UNIVERSITÄT DUISBURG ESSEN

Universität Duisburg-Essen

Campus Duisburg

Allgemeine und Theoretische Elektrotechnik

Dr.-Ing. Oliver Pertz

Examination:	**Fundamentals of Electrical Engineering 2, February 2005**
Date of Examination:	**Friday, February 25th, 03:00 pm**
Location:	**BA026/BA127, Bismarckstraße, DU**

Hints:

1. The following aids may be used during the test:
   - pocket calculator
   - dictionary
   - tools for writing and drawing
   - two pages DIN A4 with handwritten notes
2. Complete the envelope and the main form and sign both. Write your name on the squared sheets.
3. Check, whether you have got a complete set of worksheets. There must be 3 problems.
4. Solve the problems on the squared sheets.
   Do not use your own paper!
   Do not use red pens!
   Do not use pencils!
5. Give complete solutions; i.e. your line of reasoning and of deducting must be evident.
6. Results will be published by the Akademische Prüfungsamt.
7. Estimated date of inspection of papers and registration for supplementary oral examinations: **Thursday, March 24th, 10:00 am - 11:00 am, room BA 349**.
8. No inquiries by phone!

Problem 1 "AC-Network Analysis" (21 points)

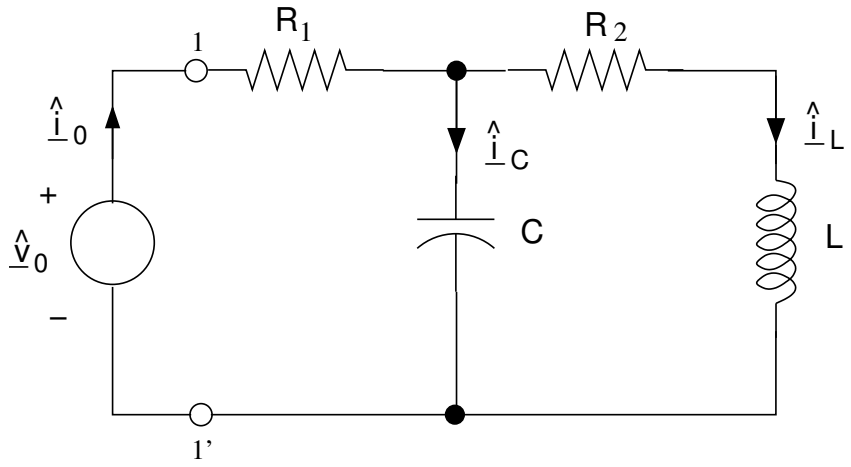


Fig. 1: AC-Network Analysis.

$$\widehat{\underline{v}}_0 = 24\ \text{V}\ \sqrt{2}\ \text{e}^{\text{j}0^\circ} \qquad R_1 = R_2 = R = \sqrt{500}\ \Omega \qquad \omega L = \frac{1}{\omega C} = R \qquad f = 50\ \text{Hz}$$

1a) Find the total equivalent impedance $\underline{Z}_{\text{eq}}$ of the network. (6p)

