INVESTICE DO ROZVOJE VZDĚLÁVÁNÍ

Název projektu**: Automatizace výrobních procesů ve strojírenství a řemeslech**
Registrační číslo: **CZ.1.07/1.1.30/01.0038**
Příjemce: **SPŠ strojnická a SOŠ profesora Švejcara Plzeň, Klatovská 109**
Tento projekt je spolufinancován Evropskou unií a státním rozpočtem České republiky

Produkt:

Zavádění cizojazyčné terminologie do výuky odborných předmětů a do laboratorních cvičení

Transformers

Návod v anglickém jazyce

Číslo tématu: **6b**

Monitorovací indikátor: **06.43.10**

INSTRUCTIONS FOR TOPIC: 6b

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Subject: Measurement and diagnostics

Year: 3.

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Transformers

Introduction

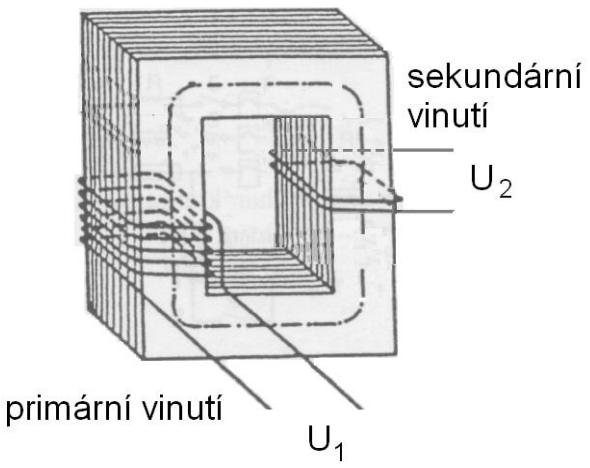
- Transformer is an electrical non-rotating machine
- It works on a principle of electromagnetic induction (Faraday's law of induction)
- It converts AC voltage to AC voltage of different intensity (or the same intensity in case of isolation transformer)
- Transformation ratio p

$$p = \frac{U_1}{U_2} = \frac{N_1}{N_2} = \frac{I_2}{I_1}$$

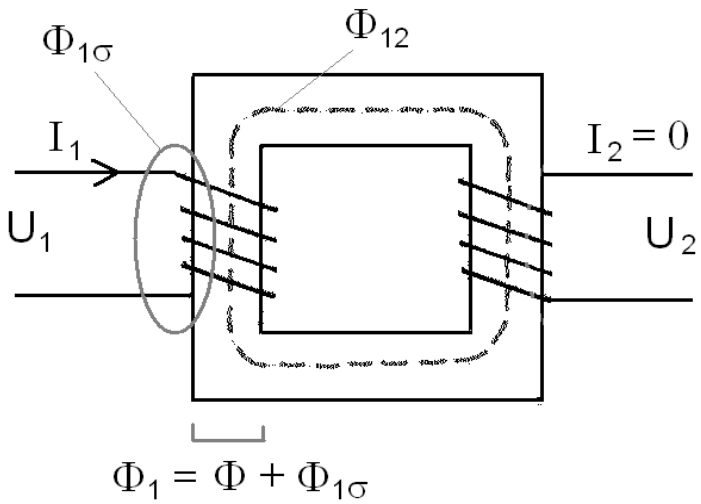
Single Phase Transformer

Basic parts of a transformer:

- magnetic circuit made of transformer sheets
- windings (primary and secondary)



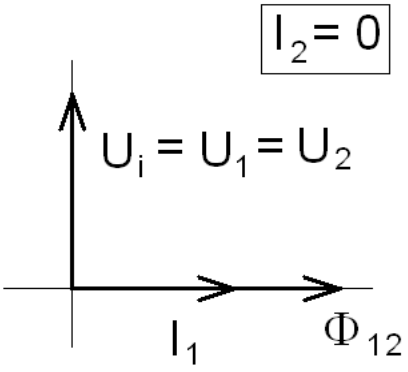
Unloaded Transformer



Magnetic flux changes sinusoidally in a time period and its course is 90° delayed after the voltage U1.

Magnetic fluxes of an unloaded transformer $\Phi 1 \Phi\ 21 \Phi\ \sigma 1$ are real, caused by current I1

Phasor Diagram of Ideal Unloaded Transformer



The resistence of winding, leakage flows and the losses of iron are neglected.

