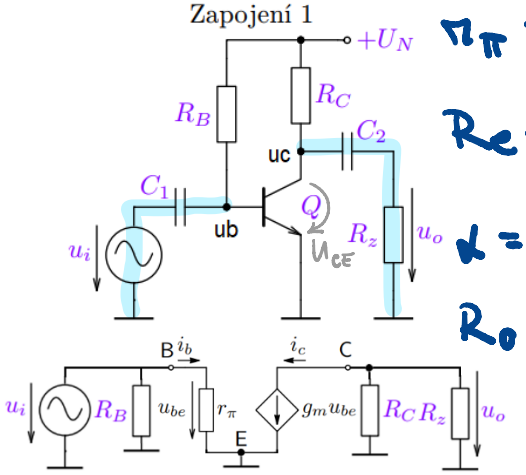
Zapojení 1



Pracovní bod

$$I_B = \frac{U_N - 0{,}7\ V}{R_B}$$

$$I_C = \beta I_B$$

$$U_{CE} = U_N - I_C R_C$$

Hodnoty prvků AC náhrady

$$g_m = 40 I_C$$

$$r_\pi = \frac{\beta}{g_m}$$

Vstupní/výstupní odpor a napěťové zesílení

$$R_{in} = R_B || r_\pi = \frac{R_B r_\pi}{R_B + r_\pi}$$

$$R_{out} = R_C$$

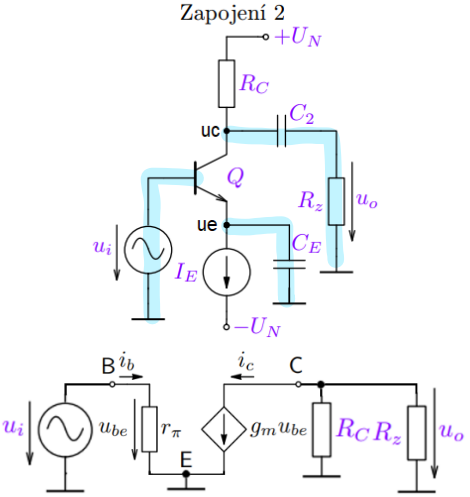
$$A_u = \frac{u_o}{u_i}$$

$$u_o = (R_C || R_Z)(-i_c) = -\frac{1}{\frac{1}{R_C} + \frac{1}{R_Z}} g_m u_{be}$$

$$u_{be} = u_i$$

$$A_u = \frac{u_o}{u_i} = -\frac{1}{\frac{1}{R_C} + \frac{1}{R_Z}} g_m$$

Zapojení 2



Pracovní bod

$$I_C = \alpha I_E$$

$$U_E = -0{,}7V$$

$$U_C = U_N - I_C R_C$$

$$U_{CE} = U_C - U_E = U_N + 0{,}7V - I_C R_C$$

Hodnoty prvků AC náhrady

$$g_m = 40 I_C$$

$$r_\pi = \frac{\beta}{g_m}$$

Vstupní/výstupní odpor a napěťové zesílení

$$R_{in} = r_\pi$$

$$R_{out} = R_C$$

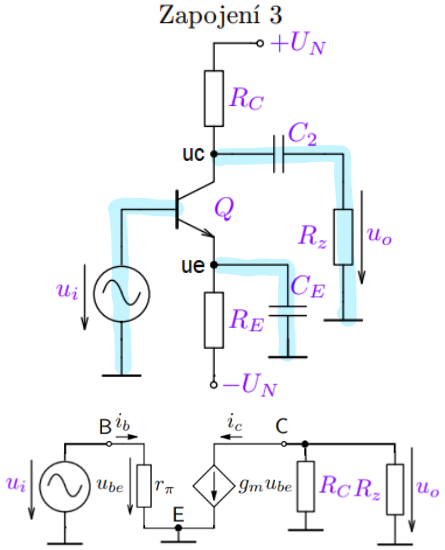
$$A_u = \frac{u_o}{u_i}$$

$$u_o = (R_C || R_Z)(-i_c) = -\frac{1}{\frac{1}{R_C} + \frac{1}{R_Z}} g_m u_{be}$$

