Övning 6

Agenda

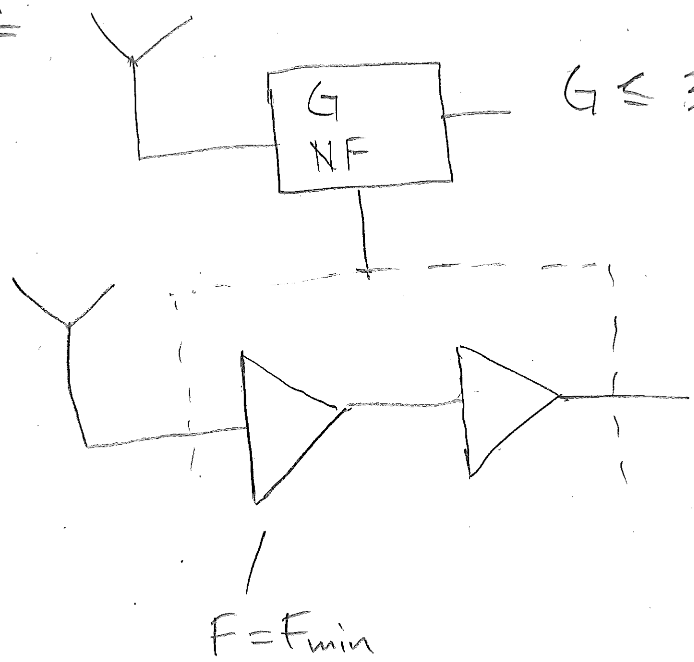
* Tenta 150116

Inledande info: Ta fram mikrovågsmottagare

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

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

1.



$G \leq 30$ dB

* 2 förstärkarsteg max
* steg 1 designas för F_{min}

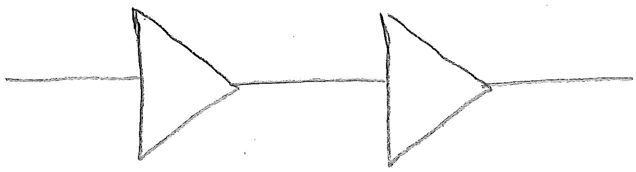
a) * F_{min} lika, men gain? unilaterala?

P. 6,47 $\quad G_{msg1} = \dfrac{|S_{21}|_1}{|S_{12}|_1} = \dfrac{3{,}2}{0{,}0015} = 2133{,}33 = 33{,}3$ dB

$G_{msg2} = \dfrac{|S_{21}|_2}{|S_{12}|_2} = \dfrac{2{,}3}{0{,}003} = 766{,}67 = 28{,}8$ dB

P6,49

$U_1 = 0{,}03 \qquad U_2 = 0{,}03 \Rightarrow$ båda unilaterala



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

$G_{steg1} = ?$ $\quad G_{steg2} = ?$

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

konjugat P6,45

$$G_{Tran1,\,TUmax} = \frac{1}{1-|S_{11}|^2}|S_{21}|^2\frac{1}{1-|S_{22}|^2} = 20{,}2\ dB$$

G_{steg2}

$$G_{Tran2,\,TUmax} = \ldots = 16{,}1\ dB$$

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

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

G_{steg1}

$$G_A(\Gamma_{opt})_{Trans2} = \ldots = 11{,}2\ dB$$

∴ välj T2 för steg 1 och T1 för steg 2

$$G_{tot} = G_{steg1} + G_{steg2} = 11{,}2 + 20{,}2 = \underline{31{,}4\ dB}$$

F för steg 1 = F_{min} = 2 dB

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

Transistor 1 = $0{,}9\angle -45°$

P6,60: $F(\Gamma_s = S_{11}^*) = F_{min} + \frac{4R_N}{Z_0} \frac{|\Gamma_s - \Gamma_{opt}|^2}{(1-|\Gamma_s|^2)|1+\Gamma_{opt}|^2}$

$= 10$ dB (!)

