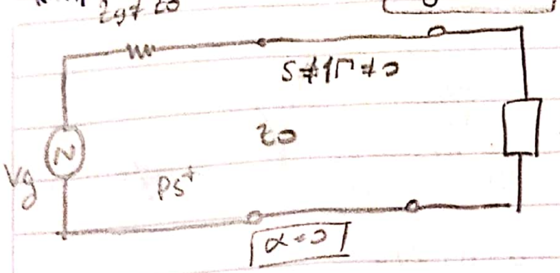
Empedans Uydurma — 9. Hafta – Mikrodalga Tekniği

(Impedance matching)

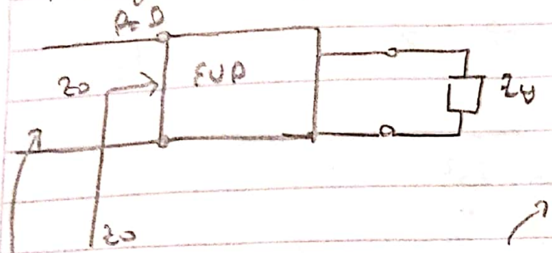
$\boxed{P_y^+ = P_s^+}$



$$P_y = P_y^+ (1 - |\Gamma_y|^2) = P_y^+ - P_y^-$$

$$P = P^+ - \cancel{P^-} \; 0$$

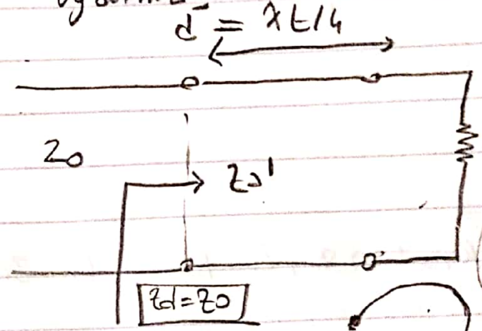
Gelen gücün tamamıyla yüke aktarılması için; ⊜ Çeyrek-dalga ($\lambda/4$) hatlı empedans uydurma:



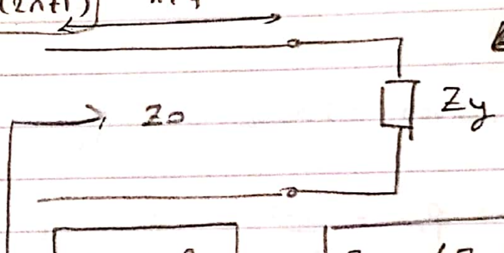
$(S = 1, \; \Gamma = 0)$

$$Z_y = R_y + j X_y$$

R_y: direnç, X_y: imaj; $X_y \to 0$ → omik



$Z_d = Z_o$ olması için Z_o' ne olmalı?



$\lambda t = ft$ – tasarım frekansındaki dalga boyu

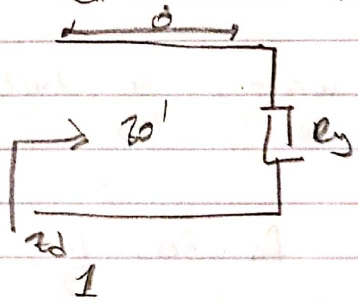
$$\boxed{Z_d = \frac{Z_o^2}{Z_y}} \qquad \boxed{Z_d = \frac{(Z_o')^2}{R_y} = Z_o}$$

$$\boxed{Z_o' = \sqrt{Z_o R_y}}$$

$f \neq ft$ frekansında;

$$\boxed{Z_d = Z_o' \, \frac{R_y + j Z_o' t}{Z_o' + j R_y t}}$$

$(t = \tan \beta d)$



$$\Gamma_d = \frac{Z_d - Z_o}{Z_d + Z_o} = \frac{R_y - Z_o}{R_y + Z_o + j 2t\sqrt{Z_o R_y}}$$

$$|\Gamma_d| = \rho = \frac{|R_y - Z_o|}{\sqrt{(R_y + Z_o)^2 + 4t^2 Z_o R_y}} \quad (ro)$$