$$u_{be} = u_i$$

$$A_u = \frac{u_o}{u_i} = -\frac{1}{\frac{1}{R_C} + \frac{1}{R_Z}} g_m$$

Zapojení 3



Pracovní bod

$$I_E = \frac{-0{,}7\ V - (-U_N)}{R_E}$$

$$I_C = \alpha I_E$$

$$U_E = -0{,}7V$$

$$U_C = U_N - I_C R_C$$

$$U_{CE} = U_C - U_E = U_N + 0{,}7V - I_C R_C$$

Hodnoty prvků AC náhrady

$$g_m = 40 I_C$$

$$r_\pi = \frac{\beta}{g_m}$$

Vstupní/výstupní odpor a napěťové zesílení

$$R_{in} = r_\pi$$

$$R_{out} = R_C$$

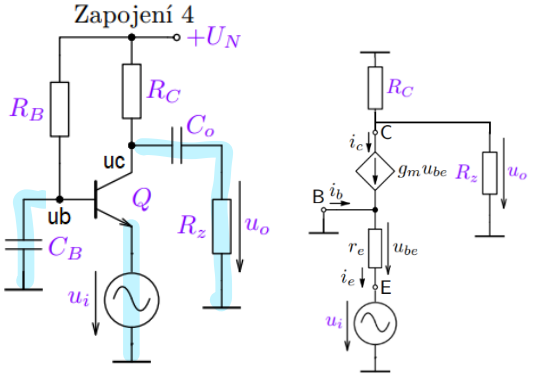
$$A_u = \frac{u_o}{u_i}$$

$$u_o = (R_C || R_Z)(-i_c) = -\frac{1}{\frac{1}{R_C} + \frac{1}{R_Z}} g_m u_{be}$$

$$u_{be} = u_i$$

$$A_u = \frac{u_o}{u_i} = -\frac{1}{\frac{1}{R_C} + \frac{1}{R_Z}} g_m$$

Zapojení 4



Pracovní bod

$$I_B = \frac{U_N - 0{,}7\ V}{R_B}$$

$$I_C = \beta I_B$$

$$U_{CE} = U_N - I_C R_C$$

Hodnoty prvků AC náhrady

$$g_m = 40 I_C$$

$$r_e = \frac{\alpha}{g_m}$$

Vstupní/výstupní odpor a napěťové zesílení

$$R_{in} = r_e$$

$$R_{out} = R_C$$

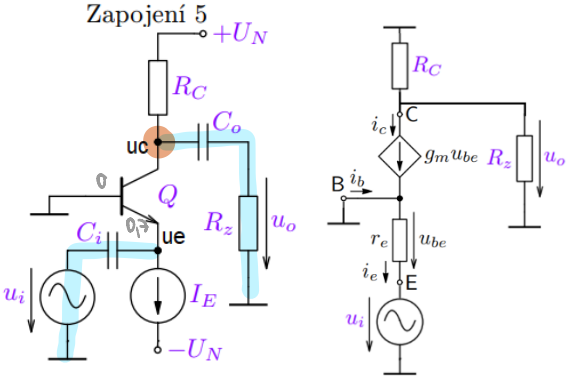
$$A_u = \frac{u_o}{u_i}$$

$$u_o = (R_C || R_Z)(-i_c) = -\frac{1}{\frac{1}{R_C} + \frac{1}{R_Z}} g_m u_{be}$$

$$u_{be} = -u_i$$

$$A_u = \frac{u_o}{u_i} = \frac{1}{\frac{1}{R_C} + \frac{1}{R_Z}} g_m$$

Zapojení 5



Pracovní bod

$$I_C = \alpha I_E$$

$$U_E = -0{,}7V$$

$$U_C = U_N - I_C R_C$$

$$U_{CE} = U_C - U_E = U_N + 0{,}7V - I_C R_C$$

Hodnoty prvků AC náhrady

$$g_m = 40 I_C$$

$$r_e = \frac{\alpha}{g_m}$$

Vstupní/výstupní odpor a napěťové zesílení

$$R_{in} = r_e$$

$$R_{out} = R_C$$

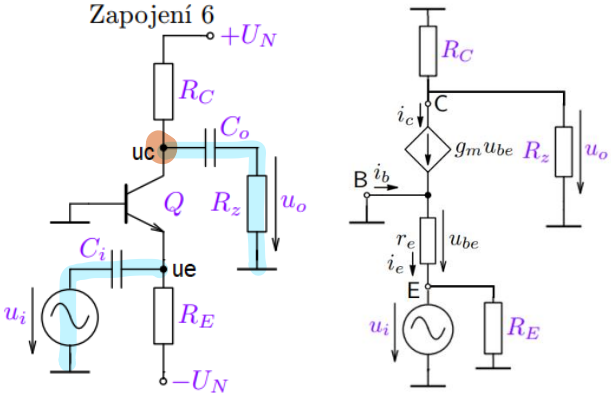
$$A_u = \frac{u_o}{u_i}$$

$$u_o = (R_C || R_Z)(-i_c) = -\frac{1}{\frac{1}{R_C} + \frac{1}{R_Z}} g_m u_{be}$$

