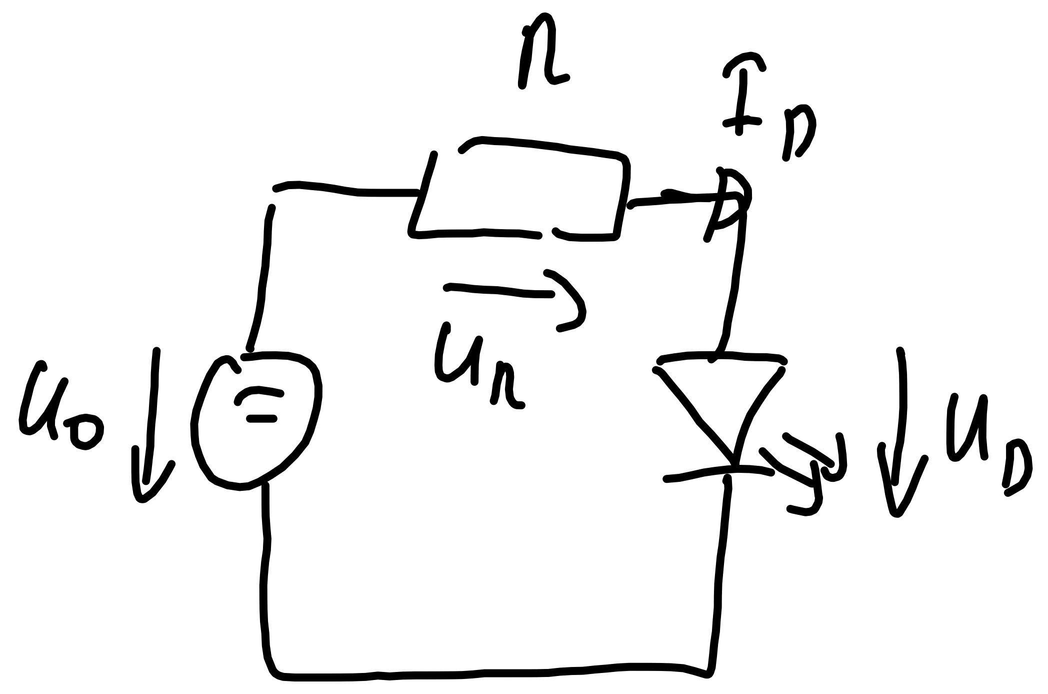
- DIODA + ODPOR

-> známe I_D, U_D

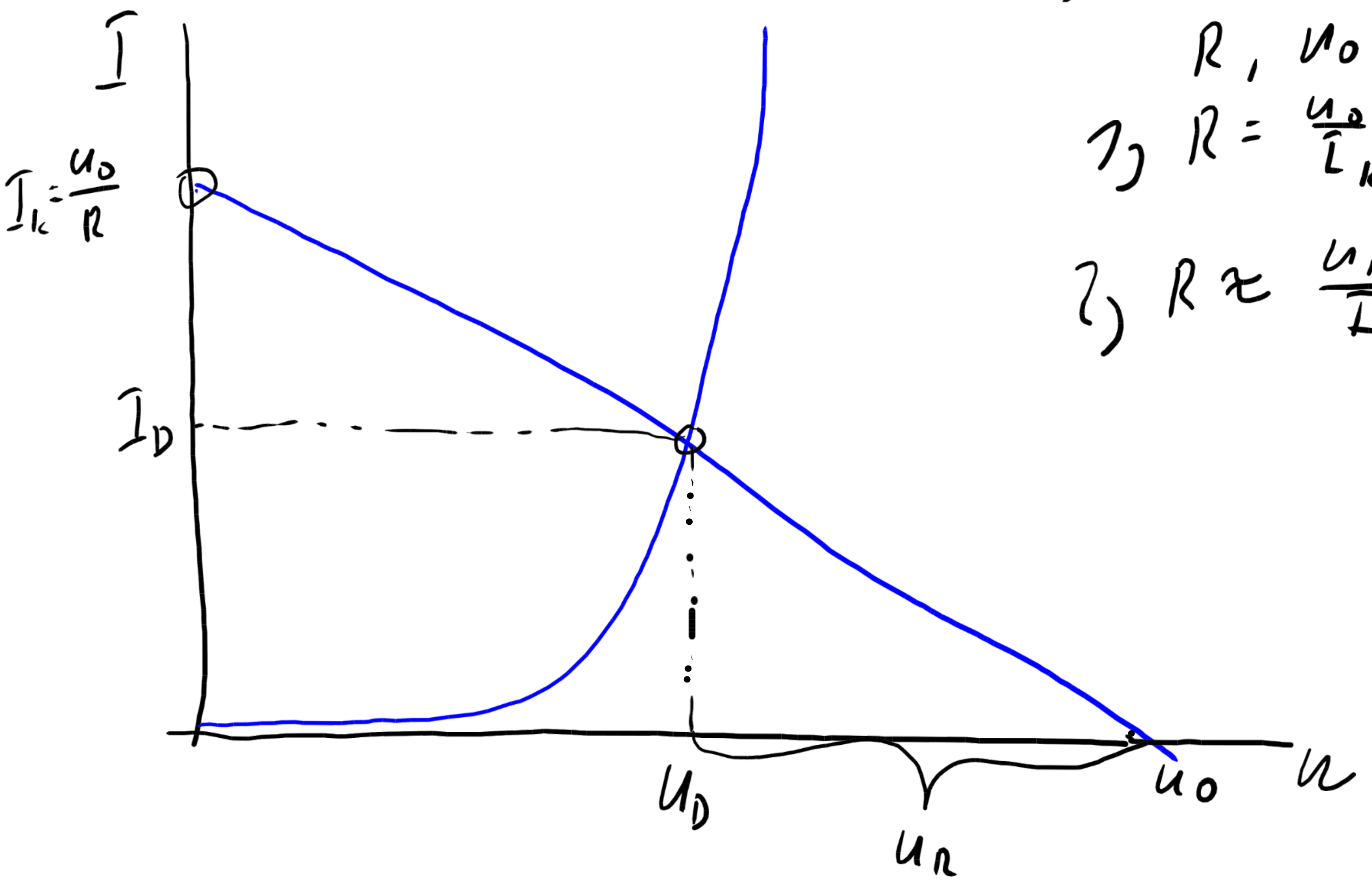
$+ U_0$ dopočítat $R = ?$



$R = \frac{\cancel{U_D}}{I_D}$ $\quad \frac{U_R}{I_D}$!