$$\rho = \frac{1}{\sqrt{1 + \left(\frac{2\sqrt{R_y Z_o}}{R_y - Z_o} \sec\theta\right)^2}}, \quad \theta = \beta d$$

istenen S_m değerine karşılık gelen $\rho_m = \dfrac{S_m - 1}{S_m + 1}$

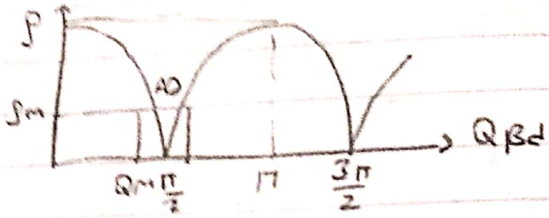
Vize-final A

seçilen (veya istenilen) ρ_m için $\theta = \theta_m$ dır,

$$\theta_m = \cos^{-1} \left| \frac{2 \rho_m \sqrt{Z_o R_y}}{|R_y - Z_o| \sqrt{1 - \rho_m^2}} \right|$$

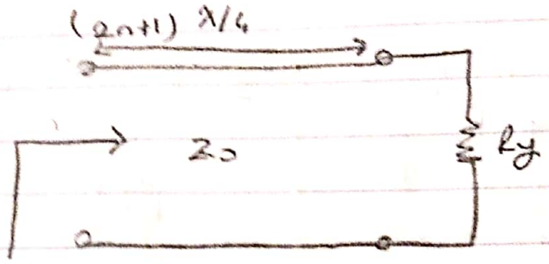
Amanogawa.com   Impedance matching

$f=f_t$'de $Q=\beta d=\frac{2\pi}{\lambda_t}\cdot\frac{\lambda_t}{4}=\frac{\pi}{2}$ olur.



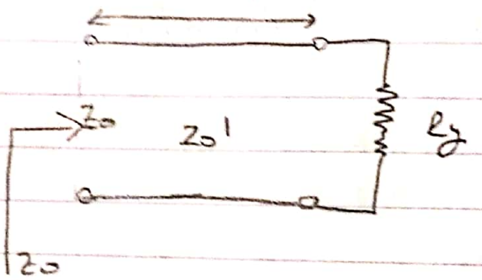
$\Delta f = 2(f_t - f_m) = 2\left(f_t - \frac{2f_t}{\pi}Q_m\right)$

$\frac{\Delta f}{f_t} = 2 - \frac{4}{\pi}Q_m$; $Q_m < \frac{\pi}{2} < \pi$ için



$Z_d = \frac{Z_0^2}{R_y}$

Örnek: $R_y = 400\Omega$, $Z_0 = 100\Omega$, $f_t = 300MHz$ $\lambda/4 = 25cm$



$\lambda_t = \frac{3\cdot10^8}{3\cdot10^8} = 1m \rightarrow \ell = \frac{\lambda_t}{4} = 25cm$

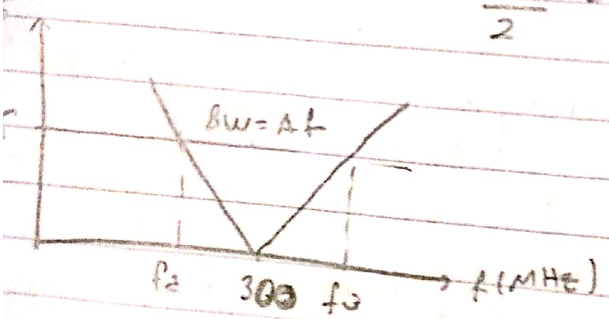
$Z_0' = \sqrt{Z_0 R_y} = \sqrt{100\cdot400} = 200\Omega$

$S \le 1,5$ olsun, $\rightarrow \rho_m = \frac{S-1}{S+1} = \frac{0,5}{S+1} = \frac{0,5}{2,5} = \boxed{0,2}$

