snubber circuit is to be used with a dc chopper as shown below. The following data is given:

Transistor switching frequency is 20 kHz.

Maximum allowable voltage overshoot across transistor is 50 V.

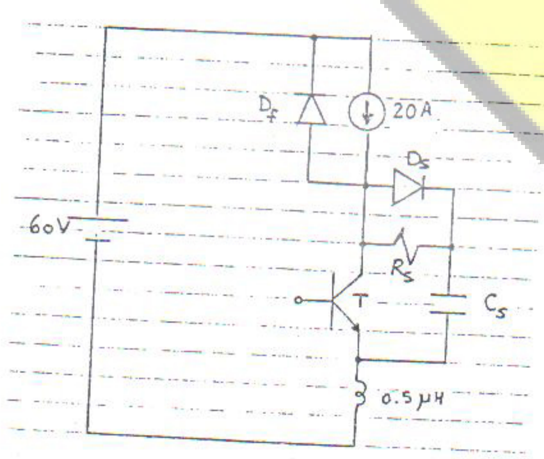
Maximum allowable transistor peak discharge current is 23 A.

Operation duty cycle varies from 90% to 30%.

Determine:

(a) the size of the snubber capacitor and resistor.

(b) the power rating of the snubber resistor.



Problem 3 : *(25 pts.)*

Design a buck-based DC-DC converter according to the following data:

Continuous-conduction mode operation. Input voltage = 240 V.

Output voltage = 150 V with ΔV_o =1.5 V.

Load current varies from 4 A to 2 A.

Switching frequency = 50 kHz.

Inductor current ripple should not exceed 1 A.

The power Mosfet available has $(R_{DS})_{on} = 1\ \Omega$, and its switching rise and fall times are 50 nsec each.

In your design specify only:

(a) size, and ratings of the output filter inductor and capacitor.

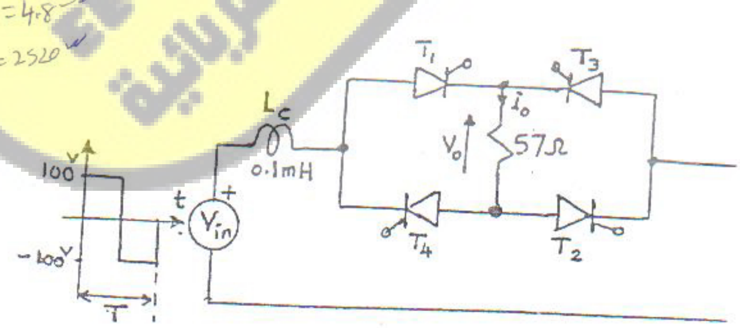
(b) converter efficiency at full load, assuming that the major losses of the circuit are due to the conduction and switching losses of the Mosfet.

Problem 4 : *(20 pts.)*

A 3-phase thyristor-controlled bridge rectifier is used to control the magnetic field of a large electromagnet. The electromagnet can be modelled as a series combination of L = 0.5 H, and R = 2.5 Ω. The 50 Hz supply has a peak phase voltage of 2000 V. Assuming the steady-state magnet current is 400 A, what is the power factor of the supply current ? How quickly can the magnet current be brought to zero from the steady-state value? Neglect circuit losses.

Problem 5 : *(20 pts.)*

For the circuit shown below, the load can be modelled as a 57 Ω resistance. Calculate the mean load voltage when the input voltage is a symmetrical square wave with a peak voltage of 100 V, and a frequency of 50 Hz. Assume α = 30°, and neglect voltage drop on thyristors.



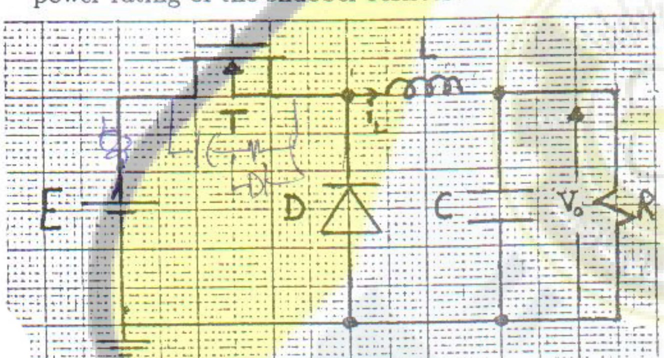
J.U.S.T.
EE532 Power Electronics
Final Exam. 2.6.2001

Problem 1: *(36 pts.)*
The buck dc-dc converter shown has the following parameters:
E = 50 V, Duty ratio = 0.4 , L = 3 mH, C = 20 μF, Switching frequency = 20 kHz, and R = 10 Ω.

