EK2390 Project Course in Integrated Circuits for RF and Microwave Technology

Group 2 - Project Presentation

by

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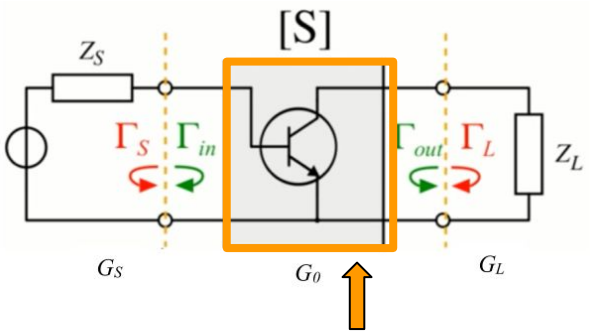
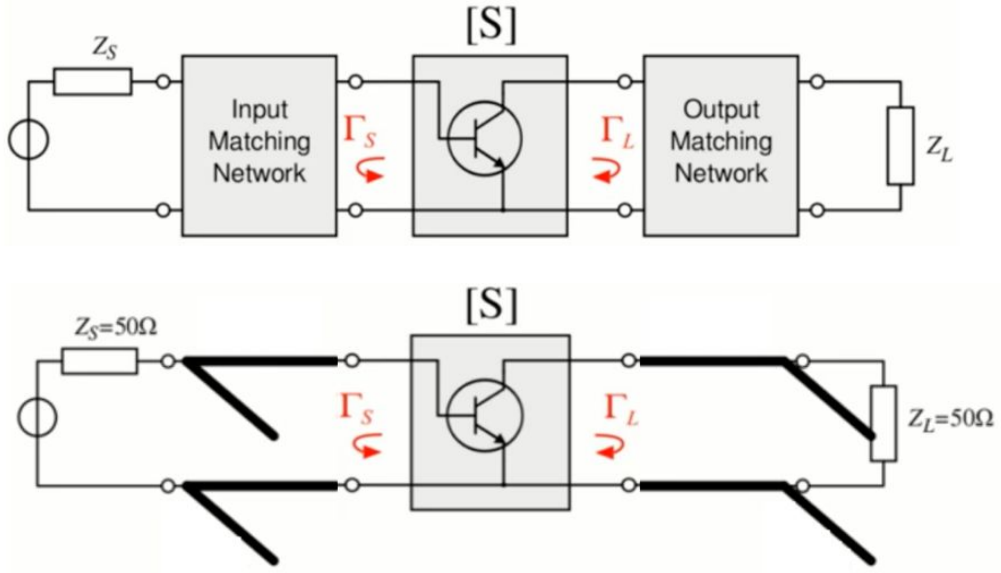
Problem Statement

- Maximizing Gain using Input and Output Matching

Reference Impedance = 50 Ohm



Infineon BFP540 at 5GHz
biasing point VCE = 2V and IC = 3mA



BJT S-Parameters and Theoretical Maximum

$$S = \begin{bmatrix} 0.6555\angle 126.9^\circ & 0.1142\angle 7.7^\circ \\ 2.011\angle 22.5^\circ & 2.001\angle -138.1^\circ \end{bmatrix}$$

Solving for conjugate matching gives a quadratic equation, hence 2 solutions for maximum gain

$$\Gamma_{S_1} = -0.8029 - j0.9732 \approx 1.2617\angle -129.52^\circ,$$
$$\Gamma_{L_1} = -0.7482 + j1.6476 \approx 1.8095\angle 114.42^\circ$$

Cannot be achieved using passive components

$$\Gamma_{S_2} = -0.5044 - j0.6114 \approx 0.7926\angle -129.52^\circ,$$
$$\Gamma_{L_2} = -0.2285 + j0.5032 \approx 0.5527\angle 114.42^\circ \quad (5)$$

Can be achieved using passive components

BJT S-Parameters and Theoretical Maximum

$$S = \begin{bmatrix} 0.6555\angle 126.9^\circ & 0.1142\angle 7.7^\circ \\ 2.011\angle 22.5^\circ & 2.001\angle -138.1^\circ \end{bmatrix}$$

Thus, our solution of reflection coefficient for which we design our matching circuits

$$\Gamma_S = -0.5044 - j0.6114 \approx 0.7926\angle -129.52^\circ, \quad \Gamma_L = -0.2285 + j0.5032 \approx 0.5527\angle 114.42^\circ$$

