1 $MAG = P_{l,amp} / P_{gen,delivered}$

$P_{amp} = I_{amp}^2 / G_{ds}$

$I_{amp} = g_m V_{gs}$

$$\frac{V_{gs}}{V_{gen}} = \frac{1/j\omega C_{gs}}{R_i + 1/j\omega C_{gs}}$$

$$= \frac{1}{R_i j\omega C_{gs} + 1}$$

$$P_{amp} = \left(\frac{g_m V_{gen}}{R_i j\omega C_{gs} + 1}\right)^2 . (R_{DS} \| Z_{out})$$

$P_{gen,\,delivered} = V_{gen}^2 / 4 Z_{gen}$.

$$MAG = \frac{\dfrac{g_m^2 V_{gen}^2}{(R_i j\omega C_{gs} + 1)^2} \cdot \dfrac{R_{DS} Z_{out}}{R_{DS} + Z_{out}}}{V_{gen}^2 / 4 Z_{gen}}$$

$$= \frac{4 g_m^2 Z_{gen}}{(R_i j\omega C_{gs} + 1)^2} \left(\frac{R_{DS} Z_{out}}{R_{DS} + Z_{out}}\right)$$

Short-circuit current gain

$I_{out} / I_{in} \big|_{Z_L = 0}$

$I_{out} = I_{amp} (1/G_{ds})$

$$= \left(\frac{g_m V_{gen}}{R_i j\omega C_{gs} + 1}\right) \frac{1}{G_{ds}}$$

$$I_{in} = \frac{V_{gen}}{Z_{in}}$$

$$Z_{in} = Z_{gen} + R_i + \frac{1}{j\omega C_{gs}}$$

$$Z_{in} = \frac{V_{gen}}{Z_{gen} + R_i + 1/j\omega C_{gs}}$$

$$\frac{I_{out}}{I_{in}} = \frac{g_m V_{gen} R_{DS}}{R_i j\omega C_{gs} + 1}$$

$$\frac{V_{gen}}{Z_{gen} + R_i + \frac{1}{j\omega C_{gs}}}$$

$$= \frac{g_m R_{DS}\left(Z_{gen} + R_i + 1/j\omega C_{gs}\right)}{R_i j\omega C_{gs} + 1}$$

b $$f_T = \frac{g_m}{2\pi C_{gs}} \qquad f_{max,fet} = \frac{f_T}{2\sqrt{(R_i + R_s)R_g)G_{ds}}}$$