(a) At steady-state, assuming ideal components, calculate: the output voltage, the inductor current ripple ΔI_L, and the output voltage ripple ΔV_o.

(b) If the power mosfet used has $(R_{DS})_{on} = 1\ \Omega$, and its switching rise and fall times are 100 nsec and 150 nsec respectively, calculate the converter efficiency assuming that the major losses of the circuit are due to the conduction and switching losses of this mosfet.

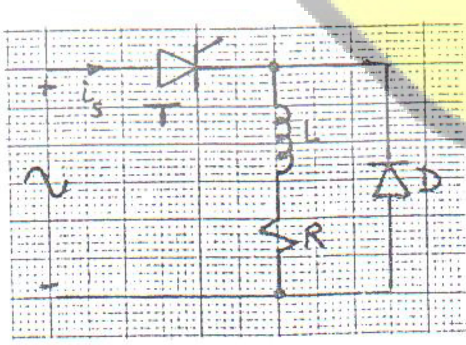
(c) A CRD snubber network is to be used to protect the transistor from dangerous spikes. Show how to connect this network to the existing buck circuit, then calculate the values of snubber capacitor and resistor. Assume that the wires stray inductance is 1 μH, and the maximum allowable voltage overshoot across the transistor is 10 V. What is the maximum peak discharge current through the transistor? What should be the power rating of the snubber resistor?



Problem 2: *(20 pts.)*
The half-wave controlled rectifier circuit shown is to be used to control a highly inductive dc load which requires 10 A at 75 V from a 220 V (rms), 50 Hz source. Assuming ideal thyristor and diode:

(a) Determine devices peak reverse voltage and rms current ratings.

(b) Calculate the power factor of the source current.



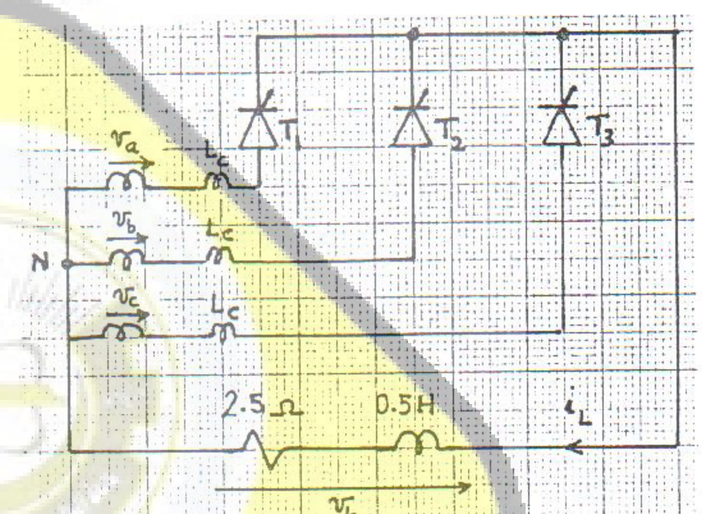
Problem 3: *(24 pts.)*
The 3-phase circuit shown is supplied at a phase voltage of 220 V (rms), 50 Hz. The source inductance is 2 mH per phase. The load is highly inductive and consists of a 2.5 Ω resistance in series with a 0.5 H inductance. The required steady-state dc load current is 40 A.

(a) Derive an expression for the load voltage V_L which includes the effect of the source inductance, then determine the necessary thyristors firing angle α.

(b) Determine the overlap angle γ.

(c) What should be the peak reverse voltage and rms current ratings of the devices?