$Q_m = \cos^{-1}\left|\frac{2\cdot(0,2)\cdot200}{300\cdot\sqrt{1-0,04}}\right| = \cos^{-1}\left|\frac{80}{288}\right| = \cos^{-1}|0,2777| \cong 74,21°$

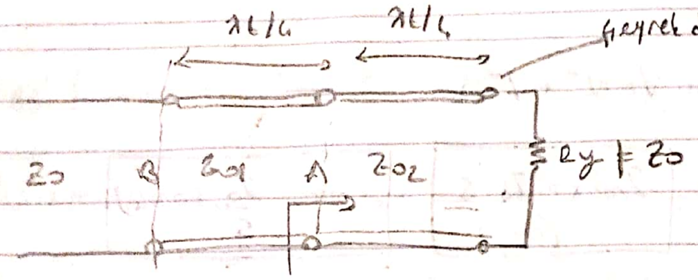
$\frac{\Delta f}{f_t} = 2 - \frac{4}{\pi}Q_m = 2 - \frac{4}{180}(74,21) = 0,35$ $\Delta f = \%35 f_t$

$\Delta f = 105 MHz$ $f_a = 300 - \frac{105}{2} = 247,5 MHz$ $f_ü = 352,5 MHz$



f_a (247,5 MHz) f_t (300 MHz) $f_ü$ (352,5 MHz) uzantılar applet

CheerpJ Applet Runner



{Cuerdos Animasyon}

$$\boxed{Z_A = \frac{Z_{02}^2}{R_y}}, \quad \boxed{Z_B = \frac{Z_{01}^2}{Z_A} = \frac{Z_{01}^2}{Z_{02}^2} R_y = \left(\frac{Z_{01}}{Z_{0}}\right)^2 \cdot R_y}$$

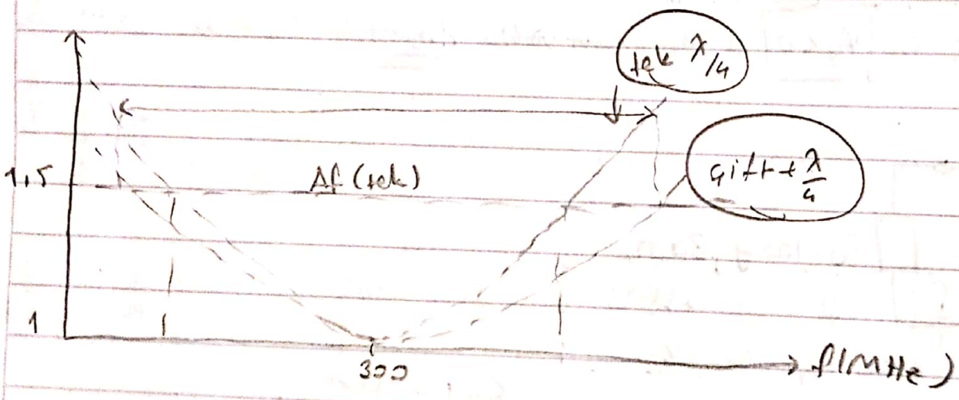
$Z_0 = 100\,\Omega$, $R_y = 400\,\Omega$ olsun

$Z_A = \sqrt{R_y Z_0}$: Geometrik ortalamadan

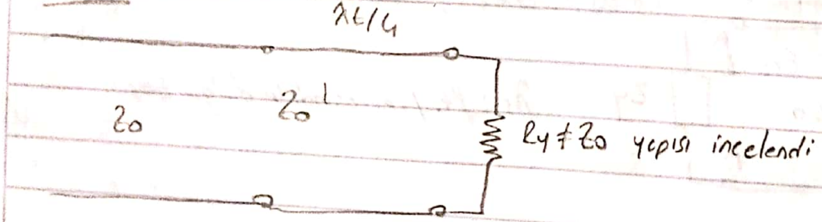
$Z_A = \sqrt{400 \cdot 100} = 200\,\Omega$

