

Övning 6

Agenda

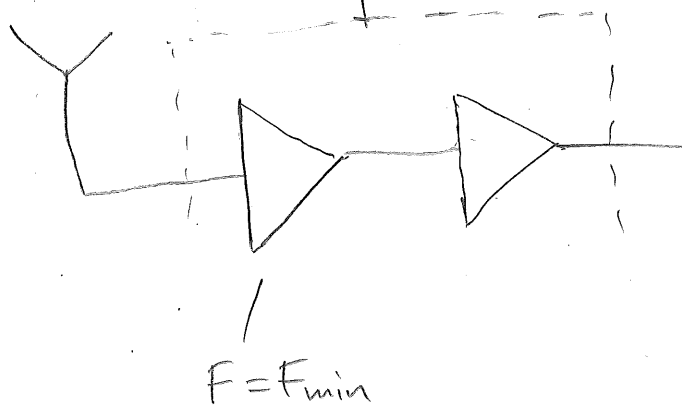
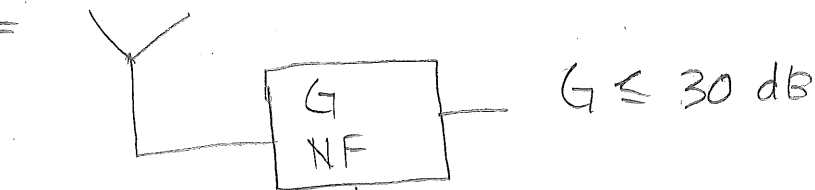
* Tenta 150116

Intedande into: Ta fram mikrovågsmottagare

$f = 10 \text{ GHz}$, substrat Rogers $\epsilon_r = 3,66$

$t_{\text{sub}} = 0,508 \text{ mm}$ $Z_0 = 50 \Omega$

1.



* 2 förstärkarsteg
max

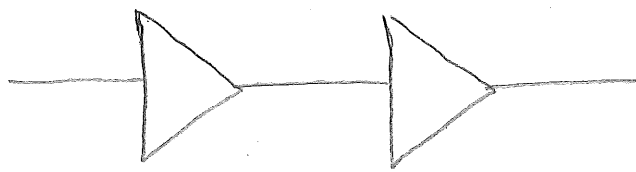
* steg 1 designas för
 F_{min}

a) * F_{min} lika, men gain? unilaterala?

P. 6.47 $G_{\text{msg}1} = \frac{|S_{21}|_1}{|S_{12}|_1} = \frac{3,2}{0,0015} = 2133,33 = 33,3 \text{ dB}$

P. 6.49 $G_{\text{msg}2} = \frac{|S_{21}|_2}{|S_{12}|_2} = \frac{2,3}{0,003} = 766,67 = 28,8 \text{ dB}$

$U_1 = 0,03$ $U_2 = 0,03 \Rightarrow$ båda unilaterala



$$F_1 = F_{\min} = 2 \text{ dB} \quad F_2 = ?$$

$$G_{\text{steg 1}} = ? \quad G_{\text{steg 2}} = ?$$

* Hur mycket gain från varje transistor vid minsta brusfaktor? (Γ_{opt}) och max gain (konjugat)

$$G_{\text{Trans1, TUm ax}} = \overset{\text{konjugat}}{\overset{P_{B,45}}{=}} \frac{1}{1 - |S_{11}|^2} |S_{21}|^2 \frac{1}{1 - |S_{22}|^2} = \overset{G_{\text{steg 2}}}{20,2 \text{ dB}}$$

$$G_{\text{Trans2, TUm ax}} = \dots = 16,1 \text{ dB}$$

Gain vid $F_{\min} \Rightarrow G_A!$

$$G_A(\Gamma_{\text{opt}})_{\text{Trans1}} = \frac{|S_{21}|^2 (1 - |\Gamma_{\text{opt}}|^2)}{|1 - S_{11} \Gamma_{\text{opt}}|^2 (1 - |\Gamma_{\text{out}}|^2)} = 5,1 \text{ dB}$$

$$G_A(\Gamma_{\text{opt}})_{\text{Trans2}} = \dots = \overset{G_{\text{steg 1}}}{11,2 \text{ dB}}$$

