Tentamen

EEM076 Elektriska Kretsar och Fält, D2

Examinator: Max Ortiz Catalan

30 May 2018 kl. 14.00-16.00, sal: "Maskin"-salar

Förfrågningar: Max Ortiz Catalan, phone: 0708461065

Lösningar: Anslås måndagen den 4 juni på institutionens anslagstavla, plan 5.

Resultat: Rapporteras in i Ladok

Granskning: Torsdag 12 juni kl. 10.00 - 11.00, rum 3311.

Plan 3 i ED-huset (Lunnerummet),

korridor parallell med Hörsalsvägen.

Bedömning: En korrekt och välmotiverad lösning med ett tydligt angivet svar ger full poäng.

Hjälpmedel

- Typgodkänd miniräknare
- Beta Mathematics Handbook
- Physics Handbook

Betygsgränser (6 uppgifter om vardera 3 poäng).

Poäng	0-7.5	8-11	11.5-14.5	15-18
Betyg	U	3	4	5

Lycka till!

1)

I) If you bought an audio amplifier with output specifications of 100 W for a load of 4 Ohms, which of the following configuration could damage your speakers?

A) Two speakers of 2 Ohms and 50 W each, in series
B) Two speakers of 4 Ohms and 100 W each, in series
C) Two speakers of 4 Ohms and 50 W each, in parallel
D) Two speakers of 8 Ohms and 100 W each, in parallel

TIP: Think about the amplifier as a voltage source delivering at its maximum with no limitations of current.

II) What is the configuration of an instrumentational amplifier?

A) Two inverting amplifiers follow by a differential amplifier
B) Two buffer amplifiers follow by a non-inverting amplifier
C) Two differential amplifiers follow by a buffer
D) Two non-inverting amplifiers follow by a differential amplifier

III) You have computed 20 Ohms as the optimal resistance value for a given circuit. This resistance needs to tolerate at least 2 Watts of power. However, your local hardware store has available 10, 12, 15, 18, and 22 Ohms resistors of 0.5 Watts. What is the equivalent resistive network that you can build with the available components to satisfy your desired optimal resistance, while also complying with the power requirements?

TIP: Think about the power supply as a DC voltage source at a fixed value and with no limitations of current.

4)

[SV] En likströmskrets i form av en tvåpol visas i figur 3.

a) Ta fram Thevenins ekvivalenta tvåpol för kretsen med avseende på polerna A och B
b) En resistans R_5 kopplas till tvåoplen mellan A och B. Beräkna spänningen U_{AB} mellan pollerna A och B. (Ansätt polaritet med plus (+) vid polen A.)

[EN] A DC circuit in the form of a two-terminal network is shown in Figure 3.

a) Find Thevenin's equivalent circuit respect to the terminals A and B
b) If resistance R5 is placed between terminals A and B, calculate the voltage across resistance R5 (consider polarity positive (+) at terminal A.)

R1= 200Ω R2= 300Ω R3=60Ω

R4= 220Ω R5= 100Ω U = 120V

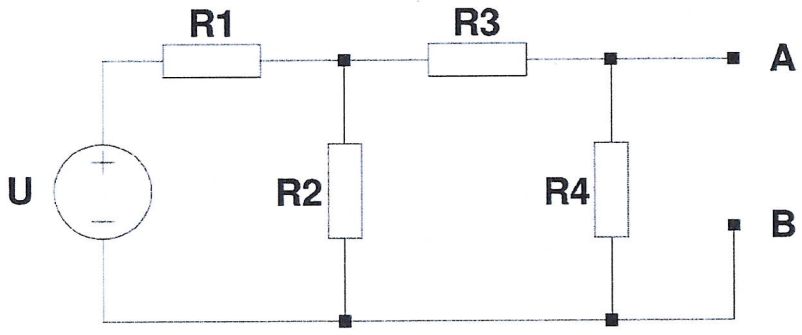
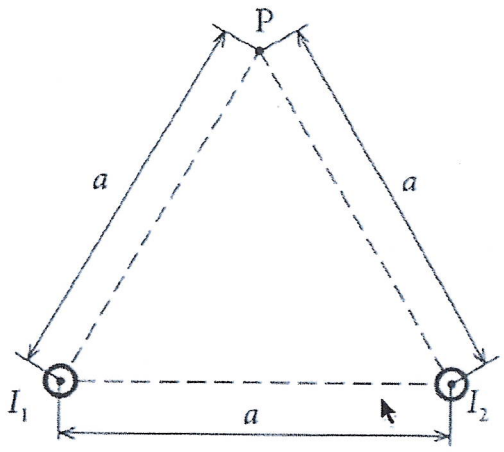


