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HW2 RF FERGAL LONERGAN

HW

3 GHz $V_{GS} = -1.7V$ $V_{DS} = 28V$ 16dB gain

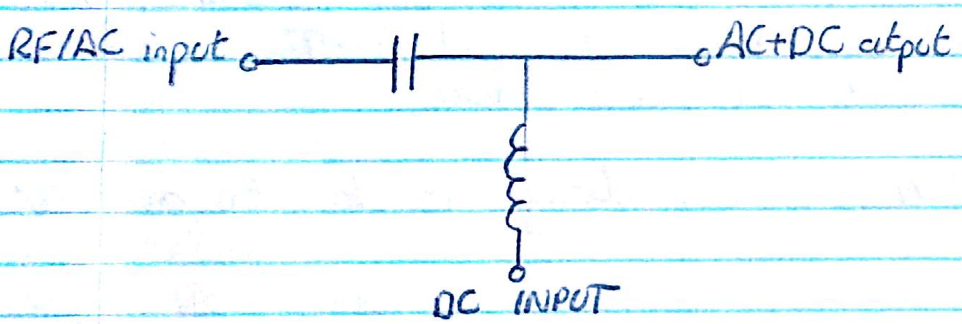
We first have to design our input and output bias networks to replace our ideal bias T's

For our ideal bias T's at 3GHz we find:

$S_{11} = 0.8131 \angle 158.7^\circ \Rightarrow Z_{in} = 10.7116 \angle 60.14^\circ$ [Ω]

$S_{22} = 0.3664 \angle 160.8^\circ \Rightarrow Z_{out} = 24.6057 \angle 15.57^\circ$ [Ω]

Our ideal bias T's will be subbed with this circuit.



Our conditions for X_{cin} and X_{Lin}, and X_{cout} and X_{Lout} for DC are as follows

$$X_{cin} \ll |Z_{in}| \ll X_{Lin}$$
$$X_{cout} \ll |Z_{out}| \ll X_{Lout}$$

And For RF

$$20 X_{cin} \geq |Z_{in}| \geq \frac{X_{Lin}}{20}$$
$$20 X_{cout} \geq |Z_{out}| \geq \frac{X_{Lout}}{20}$$

$\Rightarrow$ $0.535584 \ll X_{cin} \ll 10.7116$ $\quad$ $1.230285 \ll X_{cin} \ll 24.6057$

$10.7116 \ll X_{Lin} \ll 214.232$ $\quad$ $24.6057 \ll X_{Lin} \ll 492.114$

So we try $19 X_{cin} = |Z_{in}|$ $\quad$ $\frac{X_{Lin}}{19} = |Z_{in}|$

$$19\left(\frac{1}{\omega C_{in}}\right) = Z_{in} \Rightarrow C_{in} = \frac{19}{2\pi(3\times10^{9})(10.7116)} = 94.096\,pF$$

$$\frac{\omega L_{in}}{19} = Z_{in} \Rightarrow L_{in} = \frac{19(10.7116)}{2\pi(3\times10^{9})} = 10.797\,nH$$

similarly for Cout and Lout we get

$C_{out} = 40.966\,pF$

$L_{out} = 24.802\,nH$

As we can see from the graph our network is biased correctly, as our biased network and FET S_{11} and S_{22} are in practically the same place.

We expected this as our design is close to our design limits.

As we discovered from lab 6 the Max Gain of the system is 19dB However our desired gain is 16dB

So what I'll do is get max gain for my output matching network and I will tune the input matching network so I get an appropriate gain

For a unilateral design $S_{12} = 0$

then $\Gamma_{in} = S_{11}$ $\quad$ $\Gamma_{out} = S_{22}$

for unilateral design

$\Gamma_S = S_{11}^*$ $\quad$ $\Gamma_L = S_{22}^*$

$\Gamma_S = S_{11} = 0.8269 \angle -160.7^\circ$
$\Gamma_L = S_{22} = 0.3788 \angle -161.7^\circ$

$\Gamma_S = -0.7802 - j\,0.2733$
$\Gamma_L = -0.3597 - j\,0.1186$

LOAD Move from origin $r_s = 1$ to A

$\therefore$ stub length is $d = 0.361 - 0.25 = 0.111$

$\beta d = \frac{2\pi d}{\lambda} = 2\pi(0.111) = 0.697$ rad

from A to S_{22}^*

$d = |0.476\lambda - 406\lambda| = 0.07\lambda$

$\beta d = \frac{2\pi d}{\lambda} = 2\pi(0.07) = 0.439$ rad

Plotting this matching network to find Γ we get $\Gamma_L = 0.3861 \angle 163^\circ$
$\approx S_{22}^* \Rightarrow$ Max gain