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

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

2.

a) $\underline{\Gamma_s = \Gamma_{opt} = 0{,}9\angle -70°}$

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

b) matchningsnät med kortslutna stubbar

för ingång: $l_s = 0{,}038\lambda$ (på tavlan)

$d_s = 0{,}348\lambda - 0{,}026\lambda$

utgång: $l_L = 0{,}057\lambda$ $d_L = 0{,}282\lambda$ } beräkna själva

c) använd diagram

50 Ω-ledning $Z_0 = 50$ $\varepsilon_r = 3{,}66$

och $h = 0{,}508$ mm $\Rightarrow$ $W_{ledn} = \underline{1{,}11 \text{ mm}}$

använd diagram: bestäm $\dfrac{\lambda}{\lambda_{TEM}}$ ← kvasiterm

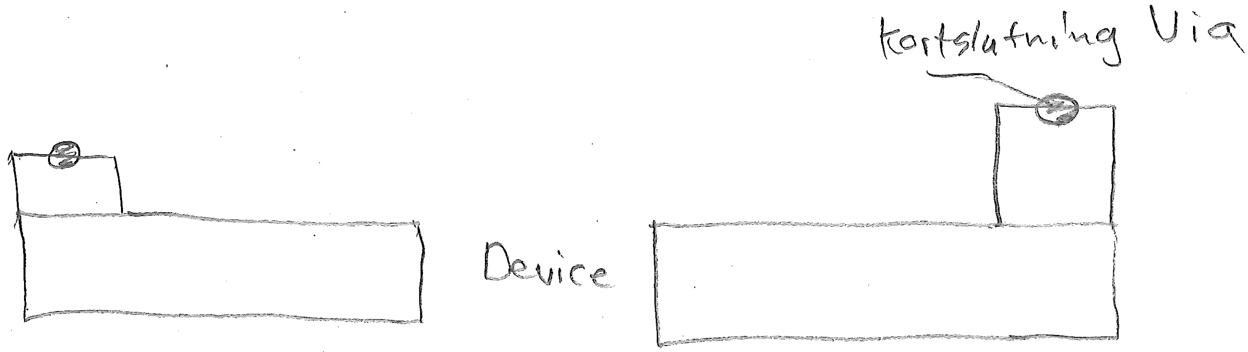
m, h, a, ε_r och w/h sen har vi

att $\lambda_{TEM} = \dfrac{\lambda_0}{\sqrt{\varepsilon_r}}$, $\lambda_0 = \dfrac{c_0}{f_0}$ ← $3 \cdot 10^8$ m/s, f_0 ← 10 GHz

$\Rightarrow$ l_s (mm) $= 0{,}038\,\lambda$ (kvasiten) $= 0{,}7$ mm

$d_s = 5{,}5$ mm

$\left.\begin{array}{l} l_e = 1 \text{ mm} \\ d_e = 5 \text{ mm} \end{array}\right\}$ beräkna själva