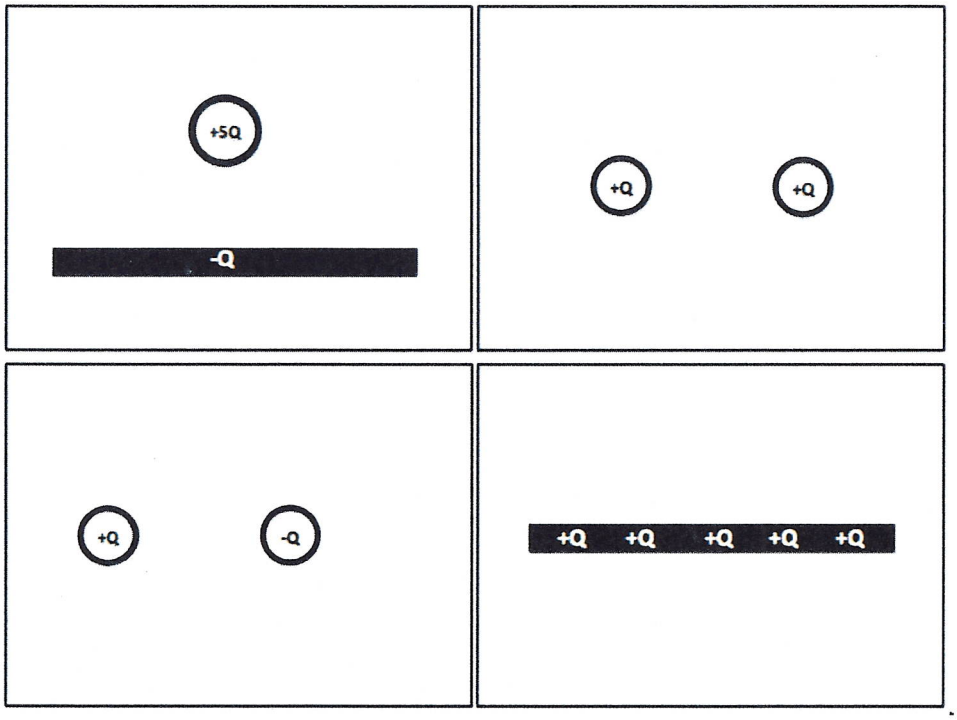
Figure 3

6)

a) Två långa, raka och tunna ledare är monterade parallellt på avståndet a från varandra enligt figuren. Ledarna går vinkelrätt in och ut mot papperets plan och leder strömmarna I_1 respective I_2. Bestäm riktning och amplitud hos den magnetiska flödestätheten **B** i punkten P för det fall då $I_1 = I_2 = 2A$ och a = 10cm. (2p)

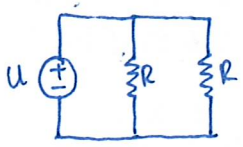


b) Skissa ekvipotentialytorna för följande laddningar. Alla bilder visar olika konfigurationer av positivt och negativt laddade punktladdningar, eller positivt och negativt laddade metallplattor. För poäng ska det principiella utseendet på fältlinjerna vara korrekt i hela det markerade kvadratiska området för respektive konfiguration. (1p)