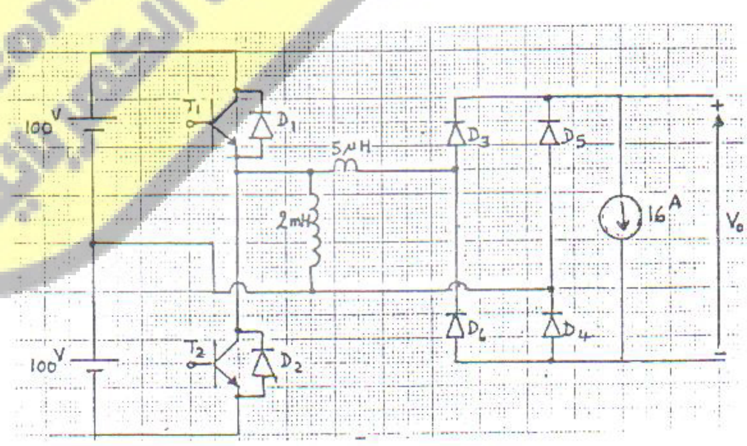
(d) Calculate each phase rms current.



Problem 4: *(20 pts.)*
For the circuit shown, the switching frequency is 20 kHz. Each transistor conducts for 50% of the cycle. Assuming ideal semiconductor devices:

(a) Derive an expression for the output voltage V_o.

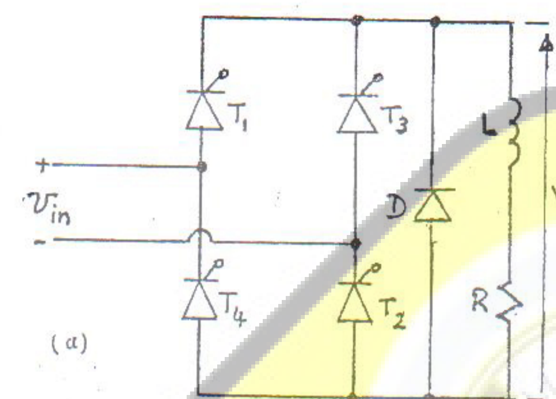
(b) Determine the peak reverse voltage and the average current rating of the semiconductor devices.

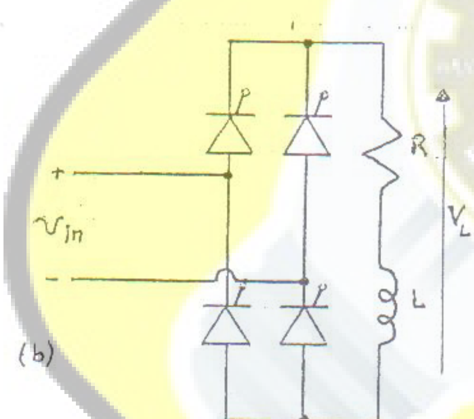


د. محمد المظفر
امتحان تكميلي

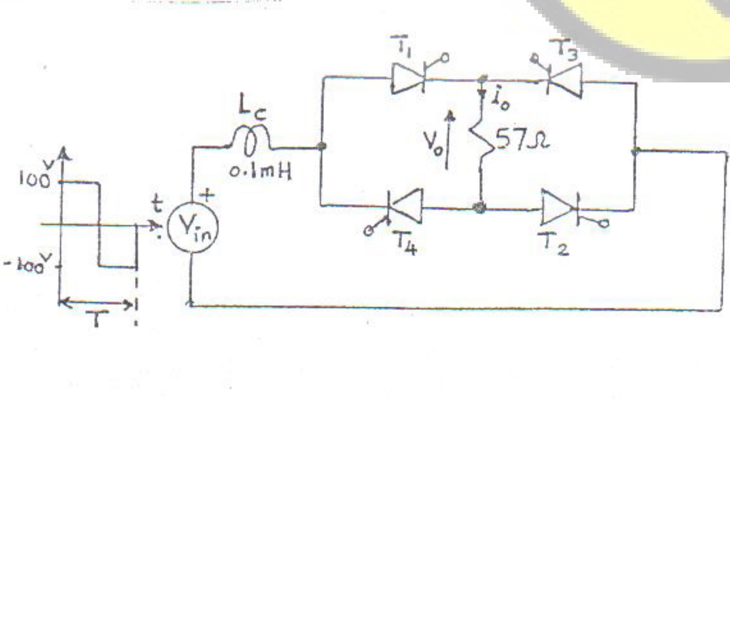
J.U.S.T.
EE532 Power Electronics
Final Exam. 27.01.2003

Problem 1: (*10 pts.*)
For each of the following configurations, determine the power factor of the supply current when $(V_L)_{mean} = 0.7(V_{Lo})_{mean}$, where $(V_{Lo})_{mean}$ is the dc output when the firing angle $\alpha = 0$.
(a) The single-phase half-controlled bridge rectifier.
(b) The single-phase fully-controlled bridge-rectifier.
The supply voltage is sinusoidal, and the devices are assumed ideal.