$$= \frac{3mS/\mu m.wg}{2\pi(0.75 f_T/\mu m.wg)}$$

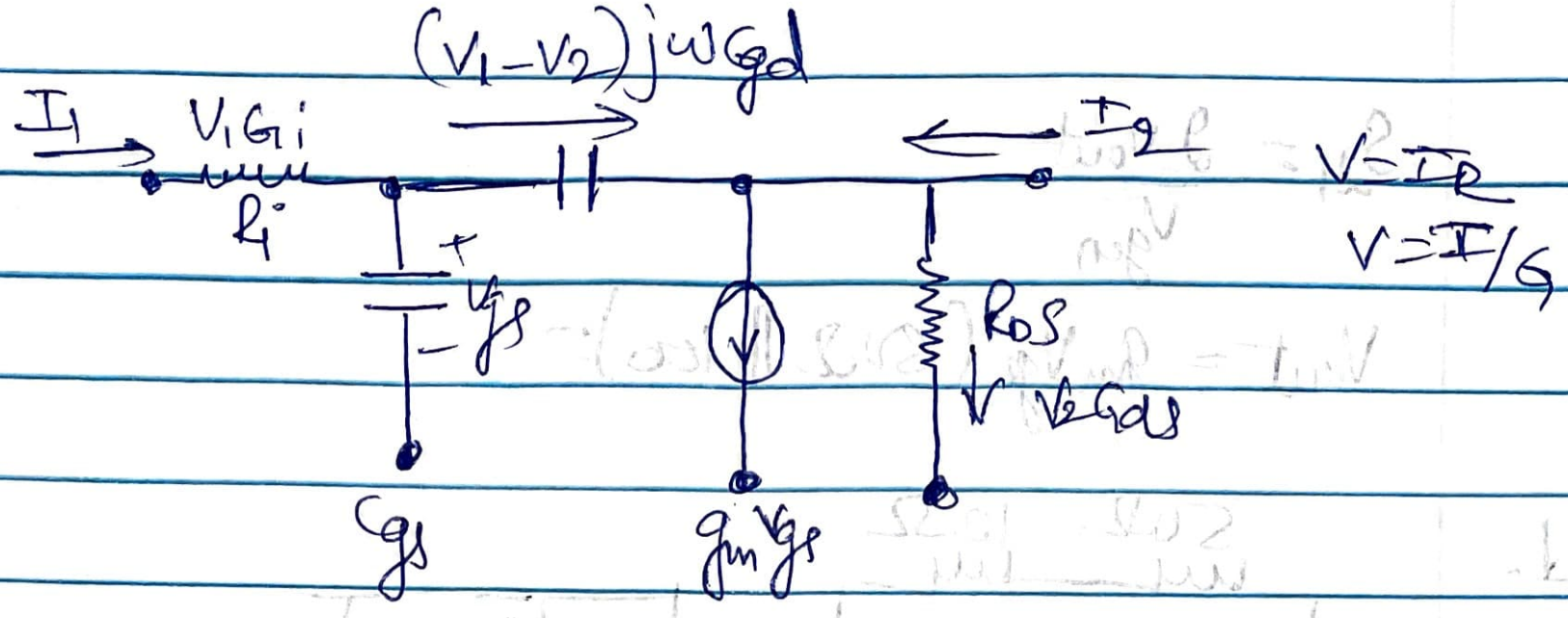
$$= \frac{3mS}{2\pi\, 0.75 f_T} = 636\,GHz$$

$$f_{max} = \frac{636\,GHz}{2\sqrt{(500)(0.1\times10^{-3})}} = 1.42\,THz$$

with generator and load impedances matched @ 50Ω

$$\boxed{f_{max/3} = 473.3\,GHz}$$

C



$$Y_{11} = 1/R_i + j\omega C_{gs}$$

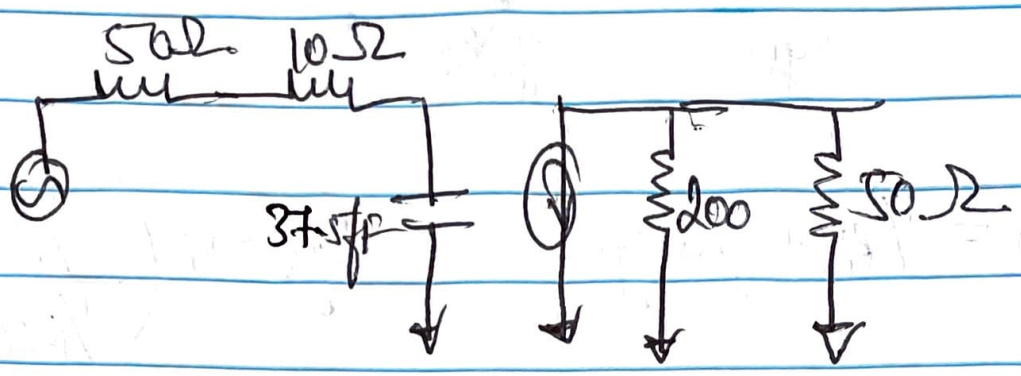
$$V_{gs} = V_i \left(\frac{1/j\omega C_{gs}}{1/j\omega C_{gs} + R_i} \right)$$

$$Y_{21} = \frac{I_2}{I_1} = g_m \frac{G_i}{G_i + j\omega C_{gs}} = \frac{G_i}{G_i + j\omega C_{gs}}$$

$$Y_{22} = G_{ds}$$

$$Y_{12} = 0$$

d.