Tenta 150116 Γ_s

NAME	TITLE	DWG. NO.
		DATE
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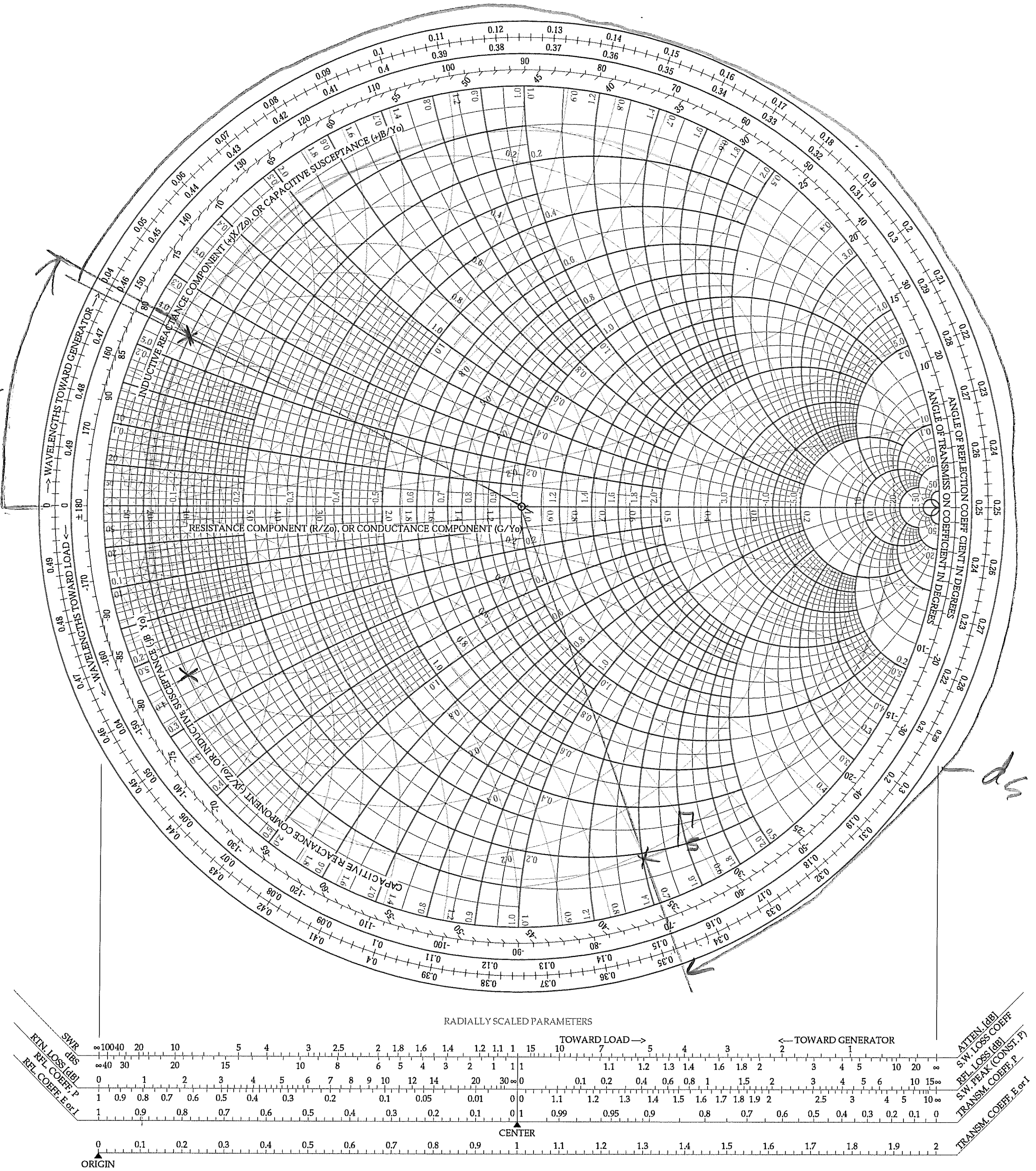
NORMALIZED IMPEDANCE AND ADMITTANCE COORDINATES



$l_s = 0{,}038\lambda$

$d_s = 0{,}348\lambda - 0{,}036\lambda = 0{,}312\lambda$

3. steg 2, minst 15 dB

$$G_{TU} = \underbrace{\frac{1-|\Gamma_s|^2}{|1-S_{11}\Gamma_s|^2}}_{G_S} \underbrace{|S_{21}|^2}_{G_0 = 10{,}1\ dB} \underbrace{\frac{1-|\Gamma_L|^2}{|1-S_{22}\Gamma_L|^2}}_{G_{Lmax} \overset{S_{22}^*}{=} 2{,}9\ dB} \qquad \boxed{\text{unilateral}}$$

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

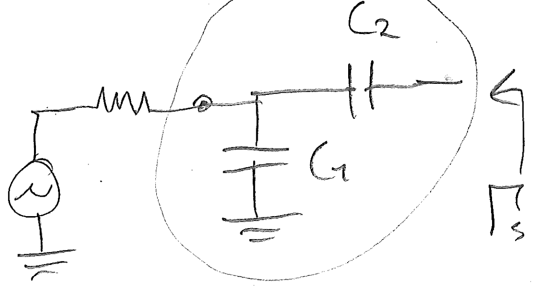
rita cirkel för $G_S = 2$ dB

Se formler och svar i facit:

OBS använde $\Gamma_s = 0{,}39\angle{-78°}$ för att få dessa (facit)

