FORMULÁRIO – PSI3483 – ONDAS ELETROMAGNÉTICAS EM MEIOS GUIADOS

$\mu = \mu_r \mu_0$	$\varepsilon = \varepsilon_r \varepsilon_0$	$\mu_0 = 4\pi 10^{-7} (H/m)$
$\varepsilon_0 = 8{,}854.10^{-12} (F/m)$		$tg\delta = \frac{\varepsilon'}{\varepsilon''} \qquad \varepsilon' = \varepsilon_r$

Guias de ondas retangulares

Modos TE e TM			
$f_c = \frac{v}{2}\sqrt{\left(\frac{m}{a}\right)^2 + \left(\frac{n}{b}\right)^2}$	*TE: m, n = 0,1, 2, ... m + n=0* *TM: m, n = 1, 2, 3, . .*		
$\gamma = \sqrt{\left(\frac{m\pi}{a}\right)^2 + \left(\frac{n\pi}{b}\right)^2 - \omega^2 \mu\varepsilon}$	$v = \frac{c}{\sqrt{\varepsilon_r}} \qquad c = 3 \cdot 10^{11} \frac{mm}{s}$		
$\lambda_g = \lambda \Big/ \sqrt{1 - \left(\frac{f_c}{f}\right)^2}$	$\lambda = \frac{c}{f.\sqrt{\varepsilon_r}}$	$Z_{TM} = \eta\sqrt{1 - \left(\frac{f_c}{f}\right)^2}$	$Z_{TE} == \eta \Big/ \sqrt{1 - \left(\frac{f_c}{f}\right)^2}$
Modos evanescentes $f < f_c$	*Modos propagantes* $f > f_c$		

Para o modo fundamental TE10

Perda dielétrica	$\alpha_{d10} = 8{,}686 \cdot \frac{\omega\sqrt{\mu_0.\varepsilon'}.(\varepsilon''/\varepsilon')}{\eta.b.\sqrt{1-(f_{c10}/f)^2}} \; (dB/m)$
Perda condutiva	$\alpha_{c10} = 8{,}686 \cdot \frac{R_s[1+(2b/a).(f_{c10}/f)^2]}{\eta.b.\sqrt{1-(f_{c10}/f)^2}} \; (dB/m)$ $R_s = \sqrt{\frac{\omega\mu}{2\sigma}} \qquad \eta = \frac{\eta_0}{\sqrt{\varepsilon_r}} = \frac{377}{\sqrt{\varepsilon_r}} \; \Omega$
Perda total	$\alpha(dB/m) = \alpha_c(dB/m) + \alpha_d(dB/m)$

Guias de ondas cilíndricos

Modos TM	
Modos TM $f_c = \frac{v}{2\pi \cdot a} \cdot p_{nm}$	Tabela abaixo: Zeros da função de Bessel de primeira ordem

n	p_{n1}	p_{n2}	p_{n3}
0	2.405	5.520	8.654
1	3.832	7.016	10.174
2	5.135	8.417	11.620

Zeros da função de Bessel de primeira ordem

Modos TE

$$f_c = \frac{v}{2\pi \cdot a} \cdot p'_{nm}$$

n	p'_{n1}	p'_{n2}	p'_{n3}
0	3.832	7.016	10.174
1	1.841	5.331	8.536
2	3.054	6.706	9.970

Zeros da derivada da função de Bessel de primeira ordem

Parâmetro	Modos TE_{nm}	Modos TM_{nm}
λ_g	$\frac{2\pi}{\beta}$	$\frac{2\pi}{\beta}$
β	$\sqrt{k^2 - k_c^2}$	$\sqrt{k^2 - k_c^2}$
k	$\omega\sqrt{\mu\epsilon} = \frac{\omega}{v} = \frac{\omega}{c} \cdot \sqrt{\varepsilon_r}$	$\omega\sqrt{\mu\epsilon} = \frac{\omega}{v} = \frac{\omega}{c} \cdot \sqrt{\varepsilon_r}$
k_c	$\frac{p'_{nm}}{a}$	$\frac{p_{nm}}{a}$

Cabos coaxiais

$Z_c = \frac{60}{\sqrt{\varepsilon_r}} ln(b/a)$	$C = \frac{2\pi.\varepsilon_r\varepsilon_0}{ln(b/a)}$	$L = \frac{\mu}{2\pi} \ln\frac{b}{a}$
$G = \omega.tg\delta.C$	$f_c = \frac{c.k_c}{2\pi.\sqrt{\varepsilon_r}}$	$k_c \approx \frac{2}{a+b}$
$\delta_S = \frac{1}{\sqrt{\pi f \mu \sigma}}$	$R_a = \frac{\rho_a}{A_a}$ e $R_b = \frac{\rho_b}{A_b}$	$\sigma = \frac{1}{\rho}$
$\lambda = \frac{\lambda_0}{\sqrt{\varepsilon_r}}$ $\lambda_0 = \frac{c}{f}$	$A_a = \delta_S.2\pi.a$ $A_b = \delta_S.2\pi.b$	$R = \frac{1}{2}\sqrt{\frac{f.\mu}{\pi.\sigma.}}\left(\frac{1}{a}+\frac{1}{b}\right)$ para $\rho_a = \rho_b$