ΤΥΠΟΛΟΓΙΟ ΗΛΕΚΤΡΟΝΙΚΗΣ ΙΙ

Διπολικό Τρανζίστορ (BJT)

$$r_d = \frac{\eta 26mV}{|\,\mathrm{I_E}\,|\, mA} \quad [\Omega]$$

$$r_{b'e} = (\beta+1)r_d$$

$$\alpha = \frac{\beta}{\beta+1}$$

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

$$\mathrm{f_\beta} \approx \frac{1}{2\pi \mathrm{r_{b'e}}(\mathrm{C_d} + \mathrm{C_{b'c}})}$$

$$f_T \approx \beta \cdot f_\beta$$

$$\mathrm{C_d} = \frac{\beta}{\omega_T \mathrm{r_{b'e}}} - \mathrm{C_{b'c}}$$

$$C_{b'c} = \frac{C_o}{\left(1+\frac{V_{CB}}{V_\Psi}\right)^{1/2}}$$

V_Ψ=0.4V (Ge) ή 0.8V (Si)

FETs

$$\mathrm{C_{gs}} = \frac{\mathrm{C_{gs0}}}{\left(1+\frac{\mathrm{V_{GS}}}{\mathrm{V_{\Psi gs}}}\right)^{\frac{1}{3}}}$$

$$\mathrm{C_{gd}} = \frac{\mathrm{C_{gd0}}}{\left(1+\frac{\mathrm{V_{GD}}}{\mathrm{V_{\Psi gd}}}\right)^{\frac{1}{3}}}$$

JFET & MOSFET Αραίωσης

$$I_D = I_{DSS} \cdot \left(1-\frac{V_{GS}}{V_p}\right)^2$$

$$n-ch: \quad V_{DS} > V_{GS} - V_p > 0$$

$$p-ch: \quad V_{DS} < V_{GS} - V_p < 0$$

$$g_{mo} = \frac{2I_{DSS}}{|V_p|}$$

$$g_m = g_{mo} \cdot \left(1-\frac{V_{GS}}{V_p}\right)$$

MOSFET Πύκνωσης:

$$I_D = K \cdot \left(\frac{V_{GS}}{V_T}-1\right)^2$$

$$n-ch: \quad V_{DS} > V_{GS} - V_T > 0$$

$$p-ch: \quad V_{DS} < V_{GS} - V_T < 0$$

$$g_m = \frac{2K}{|V_T|} \cdot \left(\frac{V_{GS}}{V_T}-1\right)$$

$$K = \frac{I_D}{\left(\frac{V_{GS}}{V_T}-1\right)^2}$$

Συχνότητες Αποκοπής

Προσεγγιστικά:

$$f_L = 1.1 \cdot \sqrt{f_{L1}^2 + f_{L2}^2 + \cdots + f_{Ln}^2}$$

$$f_H = \frac{1}{1.1 \cdot \sqrt{\frac{1}{f_{H1}^2} + \frac{1}{f_{H2}^2} + \cdots + \frac{1}{f_{Hn}^2}}}$$

Όμοιες Βαθμίδες:

$$f_L^* = \frac{f_L}{\sqrt{2^{\frac{1}{n}}-1}}$$

$$f_H^* = f_H \sqrt{2^{\frac{1}{n}}-1}$$

Βαθμίδα Κοινού Εκπομπού (CE)

$$\mathrm{A} = \frac{-\beta \cdot R_C}{\mathrm{rin}}$$

$$r_{in} = r_{bb'} + (\beta+1)\cdot R_E$$

$$R_{in} = r_{in} \,||\, R_1 \,||\, R_2$$

Χαμηλές Συχνότητες (CE)

$$f_{L1} = \frac{1}{2\pi C_1 (R_{in} + R_S)}$$

$$f_{L2} = \frac{1}{2\pi C_2 (R_L + R_C)}$$

$$f_{L3} = \frac{1}{2\pi C_E R_E}$$

$$f_{L4} = \frac{1}{2\pi C_E R_{EQ}}$$

$$R_{EQ} = R_E \,||\left\{ r_d + \frac{r_{bb'} + R_S \,||R_B}{\beta + 1} \right\}$$

Υψηλές Συχνότητες (CE)

$R_\Phi = R_C // R_L$

$$\omega_H = \frac{R_{th} + r_{bb'} + r_{b'e}}{(R_{th} + r_{bb'}).r_{b'e}}$$

$$\cdot \frac{1}{C_\pi + C_{b'c}\left(1 + g_m R_\Phi + \frac{R_C // R_L}{R}\right)}$$

