FACULTY OF ELECTRICAL
ENGINEERING
UNIVERSITY OF WEST BOHEMIA

EVROPSKÁ UNIE
Evropské strukturální a investiční fondy
Operační program Výzkum, vývoj a vzdělávání

MINISTERSTVO ŠKOLSTVÍ, MLÁDEŽE A TĚLOVÝCHOVY

ESF II – project of the University of West Bohemia
reg. no. CZ.02.2.69/0.0/0.0/18_056/0013239

Theory of Electric Machines 2

KEV/TS2

Karel Hruska / r20201118

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Potier Reactance

(De)Motivation

„Potier reactance…
I don’t like it too much, it’s kinda fiction.“

- prof. Ing. Václav Bartoš, CSc.

(De)Motivation

„Well, it is some value between leakage reactance and some different reactance, which is unknown.“

- doc. Ing. Josef Červený, CSc.

Potier Reactance

- Important for evaluation of synchronous machine properties
- Except leakage fluxes of stator and rotor it reflects also saturation effects
- It is derived graphically from the no-load characteristic and induction characteristic

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Potier Reactance

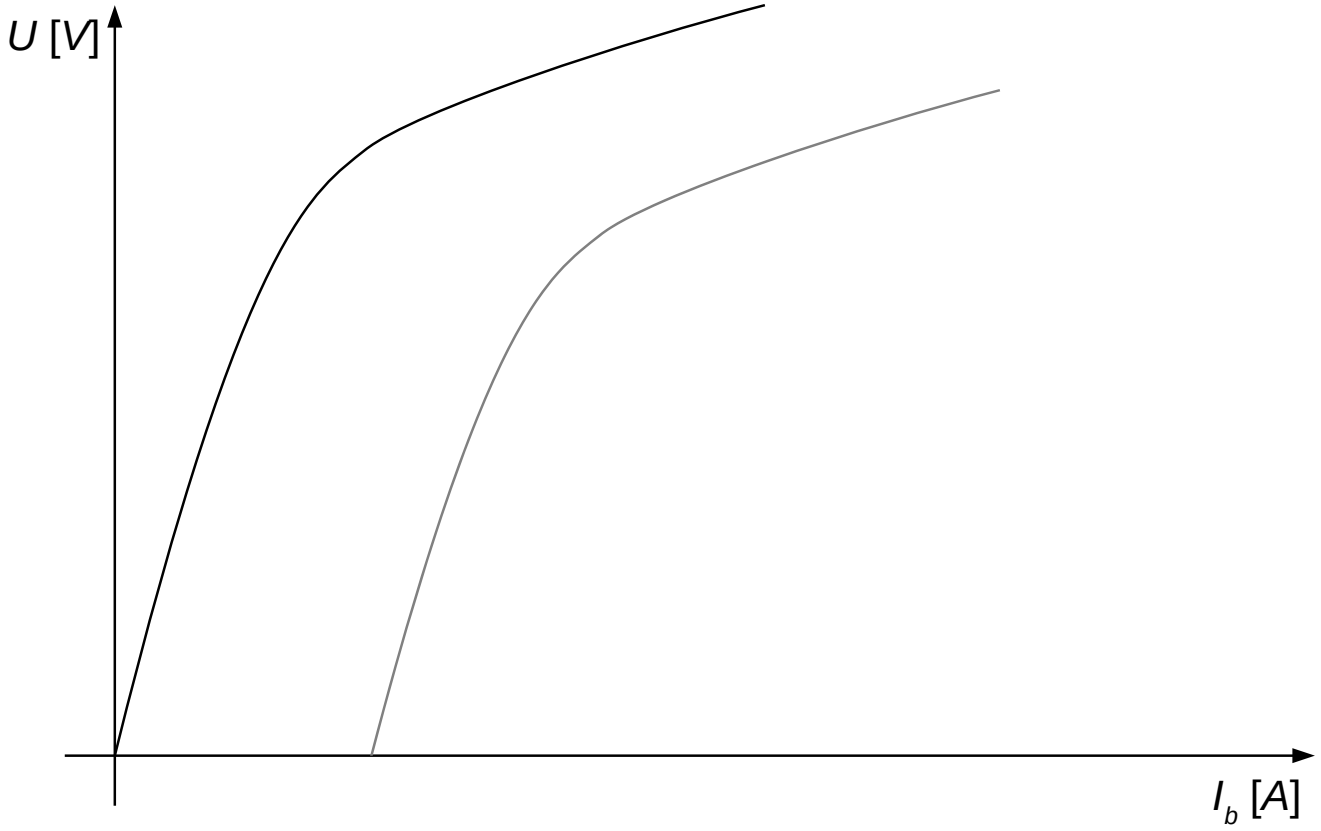
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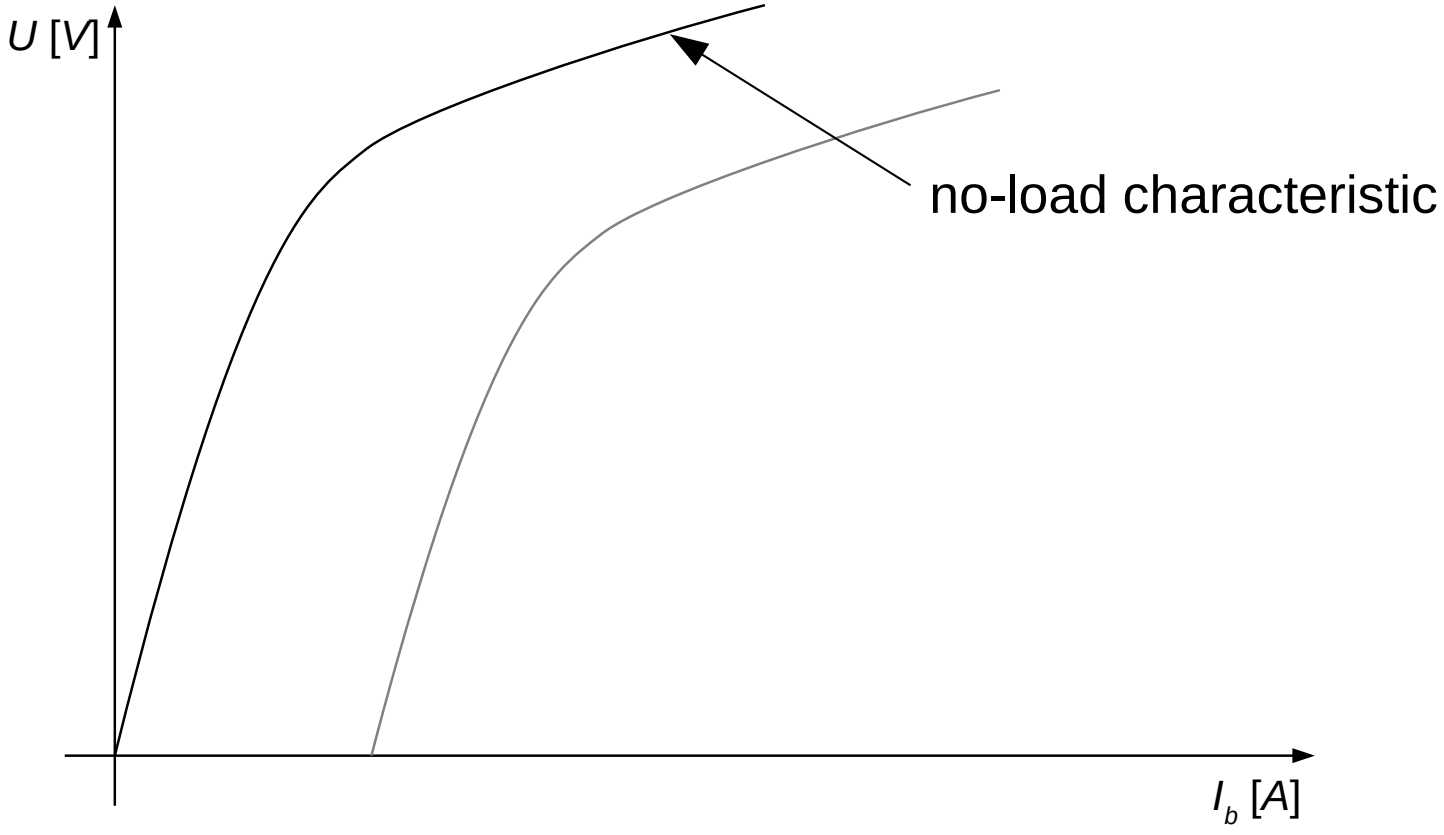
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…induction characteristic has identical shape as no-load characteristic, but it is moved downside right.