$S_{11}: Z_{in} = 10\Omega + \frac{1}{j(2\pi \cdot 100\times10^9 \cdot 37.5fF)}$

$= 10\Omega - 42.44j$

$S_{11} = \frac{10 - 42.44j\ \Omega - 50\Omega}{10 - 42.44j\ \Omega + 50\Omega} = \frac{-40 - 42.44j}{60 - 42.44j}$

$||S_{11}|| = \frac{58.3194}{73.4925} = 0.795$

$S_{12} = 0$

$S_{21} = 2\, v_{out}/v_{gen}$

$v_{out} = g_m v_{gs} (50 \,||\, 200)$

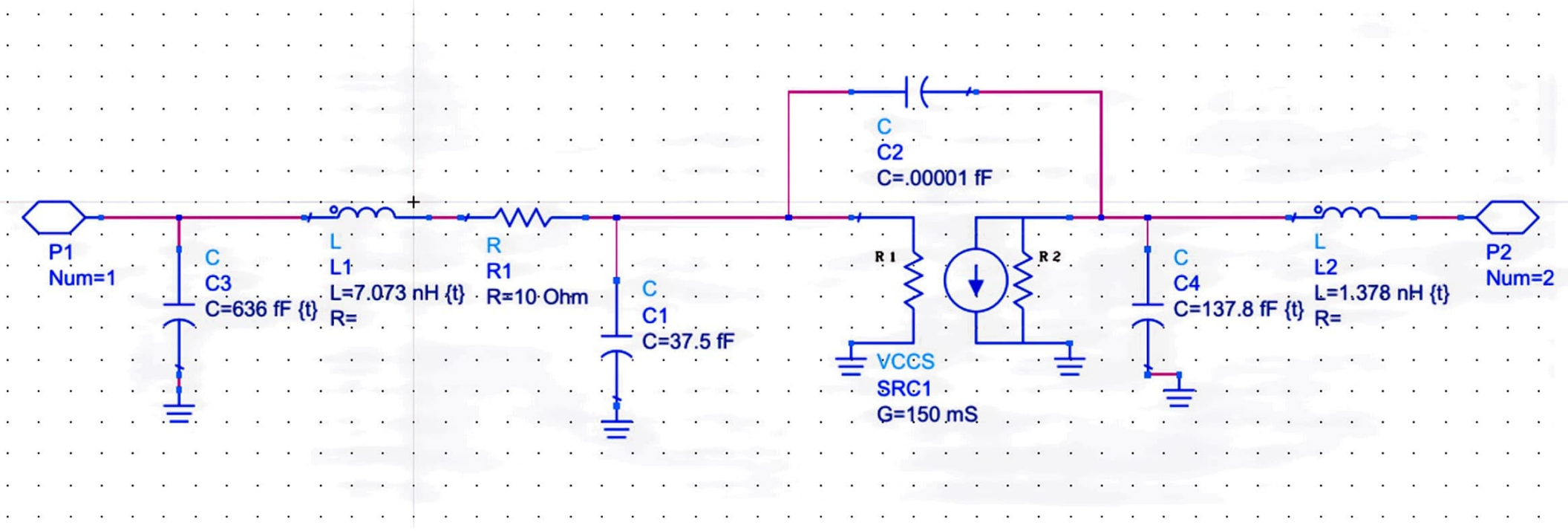
$= 6 v_{gs} \Rightarrow 2v_{out} = 12 v_{gs}$