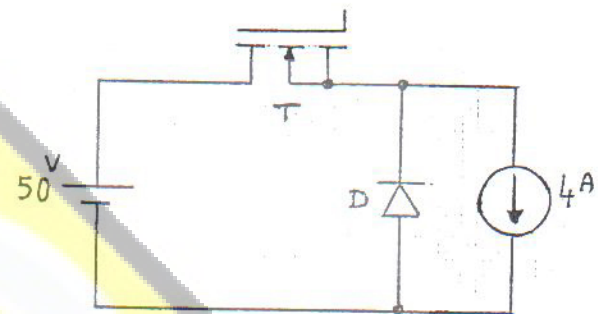




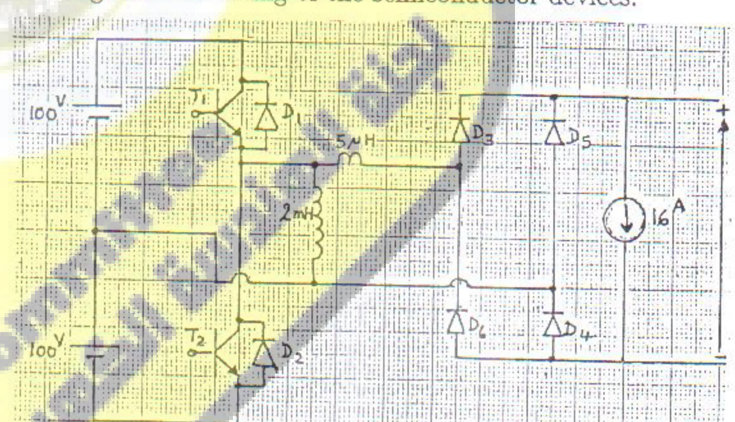
Problem 2: (*10 pts.*)
For the circuit shown, the load can be modeled as 57 Ω resistance. Calculate the mean load voltage v_o when the input voltage is a symmetrical square wave with a peak value of 100 Volts and a frequency of 50 Hz. Assume the firing angle $\alpha = 30°$ and neglect drop on the thyristors.



Problem 3: (*8 pts.*)
For the circuit shown, the following data is given for the power Mosfet:
switching frequency = 50 kHz.
switching rise and fall times = 100 nsec *each*.
$(R_{DS})_{on} = 1.6\ \Omega$.
operation duty cycle = 0.8 .
Determine the efficiency of the circuit, assuming ideal diode.



Problem 4: (*12 pts.*)
For the circuit shown, the switching frequency is 20 kHz. Each transistor conducts for 50% of the cycle. Assuming ideal semiconductor devices:
(a) Derive an expression for the output voltage V_o .
(b) Determine the peak reverse voltage and the average current rating of the semiconductor devices.



J.U.S.T.
EE532 Power Electronics
Final Exam. 27.01.2003

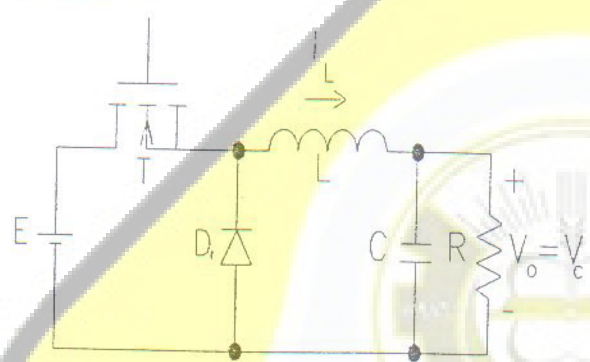
Problem 1: (*10 pts.*)

The buck dc-dc converter shown has the following parameters:

$E = 50$ V, duty ratio $= 0.4$, $L = 3$ mH, $C = 20\ \mu F$, switching frequency $= 20$ kHz, and $R = 10\ \Omega$.

(a) At steady-state, assuming ideal components, calculate: the output voltage, the inductor current ripple ΔI_L, and the output voltage ripple ΔV_o.

