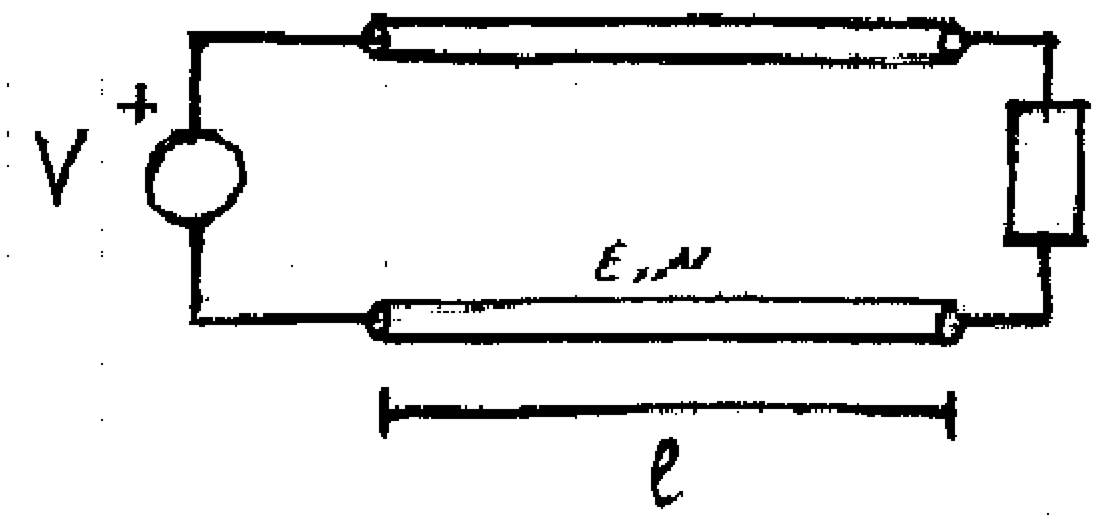
TEMA 1: LÍNEAS DE TRANSMISIÓN (L.T)



vel. propagación

$$\boxed{v_p = \frac{1}{\sqrt{\mu \varepsilon}} = \frac{c}{\sqrt{\varepsilon_r}}}$$