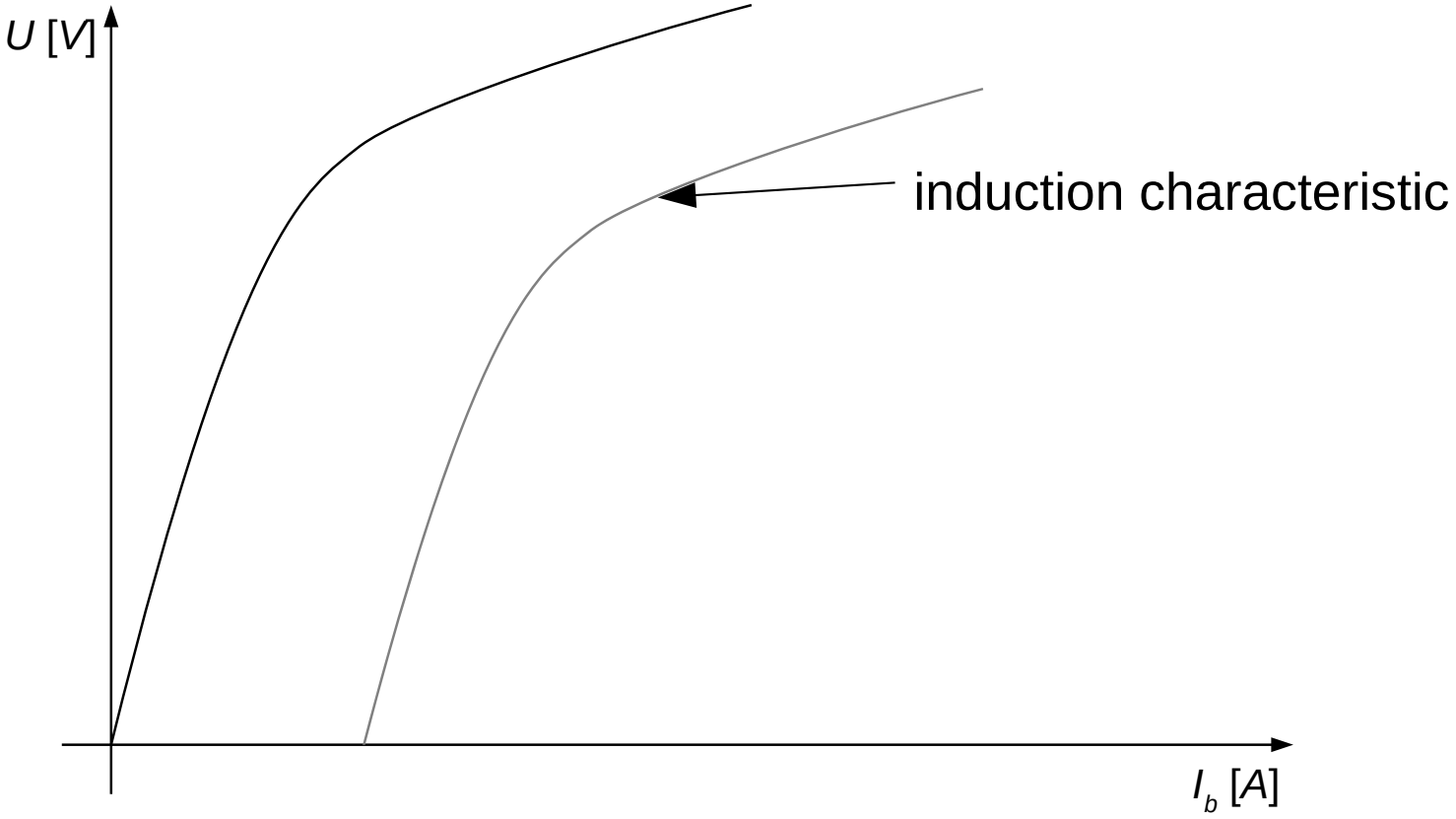
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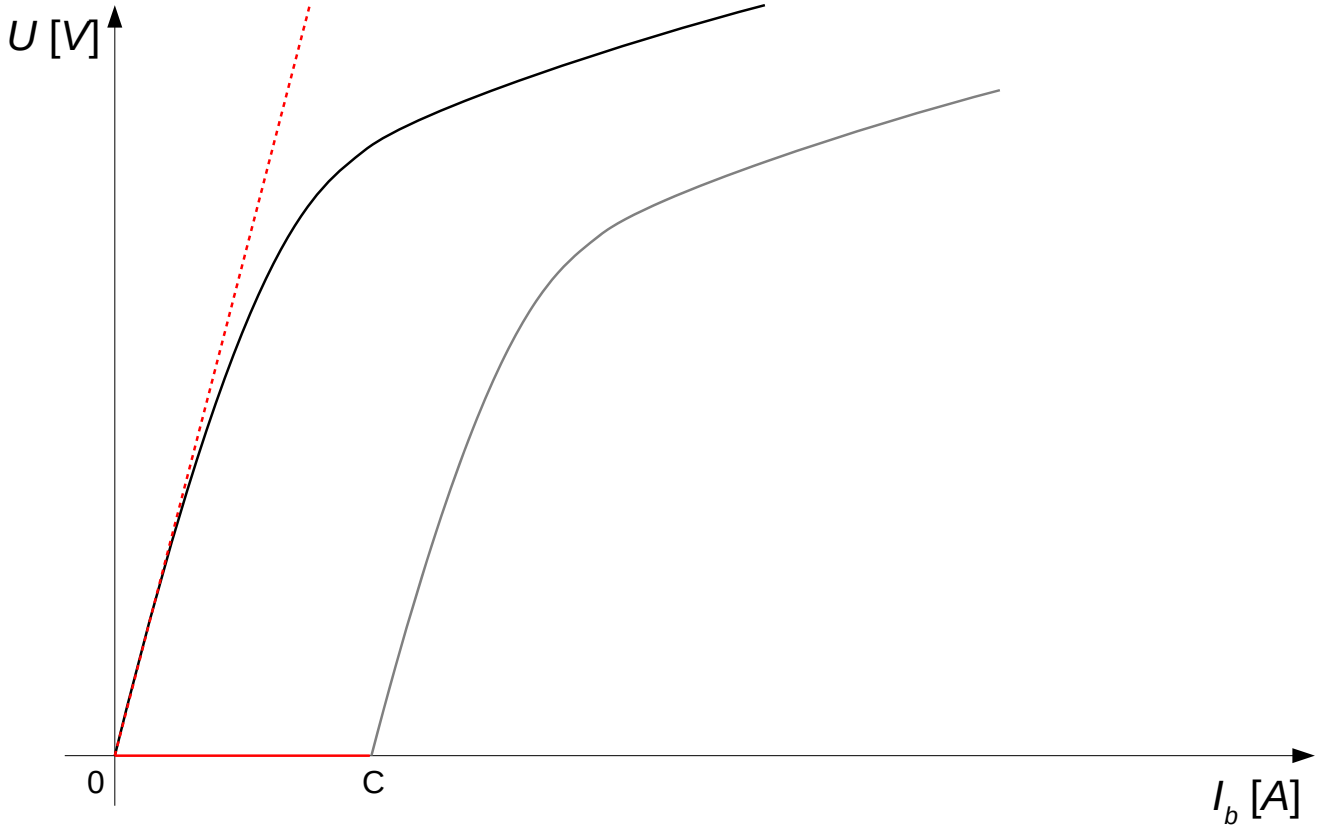
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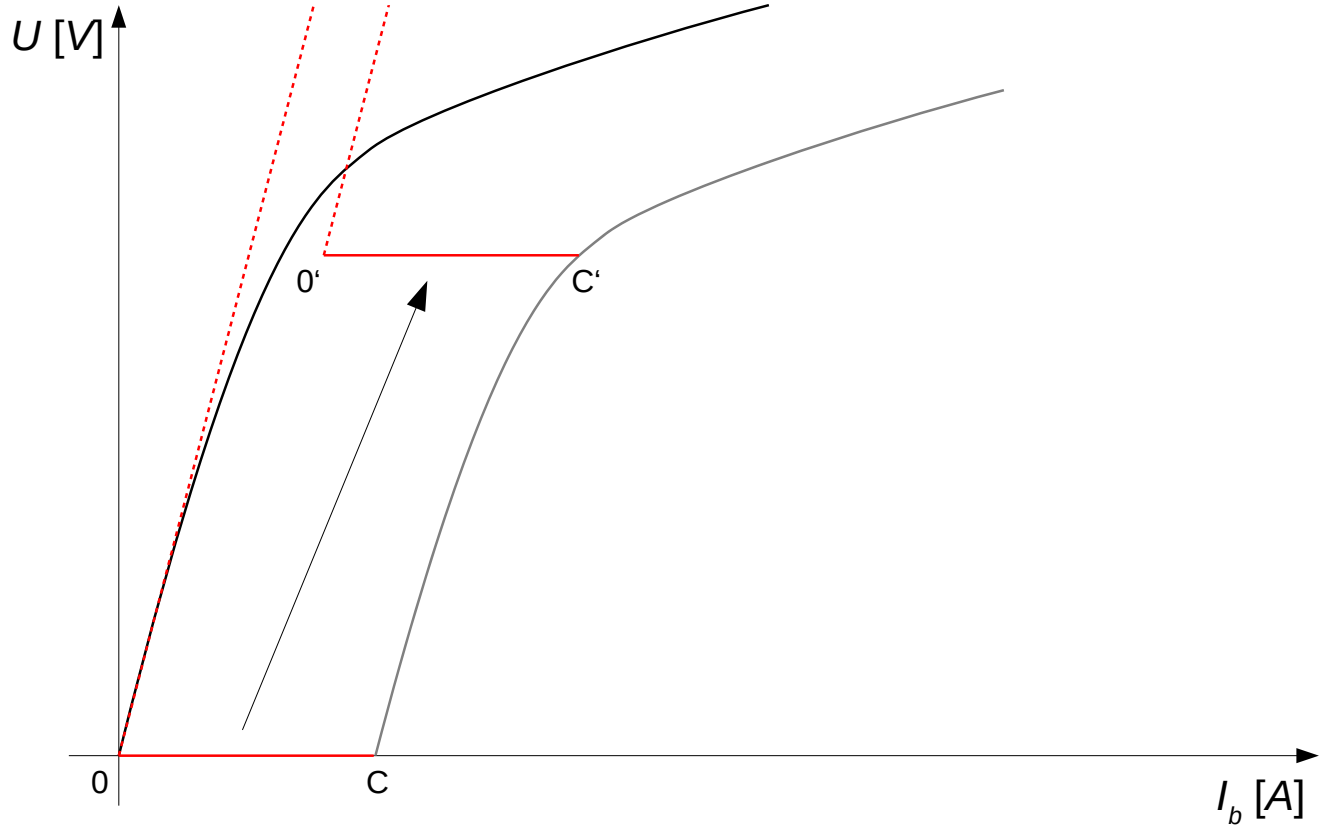
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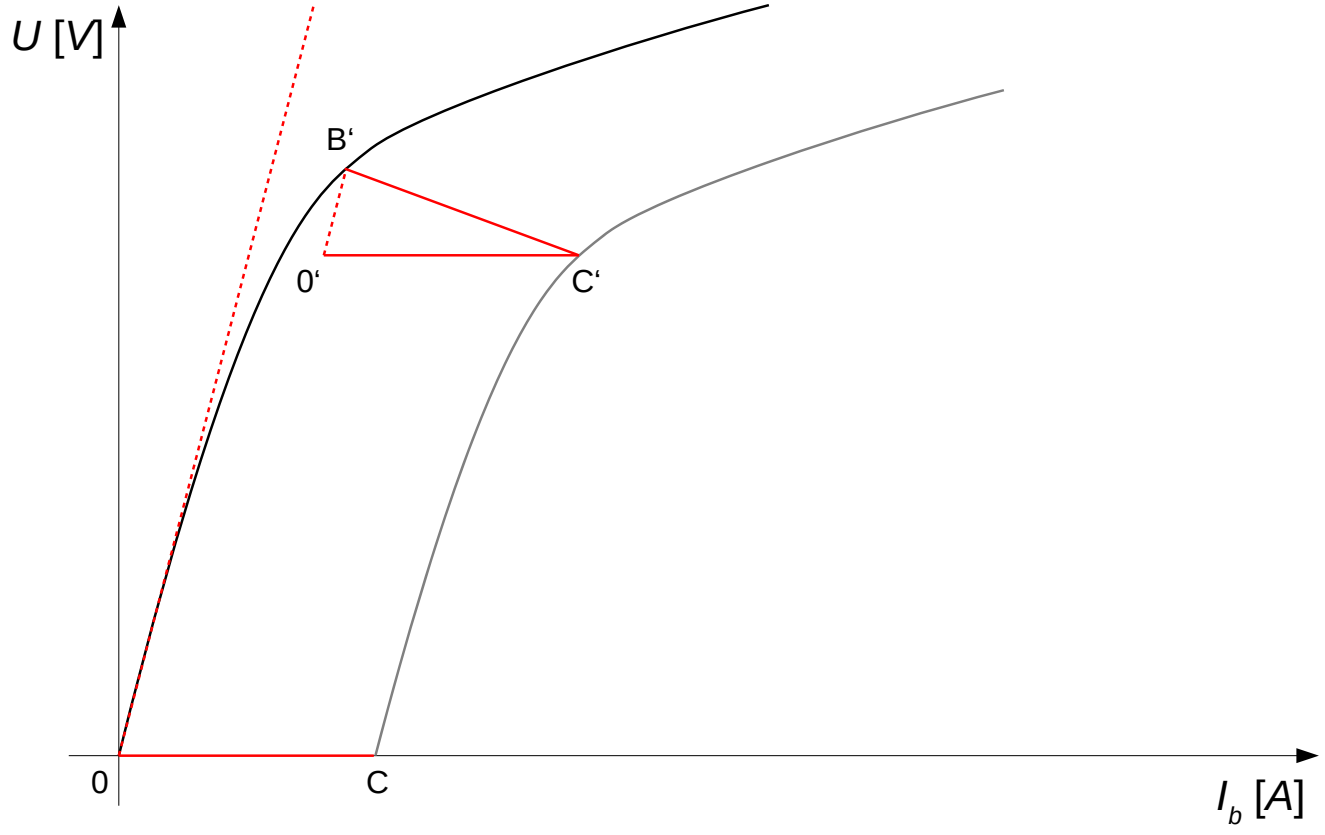
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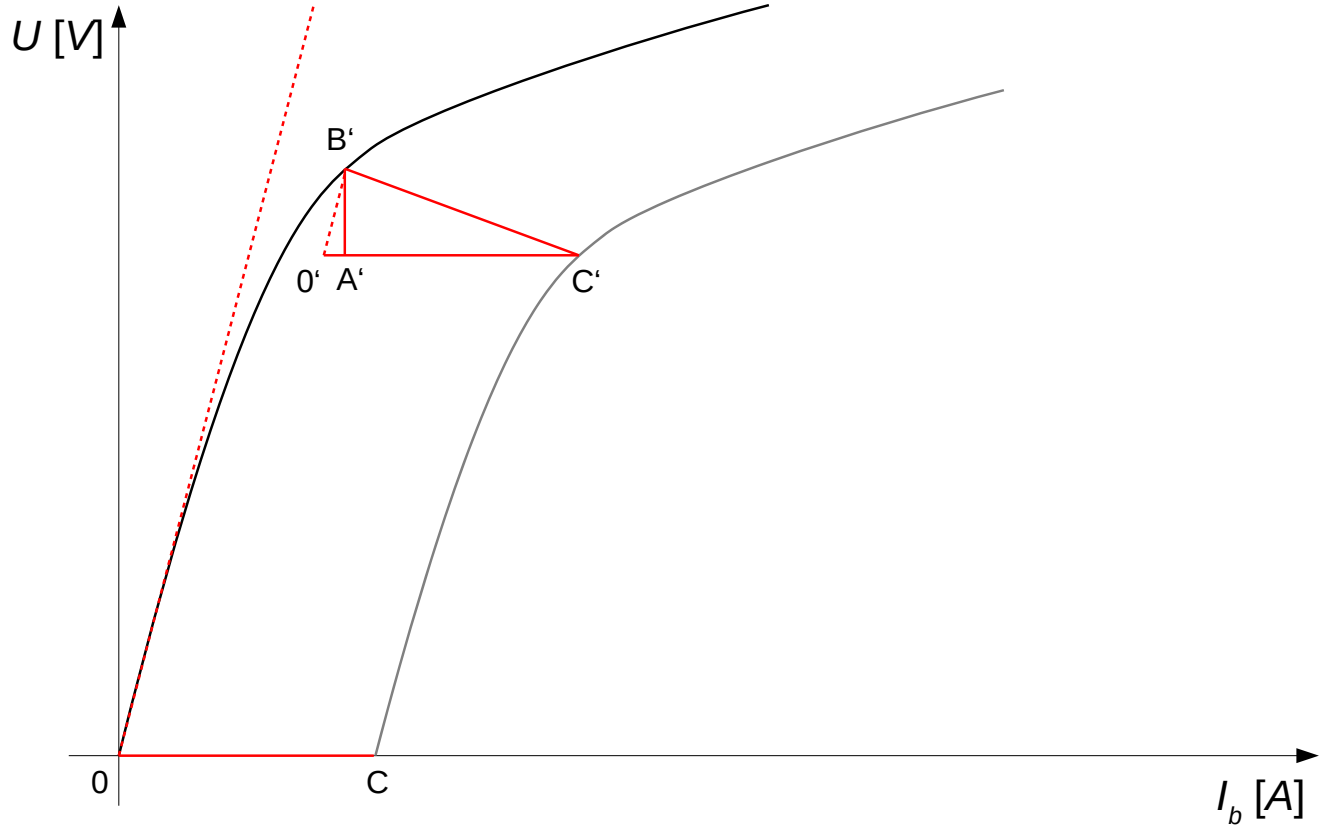
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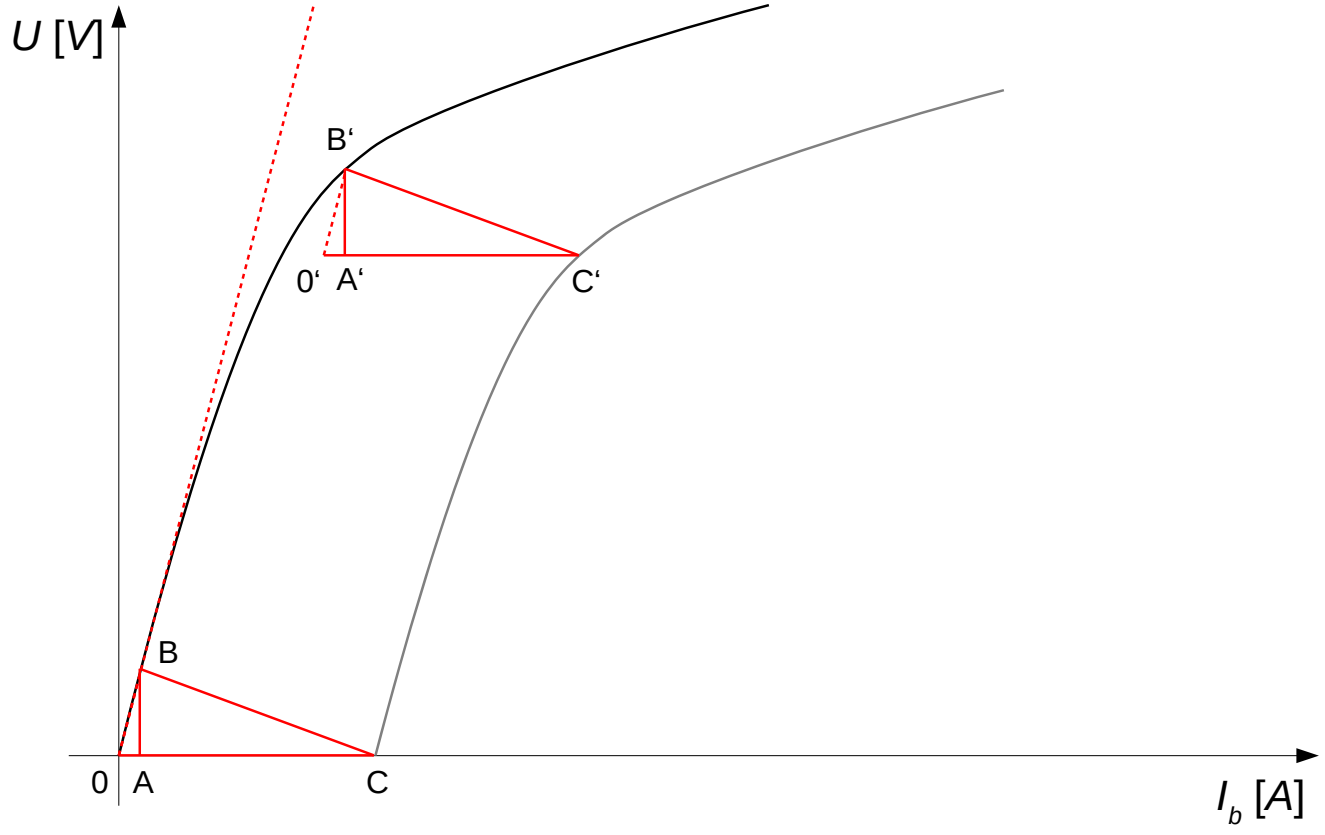
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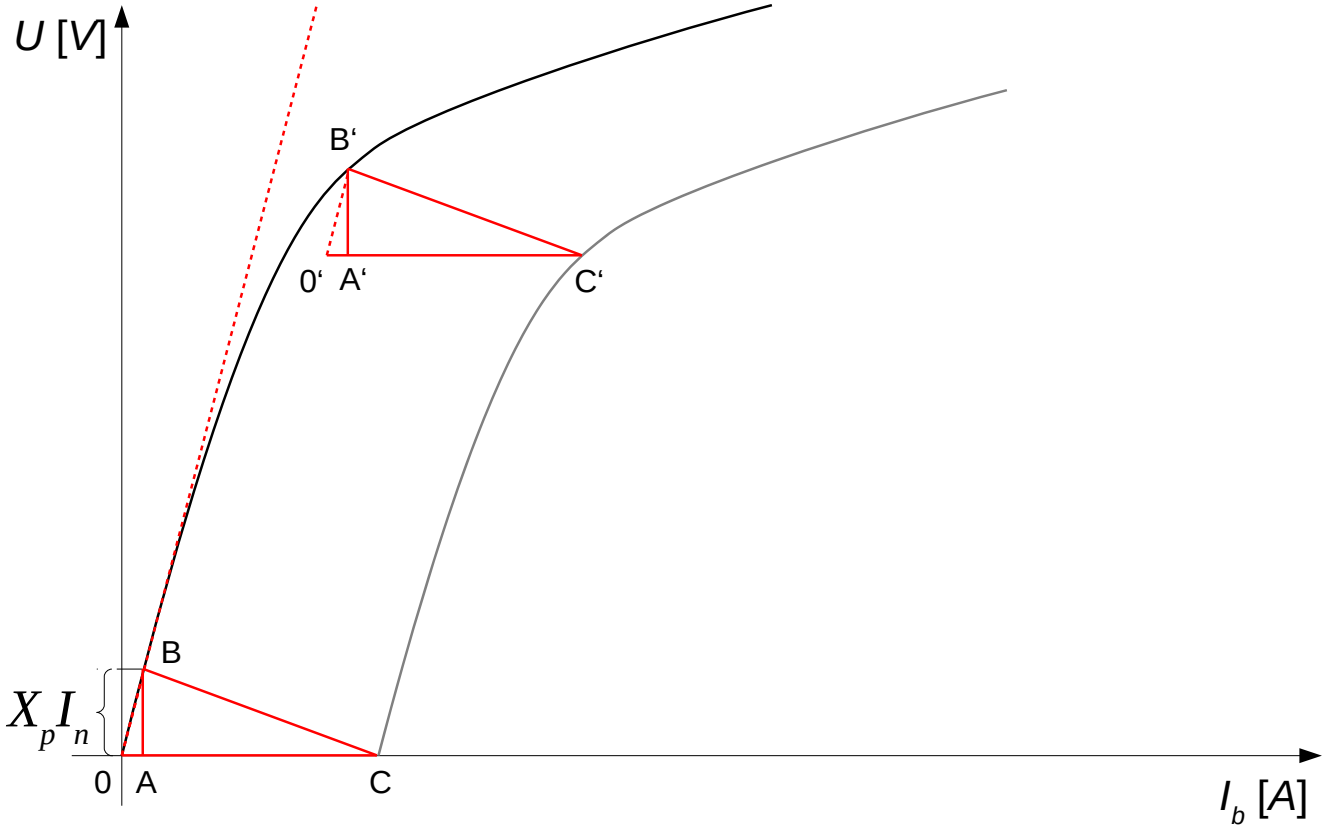
Potier Reactance



Potier Reactance



Potier Reactance



Potier Reactance

- The right triangle ABC (or A’B’C’) is called Potier triangle
- The Potier reactance then results from the leg AB of this triangle and rated current of the machine

$$X_p = \frac{|AB|}{I_n}$$

Potier Reactance

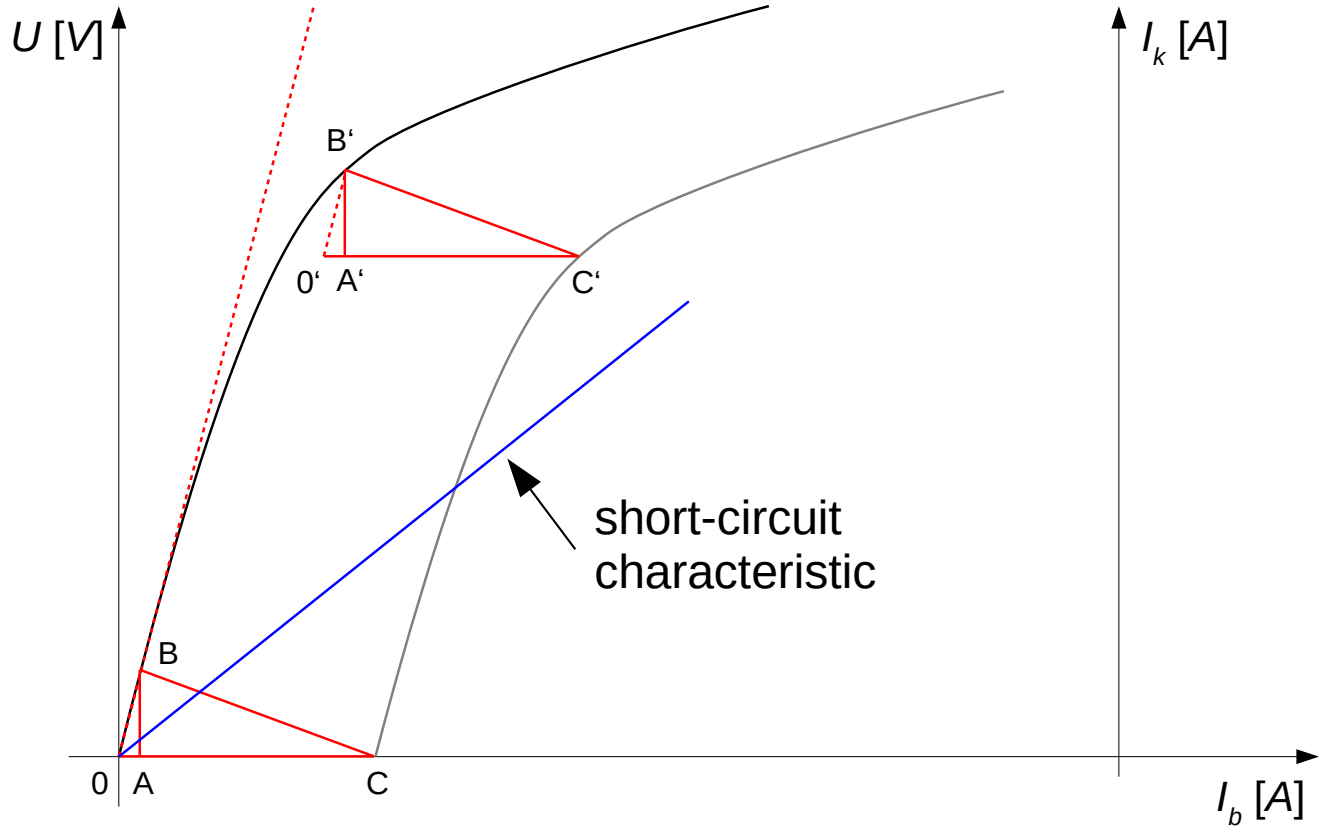
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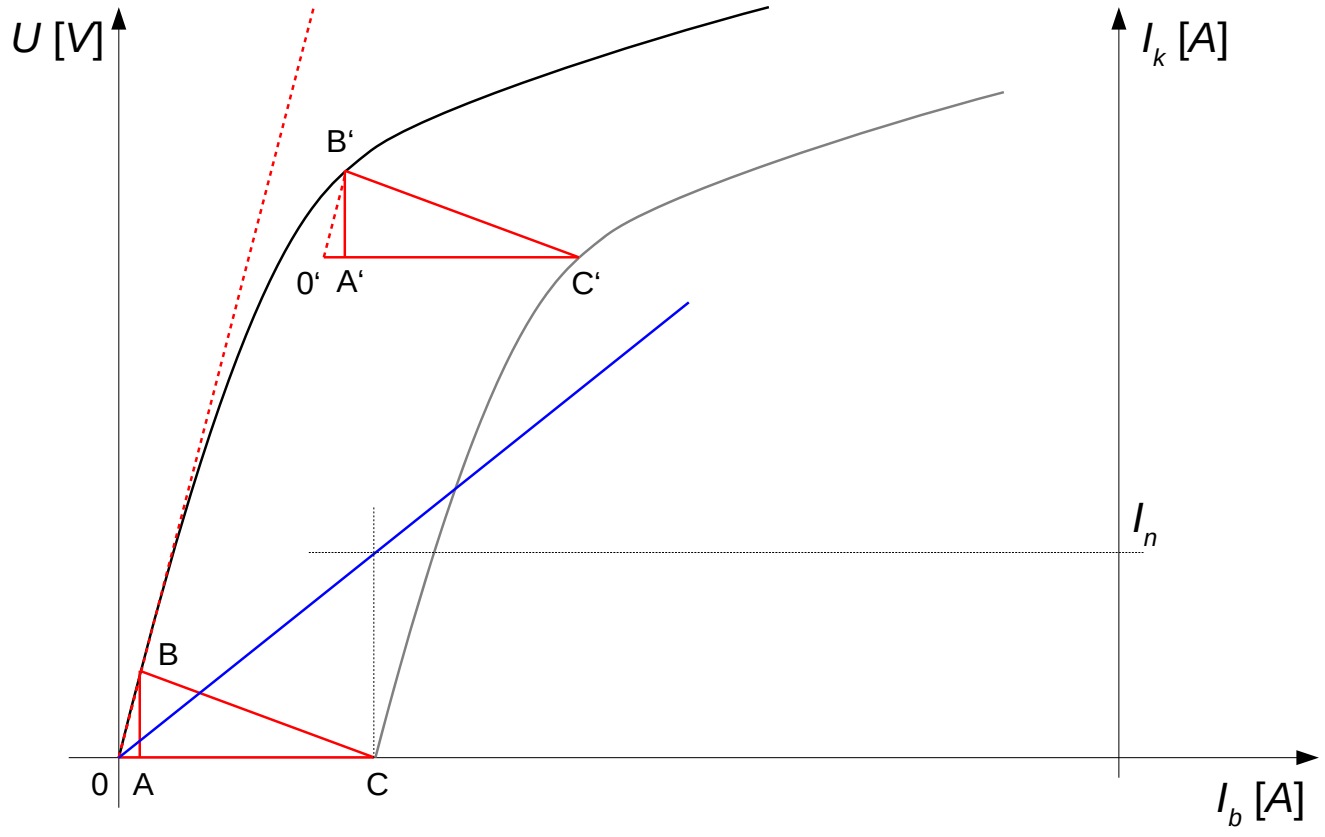
- The point C is a point corresponding with excitation current necessary for the short-circuit current equal to the rated current