II. Kir. zákon

$U_R = U_0 - U_D$



-> známe I_D

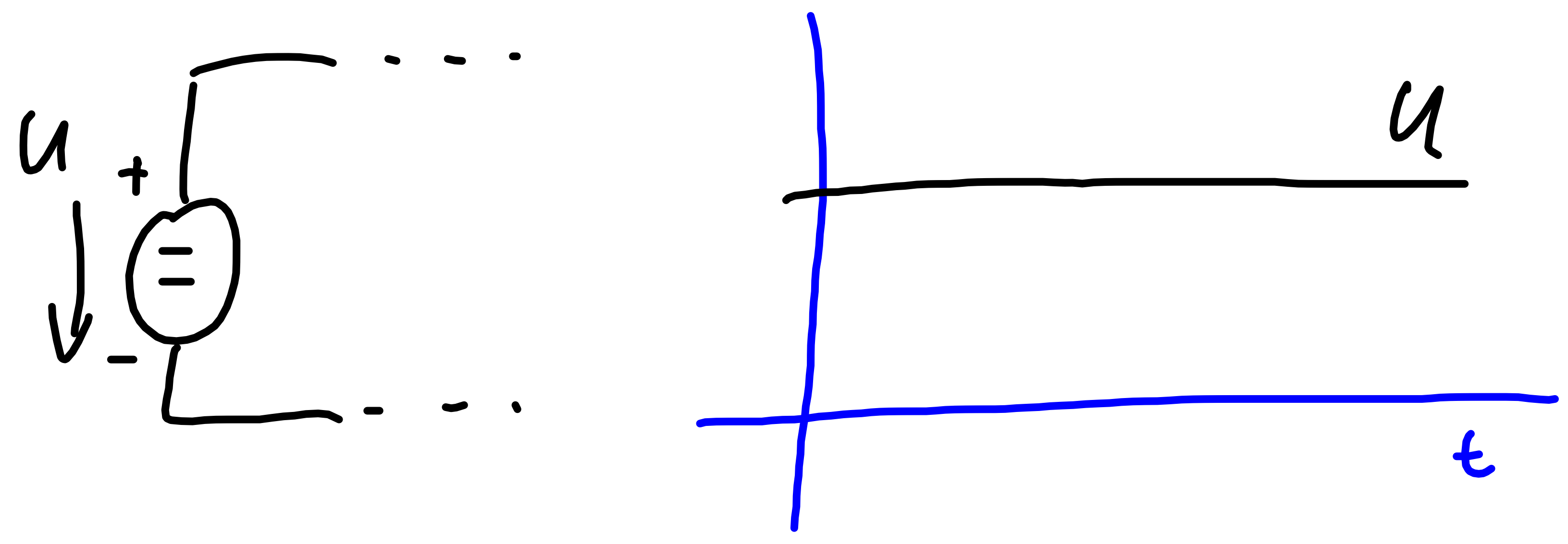
$R, U_0 = ?$

1) $R = \frac{U_0}{I_K}$

2) $R \neq \frac{U_R}{I_D}$

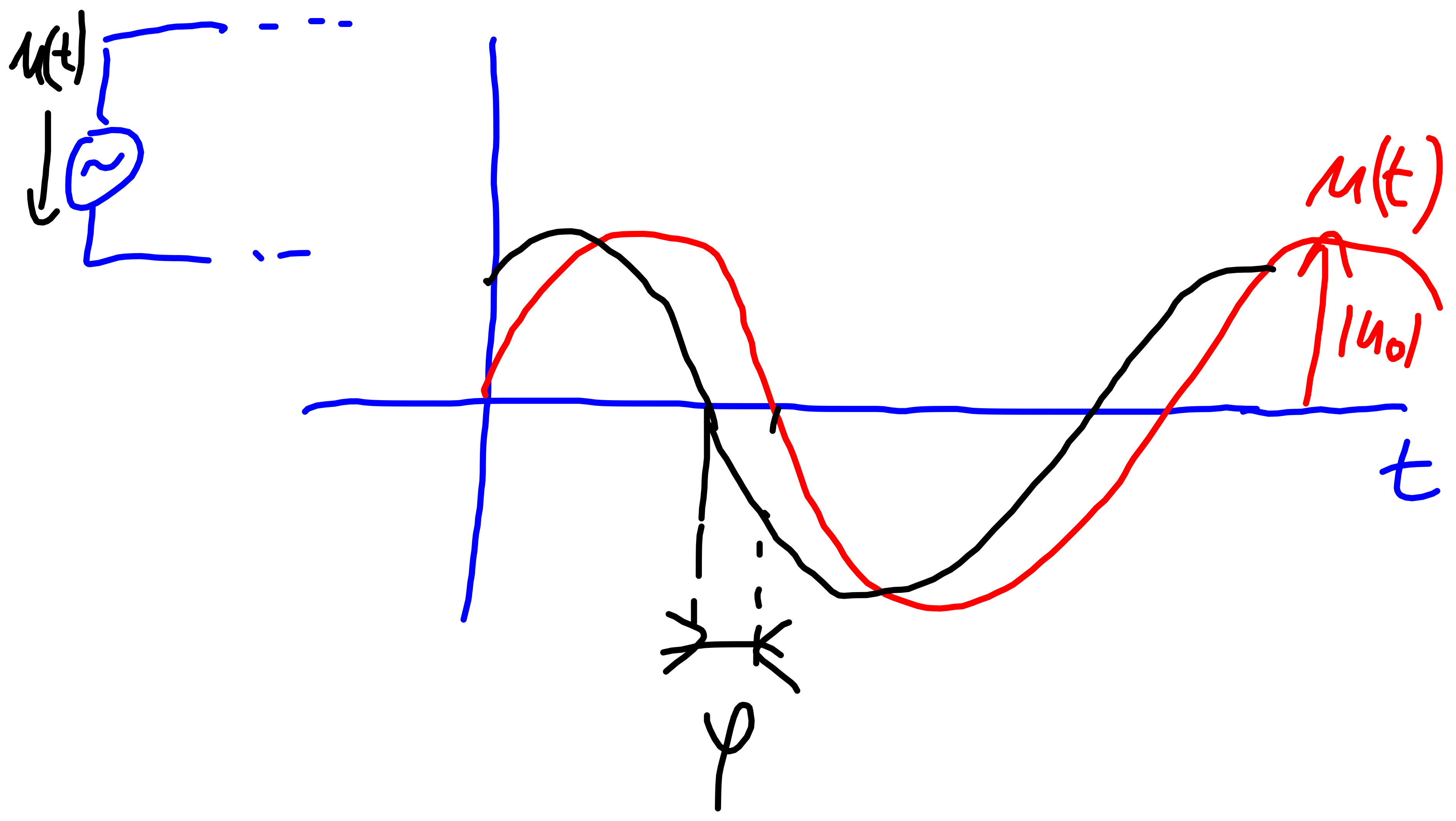
VÝPOČTY V OBVODECH SE STŘÍDAVÝMI (HARMONICKÝMI) ZDROJI NAPĚTÍ

- STEJNOSMĚRNÉ ZDROJE NAPĚTÍ (DC) → KONSTANTNÍ SIGNÁL



METODY ŘEŠENÍ: – METODA ZJEDNODUŠOVÁNÍ
– METODA UZLOVÝCH NAPĚTÍ
– –||– SMYČKOVÝCH PROUDŮ
– THEVENINOVY TEORÉMY
⋮

- STŘÍDAVÝ ZDROJ NAPĚTÍ (AC) → HARMONICKÝ SIGNÁL



$$u(t) = \underline{\underline{U_0}} \sin(\omega t + \underline{\underline{\varphi}})$$

→ ŘEŠÍME USTÁLENÝ STAV

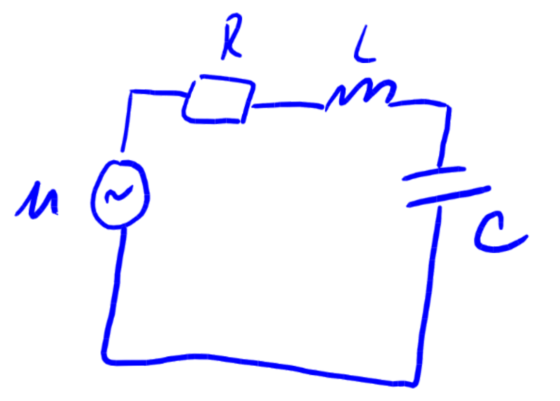
⇓

AMPLITUDY + FÁZOVÉ POSUVY

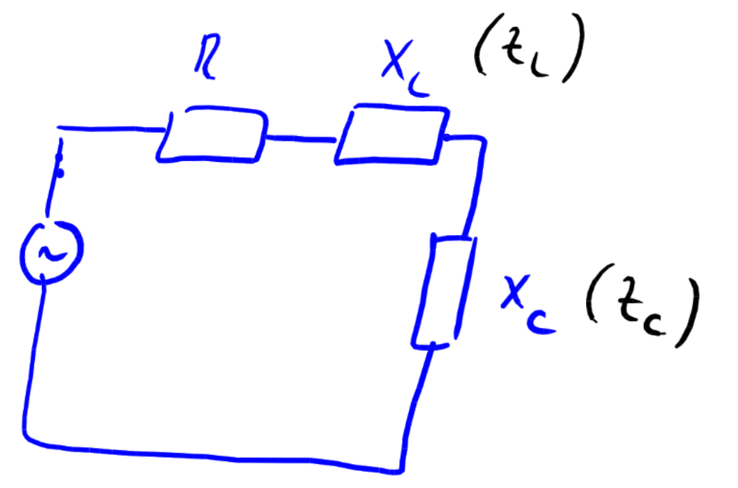
→ STEJNÉ METODY (JAKO U DC OBVODŮ) VEDOU NA VÝPOČTY S KOMPLEXNÍMI ČÍSLY

METODA ZJEDNODUŠOVÁNÍ

→ RLC V SÉRII



≡



ZNÁME: R, L, C, U_0, ω

$u = U_0 \sin(\omega \cdot t)$

ZAJÍMÁ NÁS: i, u_R, u_C, u_L

(RESP. AMPLITUDY + FÁZOVÉ POSUVY)

REAKTANCE 'X': (REÁLNÉ ČÍSLO)

$X_C = \frac{1}{\omega C}$ ... KAPACITNÍ REAKTANCE

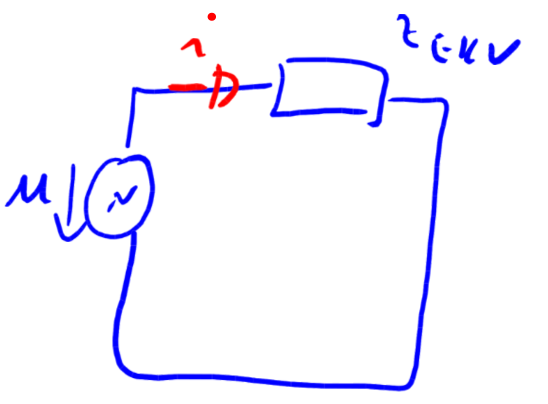
$X_L = \omega L$ ... INDUKTIVNÍ —//—

IMPEDANCE 'Z': (RYZE IMAG. ČÍSLO)

$Z_C = \frac{1}{j\omega C} \cdot \left(\frac{j}{j}\right) = \frac{-j}{\omega C} = -j \cdot X_C$

$Z_L = j\omega L = j \cdot X_L$

EKVIVALENTNÍ OBVOD



$Z_{EKV} = R + Z_L + Z_C$

$Z_{EKV} = R + j\omega L - \frac{j}{\omega C}$

$Z_{EKV} = \underbrace{R}_{\text{REZISTANCE}} + j\underbrace{\left(\omega L - \frac{1}{\omega C}\right)}_{\text{REAKTANCE}}$

– VÝPOČET PROUDU

$I_0 = \frac{U_0}{Z_{EKV}}$

$I_0 = A + jB$

AMPLITUDA

$|I_0| = \sqrt{A^2 + B^2}$

FÁZOVÝ POSUV

$\varphi = \mathrm{arctg}\left(\frac{B}{A}\right)$

+ POZOR NA II. A III. KVADRANT

$(A < 0)$

Výpočet napětí:

$U_R = I_0 \cdot R$

$U_C = I_0 \cdot Z_C$ ... amplitudy + fáze ...