Προσεγγιστικά (CE):

$$\omega_H = \frac{B}{D C_d r_{b'e}} \approx \frac{B}{D}\omega_\beta$$

όπου:

$$R = (R_{th} + r_{bb'})||r_{b'e}$$

$$R_{th} = R_1||R_2||R_S$$

$$C_\pi = C_d + C_{b'e}$$

$$B = \frac{R_{th} + r_{bb'} + r_{b'e}}{R_{th} + r_{bb'}}$$

$$D = 1 + (R_C // R_L) C_{b'c}\omega_T$$

Βαθμίδα Κοινής Βάσης (CB)

$$A = \frac{\beta \cdot R_C}{rbb' + (\beta + 1) r_d}$$

$$R_{in} = \left(r_{bb'} + (\beta + 1) r_d\right)||R_E \,||\frac{1}{g_m}$$

Χαμηλές Συχνότητες (CB)

$$f_{L1} = \frac{1}{2\pi\left[R_S + R_E \,||\left(r_{bb'} + (\beta + 1) r_d\right) \,||\, \frac{1}{g_m}\right] \cdot C_1}$$

$$f_{L2} = \frac{1}{2\pi (R_L + R_C) C_2}$$

$$f_{L3} = \frac{R_1 + R_2}{2\pi R_1 R_2 C_B}$$

$$f_{L4} = \frac{1}{2\pi C_B R_{EQ}}$$

$$R_{EQ} = (R_1 \,||\, R_2)\,||(r_{bb'} + (\beta + 1)(r_d + (R_S \,||\, R_E))$$

Υψηλές Συχνότητες (CB)

$$f_{H1} = \frac{R_C + R_L}{2\pi R_C R_L C_{b'c}}$$

$$f_{H2} = \frac{R_C + R_L}{2\pi R_{EQ} C_d}$$

$$R_{EQ} = R_S \,||\, R_E \,||\, r_{b'e} \,||\, \frac{1}{g_m}$$

Βαθμίδα Κοινού Συλλέκτη (CC)

$$A = \frac{(\beta + 1) R E}{r bb' + (\beta + 1)(r_d + R E \,||\, R_L)}$$

$$R_{out} = R_E \,||\left[r_d + \frac{r_{bb'} + R_S \,||R_1 \,||R_2}{\beta + 1} \right]$$

Χαμηλές Συχνότητες (CC)

$$f_{L1} = \frac{1}{2\pi (R_S + R_{EQ}) C_1}$$

$$R_{EQ} = R_1 // R_2 //\left(r_{be} + (\beta + 1)(R_E // R_L)\right)$$

$$f_{L2} = \frac{1}{2\pi (R_L + R_{out}) C_2}$$

$$R_{out} = R_E \,||\left[r_d + \frac{r_{bb'} + R_S \,||R_1 \,||R_2}{\beta + 1} \right]$$

Υψηλές Συχνότητες (CC)

$$\omega_{H1} \approx \frac{g_m}{C_{b'c}}$$

$$\omega_{H2} = \frac{G_4}{2 C_d C_{b'c}}\left(k + \sqrt{k^2 - 4\frac{C_d C_{b'c}}{G_4}\lambda}\right)$$

$$\omega_{H3} = \frac{G_4}{2 C_d C_{b'c}}\left(k - \sqrt{k^2 - 4\frac{C_d C_{b'c}}{G_4}\lambda}\right)$$

με

$$\lambda = G_1 + \frac{1}{r_{b'e}} + \frac{G_1}{G_4}\left(g_m + \frac{1}{r_{b'e}}\right)$$

$$k = C_d\left(1+\frac{G_1}{G_4}\right)+C_{b'c}\left(1+\frac{g_m}{G_4}+\frac{1}{G_4 r_{b'e}}\right)$$

$$G_1 = \frac{1}{R_{EQ}}$$

$$G_4 = \frac{R_E + R_L}{R_E R_L}$$

$$R_B = R_1 || R_2$$

$$R_{th} = R_S || R_B$$

$$R_{EQ} = R_{th} + r_{bb'}$$

Βαθμίδα Κοινής Πηγής (CS)

$$A = -g_m R_D$$

$$A = \frac{-g_m R_D}{1+g_m R_S} \quad \text{(με } R_S\text{)}$$

Χαμηλές Συχνότητες (CS)

$$f_{L1} = \frac{1}{2\pi(R_S + R_1 || R_2)C_1}$$

$$f_{L2} = \frac{1}{2\pi(R_D + R_L)C_2}$$

$$f_{L3} = \frac{1}{2\pi\left(R_3 || \frac{1}{g_m}\right)C_3}$$

Υψηλές Συχνότητες (CS)

$$\omega_{H1} = \frac{g_m}{C_{gd}}$$

$$\omega_{H2} = \frac{1}{\lambda}, \qquad R_\Phi = R_C // R_L$$

$$\lambda = (R_1 \| R_2 \| R_{SS})\left[C_{gs} + C_{gd}\left(\frac{R_L // R_D}{R_1 \| R_2 \| R_{SS}} + g_m R_\Phi + 1\right)\right]$$

