End Semester Examination

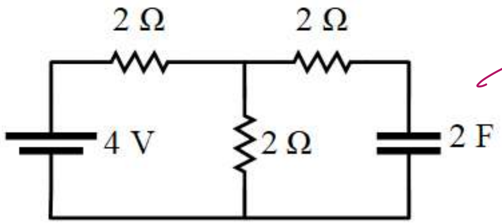
End Sem Exam for EE113

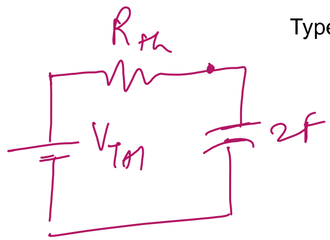
---

1. 1. What is the time constant of this circuit? **(1 mark)**

Marks: 1

Type: IMAGE_ANSWER_TYPE





$R_{th} = 2||2 + 2 = 3\Omega$,

$C = 2F$

$\Rightarrow \tau = RC = 6s$

Rubrics:

Comments:

---

2. 2. For the circuit shown below write the expression for power dissipated in 'R' as a function of supply voltage v_s, R_s and R **(0.5 mark)**
   a. At what value of 'R' power supplied by the source is maximum? if v_s=10 V and R_s=10 Ω what is the value of this power? **(0.5 mark)**
   b. Instead if R=5 Ω and 'R_s' is variable, what is the its value for which power transferred to 'R' is maximum? **(1 mark)**

Marks: 2

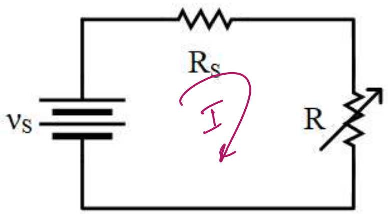
Type: IMAGE_ANSWER_TYPE

$P_R = I^2 R = \left(\frac{V_s}{R_s+R}\right)^2 \cdot R = \frac{V_s^2 \cdot R}{(R_s+R)^2}$

(a) $P_{source} = \left(\frac{V_s}{R_s+R}\right)^2 = \left(\frac{V_s}{10+R}\right)^2$

maximum when $\underline{R = 0}$,

$P_{source} = \left(\frac{10}{10}\right)^2 = 1W$



(b) $P_R = \left(\frac{V_s}{R_s+R}\right)^2 \cdot R = \left(\frac{V_s}{R_s+5}\right)^2 \cdot 5$,

This is maximum when $R_s = \underline{0}$

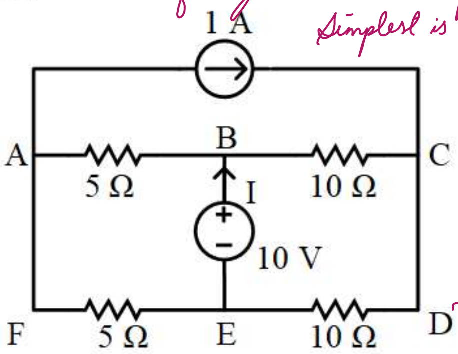
Rubrics:

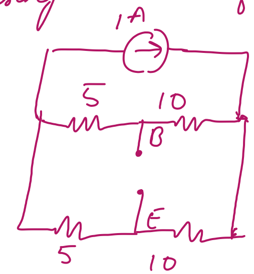
Comments:

3. 3. Determine the current flowing through the voltage source of this circuit. **(3 mark)** Number of ways to solve this problem: Simplest is using Thevenin's Equivalent

Marks: 3

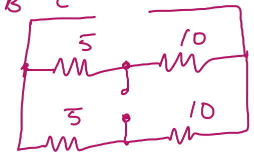
Type: IMAGE_ANSWER_TYPE



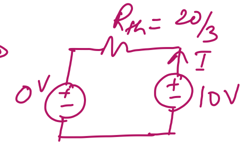


$V_{TH} = V_B - V_E = 0$

for R_{th}:



$\Rightarrow R_{th} = (5+5)\|(10+10) = 10\|20 = \frac{20}{3}$



$\Rightarrow I = \frac{10}{(20/3)} = \frac{3}{2} = 1.5\,A$

Rubrics:

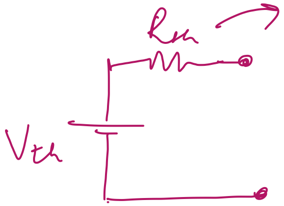
Comments:

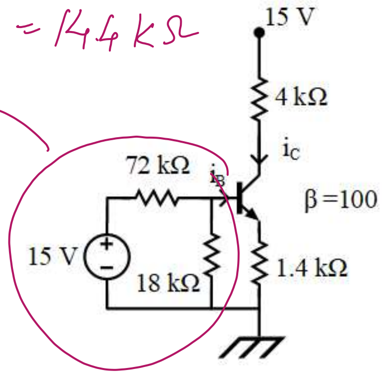
4. 4. Determine the value of i_B (in μA) and i_C (in mA). Assume V_{BE}=0.7 V **(3 mark)**