$U_L = I_0 \cdot Z_L$

- Rezonance v RLC obvodu

$Z_{EKV} = R + j \cdot \underline{X}$ $\qquad X = \emptyset$

- V našem obvodu:

$X = \omega L - \frac{1}{\omega C} = 0 \qquad / \cdot \omega C$

$\omega_{REZ} = \sqrt{\frac{1}{LC}}$ ... (Thomsonův vztah)

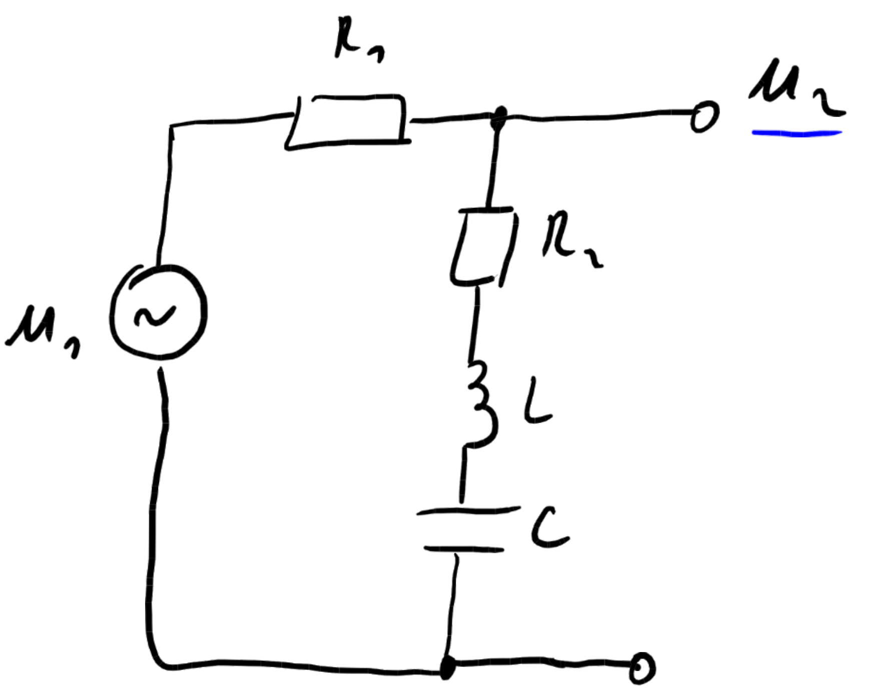
$2\pi f_{REZ} = \sqrt{\frac{1}{LC}}$

$f_{REZ} = \frac{1}{2\pi \sqrt{LC}}$

$\boxed{U_0 = U_R}$

$\boxed{\begin{array}{c} u_C = -u_L \\ |U_C| = |U_L| \end{array}}$

DÚ: zapřemýšlet nad obvodem

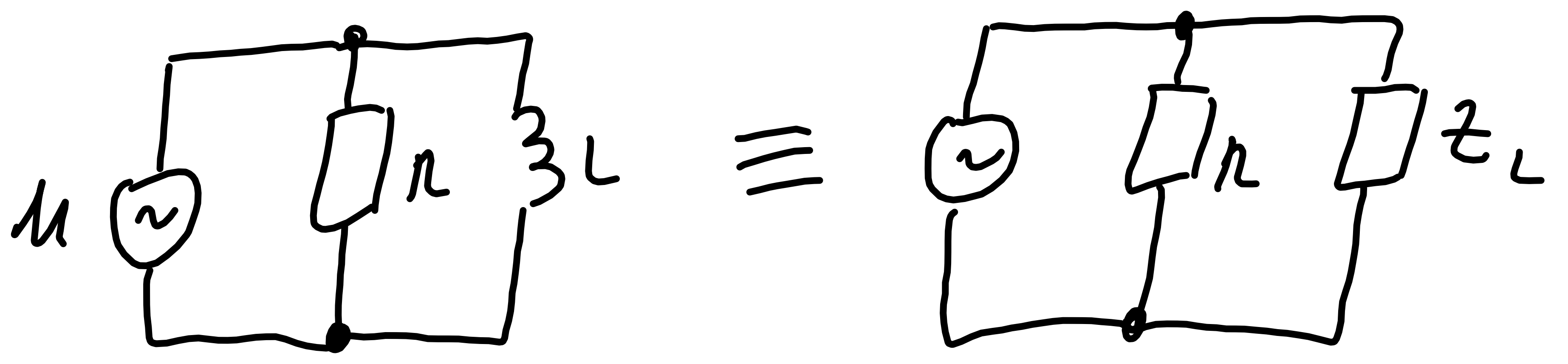


u_2 v rezonanci

Pozn. odporový dělič

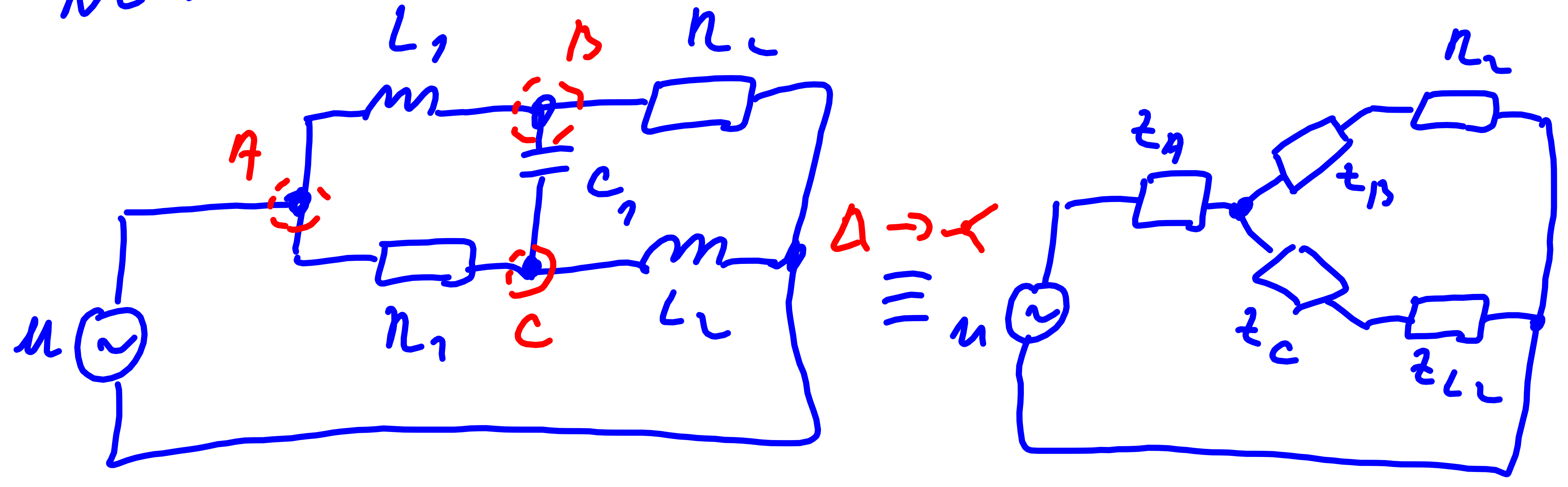
– NEBOJTE SE OSTATNÍCH ZAPOJENÍ

NAPŘ. PARALELNÍ



$$Z_{EKV} = \frac{R \cdot Z_L}{R + Z_L} = \frac{R \cdot j\omega L}{R + j\omega L}$$

