LISTA 2

1) $\rho(\ell) = \dfrac{0 - Z_0}{0 + Z_0} = -1$ $\qquad Z_0 Y_{in} = \dfrac{1 - \rho(0)}{1 + \rho(0)} = j0,5 = \dfrac{1 + e^{-j4\pi\ell}}{1 - e^{-j4\pi\ell}}$

$\rho(0) = -e^{-j2\beta\ell}$ $\qquad\qquad \ell = \dfrac{2\pi n - j \ln\left(-\frac{3}{5} - 4\frac{j}{5}\right)}{4\pi}$, $n \in \mathbb{Z}$

$\ell \approx 0,0795775 \, (6,28319(n+1) - 0,2143) \approx \left(0,3238 + \dfrac{n}{2}\right) m$, $n \in \mathbb{Z}$

2) $V_1 = V_2^+ e^{\gamma L} + V_2^- e^{-\gamma L}$

$I_1 = \dfrac{1}{Z_0}\left[V_2^+ e^{\gamma L} - V_2^- e^{-\gamma L}\right]$

$\begin{bmatrix} V_2 \\ I_2 \end{bmatrix} = \begin{bmatrix} 1 & 1 \\ 1/Z_0 & -1/Z_0 \end{bmatrix}\begin{bmatrix} V_2^+ \\ V_2^- \end{bmatrix} \Leftrightarrow \begin{bmatrix} V_2^+ \\ V_2^- \end{bmatrix} = \begin{bmatrix} 1/2 & Z_0/2 \\ 1/2 & -Z_0/2 \end{bmatrix}\begin{bmatrix} V_2 \\ I_2 \end{bmatrix}$

$V_1 = e^{\gamma L}\left(\frac{V_2}{2} + \frac{Z_0 I_2}{2}\right) + e^{-\gamma L}\left(\frac{V_2}{2} - \frac{Z_0 I_2}{2}\right)$

$I_1 = e^{\gamma L}\left(\frac{V_2}{2Z_0} + \frac{I_2}{2}\right) + e^{-\gamma L}\left(\frac{I_2}{2} - \frac{V_2}{2Z_0}\right)$

$\begin{bmatrix} V_1 \\ I_1 \end{bmatrix} = \dfrac{1}{2}\begin{bmatrix} e^{\gamma L} + e^{-\gamma L} & Z_0(e^{\gamma L} - e^{-\gamma L}) \\ \frac{1}{Z_0}(e^{\gamma L} - e^{-\gamma L}) & e^{\gamma L} + e^{-\gamma L} \end{bmatrix}\begin{bmatrix} V_2 \\ I_2 \end{bmatrix} = \begin{bmatrix} \cosh(\gamma L) & Z_0\sinh(\gamma L) \\ \frac{\sinh(\gamma L)}{Z_0} & \cosh(\gamma L) \end{bmatrix} \times \begin{bmatrix} V_2 \\ I_2 \end{bmatrix}$

3) a) $z_e = \dfrac{225}{75} = 3$ $\qquad \rho(\ell) = 0,5$ $\qquad COE = 3$

b) $z_e = 1$ $\qquad\qquad \rho(\ell) = 0$ $\qquad COE = 1$

c) $z_e = 0,2$ $\qquad\qquad \rho(\ell) = -0,65$ $\qquad COE = 5$

d) $z_e = j0,6$ $\qquad\qquad |\rho(\ell)| = 1$ $\qquad COE = \infty$

e) $z_e = j3$ $\qquad\qquad |\rho(\ell)| = 1$ $\qquad COE = \infty$

f) $z_e = 0,6 + j1,6$ $\qquad |\rho(\ell)| = 0,71$ $\qquad COE = 6$

4) $z_e = 1 + j1$ $\qquad |\rho(\ell)| = 0,45$ $\qquad COE = 2,6$

a) $z_0 = 2 - j1$ $\qquad Z_0 = 150 - j75 \, \Omega$

4) b) $z_0 = 0.5 - j0.5$ $Z_0 = 37.5 - j37.5 \ \Omega$

c) $z_0 = 0.6 + j \, 0.65$ $Z_0 = 45 + j48.75 \ \Omega$

d) $z_0 = 1 + j1$ $Z_0 = 75 + j45 \ \Omega$

e) idem acima

f) $L = \frac{\lambda}{4}(n+1) - 0.162\lambda = 0.088\lambda + \frac{\lambda}{4}n, \ n \in \mathbb{Z}$

