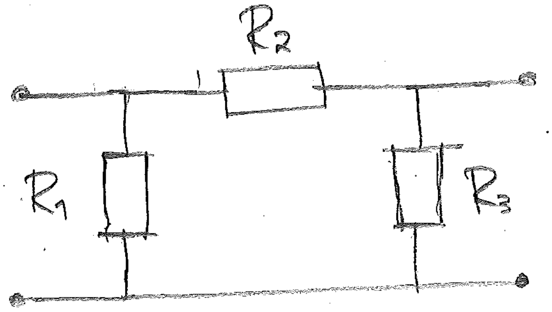
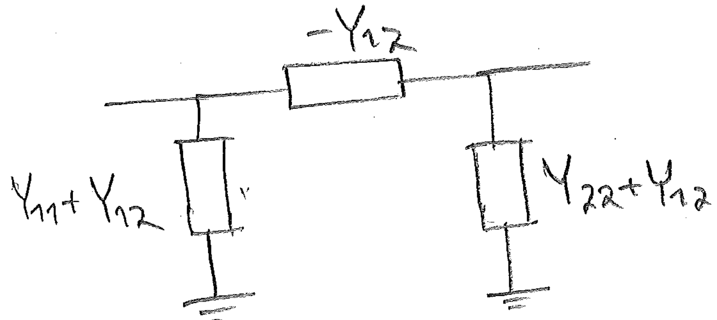
K3

$$Z = \begin{bmatrix} Z_{11} & Z_{12} \\ Z_{21} & Z_{22} \end{bmatrix} = \begin{bmatrix} 250 & 50 \\ 50 & 150 \end{bmatrix}$$



* Ett Π-schema, föreläsning 4 sid 14 (kommer finnas i tesen)

⇒



$$[Y] = [Z]^{-1}$$

* Använd tabell 4,2 (kommer finnas i tesen)
* Vi kan också göra inverteringen

Tabell:

$$Y_{11} = \frac{Z_{22}}{|Z|} \qquad |Z| = Z_{11}Z_{22} - Z_{12}Z_{21} =$$

$$= 250 \cdot 150 - 50^2 = 35000$$

$$= \frac{150}{35000} \qquad Y_{12} = \frac{-Z_{12}}{|Z|} = \frac{50}{35000}$$

$$Y_{21} = \frac{-Z_{21}}{|Z|} = \frac{50}{35000} \qquad Y_{22} = \frac{Z_{11}}{|Z|} = \frac{250}{35000}$$

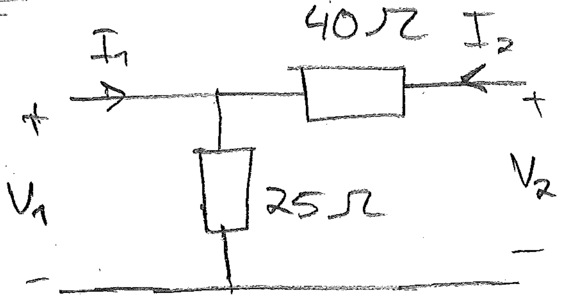
K3 forts

$$Y_{R1} = Y_{11} + Y_{12}, \quad R_1 = \frac{1}{Y_{R1}} = \underline{\underline{350\ \Omega}}$$

$$Y_{R2} = -Y_{12} \quad R_2 = \frac{1}{Y_{R2}} = \underline{\underline{700\ \Omega}}$$

$$Y_{R3} = Y_{22} + Y_{12} \quad R_3 = \frac{1}{Y_{R3}} = \underline{\underline{175\ \Omega}}$$