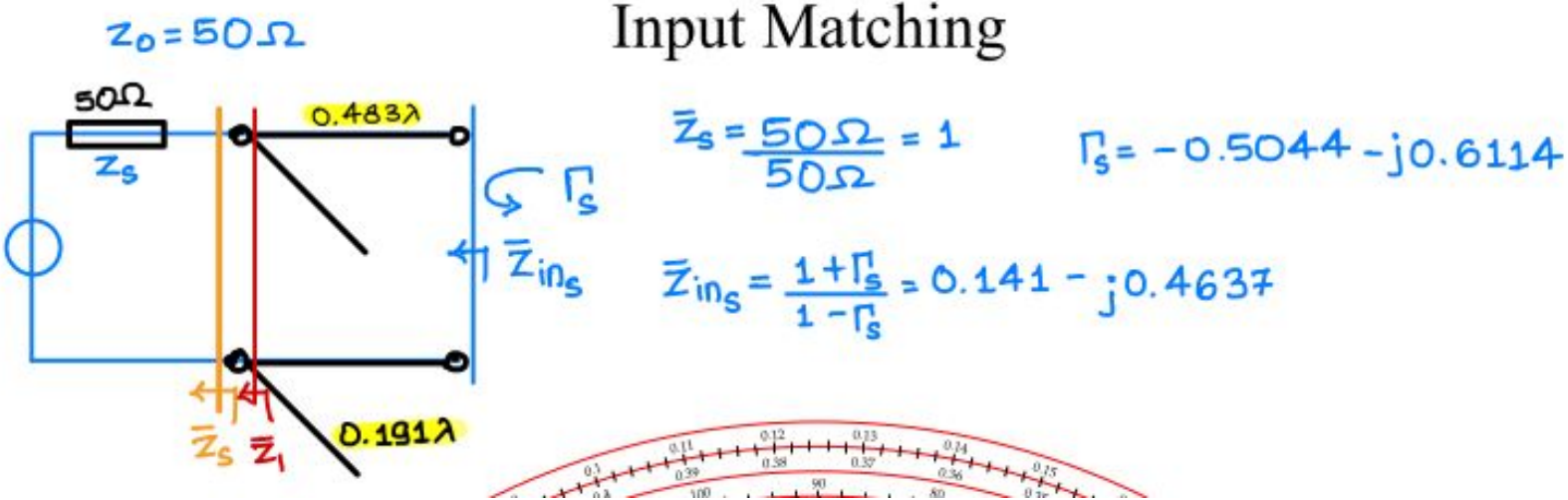
And the total maximum gain is

$$\boxed{G_{T_{max}} = 9.3329 = 9.7 \text{ dB}}$$

9.7 dB at 5 GHz

$$G_s = 2.6901 = 4.298 \text{ dB}, \qquad G_0 = 4.0441 = 6.068 \text{ dB}, \qquad G_L = 0.8579 = -0.666 \text{ dB}$$

Design of Matching Circuits : Input Matching



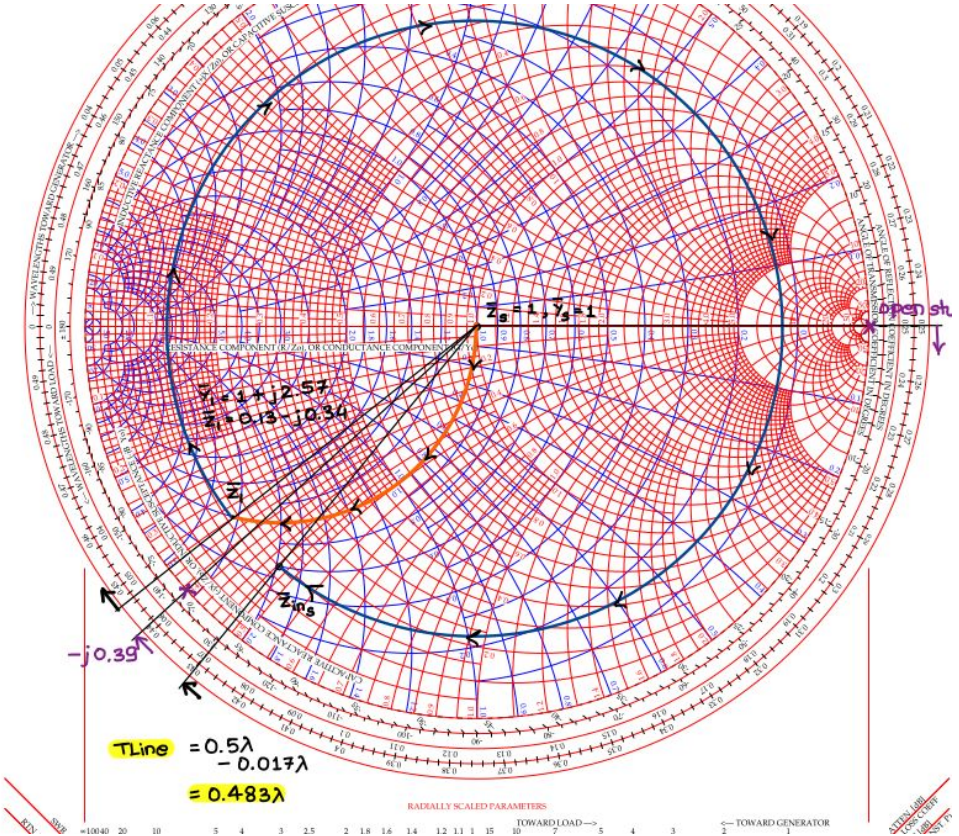
Design of Matching Circuits : Input Matching