5) a) $\rho_\ell = \dfrac{50 + j162.5 - 125}{50 + j162.5 + 125} = 0.2329 + j0.7123 = 0.7494 \ \angle 71.9°$

b) $COE = \dfrac{1 + |\rho|}{1 - |\rho|} = 6.98$

6) $\lambda = \dfrac{v}{f} = 2m$ $L = 0.17\lambda$ $r_\ell = 0.25$

$r_0 = 0.9 + j1.45$ $R_0 = 45 + j72.5$

$G_0 = 1/R_0 = 6.3685 - j10.048 \, mS$

7) $\dfrac{\lambda}{2} = 8cm$ $L_{min} = 0.09375\lambda$

$z_{min} = \dfrac{1}{COE} = 0.5$ $z_\ell = 0.65 - j0.45$

$Z_\ell = 32.5 - j22.5 \ \Omega$

8) a) $\dfrac{\lambda}{4} = 30cm$ $\lambda = 120cm$ $f = \dfrac{v}{\lambda} = \dfrac{3 \cdot 10^8}{1.2} = 250 \, MHz$

b) $COE = \dfrac{V_{max}}{V_{min}} = 3$ $|\rho| = \dfrac{COE - 1}{COE + 1} = 1/2$

c) $Z_{max} = \dfrac{V_{max}^2}{P_{en}} = 150 \ \Omega$ $Z_{min} = \dfrac{100^2}{600} = 16.67 \ \Omega$

d) $Z_0 = \dfrac{Z_{max}}{COE} = Z_{min} \, COE = 50 \ \Omega$
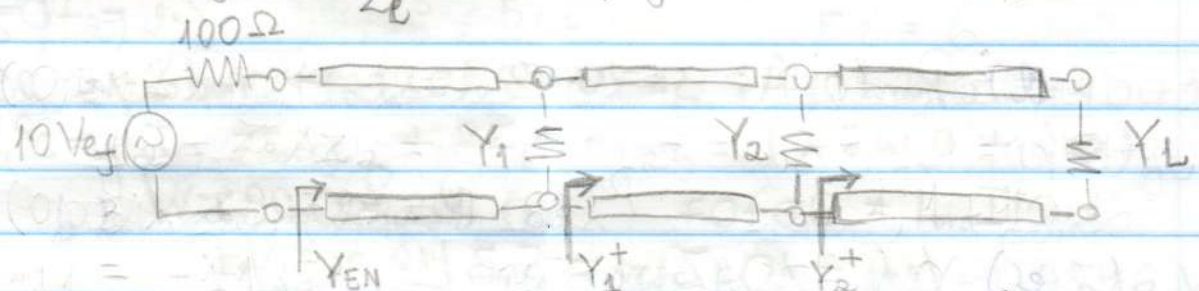
e) Maior defasagem $\rightarrow$ máximas fases em $Z(z)$

$\angle \rho = \pm 90° \rightarrow \angle Z_0 \dfrac{1 \pm j|\rho|}{1 \mp j|\rho|} = \pm 53.13°$

$(\angle (\cdot) \equiv$ argumento de $(\cdot))$

9) a) $|\rho| = 1/6$ $\qquad P_{en} = P_i(1-|\rho|^2) = 486,11 \, mW$

b) $Z_{MAX} = Z_0 \cos E = 70 \, \Omega$ $\qquad Z_{MIN} = Z_0/\cos E = 35,7 \, \Omega$

c) $V_{MAX} = \sqrt{P_{en} \cdot Z_{MAX}} = 5,833 \, V_{ef}$ $\qquad V_{MIN} = 4,167 \, V_{ef}$

$Z_0 = \dfrac{V_{MAX}}{I_{MAX}} = \dfrac{V_{MIN}}{I_{MIN}} \rightarrow I_{MAX} = 116,67 \, mA_{ef}$ $\quad I_{MIN} = 83,33 \, mA_{ef}$