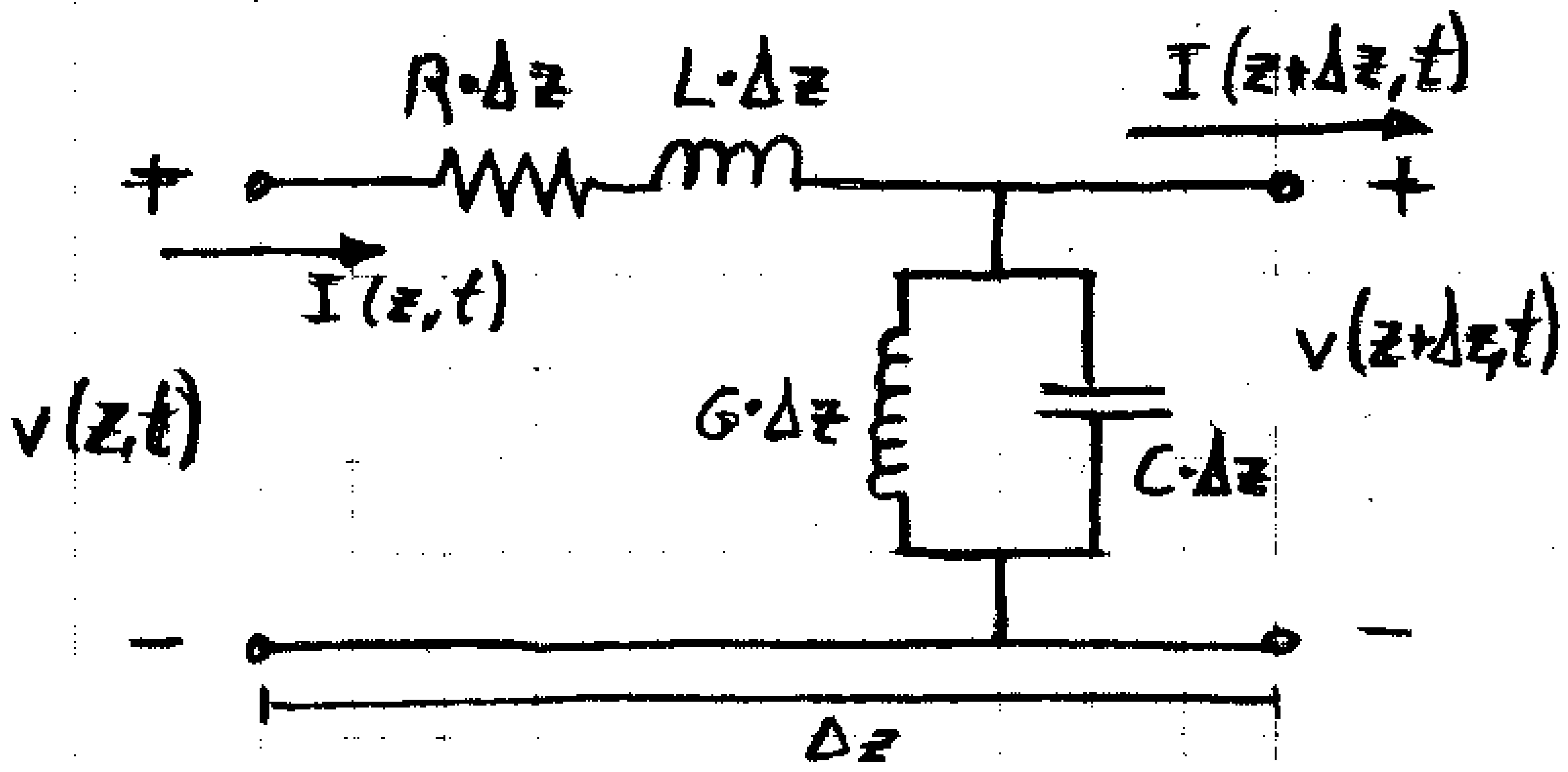
Retardo

$$\boxed{T = \ell / v_p}$$

Si $\ell << \lambda$ Parámetros concentrados $v(t), I(t)$

Si $\ell >> \lambda$ Parámetros distribuidos $v(z,t), I(z,t)$

- Modelo circuital de un Δz de una L.T.



Ec. del Telegrafista

$$-\frac{\partial v(z,t)}{\partial z} = R \cdot I(z,t) + L \frac{\partial I(z,t)}{\partial t}$$

$$-\frac{\partial I(z,t)}{\partial z} = G \cdot v(z,t) + C \frac{\partial v(z,t)}{\partial t}$$

- Línea de transmisión IDEAL $(R = G = 0)$

$$\frac{\partial^2 V}{\partial z^2} = L \cdot C \frac{\partial^2 V}{\partial t^2}$$

$$\frac{\partial^2 I}{\partial z^2} = L \cdot C \frac{\partial^2 I}{\partial t^2}$$

$$\boxed{v_p = \frac{1}{\sqrt{L \cdot C}}} \Rightarrow \boxed{LC = \mu \varepsilon}$$