$\bar{Y}_c = \bar{Y}_1 - \bar{Y}_s \quad \therefore \bar{Y}_c = j2.57$

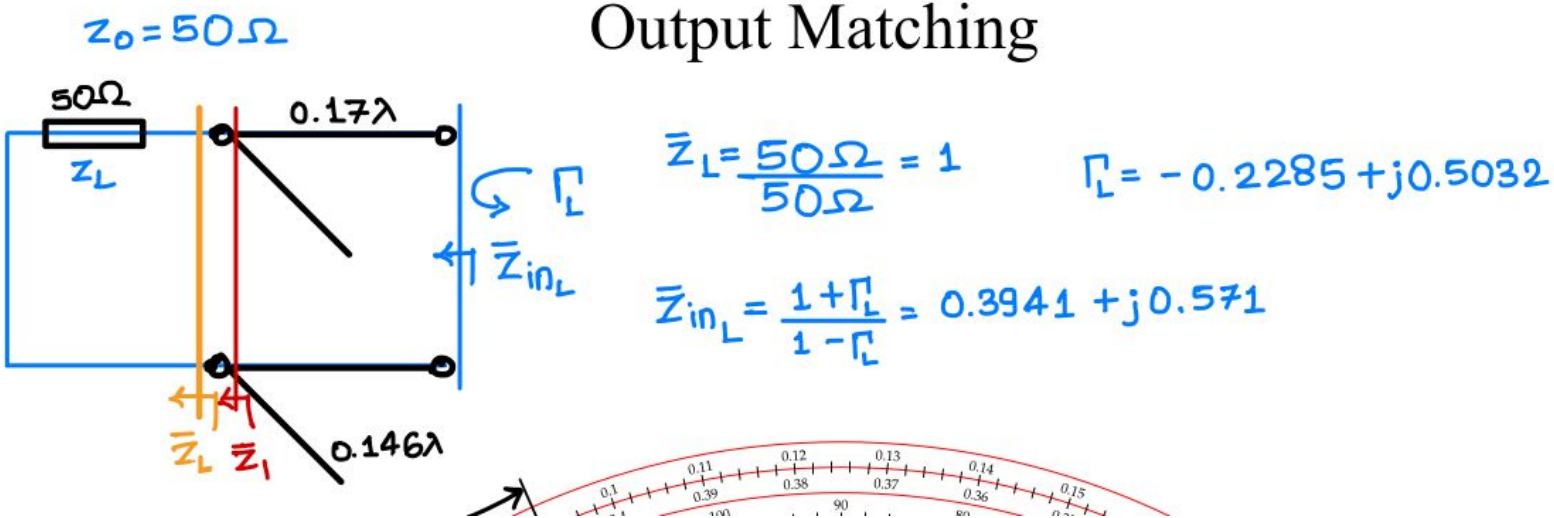
$\therefore \bar{Z}_c = -j0.39$

open stub length $= 0.441\lambda - 0.25\lambda$

$= 0.191\lambda$



Design of Matching Circuits : Output Matching



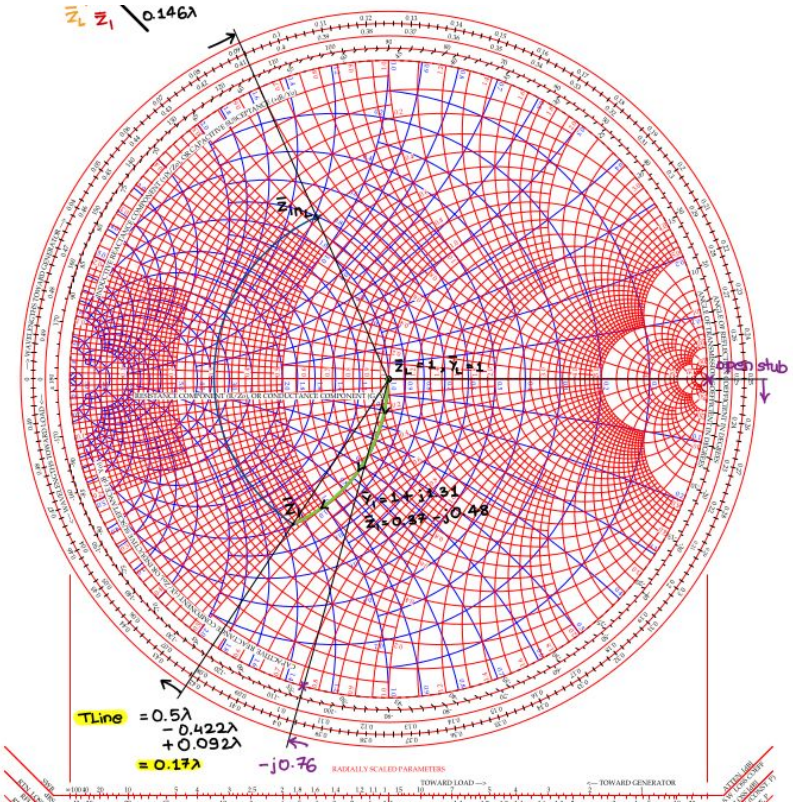
Design of Matching Circuits : Output Matching