Βαθμίδα Κοινής Πύλης (CG)

$$A = -g_m R_D$$

Χαμηλές Συχνότητες (CG)

$$f_{L1} = \frac{1}{2\pi\left(R_{SS} + R_S || \frac{1}{g_m}\right)C_1}$$

$$f_{L2} = \frac{1}{2\pi(R_D + R_L)C_2}$$

$$f_{L3} = \frac{R_1 + R_2}{2\pi R_1 R_2 C_3}$$

Υψηλές Συχνότητες (CG)

$$\omega_{H1} = \frac{R_L + R_D}{R_L R_D C_{gd}}$$

$$\omega_{H2} = \frac{1}{\left[R_S \| R_3 \| (1/g_m)\right] C_{gs}}$$

Βαθμίδα Κοινής Εκροής (CD)

$$A = \frac{g_m (R_S \| R_L)}{1 + g_m (R_S \| R_L)}$$

Χαμηλές Συχνότητες (CD)

$$f_{L1} = \frac{1}{2\pi\left(R_S + R_1 || R_2\right)C_1}$$

$$f_{L2} = \frac{1}{2\pi\left(R_L + R_3 || \frac{1}{g_m}\right)C_2}$$

Υψηλές Συχνότητες (CD)

$$\omega_{H1} \approx \frac{g_m}{C_{gs}}$$

$$\omega_{H2} = \frac{G}{2C_{gs}C_{gd}}\left(k + \sqrt{k^2 - 4\frac{C_{gs}C_{gd}}{G}\lambda}\right)$$

$$\omega_{H3} = \frac{G}{2C_{gs}C_{gd}}\left(k - \sqrt{k^2 - 4\frac{C_{gs}C_{gd}}{G}\lambda}\right)$$

με

$$\lambda = G_1 + \frac{G_1}{G} g_m$$

$$k = C_{gs}\left(1+\frac{G_1}{G}\right) + C_{gd}\left(1+\frac{g_m}{G}\right)$$

$$R_{th} = R_{SS} \| R_1 \| R_2$$

$$G_1 = 1/R_{th}$$

$$G = 1/(R_S \| R_L)$$

Διαφορικός Ενισχυτής

Διπλής εξόδου:

BJT: $A_{dD} = \dfrac{-\beta R_C}{R_S + r_{bb'} + (\beta + 1)(r_d + R_E)}$

FET: $A_{dD} = \dfrac{-g_m R_D}{1 + g_m R_S}$

Απλής Εξόδου:
BJT:

$$A_{dS} = \frac{-\beta R_C}{2(R_S + r_{bb'} + (\beta + 1)(r_d + R_E))}$$

FET: $A_{dS} = -g_m R_D / 2(1 + g_m R_S)$

$$CMRR = 1 + 2g_m R$$

$$CMRR = 20\log\left|\frac{A_d}{A_c}\right| \quad \text{dB}$$

Ενίσχυση Κοινού Σήματος:

$$A_c = \frac{-\beta R_C}{R_S + r_{bb'} + 2(\beta + 1)R + r_{b'e}}$$

$$A_c = \frac{-g_m R_D}{1 + g_m(R_S + 2R_o)}$$

Αντίσταση Εξόδου Πηγής Ρεύματος (T_3):

$$R_o = r_{ce}\left(\frac{\beta R_{E3}}{R_{th} + r_{in} + R_{E3}} + 1\right)$$

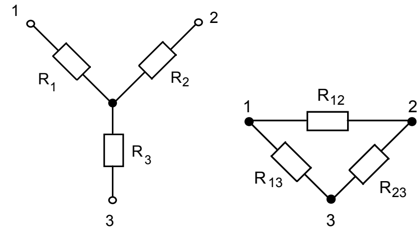
$$= \frac{1}{h_{oe}}\left(\frac{h_{fe} R_{E3}}{R_{th} + R_{E3} + h_{ie}} + 1\right)$$

Μετασχ/μός Αστέρα σε Τρίγωνο

$$R_{12} = \frac{R_1R_2 + R_1R_3 + R_2R_3}{R_3}$$

$$R_{13} = \frac{R_1R_2 + R_1R_3 + R_2R_3}{R_2}$$

$$R_{23} = \frac{R_1R_2 + R_1R_3 + R_2R_3}{R_1}$$



Μετασχ/μός Τριγώνου σε Αστέρα

$$R_1 = \frac{R_{12}R_{13}}{R_{12} + R_{13} + R_{23}}$$

$$R_2 = \frac{R_{12}R_{23}}{R_{12} + R_{13} + R_{23}}$$

$$R_3 = \frac{R_{13}R_{23}}{R_{12} + R_{13} + R_{23}}$$