Scanned by CamScanner

Unilateral transducer power gain

$$G_{TU} = 16\text{dB} = \frac{(1-|\Gamma_L|^2)\,|S_{21}|^2\,(1-|\Gamma_s|^2)}{|1-S_{22}\Gamma_L|^2\;|1-S_{11}\Gamma_s|^2}$$

$$16\text{dB} = \frac{(1-|S_{22}^*|^2)\,|S_{21}|^2\,(1-|\Gamma_s|^2)}{|1-\underbrace{S_{22}S_{22}^*}_{S_{22}^*}|^2\quad|1-S_{11}\Gamma_s|^2}$$

$$39.81 = \frac{(1-0.3861^2)(4.8216)^2(1-|\Gamma_s|^2)}{(1-0.3861^2)^2\qquad(1-0.8157\,\Gamma_s|^2}$$

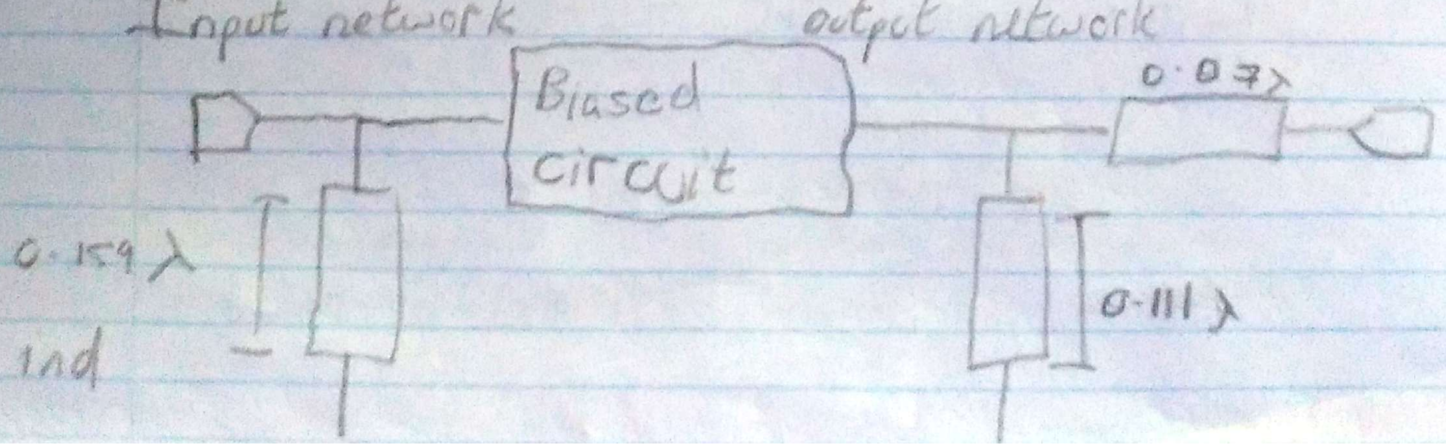
$$\Rightarrow \Gamma_s \approx 0.24$$

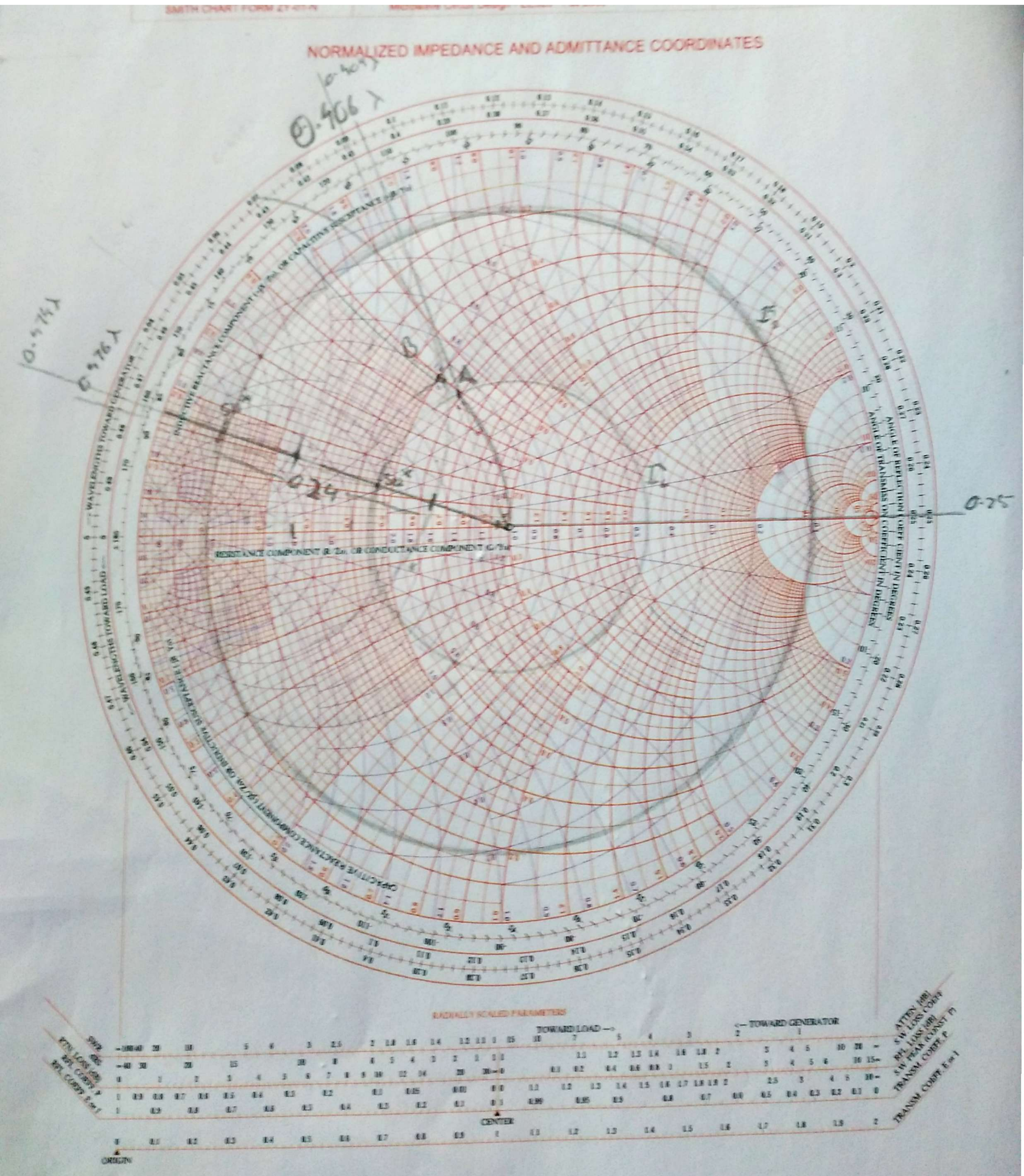
So now to get our stubs to get 16dB gain we go to S_{11}^* and swing an arc 0.24 long measured from our reflection coefficient. All points on this circle will give us a final gain of 16dB. As a point on the circle passed through our unity admittance arc I chose this for convenience. It's marked B. So we move from origin to B