10) a) $y_e = \dfrac{Z_0}{Z_e} = 0,46 - j0,7$ $\qquad (0,392\lambda)$

$y_1 = Z_0/Z_1 = -j1,15$ $\qquad y_2 = Z_0/Z_2 = 0,2$

$y_2^+ = (y_e + 0,132\lambda = 0,524\lambda) = 0,32 + j0,14$

$y_2 + y_2^+ = 0,52 + j0,14$ $\quad (0,03\lambda)$

$y_1^+ = (0,162\lambda) = 1,09 + j0,76$

$y_1 + y_1^+ = 1,5 - j0,39$ $\qquad (0,344\lambda)$

$y_{en} = (0,476\lambda) = 0,7 - j0,7$

$Z_{en} = Z_0/y_{EN} = 141,44 + j14,14 \, \Omega$

b) $|I_{en}| = \dfrac{10}{\sqrt{241,44^2 + 14,14^2}} = 41,35 \, mA_{ef}$

$P_{en} = |I_{en}|^2 R_{en} = 241,8 \, mW$

11) $z_e = 1 + j3$ $\quad$ rodo $0,077\lambda \rightarrow (0,203\lambda + 0,077\lambda = 0,28\lambda)$

$(0,3\lambda) = 2,2 - j4,2 \rightsquigarrow 110 - j210 \, \Omega$

[em rel. a Z_{02}] $= 0,88 - j1,68$ $\qquad (0,322\lambda)$

rodo $0,291\lambda \rightarrow (0,613\lambda = 0,113\lambda)$ $\quad z_{en} = 0,35 + j0,8$

$Z_{en} = 43,75 + j100 \, \Omega$

12) a) $z_e = 1,4 - j0,4$ $\lambda_2 = 3\,m$ $L_2 = 0,20067\lambda$

       $z_{en_2} = 0,62$ $Z_{on_2} = 31\,\Omega$ $P_{en_2} = (-0,2346$

b) Impedância vista pela linha 1 ($75\,\Omega$) =

$$\frac{1}{1/(31+9) + 1/360} = 36\,\Omega \qquad z = 0,48 \quad (0\lambda)$$

$\qquad\qquad\qquad\qquad\qquad\qquad\qquad\qquad \lambda_1 = 2\,m$

→ rodando $\quad 100\,cm = 0,5\lambda \quad Z_A = 36\,\Omega \quad P_A = -0,3514$

c) $z_{en_2} = 0,62 \;(0,5\lambda) \to (0,2993\lambda) = 1,4 - j0,4$

$\qquad\qquad\qquad\qquad\qquad\qquad\qquad Z_\ell = 70 - j20\,\Omega$

d) Ponto A: $z_A = 0,48 \;(0\lambda) \to$ roda-se $25\,cm$

$(0\lambda + 0,125\lambda)\quad z_{en} = 0,78 + j0,625 \quad Z_{en} = 58,5 + j46,9\,\Omega$

$\quad |I_{en}| = 0,0707 \qquad\qquad P_{en} = 0,292\,W$

e) $V_{en} = \dfrac{10\,Z_{en}}{75 + Z_{en}} = 5,3 \underline{/19,36°}\,V_{ef}$

Ao final da linha 1: $V = V_{en}\,e^{j\frac{4\pi}{\lambda}(0,625\lambda)}\,(1 - 0,3514)$

$\qquad\qquad\qquad\qquad V = 3,438 \underline{/109,36°}\,V_{ef}$

f) $|V_{en_2}| = 2,66\,V_{ef} \qquad\qquad P_{en_2} = P_L = \dfrac{2,66^2}{31} = 0,23\,W$

13) a) $|\rho(z=0)| = 1/2$ $\dfrac{1/2}{3/5} = \dfrac{5}{6} = 10^{-\frac{\alpha_{dB}L}{10}}$

$\quad |\rho(z=2,4\lambda)| = 3/5$

$A_{dB} = \alpha_{dB}L + 10\log\left(\dfrac{1 - |\rho(z=0)|^2}{1 - |\rho(z=2,4\lambda)|^2}\right) = (0,7918 + 0,6988)\,dB$

b) Primeiro mínimo: $\angle\rho_{min} = 180° = \pi$ $\qquad\qquad\qquad\qquad\qquad (-108°)$

$\angle\rho(z=2,4\lambda) = \pi + 2\beta \times 0,1\lambda = \pi + 4\pi(0,1) = 1,4\pi = 252°$

$\rho(z=2,4\lambda) = \rho_{min} \times 10^{\alpha_{dB}\,0,1\lambda} \times e^{2j\beta\,0,1\lambda} = |\rho(z=2,4\lambda)|\,e^{2j\beta\,0,1\lambda}\,e^{j\pi}$

$\qquad\qquad \rho(z=2,4\lambda) = 0,6 \underline{/-108°}$

$\qquad\qquad Z(z=2,4\lambda) = Z_0\dfrac{1+\rho}{1-\rho} = (37 - j65,9)\,\Omega$

c) $\rho(z=0) = |\rho(z=0)|\,e^{-j\,0,6\pi}\,e^{-2j\beta\,2,4\lambda} = 0,5 \underline{/-36°}$

