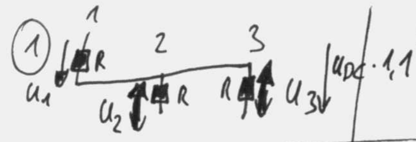
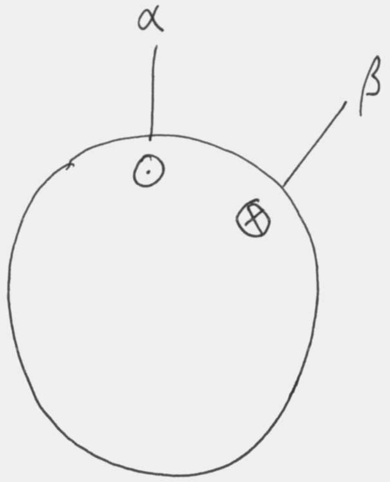
Dual-Active-Brigde und Drehtransformator

① ÜB BT2 21.07.09

Schaltzustände

①  ⑥ 



$u_1 = \frac{2}{3} \cdot 1{,}1 \cdot u_{DC}$	$u_R = \frac{1}{3} \cdot u_{DC}$
$u_2 = -\frac{1}{3} \cdot 1{,}1 \cdot u_{DC}$	$u_S = -\frac{2}{3} \cdot u_{DC}$
$u_3 = -\frac{1}{3} \cdot 1{,}1 \cdot u_{DC}$	$u_T = \frac{1}{3} \cdot u_{DC}$

Transformation in $\alpha\beta$-Koordinaten

$$\begin{pmatrix} u_\alpha \\ u_\beta \end{pmatrix} = \begin{pmatrix} 2/3 & -1/3 & -1/3 \\ 0 & 1/\sqrt{3} & -1/\sqrt{3} \end{pmatrix} \begin{pmatrix} u_1 \\ u_2 \\ u_3 \end{pmatrix}$$

$$u_\alpha = 2/3 \cdot u_1 - 1/3\, u_2 - 1/3 \cdot u_3 = 2/3 \cdot 1{,}1 \cdot u_{DC}$$

$$u_\beta = 1/\sqrt{3} \cdot u_2 - \frac{1}{\sqrt{3}} \cdot u_3 = 0$$

$$u_\alpha' = \frac{2}{3} u_R - \frac{1}{3} u_S - \frac{1}{3} u_T = \frac{1}{3} u_{DC}$$

$$u_\beta' = \frac{1}{\sqrt{3}} u_S - \frac{1}{\sqrt{3}} u_T = -\frac{1}{\sqrt{3}} \cdot u_{DC}$$

Transformation der Sekundärseite (Rotor) ins Koordinatensystem der Primärseite (Stator)

$$\begin{pmatrix} u_d' \\ u_q' \end{pmatrix} = \begin{pmatrix} \cos\vartheta & -\sin\vartheta \\ \sin\vartheta & \cos\vartheta \end{pmatrix} \cdot \begin{pmatrix} u_\alpha' \\ u_\beta' \end{pmatrix}$$

$$u_d' = u_\alpha' \cdot \cos\frac{\pi}{3} - u_\beta' \cdot \sin\frac{\pi}{3} = \frac{1}{3} u_{DC} \cdot \frac{1}{2} + \frac{1}{\sqrt{3}} u_D \cdot \frac{\sqrt{3}}{2} = \frac{2}{3} u_{DC}$$

$$u_q' = u_\alpha' \cdot \sin\frac{\pi}{3} + u_\beta' \cdot \cos\frac{\pi}{3} = \frac{1}{3} u_{DC} \frac{\sqrt{3}}{2} - \frac{1}{\sqrt{3}} u_D \cdot \frac{1}{2} = 0$$

Entkoppelte Spannungsgleichungen des Drehtransformators ②
(nach Transformation)

$$\begin{bmatrix} u_\alpha \\ u_\beta \end{bmatrix} = R_p \begin{pmatrix} i_\alpha \\ i_\beta \end{pmatrix} + \begin{bmatrix} L_p & 0 \\ 0 & L_p \end{bmatrix} \frac{d}{dt} \begin{pmatrix} i_\alpha \\ i_\beta \end{pmatrix} + \begin{bmatrix} L_m & 0 \\ 0 & L_m \end{bmatrix} \frac{d}{dt} \begin{pmatrix} i_d' \\ i_q' \end{pmatrix}$$

$$\begin{bmatrix} u_d' \\ u_q' \end{bmatrix} = R_s' \begin{pmatrix} i_d' \\ i_q' \end{pmatrix} + \begin{bmatrix} L_s' & 0 \\ 0 & L_s' \end{bmatrix} \frac{d}{dt} \begin{bmatrix} i_d' \\ i_q' \end{bmatrix} + \begin{bmatrix} L_m & 0 \\ 0 & L_m \end{bmatrix} \frac{d}{dt} \begin{pmatrix} i_\alpha \\ i_\beta \end{pmatrix}$$

mit $L_m = \frac{3}{2} L_h$, $\quad L_p = L_{p\sigma} + L_m \qquad (*)$

$L_s' = L_{s\sigma} + L_m \qquad (**)$

mit $R_p = R_s = 0$ folgt:

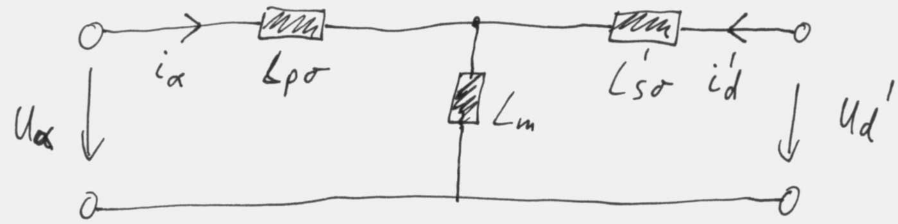
$$u_\alpha = L_p \frac{di_\alpha}{dt} + L_m \frac{di_d'}{dt}$$

$$\overset{(*)}{=} L_{p\sigma} \frac{di_\alpha}{dt} + L_m \frac{d(i_\alpha + i_d')}{dt} \qquad (1)$$

$$u_d' = L_s' \frac{di_d'}{dt} + L_m \frac{di_\alpha}{dt}$$

$$\overset{(**)}{=} L_{s\sigma}' \frac{di_d'}{dt} + L_m \frac{d(i_\alpha + i_d')}{dt} \qquad (2)$$

T - ESB : (1), (2) ③



gilt entsprechend für β und q'

Für $L_m = \frac{3}{2} L_h >> L_{p\sigma}, L'_{s\sigma}$ folgt:

$$i_\alpha \approx - i'_d \quad \Rightarrow \qquad (3)$$

$$(1) - (2) \Rightarrow u_\alpha - u'_d = L_{p\sigma} \frac{di_\alpha}{dt} - L'_{s\sigma} \frac{di'_d}{dt}$$

$$\overset{(3)}{=} \underbrace{\left(L_{p\sigma} + L'_{s\sigma}\right)}_{:= L\sigma} \cdot \frac{di_\alpha}{dt}$$

$$\Rightarrow i_\alpha(t) = \int_0^t \frac{u_\alpha - u'_d}{L\sigma} \, dt'$$

$$= \frac{0{,}1 \cdot \frac{2}{3} u_{DC}}{L\sigma} \cdot t$$

$$i_\beta(t) = 0 \quad , \text{ da } u_\beta = 0$$

$$i'_d \overset{(3)}{\approx} - i_\alpha \quad , \text{ analog } \quad i'_\alpha = - i_\beta = 0$$

$i_d^{\prime\,(3)} \approx -i_\alpha$, analog $i_\alpha^{\prime\prime} = -i_\beta = 0$

Transformation zurück ins Koordinatensystem der Sekundärseite (Rotor)

$$\begin{pmatrix} i_\alpha' \\ i_\beta' \end{pmatrix} = \begin{pmatrix} \cos\vartheta & \sin\vartheta \\ -\sin\vartheta & \cos\vartheta \end{pmatrix} \begin{pmatrix} i_d' \\ i_q' \end{pmatrix}$$

$$i_\alpha' = i_d' \cos\vartheta + i_q' \sin\vartheta$$

$$= -i_\alpha \cos\frac{\pi}{3} + 0 \cdot \sin\frac{\pi}{3} = -\frac{1}{2} i_\alpha$$

$$i_\beta' = -i_d' \sin\vartheta + i_q' \cos\vartheta$$

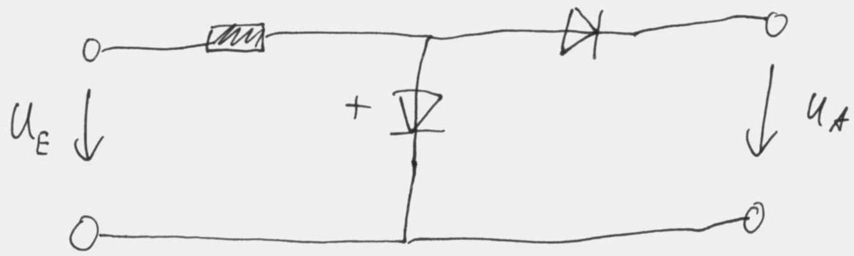
$$= i_\alpha \sin\frac{\pi}{3} + 0 \cdot \cos\frac{\pi}{3} = \frac{\sqrt{3}}{2} i_\alpha$$