∴ välj T2 för steg 1 och T1 för steg 2

$$G_{\text{tot}} = G_{\text{steg 1}} + G_{\text{steg 2}} = 11,2 + 20,2 = \underline{31,4 \text{ dB}}$$

$$F \text{ för steg 1} = F_{\min} = 2 \text{ dB}$$

steg 2 har konjugat på ingång $\Gamma_s = S_{11}^*$

$$\text{Transistor 1} = 0,9 \angle -45^\circ$$

P6,60:

$$F(\Gamma_s = S_{11}^*) = F_{\min} + \frac{4R_N}{Z_0} \frac{|\Gamma_s - \Gamma_{\text{opt}}|^2}{(1 - |\Gamma_s|^2)|1 + \Gamma_{\text{opt}}|^2}$$

$$= 10 \text{ dB (!)}$$

F_{tot} för hela med Friis formel P. 3,77:

$$F_{\text{tot}} = F_1 + \frac{F_2 - 1}{G_1} = 10^{0,2} + \frac{10^1 - 1}{10^{2,12}} = 2,27 = \underline{\underline{3,56 \text{ dB}}}$$

2.

a) $\Gamma_s = \Gamma_{\text{opt}} = 0,9 \angle -70^\circ$

$\Gamma_L = S_{22}^* = 0,8 \angle -60^\circ$

b) matchningsnät med kortslutna stubbar

för ingång: $l_s = 0,038\lambda$

(på tavlan)

$$d_s = 0,348\lambda - 0,036\lambda$$

utgång: $l_e = 0,057\lambda$ $d_e = 0,282\lambda$ } beräkna själva

c) använd diagram

50 Ω -ledning $Z_0 = 50$ $\epsilon_r = 3,66$

och $h = 0,508$ mm $\Rightarrow$ $W_{ledn} = \underline{1,71}$ mm

använd diagram: bestäm $\frac{\lambda}{\lambda_{TEM}}$ $\leftarrow$ $\frac{1}{\sqrt{\epsilon_r}}$ λ_{TEM}

m, h, a, ϵ_r och w/h sen har vi

att $\lambda_{TEM} = \frac{\lambda_0}{\sqrt{\epsilon_r}}$, $\lambda_0 = \frac{c_0}{f_0}$ $\leftarrow$ $3 \cdot 10^8$ m/s
 $f_0 \leftarrow 10$ GHz

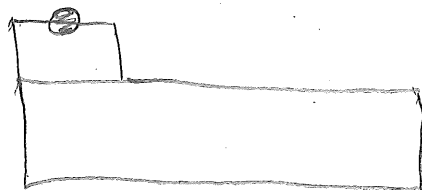
$\Rightarrow l_s$ (mm) = $0,038 \overset{\text{viasiftern}}{\lambda} = 0,7$ mm