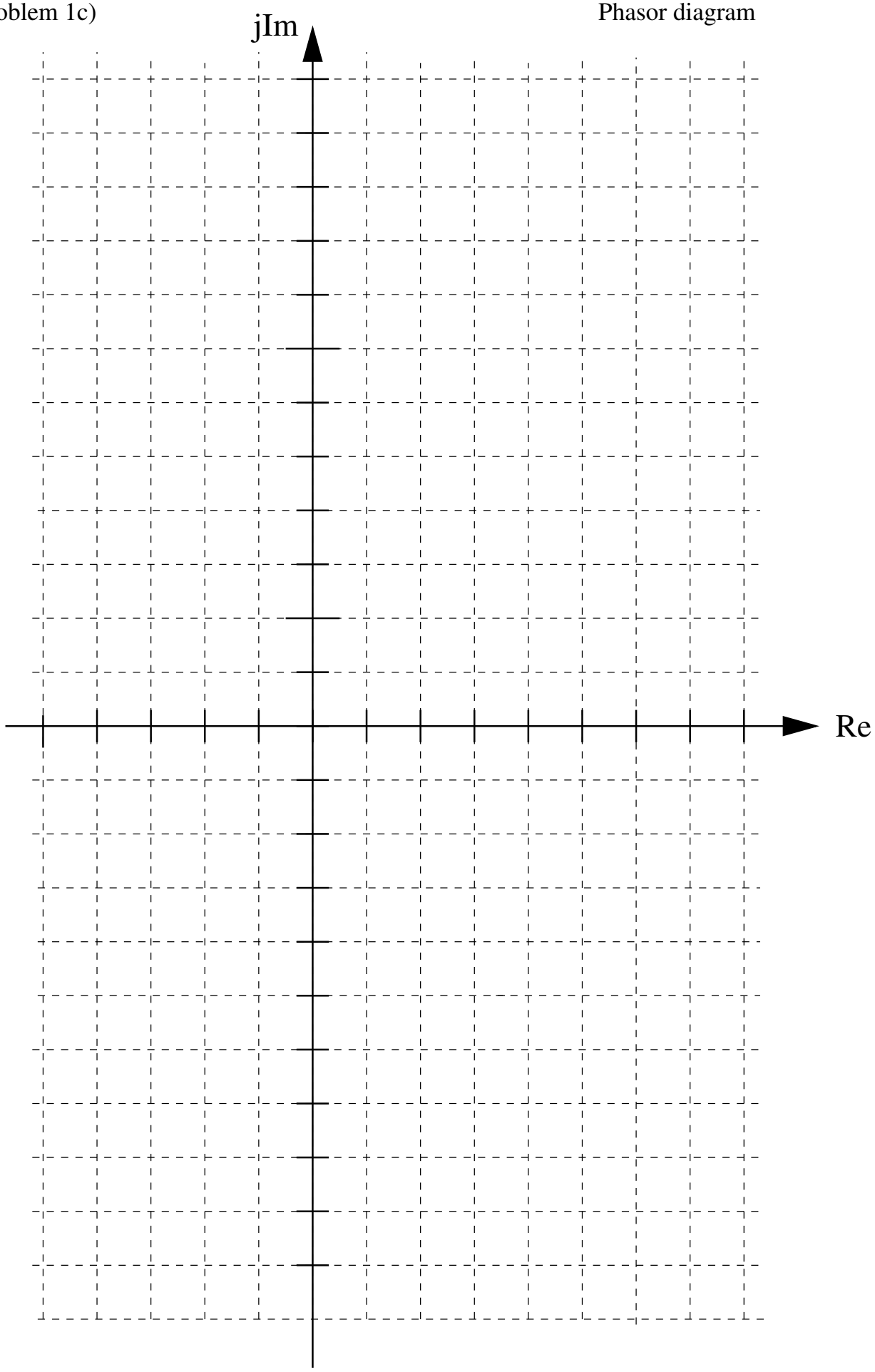
1b) Find the total current $\widehat{\underline{i}}_0$ and the current $\widehat{\underline{i}}_L$ flowing through the inductor. (6p)

1c) Draw the phasor diagram of <u>all</u> three current phasors. For that purpose, use the diagram on the next sheet. Read out the current phasor $\widehat{\underline{i}}_c$.
(Scale: 1 cm $\widehat{=}$ 0.1 A) (3p)

1d) Find the apparent power S, the real power P and the reactive power Q delivered by the voltage source. (3p)

1e) Determine the capacitance C so that the apparent power S becomes real. (3p)

Problem 1c) Phasor diagram



Problem 2 "Transients" (14 points)

The switch in Fig. 2 is **opened** at $t = 0$.