(b) A CRD snubber network is to be used to protect the transistor from dangerous spikes. Show how to connect this network to the existing buck circuit, then calculate the values of snubber capacitor and resistor. Assume that the stray inductance is $1\ \mu H$, and the maximum allowable voltage overshoot across the transistor is 10 V. What is the peak discharge current through the transistor? What should be the power rating of the snubber resistor?



Problem 2: (*10 pts.*)

A three-phase thyristor-controlled bridge rectifier is used to control the magnetic field of a large electromagnet. The electromagnet can be modelled as a series combination of $L = 0.5$ H, and $R = 2.5\ \Omega$. The 50 Hz supply has a peak phase voltage of 2000 V. Assuming the steady state magnet current is 400 A DC, and the devices are ideal:

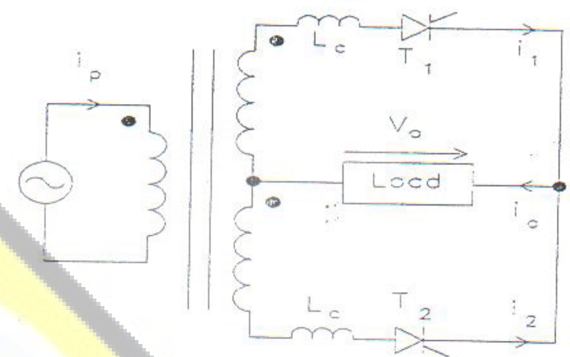
(a) What is the firing angle α that results in this value of current?

(b) Calculate the power factor of the supply current.

(c) Without any external circuitry added, how, and what is the shortest time to reduce the load current from its steady-state value to zero?

Problem 3: (*8 pts.*)

For the bi-phase converter circuit shown, the supply voltage is sinusoidal and the load is highly inductive. Derive an expression for the overlap angle assuming ideal devices. If this converter has an overlap angle of 20° with a given load current at zero firing angle. Determine the overlap angle when the firing delay angle is 60° with the load current being unchanged.



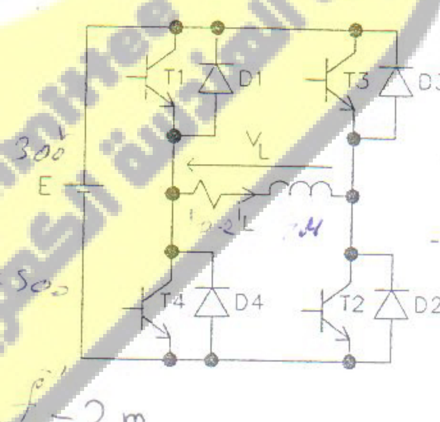
Problem 4: (*12 pts.*)

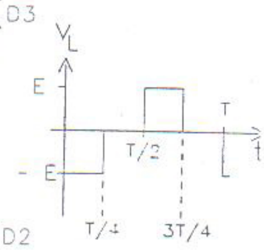
For the inverter shown, the load is modelled as a resistance of $10\ \Omega$ in series with an inductance of $2\ \mu H$. The supply voltage is 300 V, and the switching frequency is 500 Hz. The load voltage is as shown. Assuming ideal devices and that $I_L(0) = 0$ A:

(a) Calculate and plot on the same time axis with the load voltage, and with the necessary values clearly marked, the load current for the first cycle of operation.

(b) Specify the devices that are conducting for each region.

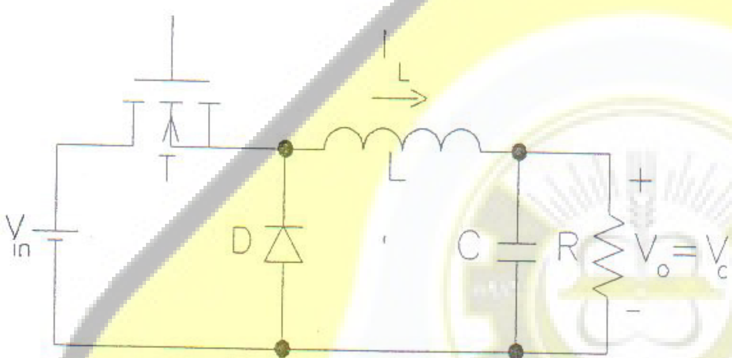
(c) Determine the mean power delivered to the load, and the mean power returned to the source.