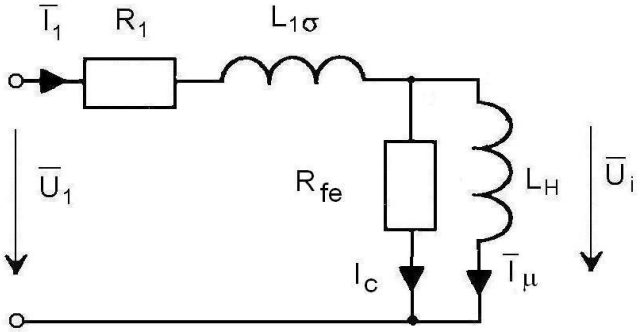
Basic Relations of Ideal Transformer:

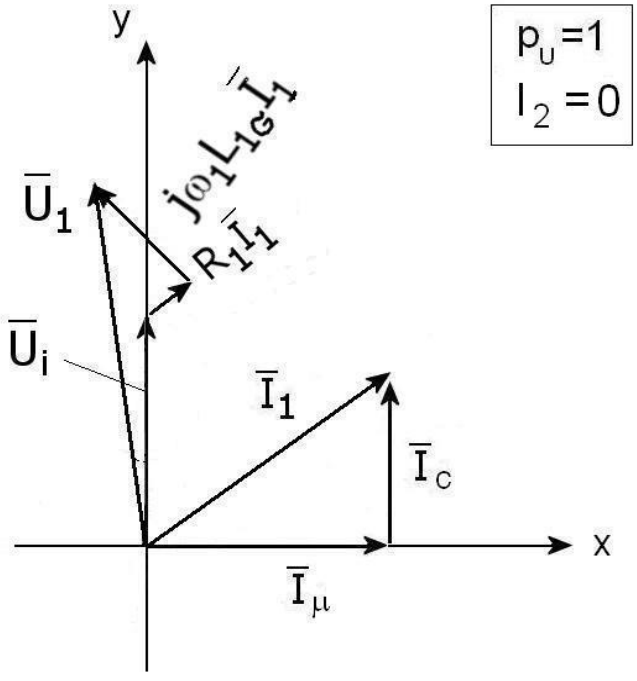
$R_1 = R_2 = 0$ $\Phi_{1\sigma} = \Phi_{2\sigma} = 0$

$U_1 = N_1 \frac{d\Phi}{dt}$ $U_2 = N_2 \frac{d\Phi}{dt}$

$U_1 I_1 = U_2 I_2 \Rightarrow \frac{I_1}{I_2} = \frac{N_2}{N_1}$ $\frac{U_1}{U_2} = \frac{N_1}{N_2}$

Phasor Diagram of Real Unloaded Transformer





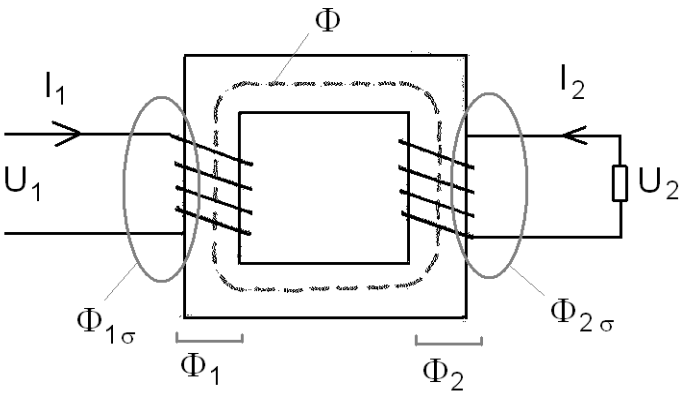
Formula of Effective Value of Induced Voltage:

$$U_i = N\frac{d\Phi}{dt} \qquad \Phi = \Phi_m e^{j\omega t}$$

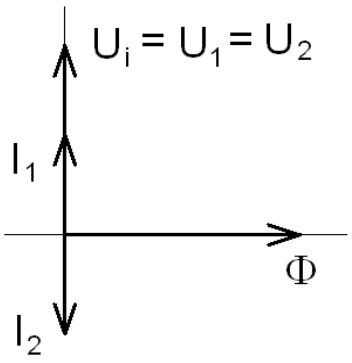
$$U_i = j\omega N\Phi_m e^{j\omega t} \qquad U_{i\max} = N\Phi_m 2\pi f$$

$$U_{ief} = \frac{U_{i\max}}{\sqrt{2}} = \frac{N\Phi_m 2\pi f}{\sqrt{2}} = 4{,}44\, fN\Phi_m$$

Ideal Loaded Transformer:

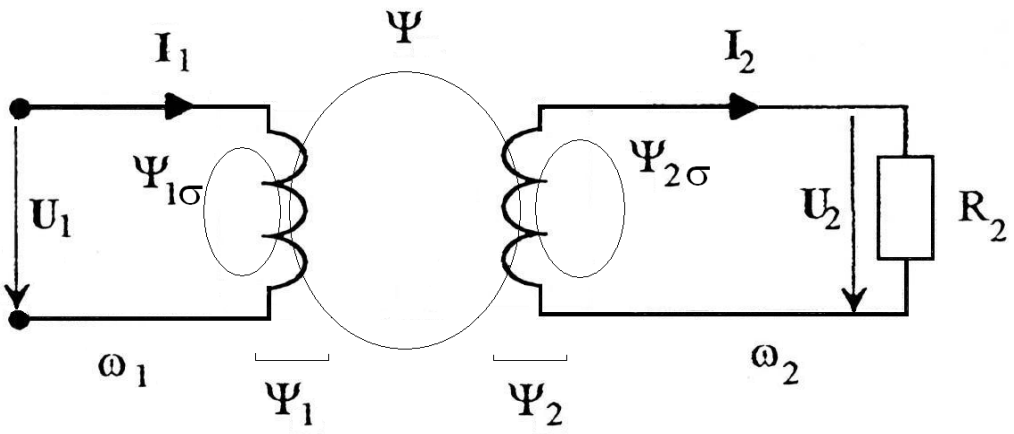


$\Phi_1 = \Phi + \Phi_{1\sigma}$ $\Phi_2 = \Phi + \Phi_{2\sigma}$



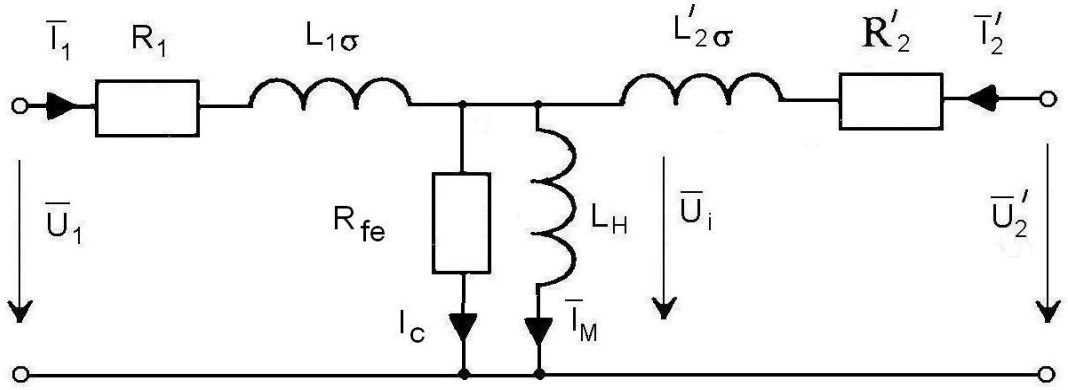
Magnetic fluxes of a loaded transformer $\Phi 1\Phi\ 2\Phi\ 21\Phi\ 12$ are fictive fluxes. The other fluxes are real.

Equivalent Circuit of Loaded Transformer :

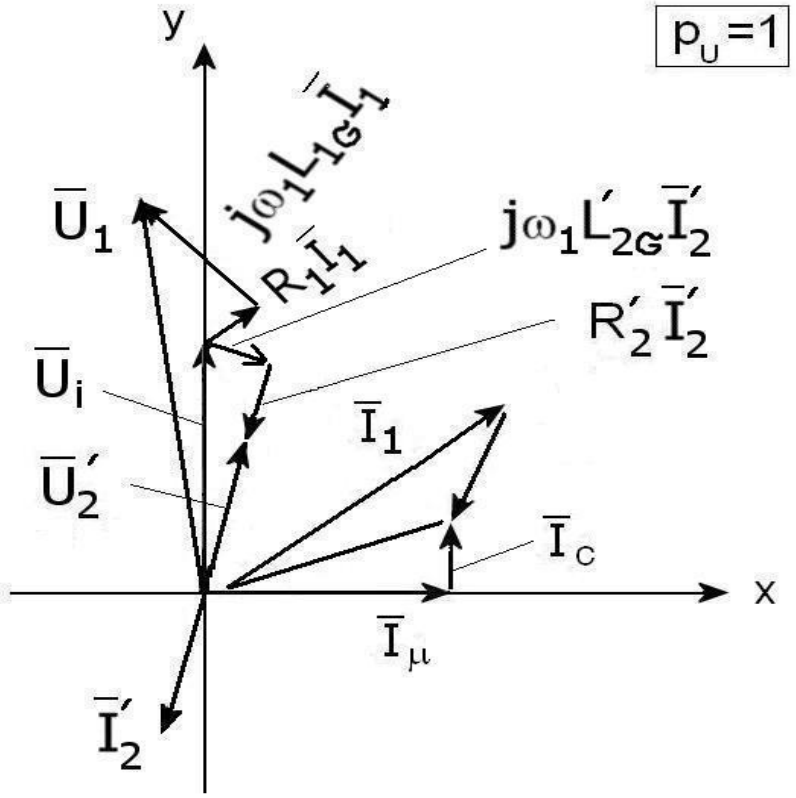


Pouze magnetický tok Φ přenáší energii ze strany primární na stranu sekundární.

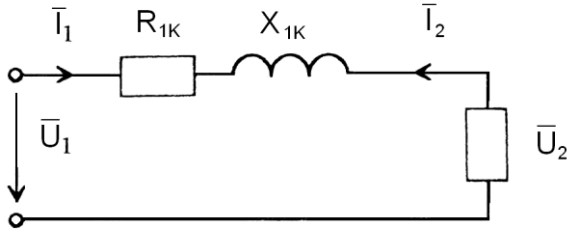
Full Equivalent Circuit of Loaded Transformer:

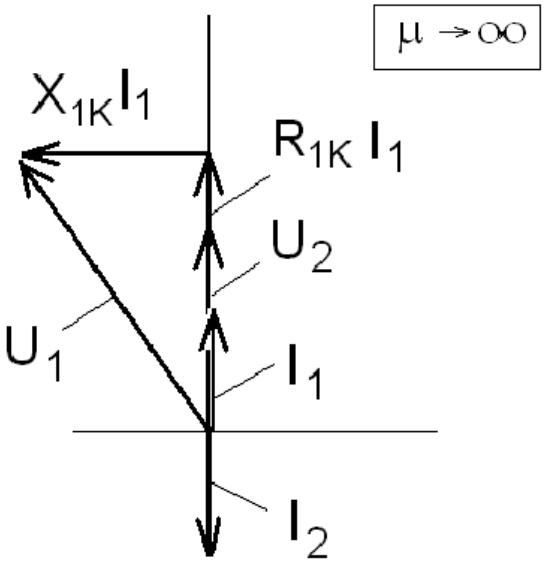


Full Phasor Diagram of Loaded Transformer:



Simplified Equivalent Circuit of Loaded Transformer :

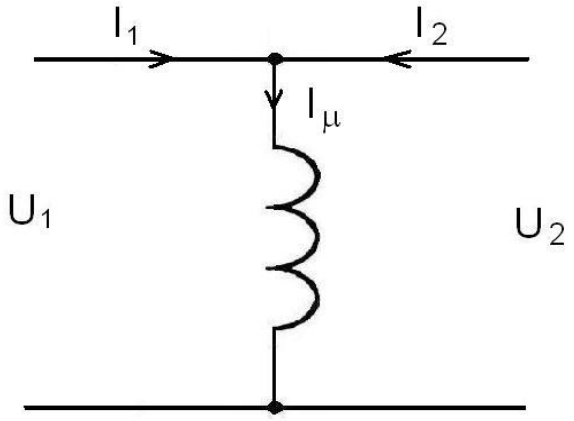


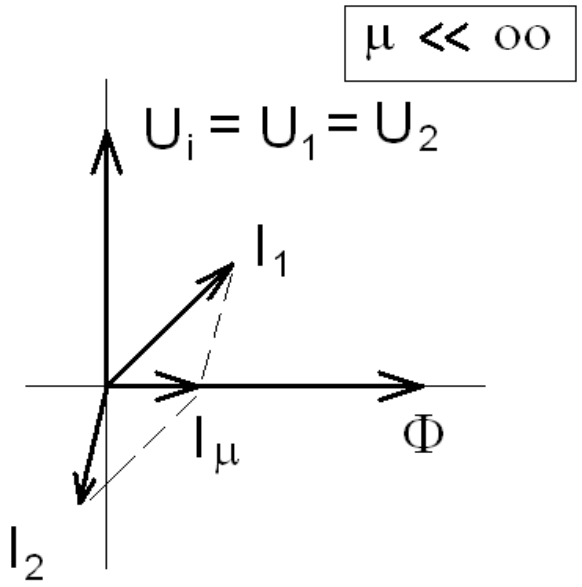


At large transformers the values R_1, R_2, $X_1\sigma$, $X_2\sigma$ are low and the values X_{12} a R_{fe} high.

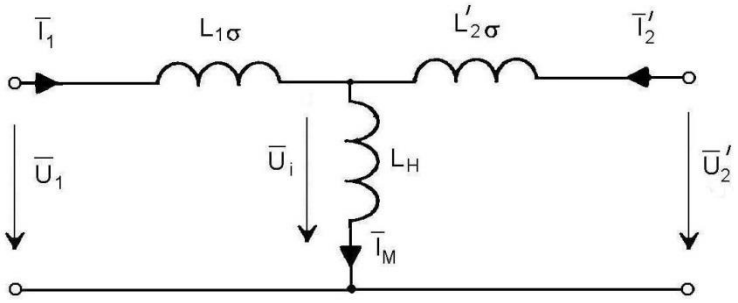
Therefore it is possible to use following simplification:

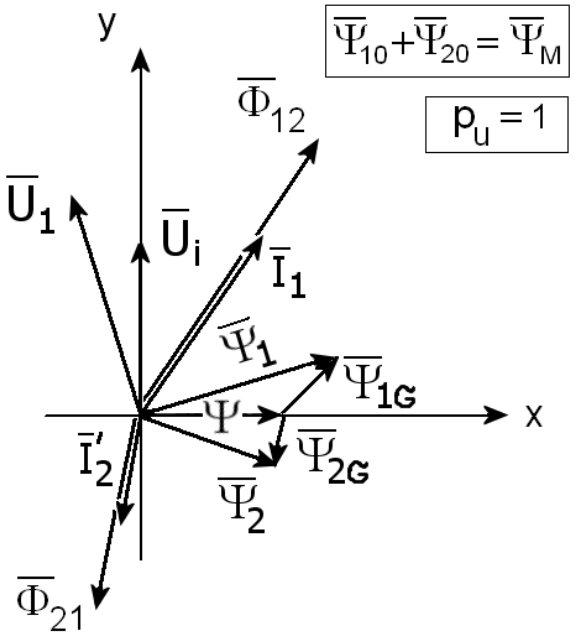
$X_{1K} = X_{1\sigma} + X_{2\sigma}$ $\quad$ $R_{1K} = R_1 + R_2$