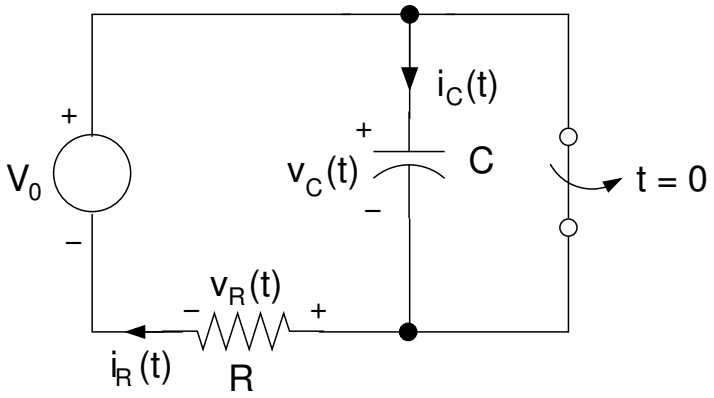


Fig. 2: Transients.

$$V_0 = 10 \text{ V} \qquad R = 50\ \Omega \qquad C = 500\ \mu\text{F}$$

2a) Using Kirchhoff's Laws find the first-order differential equation for $v_C(t)$. Do NOT solve it. (4p)

The solution of the differential equation is given by

$$v_C(t) = \begin{cases} 0 & t < 0 \\ V_0 \left(1 - e^{-\frac{t}{\mathrm{RC}}}\right) & t \geq 0 \end{cases}$$

2b) Find the current $i_C(t)$ for $-\infty < t < \infty$. (3p)

2c) Find the current $i_R(t)$ for $-\infty < t < \infty$. (2p)

2d) Find the power function $p_C(t)$ for $t \geq 0$. (2p)

2e) By integration find the total energy W_C stored in the capacitor after it is fully charged. (3p)

Hint: Calculate $W_C(t \to \infty)$.

Hints:

$$i_C(t) = C\,\frac{\mathrm{dv_C(t)}}{\mathrm{dt}}$$

Subproblems 2b)-2e) can be solved independently of 2a).

Problem 3 "Diode Circuit" (15 points)

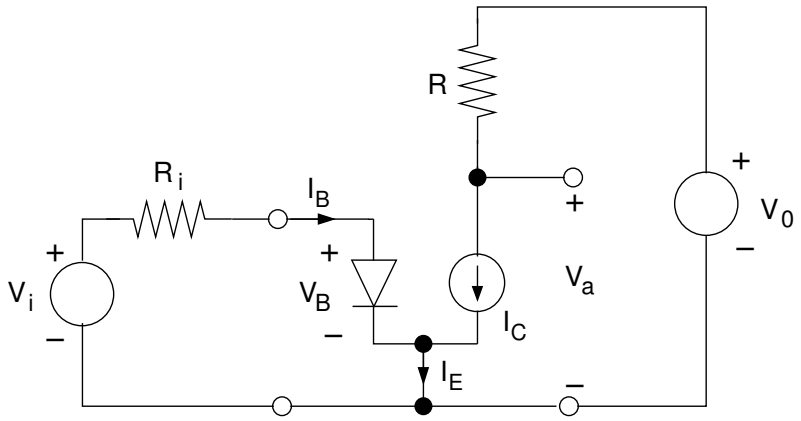


Fig. 3: Diode Circuit.

$I_C = 100 \cdot I_B$ $R_i = 4$ kΩ R = 2.7 kΩ $V_i = 1$ V $V_0 = 40$ V

The circuit in Fig. 3 consists of a diode, two voltage sources and one current source.

The current-voltage characteristic of the diode can be described by

$$I_B(V_B) = \begin{cases} 0 & V_B < 0.65 \text{ V} \\ 0.01 \ \frac{\text{A}}{\text{V}^2} \ (V_B - 0.65 \text{ V})^2 & V_B \geq 0.65 \text{ V} \end{cases}$$

and is depicted in Fig. 3b), see next page.

3a) Find graphically the current I_B using the diagram Fig. 3b). Read out I_B. (4p)

Hint: Draw the source characteristic of the voltage source (V_i, R_i) into the diagram of the diode characteristic.

3b) Using the result of 3a) find the voltage V_a. (3p)

3c) Now, find the current I_B by calculation. (6p)

Hint: - Use the current function $I_B(V_B)$ and KVL.