  => if we know X_p and no-load and short-circuit characteristics, it is possible to reversely construct the induction characteristic

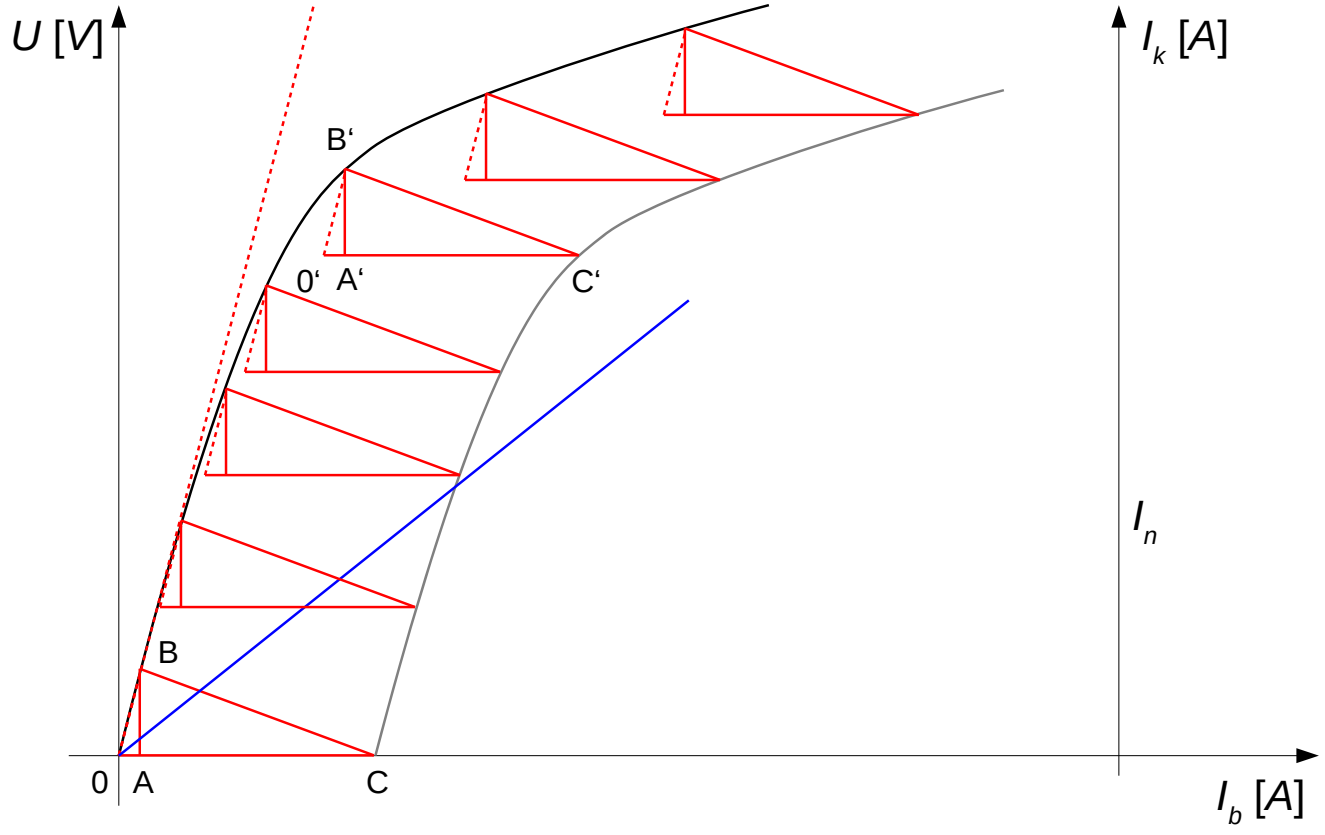
Potier Reactance



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Potier Reactance

- In comparison to the leakage reactance the Potier reactance is
  - For cylindrical rotor synchronous machines:

$$X_p = (1{,}2 - 1{,}3)\, X_{a\sigma}$$

  - For salient pole synchronous machines:

$$X_p \simeq 3\, X_{a\sigma}$$

Potier Reactance

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  - For salient pole synchronous machines:

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- In per units it is approximately:
  - For cylindrical rotor synchronous machines:

$$x_p = 0{,}15\ p.u.$$

  - For salient pole synchronous machines:

$$x_p = 0{,}32\ p.u.$$

Potier Reactance

- According to some literature, it is possible to calculate the saturated value of direct axis reactance using Potier reactance as:

$$X_{ds} = X_p + \frac{X_{dn} - X_p}{k_{sat}}$$

where X_{ds} is the saturated d-axis reactance

X_{dn} is the non-saturated d-axis reactance

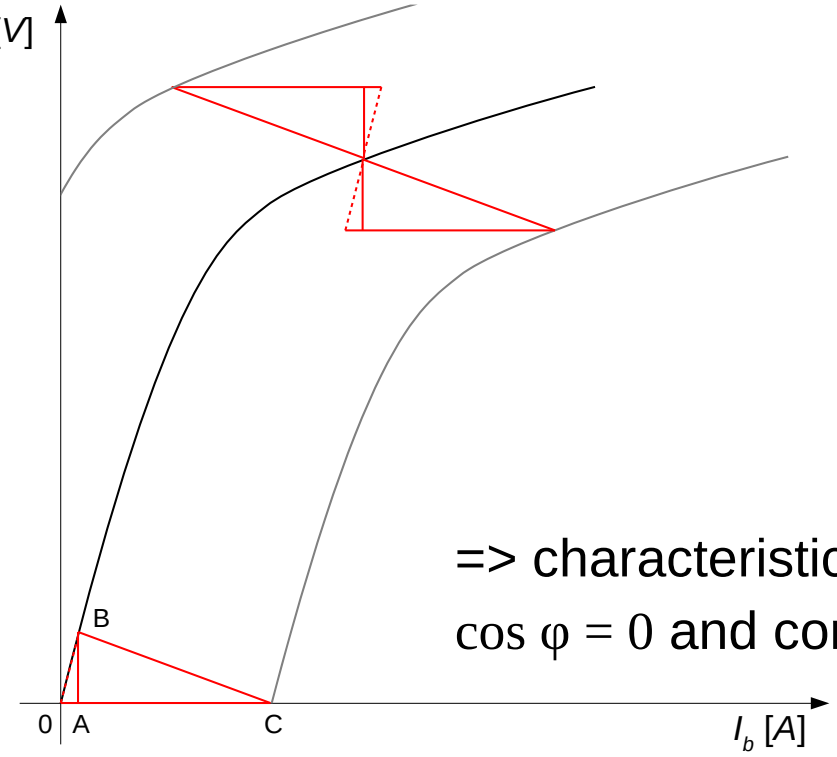
k_{sat} is the magnetic circuit saturation factor

- The Potier reactance may be then reversely calculated as

$$X_p = \frac{k_{sat} X_{ds} - X_{dn}}{k_{sat} - 1}$$

Potier Reactance

- Note: in the same way as induction characteristic it the capacitive characteristic may be drawn



=> characteristic $U = f(I_b)$ with capacitive $\cos \varphi = 0$ and constant stator current

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Calculation of Excitation Current for Given Load: Cylindrical Rotor Machine

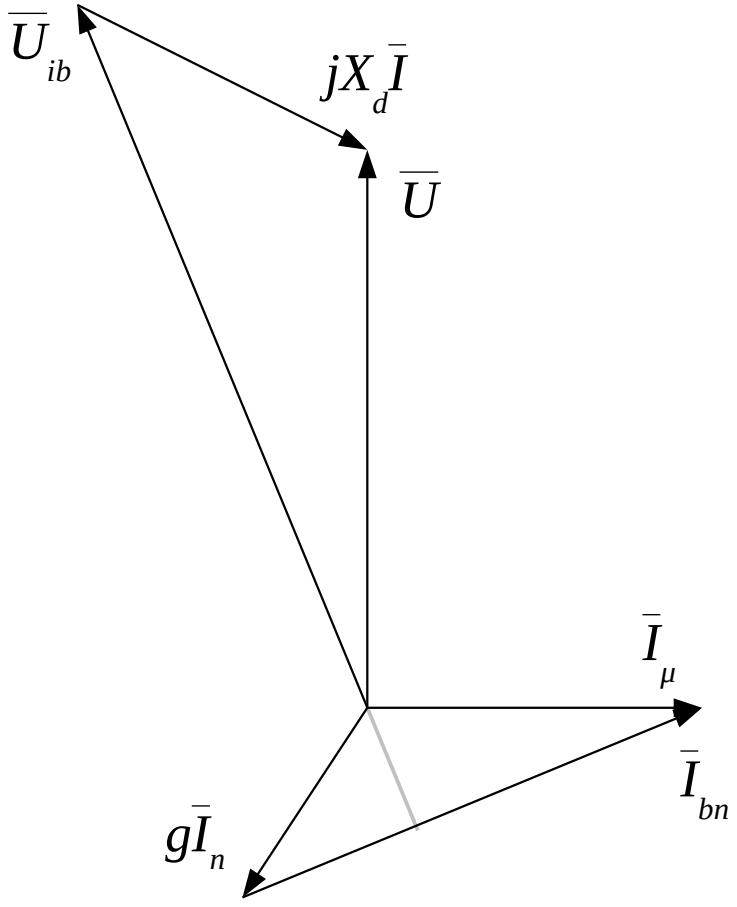
Cylindrical Rotor Synchronous Machine

- Results from phasor diagram:

Cylindrical Rotor Synchronous Machine

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$$\bar{I}_{bn} + g\,\bar{I}_n = \bar{I}_\mu$$

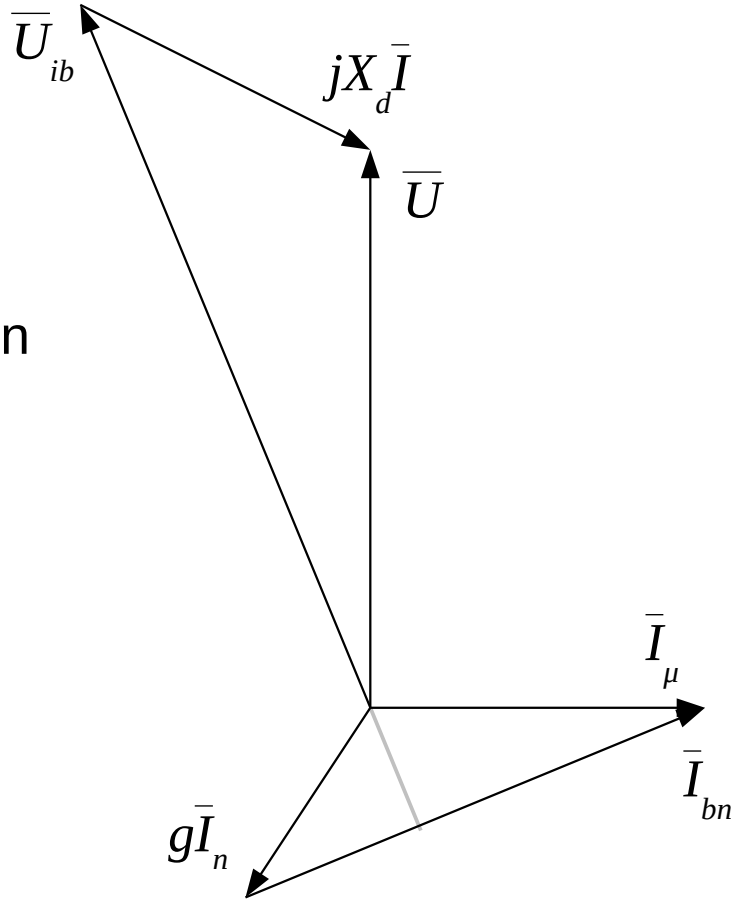


Cylindrical Rotor Synchronous Machine

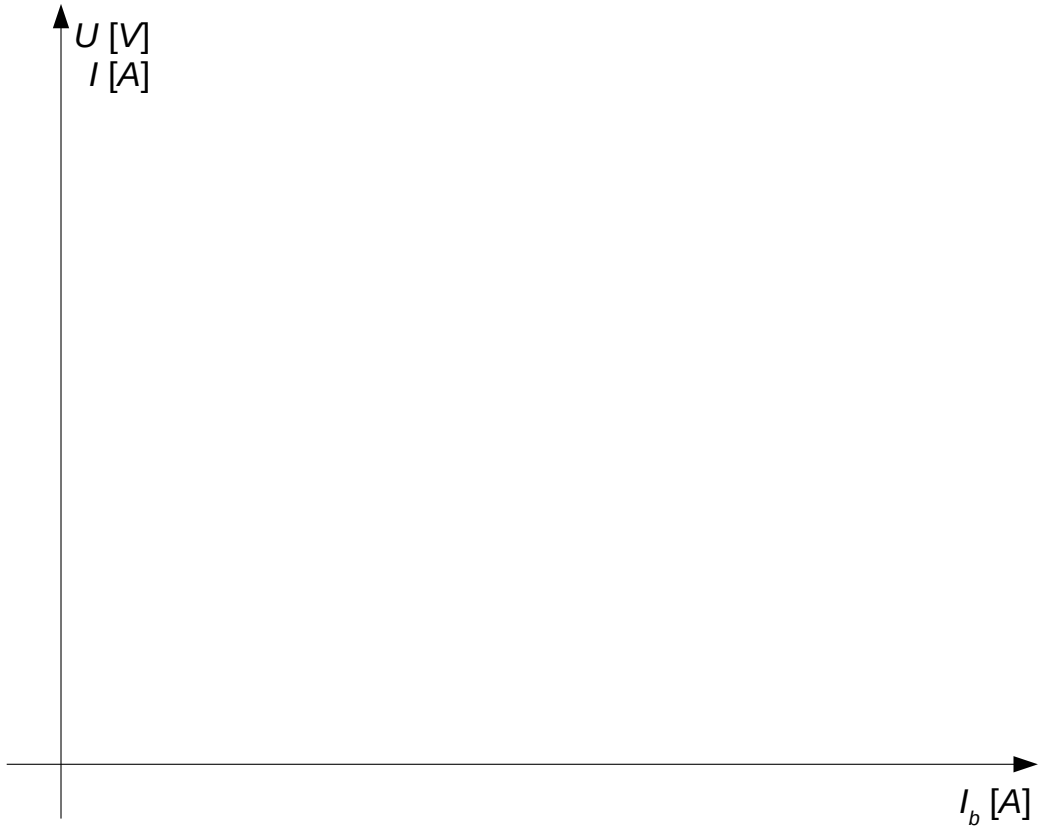
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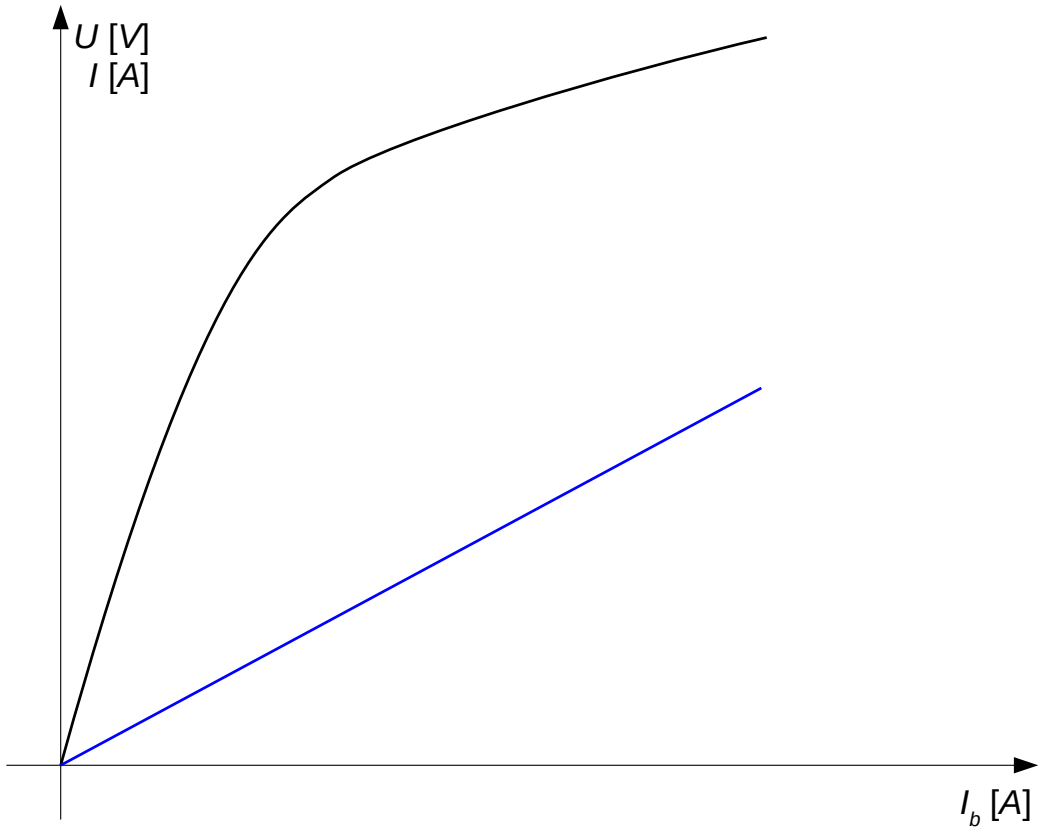
...but it is necessary to respect saturation