$g_s = 0{,}81 \qquad C_s = 0{,}62\angle{-45°} \qquad R_s = 0{,}37$

matchningsnät (lumped)



$$C_1 = \frac{\overset{j0{,}415 - j0}{0{,}415\,Y_0}}{\omega} = 0{,}13\ pF$$

$$C_2: \ \left(-j0{,}775 - (-j0{,}35)\right) Z_0 = -j\frac{1}{\omega C_2}$$

$$\Rightarrow \cancel{-j}0{,}425\,Z_0 = \cancel{-j}\frac{1}{\omega C_2} \Leftrightarrow C_2 = \frac{1}{\omega\, 0{,}425 \cdot Z_0} =$$

$$= \frac{1}{2\pi \cdot 10 \cdot 10^9 \cdot 0{,}325 \cdot 50} = \underline{0{,}75\ pF}$$

se även smithchart

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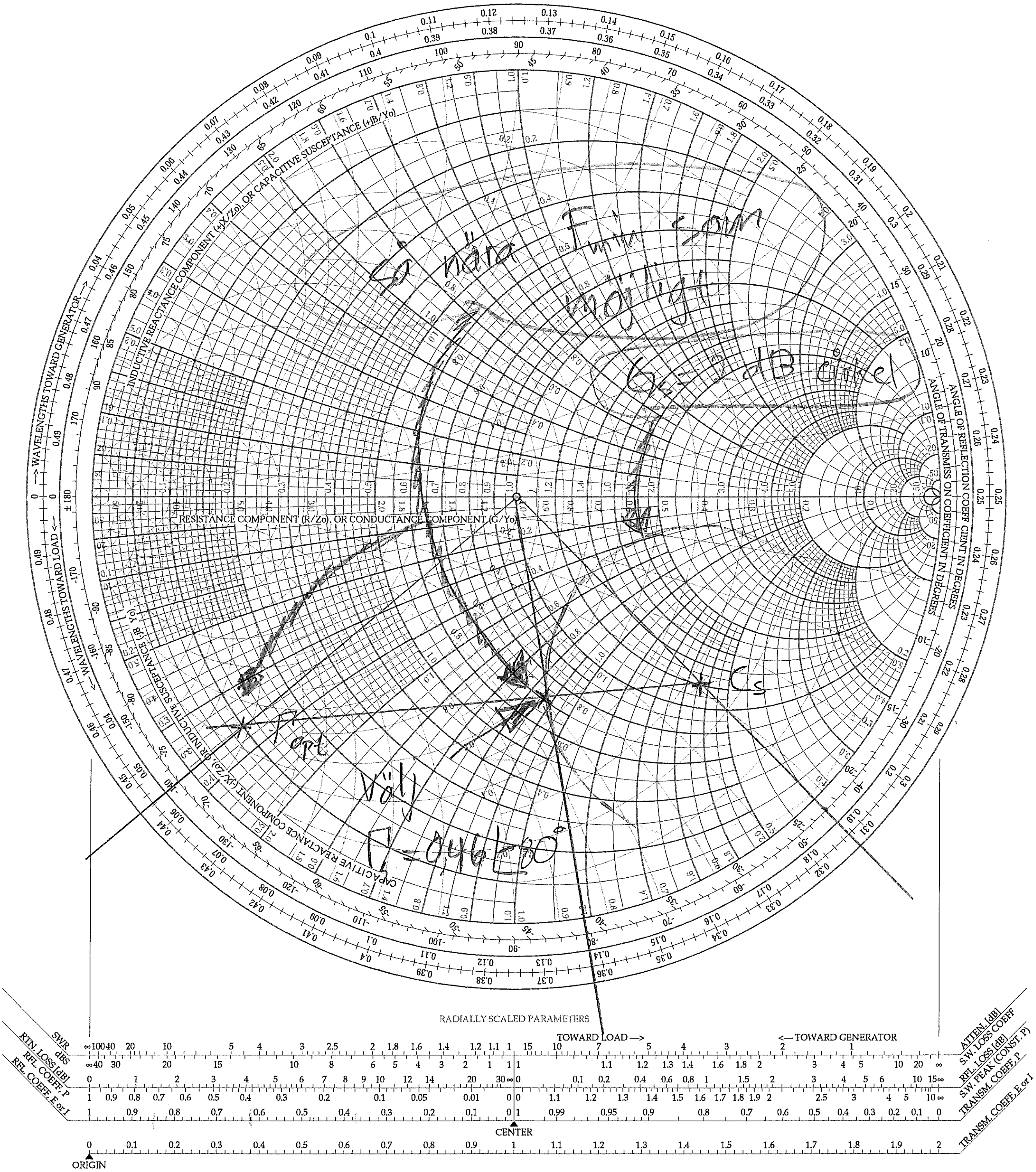
NORMALIZED IMPEDANCE AND ADMITTANCE COORDINATES