$$u_{be} = -u_i$$

$$A_u = \frac{u_o}{u_i} = \frac{1}{\frac{1}{R_C} + \frac{1}{R_Z}} g_m$$

Zapojení 6



Pracovní bod

$$I_E = \frac{-0{,}7\ V - (-U_N)}{R_E}$$

$$I_C = \alpha I_E$$

$$U_E = -0{,}7V$$

$$U_C = U_N - I_C R_C$$

$$U_{CE} = U_C - U_E = U_N + 0{,}7V - I_C R_C$$

Hodnoty prvků AC náhrady

$$g_m = 40 I_C$$

$$r_e = \frac{\alpha}{g_m}$$

Vstupní/výstupní odpor a napěťové zesílení

$$R_{in} = R_E || r_e = \frac{R_E r_e}{R_E + r_e}$$

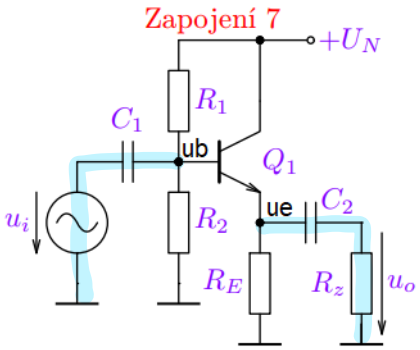
$$R_{out} = R_C$$

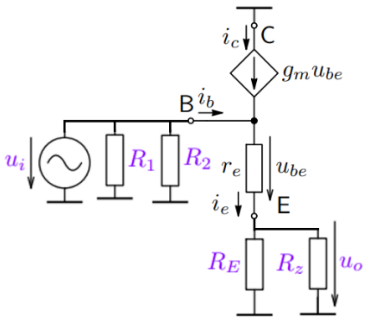
$$A_u = \frac{u_o}{u_i}$$

$$u_o = (R_C || R_Z)(-i_c) = -\frac{1}{\frac{1}{R_C} + \frac{1}{R_Z}} g_m u_{be}$$

$$u_{be} = -u_i$$

$$A_u = \frac{u_o}{u_i} = \frac{1}{\frac{1}{R_C} + \frac{1}{R_Z}} g_m$$





Pracovní bod

$$U_{bo} = U_N \frac{R_2}{R_1 + R_2}$$

$$R_{12} = R_1||R_2 = \frac{R_1 R_2}{R_1 + R_2}$$

$$U_E = \frac{U_{bo} - 0{,}7\ V}{1 + \frac{R_{B12}}{R_E}\frac{1}{\beta + 1}}$$

$$I_E = \frac{U_E}{R_E}$$

$$I_C = \alpha I_E$$

$$U_{CE} = U_N - U_E$$

Hodnoty prvků AC náhrady

$$g_m = 40 I_C$$

$$r_e = \frac{\alpha}{g_m}$$

Vstupní/výstupní odpor a napěťové zesílení

$$R_{in} = R_1||R_2||R_i$$

$$R_i = \frac{u_i}{i_i}$$

$$u_b: \frac{u_i - u_e}{r_e} - g_m(u_i - u_e) - i_i = 0$$

$$u_e: \frac{u_e - u_i}{r_e} + \frac{u_e}{R_E} + \frac{u_e}{R_Z} = 0$$

$$\frac{u_i}{r_e} - u_i g_m + u_e\left(g_m - \frac{1}{r_e}\right) = i_i$$

$$u_e = u_i \frac{1}{1 + \frac{r_e}{R_E} + \frac{r_e}{R_Z}}$$

$$u_i\left(\frac{1}{r_e} - g_m\right)\left(1 - \frac{1}{1 + \frac{r_e}{R_E} + \frac{r_e}{R_Z}}\right) = i_i$$

$$R_i = \frac{u_i}{i_i} = \frac{1}{\frac{1}{r_e} - g_m}\frac{1}{1 - \frac{1}{1 + \frac{r_e}{R_E} + \frac{r_e}{R_Z}}}$$

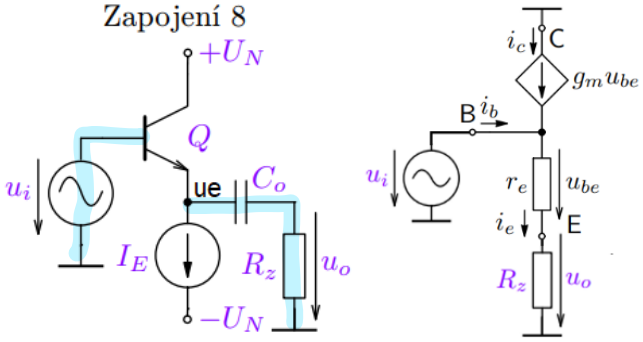
$$R_{out} = R_E||r_e$$

$$A_u = \frac{u_o}{u_i}$$

$$u_o = u_i \frac{R_E||R_Z}{R_E||R_Z + r_e}$$

$$A_u = \frac{R_E||R_Z}{R_E||R_Z + r_e}$$

Zapojení 8



Pracovní bod

$$I_C = \alpha I_E$$

$$U_E = -0{,}7V$$

$$U_{CE} = U_N - U_E = U_N + 0{,}7V$$

Hodnoty prvků AC náhrady

$$g_m = 40 I_C$$

$$r_e = \frac{\alpha}{g_m}$$

Vstupní/výstupní odpor a napěťové zesílení

$$R_{in} = \frac{u_i}{i_i}$$

$$u_b: \frac{u_i - u_e}{r_e} - g_m(u_i - u_e) - i_i = 0$$

$$u_e: \frac{u_e - u_i}{r_e} + \frac{u_e}{R_Z} = 0$$

$$\frac{u_i}{r_e} - u_i g_m + u_e\left(g_m - \frac{1}{r_e}\right) = i_i$$

$$u_e = u_i \frac{1}{1 + \frac{r_e}{R_Z}}$$

$$u_i\left(\frac{1}{r_e} - g_m\right)\left(1 - \frac{1}{1 + \frac{r_e}{R_Z}}\right) = i_i$$

$$R_i = \frac{u_i}{i_i} = \frac{1}{\frac{1}{r_e} - g_m} \frac{1}{1 - \frac{1}{1 + \frac{r_e}{R_Z}}}$$