NEBO

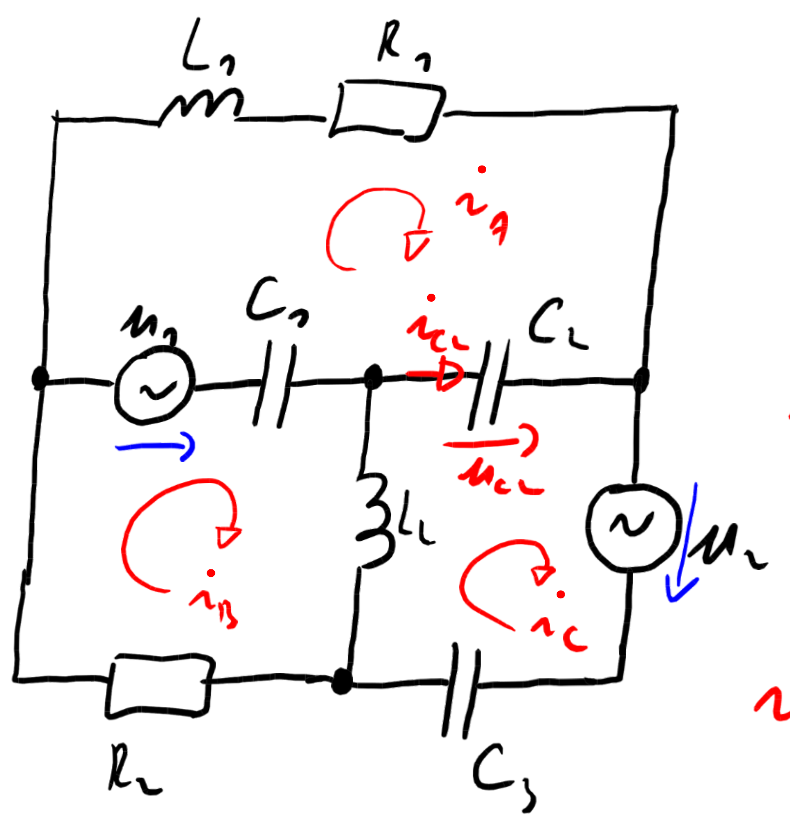


$$Z_A = \frac{Z_{L_1} \cdot R_1}{Z_{L_1} + R_1 + Z_{C_1}}$$

⋮

– SLOŽITĚJŠÍ OBVODY S VÍCE NAPÁJECÍMI ZDROJI

NAPŘ. SMYČKOVÉ PROUDY



$i_A: \; (z_{L1}+R_1)\cdot I_A + z_{C2}(I_A - I_C) +$
$\quad + z_{C1}(I_A - I_B) - U_1 = 0$

$i_B: \; R_2 \cdot I_B + z_{C1}(I_B - I_A) + z_{L2}(I_B - I_C) +$
$\quad + U_1 = 0$

$i_C: \; z_{C3}\cdot I_C + z_{L2}(I_C - I_B) + z_{C2}\cdot(I_C - I_A) +$
$\quad + U_2 = 0$

$i_{C2}, \; u_{C2} = ?$

SLAR (S KOMPLEXNÍMI ČÍSLY)

$$\begin{array}{c} \begin{array}{ccc} I_A & I_B & I_C \end{array} \\ \begin{pmatrix} z_{L1}+R_1+z_{C2}+z_{C1} & -z_{C1} & -z_{C2} \\ -z_{C1} & z_{C1}+z_{L1}+R_2 & -z_{L2} \\ -z_{C2} & -z_{L2} & z_{C3}+z_{L2}+z_{C2} \end{pmatrix} = A \end{array}$$

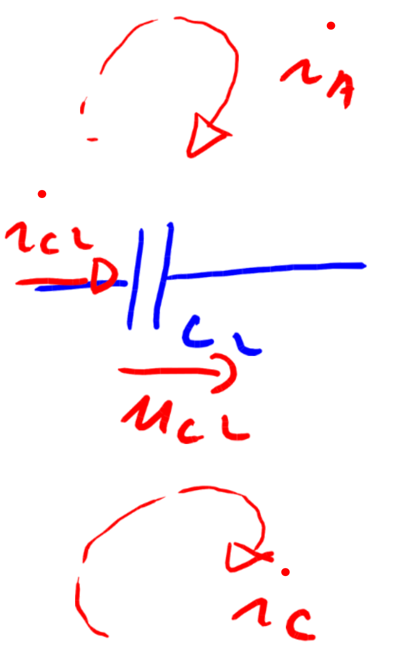
POZN. MATICE JE SYMETRICKÁ

$$A \cdot \begin{pmatrix} I_A \\ I_B \\ I_C \end{pmatrix} = \begin{pmatrix} u_1 \\ -u_1 \\ -u_2 \end{pmatrix}$$

→ ŘEŠENÍ: MATLAB, CRAMEROVO PRAVIDLO, ...

NAPŘ. $i_{C2} = ?$ $\quad u_{C2} = ?$

$$i_{C2} = |I_{C2}| \cdot \sin(\omega t + \underline{\underline{\varphi_{C2}}})$$



$$I_{C2} = I_C - I_A$$

$$U_{C2} = I_{C2} \cdot Z_{C2}$$

... komplexní čísla

↓

AMPLITUDA $|I_{C2}|$

+ FÁZOVÝ POSUV φ_{C2}

THÉVENINŮV TEORÉM

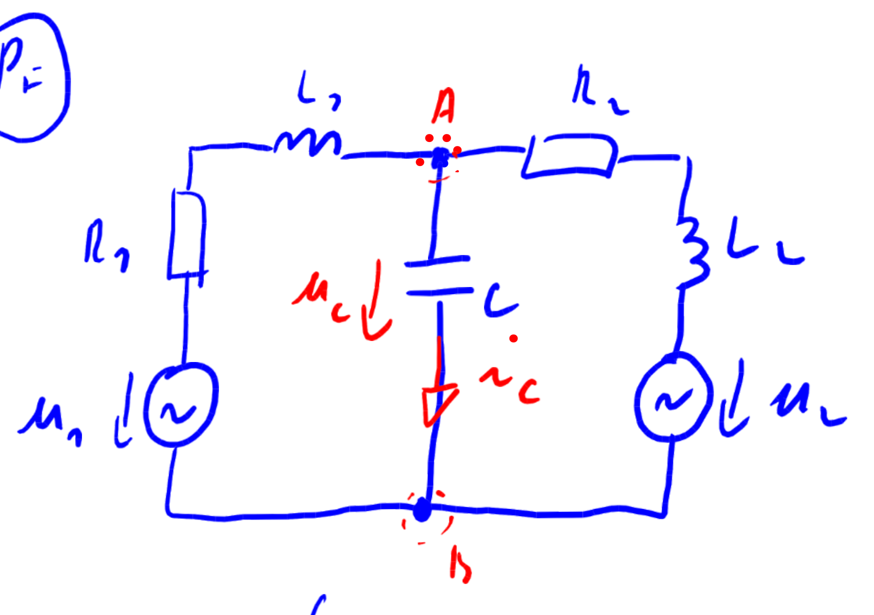
Př:

Známe: $R_1, R_2, L_1, L_2, C, \omega, U_1, U_2$

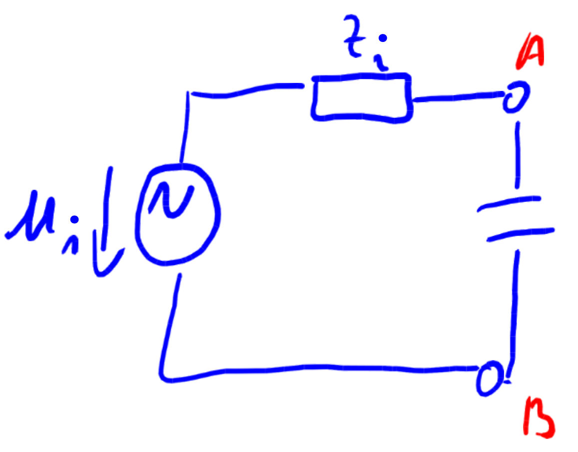
$u_1 = U_1 \sin(\omega t)$

$u_2 = U_2 \sin(\omega t)$

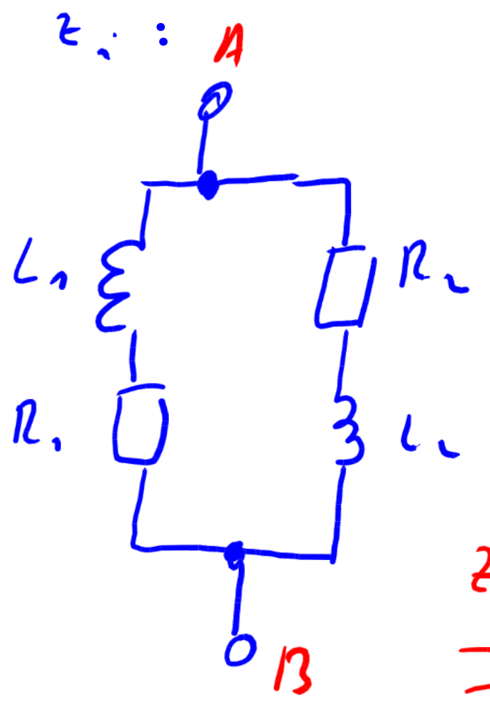
$i_C, u_C = ?$



EKVIVALENTNÍ OBVOD:



Z_i:



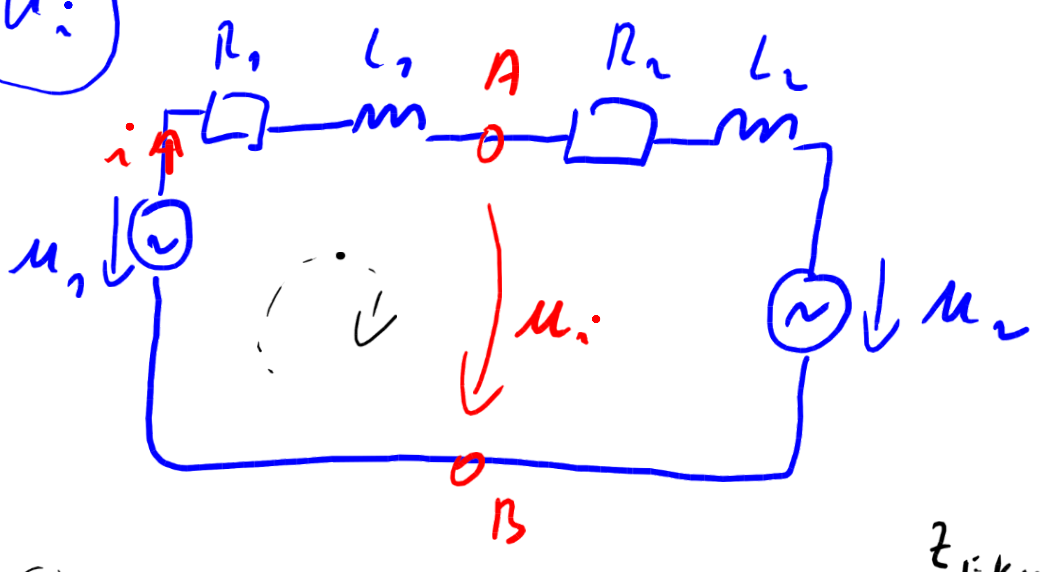
$Z_{L_1} = j\omega L_1$

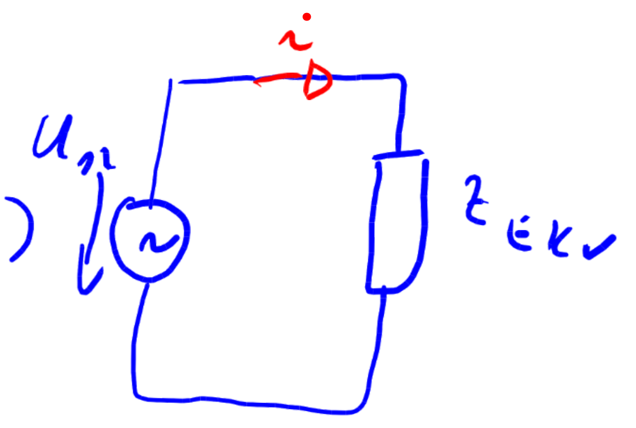
$Z_{L_2} = j\omega L_2$

$Z_i = (Z_{L_1}+R_1) \| (R_2+L_2)$

$$Z_i = \frac{(Z_{L_1}+R_1)\cdot(R_2+L_2)}{Z_{L_1}+R_1+R_2+L_2}$$

U_i:





II. KIR. Z.

$U_{R_1} + U_{L_1} + U_i - U_1 = 0$

$U_i = U_1 - U_{R_1} - U_{L_1}$

$U_i = U_1 - I\cdot R_1 - I\cdot Z_{L_1}$

$Z_{EKV} = R_1 + R_2 + j\omega(L_1+L_2)$

$U_{12} = U_1 - U_2$

$$I = \frac{U_{12}}{Z_{EKV}}$$

POZN. II K.Z.

$I\cdot Z_{EKV} + U_2 - U_1 = 0$

$$I = \frac{U_1 - U_2}{Z_{EKV}}$$

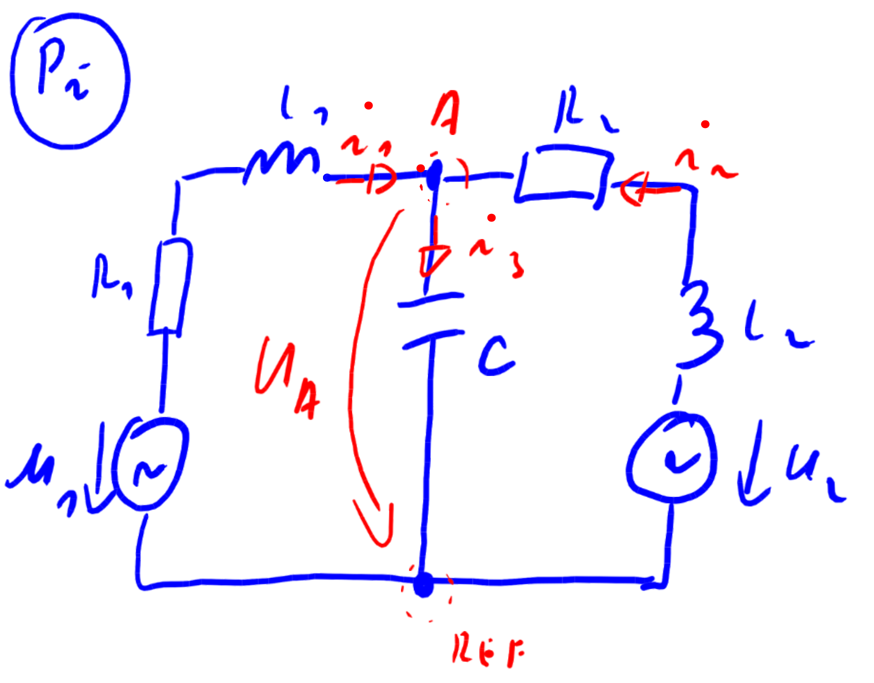
$$I_C = \frac{U_i}{Z_i + Z_C}, \quad U_C = I_C \cdot Z_C$$

KOMPLEXNÍ ČÍSLA

AMPLITUDA + FÁZ. POSUV

P₂

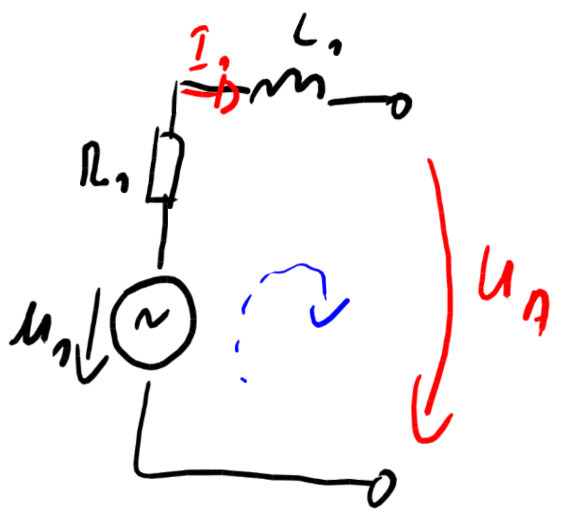
METODA UZLOVÝCH NAPĚTÍ



UZEL A (I. KIR. ZÁKON)

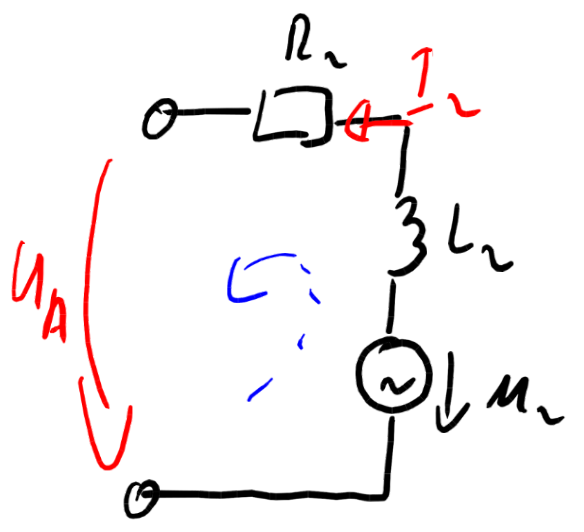
$$i_1 + i_2 = i_3$$

NÁHRADNÍ OBVODY:



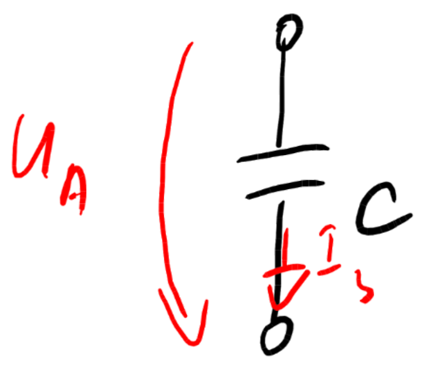
$$I_1 \cdot (Z_{L1} + R_1) + U_A - U_1 = 0$$

$$\underline{\underline{I_1 = \frac{U_1 - U_A}{Z_{L1} + R_1}}}$$



$$I_2 \cdot (Z_{L2} + R_2) + U_A - U_2 = 0$$

$$\underline{\underline{I_2 = \frac{U_2 - U_A}{Z_{L2} + R_2}}}$$



$$\underline{\underline{I_3 = \frac{U_A}{Z_C}}}$$

$$\frac{U_1 - U_A}{Z_{L1} + R_1} + \frac{U_2 - U_A}{Z_{L2} + R_2} = \frac{U_A}{Z_C}$$

$$\vdots$$

$U_A = \dots$ ✓

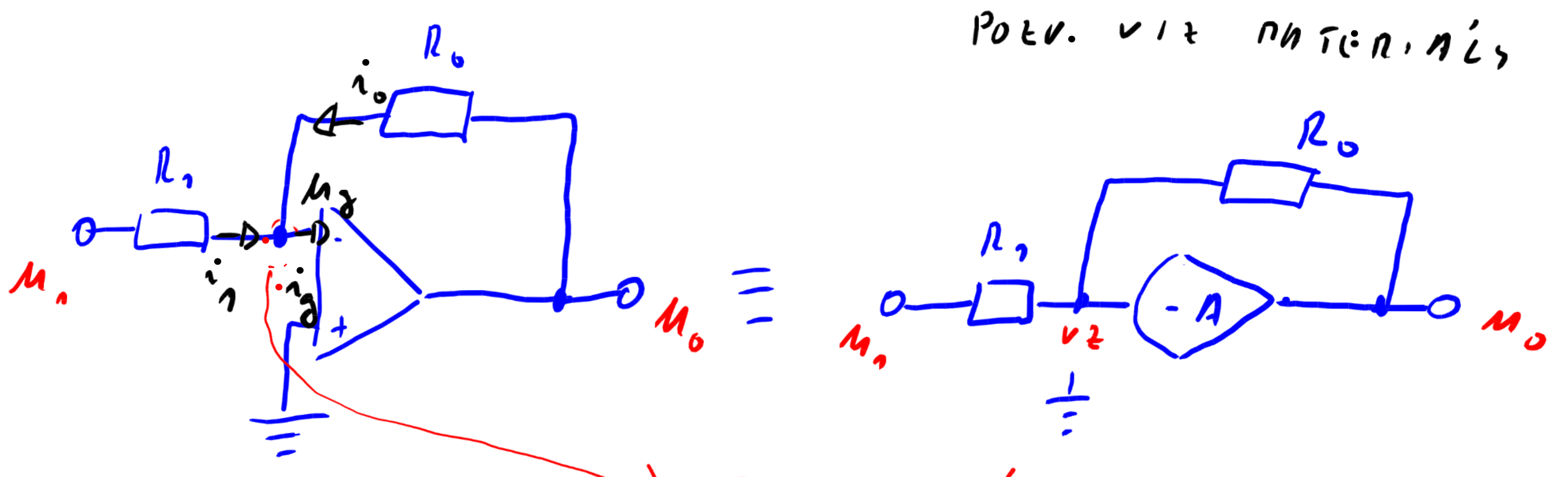
$U_C = U_A$ ✓

$I_C = \frac{U_C}{Z_C} = I_3$ ✓

POZN. MATLAB

INVERTUJÍCÍ OPERAČNÍ ZESILOVAČ (IDEÁLNÍ)

Pozn. viz materiály KPJK



I. Kir. zákon

$i_0 + i_1 = i_g$

VLASTNOSTI :

- $A = "\infty"$
- $R_{in} = "\infty"$
- $(R_{out} = "0")$

$i_g = 0A \quad \left(\frac{u_g}{R_{in}}\right)$

$u_0 = -A \cdot u_g$

$u_g = \frac{u_0}{-A} = \frac{u_0}{"-\infty"} = \underline{\underline{0V}}$ ... VZ

$i_1 = \frac{u_1 - u_g}{R_1} = \frac{u_1}{R_1}$

$i_0 = \frac{u_0 - u_g}{R_0} = \frac{u_0}{R_0}$

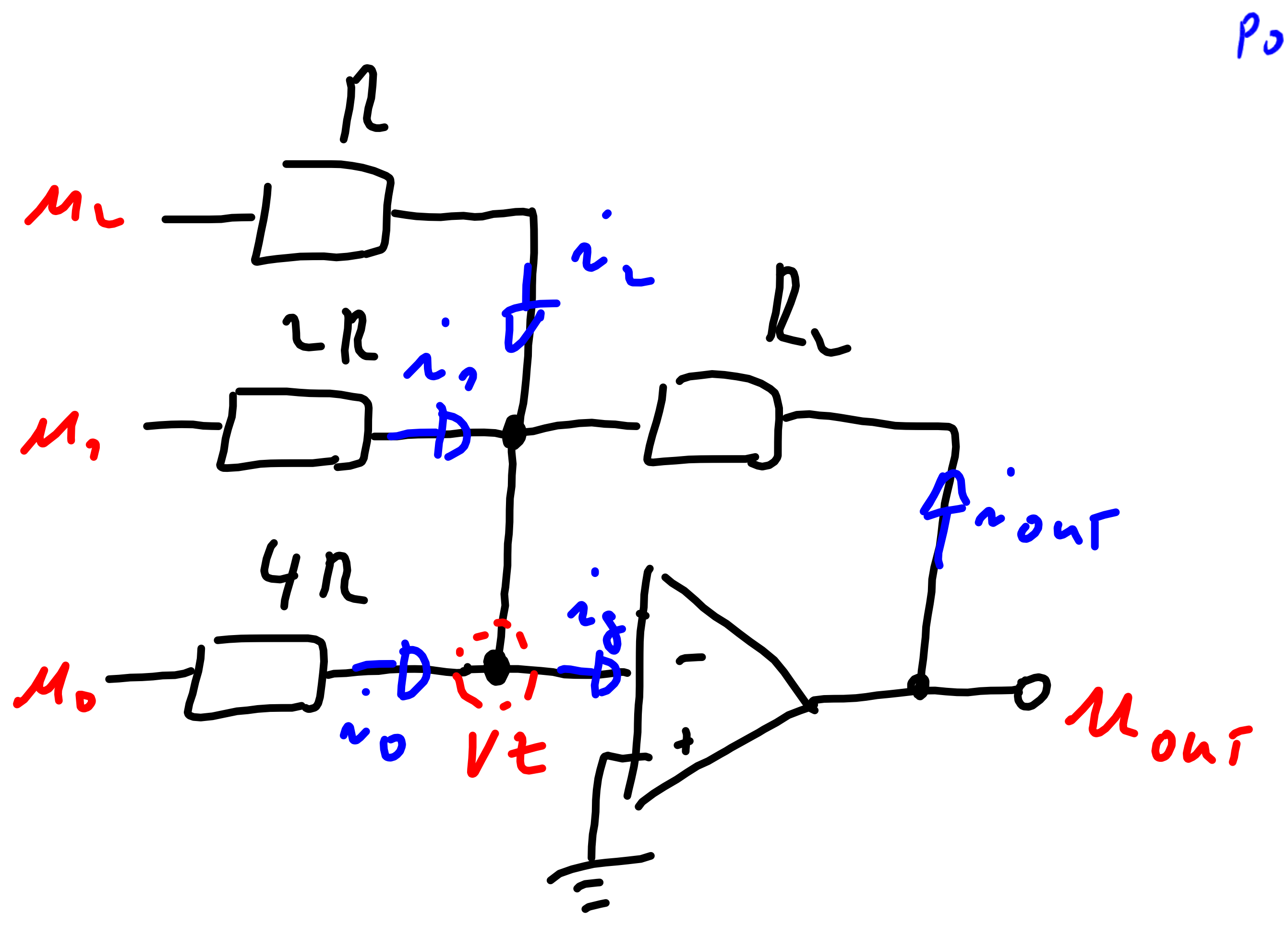
$\frac{u_1}{R_1} + \frac{u_0}{R_0} = 0 \rightarrow \boxed{u_0 = -\frac{R_0}{R_1} \cdot u_1}$

A

$R_0 = R_1$ ... INVERTOR

SČÍTAČKA (INVERTUJÍCÍ)