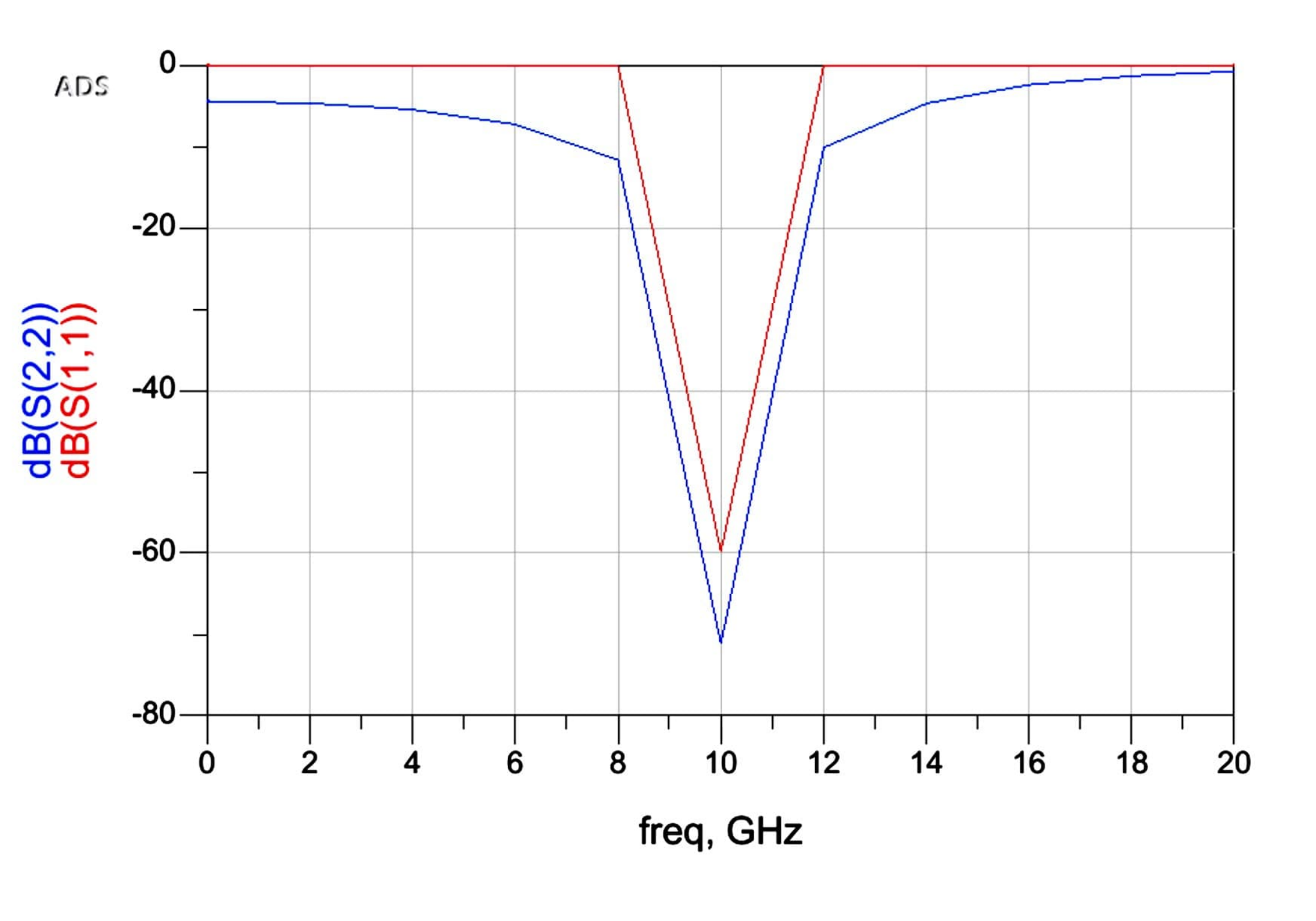
$v_{gs} = \frac{1}{1 + j\omega C_{gs} 60}$