$d_s = 5,5$ mm

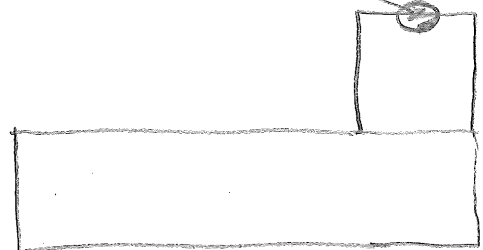
$l_e = 1$ mm

$d_e = 5$ mm

beräkna själva



Device

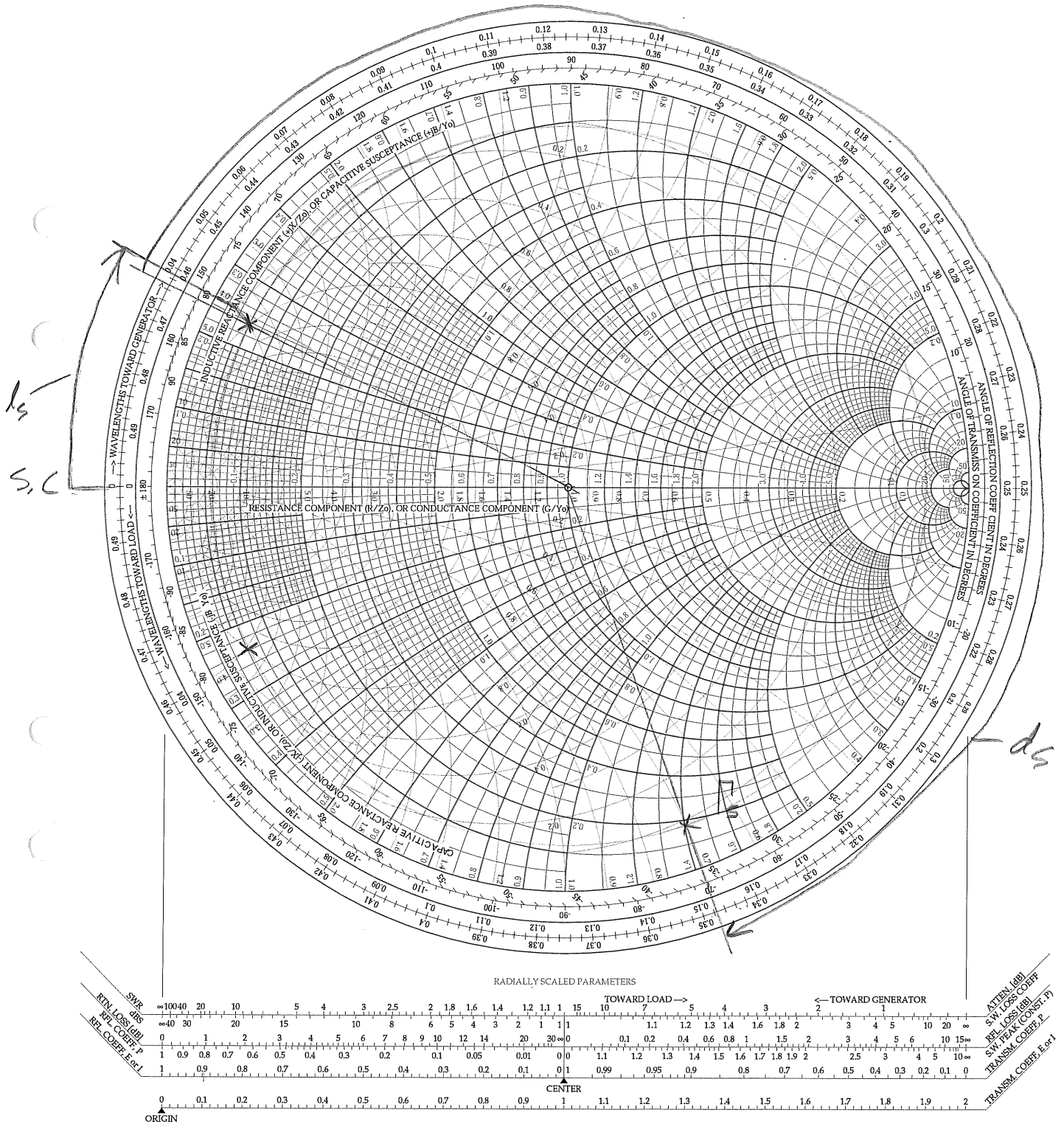


kortslutning Via

Tenta 150916 $\sqrt{3}$

NAME	TITLE	DWG. NO.
SMITH CHART FORM ZY-01-N	Microwave Circuit Design - EE523 - Fall 2000	DATE

NORMALIZED IMPEDANCE AND ADMITTANCE COORDINATES



$$l_s = 0.038\lambda$$

$$d_s = 0.348\lambda - 0.036\lambda = 0.312\lambda$$

3. steg 2, minst 15 dB ()

$$G_{TU} = \underbrace{\frac{1 - |\Gamma_S|^2}{|1 - S_{21}\Gamma_S|^2}}_{G_S} \underbrace{|S_{21}|^2}_{G_0 = 10,1 \text{ dB}} \underbrace{\frac{1 - |\Gamma_L|^2}{|1 - S_{22}\Gamma_L|^2}}_{G_{Lmax} = 2,9 \text{ dB}} \quad \boxed{\text{unilateral}}$$