1)

a) C - Two speakers of 4Ω, 50W in parallel



$R = 4\Omega$ $\quad P_u = 100W$ @ 4Ω

$R_{eq} = R//R = 2\Omega$

$P_u = 100W = \frac{u^2}{4\Omega} \Rightarrow u = 20V$

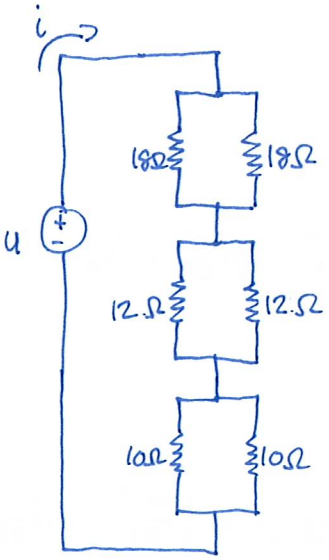
$P_R = \frac{u^2}{R} = \frac{200^2}{4} = 100W$ (> 50W load maximum!)

b) D - Two Non-Inverting Amplifiers followed by a Differential Amplifier

Non-inverting amplifiers on each differential input remove the need for impedance matching by making the input impedance nearly infinite.

c) There are many solutions. Example:

$P_u = 2W$ @ $20\Omega \Rightarrow 2W = \frac{u^2}{20\Omega} \Rightarrow u = 2\sqrt{10}V$



$R_{eq} = (18//18) + (12//12) + (10//10) = 9 + 6 + 5 = \underline{20\Omega}$

$i = \frac{2\sqrt{10}}{20} = \frac{1}{\sqrt{10}}A$

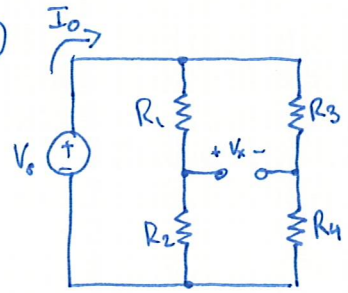
$I_{18\Omega} = I_{12\Omega} = I_{10\Omega} = \frac{1}{2\sqrt{10}}A = \frac{i}{2}$

$P_{18\Omega} = I_{18\Omega}^2 \cdot 18\Omega = \frac{18}{40} = \underline{0.45W < 0.5W}$

$P_{12\Omega} = I_{12\Omega}^2 \cdot 12\Omega = \frac{12}{40} = \underline{0.30W < 0.5W}$

$P_{10\Omega} = I_{10\Omega}^2 \cdot 10\Omega = \frac{10}{40} = \underline{0.25W < 0.5W}$

2)



$V_o = 30V$
$R_1 = 5.0k\Omega$
$R_2 = 1.0k\Omega$
$R_3 = 60k\Omega$
$R_4 = 15k\Omega$

a) $V_{x+} : V_o \cdot \frac{R_2}{R_1+R_2} = 30 \cdot \frac{1k\Omega}{1k\Omega+5k\Omega} = 5V$

$V_{x-} : V_o \cdot \frac{R_4}{R_3+R_4} = 30 \cdot \frac{15k\Omega}{60k\Omega+15k\Omega} = 6V$

$V_x = (V_{x+}) - (V_{x-}) = 5V - 6V = \boxed{-1V}$

b) $R_{eq} = (R_1+R_2) \,//\, (R_3+R_4)$

$= 6k\Omega \,//\, 75k\Omega = \frac{6k\Omega \cdot 75k\Omega}{6k\Omega+75k\Omega}$

$R_{eq} \approx 5.6k\Omega$

$I_o = \frac{V_o}{R_{eq}} = 30/5.6k = 5.4 \cdot 10^{-3} A = \boxed{5.4mA}$

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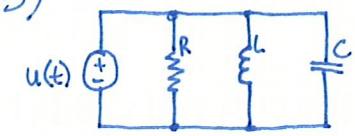
3)



$R = 50\Omega$
$L = 0.50H$
$C = 10\mu F$
$u(t) = 500\sqrt{2} \cdot \cos(\omega t)V$
$\omega = 377 \text{ rad/s}$

a) Average Power: $P_{avg} = S_R = \frac{1}{2} U I_R^* = \frac{1}{2} \frac{UU^*}{R^*} = \frac{1}{2} \frac{|U|^2}{R^*} = \frac{V_{rms}^2}{R}$