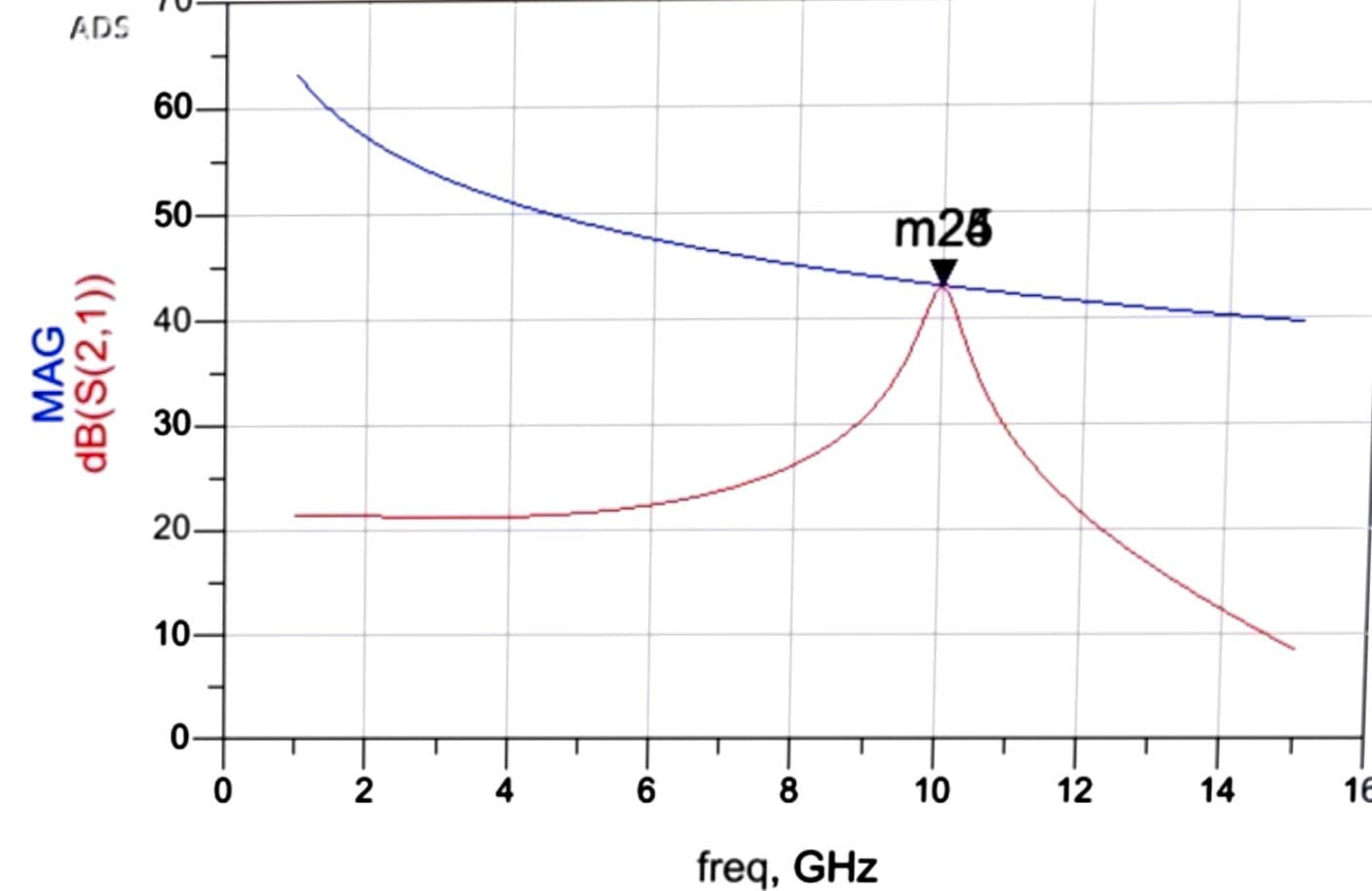
$S_{21} = \frac{12}{1 + 0.45\pi j} \Rightarrow ||S_{21}||^2 = 48.$