$\bar{Y}_c = \bar{Y}_1 - \bar{Y}_s \quad \therefore \bar{Y}_c = j1.31$

$\therefore \bar{Z}_c = -j0.76$

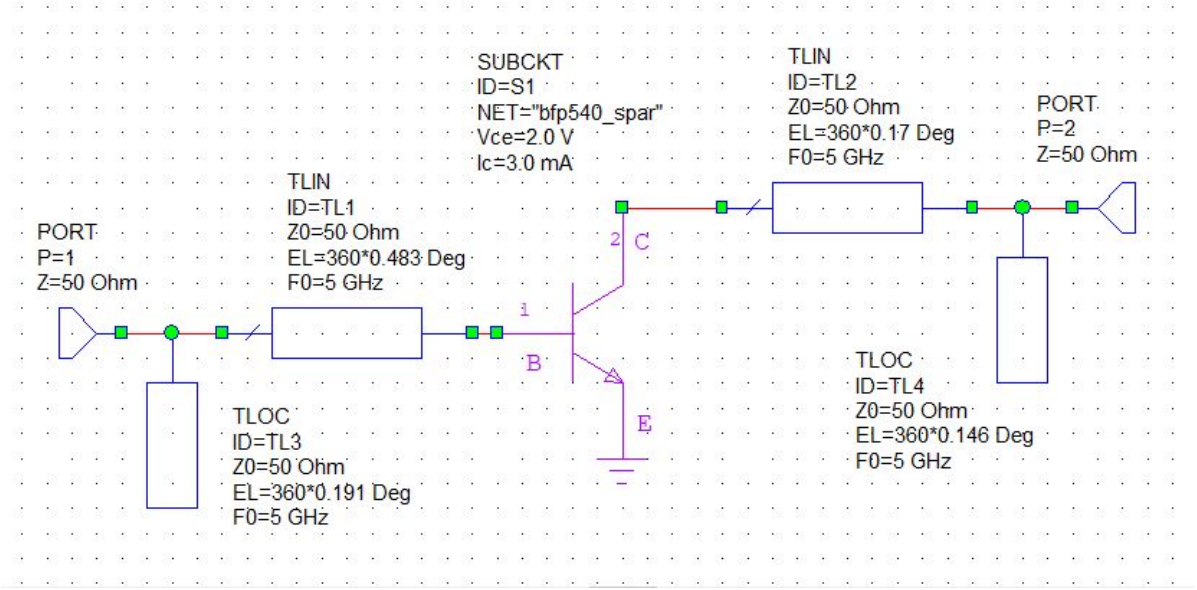
open stub length $= 0.396\lambda - 0.25\lambda$

$= 0.146\lambda$

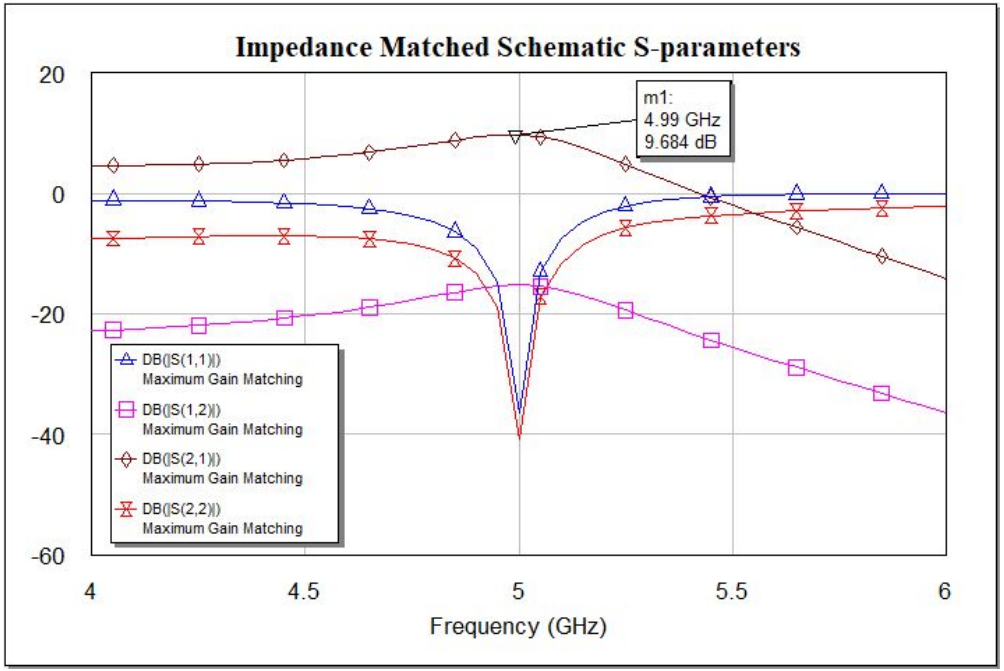


Matching : Schematic

$$\text{Electrical length } \beta L = \frac{2\pi}{\lambda} n\lambda = 2\pi \times n \text{ rad} = 360 \times n \text{ deg}$$