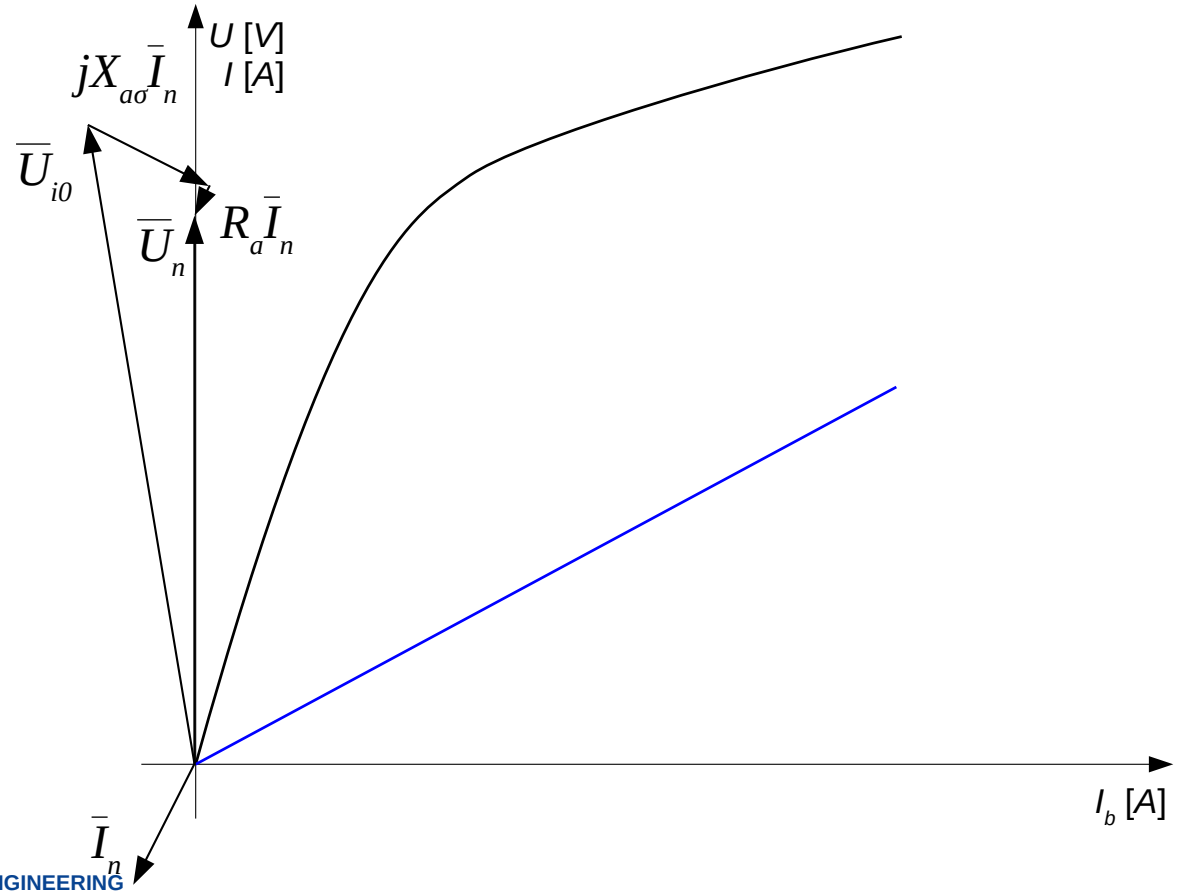
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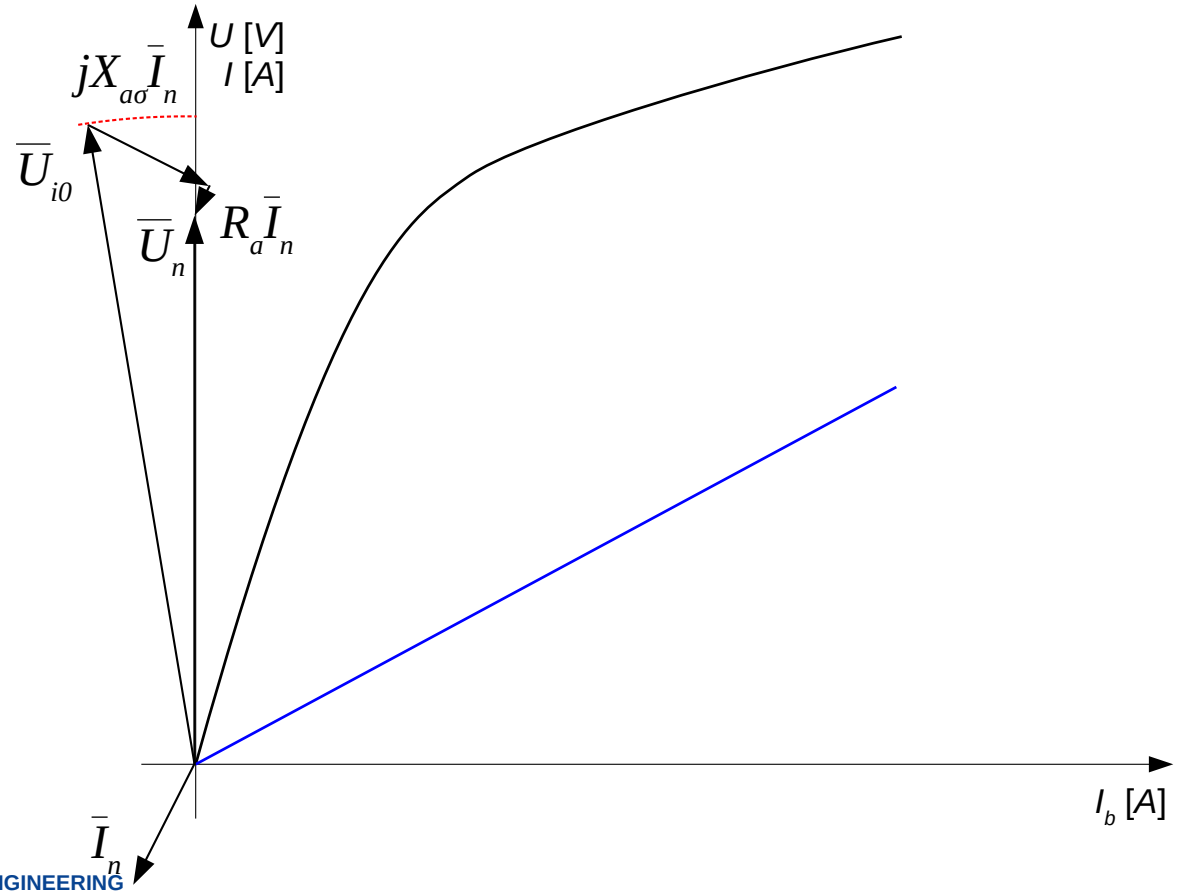
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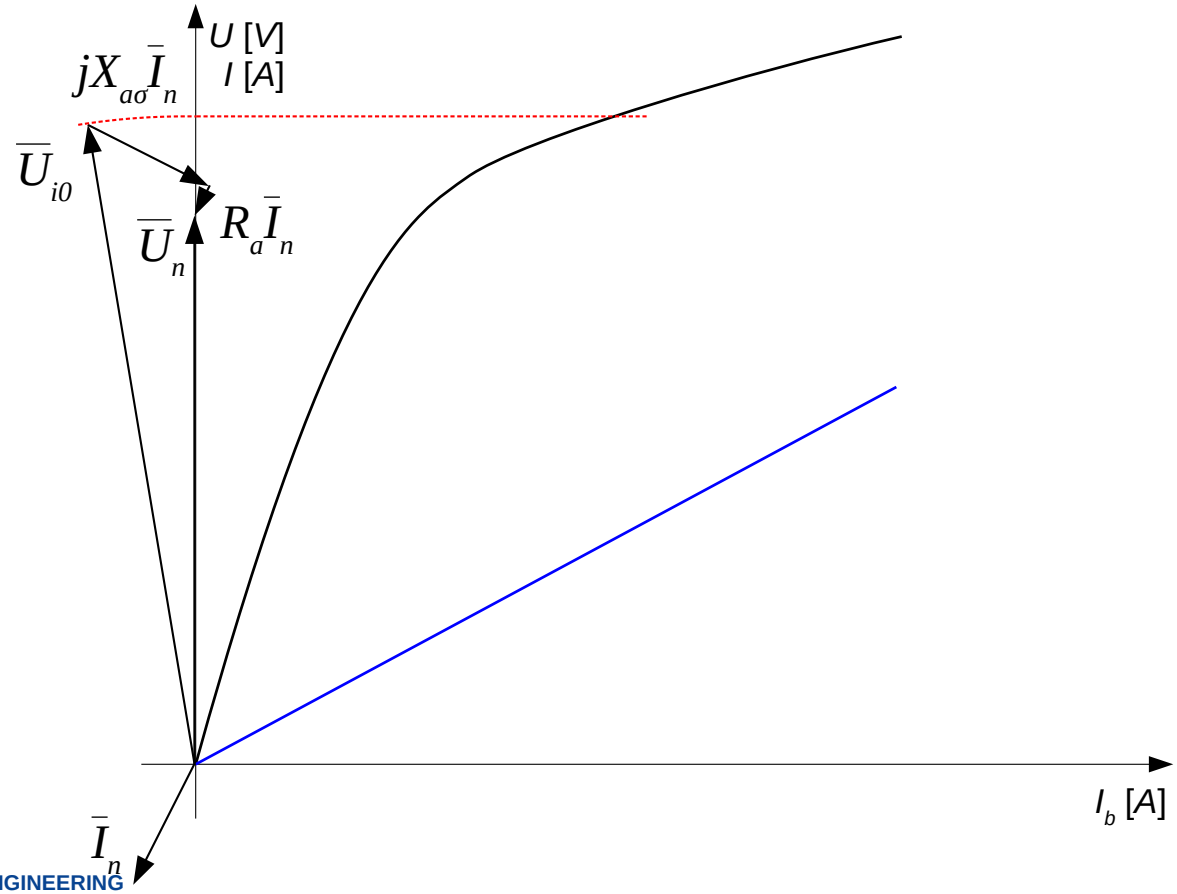
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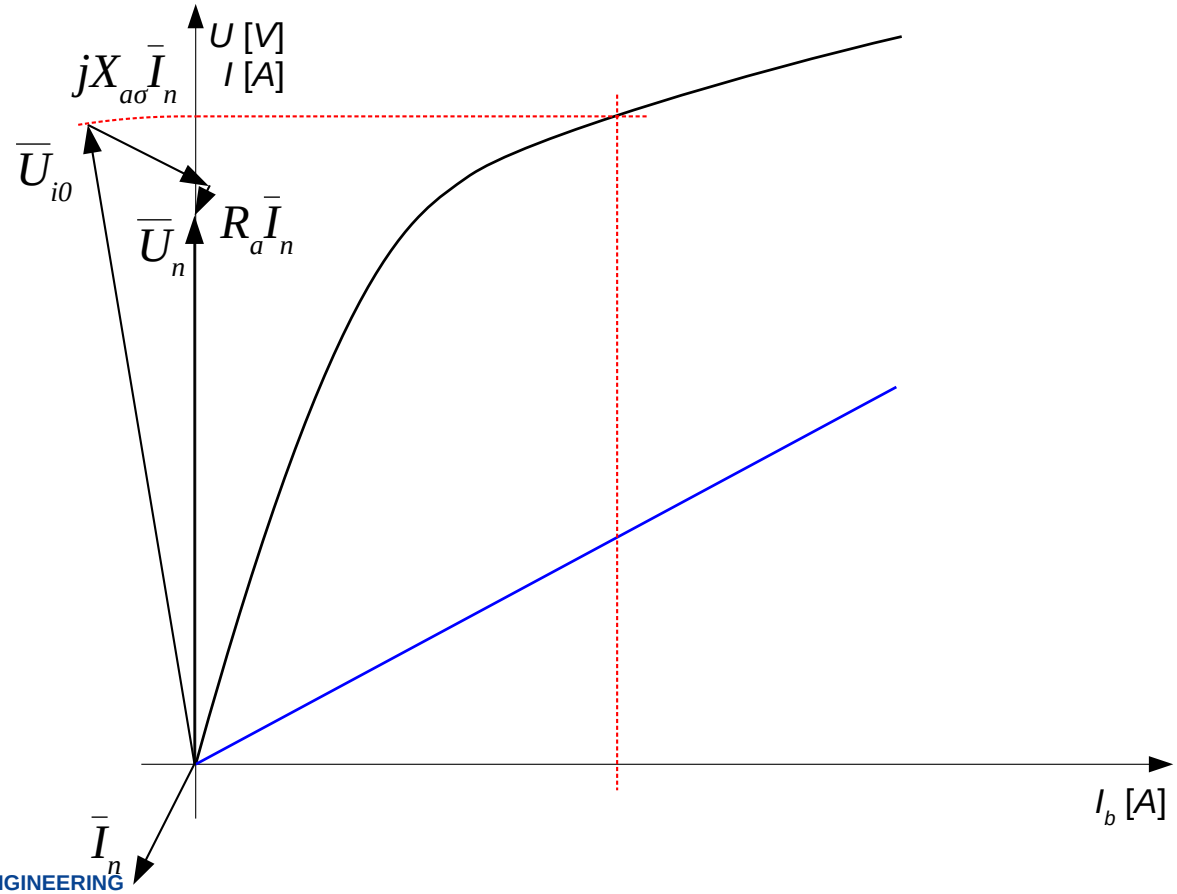
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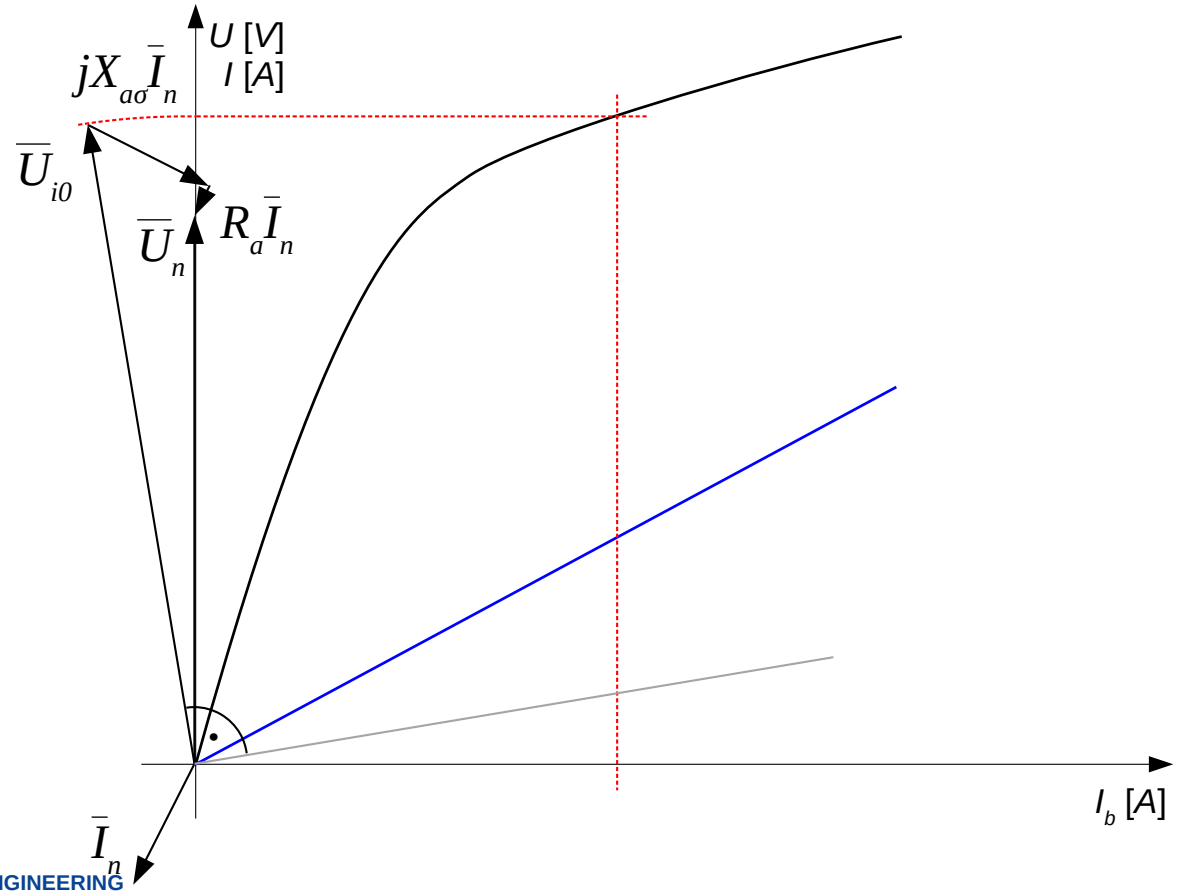
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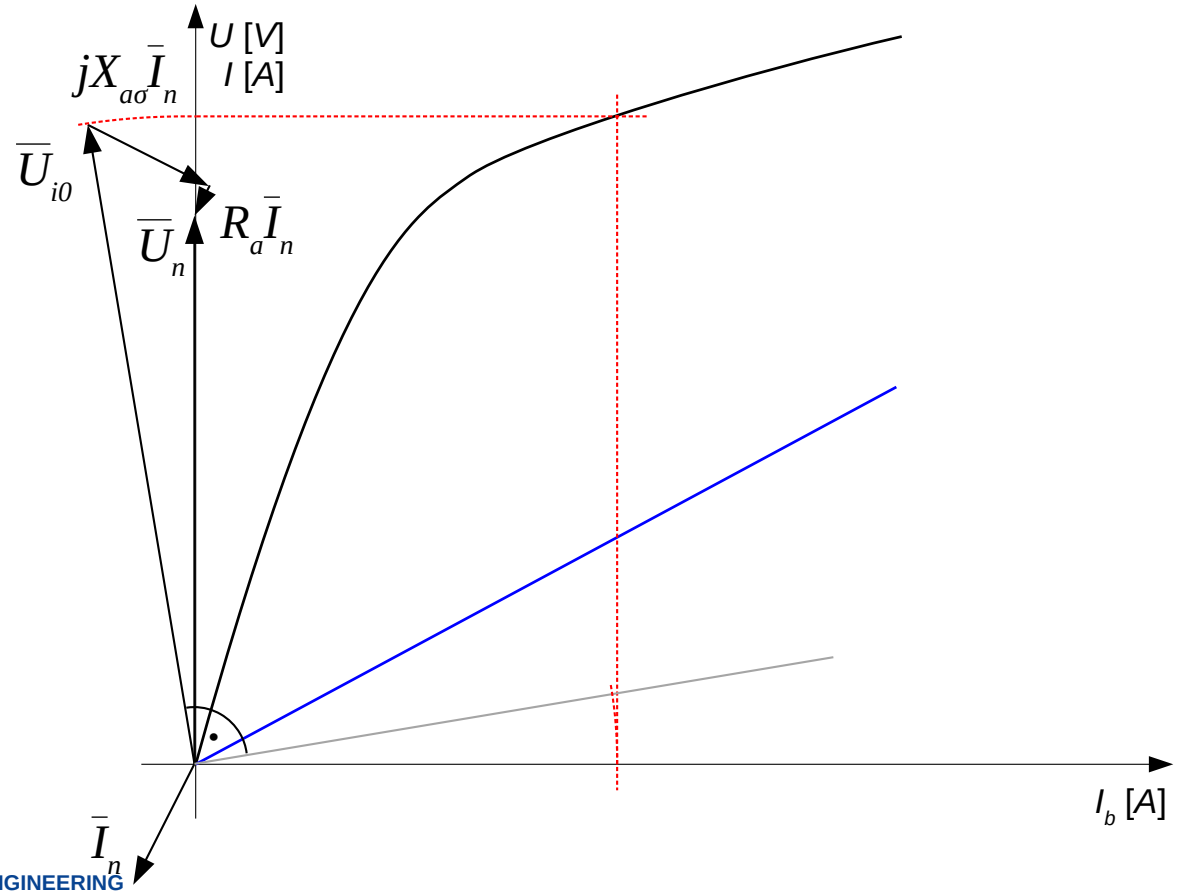
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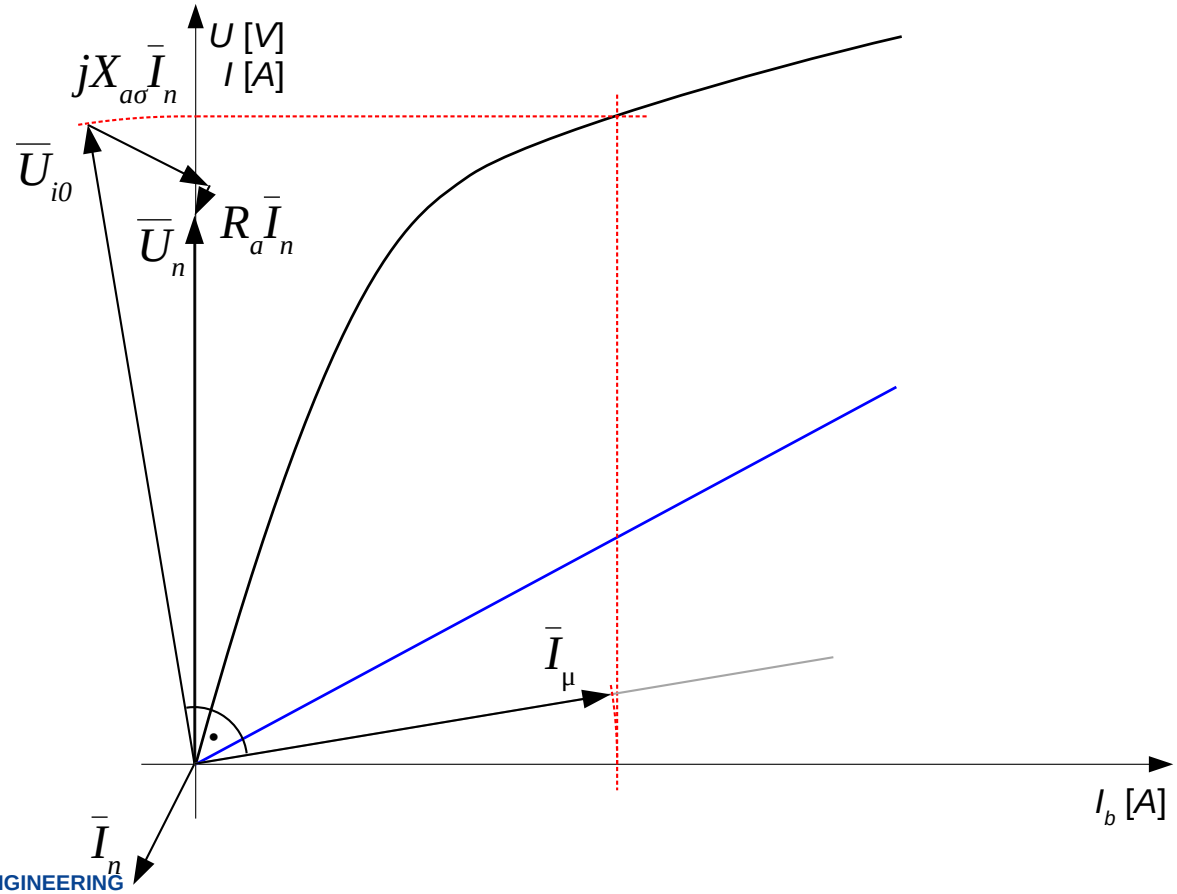