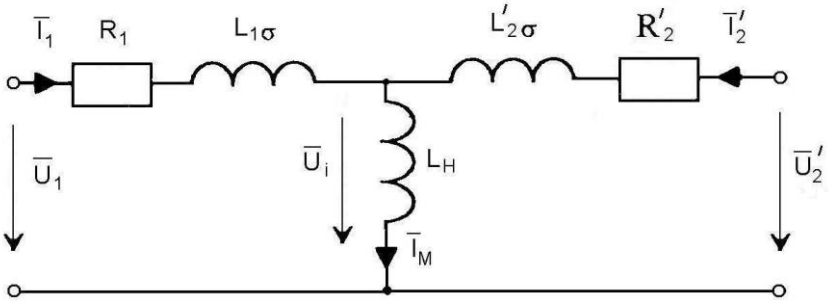


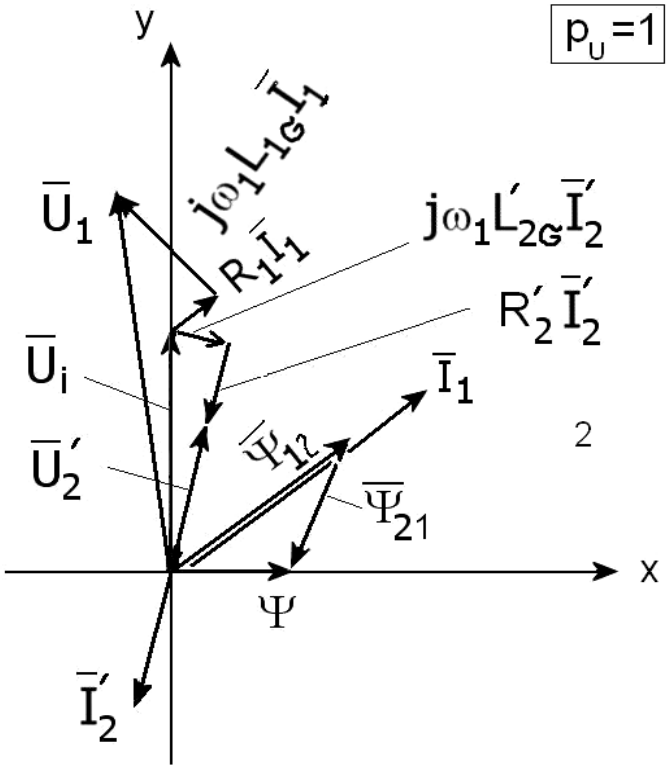
The resistence of windings, iron losses and leakage inductance are neglected.



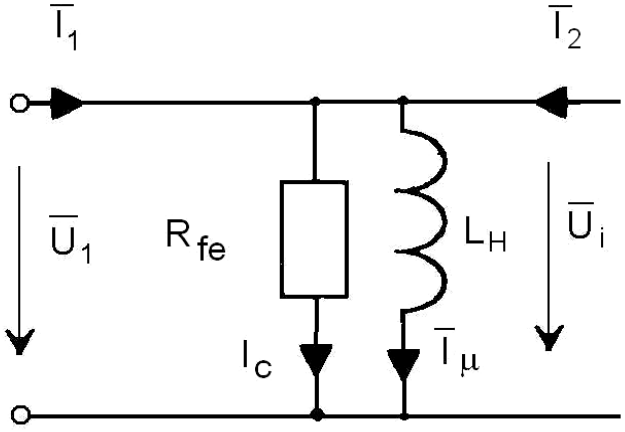


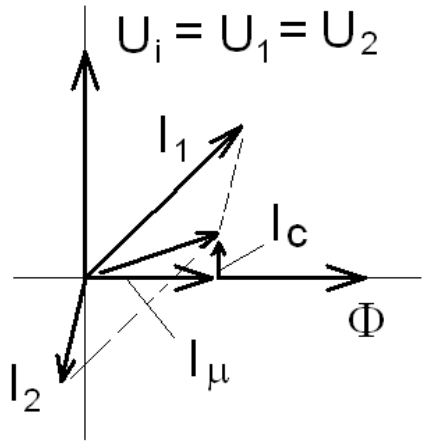
The resistence of winding and iron losses are neglected.