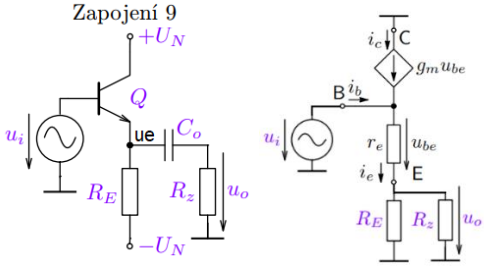
$$R_{out} = r_e$$

$$A_u = \frac{u_o}{u_i}$$

$$u_o = u_i \frac{R_Z}{R_Z + r_e}$$

$$A_u = \frac{R_Z}{R_Z + r_e}$$

Zapojení 9



Pracovní bod

$$I_E = \frac{-0{,}7\ V - (-U_N)}{R_E}$$

$$I_C = \alpha I_E$$

$$U_E = -0{,}7V$$

$$U_{CE} = U_N - U_E = U_N + 0{,}7V$$

Hodnoty prvků AC náhrady

$$g_m = 40 I_C$$

$$r_e = \frac{\alpha}{g_m}$$

Vstupní/výstupní odpor a napěťové zesílení

$$R_{in} = \frac{u_i}{i_i}$$

$$u_b: \frac{u_i - u_e}{r_e} - g_m(u_i - u_e) - i_i = 0$$

$$u_e: \frac{u_e - u_i}{r_e} + \frac{u_e}{R_E} + \frac{u_e}{R_Z} = 0$$

$$\frac{u_i}{r_e} - u_i g_m + u_e\left(g_m - \frac{1}{r_e}\right) = i_i$$

$$u_e = u_i \frac{1}{1 + \frac{r_e}{R_E} + \frac{r_e}{R_Z}}$$

$$u_i\left(\frac{1}{r_e} - g_m\right)\left(1 - \frac{1}{1 + \frac{r_e}{R_E} + \frac{r_e}{R_Z}}\right) = i_i$$

$$R_i = \frac{u_i}{i_i} = \frac{1}{\frac{1}{r_e} - g_m} \frac{1}{1 - \frac{1}{1 + \frac{r_e}{R_E} + \frac{r_e}{R_Z}}}$$