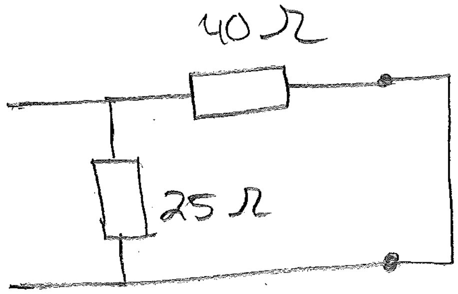
K4



a) $Z_{22} = ?$

$$Z_{22} = \frac{V_2}{I_2}\bigg|_{I_1=0} =$$

$$= 40\ \Omega + 25\ \Omega = \underline{\underline{65\ \Omega}}$$

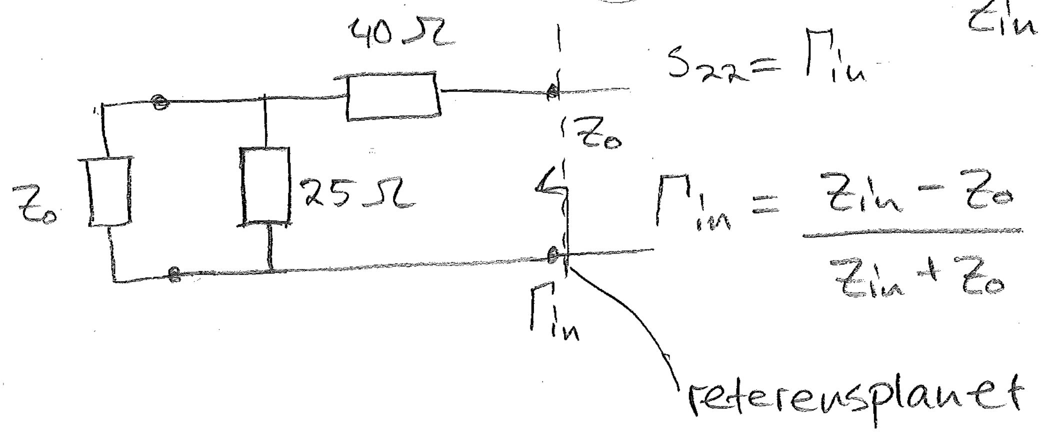


b) $$Y_{11} = \frac{I_1}{V_1}\bigg|_{V_2=0}$$

$$= \frac{1}{25} + \frac{1}{40} = \underline{\underline{0{,}0650\ S}}$$

c) $$S_{22} = ? = \frac{V_2^-}{V_2^+}\bigg|_{V_1^+=0}$$

50Ω terminering på port 1

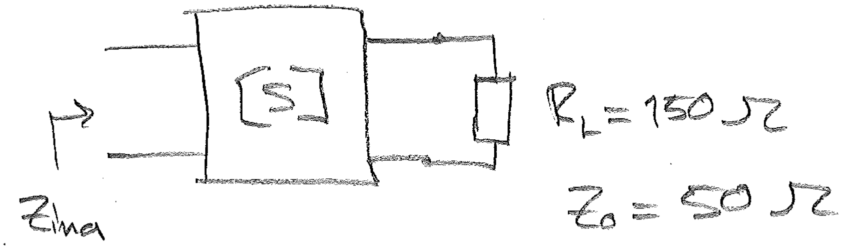


$$S_{22} = \Gamma_{in}$$

$$Z_{in} = \frac{Z_0 \cdot 25}{Z_0 + 25} + 40$$

$$\Gamma_{in} = \frac{Z_{in} - Z_0}{Z_{in} + Z_0} = -0{,}25$$

K8



$Z_0 = 50\,\Omega$

$$S = \begin{bmatrix} 0{,}6 & 0{,}2 \\ 0{,}2 & 0{,}4 \end{bmatrix}$$

\# konvertera [S] till [Z]

Föreläsn. 4 s 14, även handout paper

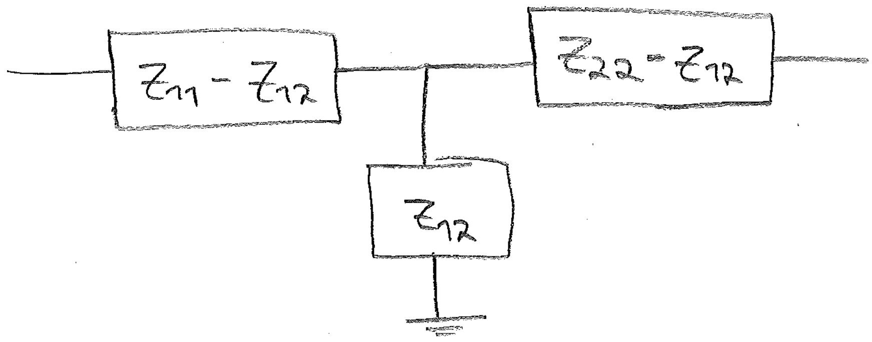


Table 4,2 (bland hjälpmedel pingpong)

$$Z_{11} = Z_0 \frac{(1-S_{11})(1-S_{22})+S_{12}S_{21}}{(1-S_{11})(1-S_{22})-S_{12}S_{21}} = \ldots = 250\,\Omega$$