$V_{rms} = \frac{500\sqrt{2}}{\sqrt{2}} = 500V$

$P_{avg} = \frac{500V^2}{50} = 5000W = \boxed{5kW}$

b) Reactive Power: $P_{req} = S_L + S_C = \frac{1}{2} U I_L^* + \frac{1}{2} U I_C^* = \frac{1}{2} \frac{|U|^2}{Z_L^*} + \frac{1}{2} \frac{|U|^2}{Z_C^*}$

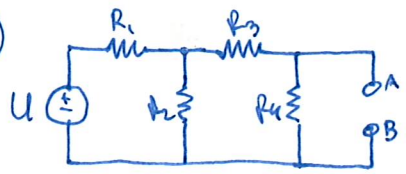
$Z_L^* = -j\omega L = -j377 \cdot 0.5$

$Z_C^* = j\frac{1}{\omega C} = \frac{j}{377 \cdot 10 \cdot 10^{-6}}$

$S_L + S_C = \frac{(500\sqrt{2})^2}{2} \left(\frac{1}{-j377 \cdot 0.5} - j377 \cdot 10 \cdot 10^{-6} \right) \approx j384 = jQ \Rightarrow \boxed{P_{req} = 384VAR}$

Effective Power: $S = \sqrt{P_R^2 + Q^2} = \sqrt{5000^2 + 384^2} = 5014VA$

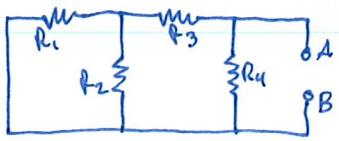
4)



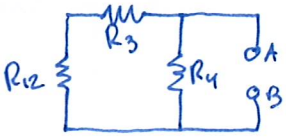
$R_1 = 200\Omega$
$R_2 = 300\Omega$
$R_3 = 60\Omega$
$R_4 = 220\Omega$
$U = 120V$

a) Thevenin Equivalent:

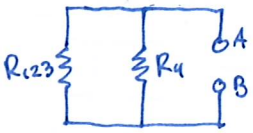
$R_{TH} = R_{eq}$ if sources $= 0$



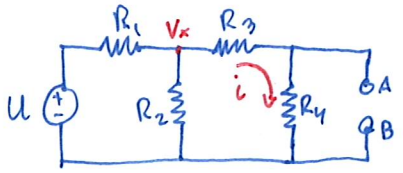
$R_{12} = R_1 // R_2 = 120\Omega$



$R_{123} = R_{12} + R_3 = 180\Omega$



$R_{1234} = R_{TH} = R_{123} // R_4 = \underline{99\Omega}$



$V_{oc} = V_{AB} = i \cdot R_4$

$V_x: \frac{U - V_x}{R_1} - \frac{V_x}{R_2} - \frac{V_x}{R_3 + R_4} = 0$

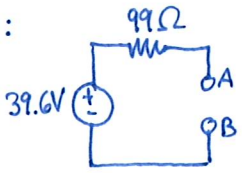
$\frac{30}{200} - \frac{V_x}{200} - \frac{V_x}{300} - \frac{V_x}{280} = 0$

$V_x = 50.4V$

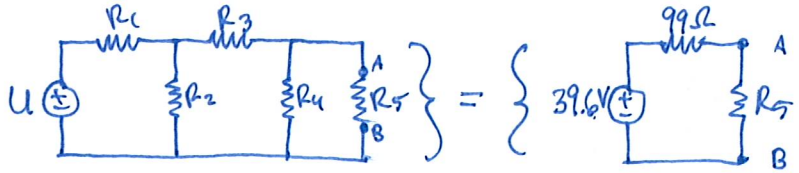
$i = \frac{V_x}{R_3 + R_4} = \frac{50.4}{60 + 220} = 0.18A$

$V_{TH} = 0.18 \cdot 220 = \boxed{39.6V}$

Answer:



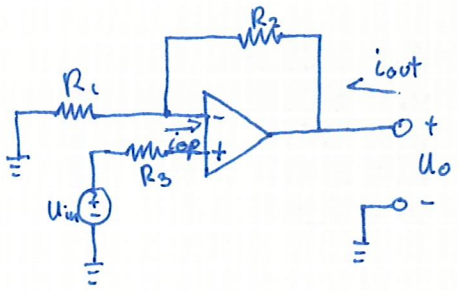
b)