$\qquad\qquad Z(z=0) = (170 - j133,3)\,\Omega$

máximo de corrente a 0°
+ 2β (0,35λ − 0)

14) a) $|\rho_\ell| = 1/3$ $\angle \rho_\ell = \dfrac{4 \cdot 180°}{\lambda} \cdot 0,35\lambda = 252° \equiv -108°$

$Z_\ell = Z_0 \dfrac{1 + \rho_\ell}{1 - \rho_\ell} = (33,8 - j24,1)\Omega$

b) $\rho_0 = \rho_\ell \cdot 10^{-\frac{0,1 \cdot 95\lambda}{10\lambda}} \cdot e^{-j\frac{4\pi}{\lambda} \cdot 95\lambda} = 0,268 \underline{/-108°}$

$Z_0 = (37,51 - j20,59)\Omega$

c) $A_{dB} = \dfrac{0,1 \cdot 95\lambda}{\lambda} + 10 \log \left(\dfrac{1 - |\rho_0|^2}{1 - |\rho_\ell|^2} \right) = 0,95 + 0,188 = 1,138$ dB

15) a) $\rho_\ell = \dfrac{300 - 50}{300 + 50} = 5/7 \underline{/0°}$ COE $\ell = 6$.

$\rho_{en} = \rho_\ell \cdot 10^{-\frac{0,02 \cdot 200}{10}} e^{-j\frac{4\pi}{\lambda} \cdot 200}$ $L = 200 m = 400\lambda$ $(\lambda = 50cm)$

$\rho_{en} = 0,28436$ COE$_{en}$ = 1,79471

b) $Z_{en} = 89,74 \Omega$

$I_{en} = \dfrac{10}{139,73} = 0,0716 A$ $P_{en} = 0,4596 W$

c) $A_{dB} = 0,02 \cdot 200 + 10 \log \left(\dfrac{1 - 0,284^2}{1 - (5/7)^2} \right) = 6,735$ dB

$P_\ell = P_{en} \cdot 10^{\frac{-A_{dB}}{10}} = 0,0975 W$

d) GERADOR: $Z_{MAX_L} = Z_0$ COE $= 90\Omega$ → ptos de V_{max} em $z = 0$ e $z = 200$

$V_{MAX_L} = \sqrt{P_\ell \cdot Z_{MAX_L}} = 6,43 V_{ef}$ $V_{MIN} = \dfrac{V_{max}}{COE} = 3,57 V_{ef}$

CARGA: $Z_{MAX} = 300\Omega$ $V_{max_{en}} = 5,42 V_{ef}$ $V_{MIN_{en}} = 0,9 V_{ef}$
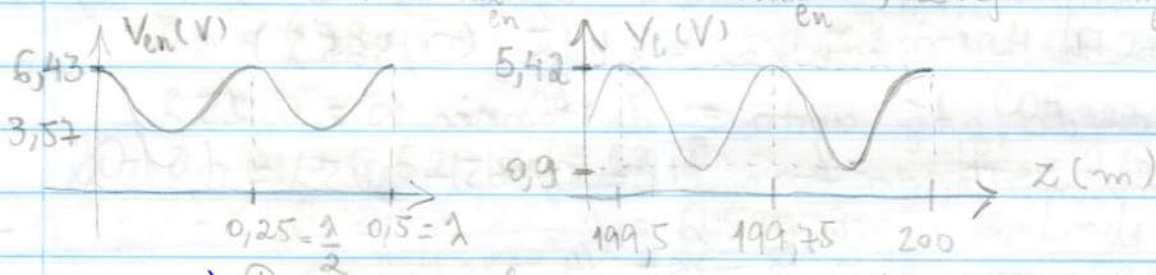
e) Para uma frequência diferente, ocorrerá defasagem nos valores de entrada (menor λ, maior fase).
A atenuação permanece igual. $\lambda' = 0,4995 m$

$\rho_{en} = 0,284 \underline{/0 - 4 \cdot 180° \cdot \frac{200}{0,4995}} = 0,284 \underline{/+72°}$

$Z_{en} = (50,8 + j29,8)\Omega$ $|I_{en}| = 0,09514 A_{ef}$ $P_{en} = 0,4598 W$

$P_\ell = 0,0975 W$

16) a) $\rho_L = 5/7 \angle 0°$ $COE_L = 6$ $\lambda = \dfrac{u}{f} = 1,25$ cm

$L = 40,1$ m $= 160,4\lambda$ $\rho_{en} = \rho_L \, 10^{-\frac{\alpha dB L}{10}} \, e^{-j\frac{4\pi}{\lambda}\cdot 160,4\lambda}$