$$d = 0.409\lambda - 0.25\lambda = 0.159\lambda$$

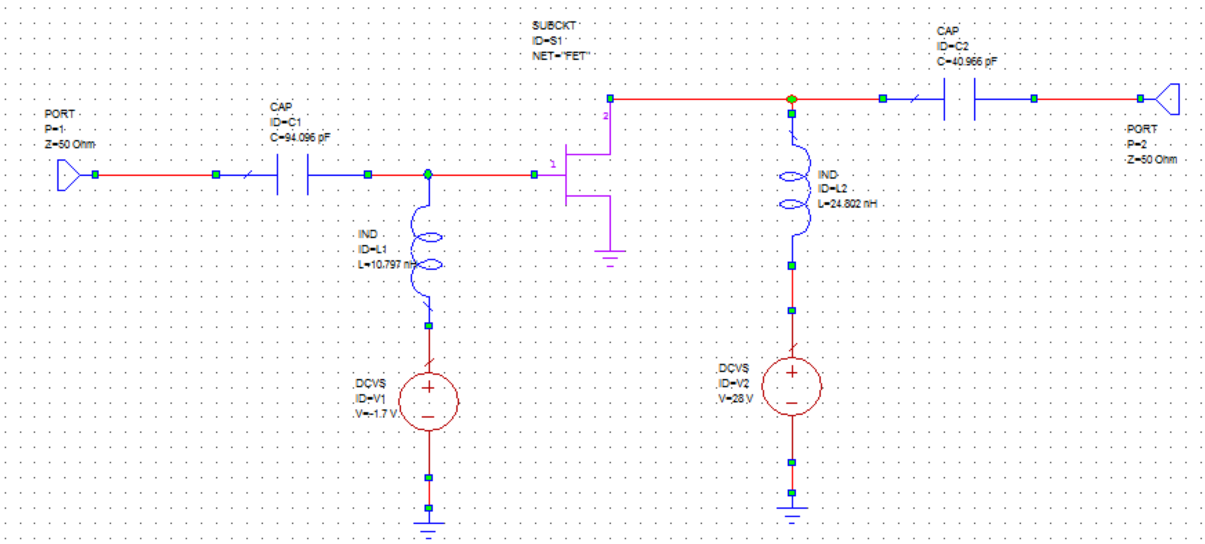
$$d = 0.159\lambda$$

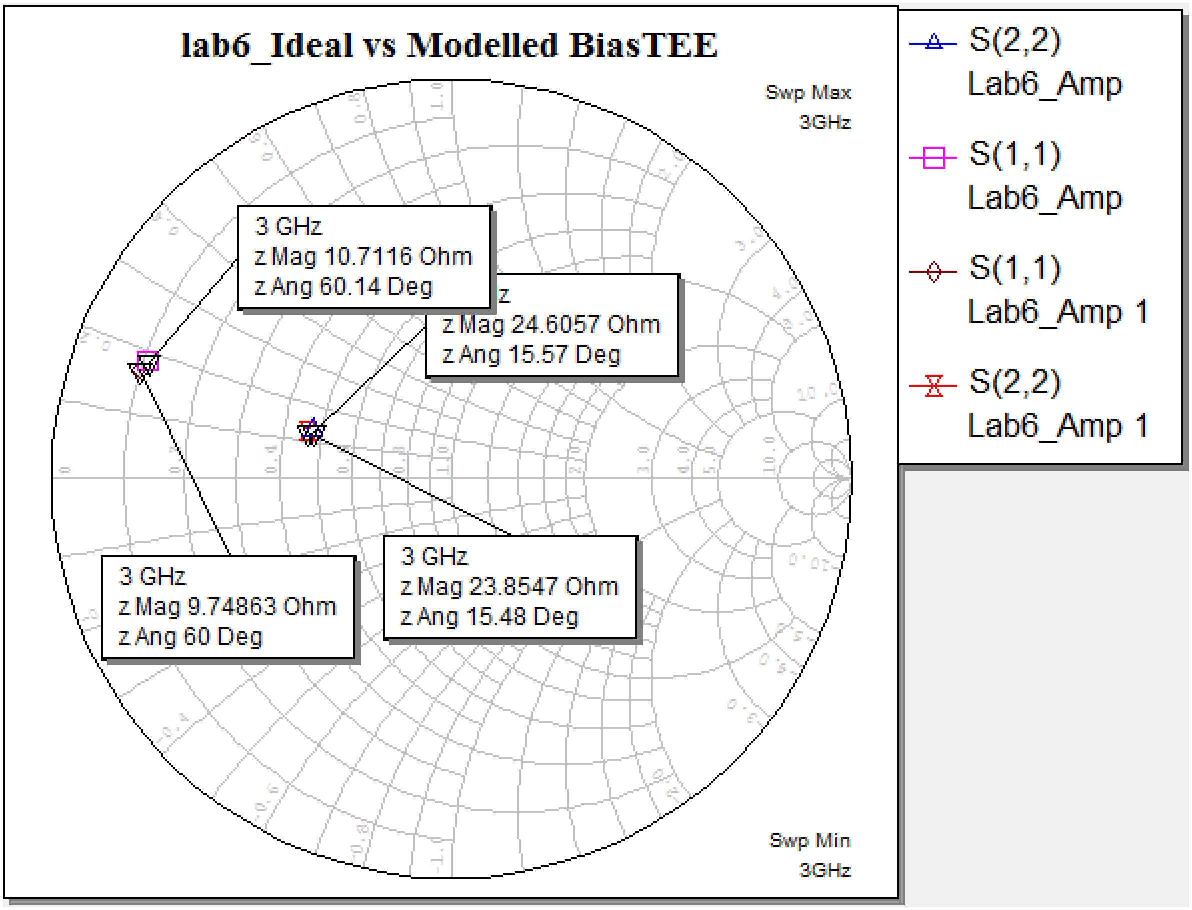
$$\beta d = \frac{2\pi d}{\lambda} = 2\pi(0.159) = 0.99\,\text{rad} = 56.87^\circ$$




NORMALIZED IMPEDANCE AND ADMITTANCE COORDINATES
0.406 λ
0.476λ
0.24
0.25
A
B
RESISTANCE COMPONENT (R/Zo), OR CONDUCTANCE COMPONENT (G/Yo)
WAVELENGTHS TOWARD GENERATOR
WAVELENGTHS TOWARD LOAD
ANGLE OF REFLECTION COEFFICIENT IN DEGREES
ANGLE OF TRANSMISSION COEFFICIENT IN DEGREES
RADIALLY SCALED PARAMETERS
TOWARD LOAD
TOWARD GENERATOR
CENTER
ORIGIN