* Impedancia característica de la línea

$$I^+ Z_o = V^+$$

$$-I^- Z_o = V^-$$

$Z_o = V^+ / I^+$

$Z_o = -V^- / I^-$

$$\boxed{Z_o = \sqrt{L/C}}$$

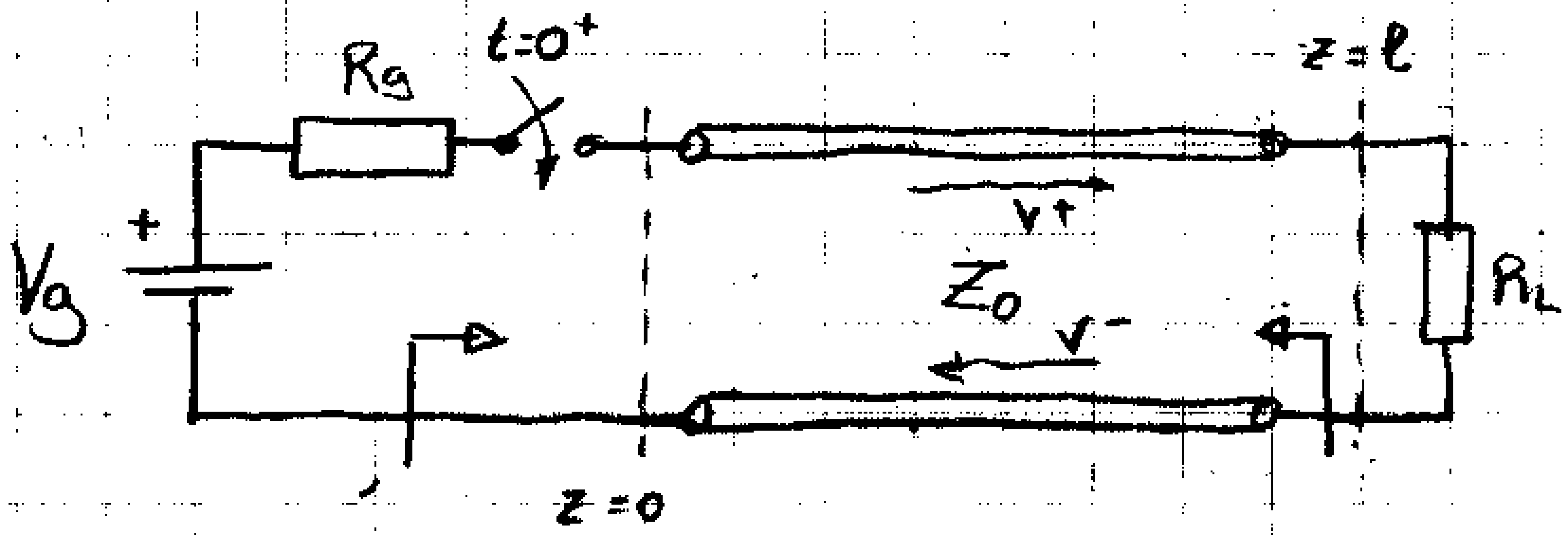
$$Z_o = \pm \frac{1}{C v_p}$$

$$\boxed{P(z,t) = P^+ - P^-} \qquad \boxed{P^+ = \frac{|V^+|^2}{Z_o}} \qquad \boxed{P^- = \frac{|V^-|^2}{Z_o}}$$