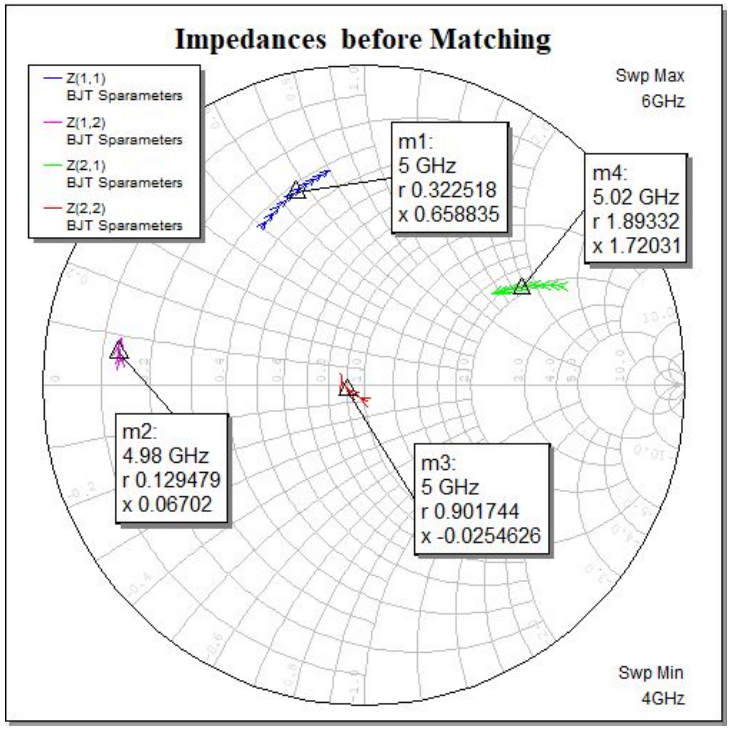


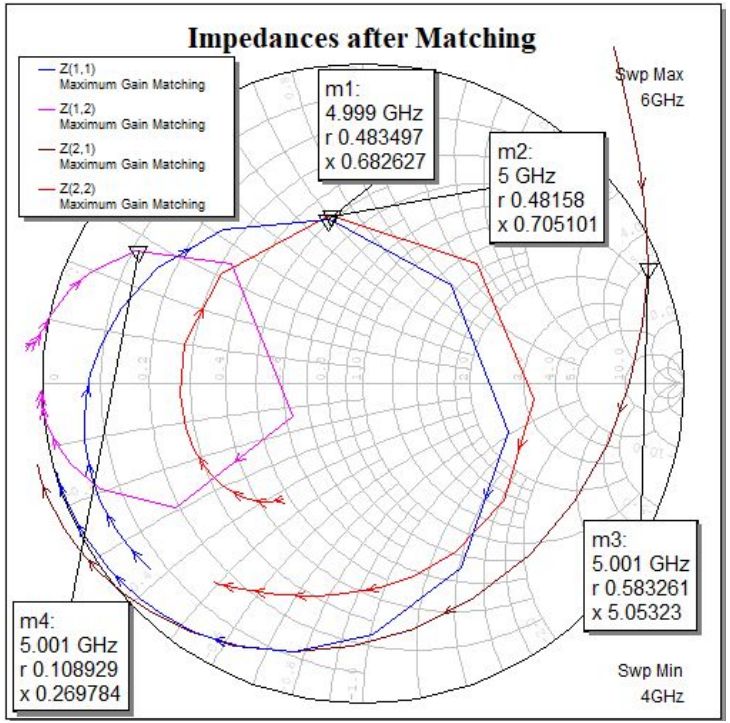
Matching : Schematic



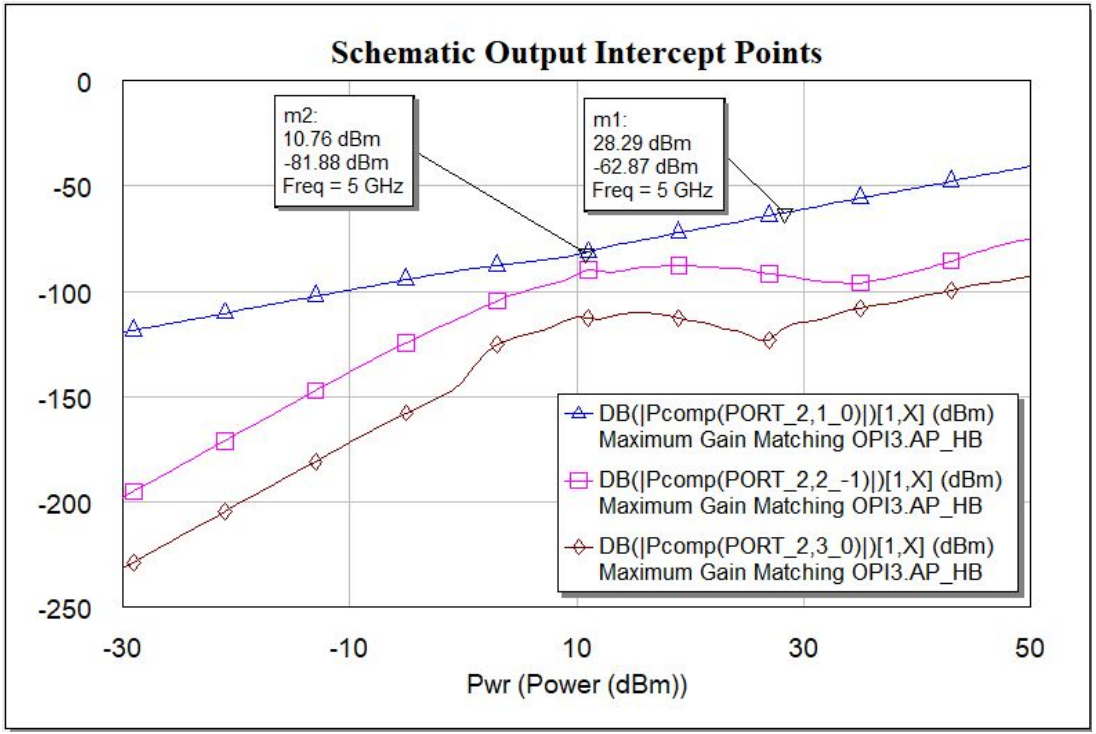