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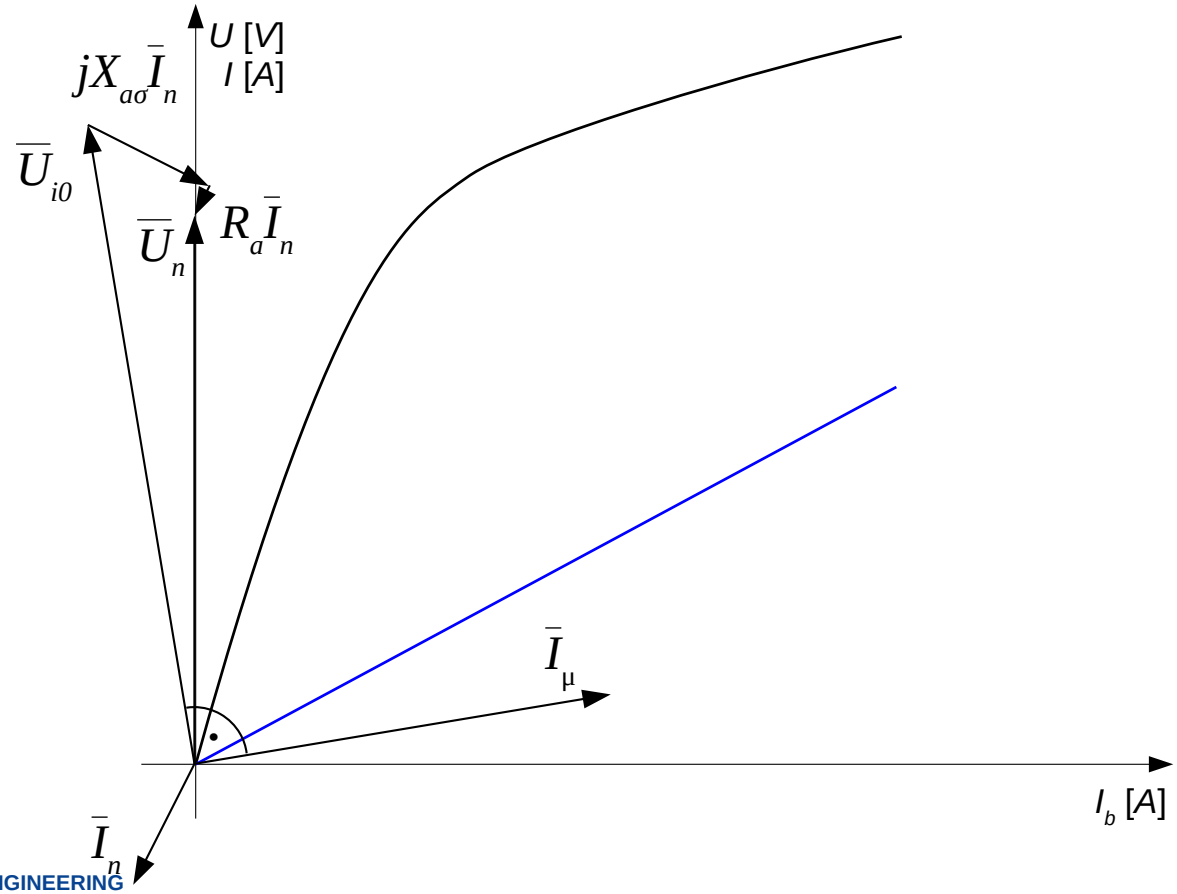
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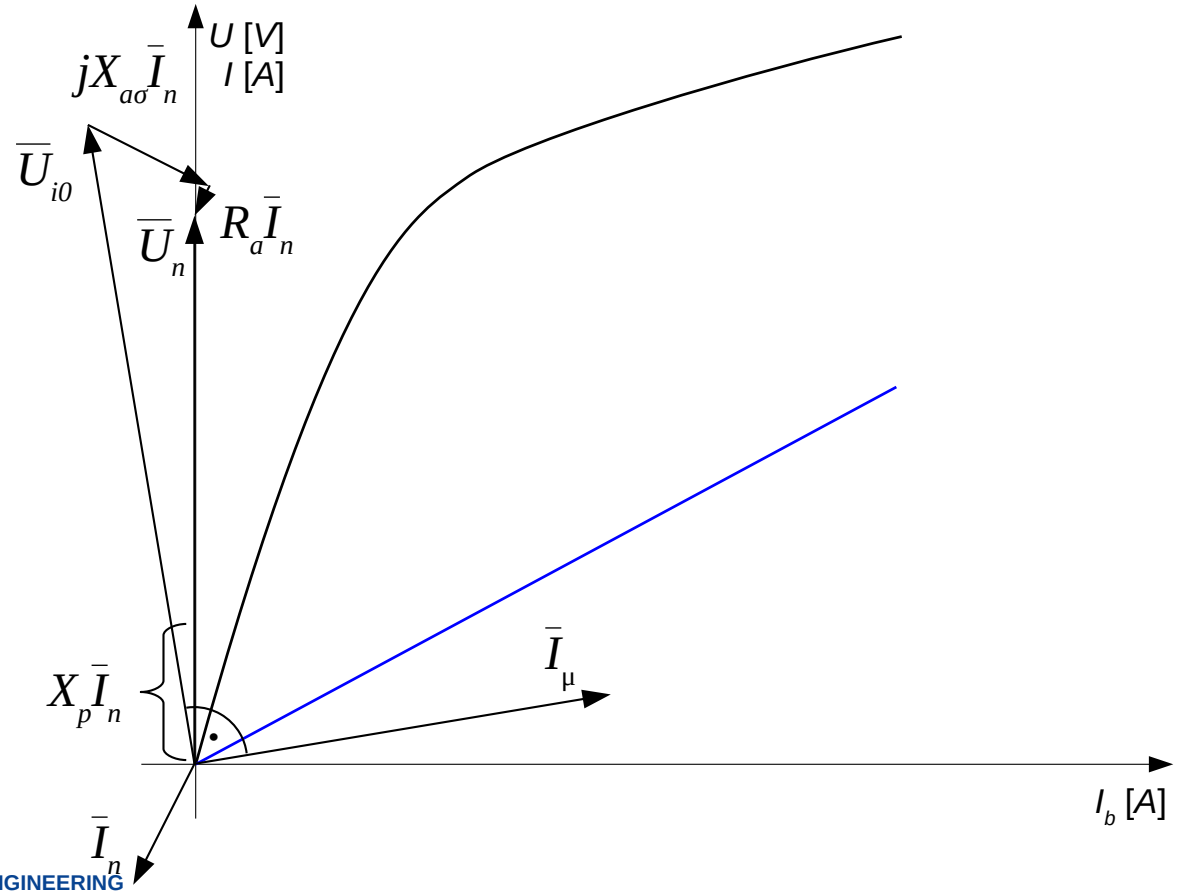
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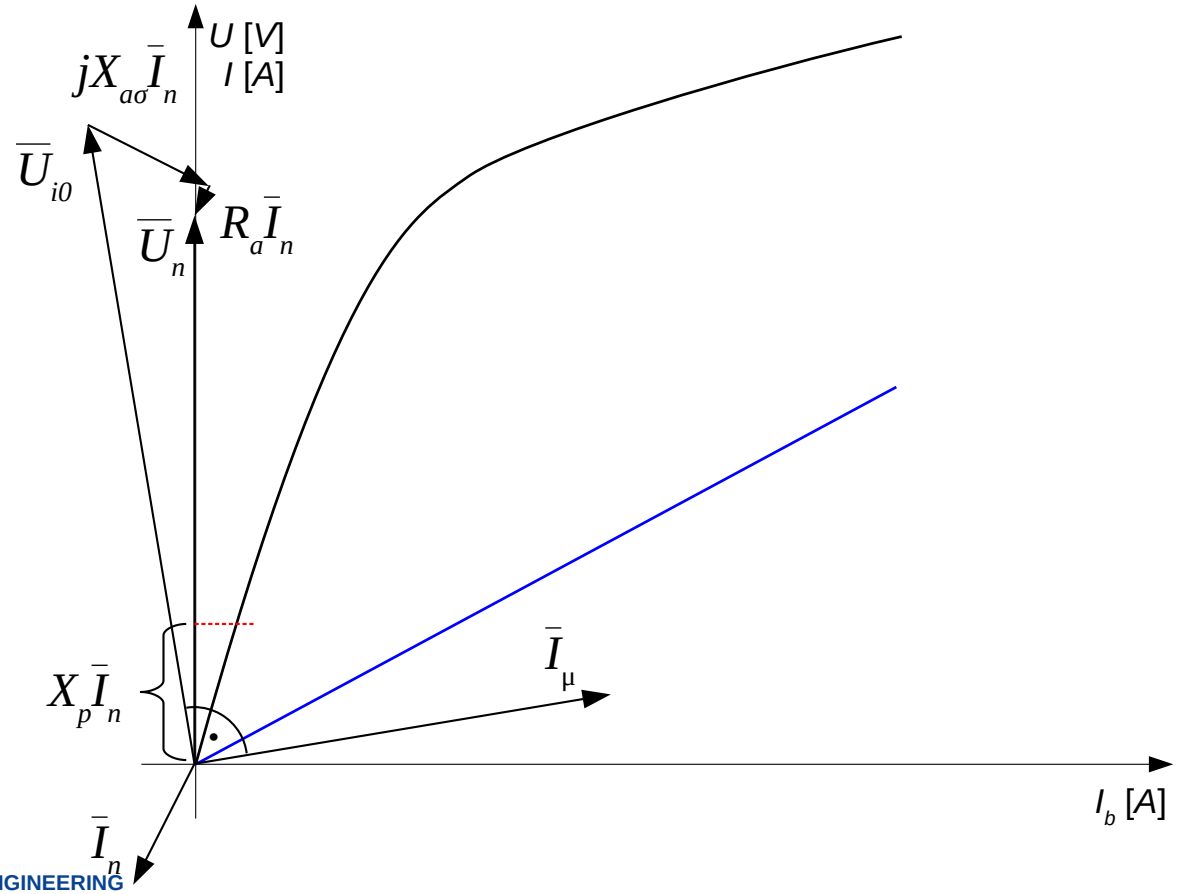
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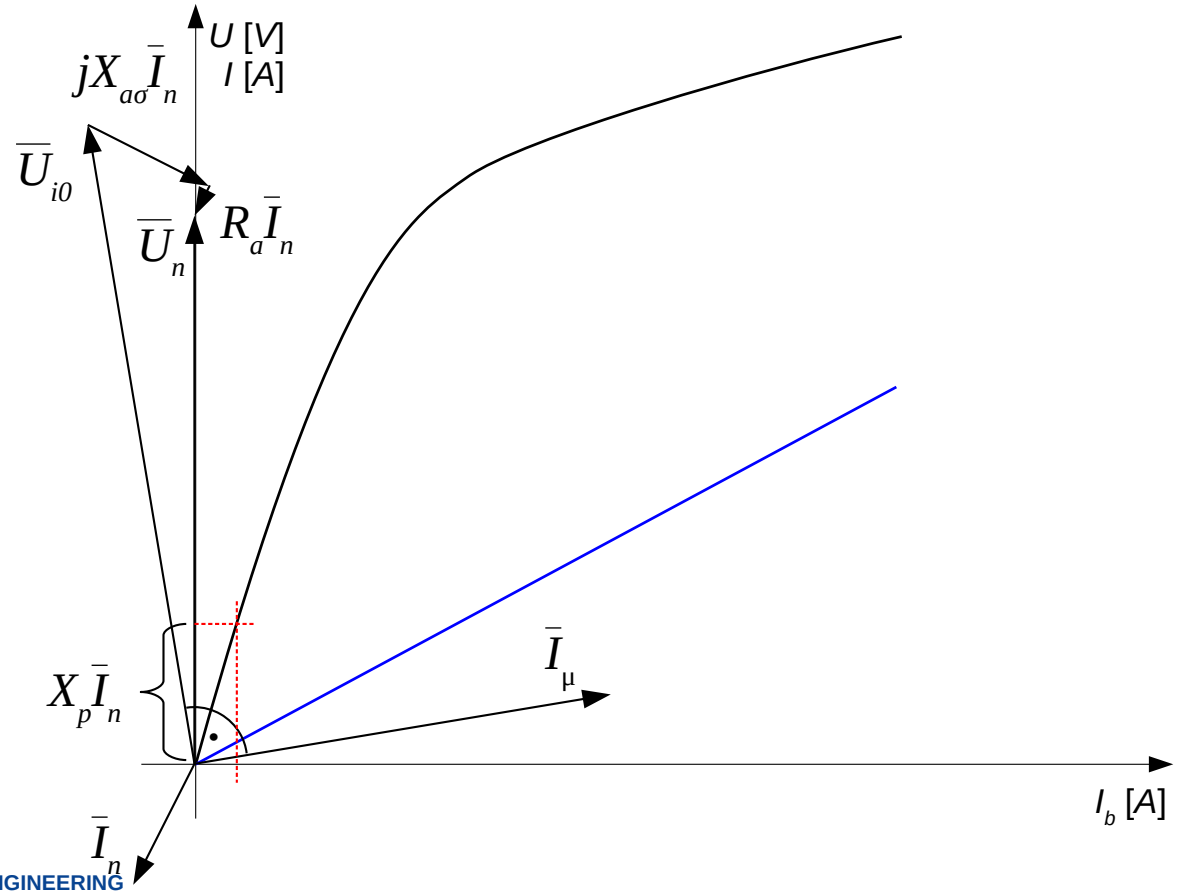
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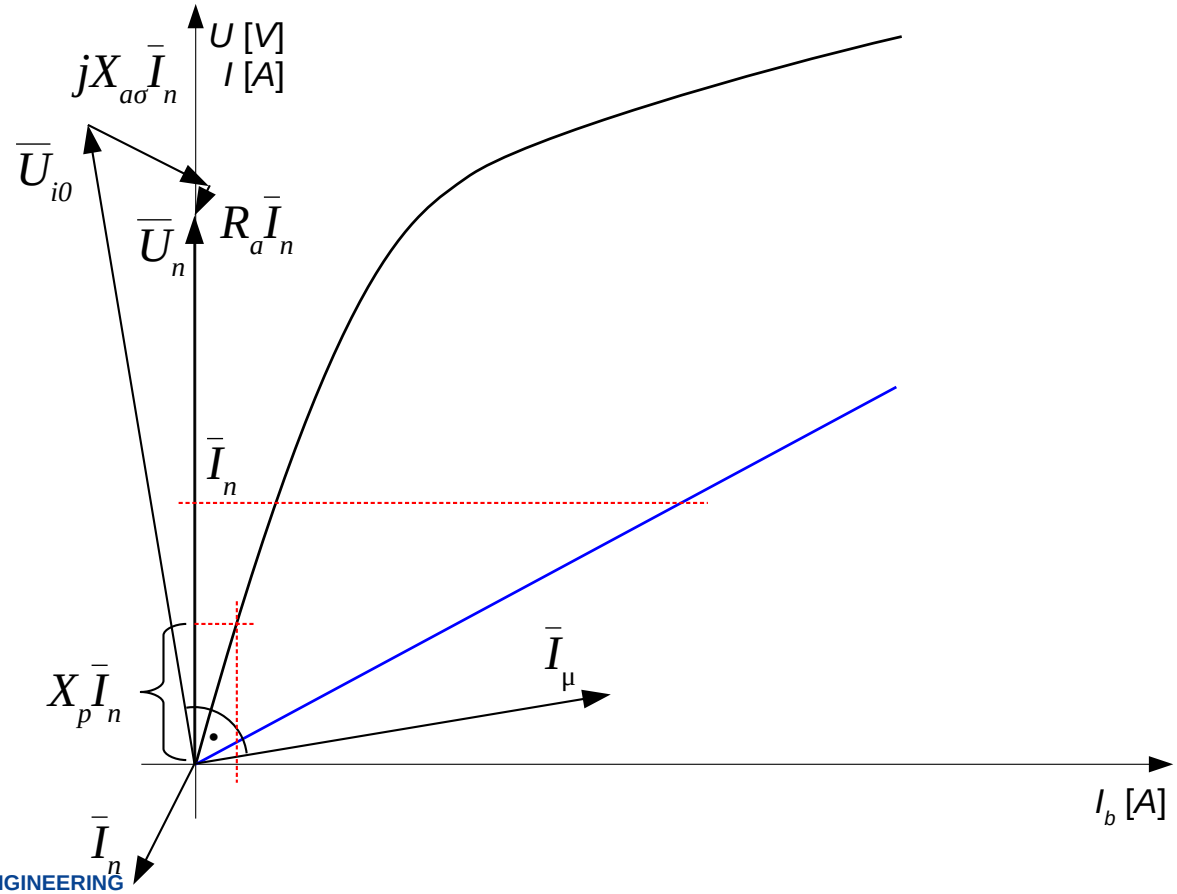
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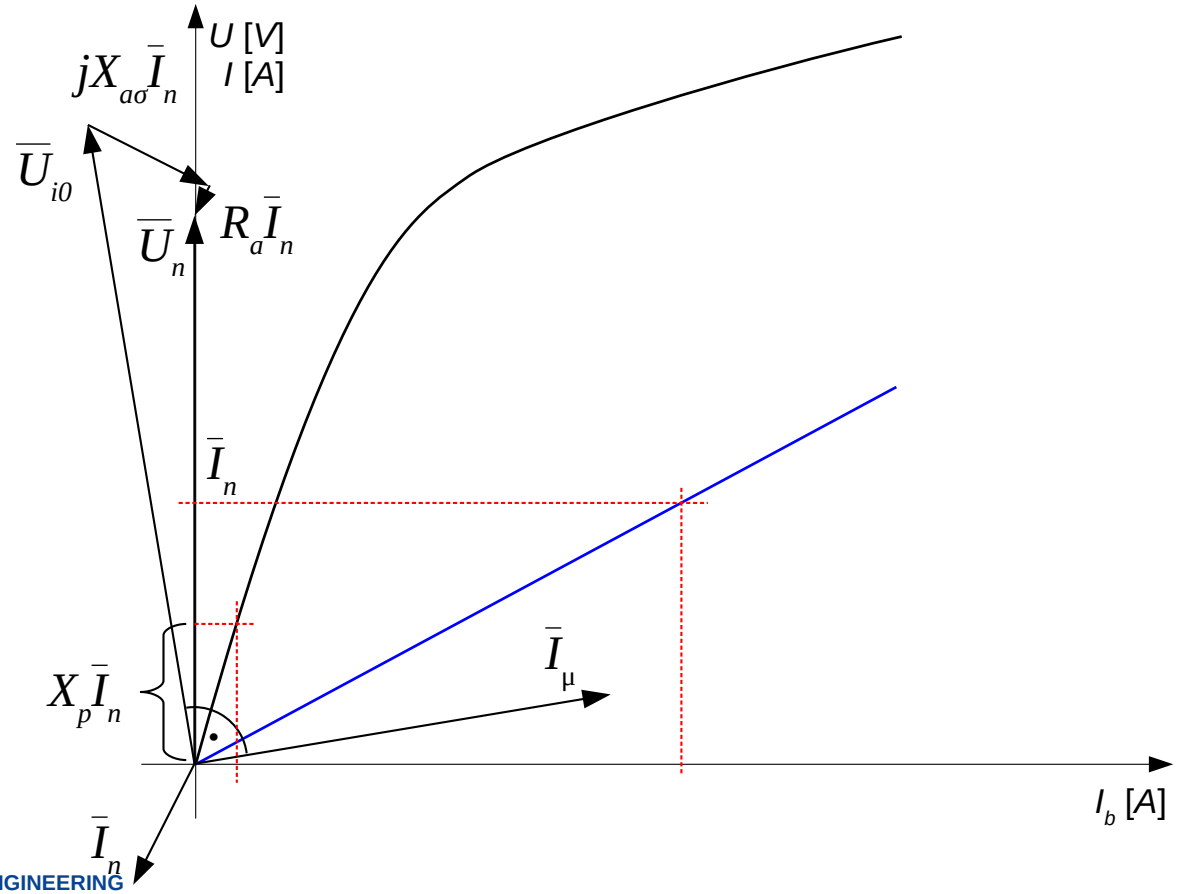