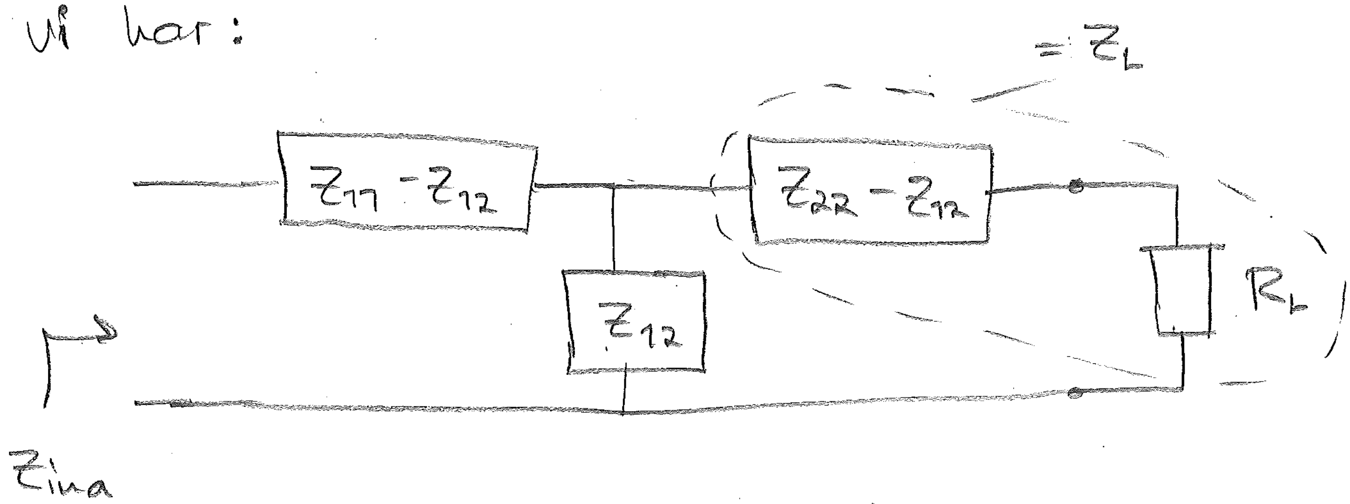
$$Z_{12} = Z_0 \frac{2S_{12}}{(1-S_{11})(1-S_{22})-S_{12}S_{21}} = \ldots = 100\,\Omega$$

$$Z_{21} = Z_0 \frac{2S_{21}}{\text{———}\,''\,\text{———}} = \ldots = 100\,\Omega$$

$$Z_{22} = Z_0 \frac{(1-S_{11})(1+S_{22})+S_{12}S_{21}}{(1-S_{11})(1-S_{22})-S_{12}S_{21}} = \ldots = 150\,\Omega$$

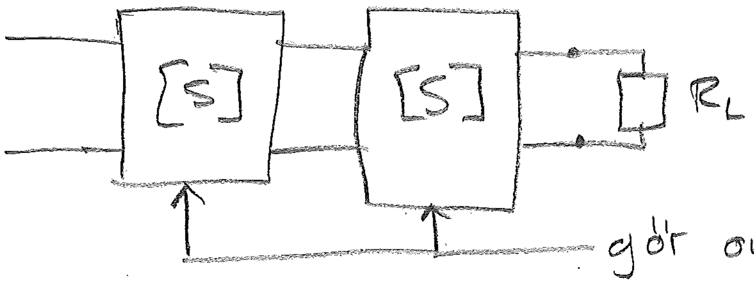
K8 forts

Vi har:



$$Z_{ina} = Z_{11} - Z_{12} + \frac{Z_L Z_{12}}{Z_L + Z_{12}} = \ldots = \underline{\underline{216{,}7\ \Omega}}$$

b)



gör om till ABCD

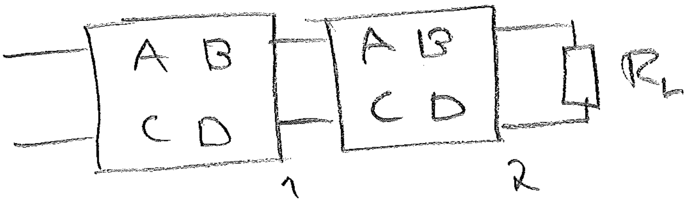
$$A = \frac{(1+S_{11})(1-S_{22}) + S_{12}S_{21}}{2S_{21}} = \ldots = 2{,}5$$

$$B = Z_0 \frac{(1+S_{11})(1+S_{22}) - S_{12}S_{21}}{2S_{21}} = \ldots = 275$$

$$C = \frac{1}{Z_0} \frac{(1-S_{11})(1-S_{22}) - S_{12}S_{21}}{2S_{21}} = \ldots = 0{,}01$$

$$D = \frac{(1-S_{11})(1+S_{22}) + S_{12}S_{21}}{2S_{21}} = \ldots = 1{,}5$$

K8 forts



multiplicera ihop

$$\begin{bmatrix} A_{tot} & B_{tot} \\ C_{tot} & D_{tot} \end{bmatrix}_{tot} = \begin{bmatrix} A & B \\ C & D \end{bmatrix} \begin{bmatrix} A & B \\ C & D \end{bmatrix} = \begin{bmatrix} 9 & 1100 \\ 0{,}04 & 5 \end{bmatrix}$$