9.684 dB at 5 GHz

Impedance Plots

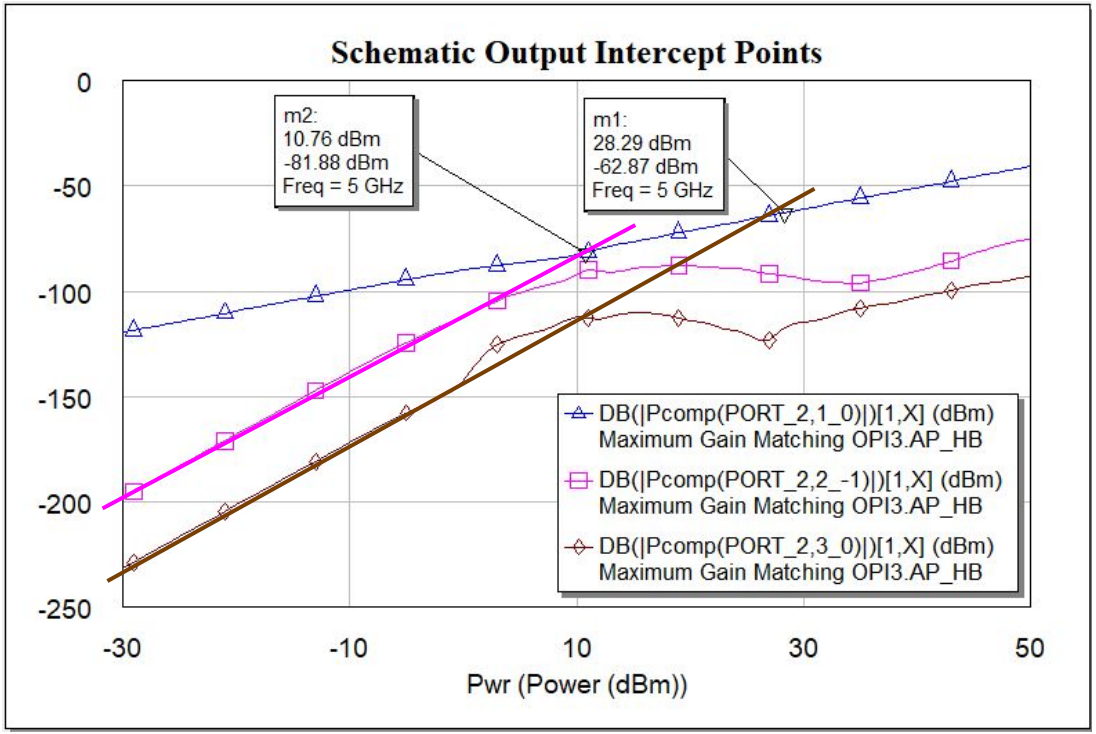




Third Order Intercept Points (OIP3)



