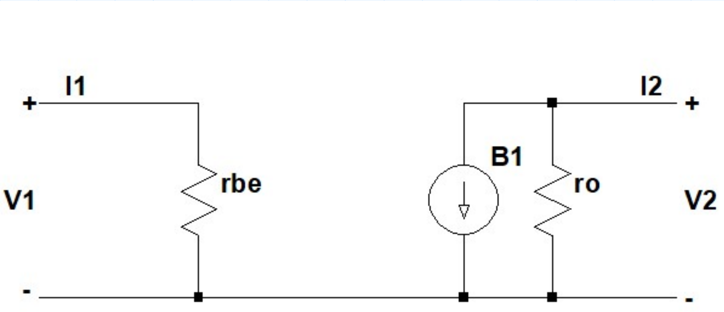
Transistors and small-signal description

13-03-2018

Calculate Y-parameters for selected circuit (passive)



$I_1 = y_{11} \cdot V_1 + y_{12} \cdot V_2$

$I_2 = y_{21} \cdot V_1 + y_{22} \cdot V_2$

$V_2 = 0$

$y_{11} = \frac{I_1}{V_1}$ $\qquad y_{11} := \frac{\frac{V_1}{r_{be}}}{V_1} \rightarrow \frac{1}{r_{be}}$

$I_2 := \beta \cdot i_b$ $\qquad i_b := \frac{V_1}{r_{be}}$

$y_{21} = \frac{I_2}{V_1}$ $\qquad y_{12} := \frac{\beta \cdot i_b}{V_1} \rightarrow \frac{\beta}{r_{be}}$

$V_1 := 0$

$y_{12} = \frac{I_1}{V_2}$ $\qquad y_{12} := \frac{\frac{V_1}{r_{be}}}{V_2} \rightarrow 0$

$y_{22} = \frac{I_2}{V_2}$ $\qquad y_{22} := \frac{\frac{V_2}{r_o}}{V_2} \rightarrow \frac{1}{r_o}$

Calculate Y-parameters from S-parameters and draw equivalent diagram (f=400 MHz)
Importer S-parametre fra **'BFP420 S-parameters- VCE=2.0V , IC=4 mA'**
$A := \mathrm{READEXCEL}\left(\text{".\textbackslash BFP420.xlsx"}, \text{"Sheet1!A1:I36"}\right)$

$A =$

f	S11		S21		S12		S22	
GHZ	MAG	ANG	MAG	ANG	MAG	ANG	MAG	ANG
0.01	0.826	−1.2	12.639	179.3	0.001	84.2	0.991	−0.7
0.02	0.829	−2.1	12.432	178.6	0.002	86.6	0.992	−1
0.05	0.826	−5.2	12.526	175.9	0.005	84.3	0.99	−2.9
0.1	0.822	−10.6	12.489	172.5	0.009	84.1	0.986	−5.7
0.15	0.823	−16	12.488	168.6	0.014	80.9	0.98	−8.6
0.2	0.818	−20.9	12.264	164.7	0.018	79.3	0.973	−11.3
0.25	0.808	−26.3	12.176	161.3	0.022	77.1	0.961	−14.3
0.3	0.799	−31.5	12.101	157.6	0.027	73.7	0.949	−16.9
0.4	0.777	−41.8	11.676	150	0.035	68.5	0.921	−22.2
0.5	0.752	−50.5	11.065	143.1	0.042	64.6	0.884	−27
0.6	0.728	−60.2	10.69	136.7	0.047	59.4	0.846	−31.2
0.7	0.705	−68.9	10.084	131.1	0.053	55.6	0.809	−35.4
0.8	0.68	−77.3	9.598	125.4	0.058	52.7	0.769	−39.3
0.9	0.655	−84.8	9.073	120.4	0.062	49.6	0.727	−42.6
1	0.639	−92.2	8.613	115.9	0.065	47.1	0.693	−45.3
1.1	0.62	−99.8	8.127	111.3	0.068	44.1	0.664	−48.3
1.2	0.604	−106.6	7.668	107.2	0.071	41.9	0.631	−51.5
1.3	0.586	−112.5	7.255	103.6	0.074	40.3	0.595	−53.8
1.4	0.574	−118.7	6.86	100	0.075	38.5	0.57	−55.6
1.5	0.565	−124.2	6.554	96.3	0.077	37	0.548	−57.8
1.6	0.557	−130.4	6.23	93	0.079	35.9	0.524	−60.4
1.7	0.553	−135.4	5.957	90.1	0.08	34.7	0.493	−62
1.8	0.545	−140.1	5.676	87	0.082	33.4	0.475	−62.6
1.9	0.542	−145.3	5.421	84.3	0.083	32.6	0.463	−64.7
2	0.536	−149.9	5.21	81.5	0.085	31.6	0.444	−67.1
2.2	0.532	−158.3	4.791	76.6	0.088	30.3	0.406	−68.9
2.4	0.525	−166.6	4.425	71.8	0.09	29.2	0.385	−73.5
2.6	0.528	−174.2	4.099	67.2	0.093	28.4	0.35	−74.4
2.8	0.527	179.1	3.85	62.9	0.095	27	0.337	−79.7
3	0.532	172.5	3.606	58.4	0.098	26	0.303	−80.6
3.5	0.544	157	3.103	48.4	0.105	23.3	0.271	−89.4
4	0.565	144.9	2.706	39	0.111	21.5	0.237	−103.9
4.5	0.592	133.7	2.382	30.3	0.118	19.1	0.198	−118.6
5	0.615	125.6	2.135	22.1	0.125	16.6	0.175	−126.4
5.5	0.636	117.7	1.931	14.1	0.132	14.5	0.186	−138.1
6	0.643	111.4	1.758	6.3	0.139	11.4	0.188	−158