S_{22}^*

$= 15 \text{ dB}$

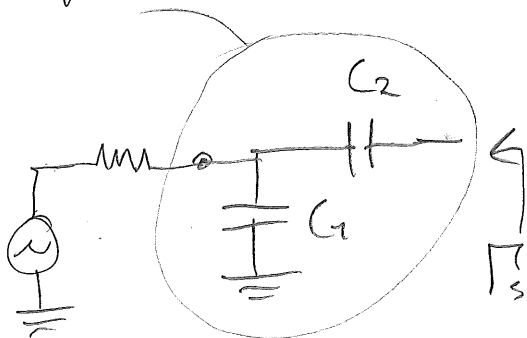
$$G_{TU} = G_S + G_0 + G_{Lmax} \Rightarrow G_S = 15 - 10,1 - 2,9 = 2 \text{ dB}$$

rita cirkel för $G_S = 2 \text{ dB}$

Se formuler och svar i tacit:

$$g_s = 0,81 \quad C_s = 0,62 \angle -45^\circ \quad R_s = 0,37$$

matchningsnät (lumped)



$$C_1 = \frac{0,415 Y_0}{\omega} = 0,13 \text{ pF}$$

$$C_2: (-j0,775 - (-j0,45)) Z_0 = -j \frac{1}{\omega C_2}$$

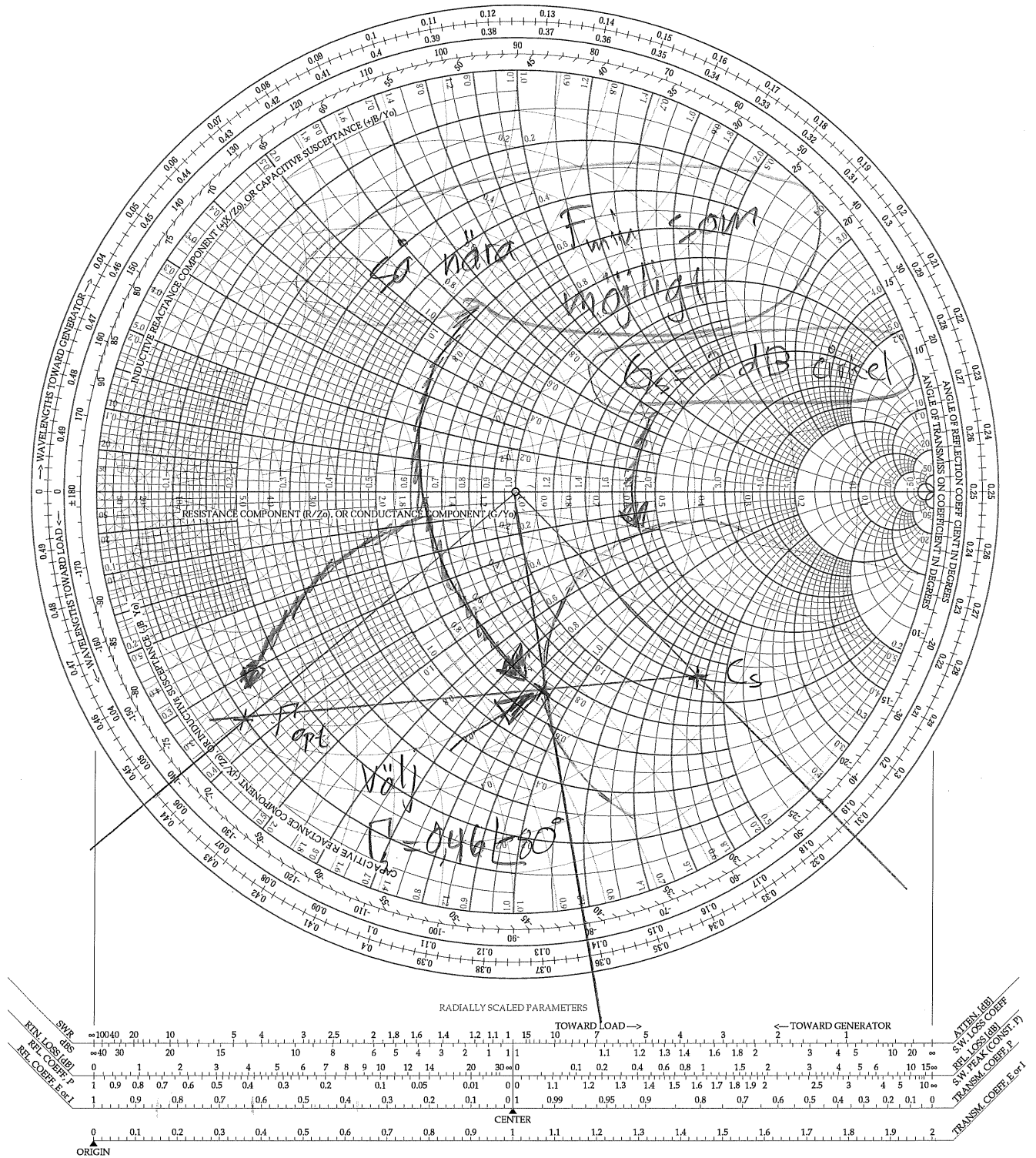
$$\Rightarrow \cancel{j0,325 Z_0} = \cancel{j \frac{1}{\omega C_2}} \Leftrightarrow C_2 = \frac{1}{\omega 0,325 \cdot Z_0} =$$