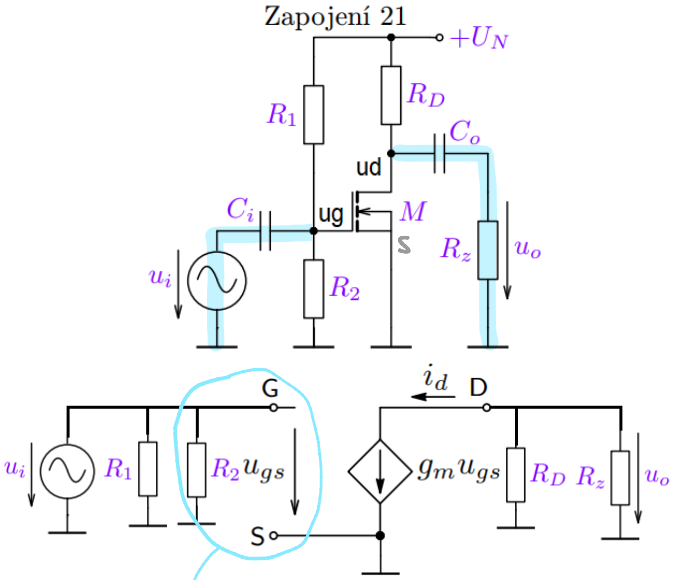
$$R_{out} = R_E || r_e$$

$$A_u = \frac{u_o}{u_i}$$

$$u_o = u_i \frac{R_E || R_Z}{R_E || R_Z + r_e}$$

$$A_u = \frac{R_E || R_Z}{R_E || R_Z + r_e}$$

Zapojení 21



Pracovní bod

$$U_{GS} = U_N \frac{R_2}{R_1 + R_2}$$

$$I_D = \frac{1}{2} K_P \frac{W}{L} (U_{GS} - U_T)^2$$

$$U_{DS} = U_N - I_D R_D$$

Hodnoty prvků AC náhrady

$$g_m = K_P \frac{W}{L} |U_{GS} - U_T|$$

Vstupní/výstupní odpor a napěťové zesílení

$$R_{in} = R_1 || R_2$$

$$R_{out} = R_D$$

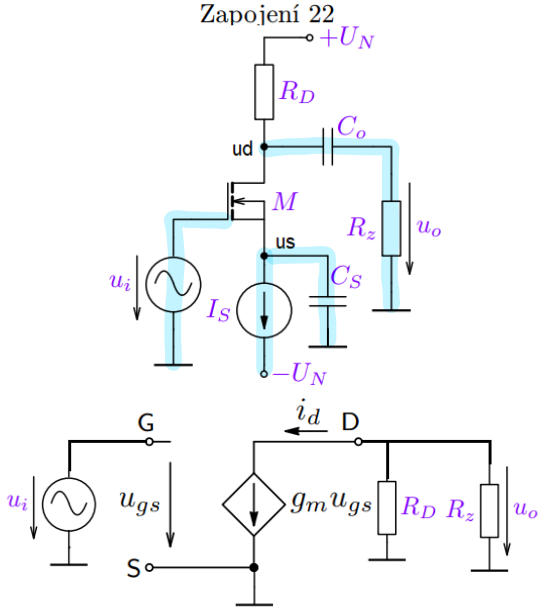
$$A_u = \frac{u_o}{u_i}$$

$$u_o = (R_D || R_Z)(-i_D) = -\frac{1}{\frac{1}{R_D} + \frac{1}{R_Z}} g_m u_{gs}$$

$$u_{gs} = u_i$$

$$A_u = \frac{u_o}{u_i} = -\frac{1}{\frac{1}{R_D} + \frac{1}{R_Z}} g_m$$

Zapojení 22



Pracovní bod

$$I_D = I_S$$

$$U_{GS} = \sqrt{\frac{2I_D}{K_P \frac{W}{L}}} + U_{TO}$$

$$U_S = -U_{GS}$$

$$U_D = U_N - I_D R_D$$

$$U_{DS} = U_D - U_S$$

Hodnoty prvků AC náhrady

$$g_m = \sqrt{2 K_P \frac{W}{L} I_D}$$

Vstupní/výstupní odpor a napěťové zesílení

$$R_{in} = \infty$$

$$R_{out} = R_D$$

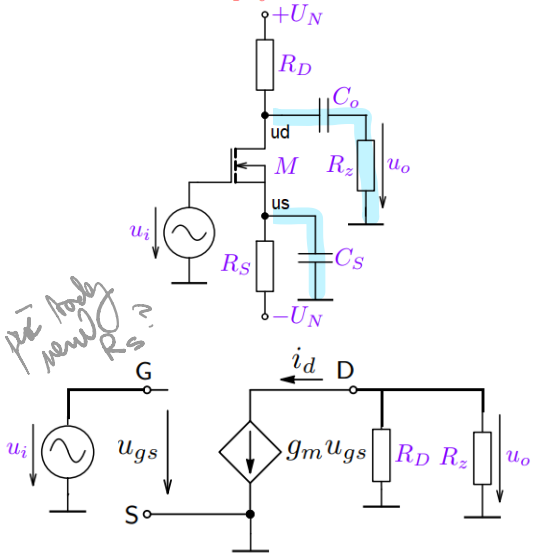
$$A_u = \frac{u_o}{u_i}$$

$$u_o = (R_D || R_Z)(-i_D) = -\frac{1}{\frac{1}{R_D} + \frac{1}{R_Z}} g_m u_{gs}$$

$$u_{gs} = u_i$$

$$A_u = \frac{u_o}{u_i} = -\frac{1}{\frac{1}{R_D} + \frac{1}{R_Z}} g_m$$

Zapojení 23



Pracovní bod

$$U_S = -U_{GS}$$

$$I_D = \frac{U_S - (-U_N)}{R_S} = \frac{U_N - U_{GS}}{R_S}$$

$$I_D = \frac{1}{2} K_P \frac{W}{L} (U_{GS} - U_T)^2$$

$$\beta = K_P \frac{W}{L}$$

$$\frac{U_N}{R_S} - \frac{U_{GS}}{R_S} = \frac{1}{2}\beta {U_{GS}}^2 - \beta U_{GS} U_T + \frac{1}{2}\beta {U_T}^2$$

$$\frac{1}{2}\beta {U_{GS}}^2 + U_{GS}\left(\frac{1}{R_S} - \beta U_T\right) + \frac{1}{2}\beta {U_T}^2 - \frac{U_N}{R_S} = 0$$

$$x = U_{GS}; a = \frac{1}{2}\beta; b = \frac{1}{R_S} - \beta U_T; c = \frac{1}{2}\beta {U_T}^2 - \frac{U_N}{R_S}$$

