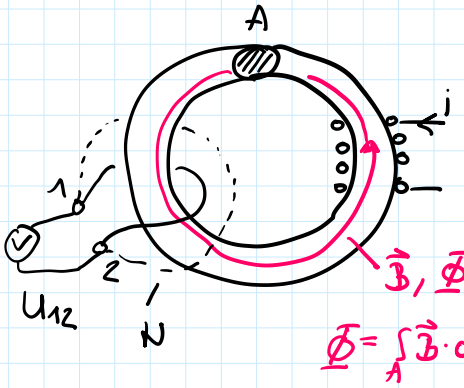
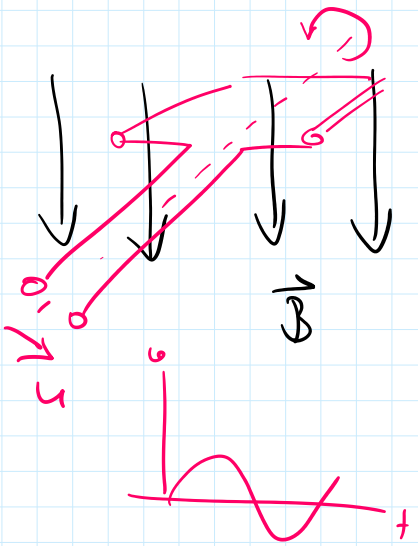
## RUHEINDUKTION




$\Phi = \int_A \vec{B} \cdot d\vec{A}$



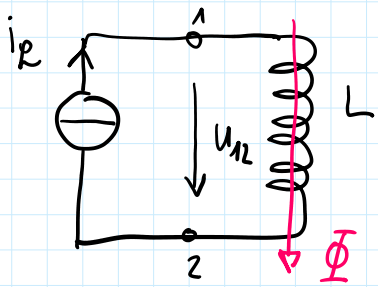

$$U_{12} = \frac{d\Phi}{dt}$$

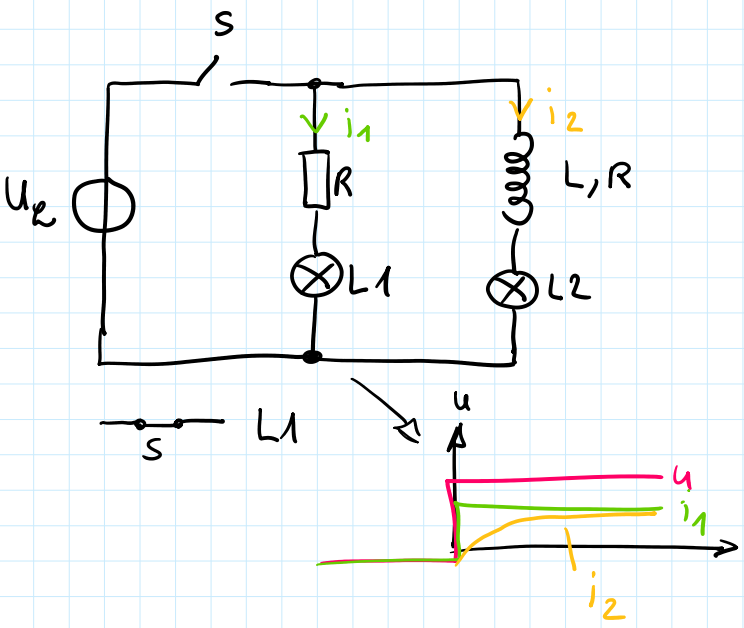
$$U_{12} = N \cdot \frac{d\Phi}{dt}$$

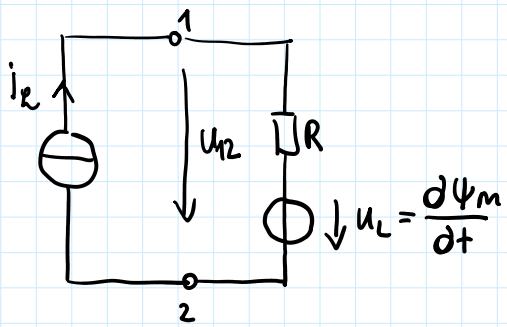
$$\boxed{\Psi_m = \sum_{k=1}^{N} \Phi_k}$$

2. Maxwellsche Gleichung $\oint \vec{E} d\vec{s} = -\frac{d}{dt} \int_A \vec{B} d\vec{A}$

## SELBSTINDUKTION




DC: $\frac{d\Psi_m}{dt} = 0 \rightarrow U_L = 0 \quad U_{12} = R \cdot i_R$

AC: $\frac{d\Psi_m}{dt} \neq 0 \quad U_{12} = R \cdot i + \frac{d\Psi_m}{dt}$

/ $\frac{di}{dt} > 0 \quad U_L > 0$ L ≙ Verbraucher (Aufbau Magnetfeld)