Marks: 3

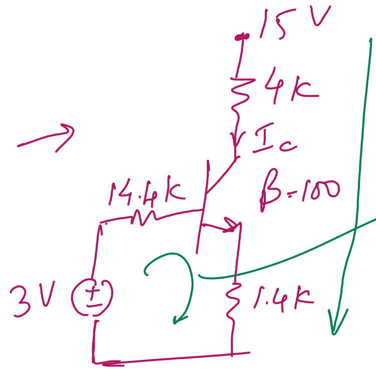
Type: IMAGE_ANSWER_TYPE

$R_{th} \rightarrow R_{th} = 72\|18 = 14.4\,k\Omega$





$V_{th} = \left(\frac{18}{72+18}\right)15 = 3V$



$I_C = 100 I_B$, $I_E = I_C + I_B = 101 I_B$

$3 - (14.4)(I_B) - 0.7 - (1.4)(101 I_B) = 0$

mA

$\therefore 2.3 = 14.4 I_B + 141.4 I_B$

$\therefore I_B = 0.01476\,mA = 14.76\,\mu A$

So $I_C = \beta I_B = 14.76 \times 100\,\mu A = 1.48\,mA$

Rubrics:

Comments:

5.

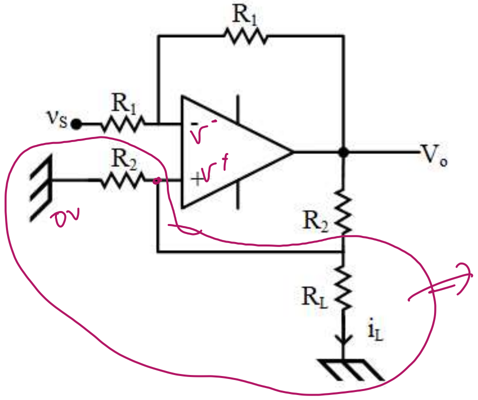
5. Assume that OP-AMP in the circuit is working in the linear range

Marks: 2

Type: IMAGE_ANSWER_TYPE

a. Obtain V_o in terms of v_S. **(1 mark)**

b. Obtain i_L. **(1 mark)**



$$\frac{V_s - v^-}{R_1} = \frac{v^- - V_o}{R_1} \Rightarrow V_s - v^- = v^- - V_o \quad \text{— ①}$$

$$\Rightarrow V_o = 2v^- - V_s$$

These two are in parallel $\Rightarrow R_{eq} = \frac{R_2 \cdot R_L}{R_2 + R_L}$

$$\therefore v^+ = \frac{R_{eq}}{R_{eq} + R_2} \cdot V_o \rightarrow ②$$

using ① and ② and $v^- = v^+ \Rightarrow V_o = 2\left(\frac{R_{eq}}{R_{eq}+R_2}\right)V_o - V_s$

$$\therefore V_o\left(1 - \frac{2R_{eq}}{R_{eq}+R_L}\right) = -V_s$$

$$\therefore V_o\left(\frac{R_L - R_{eq}}{R_{eq}+R_L}\right) = -V_s$$

$$\Rightarrow \boxed{V_o = -\left(\frac{R_{eq}+R_L}{R_L - R_{eq}}\right)V_s}$$

Rubrics:

Comments:

$$i_L = \frac{v^+}{R_L} = \frac{R_{eq} \cdot V_o}{(R_{eq}+R_2)}$$

6.

6. Stepper motor (rotates in steps) has 4 coils. For motor to rotate properly coil 1 and 2 must always be in opposite states, so are coils 3 and 4 (If coil 1 is ON, coil 2 is OFF). It is desired to control this motor using 2-bit synchronous counter. For clockwise rotation the required sequences are 11, 10, 00 & 01, and for counter clockwise rotation it is 11, 01, 00 & 10. Direction of rotation can be reversed using a control bit D (D=0 for clockwise and D=1 for counter-clockwise rotation)
Bit A (given in table below) is used to turn ON/OFF coil 1 and 2 while B is used to turn ON/OFF coil 3 and 4.
Design the synchronous counter. **(5 mark)**

Marks: 5

Type: IMAGE_ANSWER_TYPE

Present States			Next State		J_B	K_B	J_A	K_A
D	B	A	B	A				
0	0	0	0	1	0	x	1	x
0	0	1	1	1	1	x	x	0
0	1	0	0	0	x	1	0	x
0	1	1	1	0	x	0	x	1
1	0	0	1	0	1	x	0	x
1	0	1	0	0	0	x	x	1
1	1	0	1	1	x	0	1	x
1	1	1	0	1	x	1	x	0

	$\bar{D}$	D
$\bar{B}\bar{A}$	0	1
$\bar{B}A$	1	0
BA	x	x
$B\bar{A}$	x	x

$J_B = D \oplus A$

$\bar{D}$	D
x	x
x	x
0	1
1	0

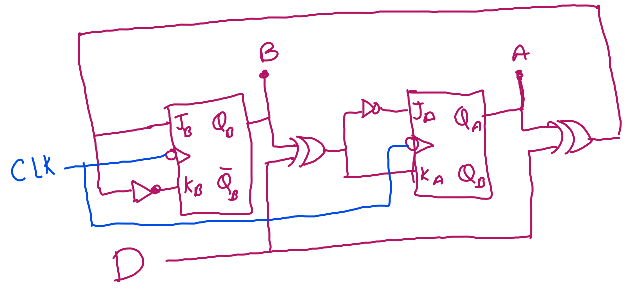
$K_B = \overline{D \oplus A}$

$\bar{D}$	D
1	0
x	x
x	x
0	1

$J_A = \overline{D \oplus B}$

$\bar{D}$	D
x	x
0	1
1	0
x	x

$K_A = D \oplus B$



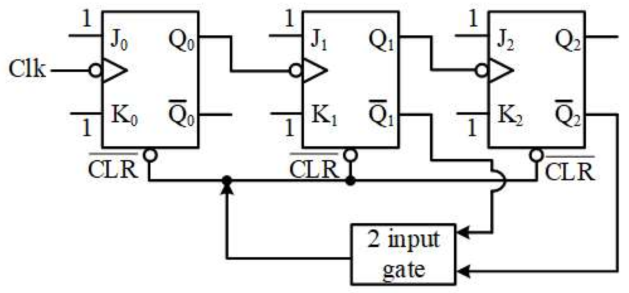
Rubrics: Draw the k-map for the above table