$S_{22} = \frac{200 - 50}{200 + 50} = 0.6$

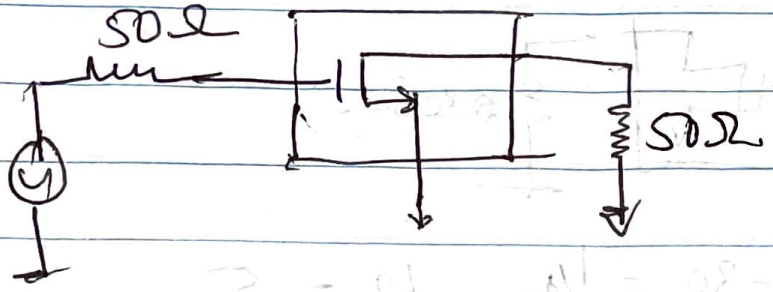
Insertion gain


P1
Num=1
C
C3
C=636 fF {t}
L
L1
L=7.073 nH {t}
R=
R
R1
R=10 Ohm
C
C1
C=37.5 fF
C
C2
C=.00001 fF
R1
R2
VCCS
SRC1
G=150 mS
C
C4
C=137.8 fF {t}
L
L2
L=1.378 nH {t}
R=
P2
Num=2


ADS
0
-20
-40
-60
-80
dB(S(2,2))
dB(S(1,1))
0
2
4
6
8
10
12
14
16
18
20
freq, GHz


ADS
70
60
50
40
30
20
10
0
MAG
dB(S(2,1))
m2
0
2
4
6
8
10
12
14
16
freq, GHz

2a.



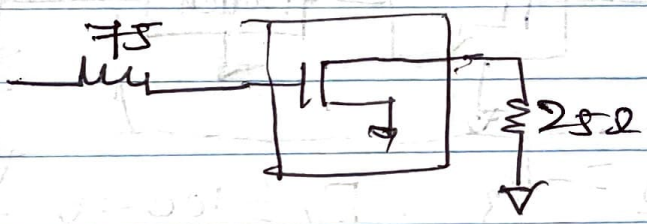
$S_{12} = 0$ No feedback.

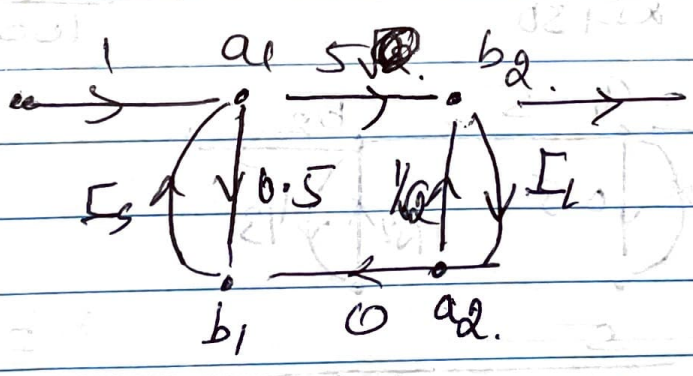
$\|S_{21}\|^2 = P_{deliv}/P_{av}$ $50\Omega = Z_0$ network

$25\Omega = P_{deliv}/1mW.$

$P_{deliv} = 25mW$

2b.





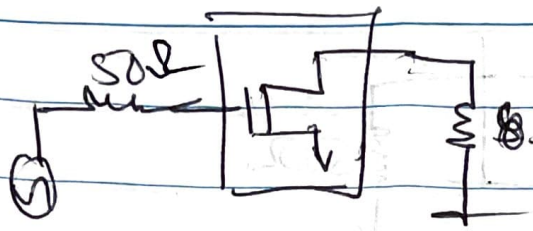
$\Gamma_S = \frac{75-25}{75+25} = 1/2$ $\quad \frac{b_2}{a_1} = \frac{\sqrt{2}}{1-[0.5(0.5)+\sqrt{2}(-0.5)}$