TRANSITORIOS EN L.T IDEALES

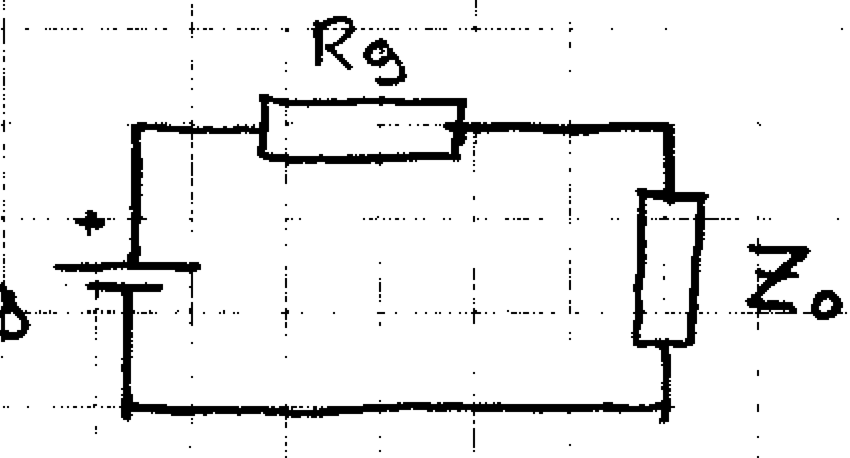
- RESPUESTA AL ESCALON UNIDAD

$$\boxed{V(z) = V^+ + V^-}$$



$\underline{t=0^+}$ $V_g - V(z=0, t=0^+) = I(z=0, t=0^+) R_g$

$$V_g - V^+ = \frac{V^+}{Z_0} R_g \Rightarrow \boxed{V^+ = \frac{Z_0}{Z_0+R_g} V_g} \Rightarrow$$



Coeficiente de reflexión de la carga

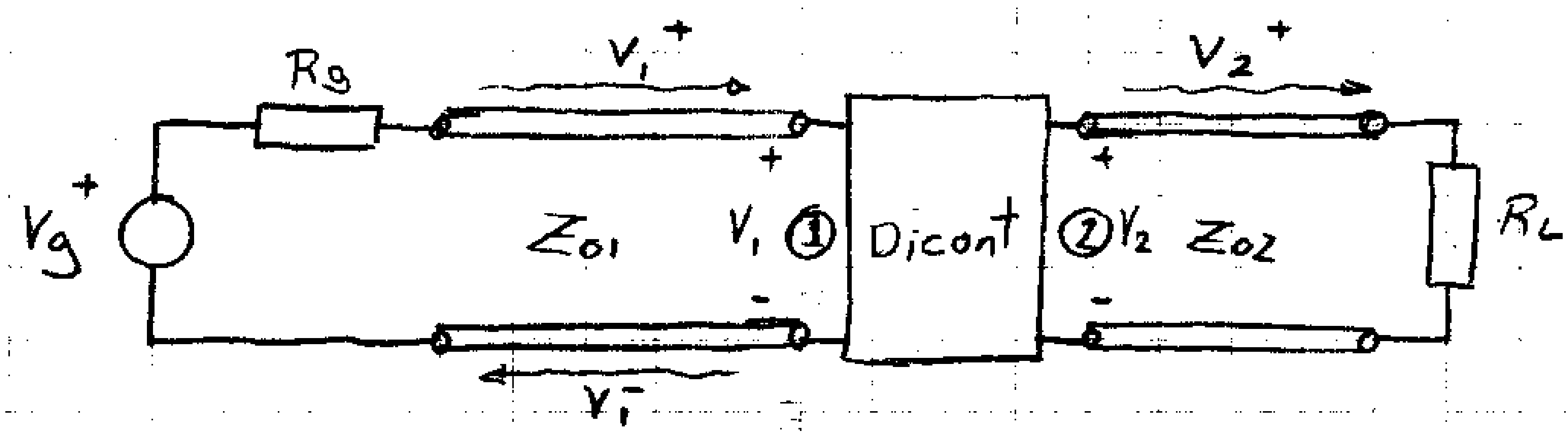
$$\boxed{\rho_L = \left.\frac{V^-}{V^+}\right|_{z=\ell} = -\left.\frac{I^-}{I^+}\right|_{z=\ell}} \qquad \boxed{\rho_L = \frac{R_L - Z_0}{R_L + Z_0}}$$

Coeficiente de reflexión del generador

$$\boxed{\rho_g = \frac{R_g - Z_0}{R_g + Z_0}}$$

$\rho = -1 \rightarrow$ Cortocircuitado
$\rho = 0 \rightarrow$ Adaptado
$\rho = 1 \rightarrow$ Circuito abierto

