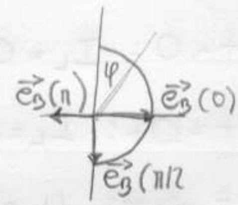
1.) $\vec{B} = \frac{\mu_0 I'}{2\pi(c-b)}(-\vec{e}_y) = \frac{\mu_0 I}{2\pi\left(\frac{a^2}{b}-b\right)} \frac{\mu_r - 1}{\mu_r + 1}(-\vec{e}_y)$

$$\vec{F}' = I B \, \vec{e}_z \times (-\vec{e}_y) = \boxed{\frac{\mu_0 I^2 b}{2\pi(a^2-b^2)} \frac{\mu_r - 1}{\mu_r + 1} \vec{e}_x}$$

2.) (i)

(ii) $d\vec{B} = \frac{\mu_0 dI}{2\pi a} \vec{e}_B \quad \text{mit } dI = \frac{I}{\pi a}$



$$\vec{e}_B = \vec{e}_B(\varphi) = \cos\varphi \, \vec{e}_x - \sin\varphi \, \vec{e}_y$$

$$\vec{B}(0) = \frac{\mu_0 I}{2\pi^2 a^2} \int_0^{\pi} \cos\varphi \, \vec{e}_x - \sin\varphi \, \vec{e}_y = \frac{\mu_0 I}{2\pi^2 a^2} \left(\sin\varphi \, \vec{e}_x + \cos\varphi \, \vec{e}_y\right)\Big|_0^{\pi}$$

$$= \boxed{\frac{\mu_0 I}{\pi^2 a^2}(-\vec{e}_y)}$$

3.) $\frac{\underline{U}_C}{\underline{U}} = \frac{\frac{1}{j\omega C}}{R + j\omega L + \frac{1}{j\omega C}} = \frac{1}{1 - \omega^2 LC + j\omega RC}$

$$\left|\frac{\underline{U}_C}{\underline{U}}\right| = \frac{1}{\sqrt{(1-\omega^2 LC)^2 + (\omega RC)^2}} = \frac{1}{\sqrt{f(\omega)}} \quad \text{max für} \quad f(\omega) = \min$$

$$f(\omega) = \omega^4 L^2 C^2 + \omega^2 (R^2 C^2 - 2LC) + 1$$

$$\frac{df(\omega)}{d\omega} = 4\omega^3 L^2 C^2 + \omega(2R^2C^2 - 4LC) = 0$$

$$2\omega^2 L^2 C^2 = 2LC - R^2 C^2$$

$$\boxed{\omega = \sqrt{\frac{1}{LC} - \frac{R^2}{2L^2}}} \qquad f = \frac{\omega}{2\pi}$$

4.) $$\bar{u} = \frac{1}{T}\int_0^T u(t)\,dt = \frac{1}{T}\left(2\,\frac{2}{7}T\cdot 5V\cdot\frac{1}{2} + \frac{1}{7}T\cdot 5V\right)$$

$$= \frac{10}{7}V + \frac{5}{7}V = \frac{15}{7}V \approx \boxed{2{,}143\,V}$$

5.)

$$B = \frac{\Phi'}{\alpha\rho} = \frac{\Phi}{c\alpha\rho} \qquad H = \frac{B}{\mu_0} = \frac{\Phi}{\mu_0 c\alpha\rho}$$

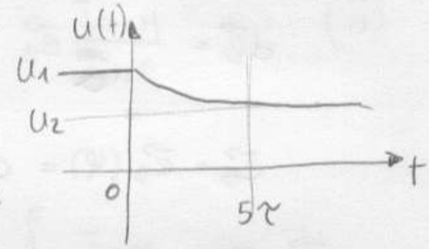
$$V = \int_a^b H\,d\rho = \frac{\Phi}{\mu_0 c\alpha}\ln\left(\frac{b}{a}\right) \qquad G_m = \frac{\Phi}{V} = \boxed{\frac{\mu_0 c\alpha}{\ln(b/a)}}$$

6.)