Comments:

7. 7. In the modulo-6 ripple counter shown in figure the output through 2-input gate is used to clear the J-K flip-flop. Name this 2 input gate. Assume J=1 and K=1 for all Flip-Flops **(1 mark)**

Marks: 1

Type: IMAGE_ANSWER_TYPE

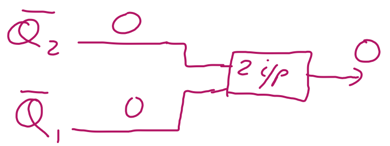


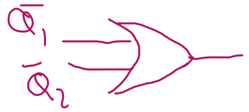
$\bar{Q}_2$	$\bar{Q}_1$	$\overline{CLR}$
1	1	1
1	0	1
0	1	1
0	0	0

modulo 6 means once the o/p state reaches 110 it is reset to 000. Also the J-K FF's are active low hence when the o/p of 2i/p gate is 0 it will be reset.

Q_2	Q_1	Q_0
1	1	0
0	0	0

$\Rightarrow$





$\therefore$ 2 i/p gate is OR gate

Rubrics:

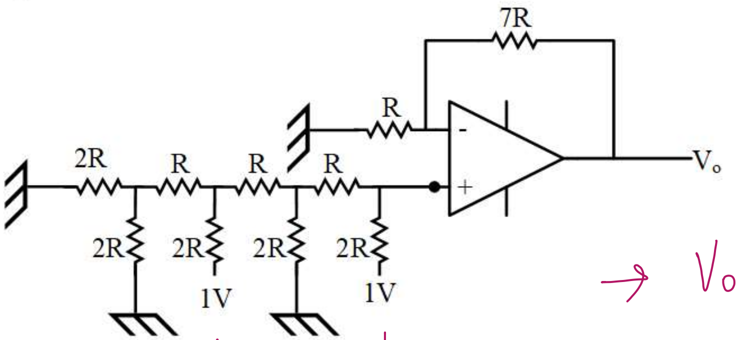
Comments:

---

8. 8. Determine the output voltage V_o of a 4 bit DAC shown below. **(3 mark)**

Marks: 3

Type: IMAGE_ANSWER_TYPE



$\frac{1}{8}V$ $\frac{1}{2}V$

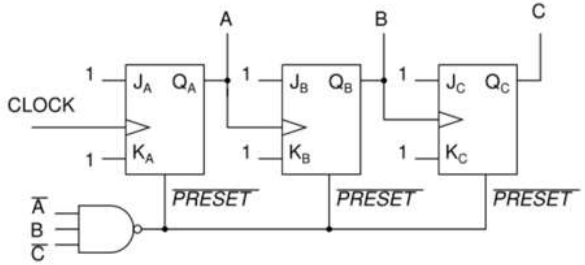
$\rightarrow V_o = \left(\frac{1}{8} + \frac{1}{2}\right) \times 8 = \frac{5}{8} \times 8 = \underline{\underline{5V}}$

Rubrics: Eq.:

Comments:

9.

9. The circuit diagram of a Mod-N Ripple counter is shown below. The counter uses positive edge triggered JK flip flops. The JK flip-flops also have active-low $\overline{PRESET}$ inputs, i.e. when the $\overline{PRESET}$ = '0', the Q output of the corresponding JK flip-flop will be '1' irrespective of the Clock.



Answer the following:

a) Write the sequence of stable states (CBA) of the above counter. You may assume the initial state (CBA) of the counter to be '000'. Based on the sequence of stable states, state the value of N of this Mod-N counter, where N is the number of stable states. **(2 mark)**

b) Sketch the A, B, and C outputs of the Ripple counter with respect to the Clock for at least 10 Clock periods. **(3 mark)**

Marks: 5

Type: IMAGE_ANSWER_TYPE

(Explanation - This is a Ripple counter using +ve edge-triggered JK flip-flops, with the QA output connected as Clock of Flip-flop B, and QB output connected as the Clock input of the C flip-flop. This will be a down counter).

a) Sequence of states (CBA) will be: 111, 110, 101, 100, 011, 111,... Value of N: 5

(it is a mod-5 counter) (Marks: 2)