Third Order Intercept Points (OIP3)

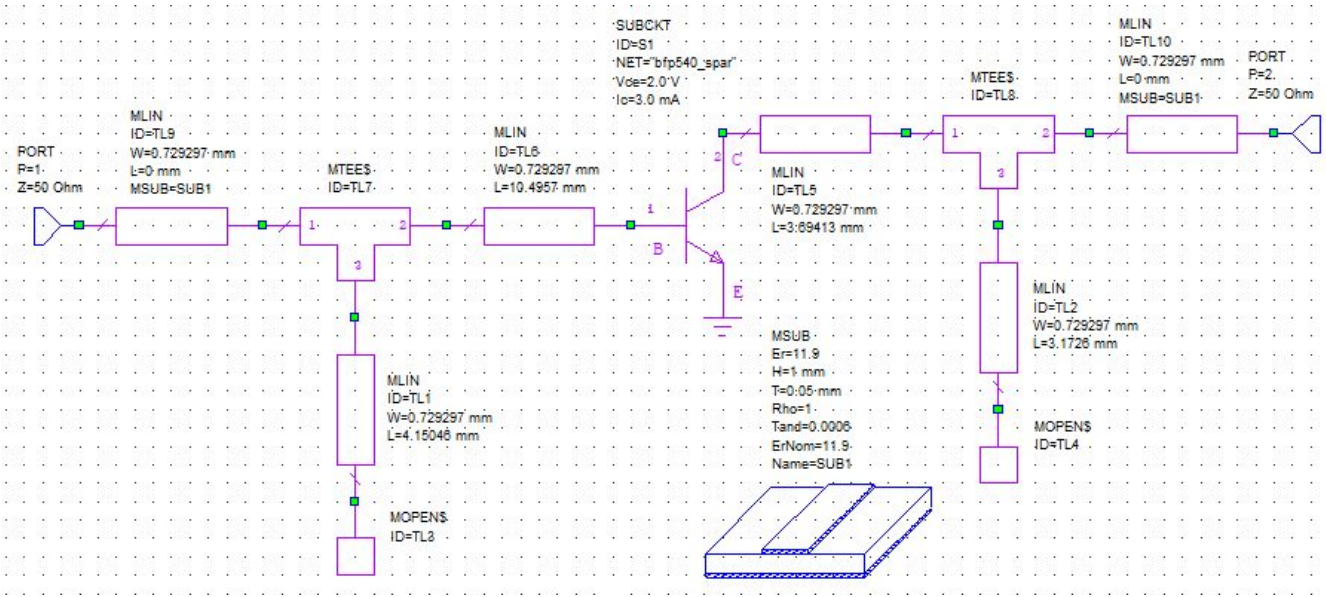


OIP3 Intermodulation : -81.88 dBm

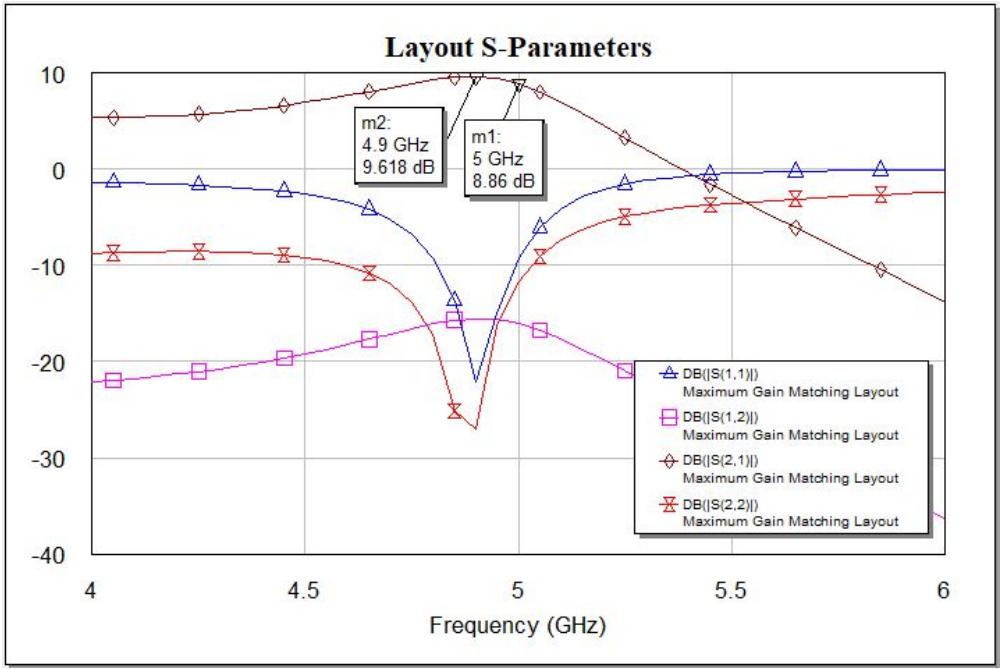
OIP3 Harmonic : -62.87 dBm

Matching : Layout

$$\text{Electrical length } \beta L = \frac{2\pi}{\lambda} n\lambda = 2\pi \times n \text{ rad} = 360 \times n \text{ deg}$$