\ $\frac{di}{dt} < 0 \quad U_L < 0$ L ≙ Erzeuger (Abbau Magnetfeld)

$$L = \frac{\Psi_m}{I} \qquad [L] = 1\,H$$

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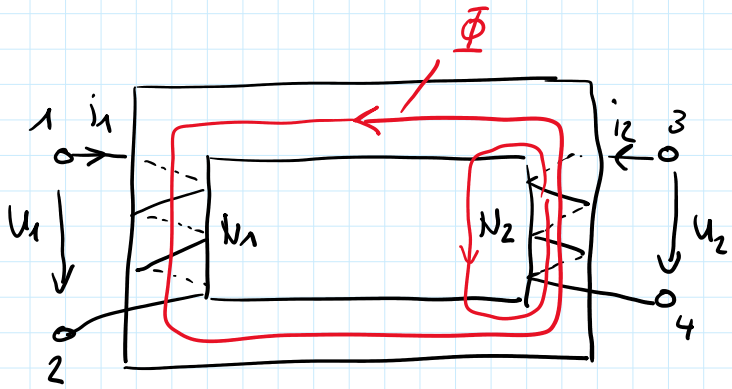
Spezialfall Spule $\Psi_m = N \cdot \Phi \Rightarrow L = N\frac{\Phi}{I}$ $(N\Phi = L \cdot I)$

$$u_L = \frac{d\Psi_m}{dt} = \frac{d(L \cdot i)}{dt} = L\frac{di}{dt}$$

## ÜBERTRAGER




$$u_1 = L_1 \cdot \frac{di_1}{dt} + L_{12} \cdot \frac{di_2}{dt}$$

$$u_2 = L_2 \cdot \frac{di_2}{dt} + L_{12} \cdot \frac{di_1}{dt}$$

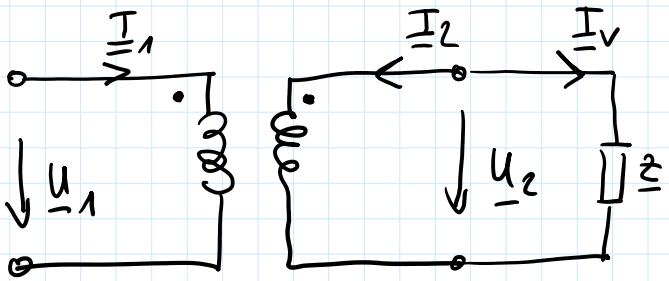
Verlustlos + sinusförmige Größe

$$\underline{U}_1 = j\omega L_1 \underline{I}_1 + j\omega L_{12} \underline{I}_2$$

$$\underline{U}_2 = j\omega L_2 \underline{I}_2 + j\omega L_{12} \underline{I}_1$$

ideder Übertrager
- $U_1/U_2$ = konst.
- Energiefluss o. Verlust/Speicherung

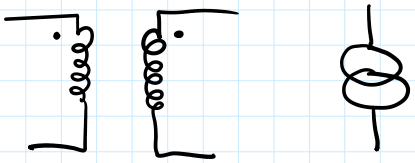
$$\frac{\underline{U}_1}{\underline{U}_2} = \sqrt{\frac{L_1}{L_2}} = \frac{N_1}{N_2} = \ddot{u} \qquad \frac{\underline{I}_1}{\underline{I}_2} = -\frac{1}{\ddot{u}}$$




$$\underline{Z}_e = \frac{\underline{U}_1}{\underline{I}_1} = \frac{\ddot{u}^2 \underline{U}_2}{-\underline{I}_2} = \ddot{u}^2 \frac{\underline{U}_2}{\underline{I}_V} =$$

$$= \ddot{u}^2 \cdot \underline{Z}$$

## TRANSFORMATOR



Primär → Sekundär nicht eng

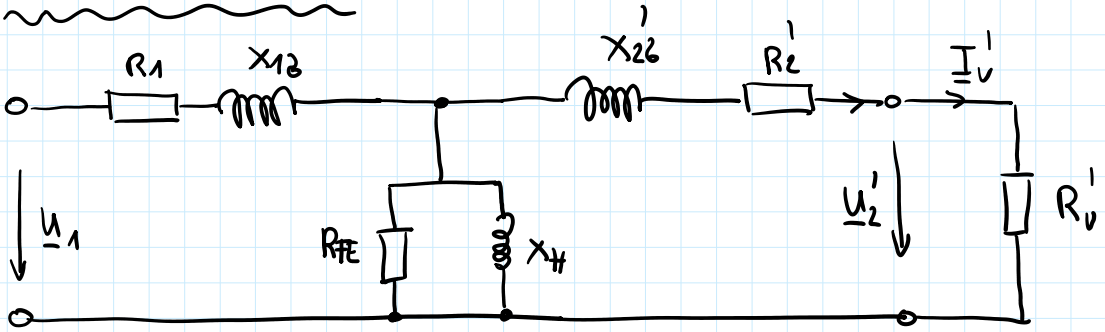
$$\frac{\underline{U}_1}{\underline{U}_2} = \sqrt{\frac{L_1}{L_2}} = \frac{N_1}{N_2} = \ddot{u} \qquad \frac{\underline{I}_1}{\underline{I}_2} = -\frac{1}{\ddot{u}}$$