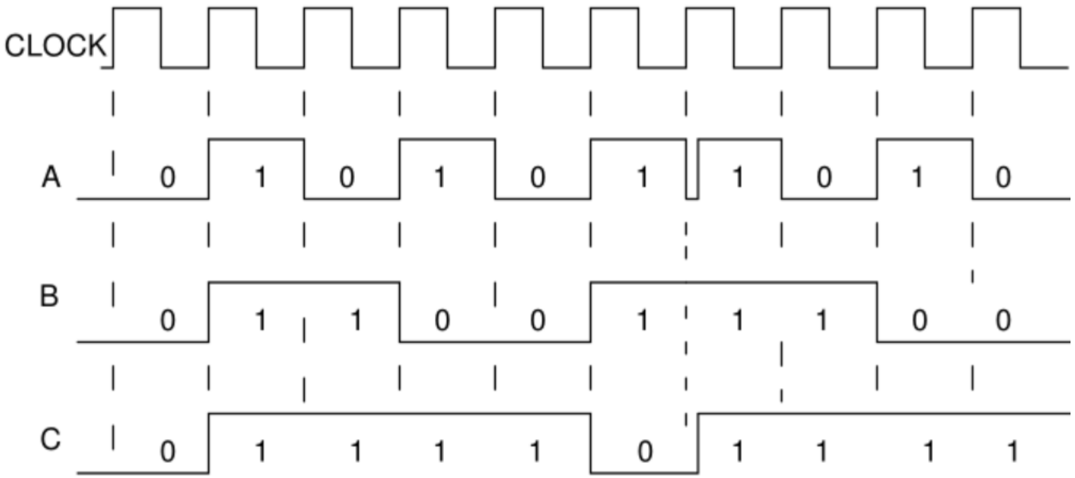
b) Clock periods.

(Note: It is ok, even if the glitch in waveform A is not shown. Students were asked to start from CBA: 000. So, they should start from '000' and show 10 clock

(Marks: 3)

(Total Marks :

)



$x(t) = 1$ for $t \in [-\frac{1}{2}, \frac{1}{2}]$

$$\langle x(t), \exp(j2\pi f t)\rangle = \int_{-\frac{1}{2}}^{\frac{1}{2}} x(t)\exp(-j\,2\pi f t)\,dt$$

$$= \left[\frac{e^{-j2\pi f t}}{-j2\pi f}\right]_{-1/2}^{1/2} = \frac{\sin(2\pi f/2)}{\pi f}$$

$$\therefore \quad X(f) = \frac{\sin(\pi f)}{\pi f}$$

$-X(f)$ maximum at $f = \frac{3}{2}$ and $f = -\frac{3}{2}$ //

maximum value is $\frac{2}{3\pi}$ //

Marks: 5

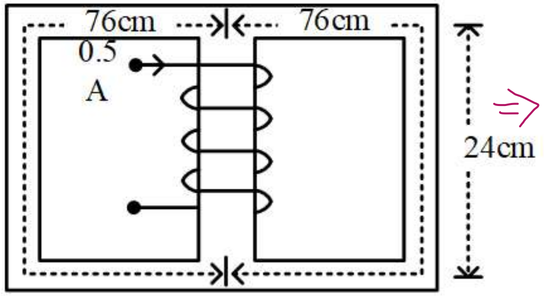
Type: IMAGE_ANSWER_TYPE

10. The frequency content of a signal $x(t)$ at a frequency of f Hz can be computed as $X(f) = \langle x(t), \exp(j\,2\,\pi\,f\,t)\rangle$. For the signal $x(t) = 1$ in $-0.5 \le t \le 0.5$ and zero everywhere else,, find the set of frequencies at which $-X(f)$ (i.e. negative of $X(f)$) is the maximum. **(5 mark)**

11. 11. In the magnetic circuit shown in figure, the cross sectional area of the central limb is 12 cm^2 and the cross sectional area of rest of the core is 6 cm^2. A coil having 750 turns and carrying a current of 0.5 A produces a flux of 5 mwb in the central limb. Find μ_r of the core for this operating condition. Also what could be the reason for having the cross sectional area of the central limb at twice the other limbs. **(3 mark)**

Marks: 3

Type: IMAGE_ANSWER_TYPE

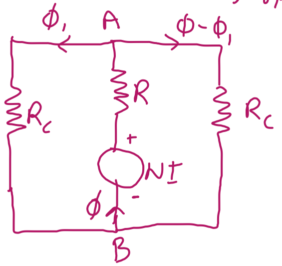


$\phi = 5\,mwb \quad N = 750 \quad I = 0.5A \quad A = 12cm^2$

$A_c = 6cm^2 \qquad R = \frac{24\times10^{-2}}{\mu_r\mu_0\, 12\times10^{-4}} = \frac{200}{\mu_r\mu_0}$

$R_c = \frac{76\times10^{-2}}{\mu_r\mu_0\times6\times10^{-4}} = \frac{1266.67}{\mu_r\mu_0}$

$\Rightarrow$



$MMF_{AB} = NI - \phi R = 375 - \frac{200\times5m}{\mu_r\mu_0}$

Also $\left.\begin{array}{l} MMF_{AB} = \phi_1 R_c \\ MMF_{AB} = (\phi-\phi_1)R_c \end{array}\right\} \Rightarrow \phi_1 = \frac{\phi}{2} = 2.5mwb$

Rubrics: $MMF_{AB} = 375 - \frac{1}{\mu_r\mu_0} = \frac{2.5m\times1126.67}{\mu_r\mu_0} \Rightarrow 375 = \frac{4.16675}{\mu_r\mu_0} \quad \therefore \mu_r = \underline{8842}$

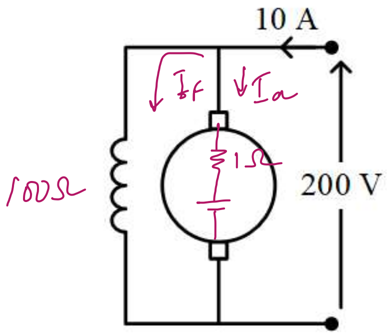
Comments:

To maintain the same peak flux density througout the core we keep the central limb C.S.A as double that of rest of the limbs.