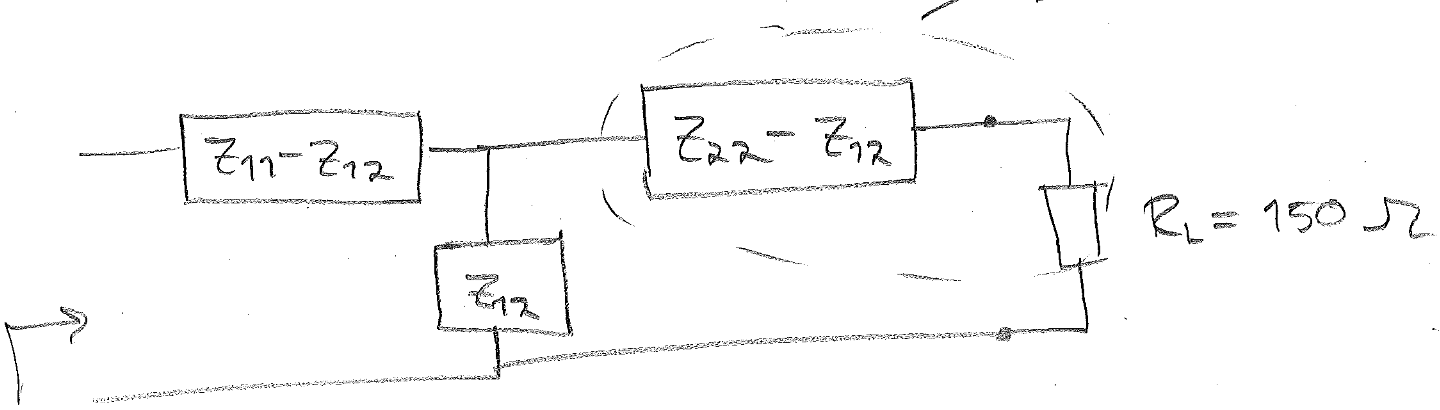
konvertera $[\ \ ]_{ABCD} \longrightarrow [Z]$

$Z_{11} = A/C = 9/0{,}04 = 225$ $\quad Z_{12} = \dfrac{AD - BC}{C} = 25$

$Z_{21} = 1/C = 25$ $\quad Z_{22} = D/C = 125\ \Omega$

och vi får:

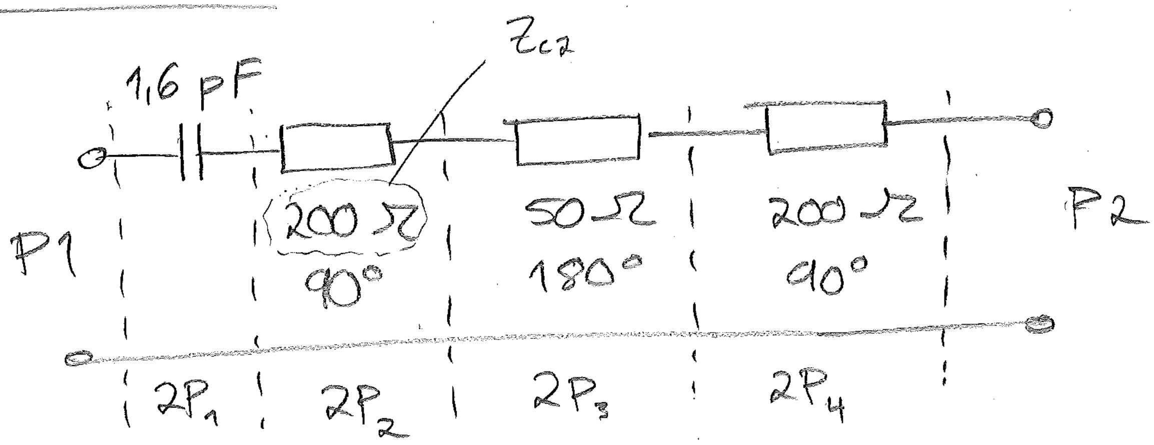
$Z_L = Z_{22} - Z_{12} + R_L$



Zinb

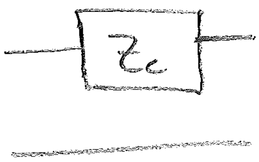
$$Z_{inb} = Z_{11} - Z_{12} + \frac{Z_L Z_{12}}{Z_L + Z_{12}} = \ldots = \underline{\underline{222{,}2\ \Omega}}$$

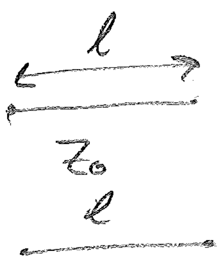
170411 1 b



- Flera 2 portar i kaskadkoppling
- Ta fram ABCD-matris för varje 2-port (används vid kaskadkoppl.)
- Multiplicera ihop alla ABCD-matriser
- översätt totala ABCD-matrisen till S-parametrar

P. table 2.1

$[2P_1]_{ABCD} =$  $= \begin{bmatrix} 1 & Z_c \\ 0 & 1 \end{bmatrix} \quad Z_c = \frac{1}{j\omega C}$

$[2P_2]_{ABCD} =$  $= \begin{bmatrix} \cos\beta l & jZ_0 \sin\beta l \\ jY_0 \sin\beta l & \cos\beta l \end{bmatrix} \quad \begin{matrix} Z_0 = Z_{c2} \\ Y_0 = Y_{c2} \end{matrix}$