$\Gamma_s = 0{,}46\angle -80°$

upg 3 b

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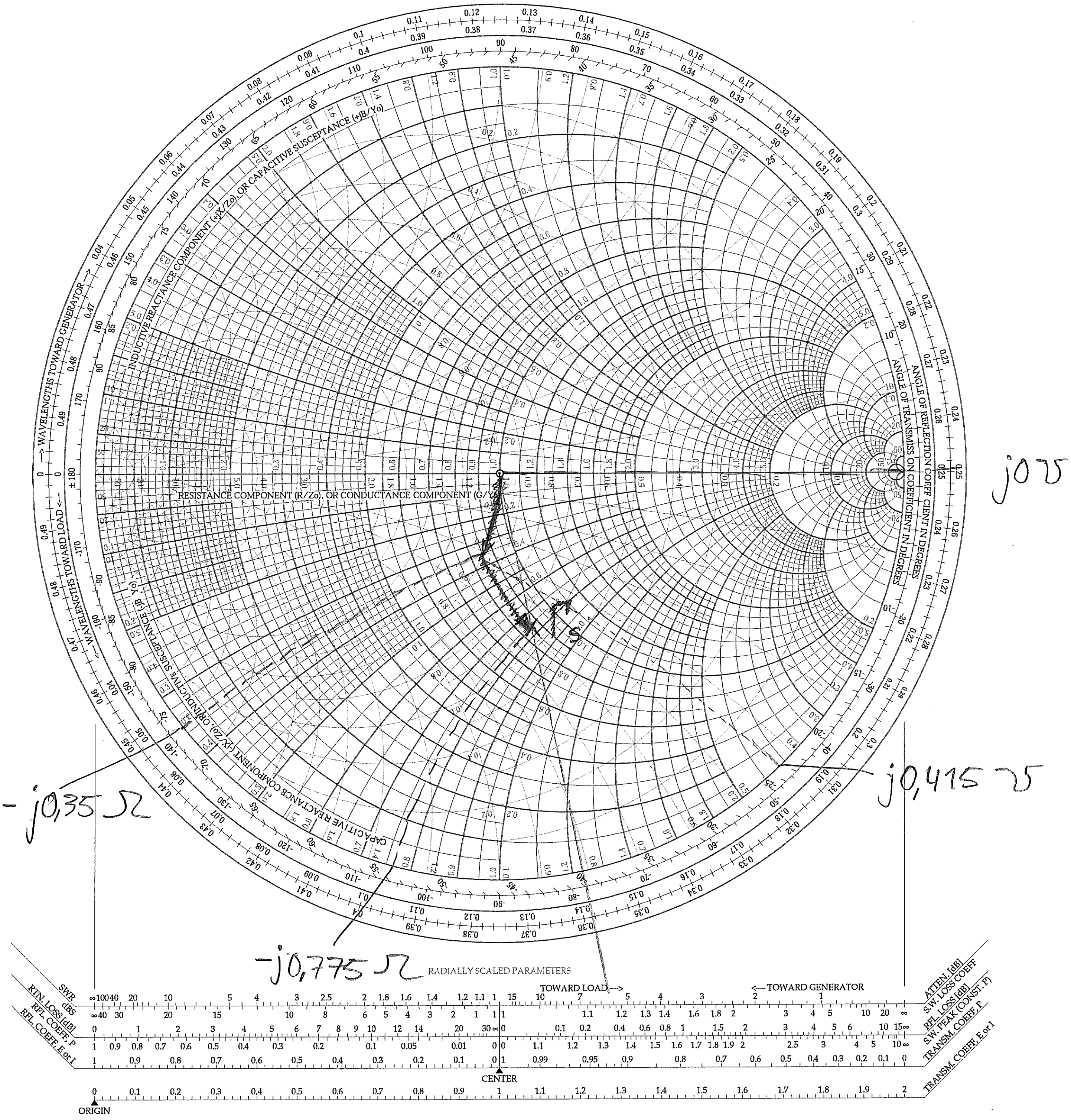
NORMALIZED IMPEDANCE AND ADMITTANCE COORDINATES