Pozn. D/A převodníky



I. Kir. zákon:

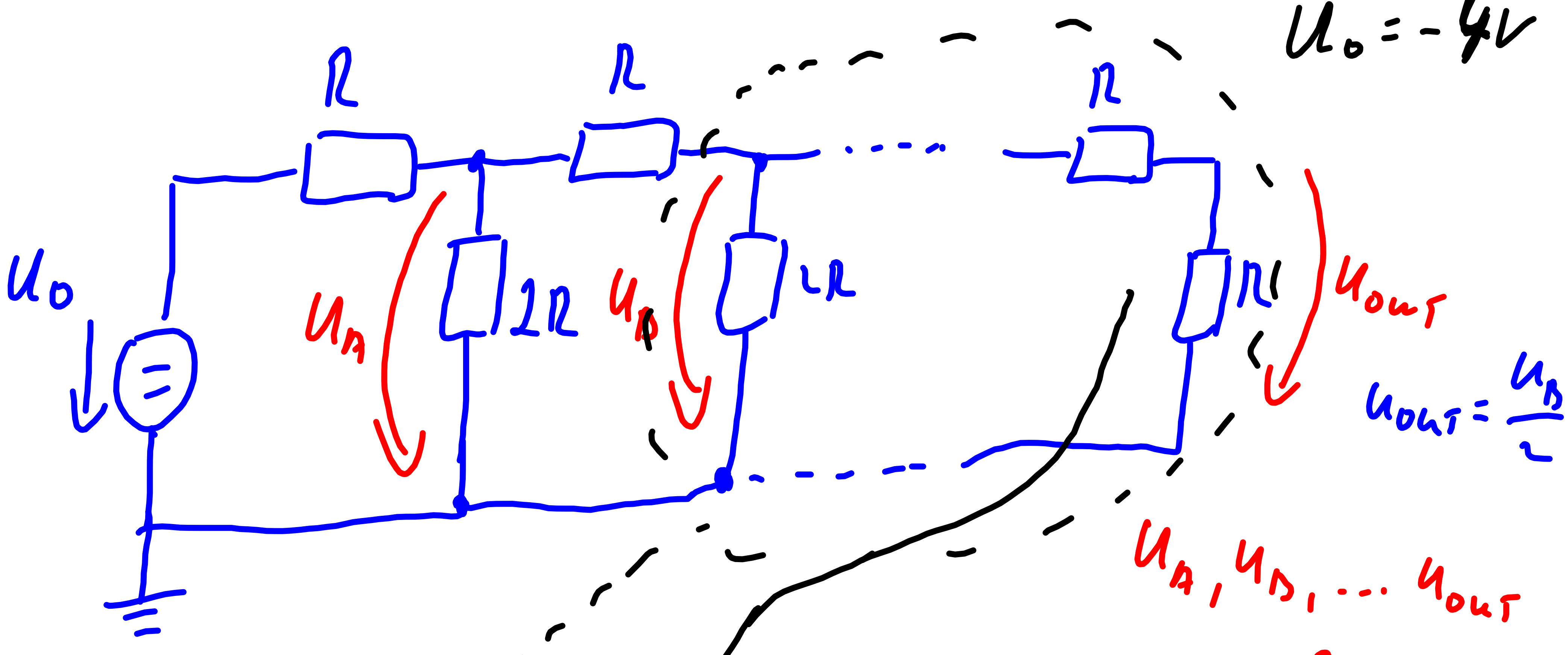
$$\boxed{i_0 + i_1 + i_2 + i_{out} - \cancel{i_g} = 0}$$

$$\frac{u_0}{4R} + \frac{u_1}{2R} + \frac{u_2}{R} + \frac{u_{out}}{R_2} = 0$$

$$\boxed{u_{out} = -\frac{R_2}{R}\left(\frac{u_0}{4} + \frac{u_1}{2} + \frac{u_2}{1}\right)}$$

R - 2R ELEKTRICKÝ OBVOD

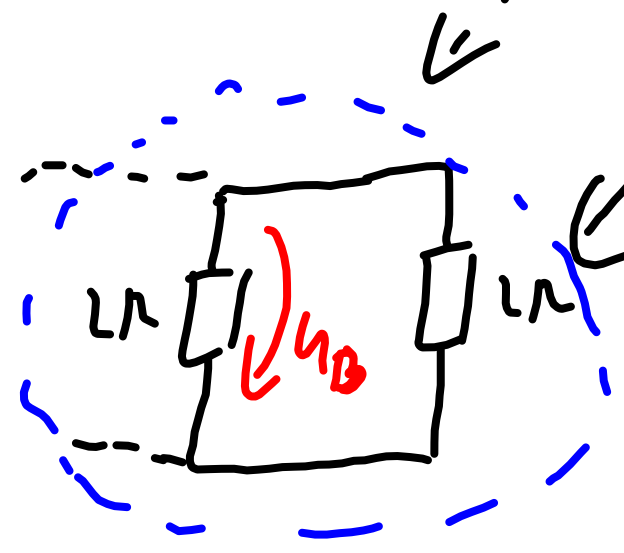
$U_0 = -4V$



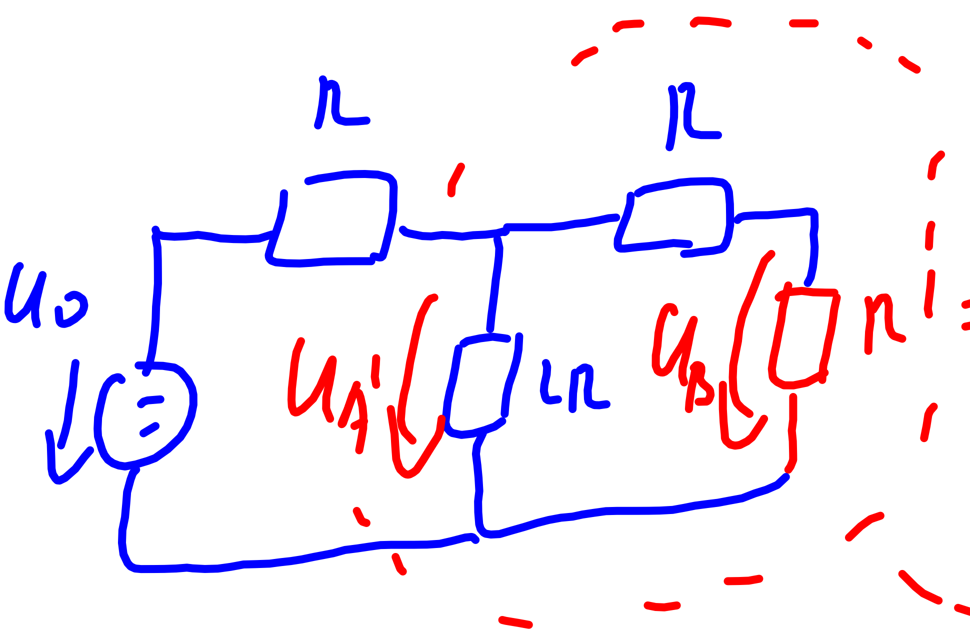
$U_{OUT} = \frac{U_B}{2}$

$U_A, U_B, \ldots U_{OUT}$?