$$ax^2 + bx + c = 0$$

$$x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$$

$$I_D = \frac{1}{2} K_P \frac{W}{L} (U_{GS} - U_T)^2$$

$$U_S = -U_{GS}$$

$$U_D = U_N - I_D R_D$$

$$U_{DS} = U_D - U_S$$

Hodnoty prvků AC náhrady

$$g_m = K_P \frac{W}{L} |U_{GS} - U_T|$$

Vstupní/výstupní odpor a napěťové zesílení

$$R_{in} = \infty$$

$$R_{out} = R_D$$

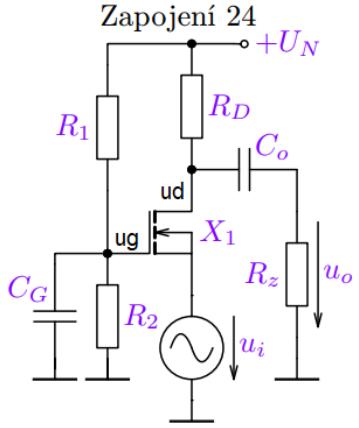
$$A_u = \frac{u_o}{u_i}$$

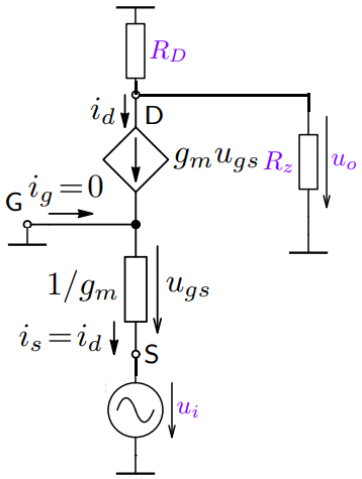
$$u_o = (R_C || R_Z)(-i_D) = -\frac{1}{\frac{1}{R_D} + \frac{1}{R_Z}} g_m u_{gs}$$

$$u_{gs} = u_i$$

$$A_u = \frac{u_o}{u_i} = -\frac{1}{\frac{1}{R_D} + \frac{1}{R_Z}} g_m$$

Zapojení 24





Pracovní bod

$$U_{GS} = U_N \frac{R_2}{R_1 + R_2}$$

$$I_D = \frac{1}{2} K_P \frac{W}{L} (U_{GS} - U_T)^2$$

$$U_{DS} = U_N - I_D R_D$$

Hodnoty prvků AC náhrady

$$g_m = K_P \frac{W}{L} |U_{GS} - U_T|$$

Vstupní/výstupní odpor a napěťové zesílení

$$R_{in} = \frac{1}{g_m}$$

$$R_{out} = R_D$$

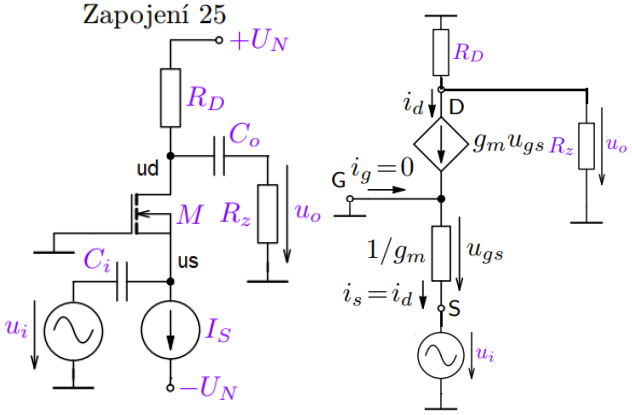
$$A_u = \frac{u_o}{u_i}$$

$$u_o = (R_C || R_Z)(-i_D) = -\frac{1}{\frac{1}{R_D} + \frac{1}{R_Z}} g_m u_{gs}$$

$$u_{gs} = -u_i$$

$$A_u = \frac{u_o}{u_i} = \frac{1}{\frac{1}{R_D} + \frac{1}{R_Z}} g_m$$

Zapojení 25



Pracovní bod

$$I_D = I_S$$

$$U_{GS} = \sqrt{\frac{2I_D}{K_P \frac{W}{L}}} + U_{TO}$$

$$U_S = -U_{GS}$$

$$U_D = U_N - I_D R_D$$

$$U_{DS} = U_D - U_S$$

Hodnoty prvků AC náhrady

$$g_m = \sqrt{2K_P \frac{W}{L} I_D}$$

Vstupní/výstupní odpor a napěťové zesílení

$$R_{in} = \frac{1}{g_m}$$

$$R_{out} = R_D$$

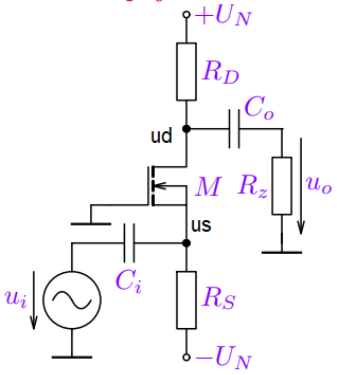
$$A_u = \frac{u_o}{u_i}$$

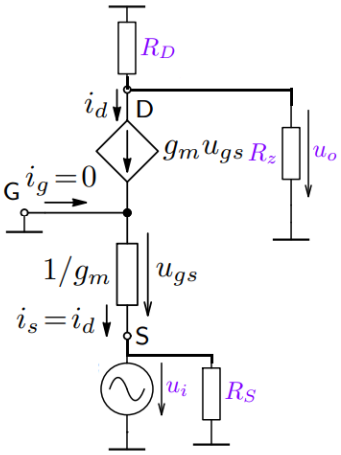
$$u_o = (R_C || R_Z)(-i_D) = -\frac{1}{\frac{1}{R_D} + \frac{1}{R_Z}} g_m u_{gs}$$