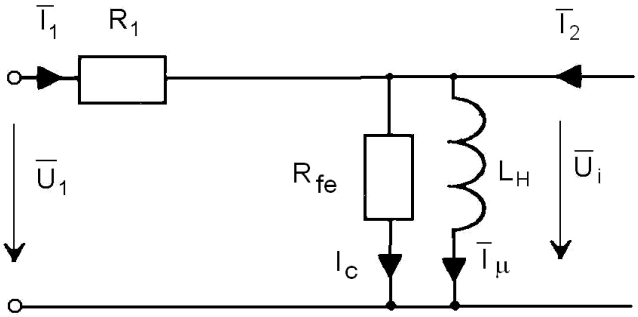


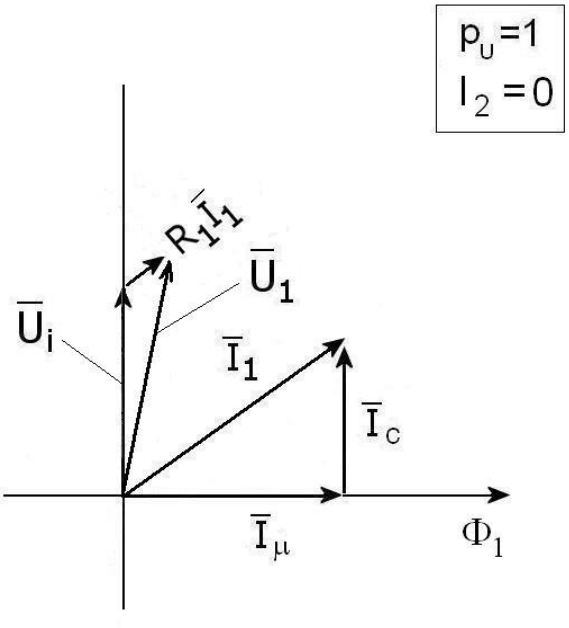
Iron losses are neglected in this case.





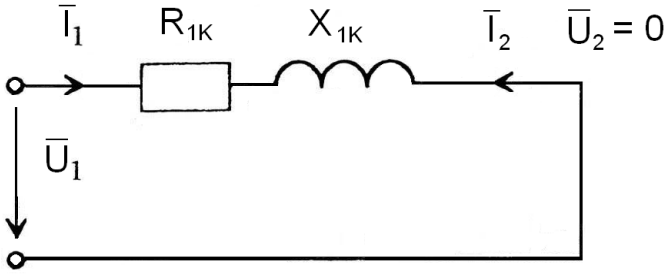
The resistance of windings and the leakage inductance are neglected.

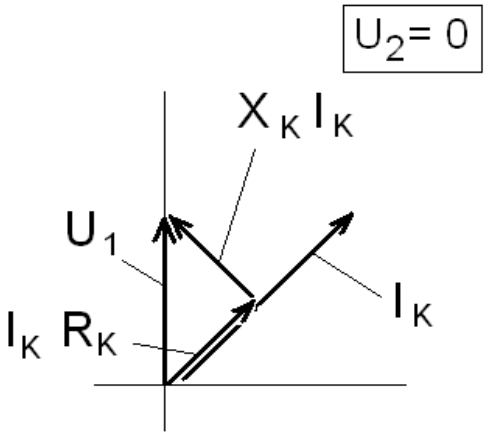




Leakage inductance is neglected.

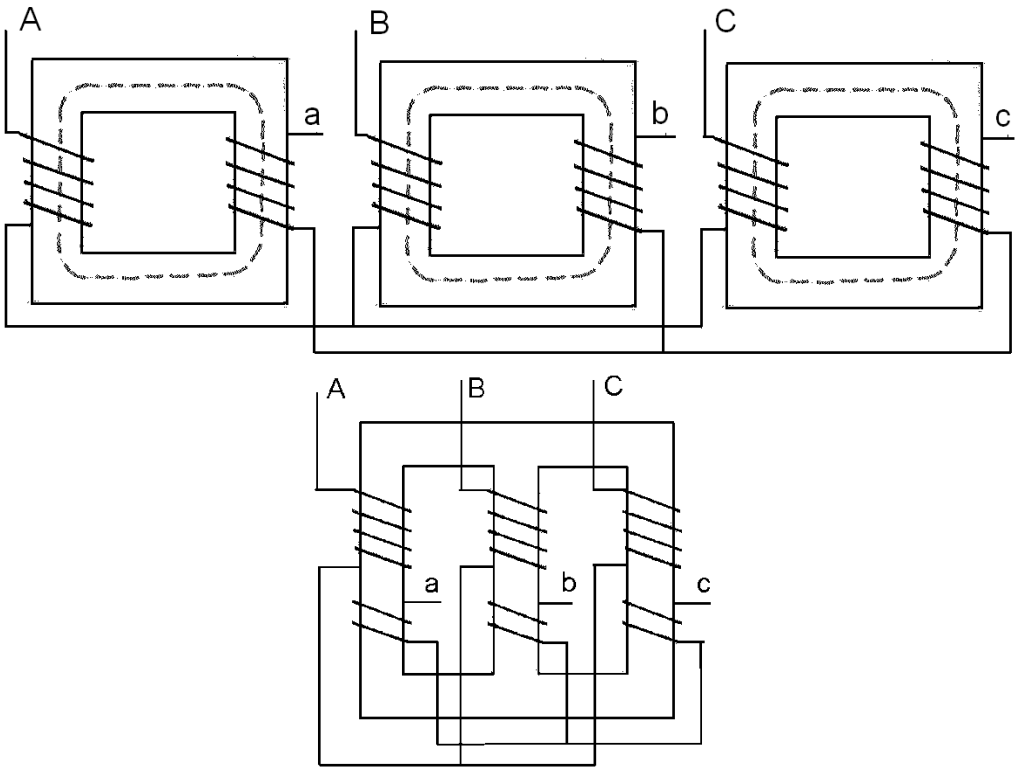
Transformer in Short Circuit





Iron losses are neglected in this case.