12. 12. A DC shunt motor having a field resistance of 100 Ω and an armature resistance of 1 Ω is connected to 200V supply and it draws 10A of current from the source. Determine the following:

Marks: 4

Type: IMAGE_ANSWER_TYPE



$I_f = \frac{200}{100} = 2A, \Rightarrow I_a = 10 - 2 = \underline{8A}$

a. Field copper loss in watts. **(1 mark)**
b. Armature copper loss in watts. **(1 mark)**
c. Assume that there are no other losses (except as mentioned in a & b), determine the efficiency of the motor. **(2 mark)**

$I_f^2 \times R_f = 2^2 \times 100 = \underline{400\,W}$

$I_a^2 \cdot R_a = 8^2 \times 1 = \underline{64W}$

$\eta = \frac{Output}{input} = \frac{input - losses}{input} = \frac{(200\times10) - 464}{200\times10}$

$= 0.768$

$\Rightarrow \underline{76.8\%}$

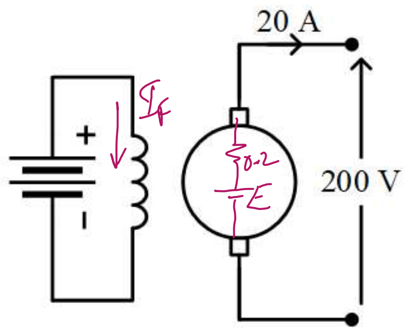
Rubrics:

Comments:

13. 13. A separately excited generator is supplying a current of 20 A at 200V. The armature resistance is 0.2 Ω

Marks: 3

Type: IMAGE_ANSWER_TYPE



$E = 200 + I_a R_a = 200 + 20 \times 0.2 = \underline{204\,V}$.

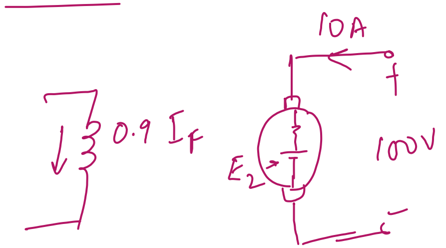
$E = K\Phi_1 N_1 \Rightarrow K = \dfrac{204}{\Phi_1 N_1}$ (for this mode)

a. Determine the induced voltage (in volts) in the armature. **(1 mark)** (204V)

Assume that the same machine is now connected to 100V source (running as motor) and its field current is reduced by 10%. For this operating condition the armature current is 10 A.

a) Determine its back emf in volts. **(1 mark)** (98V)

b) Ratio of speed of rotation as generator to speed of rotation of motor. **(1 mark)** (Ans: 1.87)



$E_2 = 100 - 10 \times 0.2$
$= \underline{98\,V}$.

Now, $\dfrac{E_2}{E_1} = \dfrac{\Phi_2 N_2}{\Phi_1 N_1} \Rightarrow \dfrac{N_1}{N_2} = \dfrac{E_1}{E_2} \times \dfrac{\Phi_2}{\Phi_1}$

$= \dfrac{204}{98} \times \dfrac{0.9\Phi_1}{\Phi_1}$

$= 1.87$

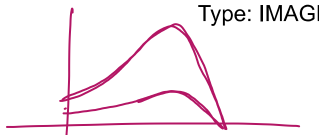
Rubrics:

Comments:

14. 14. During the lecture You were told that 3 phase induction motor draws 6-8 times the rated current during starting when it is started direct on-line (rated voltage at rated frequency is applied.) State whether this current would either increase or decrease with one-line justification, if it started with

Marks: 3

Type: IMAGE_ANSWER_TYPE



$E = 4.44 \cdot \Phi_m \cdot N \cdot f$.

a) 50% of rated voltage at rated frequency. **(1 mark)**

decrease because flux intensity is reduced.

b) 50% of rated voltage at 50% of rated frequency. **(1 mark)**

decrease, although the flux intensity is same, the rate at which the flux cuts the rotor bars is reduced. ∴ $\frac{d\Phi}{dt}$ is small as compared to rated frequency case

State the effect of increasing the rotor inertia on the duration of this high current and give justification. **(1 mark)**

NOTE: No credit will be given if the justification is wrong.

higher inertia → longer duration.

Rubrics:

Comments:

15. 15. The speed of a 3 phase 400 V, 50Hz induction motor when fed from an inverter is 855 rpm. The corresponding frequency of the stator current is 30 Hz. Therefore

Marks: 4

Type: IMAGE_ANSWER_TYPE

a. Number of poles of the motor is 4. **(1 mark)**
b. Speed (in rpm) of the rotor field with respect to stator is 900rpm. **(0.5 mark)**
c. Speed (in rpm) of the rotor field with respect to rotor is 45rpm. **(0.5 mark)**
d. Frequency of rotor current is 1.5 (in Hz). **(0.5 mark)**
e. Approximate value of the applied voltage in volts to the stator is 240. **(1 mark)**
f. Percentage slip is 5. **(0.5 mark)**

$\frac{120 \times 30}{P} \approx 855$ rpm $\Rightarrow P = 4$ poles ($N_s = 900$ rpm)