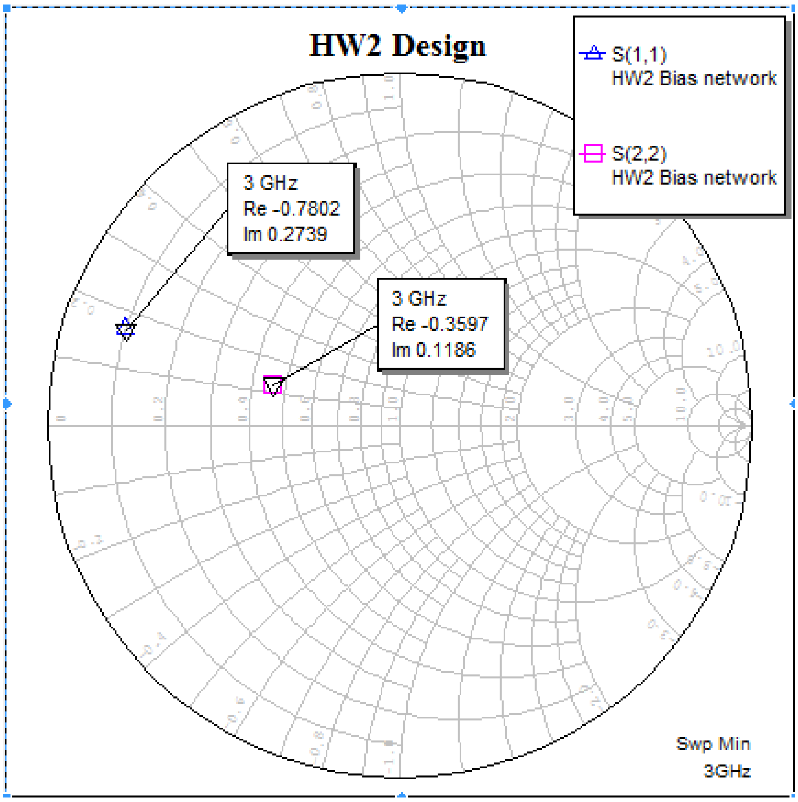
Biased network



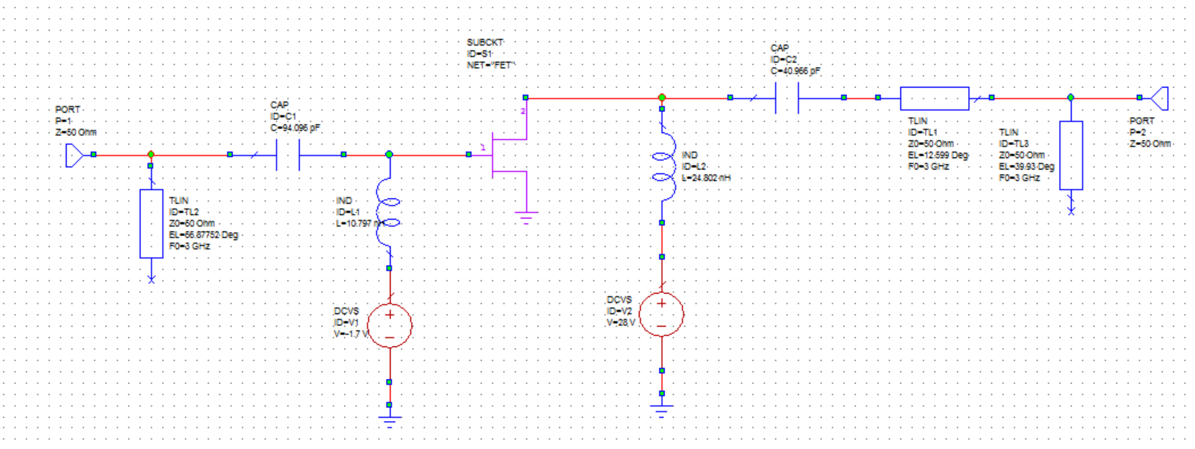


We see that our circuit is biased correctly.

Matched and Biased



Frequency (GHz)	|S(2,1)| HW2 Bias network	Ang(S(2,1)) (Deg) HW2 Bias network
3	4.8216	13.024



DB(GT()) (GHz) HW2 Matched Amplifier Frequency	DB(GT()) HW2 Matched Amplifier
3	16.043

We see that our final gain is 16.043dB which is very close to our desired value of 16 so I'm happy my design satisfies the solution.