Rücktransformation ins Dreiphasensystem :

$\alpha\beta \rightarrow 123$	$\alpha'\beta' \rightarrow RST$
$\begin{pmatrix} i_1 \\ i_2 \\ i_3 \end{pmatrix} = \begin{pmatrix} 1 & 0 \\ -\frac{1}{2} & \frac{\sqrt{3}}{2} \\ -\frac{1}{2} & -\frac{\sqrt{3}}{2} \end{pmatrix} \begin{pmatrix} i_\alpha \\ i_\beta \end{pmatrix}$	mit anderem Index – " –
$i_1 = i_\alpha = \frac{0{,}2}{3} \cdot \frac{U_{DC}}{L\sigma} \cdot t$ $i_2 = -\frac{1}{2} i_\alpha + \frac{\sqrt{3}}{2} \cdot \underbrace{i_\beta}_{=0}$ $= -\frac{0{,}1}{3} \frac{U_{DC}}{L\sigma} \cdot t$ $i_3 = -\frac{1}{2} i_\alpha - \frac{\sqrt{3}}{2} \underbrace{i_\beta}_{=0}$ $= i_2$	$i_R = i_\alpha' = -\frac{1}{2} i_\alpha = -\frac{0{,}1}{3} \frac{U_{DC}}{L\sigma} \cdot t$ $i_S = -\frac{1}{2} i_\alpha' + \frac{\sqrt{3}}{2} i_\beta'$ $= \left(-\frac{1}{2} \cdot \left(-\frac{1}{2}\right) + \frac{\sqrt{3}}{2} \cdot \frac{\sqrt{3}}{2}\right) i_\alpha = i_\alpha = i_1$ $i_T = -\frac{1}{2} i_\alpha' - \frac{\sqrt{3}}{2} i_\beta'$ $= \left(-\frac{1}{2} \cdot \left(-\frac{1}{2}\right) - \frac{\sqrt{3}}{2} \frac{\sqrt{3}}{2}\right) i_\alpha = -\frac{1}{2} i_\alpha$

A 9 Fragen-Aufgaben bei Klausuren

9.1 Hochsetzsteller



9.2 Varistor

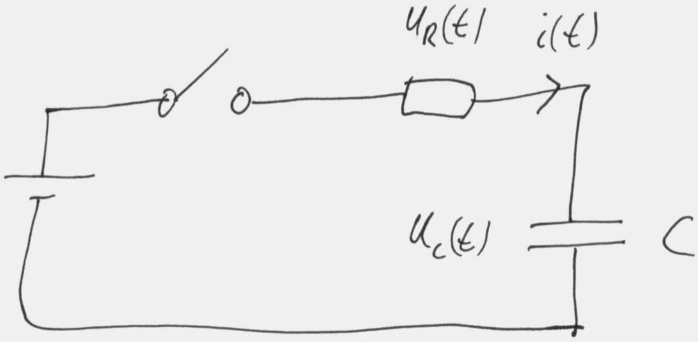
⇒ spannungsabhängiger Widerstand

9.3 Hybrid-Fahrzeug Batterieauswahl

⇒ Hochleistungs-Batterie

nicht: Hoch-energie od. Spannung

9.4



$$\Rightarrow U_0 = R \cdot C \; \frac{d\, u_C(t)}{dt} + U_R(t)$$

9.5 Schaltung eines Drehstromtransformators

Dd 0

× Dd 6

Dy 5

R S T

Bild fehlt

"1" Wirbelstromverluste
Zusammenhänge

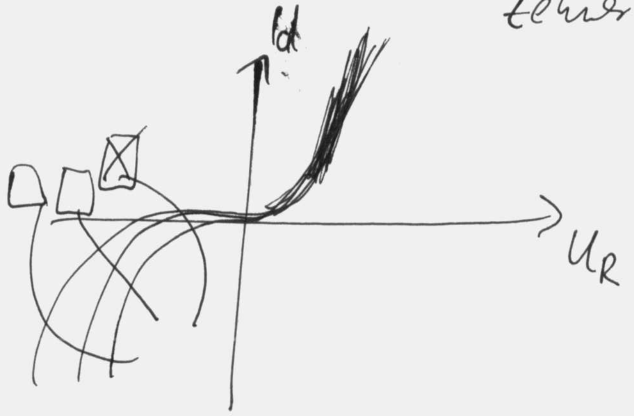
X $P_W \sim f^2 \cdot B^2$

$P_W \sim f \; B$

$P_W \sim f^2 \; B$

"2" Was ist kein LTI System?

RC-Glied
LC-Schwingkreis
Photozelle

"3" 

Zehnerdiode

Verlustleistungsgrenze

"4" Wechselsp.-quelle