$$u_{gs} = -u_i$$

$$A_u = \frac{u_o}{u_i} = \frac{1}{\frac{1}{R_D} + \frac{1}{R_Z}} g_m$$

Zapojení 26





Pracovní bod

$$U_S = -U_{GS}$$

$$I_D = \frac{U_S - (-U_N)}{R_S} = \frac{U_N - U_{GS}}{R_S}$$

$$I_D = \frac{1}{2} K_P \frac{W}{L} (U_{GS} - U_T)^2$$

$$\beta = K_P \frac{W}{L}$$

$$\frac{U_N}{R_S} - \frac{U_{GS}}{R_S} = \frac{1}{2}\beta {U_{GS}}^2 - \beta U_{GS} U_T + \frac{1}{2}\beta {U_T}^2$$

$$\frac{1}{2}\beta {U_{GS}}^2 + U_{GS}\left(\frac{1}{R_S} - \beta U_T\right) + \frac{1}{2}\beta {U_T}^2 - \frac{U_N}{R_S} = 0$$

$$x = U_{GS}; a = \frac{1}{2}\beta; b = \frac{1}{R_S} - \beta U_T; c = \frac{1}{2}\beta {U_T}^2 - \frac{U_N}{R_S}$$

$$ax^2 + bx + c = 0$$

$$x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$$

$$I_D = \frac{1}{2} K_P \frac{W}{L} (U_{GS} - U_T)^2$$

$$U_S = -U_{GS}$$

$$U_D = U_N - I_D R_D$$

$$U_{DS} = U_D - U_S$$

Hodnoty prvků AC náhrady

$$g_m = K_P \frac{W}{L} |U_{GS} - U_T|$$

Vstupní/výstupní odpor a napěťové zesílení

$$R_{in} = \frac{1}{g_m} || R_S$$

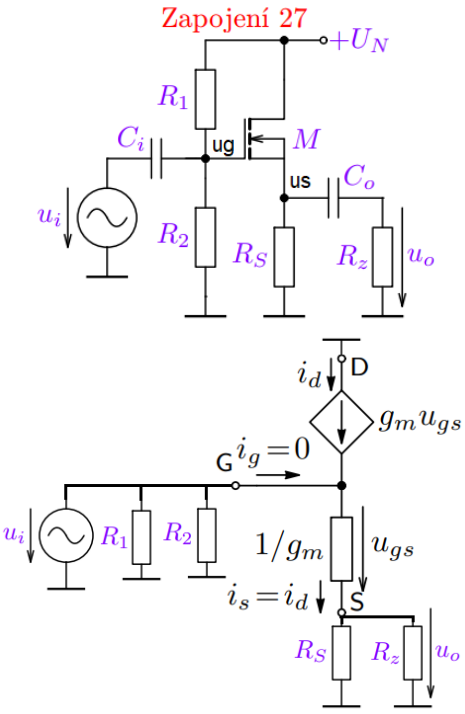
$$R_{out} = R_D$$

$$A_u = \frac{u_o}{u_i}$$

$$u_o = (R_C || R_Z)(-i_D) = -\frac{1}{\frac{1}{R_D} + \frac{1}{R_Z}} g_m u_{gs}$$

$$u_{gs} = -u_i$$

$$A_u = \frac{u_o}{u_i} = \frac{1}{\frac{1}{R_D} + \frac{1}{R_Z}} g_m$$



Pracovní bod

$$U_G = U_N \frac{R_2}{R_1 + R_2}$$

$$U_S = U_G - U_{GS}$$

$$I_D = \frac{U_S}{R_S} = \frac{U_G - U_{GS}}{R_S}$$

$$I_D = \frac{1}{2} K_P \frac{W}{L} (U_{GS} - U_T)^2$$

$$\beta = K_P \frac{W}{L}$$

$$\frac{U_G}{R_S} - \frac{U_{GS}}{R_S} = \frac{1}{2}\beta {U_{GS}}^2 - \beta U_{GS} U_T + \frac{1}{2}\beta {U_T}^2$$

$$\frac{1}{2}\beta {U_{GS}}^2 + U_{GS}\left(\frac{1}{R_S} - \beta U_T\right) + \frac{1}{2}\beta {U_T}^2 - \frac{U_G}{R_S} = 0$$