$\rho_{en} = 0,2837 \angle +72°$ $COE_{en} = 1,792$

b) $Z_{en} = 50 \dfrac{1+\rho_{en}}{1-\rho_{en}} = (50,8 + j\,29,8)\,\Omega$

c) $A_{dB} = 0,1\cdot 40,1 + 10 \log\left(\dfrac{1-0,2837^2}{1-(5/7)^2}\right) = 6,745$ dB

$P_L = 20 \cdot 10^{\frac{-A_{dB}}{10}} = 4,2314$ W

d) Para uma linha com perdas, uma maior distância carga-gerador causa maior atenuação no módulo do coef. de reflexão. Quando o mesmo tende p/ 0, a impedância $Z(z=0) = Z_0 \dfrac{1+\rho(z)}{1-\rho(z)\to 0}$ vale $\approx Z_0 \times 1$

e) A atenuação é em base no quanto de potência cai na carga em relação a de entrada.

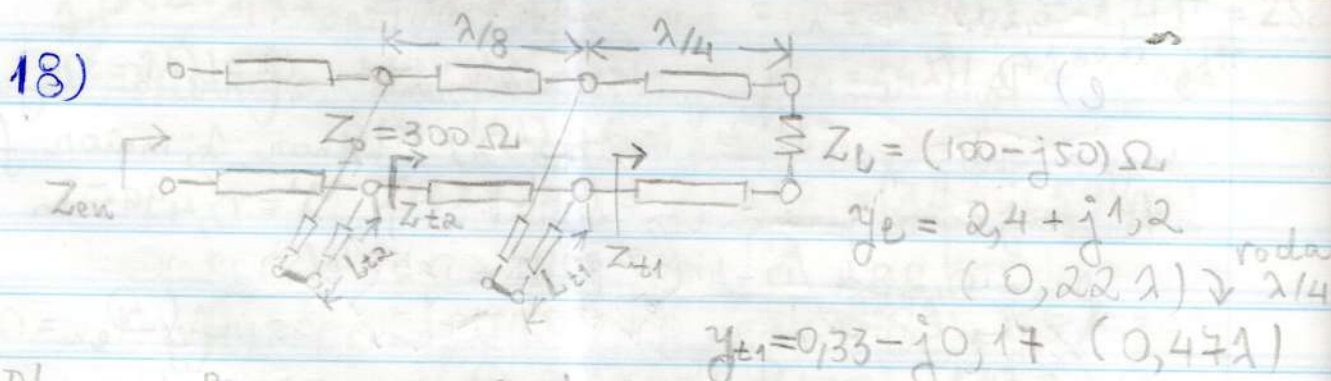17) $y_L = Z_0/Z_L = 1,25 + j\,1,25$ $(0,182\lambda)$

rodando até admitância unitária $\to (0,167\lambda) = 1 + j\,1,15$

• distância do toco $d_1 = 0,167 - 0,182\lambda + 0,5\lambda = 0,485\lambda$

toco de admitância $-j\,1,15$ $(0,365\lambda)$

girando até curto ≡ admitância ∝ $= 0,25\lambda$

• comprimento do toco $L_1 = 0,365\lambda - 0,25\lambda = 0,115\lambda$

18)

$Z_0 = 300\,\Omega$ $Z_L = (100 - j\,50)\,\Omega$

$y_L = 2,4 + j\,1,2$

$(0,22\lambda) \searrow \lambda/4$

$y_{+1} = 0,33 - j\,0,17$ $(0,47\lambda)$

Na circunferência de admit. unitária deslocada: $0,33 + j\,0,25$

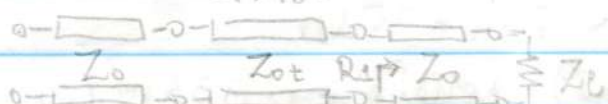• $y_{toco\,1} = +j\,0,42 = 0,064\lambda$ $L_{+1} = 0,064 + \dfrac{\lambda}{4} = 0,314\lambda$

rodando
$\lambda/8$

$0,33 + j0,25 \ (0,045\lambda) \longrightarrow 1 + j1,25 \ (0,17\lambda)$

• $\quad y_{TOCO\,2} = -j1,25 = 0,357\lambda \quad L_{t2} = 0,357\lambda - \dfrac{\lambda}{4} = 0,107\lambda$