- DISCONTINUIDADES

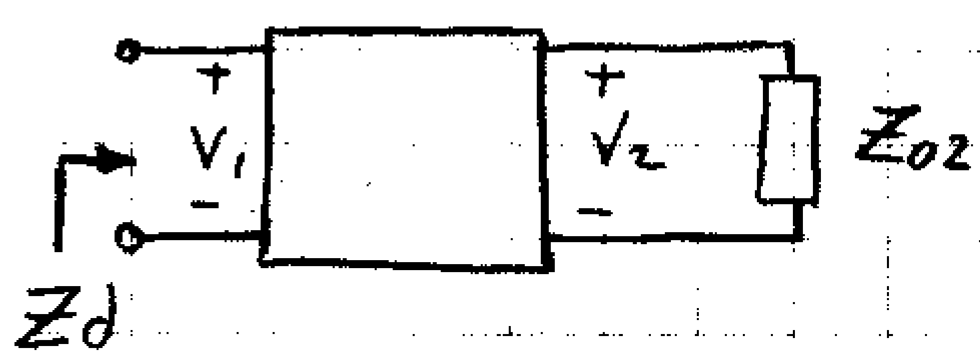


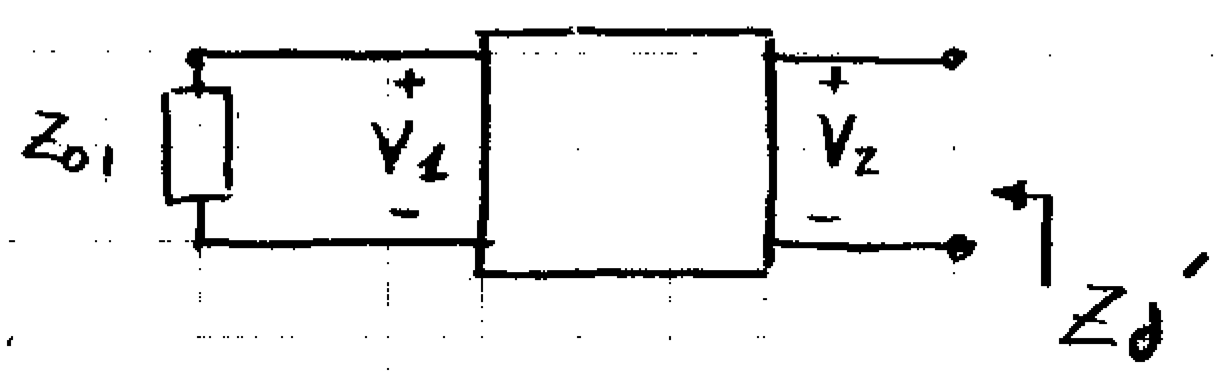
Coef. reflex. discont

$$\boxed{\rho_d = \left.\frac{V_1^-}{V_1^+}\right|_{①} = \frac{Z_d - Z_{01}}{Z_d + Z_{01}}}$$

Coef. transmisión

$$\boxed{\eta_{12} = \frac{V_2^+}{V_1^+} = \frac{V_2}{V_1}(1+\rho_d)}$$





$$\boxed{\rho_d' = \frac{Z_d' - Z_{02}}{Z_d' + Z_{02}}} \qquad \boxed{\eta_{21} = \frac{V_1}{V_2}(1+\rho_d')}$$

- Resolución de problemas de transitorios

① Determinar las condiciones iniciales en la L.T

En la línea
$$V(z,t<0) = V_i \qquad V(z=0,t=0) = V^+ + V_i$$
$$I(z,t<0) = I_i \qquad I(z=0,t=0) = I^+ + I_i = \frac{V^+}{Z_0} + I_i$$