$\Gamma_L = \frac{25-75}{75+25} = -1/2$ $\quad S_{21,eff} = 4.531$

$G_p = \frac{1}{1-\|\Gamma_{in}\|^2} \cdot \|S_{21}\|^2 \cdot \frac{1-\|\Gamma_L\|^2}{\|1-S_{22}\Gamma_L\|^2} = \frac{4(4.531)^2}{3} \frac{1.25}{(1+1/\sqrt{2}\,1/2)^2}$

$= 18.6\ mW = 18.6mW$

2c

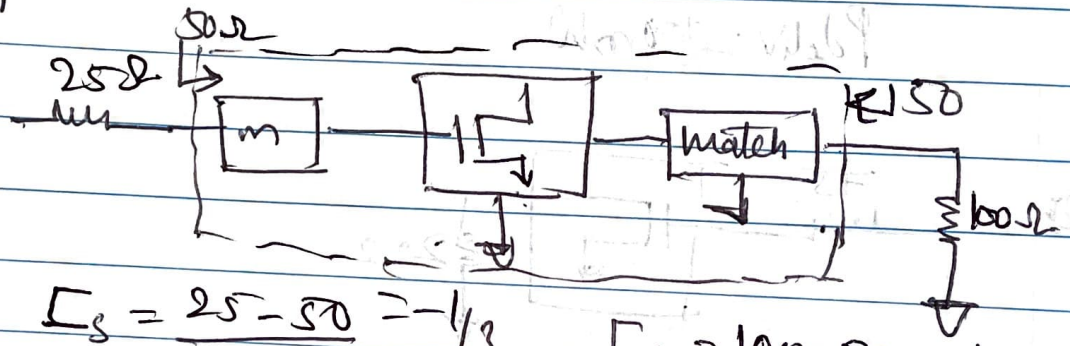


$$\Gamma_S = \frac{50-30}{50+30} = 1/4 \qquad \frac{b_2}{a_1} = \frac{5}{1-(0.5(0.25)-0.25\,1/\sqrt{2})}$$

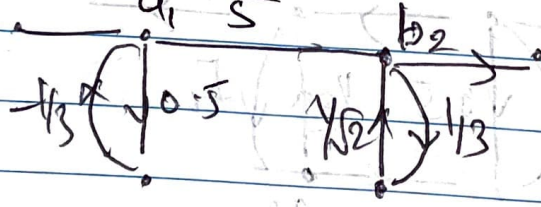
$$\Gamma_L = \frac{30-50}{50+30} = -1/4 \qquad S_{21,eff} = 4.754$$

$$G_p = 20.57(m)W = 20.57mW.$$

2d.



$$\Gamma_S = \frac{25-50}{25+50} = -1/3 \qquad \Gamma_L = \frac{100-50}{100+50} = 1/3$$

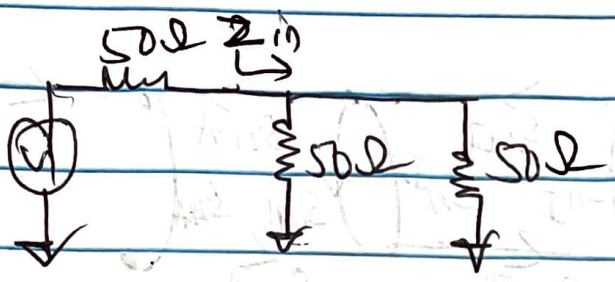


$$\frac{b_2}{a_1} = \frac{5}{1-(0.5(-1/3)+(1/\sqrt{2}\cdot 1/3))} = 5.3708$$

$$G_p = \frac{(S_{21})^2}{|1-|\Gamma_S|1/3|^2} \cdot \frac{1-|\Gamma_L|^2}{|1-1/3(1/\sqrt{2})|^2}$$

$$= 43.89mW.$$

3a.