19) $\quad \rho_L = 0,6 \underline{/62,0°} \qquad \lambda = \dfrac{3 \cdot 10^8}{300 \cdot 10^6} = 1\,m$

$L_1 = \dfrac{62°}{4 \times 180°}\lambda = 0,086\,\lambda \qquad R_1 = 300\,\Omega$

$\qquad Z_{ot} = \sqrt{R_1 Z_0} = 150\,\Omega$

$\qquad L_1 = 8,6\,cm$

$\qquad L_t = \lambda/4 = 25\,cm$

Linha casada, $COE = 1$

• Para $f = 272,5\,MHz \qquad \lambda = 1,101\,m$

Saída do transformador: $\rho_1 = \rho_L \, e^{-j0,312\pi} = 0,6\underline{/5,76°}$

$Z_1 = (289,1 + j54,4)\,\Omega \qquad \rho_{t1} = 0,338\underline{/14,3°}$

Entrada do trafo: $\rho_{t2} = \rho_{t1} \cdot e^{-j0,908\pi} = 0,338\underline{/-149,19°}$

$Z_2 = (78,4 - j30,6)\,\Omega \qquad \rho_{en} = 0,197\underline{/-72,38°}$

$\qquad\qquad\qquad COE_{272,5} = 1,49$

• Para $f = 327,5\,MHz \qquad \lambda = 0,916\,m$

Saída do trafo: $\rho_1 = 0,6\underline{/62° - \dfrac{4 \cdot 180° \cdot 0,086}{0,916}} = 0,6\underline{/-5,596°}$

$Z_1 = (289,65 - j53)\,\Omega \qquad \rho_{t1} = 0,337\underline{/-13,9°}$

Entrada: $\rho_{t2} = 0,337\underline{/-13,9° - \dfrac{4 \cdot 180° \cdot 0,25}{0,916}} = 0,337\underline{/-210,4°}$

$Z_2 = (78,45 + j30,2)\,\Omega \qquad \rho_{en} = 0,194\underline{/72,35°}$

$\qquad\qquad\qquad COE_{327,5} = 1,48$

20) a) $\rho_L = 0,62017\underline{/7,125°} \qquad \lambda = \dfrac{2 \cdot 10^8}{300 \cdot 10^6} = 2/3\,m$

$d_1 = \dfrac{7,125°}{4 \times 180°}\lambda = 6,597\,mm \qquad z_1 = L - d_1 = 49,9934\,m$

$\qquad R_1 = Z_0 \dfrac{1+\rho}{1-\rho} = 319,92\,\Omega$

b) $L_t = \lambda/4 = \dfrac{1}{6} = 16,667\,cm$

$Z_0' = \sqrt{R_1 Z_0} = 154,9\,\Omega$

c) $y_L = 0,235 - j0,059$ rodando até $1 + j1,6 \ (0,178\lambda)$

$(0,5\lambda - 0,49\lambda + 0,178\lambda) = 0,188\lambda \qquad d_2 = 0,1253\,cm$

$Z_2 = L - d_2 = 49,8747\,m$

$Y_{d2} = \dfrac{1}{Z_0}(1 + j1,6) = (13,33 + j21,33)\,mS$

d) Admitância de entrada do toco $= -j21,33 \, mS$

Normalizada $= -j1,0667 \quad (0,37\lambda_t)$

$\rightarrow$ rodando até $0,25\lambda_t \, (Y_{final_{toco}} \rightarrow \infty) = 0,37\lambda_t - 0,25\lambda_t =$

$$\ell_t = 0,12\lambda_t$$

e) $\lambda_t = \dfrac{3 \cdot 10^8}{300 \cdot 10^6} = 1 \, m \qquad \ell_t = 12 \, cm$

f) Carga casada $\rightarrow Z_{en} = 75 \, \Omega$

$$P_{en} = P_{max} = \dfrac{E_g^2}{4 \cdot R_g} = \dfrac{10^2}{4 \cdot 75} = 0,333 \, W$$

g) $|I_\ell| = \sqrt{\dfrac{1/3}{300}} = 33,333 \, mAef$

21) a) $y_L = 0,8 - j0,4 \, (0,395\lambda) \rightarrow (145\lambda) \, 1+j0,5$

$0,5\lambda - 0,395\lambda + 0,145\lambda = 0,25\lambda \qquad d = 75 \, cm$

b) Impedância do componente $= +j600 \, \Omega$

$j\omega L = j2\pi f L = j600 \qquad L = \dfrac{600}{200\pi \cdot 10^6} = 954,93 \, nH$

c) $z_t = j2 \, (0,176\lambda) \rightarrow (0\lambda) \, j0 \, (curto)$

$$\ell_t = 52,8 \, cm$$

d) $V_{en} = \dfrac{10 \times 300}{600} = -5 \, Vef \qquad \rho_{en} = \rho_L e^{-2j\beta L}$