$\beta l = \{ l = \frac{\lambda}{4} \} = \frac{2\pi}{\cancel{\lambda}} \cdot \frac{\cancel{\lambda}}{4} = \frac{\pi}{2} \qquad \cos\frac{\pi}{2} = 0 \quad \sin\frac{\pi}{2} = 1$

$\Rightarrow [2P_2]_{ABCD} = \begin{bmatrix} 0 & jZ_{c2} \\ jY_{c2} & 0 \end{bmatrix}$

170411 16 forts

$\left[2P_3\right]_{ABCD}$ = samma som innan men $\frac{\lambda}{2}$ nu $\quad \beta l = \frac{2\pi}{\cancel{\lambda}} \cdot \frac{\cancel{\lambda}}{2} = \pi$

$\cos\pi = -1 \quad \sin\pi = 0$

$$\Rightarrow \left[2P_3\right]_{ABCD} = \begin{bmatrix} -1 & 0 \\ 0 & -1 \end{bmatrix}$$

$$\left[2P_4\right]_{ABCD} = \text{samma som } \left[2P_2\right]_{ABCD} = \begin{bmatrix} 0 & jZ_{c4} \\ jY_{c4} & 0 \end{bmatrix}$$

Nu totala ABCD

$$\left[2P\right]_{ABCD} = \left[2P_1\right]\left[2P_2\right]\left[2P_3\right]\left[2P_4\right] =$$

$$= \begin{bmatrix} 1 & Z_c \\ 0 & 1 \end{bmatrix} \begin{bmatrix} 0 & jZ_{c2} \\ jY_{c2} & 0 \end{bmatrix} \begin{bmatrix} -1 & 0 \\ 0 & -1 \end{bmatrix} \begin{bmatrix} 0 & jZ_{c4} \\ jY_{c4} & 0 \end{bmatrix} =$$

$$= \begin{bmatrix} Y_{c4} Z_{c2} & -jY_{c2}Z_{c4}/(C \cdot \omega) \\ 0 & Y_{c2}Z_{c4} \end{bmatrix} = \begin{array}{cc} A & B \\ \begin{bmatrix} 1 & -j99{,}5 \\ 0 & 1 \end{bmatrix} & \\ C & D \end{array}$$

Använd tabell i föreläsning 4 s 24

(kommer finnas i tentatesen)

170411 1b forts

$$S_{11} = \frac{A + B/Z_0 - CZ_0 - D}{A + \frac{B}{Z_0} + CZ_0 + D} = \frac{1 - j100/50 - 0 \cdot 50 - 1}{1 - j100/50 + 0 \cdot 50 + 1} = \underline{\underline{0{,}705 \angle -45{,}2^\circ}}$$

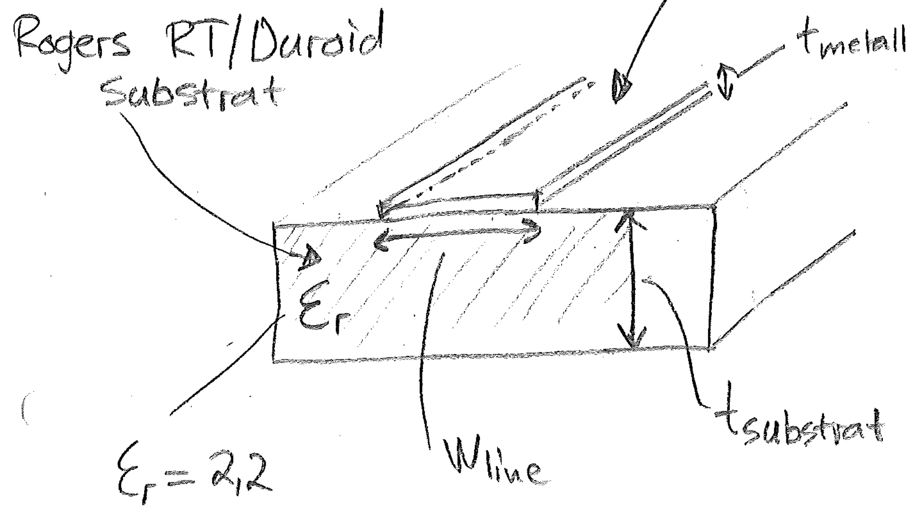
$$S_{12} = \frac{2(AD - BC)}{A + B/Z_0 + CZ_0 + D} = \ldots = \underline{\underline{0{,}709 \angle 44{,}8^\circ}}$$

$$S_{21} = \frac{2}{A + B/Z_0 + CZ_0 + D} = \ldots = \underline{\underline{0{,}709 \angle 44{,}8^\circ}}$$