Same as $N_s = 900$ rpm

$N_s - N = 900 - 855 = 45$ rpm

$= sf = \left(\frac{N_s - N}{N_s}\right) \times 30 = 0.05 \times 30 = 1.5$ Hz

$V_2 = \frac{V_1 f_2}{f_1} = \frac{400 \times 30}{50} = 240$ V

$S = \left(\frac{N_s - N}{N_s}\right) = 0.05 \Rightarrow 5\%$

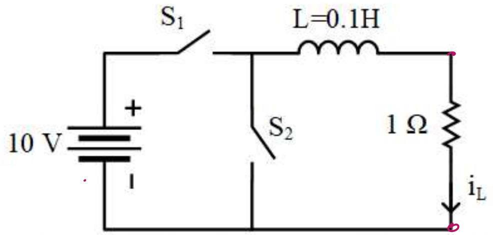
Rubrics:

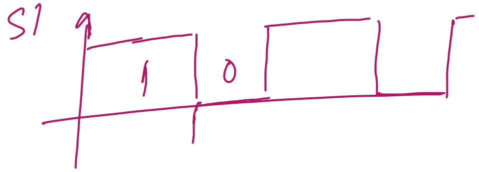
Comments:

16. 16. In the circuit shown below S_1 and S_2 are ~~periodically~~ switched ON and OFF.

Marks: 5

Type: IMAGE_ANSWER_TYPE





When S_1 is ON, S_2 is OFF, and vice-versa. The period for which S_1 is ON in one cycle is 1 msec while the period for which S_2 is ON is 0.5 msec. Assume that there is always some finite current flowing through L. Determine

a. Average value of inductor current. **(2 mark)**
b. Assume that S_1, S_2 and L are ideal. Average power (in watts) supplied by the source ______. **(2 mark)**
c. Average value of the current supplied by the source ______ (in Amp). **(1 mark)**

$D = \frac{2}{3}$, $\therefore V_o = D V_{in} = \frac{20}{3}$ V

$I_{L,average} = I_{load,average} = \frac{V_o}{R} = \frac{20}{3}$ A

$P_{Loss} = P_{output} = I_{load}^2 \cdot R = \left(\frac{20}{3}\right)^2 \times 1 = \frac{400}{9}$

$I_{in,average}$: $P_{in} = P_{output} \Rightarrow I_{in} = \frac{P_{output}}{V_{in}} = \frac{400}{9 \times 10} = \frac{40}{9}$ A

Rubrics:

Comments:

17. 17. Figure X shows the DC- DC converter used to operate the DC machine which has negligible r_a. S_1 and S_2 are controllable switches and they are never turned ON simultaneously. If S_1 is turned ON/OFF (S_2 is permanently OFF) DC-DC converter operates like a buck converter as shown in Figure A. During a particular operating condition back emf of the motor is found to be 8 V and there is always some inductor current flowing. Determine the duty cycle of S_1. **(1 mark)**

At this operating condition S_1 is made permanently OFF and S_2 is turned ON/OFF (DC-DC converter now works as boost converter with 'E_b' as source and 12V as the output as shown in Figure B), Determine the duty cycle of S_2 for this operating condition. **(1 mark)**

What is the advantage of operating this circuit in this manner? (Explain in one short sentence) **(1 mark)**

Marks: 3

Type: IMAGE_ANSWER_TYPE

$\rightarrow V_{in} = 12V, \; V_{out} = 8V.$

$D = \frac{8}{12} = \frac{2}{3}$

$\rightarrow E_b = 8V$ (this operating condition only)

For this mode, E_b is input and V_{in} is output voltage

$\therefore \; 12 = \frac{8}{(1-D)}$

$\Rightarrow 12 - 12D = 8 \Rightarrow D = \frac{4}{12} = \frac{1}{3}$

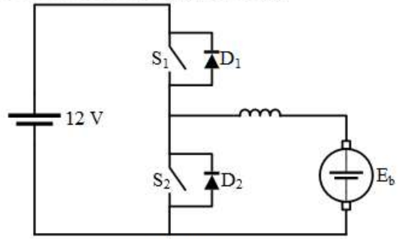


Figure X

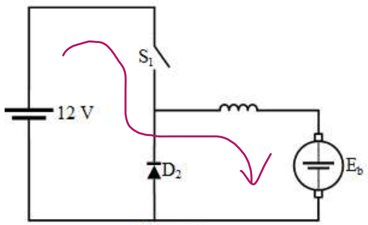


Figure A

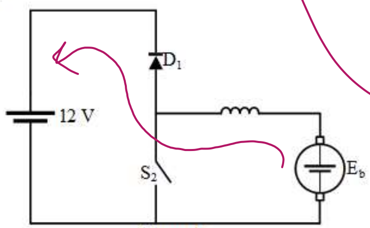


Figure B

$\rightarrow$ The stored Energy in the motor inertia can be fed back to the source during braking. "regenerative braking"

Rubrics:

Comments:

---

18. 18. Two transformers are designed for same power and voltage ratings. One is designed for 50Hz and another one is designed for 5000Hz. Comment on the size of these two transformers with justification. **(1 mark)**

Marks: 1

Type: IMAGE_ANSWER_TYPE

50 Hz size >> 5000 Hz Transformer

$E = 4.44\, \phi_m \cdot f \cdot T \Rightarrow$ as the frequency increases, Number of turns can be reduced! size reduces

$E = 4.44\, \overline{B_m \cdot A_c} \cdot f T \rightarrow$ or core size can be reduced with higher frequency.