$$= \frac{1}{2\pi \cdot 10 \cdot 10^9 \cdot 0,325 \cdot 50} = \underline{0,98 \text{ pF}}$$

OBS använde $\Gamma_S = 0,39 \angle -78^\circ$ för att få dessa (tacit)

NAME	TITLE	DWG. NO.
SMITH CHART FORM ZY-01-N	Microwave Circuit Design - EE523 - Fall 2000	DATE

NORMALIZED IMPEDANCE AND ADMITTANCE COORDINATES



$$\Gamma_s = 0.46 \angle 80^\circ$$

4.a)

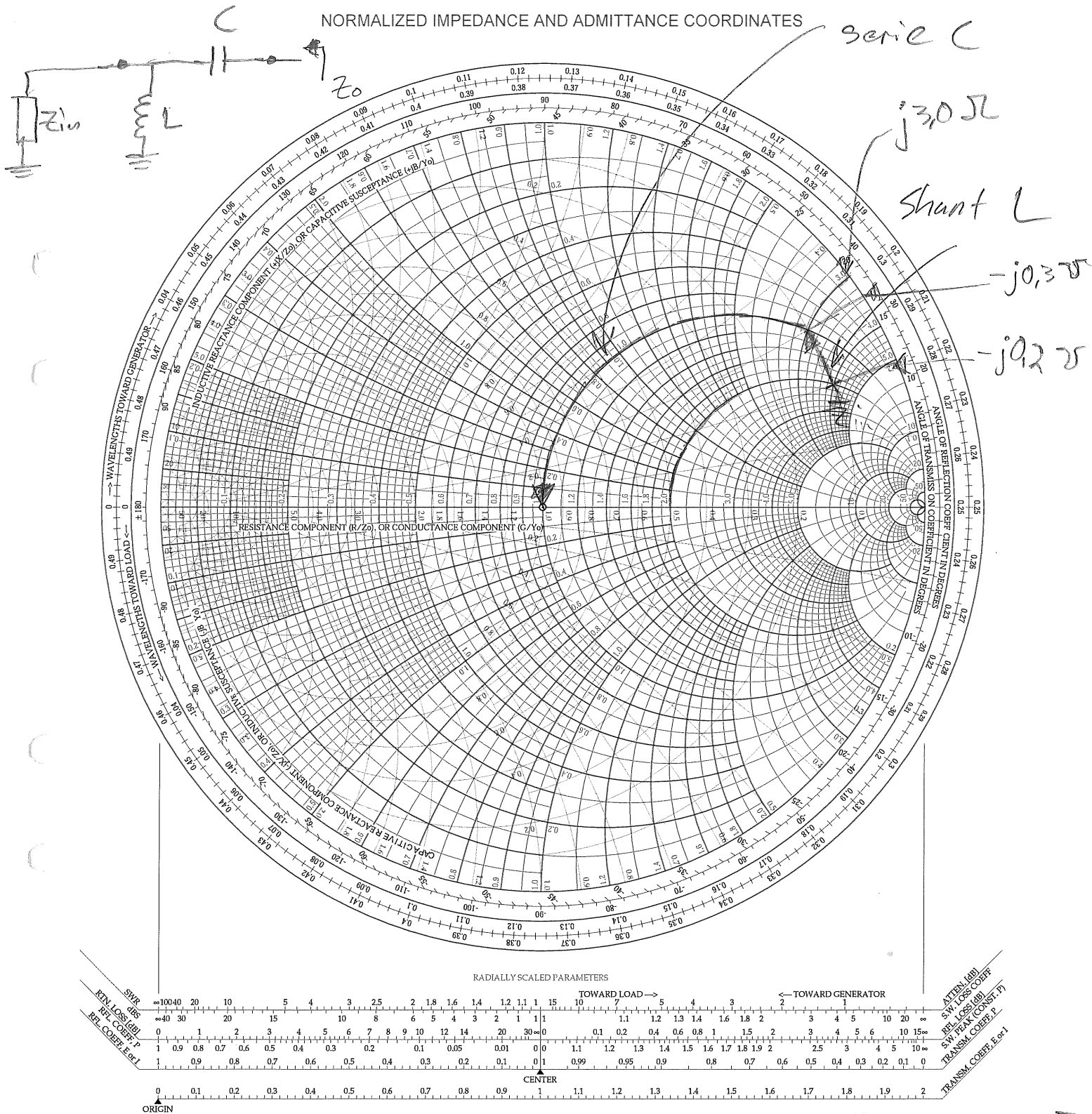
$$\bar{Z}_w = \frac{Z_{in}}{Z_0} = 2 + j4 \sqrt{2}$$