Cond. Iniciales + Ec. impuestas por el circuito $\Rightarrow$ $\boxed{V^+}$

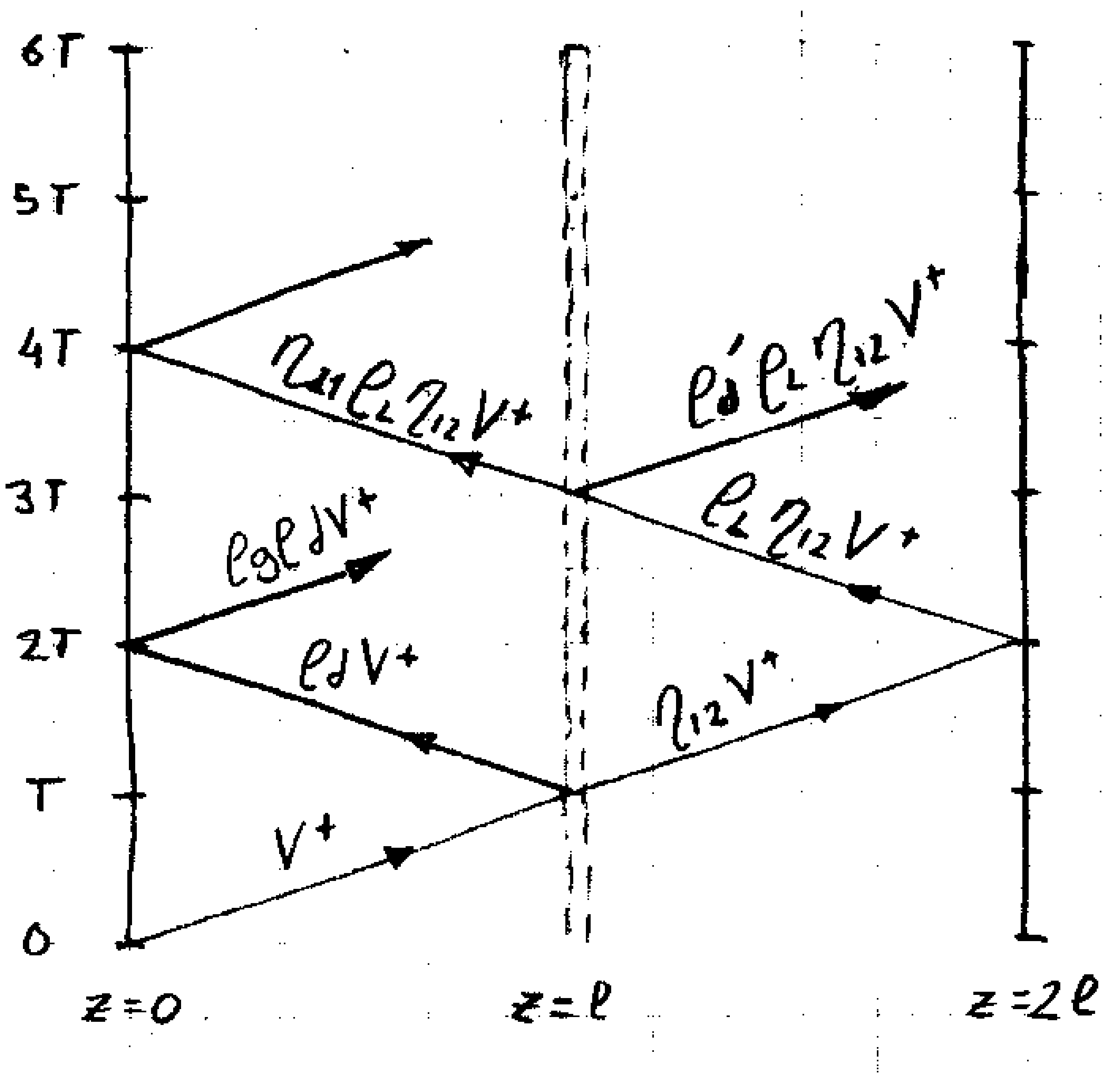
② Determinar los coef. de reflexión

Si hay discont $\Rightarrow$ calcular las resistencias y tensiones que se "ven" a cada lado de la discon.

$\Rightarrow$ calcular coef. reflexión a cada lado de la discont.