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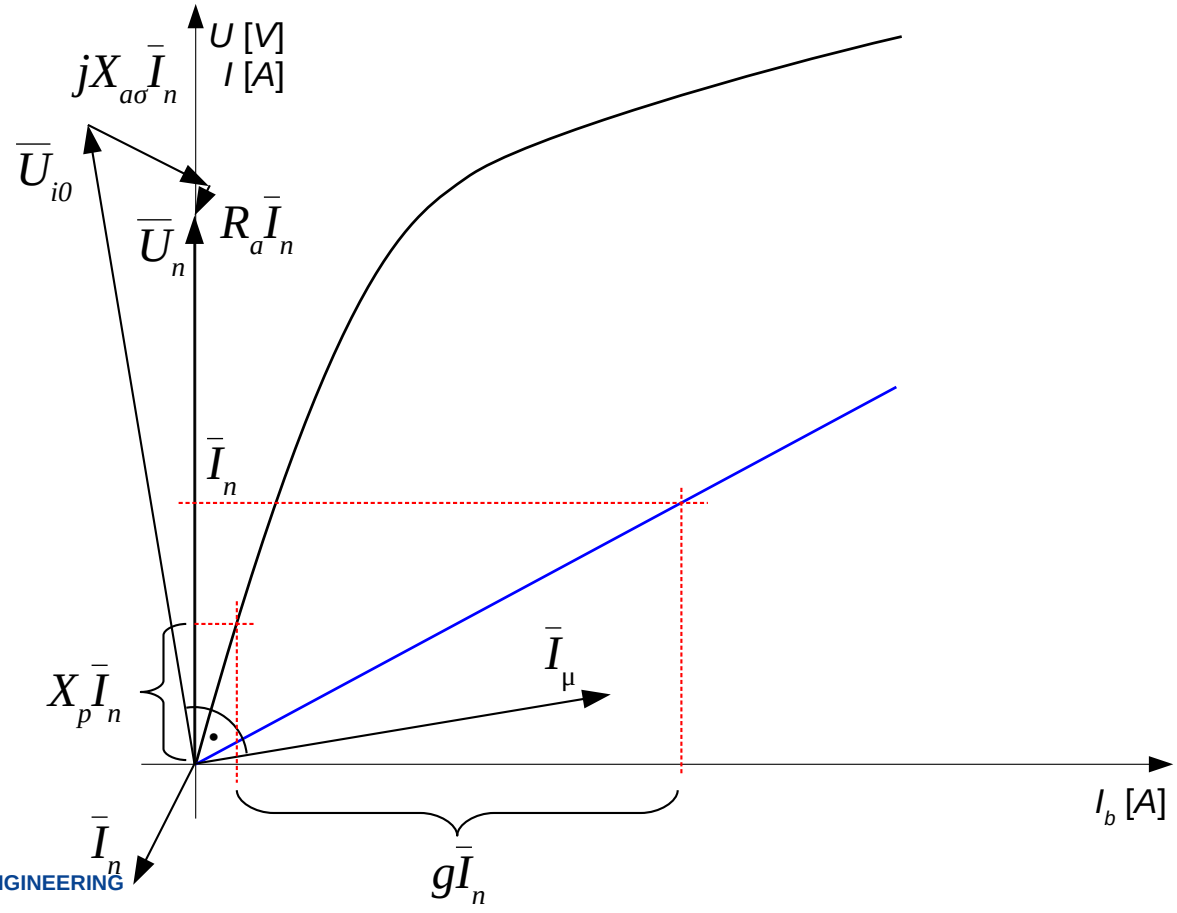
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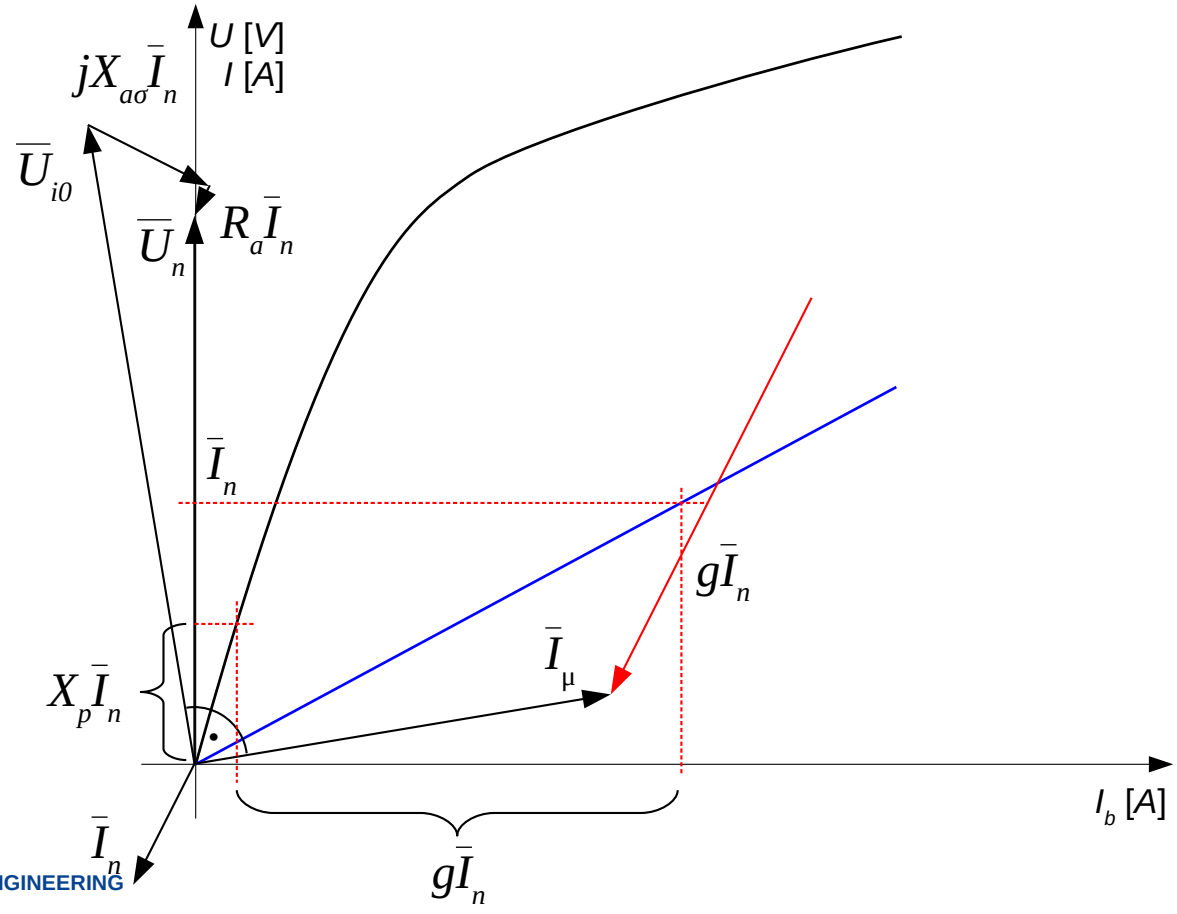
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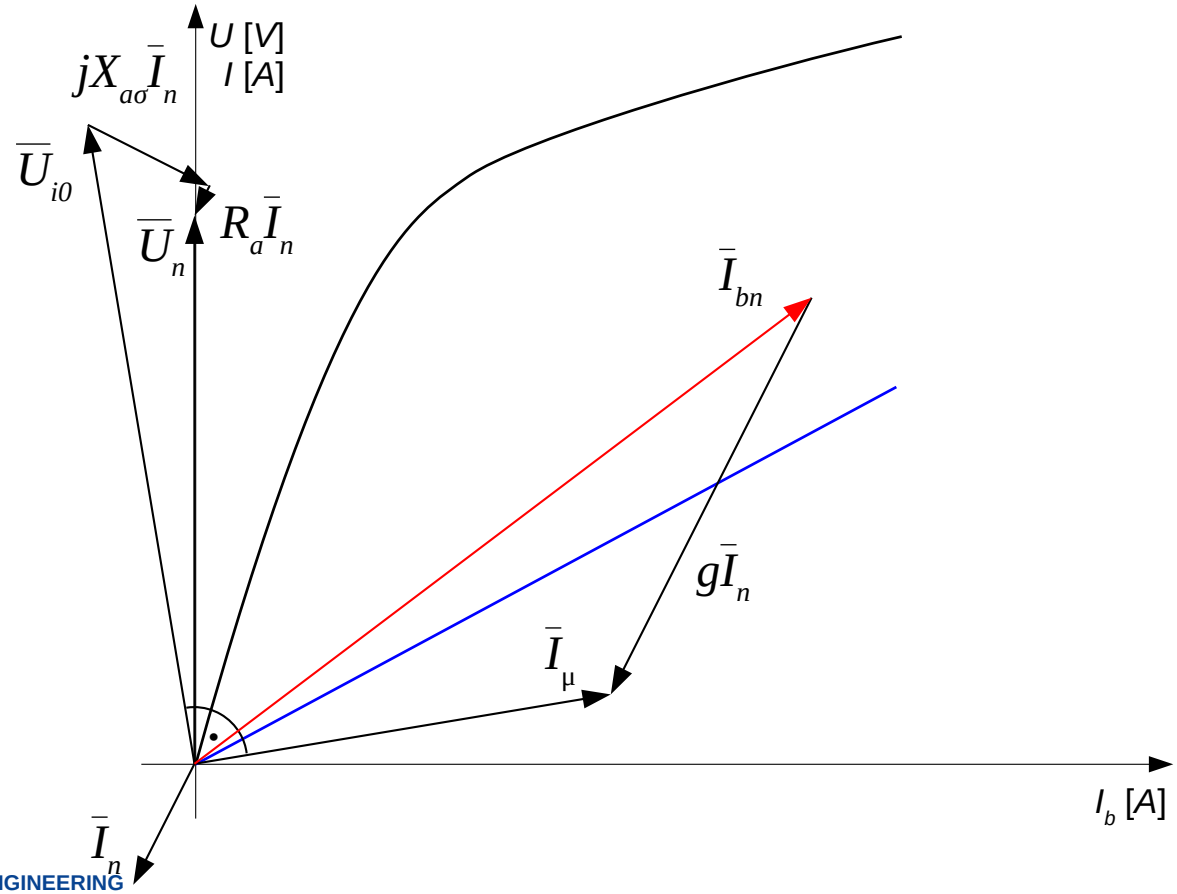
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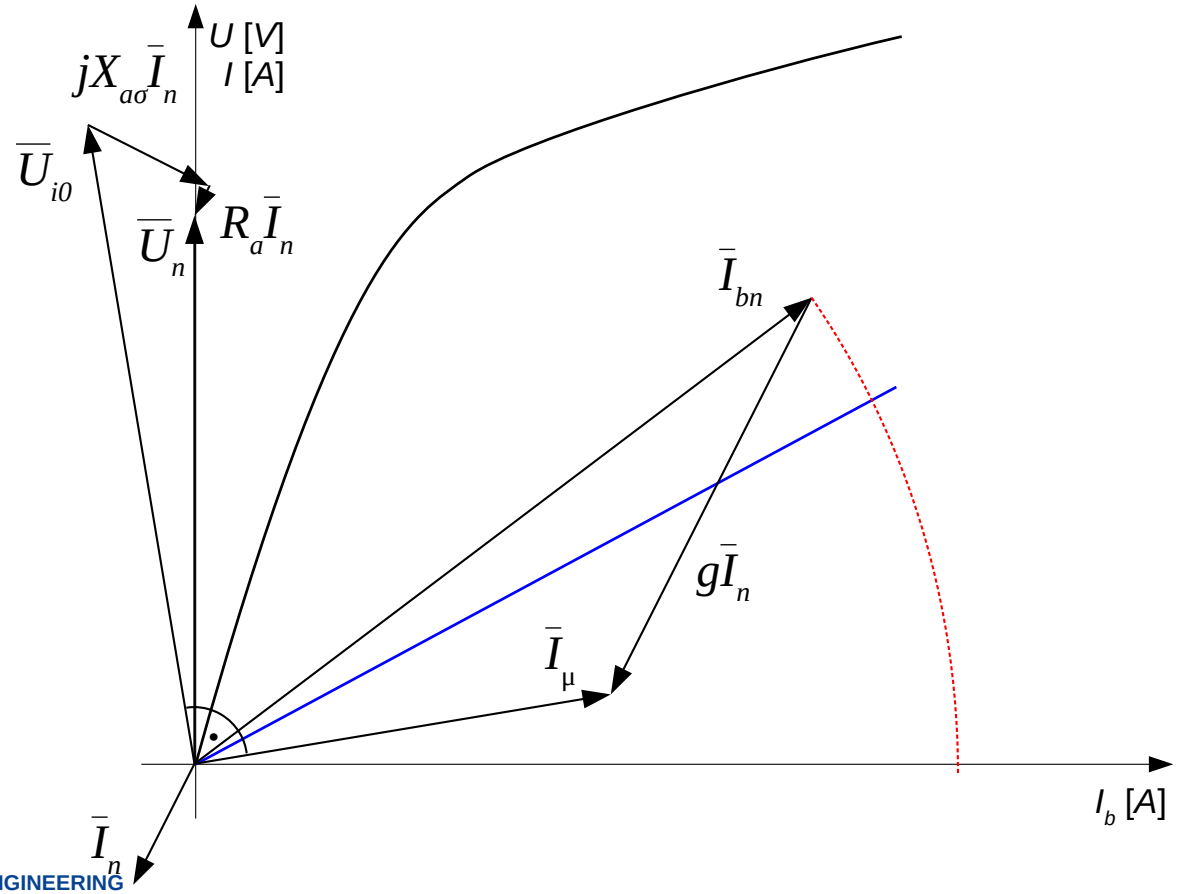
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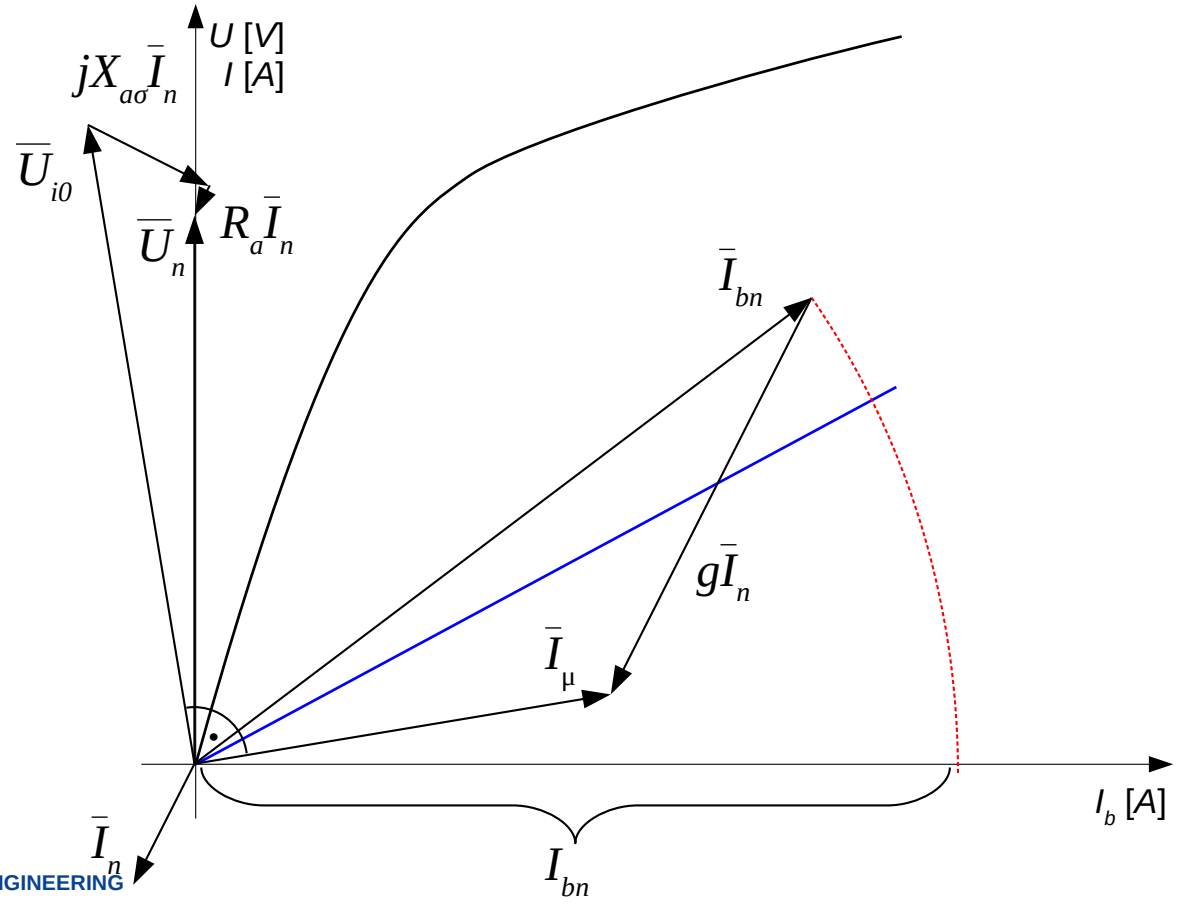
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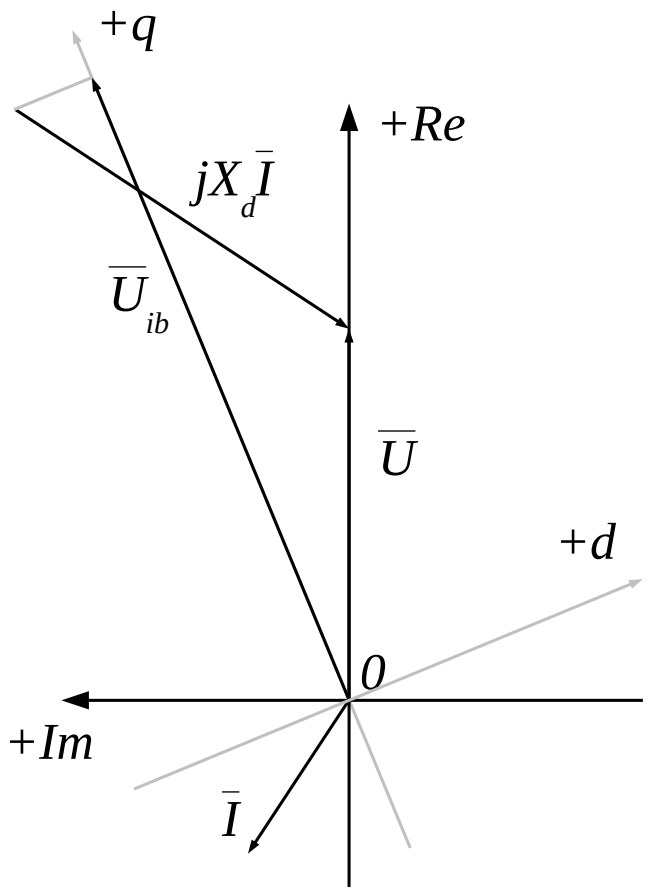
Calculation of Excitation Current for Given Load: Cylindrical Rotor Machine