Rubrics:

Comments:

---

19. 19. The three coils of an induction motor are Coil-A, Coils-B, and Coil-C and these coils are displaced in space by 120°. These three coils are excited by current i_a, i_b & i_c, respectively. These currents are given by

$$i_a = I_m \sin(\omega_s t), \quad i_b = I_m \sin\left(\omega_s t - \frac{2\pi}{3}\right), \quad \text{and} \quad i_c = I_m \sin\left(\omega_s t - \frac{4\pi}{3}\right),$$

where $\omega_s = 2\pi f$. With this, the induction motor rotates in clockwise direction. Suggest a method to change the direction of motor rotation. **(2 marks)**

Marks: 2

Type: IMAGE_ANSWER_TYPE

We can excite the coils with following currents:

Coil A → i_a	Coil A → i_a	i_b	i_c
Coil B → i_b	Coil B → i_c	i_a	i_b
Coil C → i_c	Coil C → i_b	i_c	i_a
clockwise	counter-clockwise		

Rubrics:

Comments:

---

20. 20. The output of a buck-convertor is regulated to 5 V (using some closed-loop control). A fixed resistor of value 4 ohm is connected across the output. The converter is operating at the switching frequency of 50000Hz. Assume that there is some finite current in the inductor all the time and the switches are ideal.

a. Sketch and label the waveform of voltage across the inductor when the input voltage is 10 V. **(1 mark)**

b. Sketch and label the waveform of voltage across the inductor when the input voltage is 15 V. **(1 mark)**

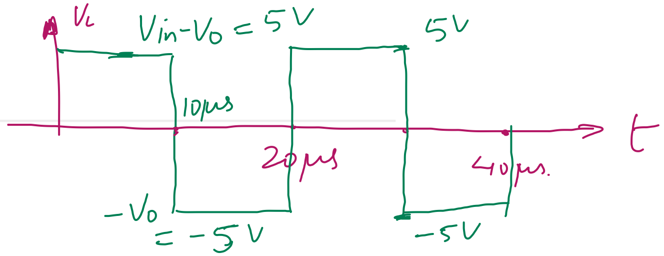
Marks: 2

Type: IMAGE_ANSWER_TYPE

$V_o = 5V$ constant (irrespective of input, as long as input > 5V)

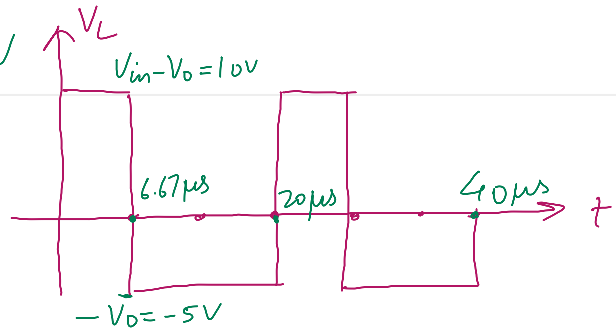
$V_{in} = 10V$, $V_o = 5V \Rightarrow D = 0.5$

$f = 50KHz \rightarrow T = 20\mu s$



Rubrics:

Comments:



21.

Consider the system with transfer function $G(s) = \frac{3s-15}{s+5}$.
Consider the step response y for input u as the unit step input.
The initial value $y(0+)$ is

Ans : 3

Marks: 3
Type: FILL_IN_THE_BLANKS_TYPE

22. Consider the system with transfer function $G(s) = \frac{2s-8}{s+2}$.
Consider the step response y for input u as the unit step input.
The initial value $y(0+)$ is

Ans : 2

Marks: 3
Type: FILL_IN_THE_BLANKS_TYPE

23. Consider the system with transfer function $G(s) = \frac{s-18}{s+2}$.
Consider the step response y for input u as the unit step input.
The final value $y(\infty)$ equals

Ans : -9

Marks: 3
Type: FILL_IN_THE_BLANKS_TYPE

24.

Consider the system with transfer function
$G(s) = \dfrac{s-25}{s+5}$.
Consider the step response y for
The final value $y(\infty)$ equals

Ans: -5

Marks: 3

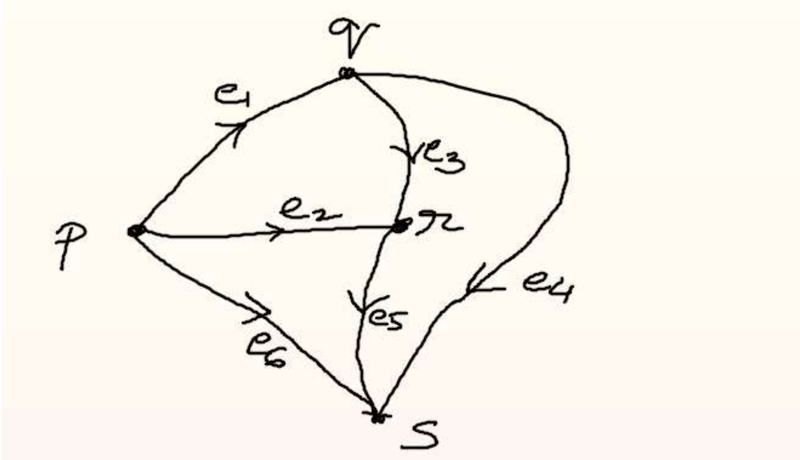
Type: FILL_IN_THE_BLANKS_TYPE

---

25. Consider the graph shown below
with 4 nodes and 6 edges.

Marks: 5

Type: MULTIPLE_CHOICE



Consider the node-edge incidence matrix A and
the loop-edge occurrence matrix B. No need to explicitly
construct A and B. Let v be the voltage drops across
the edges and i be the currents through the edges.
Pick all the correct statements and only the right ones.
(No partial marking.)