R+R v sérii

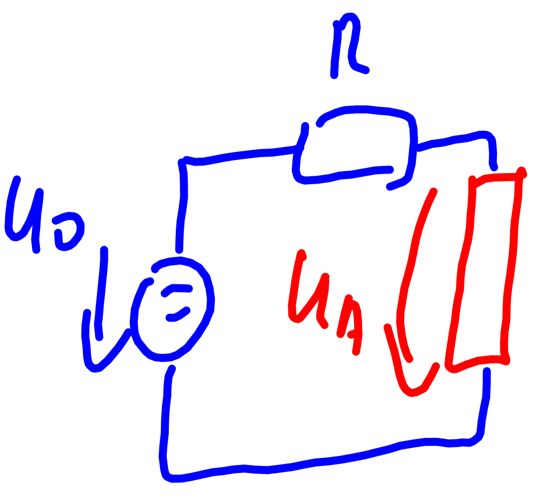


$$R_{ekv_1} = \frac{2R \cdot 2R}{2R+2R} = \frac{4R^2}{4R} = R$$



$= R_{ekv_1}$

$$\rightarrow R_{ekv_2} = \frac{2R \cdot 2R}{2R+2R} = R$$



$R = R_{ekv_2}$

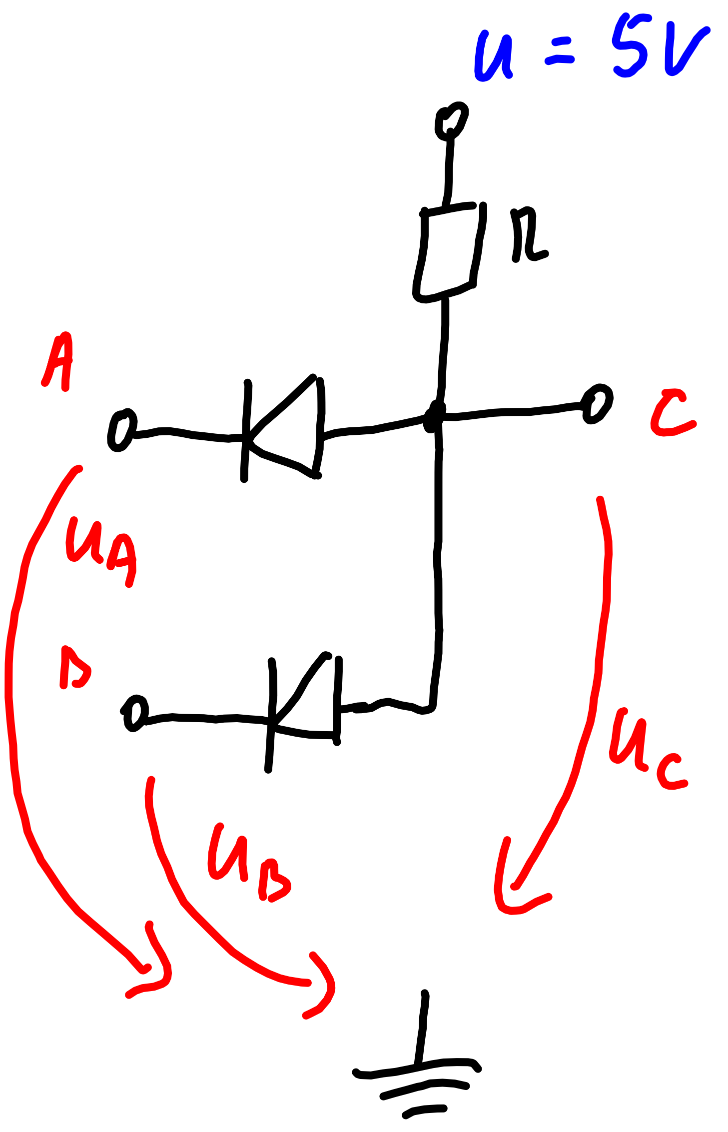
$$U_A = \frac{1}{2} U_0$$

$$U_B = \frac{1}{2} U_A$$

$$\vdots$$

$$U_{OUT} = \frac{1}{2} U_F$$

ANALYZOVAT LOGICKÝ OBVOD S DIODAMI



LOG. 0 = 0 - 2 V

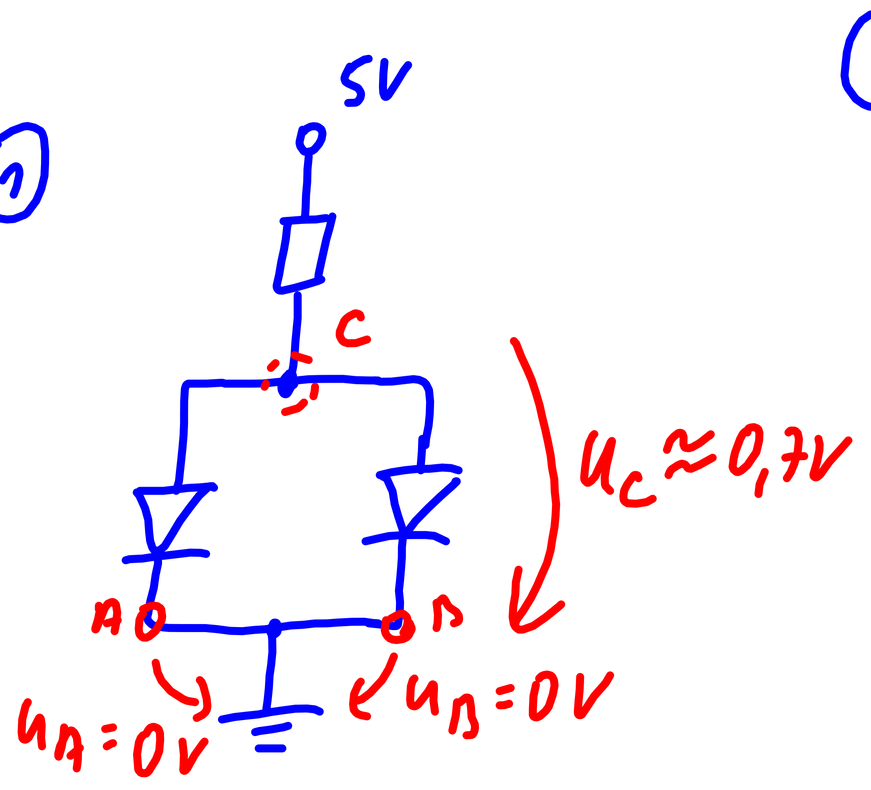
LOG. 1 = 3V - 5V

LOGICKÉ HODNOTY

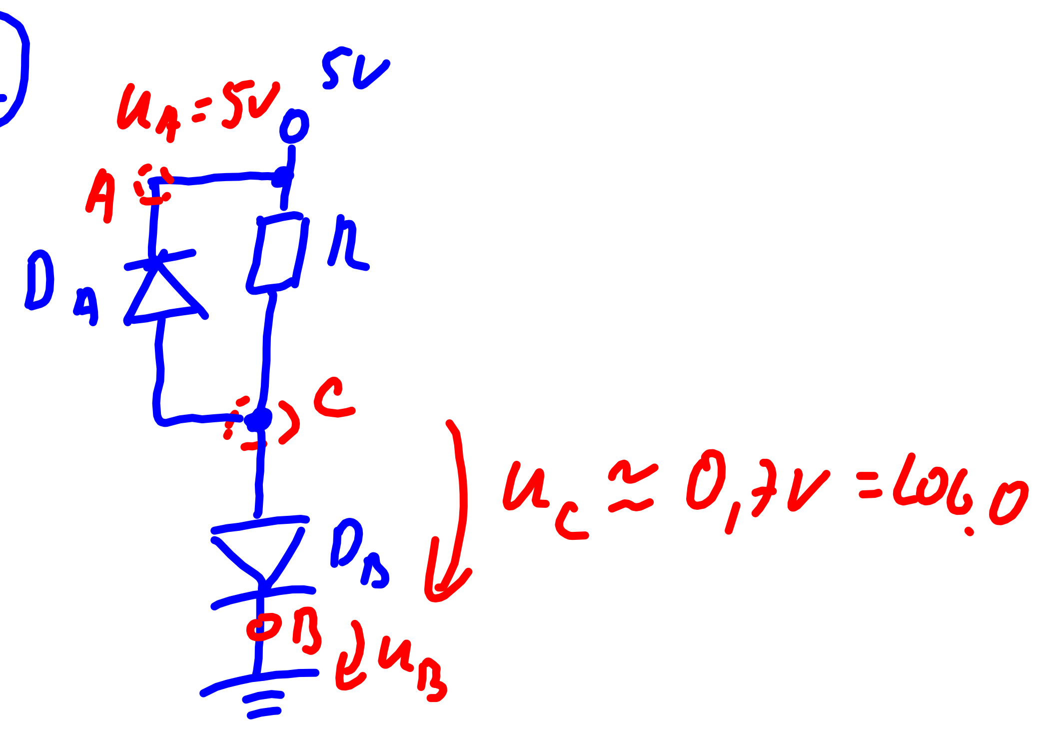
	VSTUP A	VSTUP B	VÝSTUP C
1	0	0	0
	0	1	0
2	1	0	0
3	1	1	1

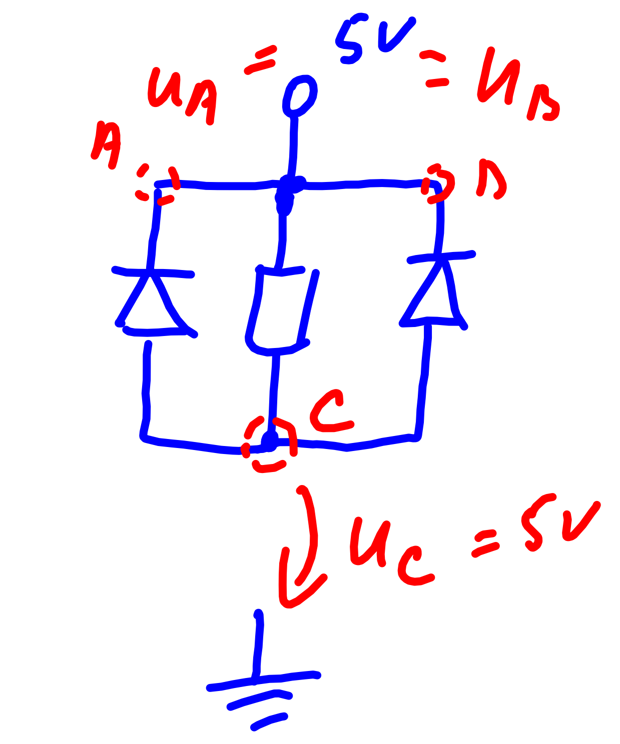
AND

1



2





DÚ OR :