$V_L = V_{en}^+ \cdot (1 + \rho_L) \cdot e^{-2j\beta L} = \dfrac{V_{en}(1+\rho_L) \, e^{-j\frac{4\pi}{\lambda}L}}{(1+\rho_{en})}$

Linha casada $= \rho(z=32,7) = 0 \quad$ e $\quad V(z=32,7) = V_{en}$

$\rho_L = 0,2425 \, \underline{/75,964°} \qquad V_L = 5,4232 \, \underline{/-167,5°} \, Vef$

e) $\rho_{max} = |\rho_L| \, \underline{/0°}$

$d_{max} = \dfrac{75,964°}{4 \times 180°} \lambda = 0,3165 \, m$
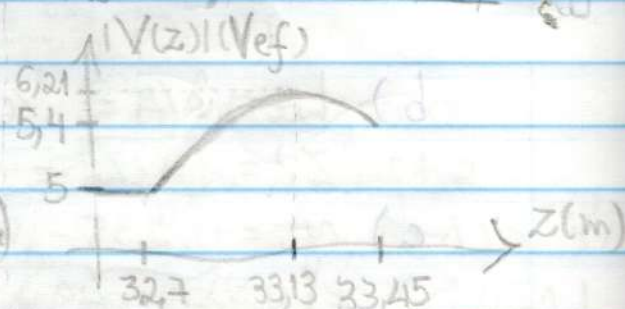
Pto de máximo $= 32,7 + (0,75 - d_{max})$

$= 33,13 \, m$

$V(33,13) = \dfrac{V_{en}(1+|\rho_L|) \, e^{-j\frac{4\pi}{\lambda}L}}{(1+\rho_{en})} = 6,2125 \, \underline{/180°} \, Vef$

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22) a) $A_{dB} = 0,01 \cdot 150 + 10\log\left(\frac{1-|\rho_{en}|^2}{1-|\rho_L|^2}\right)$ $\rho_L = 0,4152\underline{/-41,6°}$

$A_{dB} = 1,929\ dB$ $|\rho_{en}| = 0,294$

b) $\eta = \frac{P_{carga}}{P_{disponível}} \cdot 100\% = \frac{P_{en} \cdot A}{P_d} \cdot 100\% = (1-|\rho_{en}|^2)10^{\frac{-A_{dB}}{10}} \cdot 100\%$

$\eta = 58,59\%$

c) $y_L = 0,46 + j0,31\ (0,058\lambda) \to (0,16\lambda)\ 1+j0,95$

$d_t = 0,102\lambda = 2,04\ cm$

$y_t = -j0,95\ (Z_{ot}=Z_0)\ (0,380\lambda) \to (0,25\lambda)j\infty$

$L_t = 0,130\lambda = (\lambda_t=\lambda)\ 2,60\ cm$

d) $A_{dB} = \alpha_{dB}(L-d_t) = 1,5\ dB$

$P_{carga} = P(z=49,9\mp 96) = P_d(1-|\rho_{en}|^2) \cdot A$ $\eta = (1-|\rho_{en}|^2)10^{\frac{-A_{dB}}{10}} \cdot 100\%$

$\eta = 70,8\%$

e) $\rho_{en} = 0,294\underline{/-41,6°}$ $d_T = \frac{41,6°}{4\times 180°}\lambda = 0,058\lambda = 1,16\ cm$

$L_T = \lambda/4 = 5\ cm$ $Z(d_T) = 92,5\ \Omega$ $Z_{oT} = 68\ \Omega$

f) $A_{dB} = 0,01 \cdot 150,0 + 10\log\left(\frac{1-|\rho(d_T)|^2}{1-|\rho_L|^2}\right) = 1,93\ dB$

$\eta = \frac{P_d(1-|\rho_{en}|^2)10^{-A_{dB}/10}}{P_d} \cdot 100\% = 64,12\%$ $\to$ (linha cascata)