$R_5 = 100\Omega$. Find V_{AB}

$V_{AB} = \underbrace{39.6V \cdot \frac{100\Omega}{99\Omega + 100\Omega}}_{\text{Voltage Divider}} = \boxed{19.9V}$

5)



Ideal Op-Amp $\Rightarrow$ $\varepsilon = (V_-) - (V_+) = 0$

$R_i = \infty\Omega \Rightarrow i_{op} = 0A$

$R_o = 0\Omega$

a) Gain $\left(\frac{U_o}{U_{in}}\right)$: $(V_+) = U_{in}$, $(V_-) = U_{in}$

$U_o \cdot \frac{R_1}{R_1+R_2} = U_{in}$ } Voltage Divider

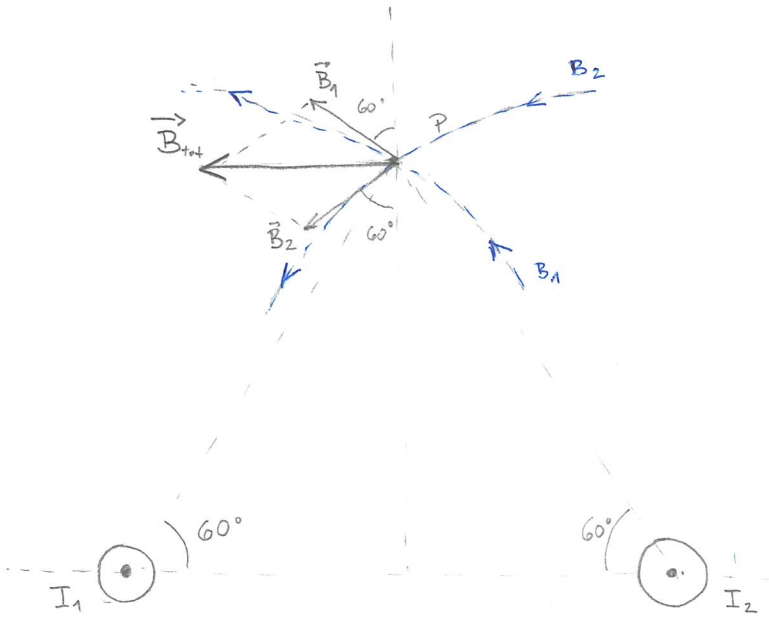
$\frac{U_o}{U_{in}} = \frac{R_1+R_2}{R_1}$

$$\boxed{\frac{U_o}{U_{in}} = 1 + R_2/R_1}$$

b) Input Resistance: $R_{in} = \frac{U_{in}}{i_{in}} = \frac{U_{in}}{0A} = \boxed{\infty\Omega}$

c) Output Resistance: $R_{out} = \left.\frac{U_o}{i_{out}}\right|_{U_{in}=0} = R_2 // R_o = R_2 // 0\Omega = \boxed{0\Omega}$

6a)



Bidragen $\vec{B}_1$ och $\vec{B}_2$ till flödestätheten ligger utefter tangenterna i P till respektive cirkelbågar och är lika stora;

$$|\vec{B}_1| = |\vec{B}_2| = \frac{\mu_0 I}{2\pi a} = 4\,\mu T$$

Vi uttrycker $\vec{B}_1$ och $\vec{B}_2$ i polära koordinater och får då

$\vec{B}_1 = (4\,\mu T,\ 150°)$ $\quad$ $\vec{B}_2 = (4\,\mu T,\ -150°)$ $\quad$ i rektangulär form $\longrightarrow$ $\quad$ $\vec{B}_1 = (-3{,}464\,;\,2)\,\mu T$ $\quad$ $\vec{B}_2 = (-3{,}464\,;\,-2)\,\mu T$

$$\vec{B}_{TOT} = \vec{B}_1 + \vec{B}_2 = (-6{,}93\,;\,0)\,\mu T$$

$$|B_{TOT}| = 6{,}93\,\mu T$$

6b)