$Z_{02} = \sqrt{Z_A \cdot R_y} = \sqrt{200 \cdot 400} \cong 283\,\Omega$

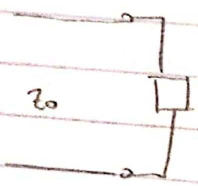
$Z_{01} = \sqrt{Z_A \cdot Z_0} = \sqrt{200 \cdot 100} \cong 141\,\Omega$



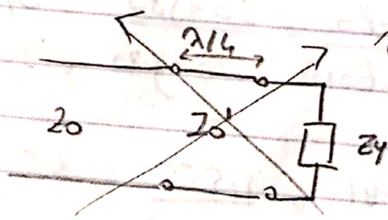
10. Hafta



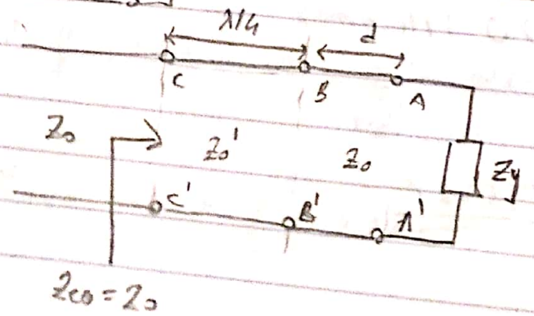
$Z_0' = \sqrt{Z_0 R_y}$



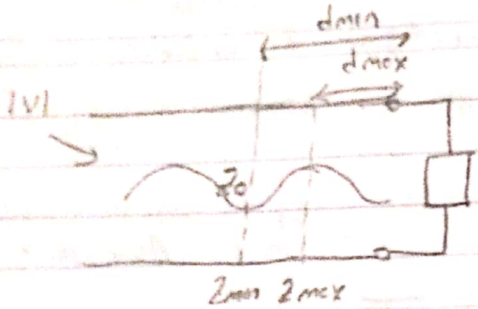
$Z_y = R_y + jX_y$ → Endüktif, → Kapasitif } olabilir



Z_y'yi, R_y yapamadığımız için bu şekilde kullanamayız



Bu empedans uydurma devresinde $Z_{BB'}$ pozitif reel (omik) olmalı.



$V = V^+ + V^-$

$\boxed{Z_{max} = Z_0 . S \text{ (omik)}}$ $\boxed{Z_{min} = \frac{Z_0}{S} \text{ (omik)}}$

Demek ki $d = (d_{max}, d_{min})$

$d = d_{max}$ alırsak $\boxed{Z_{BB}' = Z_{max} = Z_0 S}$

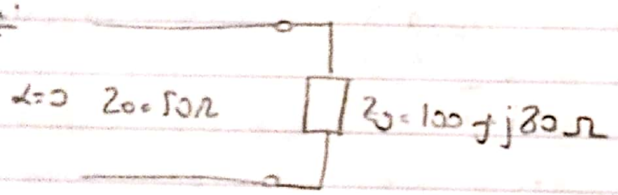
$\boxed{Z_0' = \sqrt{Z_0 Z_{BB}'} = \sqrt{Z_0 S} = Z_0 \sqrt{S}}$

$d = d_{min}$ alırsak $\boxed{Z_{BB}' = Z_{min} = \frac{Z_0}{S} \rightarrow Z_0' = \sqrt{Z_0 \frac{Z_0}{S}} = Z_0 / \sqrt{S}}$

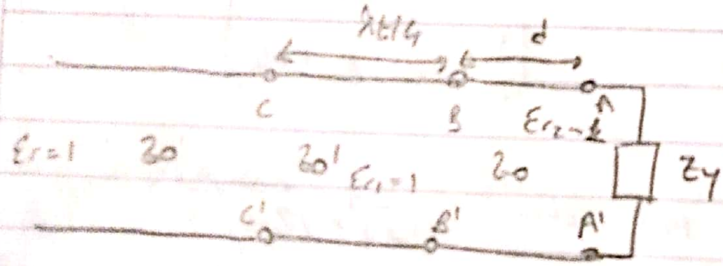
$\boxed{Z_y = R_y + jX_y}$ endüktif ise $\boxed{\varphi_y > 0}$ ilk ekstremum nokta d_{max1}