23) a) $z_{L2} = \frac{50}{50\sqrt{2}} = \sqrt{2}/2 \to$ girando $\lambda/4 \to z_{en_2} = \sqrt{2}$ $Z_{en_2} = 50\sqrt{2}\ \Omega$

b) $\rho_{L1} = \frac{25\sqrt{2}-50}{25\sqrt{2}+50} = -0,1716$ $\rho_{en_1} = +0,1716$

c) $Z_{en} = 70,71\ \Omega$ $I_{en} = 58,58\ mA_{ef}$ $P_{en} = 0,243\ W$

$P_{L3} = P_{L2} = 0,121\ W$

d) $Z_{th_{L2}} = 50//50\sqrt{2} = 29,29\ \Omega$ $E_{th_2} = 4,14\ V_{ef} = 5,86\ V$

e) $P_{L2} = 0,414\ W$

24) a) $y_t = 0,5$ $(0\lambda) \to (0,25\lambda)$ $2 = \bar{z}_2$ $Z_2 = 600\,\Omega$

$\dfrac{Z_2}{Z_{01}} = \infty$ $(0,25\lambda) \to (0,15\lambda)$ $0,35 + j1,32$ $Z_1 = (26,4 + j98,7)\,\Omega$

b) $V_1 = 3,61 \underline{/30,81°}\,V_{ef}$ $\qquad V_2 = 4,44\underline{/72°}\,V_{ef}$

$V_L = V_2^+ (1+\rho_L) e^{-2\beta L_2} = \dfrac{V_2(1+\rho_L)}{(1+\rho_{z2})} e^{-\frac{4\pi}{\lambda}L_2} = 2,22\underline{/-108°}\,V_{ef}$

c) $y_2 = 1/8$ $(0\lambda) \to (0,196\lambda)$ $1 + j2,5$ $\quad d_t = 0,196\lambda$

$y_t = -j2,5 (0,311\lambda) \to (0,25\lambda)\infty$ $\quad L_t = 0,061\lambda$

d) Com to $\omega \to Z_1 = 75\,\Omega$ $\quad V_1 = E_g/2 = 2,5\,V_{ef}$

$P_{en} = 83,33\,mW$

e) $A_{dB} = \alpha_{dB}\cdot L + 10\log\left(\dfrac{1-|\rho(31,704\lambda)|^2}{1-|\rho(31,9\lambda)|^2}\right)$

$\rho(31,704\lambda) = \dfrac{7}{9} e^{-\frac{4\pi}{\lambda}d_t} 10^{-\frac{\alpha_{dB}d_t}{10}} = 0,7743\underline{/-141,12°}$

$A_{dB} = (3,19 + 0,059)\,dB = 3,249\,dB$

$P_L = P_{en} 10^{-A_{dB}/10} = 39,44\,mW$

25) a) $\rho_{z2} = -\dfrac{157}{443}$ $\quad \rho_L = \rho_{z2} e^{\frac{4\pi}{\lambda}L_2} = 0,3544\underline{/150,48°}$
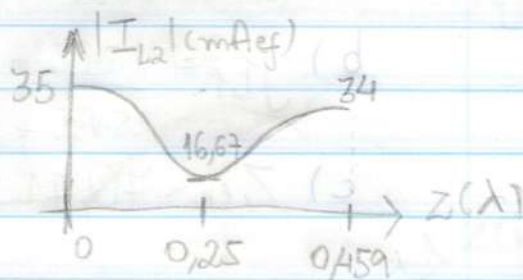
$Z_L = (150,55 + j60,13)\,\Omega$

b) $P_{z2} = P_L = 0,175\,W$ $\quad V_L = V_2^+(1+\rho_L) e^{-\frac{4\pi}{\lambda}L_2}$

$V_L = 5,5244\underline{/13,7°}\,V_{ef}$

c) Pto de mín: $\rho_{min} = 0$

$d_{min} = 0,209\lambda$

$Z_{máx} = 629,368\,\Omega$ $\quad |I_{mín}| = 16,67\,mA_{ef}$

d) $\rho_{L1} = 93/193 = 0,482$

e) $\rho_{z1} = 0,184\underline{/144°}$ $\quad Z_1 = (36,28 + j8,12)\,\Omega$

f) $A_{dB} = (4,18 + 1)\,dB$ $\quad P_{z1} = P_{z2}10^{A_{dB}/10} = 0,577\,W$

g) $L_t = 0,25\lambda$ $\quad Z_{0t} = 84,56\,\Omega$ $\quad A_{dB} = (4,18 + 0,14)\,dB$