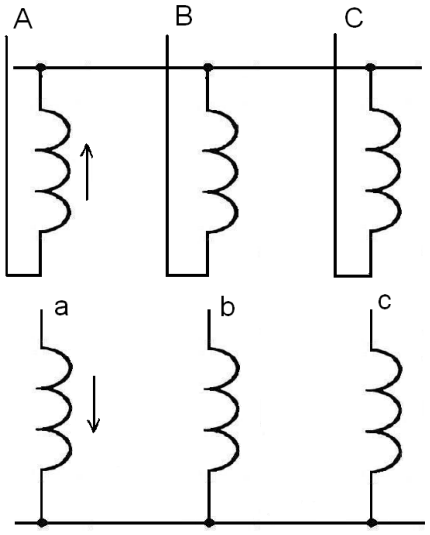
Three-phase Transformer:

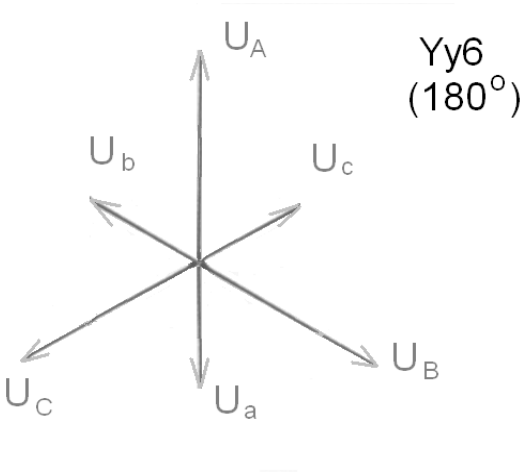


Possible Winding Circuits of Three-phase Transformer- Hour Angle

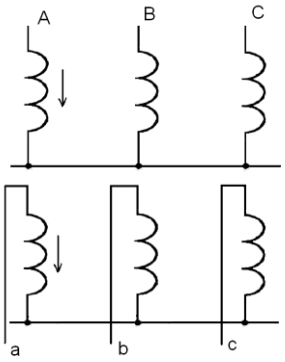
- Dd: 0 1 2 4 6 8 10
- Dy: 5 7 11
- Dz: 0 2 4 6 8 10
- Yd: 1 5 7 11
- Yy: 0 6
- Yz: 1 5 7 11

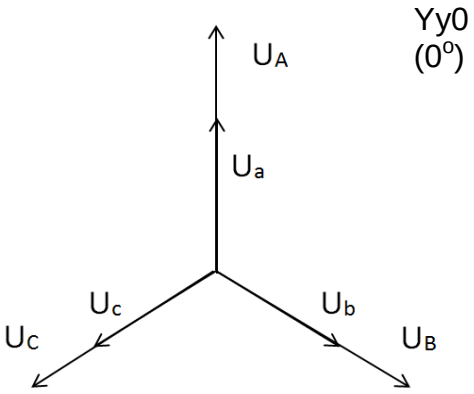
Examples of Winding Circuits of Three-phase Transformer – Yy6



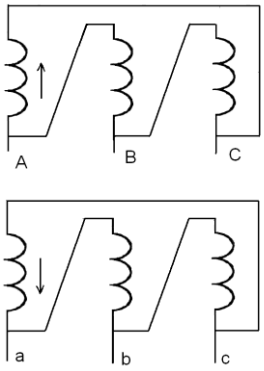


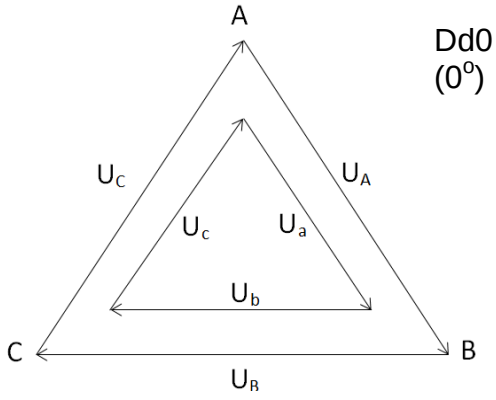
Examples of Winding Circuits of Three-phase Transformer – Yy0



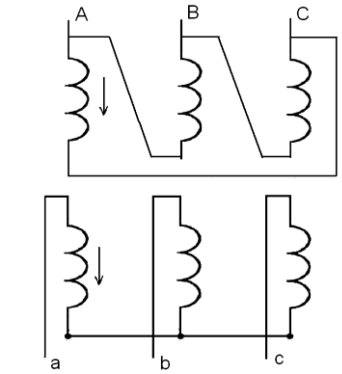


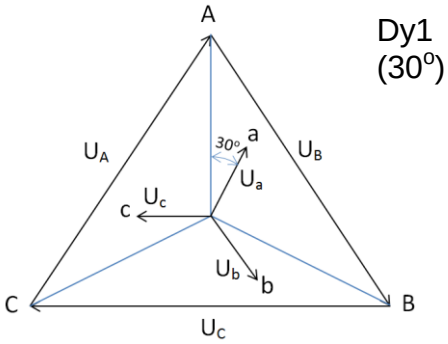
Examples of Winding Circuits of Three-phase Transformer – Dd0





