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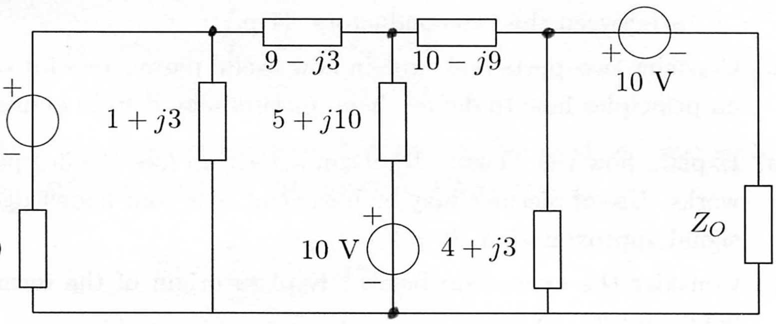
SMG-8146 RF-electronics preparatory II

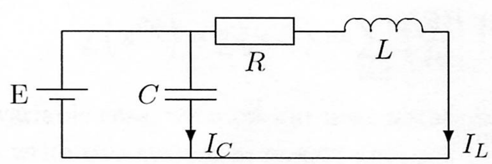
Small Exam I 14.11.2011
Answer to three of the four questions.
Jari Kangas

1. (a) Consider the circuit below. Form a graph, a tree, and cotree associated with the circuit. Using them describe how many loops would be needed to state the KVL. How many equations would be needed to state the KCL? (3 p.) $b-(n-1)$ b-branch
(n-1) n-node



   (b) i. Consider electric networks, explain what are active, apparent, and reactive power and how to interpret them. $p=P_r+jP_i \Rightarrow p=\sqrt{P_r^2+P_i^2}$

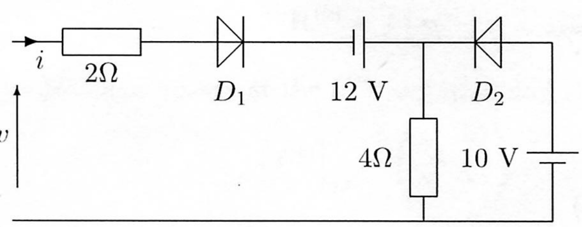
   ii. Find the complex power that the voltage source delivers. Let $E = 10\angle 90°$ V, $R = 2\Omega$, $L = 2$ H, $C = 0.4$ F, $\omega = 2$ rad/s .



   (3 p.)

2. (a) Explain how the electric susceptibility is defined. Explain also briefly (physical) origin of it. (3 p.)

   (b) In the circuit below find i as a function of v ($-\infty < v < \infty$), assume ideal diodes. (3 p.)



3. (a) Correct or incorrect? *To get points, support your answer by an argument or an example.*

   i. Let $F : \mathbb{R} \to \mathbb{R}^3$, $h : \mathbb{R} \to \mathbb{R}^3$, $g : \mathbb{R}^2 \to \mathbb{R}$. The composition $F(h(g(x)))$ is of type $\mathbb{R}^2 \to \mathbb{R}^3$ (1 p.)

   ii. Given a conducting body (such as a ball whose outer surface is covered with metal), if a positive charged body (rod, for instance) is taken close to the conducting body, charge distribution in the conducting body is altered. (1 p.)

   iii. When using a bipolar junction transistor in the active region it holds that $I_B > 0$ and $I_E = \beta I_B$. (1 p.) $I_E = I_C + I_B$

   iv. Capacitor (parallel plate capacitor, for example) is such a device that it allows alternating current (AC) to carry charge (i.e. current) through the insulating material that is between the two conductors. (1 p.)

   (b) Consider two–ports and explain how useful parameters for two–ports can be defined (focus on principles how to define them, picture may help in giving your answer). (2 p.)

4. (a) Explain how the Newton-Raphson algorithm (see the 3rd page for additional information) works. Use of pictures may be beneficial as is your knowledge on the principles of the small signal approximation. (3 p.)

   (b) Consider the expression below. Explain origin of the terms (picture may help in giving your answer). (3 p.)

$$\int_S \frac{q}{4\pi\epsilon_0} \frac{\mathbf{r} - \mathbf{r}'}{|\mathbf{r} - \mathbf{r}'|^3} \cdot \mathbf{n}\, da.$$

Constants in free space and some formulas:

- dielectric constant $\epsilon_0 \approx 8.854 * 10^{-12}\mathrm{F/m}$
- permeability $\mu_0 \approx 4\pi * 10^{-7}\mathrm{H/m}$
- speed of light $c \approx 2.997925 * 10^8\mathrm{m/s}$
- intrinsic impedance $\eta_0 = \sqrt{\frac{\mu_0}{\epsilon_0}} \approx 120\pi\ \Omega$
- $e^x \approx 1 + x$ if $|x|$ small
- $\mathbf{r} = \mathbf{i}x + \mathbf{j}y + \mathbf{k}z$, $\mathbf{r}' = \mathbf{i}x' + \mathbf{j}y' + \mathbf{k}z'$
- $\mathrm{curl}\,(\mathbf{E}) = 0$, $\mathrm{div}\,(\mathbf{D}) = \rho$, and $\mathbf{D} = \epsilon\mathbf{E}$
- $P_{ave} = \frac{1}{2}U_{max}I^*_{max} = \frac{U_{max}}{\sqrt{2}}\frac{I^*_{max}}{\sqrt{2}} = U_{rms}I^*_{rms}$
- $\int_S \mathrm{curl}(\mathbf{F}) \cdot \mathbf{n}da = \int_{\partial S} \mathbf{F} \cdot \mathbf{dl}$
- $\int_V \mathrm{div}(\mathbf{F})\, dv = \int_{\partial V} \mathbf{F} \cdot \mathbf{n}da$
- $\int_C \mathrm{grad}(f) \cdot \mathbf{dl} = f(b) - f(a)$
- $\mathrm{grad}(f) = \mathbf{i}\frac{\partial f}{\partial x} + \mathbf{j}\frac{\partial f}{\partial y} + \mathbf{k}\frac{\partial f}{\partial z}$