3d) Find the power P dissipated at the resistor R. (2p)

Hint: Give results in μA and V, respectively, each with three decimal places.

Problem 3b)

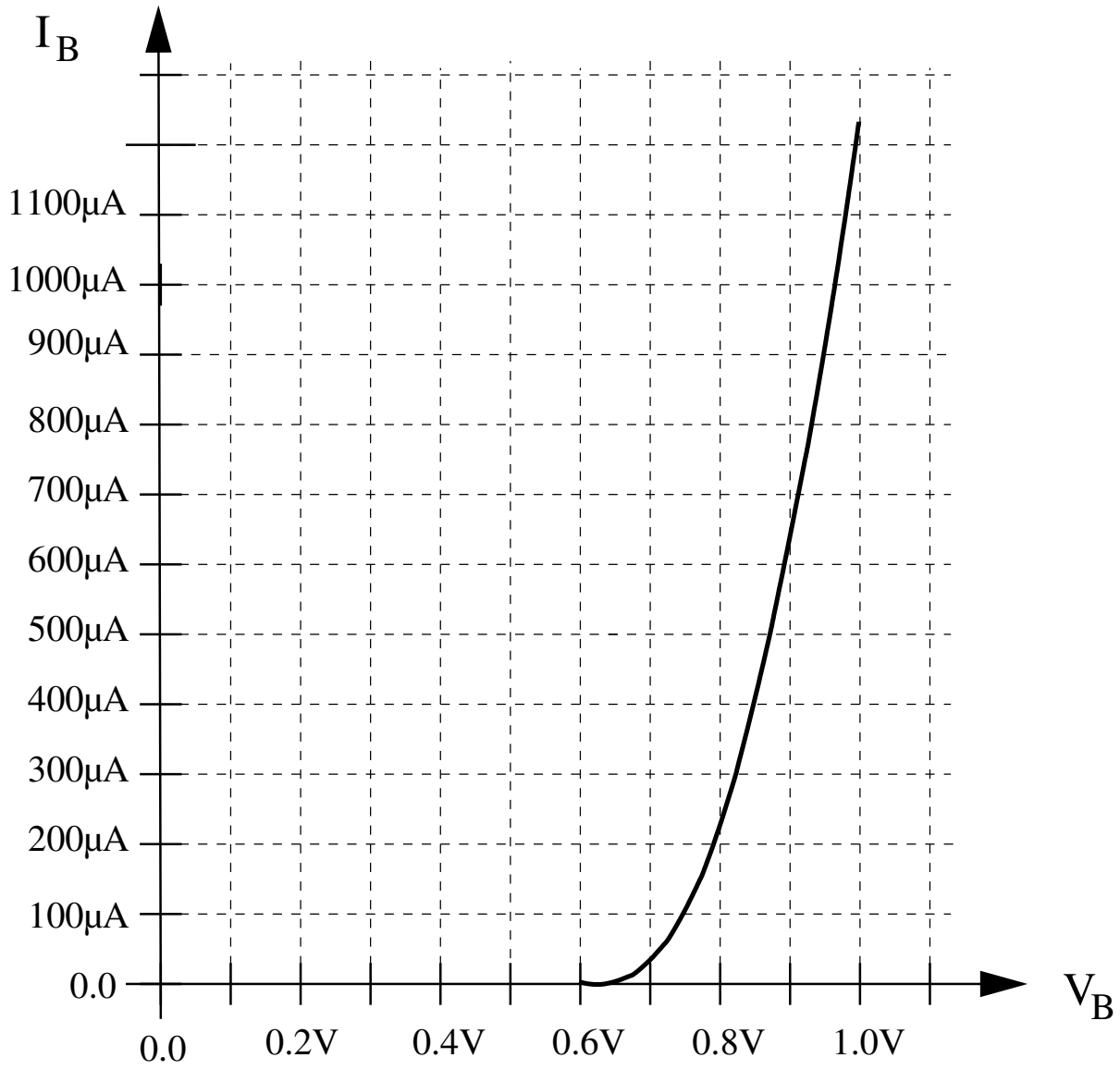


Fig. 3b)