$$Z_0 \rightarrow 75$$

högpass:

(i serie

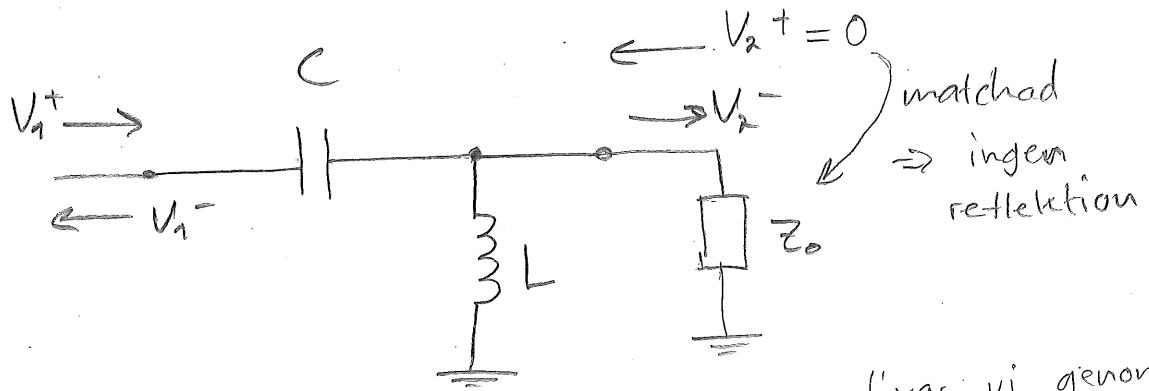
NAME	TITLE	DWG. NO.
SMITH CHART FORM ZY-01-N	Microwave Circuit Design - EE523 - Fall 2000	DATE



$$L: (-j0.3 - (-j0.2)) Y_0 = j0.1 Y_0 = j \frac{1}{\omega L} \Rightarrow L = \frac{1}{\omega 0.1 Y_0} = \frac{75}{2\pi \cdot 100 \cdot 10^6 \cdot 0.1} = 1.2 \mu F$$

$$C: (j0 - j3.0) Z_0 = -j3 Z_0 = -j \frac{1}{\omega C} \Rightarrow C = \frac{1}{\omega 3 Z_0} = \frac{1}{2\pi \cdot 100 \cdot 10^6 \cdot 3 \cdot 75} = 7.1 pF$$