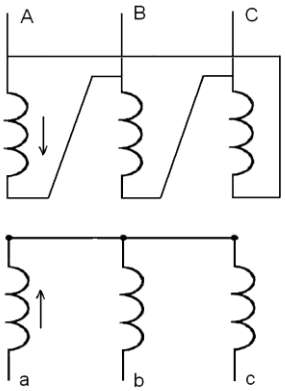
Examples of Winding Circuits of Three-phase Transformer – Dy1

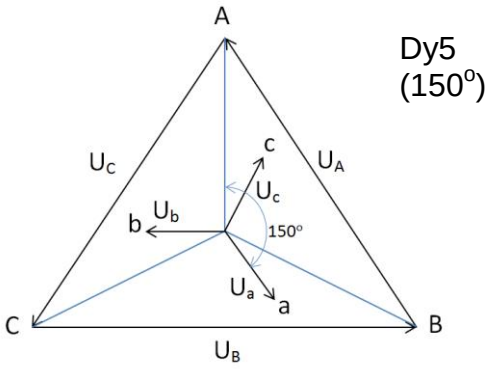




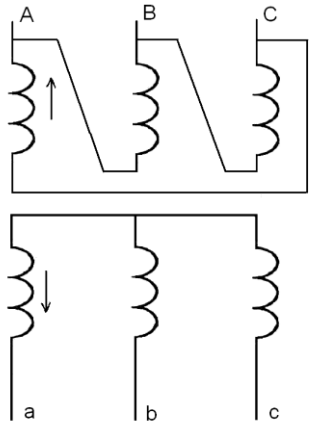
Dy1
(30^o)

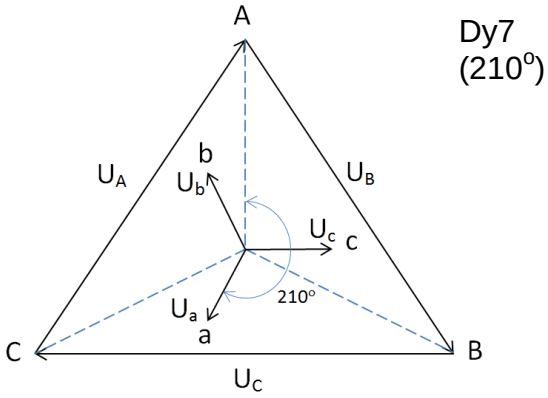
Examples of Winding Circuits of Three-phase Transformer – Dy5





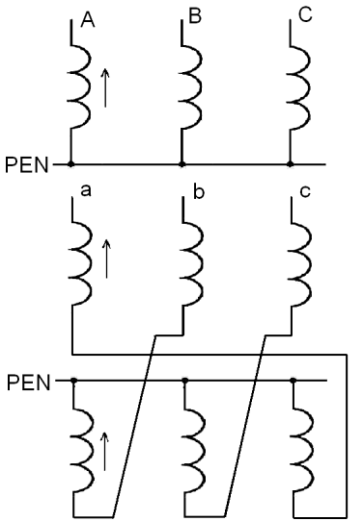
Examples of Winding Circuits of Three-phase Transformer – Dy7

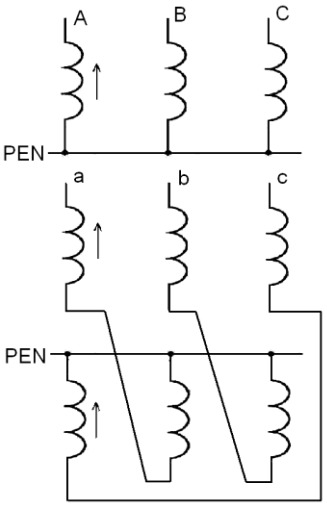




Secondary Winding Connected to Angled Star

- The secondary winding is divided into two stages and each one happens on a different core of the transformer.
- The advantage is that the phase voltage on the secondary side stays the same even if the transformer is asymmetrically loaded (that means there is current in a zero conductor).





Zdroje:

poznámky z předmětu *Základy teoretické elektrotechniky* - 2. semestr při ZČU Plzeň

BLAHOVEC, A., *Elektrotechnika I,* Praha: Informatorium s.r.o., 2002. ISBN 978-80-7333-043-1.

BLAHOVEC, A., *Elektrotechnika II,* Praha: Informatorium s.r.o., 2002. ISBN 978-80-7333-044-6.

Transformátory - Transformers - slovníček odborných termínů

Vocabulary	Slovníček
transformátor	transformer
napětí	voltage
vinutí	winding
nezatížený transformátor	unloaded transformer
zatížený transformátor	loaded transformer
proud	current
magnetický tok	magnetic flux
rozptylová indukčnost	leakage inductance
elektromagnetická indukce	electromagnetic induction
odpor	resistance
zapojení	circuit