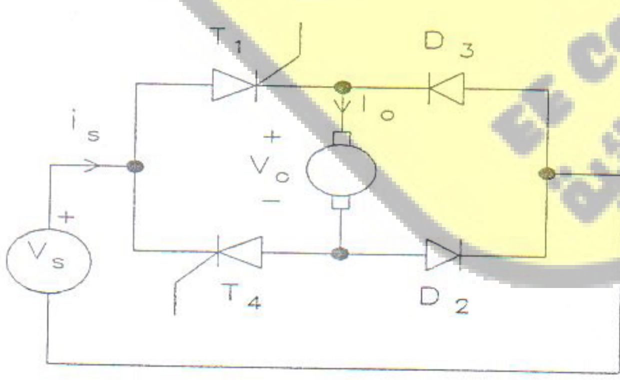


J. U. S. T.
EE 532 Power Electronics
Final Exam. 16.06.2004

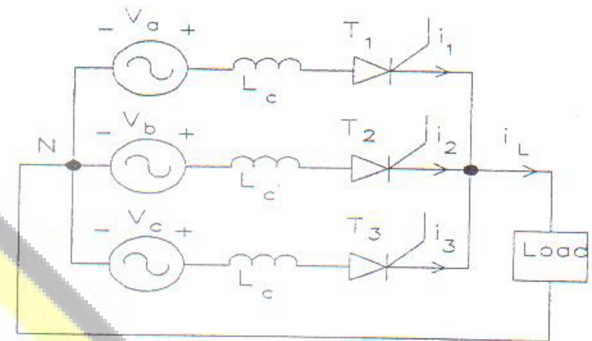
Problem 1 : (*30 pts.*)
A buck-based DC-DC converter is to be built using the following specifications: Continuous-conduction mode. Input voltage = 50 V, Output voltage = 20 V with ΔV_o =60 mV. Load current varies from $(I_o)_{\max}$ =5 A to $(I_o)_{\min}$ =1 A. Switching frequency = 20 kHz. Inductor current ripple should not exceed 0.2 A. (a) determine the size, and voltage and current ratings of the output filter inductor and capacitor, (b) What should be voltage and rms current ratings of the semiconductor devices? (c) If the power Mosfet to be used has $(R_{DS})_{on}$ = 1 Ω, and its switching rise and fall times are 100 nsec each, calculate the conduction and switching losses of this Mosfet, (d) If you want to protect the transistor from dangerous spikes using a CRD snubber circuit, show how to connect this snubber network to the existing buck circuit. (i.e. redraw the buck circuit with the snubber connected)



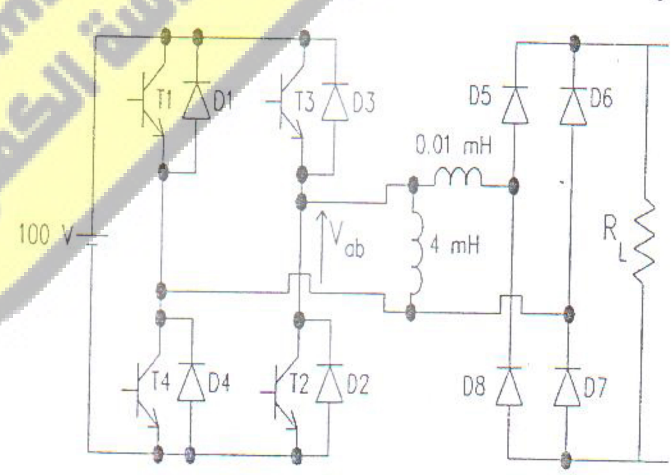
Problem 2: (*20 pts.*)
The circuit shown is supplied at 220 V (rms), 50 Hz. The firing angle is 66°, and the load current is level at 10 A . Assuming ideal devices determine: (a) the average output voltage V_o , (b) the rms value of the supply current i_S , (c) the input power factor, distortion factor, and displacement factor of the supply current.



Problem 3: (*25 pts.*)
The 3-phase circuit shown is supplied at a voltage of 220 V (rms), 50 Hz. The source induc is L_C = 2 mH. The load is highly inductive anc sists of a 2.5 Ω resistance in series with a 0.5 H i tance. The required steady-state dc load current A. Assuming ideal thyristors: (a) Derive an expre for the load voltage V_L which includes the effe the source inductance, then determine the nece thyristors firing angle α , (b) Determine the ov angle γ .