4. b)



fixar vi genom att
sätta Z_0 på utgång

$$S_{11} = \left. \frac{V_1^-}{V_1^+} \right|_{V_2^+ = 0} = \Gamma_{in} = \frac{Z_{in} - Z_0}{Z_{in} + Z_0}$$

$$Z_{in} = \frac{Z_0 Z_L}{Z_0 + Z_L} + Z_c = \left\{ \begin{array}{l} Z_0 = 50 \, \Omega \\ Z_L = j\omega L \\ Z_c = 1/j\omega C \end{array} \right. \left. \begin{array}{l} \omega = 2\pi \cdot f \\ f = 100 \, \text{MHz} \end{array} \right\} =$$

$$= 49,8 + j220,9 \, \Omega \Rightarrow \Gamma_{in} = S_{11} = 0,91 \angle -24,4^\circ$$

$$S_{21} = \left. \frac{V_2^-}{V_1^+} \right|_{V_2^+ = 0} \quad \left\{ \begin{array}{l} V_2 = V_2^+ + V_2^- = V_2^- \quad (1) \\ V_2 = V_1 \frac{Z_P}{Z_P + Z_c} \quad Z_P = \frac{Z_0 Z_L}{Z_0 + Z_L} \quad (2) \\ V_1 = V_1^+ + V_1^- = V_1^+ \left(1 + \frac{V_1^-}{V_1^+} \right) = V_1^+ (1 + S_{11}) \quad (3) \end{array} \right.$$

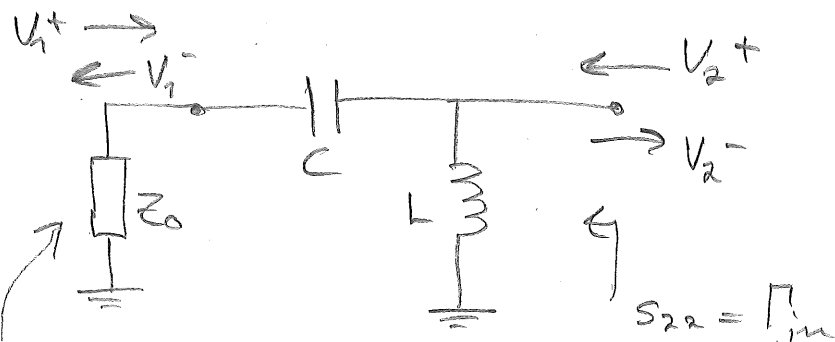
express V_2^- in V_1^+

$$\Rightarrow (1), (3) \rightarrow (2)$$

$$V_2^- = \frac{V_1^+ (1 + S_{11}) Z_P}{Z_P + Z_c}, \quad S_{21} = \frac{V_2^-}{V_1^+} = \frac{(1 + S_{11}) Z_P}{Z_P + Z_c} =$$

$$= 0,412 \angle 69,5^\circ$$

S_{12}, S_{22} :



$$S_{22} = \left. \frac{V_2^-}{V_2^+} \right|_{V_1^+ = 0} = \Gamma_{in} = \frac{Z_{in} - Z_0}{Z_{in} + Z_0}$$

$$Z_{in} = \frac{(Z_0 + Z_c) Z_L}{Z_0 + Z_c + Z_L} = 100,4 - j309,5 \, \Omega$$

$$\Rightarrow \Gamma_{in} = S_{22} = \underline{0,91 \angle -16,67^\circ}$$

$$S_{12} = \left. \frac{V_1^-}{V_2^+} \right|_{V_1^+ = 0}$$

express V_1^- in V_2^+ :

$$V_1 = \cancel{V_1^+} + V_1^- = V_1^-$$

$$V_1 = V_1^- = V_2 \frac{Z_0}{Z_0 + Z_c}$$

$$V_2 = V_2^+ + V_2^- = V_2^+ (1 + S_{22})$$

$$\Rightarrow V_1^- = \frac{V_2^+ (1 + S_{22}) Z_0}{Z_0 + Z_c}$$

$$\Rightarrow S_{12} = \frac{(1 + S_{22}) Z_0}{Z_0 + Z_c} =$$

$$= \underline{0,412 \angle 69,5^\circ}$$

comment: $S_{21} = S_{12}$ p.g.a
reciprokt nätverk

$S_{21} < 1 \Rightarrow$ inget gain
(passivt nätverk)