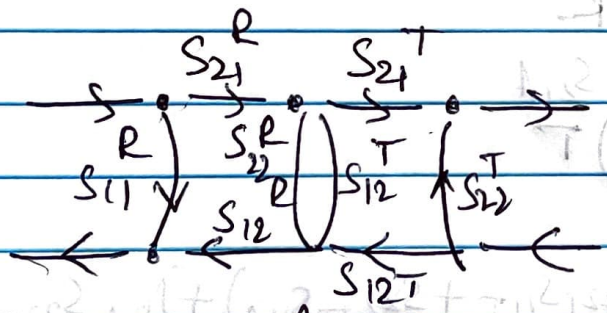


$$S_{11} = \frac{25\Omega - 50}{25 + 50} = -1/3$$

$S_{22} = -1/3$ $\quad S_{12} = 2/3$ by symmetry

$$S_{21} = 2\left(\frac{25}{50+25}\right) = 2/3$$

3b



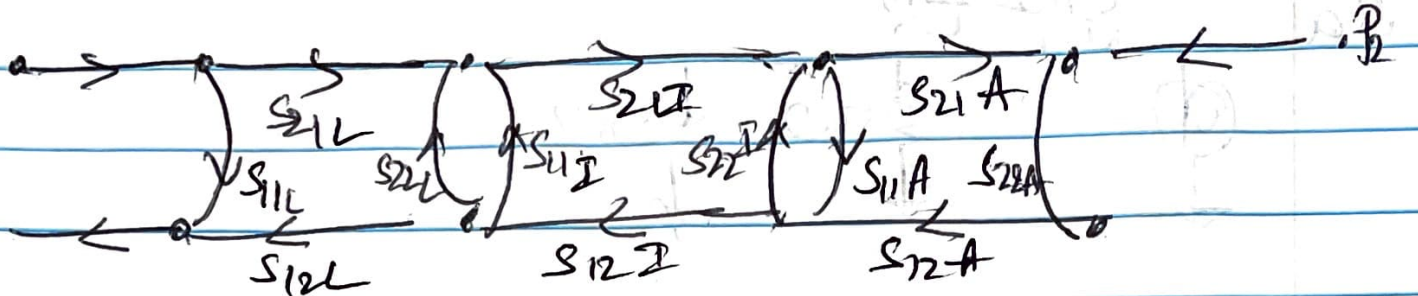
$$S_{21} = \frac{S_{21}^R S_{21}^T}{1 - S_{22}^R S_{11}^T} = 6.4004$$

$$S_{11} = \frac{S_{11}^T\left(1 - S_{22}^R S_{11}^T\right) + S_{21}^R S_{11}^T S_{12}^R}{1 - S_{22}^R S_{11}^T} = 0.143$$

$$S_{12} = \frac{S_{12}^R S_{12}^T}{1 - S_{22}^R S_{11}^T} = 0.645$$

$$S_{22} = \frac{S_{22}^T\left(1 - S_{22}^R S_{11}^T\right) + S_{12}^T S_{22}^R S_{21}^T}{1 - S_{22}^R S_{11}^T} = -3.1007$$

4.



$$a = 1 - \sum L(1)$$
$$= 1 - (S_{22L} S_{11I} + S_{22I} S_{11A})$$
$$= 1 - 0 = 1$$

$$S_{11} = S_{11L}(1 - S_{22L} S_{11I} + S_{22I} S_{11A}) + S_{21L} S_{11I} S_{12L}(1 - S_{22I} S_{11A}) + S_{21L} S_{21I} S_{11A} S_{12I} S_{12L}$$
$$= 0.1 + 10(0.5)(R)(0.25)(10).$$
$$= 0.1 + 12.5R.$$

$$S_{21} = S_{21L} S_{21I} S_{21A}$$
$$= 10(0.5)T$$
$$= 5T$$

$$S_{22} = S_{22A}(1 - S_{22L} S_{11I} + S_{22L} S_{11A}) + S_{12A} S_{22I} S_{12A}(1 - S_{22I} S_{11A}) + S_{12A} S_{12I} S_{22L} S_{21I} S_{21A}$$
$$= R + T^2(0.25)(0.1)(0.5).$$
$$= R + T^2(0.0125)$$