Problem 4: (*25 pts.*)
For the circuit shown, the inverter works at a sw ing frequency of 10 kHz, and its output V_{ab} is a q square wave with an on-period of (0.5). The load r tor R_L = 12 Ω. Assuming ideal devices, determine: the average load voltage, (b) the peak voltage ra of the transistors while not conducting, (c) the PI the inverter diodes, (d) the PIV of the rectifier dio (e) the average current rating of the transistors, (f) average current rating of the inverter diodes, (g) average current rating of the rectifier diodes.



J.U.S.T.
EE532 Power Electronics
Final Exam. 27.01.2003

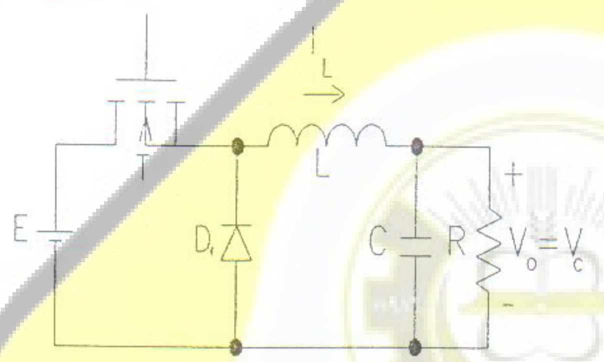
Problem 1: *(10 pts.)*

The buck dc-dc converter shown has the following parameters:

E = 50 V, duty ratio = 0.4 , L = 3 mH, C = 20 μF, switching frequency = 20 kHz, and R = 10 Ω.

(a) At steady-state, assuming ideal components, calculate: the output voltage, the inductor current ripple ΔI_L, and the output voltage ripple ΔV_o.

(b) A CRD snubber network is to be used to protect the transistor from dangerous spikes. Show how to connect this network to the existing buck circuit, then calculate the values of snubber capacitor and resistor. Assume that the stray inductance is 1 μH, and the maximum allowable voltage overshoot across the transistor is 10 V. What is the peak discharge current through the transistor? What should be the power rating of the snubber resistor?



Problem 2: *(10 pts.)*

A three-phase thyristor-controlled bridge rectifier is used to control the magnetic field of a large electromagnet. The electromagnet can be modelled as a series combination of L = 0.5 H, and R = 2.5 Ω . The 50 Hz supply has a peak phase voltage of 2000 V. Assuming the steady state magnet current is 400 A DC, and the devices are ideal:

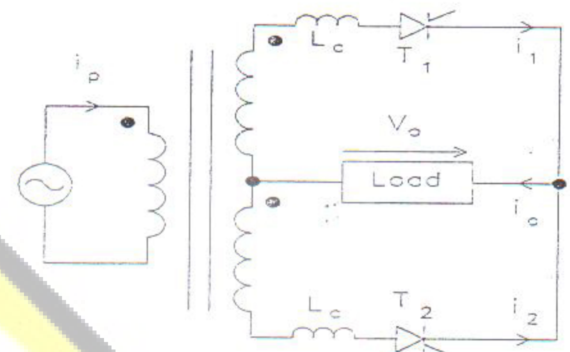
(a) What is the firing angle α that results in this value of current?

(b) Calculate the power factor of the supply current.

(c) Without any external circuitry added, how, and what is the shortest time to reduce the load current from its steady-state value to zero?

Problem 3: *(8 pts.)*

For the bi-phase converter circuit shown, the supply voltage is sinusoidal and the load is highly inductive. Derive an expression for the overlap angle assuming ideal devices. If this converter has an overlap angle of 20° with a given load current at zero firing angle . Determine the overlap angle when the firing delay angle is 60° with the load current being unchanged.



Problem 4: *(12 pts.)*

For the inverter shown , the load is modelled as a resistance of 10 Ω in series with an inductance of 2 μH. The supply voltage is 300 V, and the switching frequency is 500 Hz. The load voltage is as shown. Assuming ideal devices and that $I_L(0) = 0$ A :

(a) Calculate and plot on the same time axis with the load voltage, and with the necessary values clearly marked, the load current for the first cycle of operation.

(b) Specify the devices that are conducting for each region.

(c) Determine the mean power delivered to the load, and the mean power returned to the source.