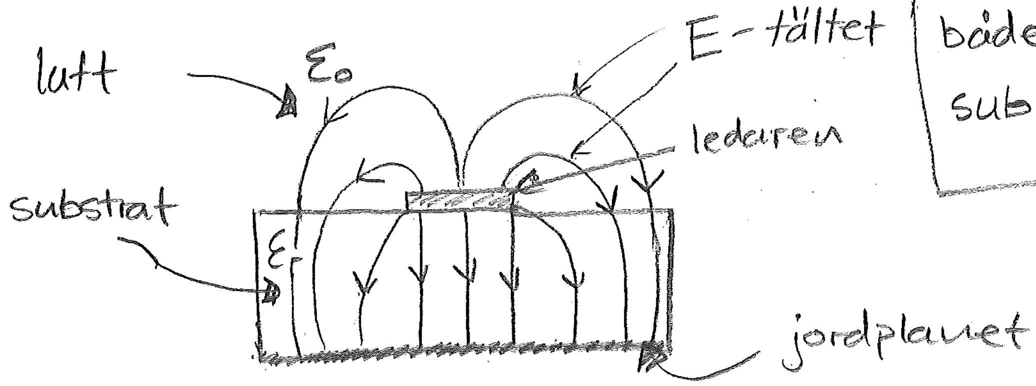
$$S_{22} = \frac{-A + B/Z_0 - CZ_0 + D}{A + B/Z_0 + CZ_0 + D} = \ldots = \underline{\underline{0{,}705 \angle -45{,}2^\circ}}$$

Tenta 170411, 2

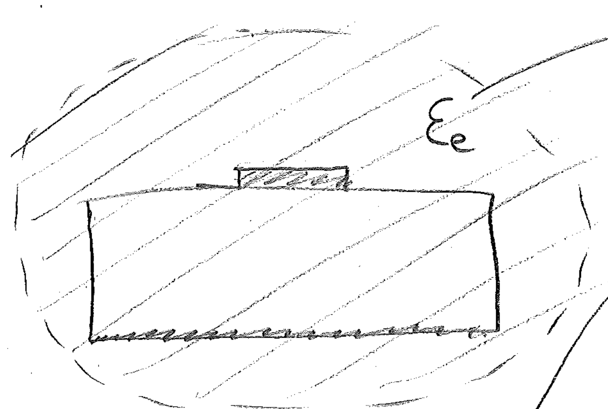
Microstrip line



Fältet (vågorna) utbreder sig i både luften och i substratet



Vi får en viktning mellan ε_0 och ε_r.
den effektiva permittiviteten blir ε_e



Effektiva permittiviteten

våglängden i ε_e ?

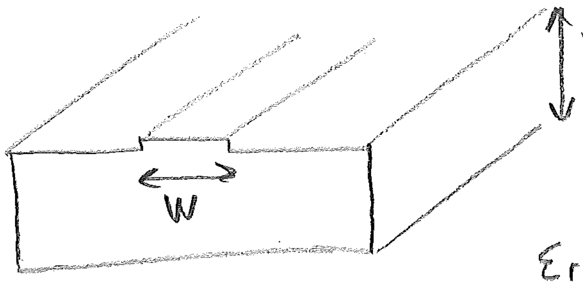
→ $\lambda_{quasi,TEM}$

kallas kvasi TEM våglängden och det är den vi hittar i våra diagram

λ — våglängden i ε_e

λ_{TEM} — våglängden i substratet ε_r

Tenta 170411, 2 forts



$h = t_{sub} = 0{,}5$ mm

$\varepsilon_r = 2{,}2$

$l_{bias} = 18{,}6$ mm, $l_s = 2{,}8$ mm, $l_\ell = 10$ mm

$d_s = 24{,}5$ mm $\qquad d_\ell = 6{,}1$ mm

$W_{bias} = 0{,}8$ mm $\qquad W_{lines} = 1{,}6$ mm $\qquad C = 100$ pF

a) $Z_{0,line} = ?$ $\quad Z_{0,bias} = ?$ $\quad$ * använd diagram

bias

$$\frac{W}{h} = \frac{0{,}8}{0{,}5} = 1{,}6 \Rightarrow Z_0 = 70\ \Omega$$

75 } facit

Lines

50

$$\frac{W}{h} = \frac{1{,}6}{0{,}5} = 3{,}2 \Rightarrow Z_0 = 45\ \Omega$$

läs av från diagram

b) kvasi tem

$$\frac{\lambda}{\lambda_{TEM}} = \frac{\lambda\sqrt{\varepsilon_r}}{\lambda_0} = 1{,}075 \quad (1)$$

vanlig TEM
i homogent material

biasledningen

$$\frac{\lambda}{4} = 18{,}6 \text{ mm} \Rightarrow \lambda = 74{,}4 \text{ mm}$$