$\Gamma_s = 0{,}39\angle -78°$ från facit

4 a) $\bar{Z}_{in} = \frac{Z_{in}}{75} = 2 + j4\ \Omega$ högpass:

$Z_0 \to$ C i serie

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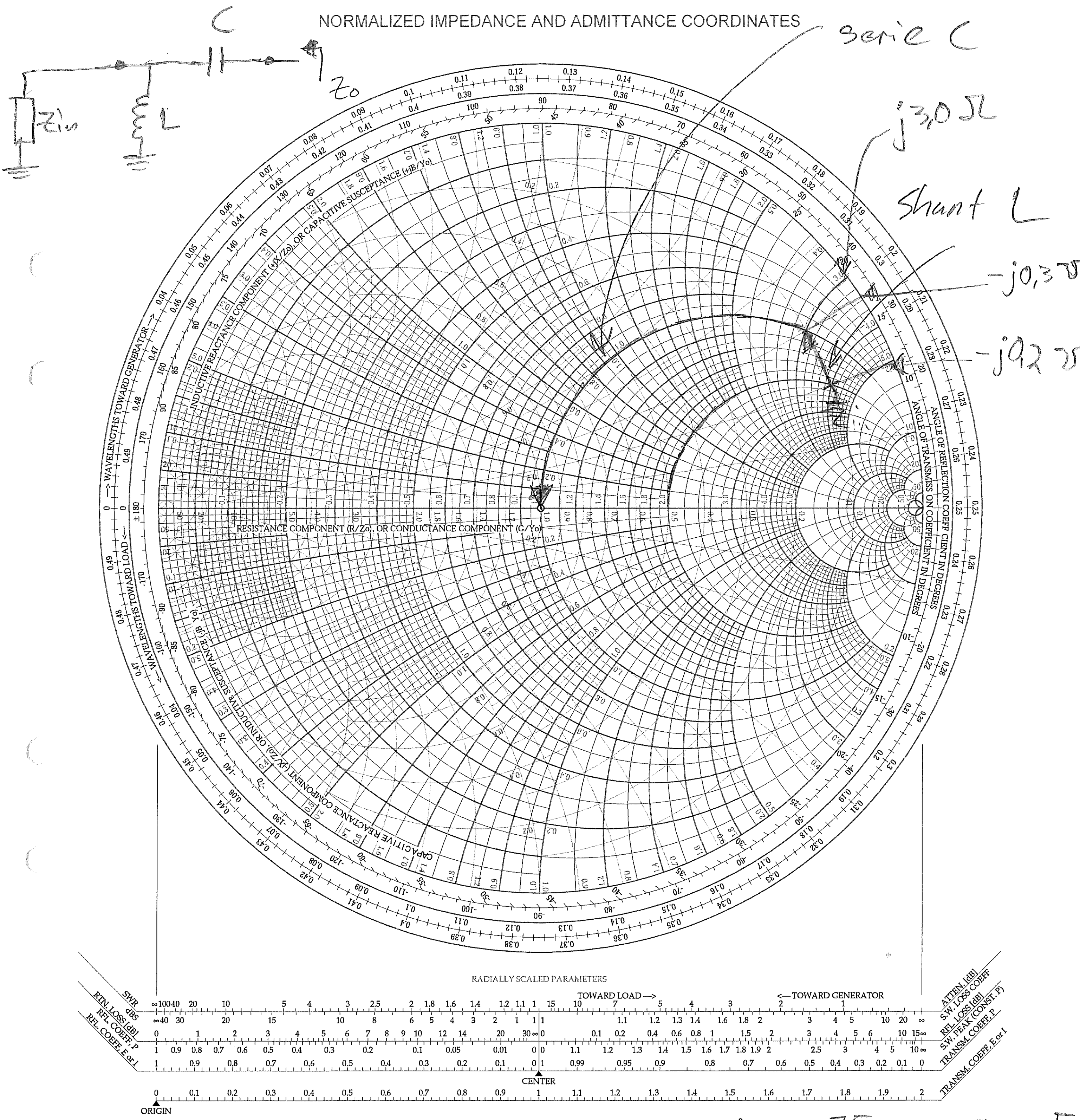
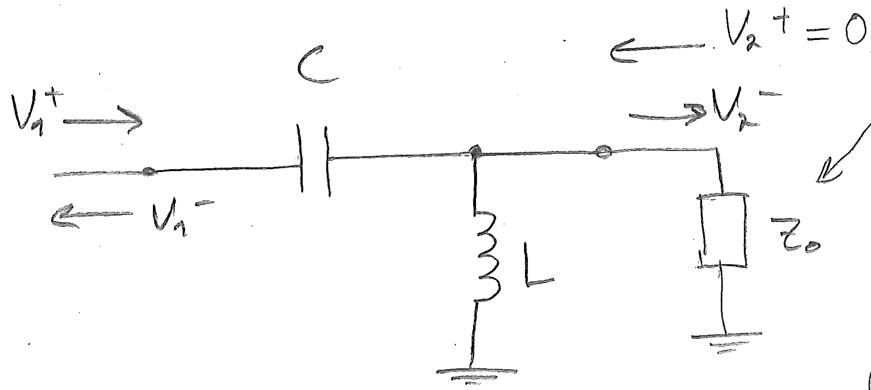