$\boxed{Z_y = R_y + jX_y}$ kapasitif ise $\boxed{\varphi_y < 0}$ ilk ekstremum nokta d_{min1}

Örnek:



$\frac{\lambda}{4}$ hat kullanarak Z_y hatta uyumlanacak



$\varepsilon_r = 1 \rightarrow$ Hava

$d = ?$, $Z_0' = ?$

λt: f_t frekansındaki dalga boyu

$\Gamma_y = \frac{Z_y - Z_0}{Z_y + Z_0} = \frac{50 + j80}{150 + j80} = 0{,}481 + j\,0{,}277 \cong 0{,}555 \angle 30°$

$S = \frac{1 + |\Gamma_y|}{1 - |\Gamma_y|} = \frac{1{,}555}{0{,}455} \cong 3{,}5$, $\varphi_\Gamma = 30° > 0$ ilk d_{max}

1. çözüm: $d = d_{max} = \frac{\varphi}{4\pi} \lambda = \frac{30°}{720°} \lambda \cong \underline{0{,}042 \lambda}$

$Z_{BB'} \Big| _{d=d_{max}} = Z_0 . S = 50(3,5) = \underline{\underline{175\,\Omega}} \rightarrow Z_0' = Z_0\sqrt{S} = 93,5\,\Omega$

2. çözüm : $d = d_{min} = d_{max} + \frac{\lambda}{4} = 0,292\,\lambda$

$Z_{BB'} \Big| _{d=d_{min}} = \frac{Z_0}{S} = \frac{50}{3,5} \cong 14,3\,\Omega \rightarrow Z_0' = \frac{Z_0}{\sqrt{S}} = 26,7\,\Omega$

$\lambda_t = \frac{30}{1} = 30\,cm$

1. çözüm için : $d = 0,042 = 0,042(30) = 1,26\,cm$
2. çözüm için : $d = 0,292\,\lambda = 0,292\,(30) = 8,76\,cm$

$\lambda/4$ hattın uzunluğu $\ell = 7,5\,cm$

Örnek : $h = 0,127\,cm$, $\varepsilon_r = 2,2$, $Z_0 = 50\,\Omega$, mikroşerit hat genişliği ve 2,5 GHz $90°$ Faz kaydır $\ell = ?$

$Z_0 = 50\,\Omega$ $\quad w/h > 2$ alalım.

$$B = \frac{377\pi}{2Z_0\sqrt{\varepsilon_r}} = \frac{377\pi}{2.50\sqrt{2,2}} = 7,985$$

$$\frac{w}{h} = \frac{2}{\pi}\left[B - 1 - \ln(2B-1) + \frac{\varepsilon_r - 1}{2\varepsilon_r}\left(\ln(B-1) + 0,39 - \frac{0,61}{\varepsilon_r}\right)\right], \quad \frac{w}{h} > 2$$

$$\frac{w}{h} = \frac{2}{\pi}\left[7,985 - 1 - 2,706 + 0,2727\,(2,0565)\right] = \frac{2}{\pi}\left[4,279 + 0,560\right] =$$

$$\frac{w}{h} = \frac{9,678}{3,14} = 3,081 \qquad \frac{w}{h} = 3,081 > 2 \qquad W = 3,081.(0,127) = 0,391\,cm$$

$$\varepsilon_e = \frac{1}{2}\left[(\varepsilon_r + 1) + (\varepsilon_r - 1)\frac{1}{\sqrt{1 + 12(w/h)}}\right] = \frac{1}{2}\left[3,2 + 1,2\left(\frac{1}{2,2124}\right)\right] = 1,87$$

$$B\ell = \frac{\pi}{2} \qquad \ell = \frac{\lambda}{4} \qquad \lambda = \frac{\lambda_0}{\sqrt{\varepsilon_e}} = \frac{30/2,5}{\sqrt{1,87}} = 8,775\,cm$$

$90°$ kaydır $\rightarrow \ell = \frac{\lambda}{4} \simeq 2,2\,cm$