$$x = U_{GS}; a = \frac{1}{2}\beta; b = \frac{1}{R_S} - \beta U_T; c = \frac{1}{2}\beta {U_T}^2 - \frac{U_G}{R_S}$$

$$ax^2 + bx + c = 0$$

$$x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$$

$$I_D = \frac{1}{2} K_P \frac{W}{L} (U_{GS} - U_T)^2$$

$$U_S = U_G - U_{GS}$$

$$U_{DS} = U_N - U_S$$

Hodnoty prvků AC náhrady

$$g_m = K_P \frac{W}{L} |U_{GS} - U_T|$$

Vstupní/výstupní odpor a napěťové zesílení

$$R_{in} = R_1 || R_2$$

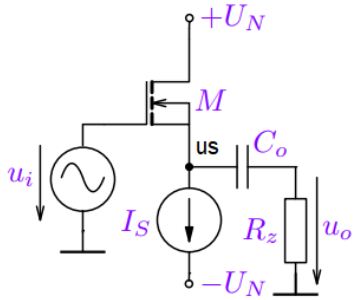
$$R_{out} = \frac{1}{g_m} || R_S$$

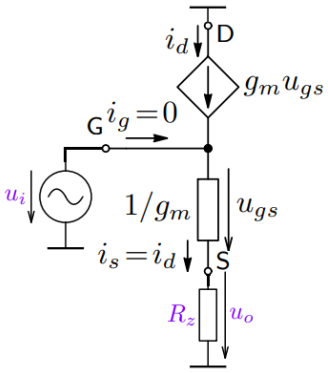
$$A_u = \frac{u_o}{u_i}$$

$$u_o = u_i \frac{R_S || R_Z}{R_S || R_Z + \frac{1}{g_m}}$$

$$A_u = \frac{R_S || R_Z}{R_S || R_Z + \frac{1}{g_m}}$$

Zapojení 28





Pracovní bod

$$I_D = I_S$$

$$U_{GS} = \sqrt{\frac{2I_D}{K_P \frac{W}{L}}} + U_{TO}$$

$$U_S = -U_{GS}$$

$$U_{DS} = U_N - U_S$$

Hodnoty prvků AC náhrady

$$g_m = \sqrt{2K_P \frac{W}{L} I_D}$$

Vstupní/výstupní odpor a napěťové zesílení

$$R_{in} = \infty$$

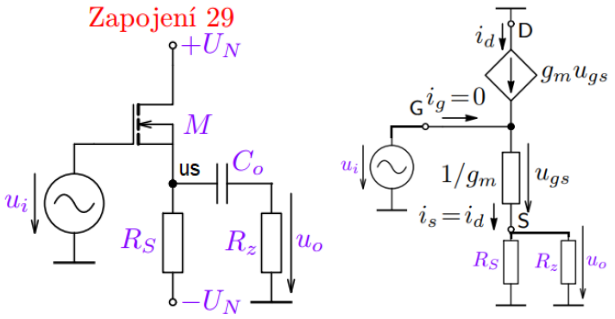
$$R_{out} = \frac{1}{g_m}$$

$$A_u = \frac{u_o}{u_i}$$

$$u_o = u_i \frac{R_Z}{R_Z + \frac{1}{g_m}}$$

$$A_u = \frac{R_Z}{R_Z + \frac{1}{g_m}}$$

Zapojení 29



Pracovní bod

$$U_S = -U_{GS}$$

$$I_D = \frac{U_S - (-U_N)}{R_S} = \frac{U_N - U_{GS}}{R_S}$$

$$I_D = \frac{1}{2} K_P \frac{W}{L} (U_{GS} - U_T)^2$$

$$\beta = K_P \frac{W}{L}$$

$$\frac{U_N}{R_S} - \frac{U_{GS}}{R_S} = \frac{1}{2}\beta {U_{GS}}^2 - \beta U_{GS} U_T + \frac{1}{2}\beta {U_T}^2$$

$$\frac{1}{2}\beta {U_{GS}}^2 + U_{GS}\left(\frac{1}{R_S} - \beta U_T\right) + \frac{1}{2}\beta {U_T}^2 - \frac{U_N}{R_S} = 0$$

$$x = U_{GS}; a = \frac{1}{2}\beta; b = \frac{1}{R_S} - \beta U_T; c = \frac{1}{2}\beta {U_T}^2 - \frac{U_N}{R_S}$$

$$ax^2 + bx + c = 0$$

$$x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$$

$$U_{DS} = U_N - U_S$$

Hodnoty prvků AC náhrady

$$g_m = K_P \frac{W}{L} |U_{GS} - U_T|$$

Vstupní/výstupní odpor a napěťové zesílení

$$R_{in} = \infty$$

$$R_{out} = \frac{1}{g_m} || R_S$$

$$A_u = \frac{u_o}{u_i}$$

$$u_o = u_i \frac{R_S || R_Z}{R_S || R_Z + \frac{1}{g_m}}$$

$$A_u = \frac{R_S || R_Z}{R_S || R_Z + \frac{1}{g_m}}$$