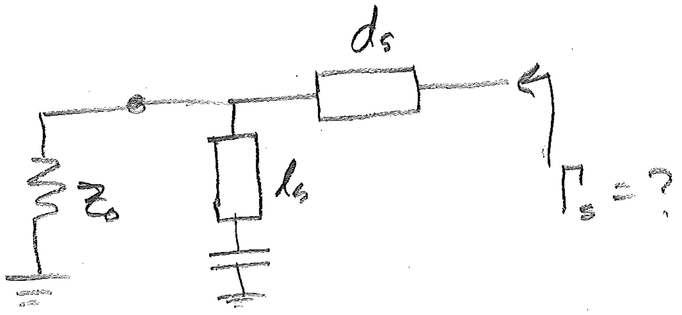
$$(1) \Rightarrow \lambda_0 = \frac{74{,}4\sqrt{\varepsilon_r}}{1{,}075} \text{ mm} = 102{,}65 \text{ mm} \qquad \lambda_0 = \frac{c_0}{f_0}$$

$$\Rightarrow f_0 = \frac{3 \cdot 10^8}{102{,}65 \cdot 10^{-3}} = 2{,}92 \text{ GHz} \quad (3 \text{ GHz facit})$$

Tenta 170417 forts.

$\lambda = 74{,}4$ mm

c)



$d_s = 24{,}5$ mm

$\frac{24{,}5}{74{,}4} = 0{,}33$

$\Rightarrow d_s = 0{,}33\,\lambda$

$\frac{l_s}{\lambda} = \frac{2{,}8}{74{,}4} = 0{,}04 \Rightarrow l_s = 0{,}04\,\lambda$ (0,038 λ facit)

helt ok

S.D $\Rightarrow$ $\Gamma_s = 0{,}9\angle -94°$

$l_l = 0{,}134\,\lambda$

$d_l = 0{,}082\,\lambda$

S.D $\Rightarrow$ $\Gamma_L = 0{,}5\angle -180°$

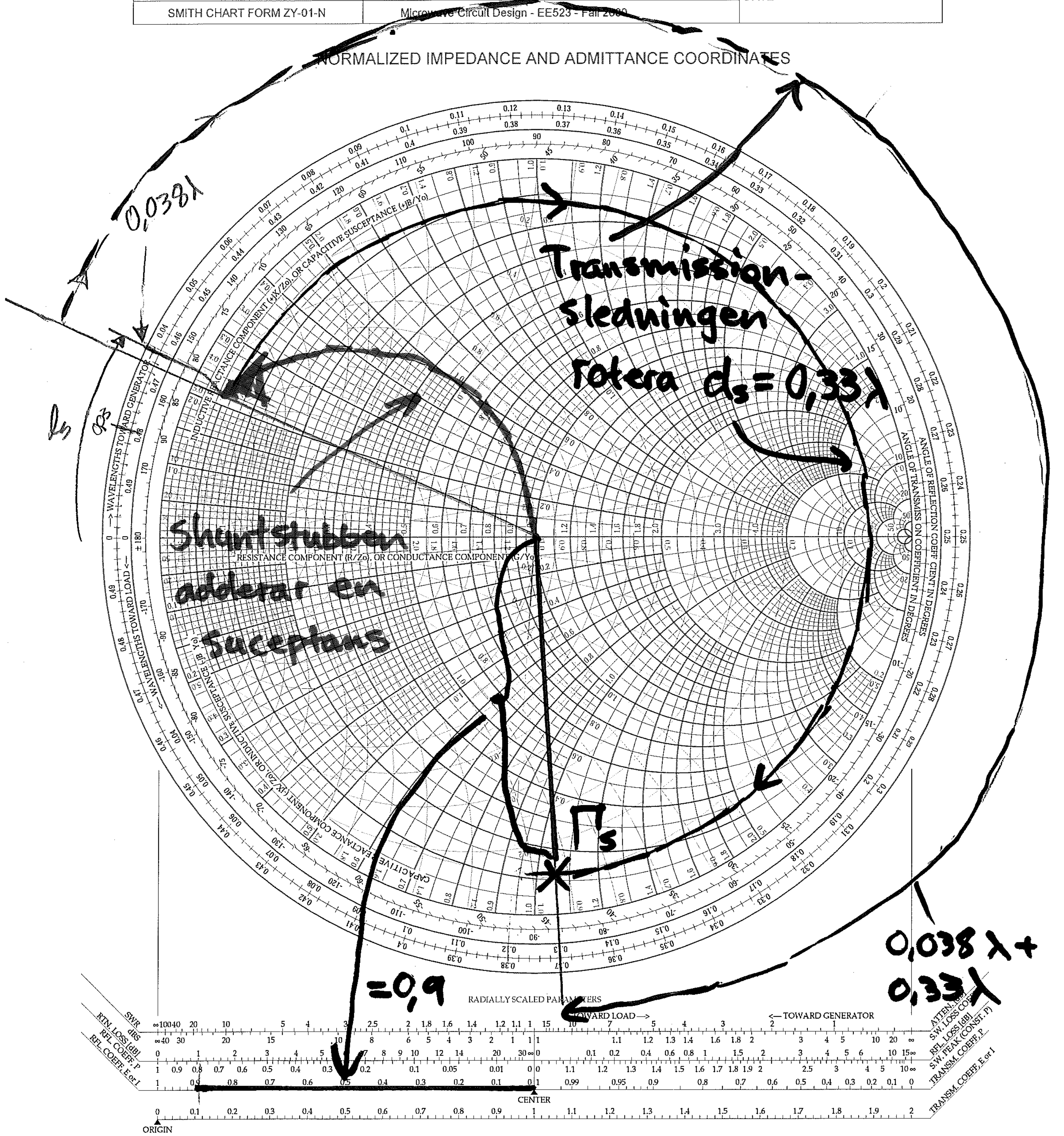
samma för Γ_L ....