L: $(-j0{,}3 - (-j0{,}2))Y_0 = \cancel{-j}0{,}1 Y_0 = \cancel{-j}\frac{1}{\omega L} \Rightarrow L = \frac{1}{\omega 0{,}1 Y_0} = \frac{75}{2\pi \cdot 100 \cdot 10^6 \cdot 0{,}1} = \underline{\underline{1{,}2\ \mu F}}$

C: $(j0 - j3{,}0)Z_0 = \cancel{-j}3Z_0 = \cancel{-j}\frac{1}{\omega C} \Rightarrow C = \frac{1}{\omega 3 Z_0} = \frac{1}{2\pi \cdot 100 \cdot 10^6 \cdot 3 \cdot 75} = \underline{\underline{7{,}1\ pF}}$

4. b)



matchad
$\Rightarrow$ ingen reflektion

fixar vi genom att sätta Z_0 på utgång

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

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

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

$$S_{21} = \frac{V_2^-}{V_1^+}\bigg|_{V_2^+=0}$$

express V_2^- in V_1^+ $\rightarrow$

$$\left\{ \begin{array}{ll} V_2 = V_2^+ + V_2^- = V_2^- & (1) \\ V_2 = V_1 \dfrac{Z_P}{Z_P + Z_C} \qquad Z_P = \dfrac{Z_0 Z_L}{Z_0 + Z_L} & (2) \\ V_1 = V_1^+ + V_1^- = V_1^+\left(1 + \underbrace{\dfrac{V_1^-}{V_1^+}}_{S_{11}}\right) = V_1^+(1 + S_{11}) & (3) \end{array} \right.$$

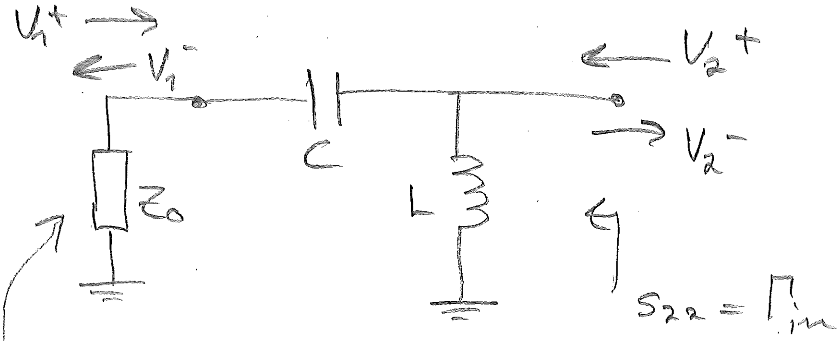
$(1), (3) \rightarrow (2)$

$\Rightarrow$

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

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

S_{12}, S_{22}:



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

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

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

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

express V_1^- in V_2^+:

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

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

$$\Rightarrow \quad V_1^- = \frac{V_2^+(1 + S_{22}) Z_0}{Z_0 + Z_c} \quad \Rightarrow \quad S_{12} = \frac{(1 + S_{22}) Z_0}{Z_0 + Z_c} =$$

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

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

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