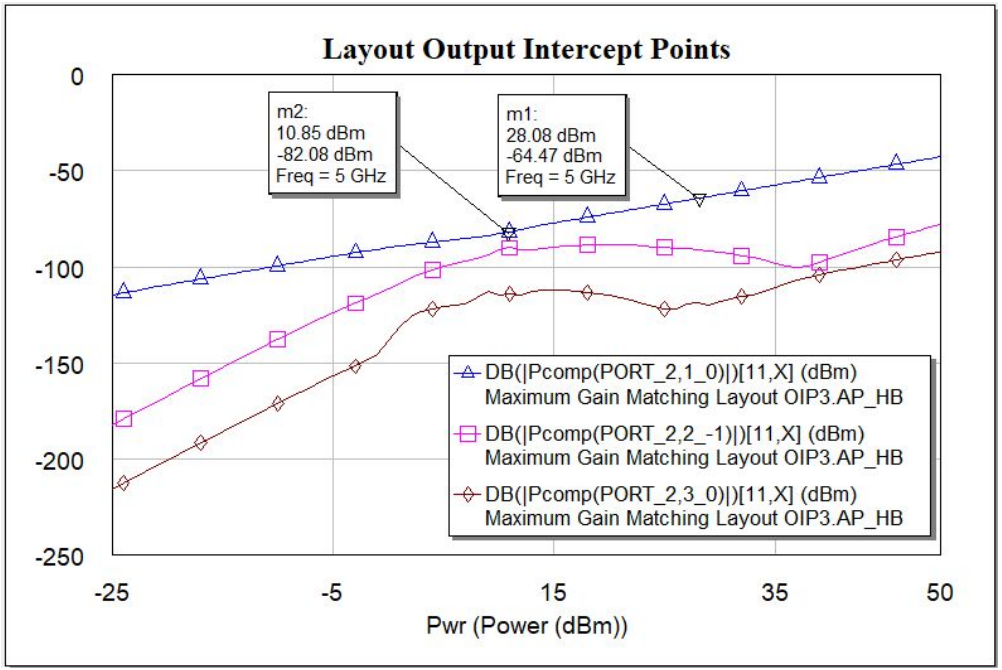
Matching : Layout



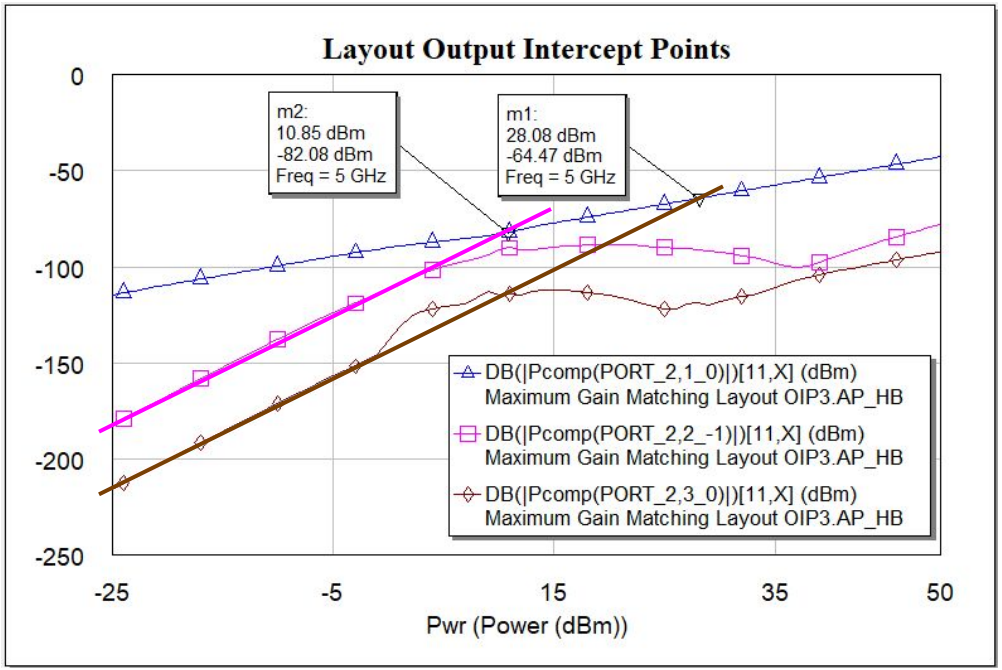
9.618 dB at 4.9 GHz

8.86 at 5 GHz

Third Order Intercept Points (OIP3)



Third Order Intercept Points (OIP3)



OIP3 Intermodulation : -82.08 dBm

OIP3 Harmonic : -64.47 dBm

Tapeout