Options:

0) The KCL laws are specified by $Ai = 0$.

1) The KVL laws are specified by $Av = 0$.

2) The KCL laws are specified by $Bi = 0$.

3) The KVL laws are specified by $Bv = 0$.

4) $A^T B = 0$

5) $BA = 0$

---

26. Consider the inverted pendulum (linearized) model $\frac{d^2}{dt^2}\theta - \theta = F$, with θ the deviation from the equilibrium point (the **up**right position) P, and F the force used to move the base.
Consider a feedback law in which F is made to depend on θ (and/or θ's derivatives) in order to stabilize about P.
Pick all the right statements and only the right ones.
(No partial marking.)

Marks: 6

Type: MULTIPLE_CHOICE

Options:

0) The equilibrium position is stable

1) The equilibrium position is unstable

2) A proportional controller can stabilize

3) A proportional+derivative controller can stabilize

4) A proportional controller cannot stabilize

5) A proportional+derivative controller cannot stabilize

27.

The convolution of signals $3e^{2t}$ and $5e^{-3t}$
(for $t \geqslant 0$, and each signal is 0 for $t < 0$) is
(Show brief intermediate calculations and final answer.)

Marks: 4
Type: IMAGE_ANSWER_TYPE

Rubrics:
Comments:

---

28. The Laplace transform of the unit impulse δ equals:
Pick all the right statements and only the right ones.
(No partial marking.)

Marks: 2
Type: MULTIPLE_CHOICE

Options:

0) 1
1) the impulse response of the system
2) the step response of the system
3) undefined
4) $1/s$
5) s

---

29. The convolution of signals $2e^{3t}$ and $9e^{-5t}$
(for $t \geqslant 0$, and each signal is 0 for $t < 0$) is
(Show brief intermediate calculations and final answer.)

Marks: 4
Type: IMAGE_ANSWER_TYPE

Rubrics:
Comments:

27) Convolution of $3e^{2t}$ & $5e^{-3t}$

Solution is similar for Q.29 as well.

$$= \mathcal{L}^{-1} \text{ of } \left(\frac{3}{s-2} \times \frac{5}{s+3}\right)$$

$$\downarrow$$

$$\frac{15}{(s-2)(s+3)} = \frac{3}{s-2} + \frac{-3}{s+3}$$

$$\mathcal{L}^{-1}(\downarrow) = 3e^{+2t} - 3e^{-3t} \quad \text{for } t \geq 0.$$

$$= 0 \text{ for } t < 0$$

Convolution of $2e^{3t}$ & $9e^{-5t}$

$$= \mathcal{L}^{-1} \text{ of} \left(\frac{2}{s-3} \times \frac{9}{s+5}\right)$$

$$\downarrow$$

$$\frac{18}{(s-3)(s+5)} = \frac{18/8}{s-3} + \frac{-18/8}{s+5}$$

$$\mathcal{L}^{-1}(\downarrow) = \frac{18}{8}e^{3t} - \frac{18}{8}e^{-5t} \quad \text{for } t \geq 0$$

$$= 0 \text{ for } t \leq 0.$$

No mark deduction for mistake in constant in partial fraction expansion

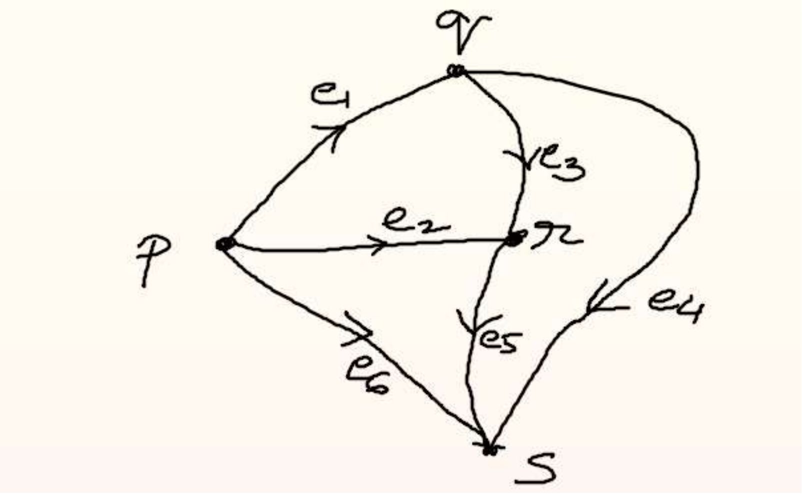
Convolution by brute force (definition) also: no deduction of marks.

Also method: 50% marks → either convolution defn or product of Laplace transforms.

30. Consider the circuit-graph with 4 nodes and 6 edges

Marks: 2

Type: SINGLE_CORRECT_ANSWER



For a link between the Euler formula ($F - E + V = 2$) with KCL/KVL laws' counts, the polyheron concerned is:

Options:

0) Tetrahedron

1) Cube

2) Triangular prism

3) No link with these polyhedra