se även lösn i facit

Tenta 170411 2c

Γ_s

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



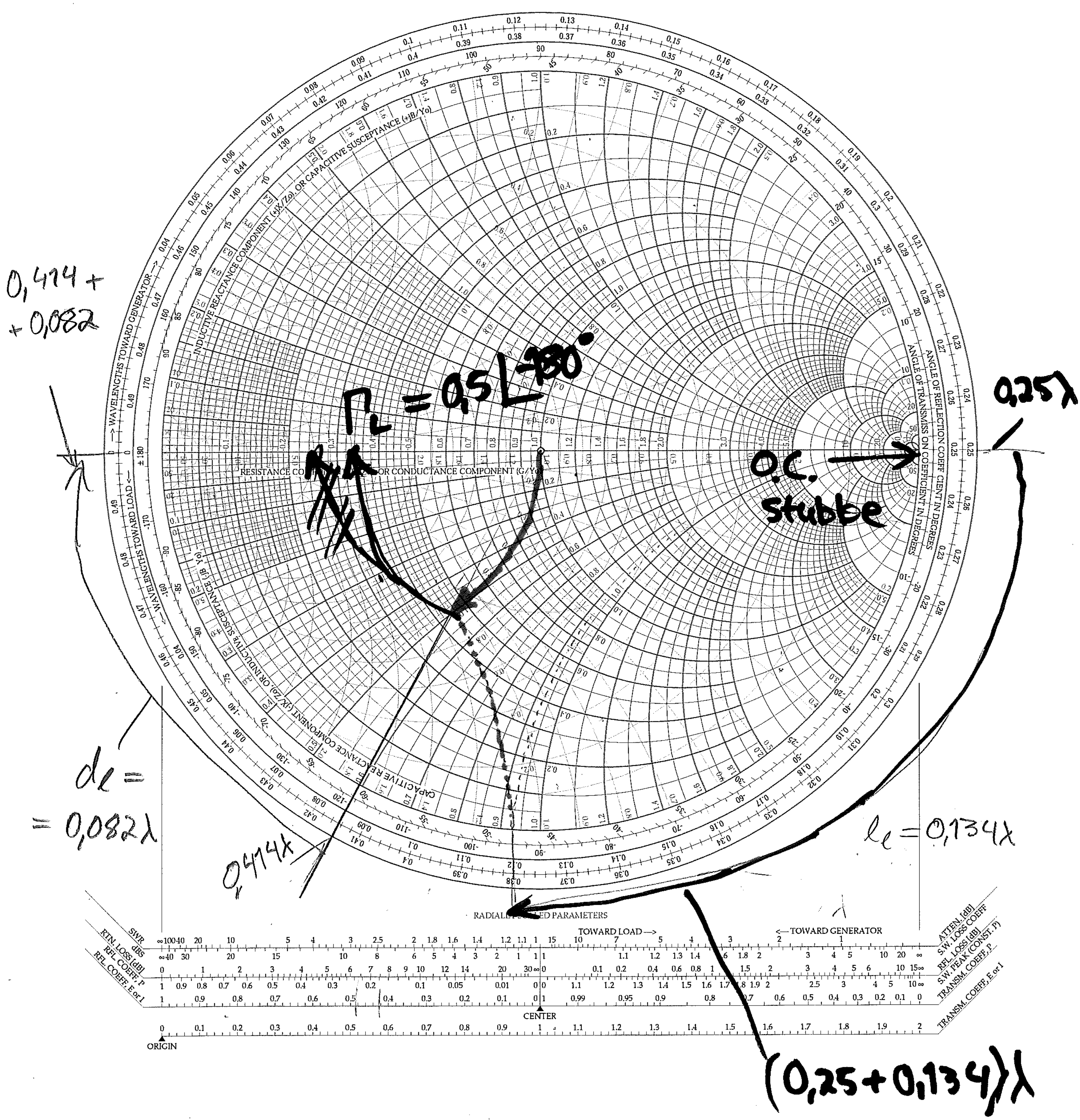
$\Gamma_s = 0{,}9\angle -87^\circ$

Tenta 170417 2c

Γ_L

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

NORMALIZED IMPEDANCE AND ADMITTANCE COORDINATES



$\Gamma_L = 0,5 \angle -180°$