400 MHz

Tilgå værdi i matrix $A_{0,0} = 0.01$

Conversion formulas

$$y_{11} = \frac{(1+S_{22})\ (1-S_{11})+S_{12}\cdot S_{21}}{(1+S_{11})\ (1+S_{22})-S_{12}\cdot S_{21}}\cdot\frac{1}{Z_o}$$

$$y_{12} = \frac{-2\ S_{12}}{(1+S_{11})\ (1+S_{22})-S_{12}\cdot S_{21}}\cdot\frac{1}{Z_o}$$

$$y_{21} = \frac{-2\ S_{21}}{(1+S_{11})\ (1+S_{22})-S_{12}\cdot S_{21}}\cdot\frac{1}{Z_o}$$

$$y_{22} = \frac{(1+S_{11})\ (1-S_{22})+S_{12}\cdot S_{21}}{(1+S_{22})\ (1+S_{11})-S_{12}\cdot S_{21}}\cdot\frac{1}{Z_o}$$

$Z_o := 50$

$S_{11} := A_{8,1} \angle A_{8,2}\ \textbf{deg} = 0.777\angle{-41.8°}$

$S_{21} := A_{8,3} \angle A_{8,4}\ \textbf{deg} = 11.676\angle 150°$

$S_{12} := A_{8,5} \angle A_{8,6}\ \textbf{deg} = 0.035\angle 68.5°$

$S_{22} := A_{8,7} \angle A_{8,8}\ \textbf{deg} = 0.921\angle{-22.2°}$

$$y_{11} := \frac{(1+S_{22})\ (1-S_{11})+S_{12}\cdot S_{21}}{(1+S_{11})\ (1+S_{22})-S_{12}\cdot S_{21}}\cdot\frac{1}{Z_o} = 5.2\cdot 10^{-3}\angle 63.4° \qquad y_i := y_{11}$$

$$y_{12} := \frac{-2\ S_{12}}{(1+S_{11})\ (1+S_{22})-S_{12}\cdot S_{21}}\cdot\frac{1}{Z_o} = 419.4\cdot 10^{-6}\angle{-89.2°} \qquad y_r := y_{12}$$

$$y_{21} := \frac{-2\ S_{21}}{(1+S_{11})\ (1+S_{22})-S_{12}\cdot S_{21}}\cdot\frac{1}{Z_o} = 141.1\cdot 10^{-3}\angle{-7.7°} \qquad y_f := y_{21}$$

$$y_{22} := \frac{(1+S_{11})\ (1-S_{22})+S_{12}\cdot S_{21}}{(1+S_{22})\ (1+S_{11})-S_{12}\cdot S_{21}}\cdot\frac{1}{Z_o} = 1.5\cdot 10^{-3}\angle 88.7° \qquad y_o := y_{22}$$

Calculate Stability, MAG, simultaneous conjugate match for BFP 420 at f=400 MHz
(VCE=2.0V and IC=4.0 mA)

Linvill Stability Factor C

$g_i := \mathrm{Re}\left(y_i\right) = 2.31 \cdot 10^{-3}$

$g_o := \mathrm{Re}\left(y_o\right) = 32.51 \cdot 10^{-6}$

$$C := \frac{\left|y_r \cdot y_f\right|}{2 \cdot g_i \cdot g_o - \mathrm{Re}\left(y_r \cdot y_f\right)} = 8.16$$

$C < 1$ Unconditionally stable

Maximum Available Gain

$$MAG := \frac{\left|y_{21}\right|^2}{4 \cdot g_i \cdot g_o} = 66.3 \cdot 10^3$$

$MAG_{dB} := 20 \cdot \log\left(MAG\right) = 96.43$

Install Microwave Office and verify selected circuit (passive) calculation