Salient Pole Synchronous Machine

- Results from phasor diagram:

Salient Pole Synchronous Machine

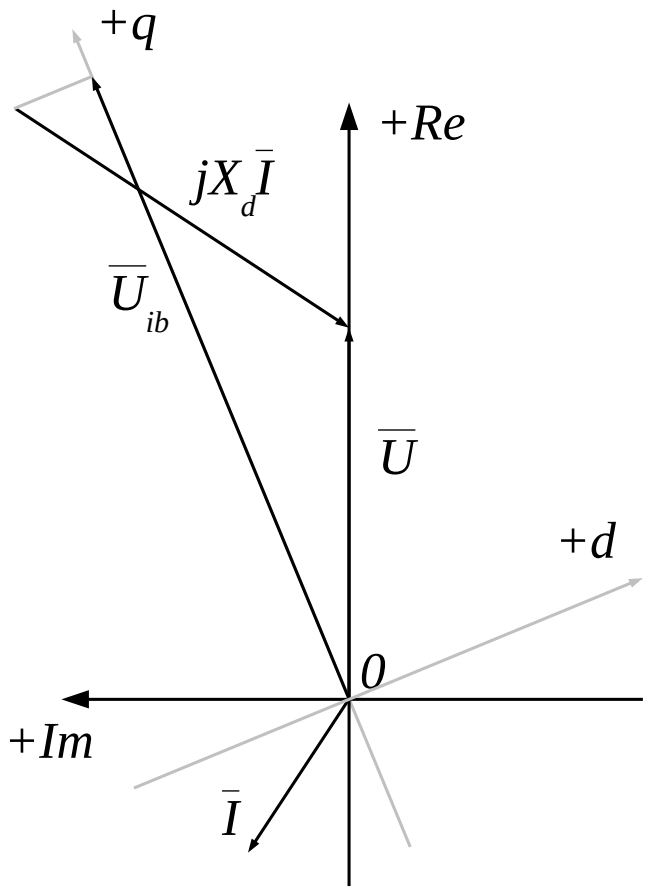
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Salient Pole Synchronous Machine

- Results from phasor diagram:

  …it is necessary to respect saturation and saliency of the machine

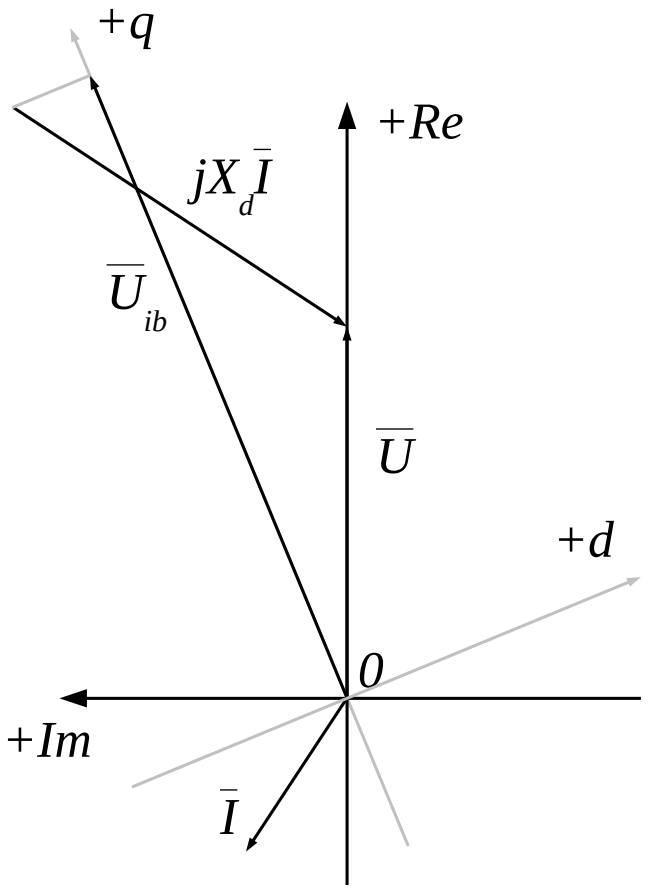


Salient Pole Synchronous Machine

- Thanks to differences in inductances it is more suitable to proceed using armature magnetomotive force in each axis:

$$F_{ad} = C_{d1} \cdot \frac{m}{\pi} \cdot \frac{N_s k_{v1} \sqrt{2} I_n}{p}$$

$$F_{aq} = C_{q1} \cdot \frac{m}{\pi} \cdot \frac{N_s k_{v1} \sqrt{2} I_n}{p}$$



Salient Pole Synchronous Machine

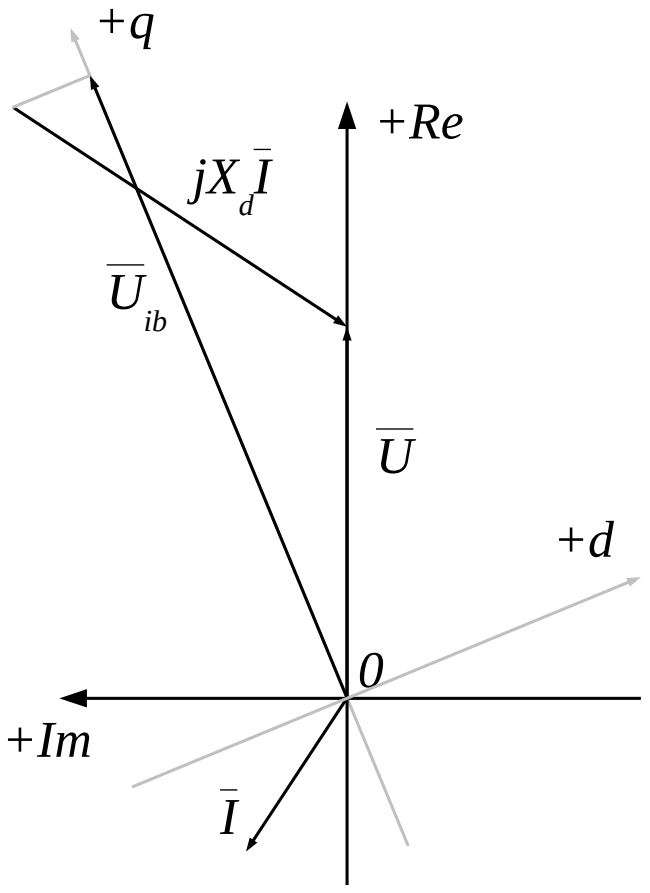
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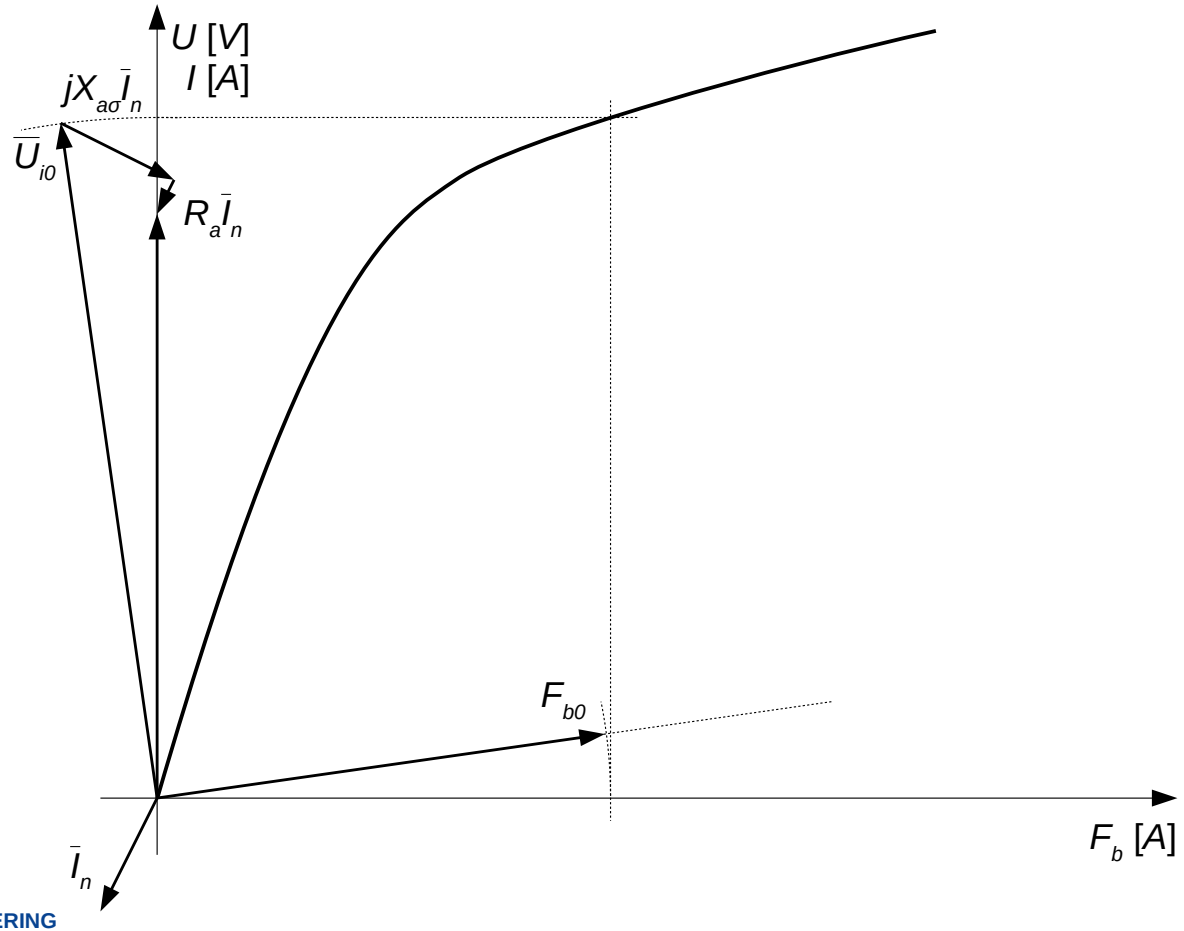
$$F_{aq} = C_{q1} \cdot \frac{m}{\pi} \cdot \frac{N_s k_{v1} \sqrt{2} I_n}{p}$$

and use the no-load characteristic drawn as dependency on excitation magnetomotive force:

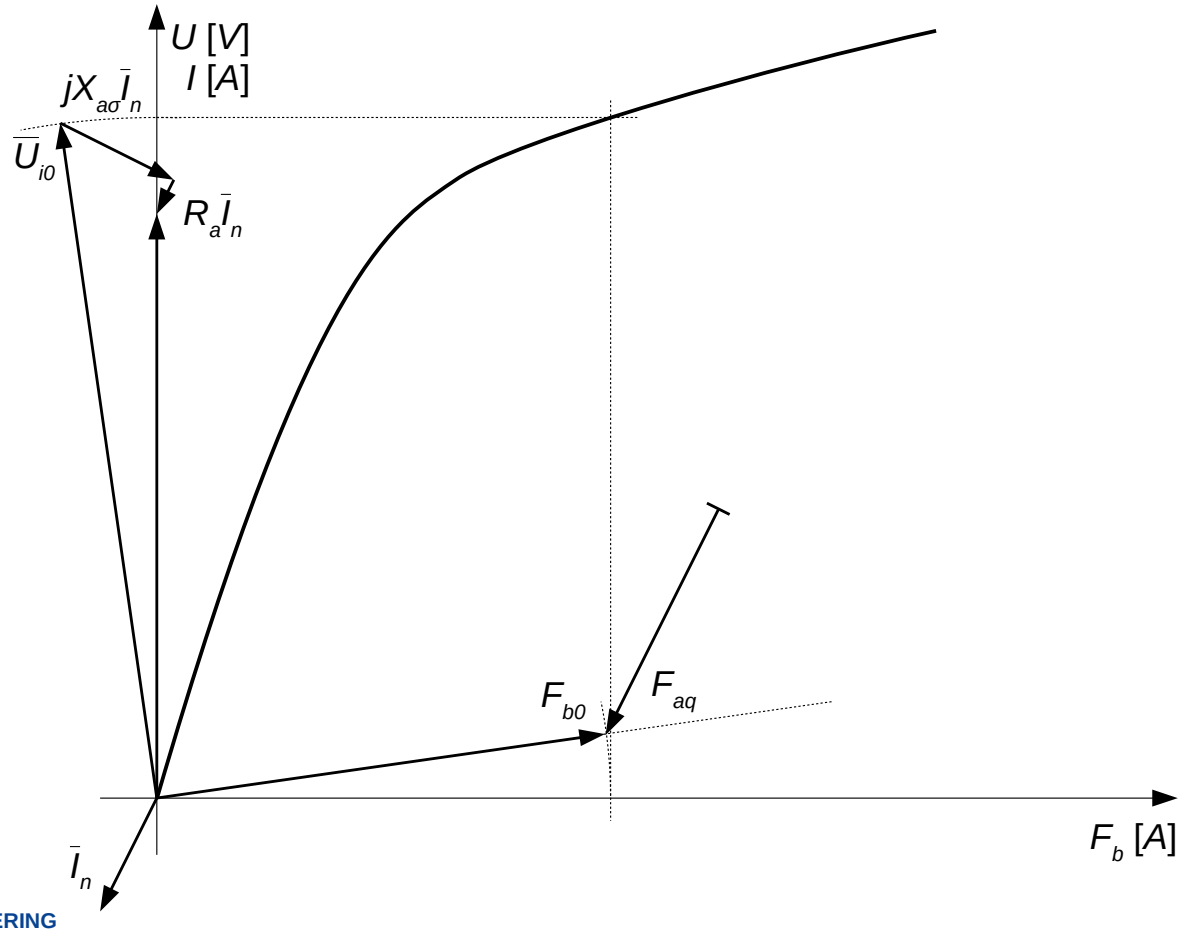
$$U_i = f\left(F_b\right)$$



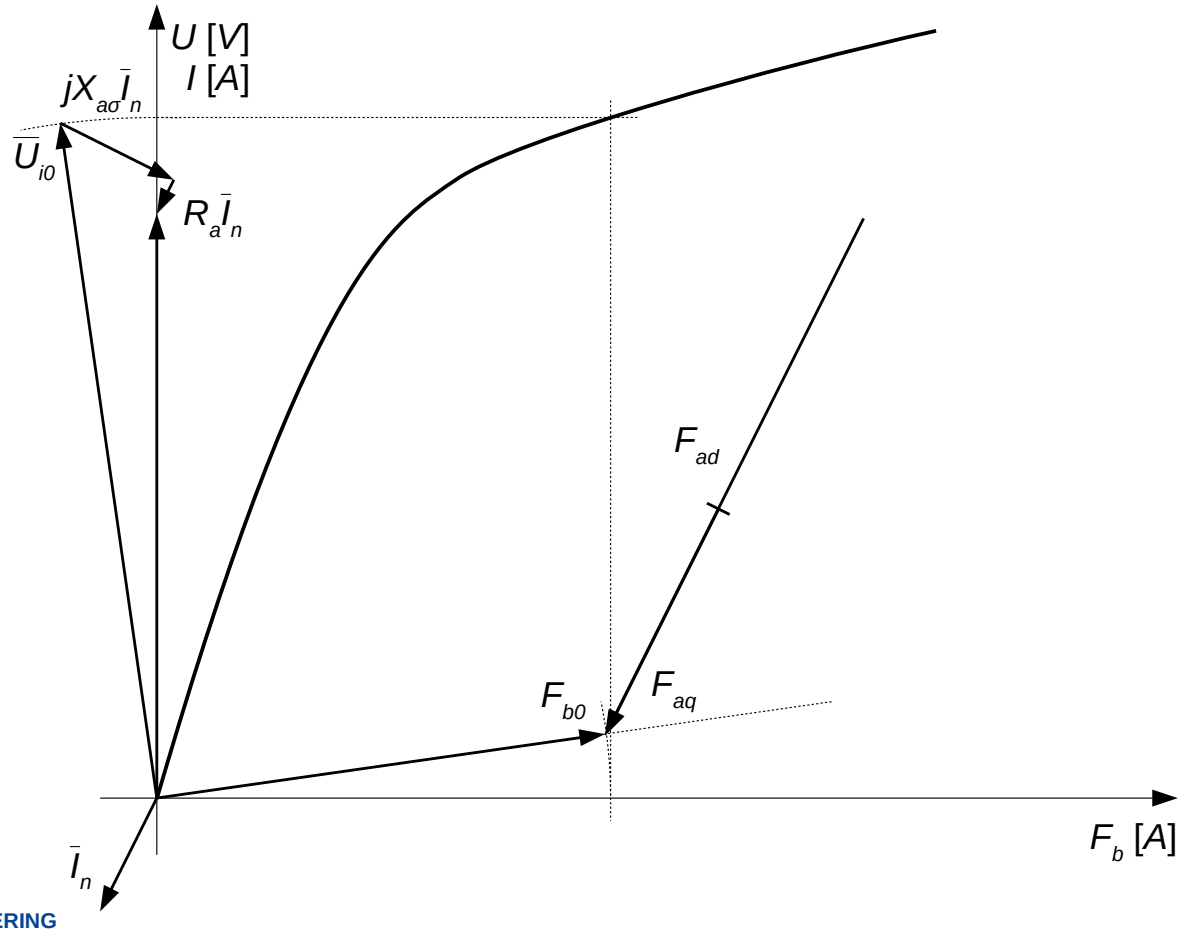
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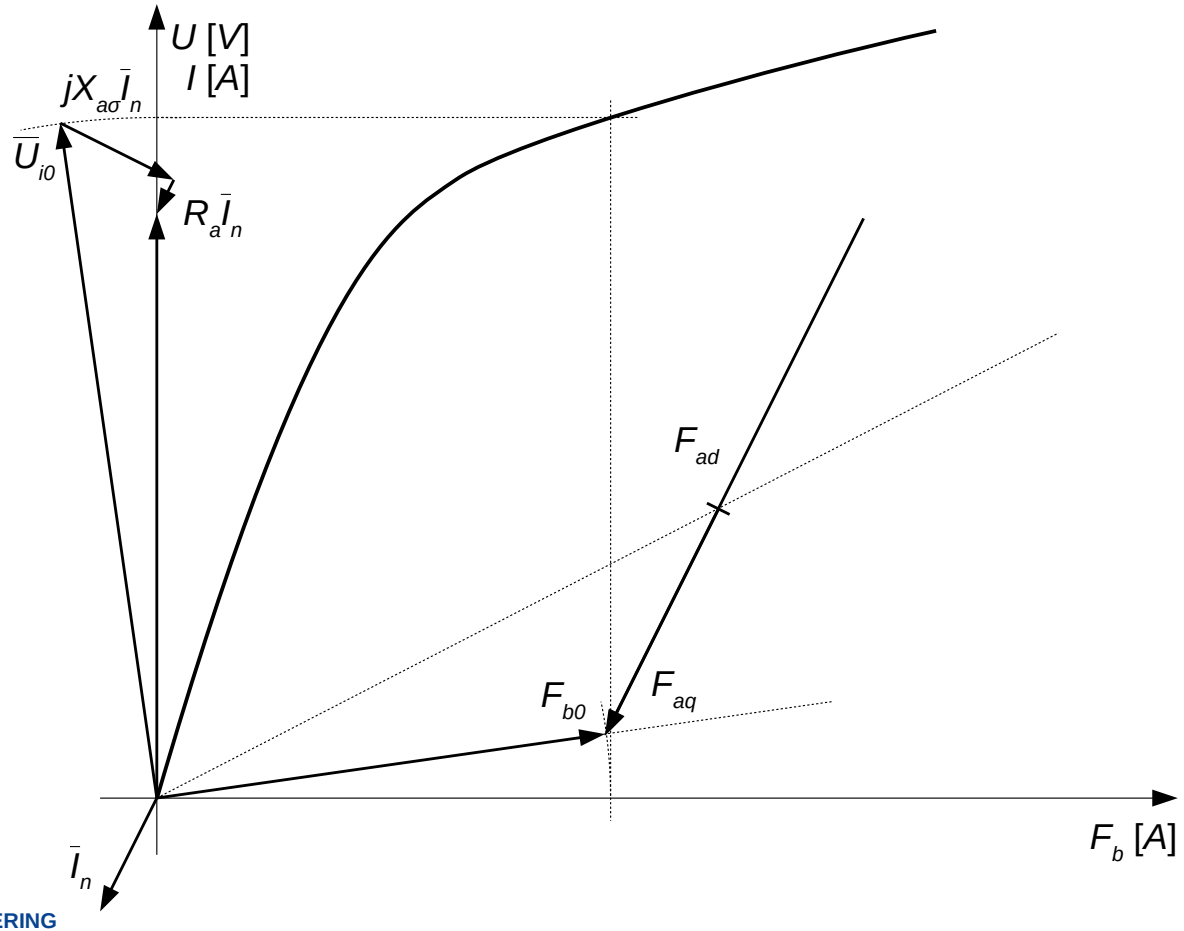
Salient Pole Synchronous Machine



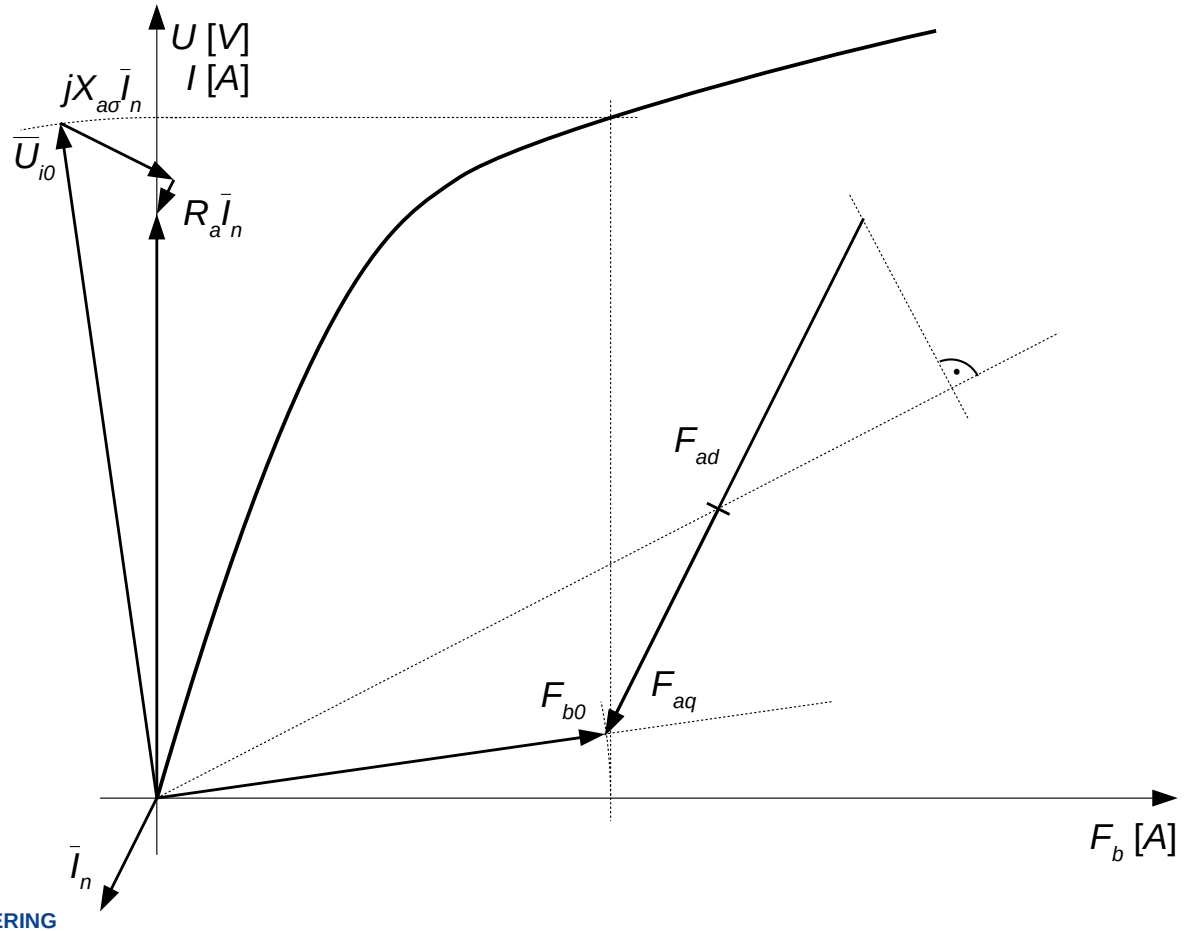
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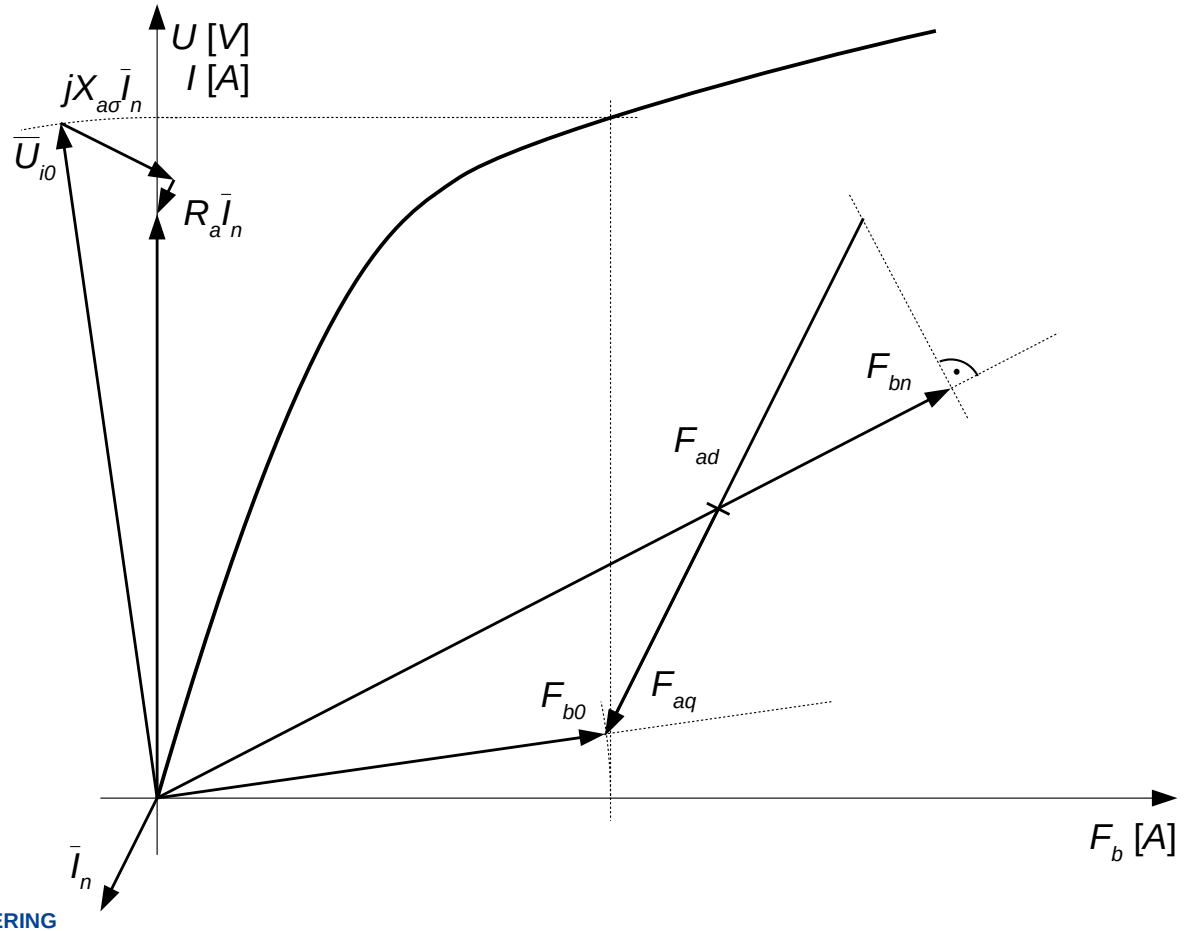
Salient Pole Synchronous Machine



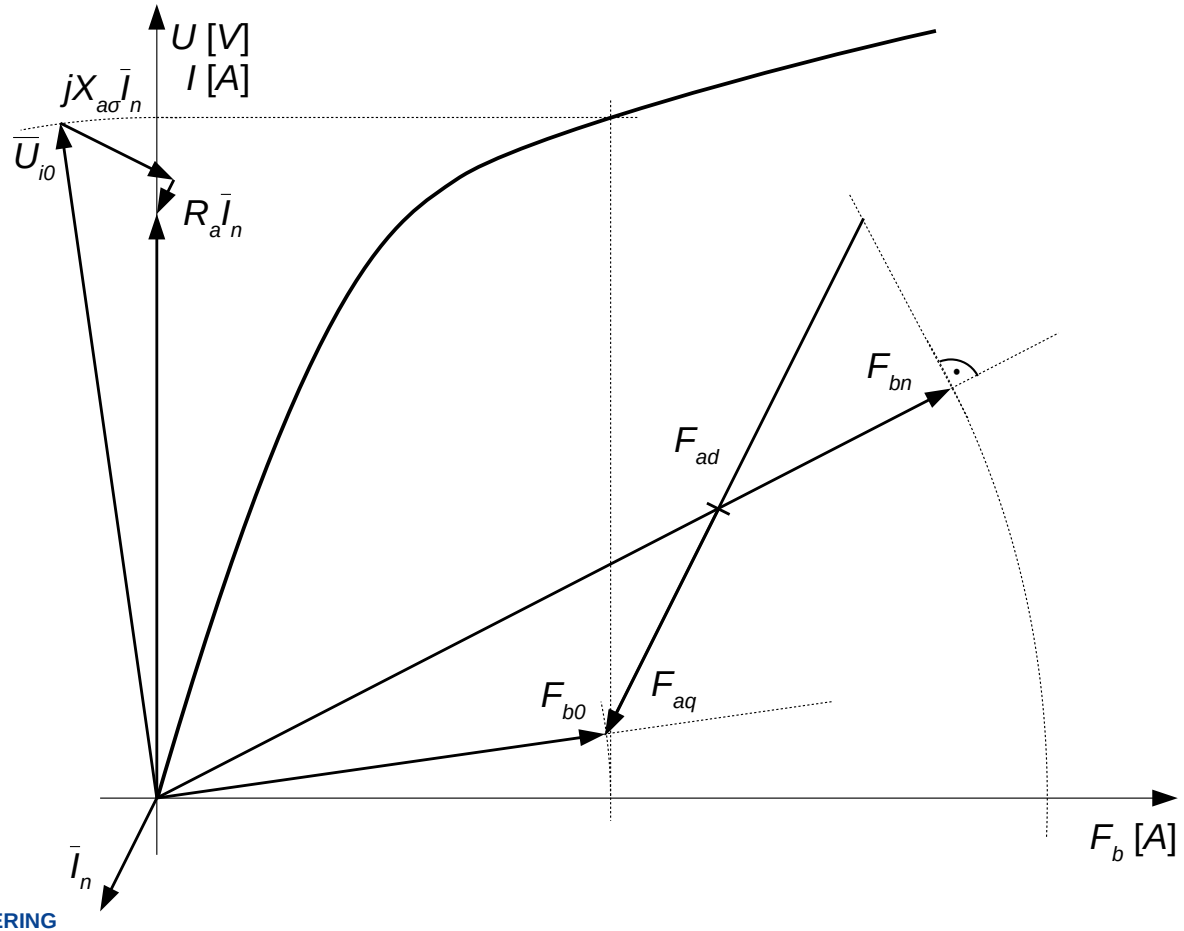
Salient Pole Synchronous Machine



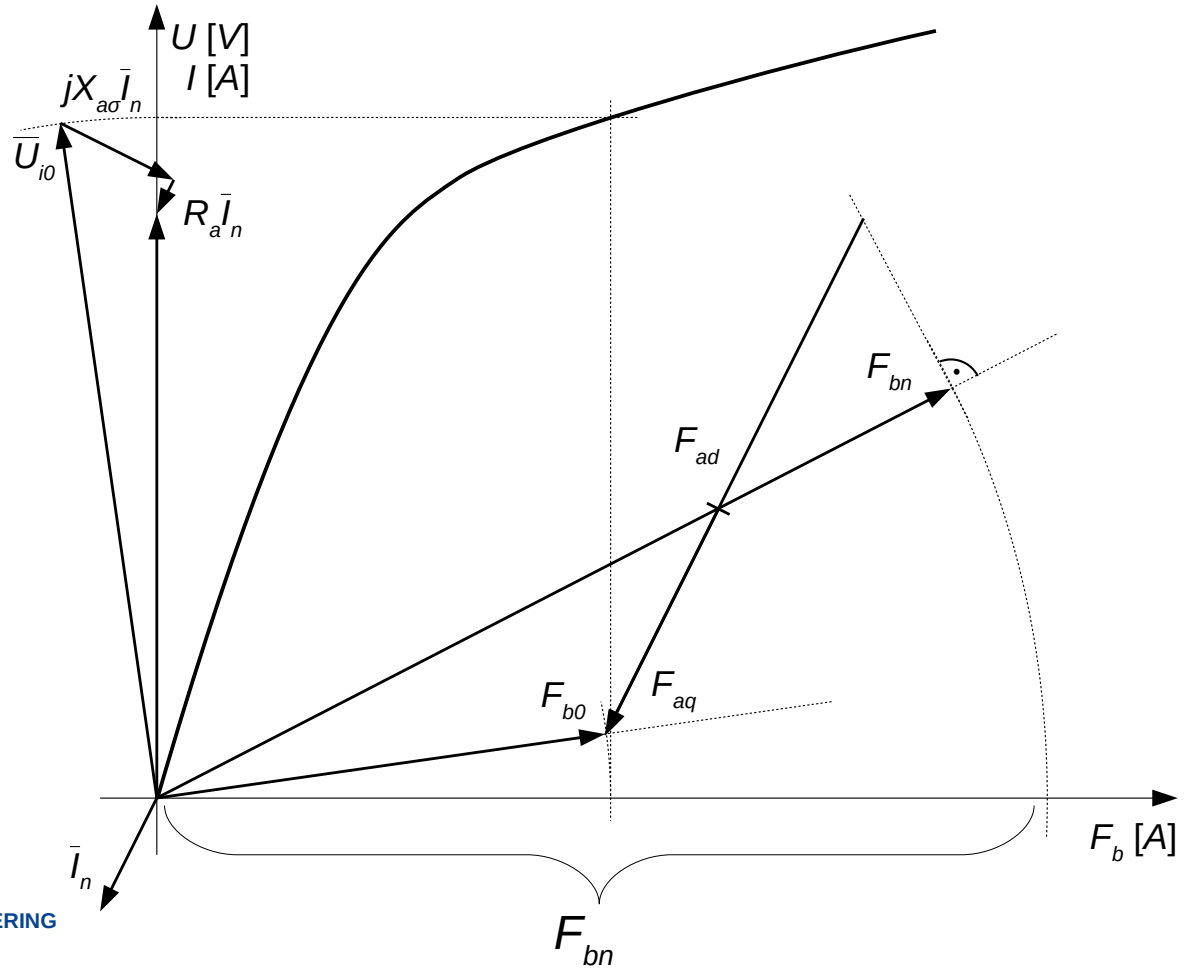
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Epilogue

Epilogue

- In the phasor diagram it is possible to use the Potier reactance instead of $X_{a\sigma}$ for the purpose of determination of I_{μ} (F_{b0})
  - In this case a higher excitation current than necessary is obtained

Epilogue

- Does Potier reactance appear even in case of permanent magnet synchronous machines?

- Is there an explicit way to calculate the Potier reactance?

- And what about Jan Tleskač?

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Thank You for Your Attention!

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