$$\frac{U_1}{U_2} = \sqrt{\frac{L_1}{L_2}} = \frac{N_1}{N_2} = \ddot{u} \qquad \frac{I_1}{I_2} = -\frac{1}{\ddot{u}}$$

ideal – realer Transformator

- streng magnet. Fluss
- Stromwärme – Eisenverluste
- Magnetisierungsstrom für Erregung Hauptfluss

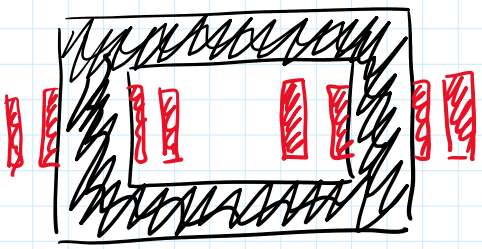
Ersatzschaltbild



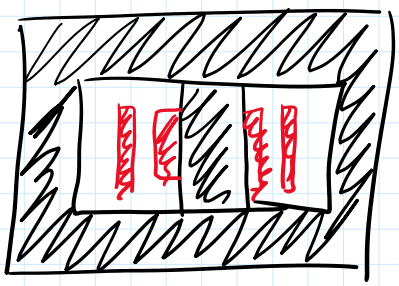

$$R_2' = \ddot{u}^2 R_2 \qquad X_{26}' = \ddot{u}^2 X_{26}$$

$$U_2' = \ddot{u} U_2 \qquad I_V' = \frac{I_V}{\ddot{u}}$$

Bauform Kerntyp



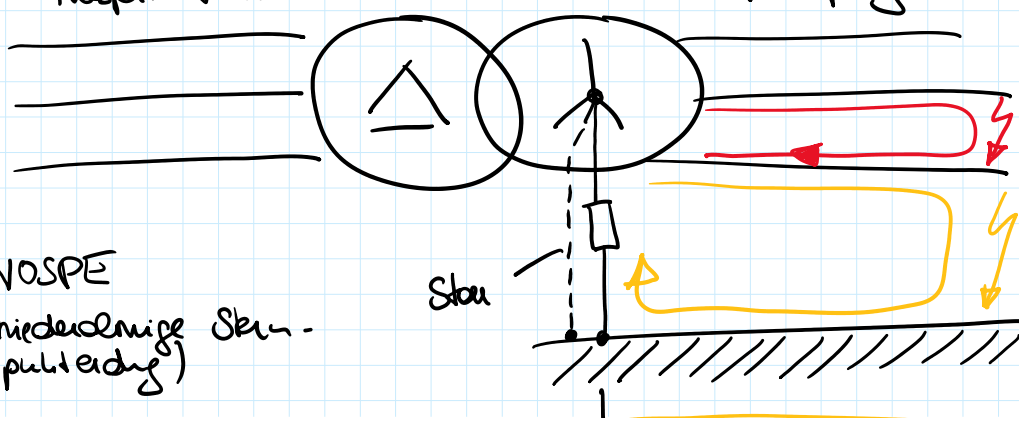
Manteltyp



STERNPUNKTERDUNG

Transformator Mobil

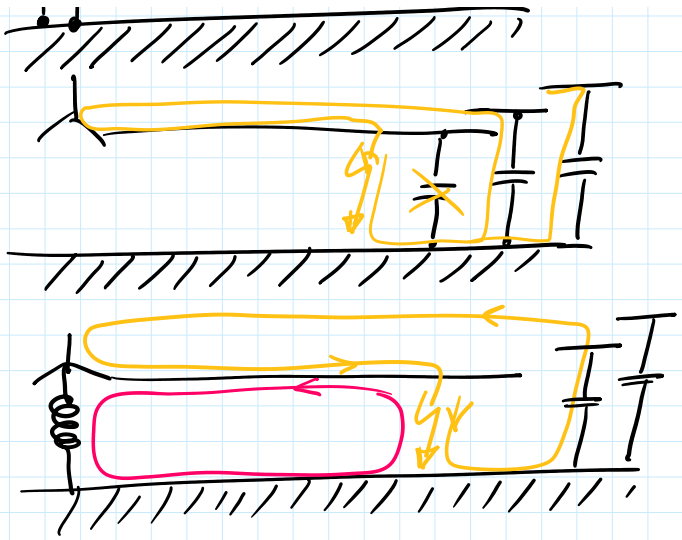
Mittelspannung 20kV




NOSPE
(niederohmige Sternpunkterdung)

(mehrfache Ort-
punktierung)

isoliert



RESPE (gelöschte)
Resonanzpunktierung