$t<0$: $I_L = 0$ $\quad u(t) = R_1 I_q = U_1$

$t=0+$: $I_L = 0$ $\quad u(t) = R_1 I_q = U_1$

$t \to \infty$: $U_L = 0$ $\quad u(t) = I_q \frac{R_1 R_2}{R_1+R_2} = U_2$ $\qquad \tau = \frac{L}{R_1+R_2}$



7.)

$$\underline{Z}_L = R_1 + j\omega L$$

$$\underline{Z}_C = \frac{R_2}{1+j\omega R_2 C}$$

$$\underline{Z} = \underline{Z}_L + \frac{\underline{Z}_C\underline{Z}}{\underline{Z}_C+\underline{Z}}$$

$$\underline{Z}^2 + \underline{Z}\,\underline{Z}_C = \underline{Z}_L\underline{Z}_C + \underline{Z}_L\underline{Z} + \underline{Z}_C\underline{Z}$$

$$\underline{Z}^2 - \underline{Z}_L\underline{Z} - \underline{Z}_L\underline{Z}_C = 0$$

$$\underline{Z} = \frac{\underline{Z}_L}{2} \pm \sqrt{\frac{\underline{Z}_L^2}{4} + \underline{Z}_L\underline{Z}_C} = \boxed{\frac{\underline{Z}_L}{2}\left(1 \pm \sqrt{1 + 4\frac{\underline{Z}_C}{\underline{Z}_L}}\right)}$$

8.) $\underline{I}_1 + \underline{I}_2 + \underline{I}_3 = 0 \qquad \underline{I}_1 = \frac{\underline{U}_1}{\underline{Z}_1} \qquad \underline{I}_2 = \frac{\underline{U}_2}{\underline{Z}_2} \qquad \underline{I}_3 = \frac{\underline{U}_3}{\underline{Z}_3}$

$\underline{U}_{23} = \underline{a}^2 \underline{U} \qquad \underline{U}_{31} = \underline{a}\,\underline{U}$ mit $\underline{a} = e^{j2\pi/3}$

Maschengleichungen

$$\underline{U}_1 = \underline{U}_2 + \underline{U} \qquad \underline{U}_3 = \underline{U}_2 - \underline{a}^2 \underline{U}$$

In Knotengleichung einsetzen $\quad \frac{\underline{U}_2 + \underline{U}}{\underline{Z}_1} + \frac{\underline{U}_2}{\underline{Z}_2} + \frac{\underline{U}_2 - \underline{a}^2\underline{U}}{\underline{Z}_3} = 0$

$$\boxed{\underline{U}_2 = \underline{U}\,\frac{\underline{a}^2 \underline{Z}_1 \underline{Z}_2 - \underline{Z}_2 \underline{Z}_3}{\underline{Z}_1 \underline{Z}_2 + \underline{Z}_2 \underline{Z}_3 + \underline{Z}_3 \underline{Z}_1}}$$

9.) $\underline{Z}_W = \sqrt{\underline{Z}_K \underline{Z}_L}$

$$\frac{1}{\underline{Z}_K} = \frac{\underline{Y}'l}{2} + \frac{1}{\underline{Z}'l} = \frac{\underline{Y}'\underline{Z}'l^2 + 2}{2\underline{Z}'l} \qquad \underline{Z}_K = \frac{2\underline{Z}'l}{\underline{Y}'\underline{Z}'l^2 + 2}$$

$$\frac{1}{\underline{Z}_L} = \frac{\underline{Y}'l}{2} + \frac{\underline{Y}'l}{\underline{Z}'\underline{Y}'l^2 + 2} = \frac{\underline{Y}'l(\underline{Z}'\underline{Y}'l^2 + 4)}{2(\underline{Z}'\underline{Y}'l^2 + 2)} \qquad \underline{Z}_L = \frac{2(\underline{Z}'\underline{Y}'l^2 + 2)}{\underline{Y}'l(\underline{Z}'\underline{Y}'l^2 + 4)}$$

$$\underline{Z}_W = \sqrt{\frac{4\underline{Z}'}{\underline{Y}'(\underline{Z}'\underline{Y}'l^2 + 4)}} = \boxed{2 \cdot \sqrt{\frac{\underline{Z}'}{\underline{Y}'(\underline{Z}'\underline{Y}'l^2 + 4)}}}$$

10.) $E = \frac{Q}{4\pi\varepsilon_0 \varrho^2} \qquad U = \frac{Q}{4\pi\varepsilon_0}\int_a^\infty \frac{1}{\varrho^2}\,d\varrho = \frac{Q}{4\pi\varepsilon_0}\left(\frac{1}{a}\right) \qquad C = 4\pi\varepsilon_0 a$

(i) $W_e = \frac{CU^2}{2} = \frac{Q^2}{2C} = \boxed{\frac{Q^2}{8\pi\varepsilon_0 a}}$

(ii) $Q = -e \qquad W_e = m_e c_0^2 \qquad a = \frac{Q^2}{8\pi\varepsilon_0 m_e c_0^2} \approx \boxed{1{,}407 \cdot 10^{-15}\,\mathrm{m}}$