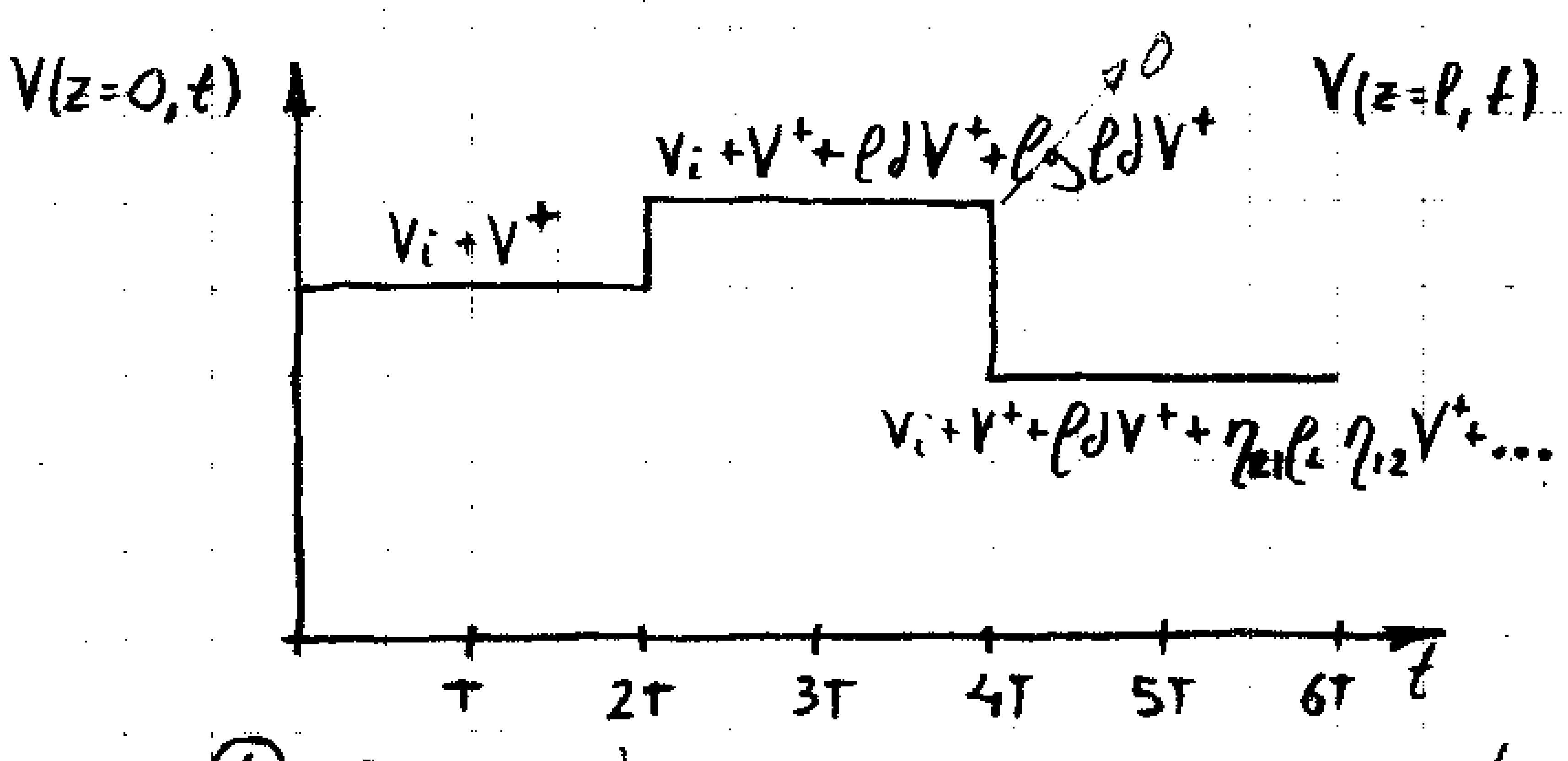
$\Rightarrow$ calcular coef de transmisión

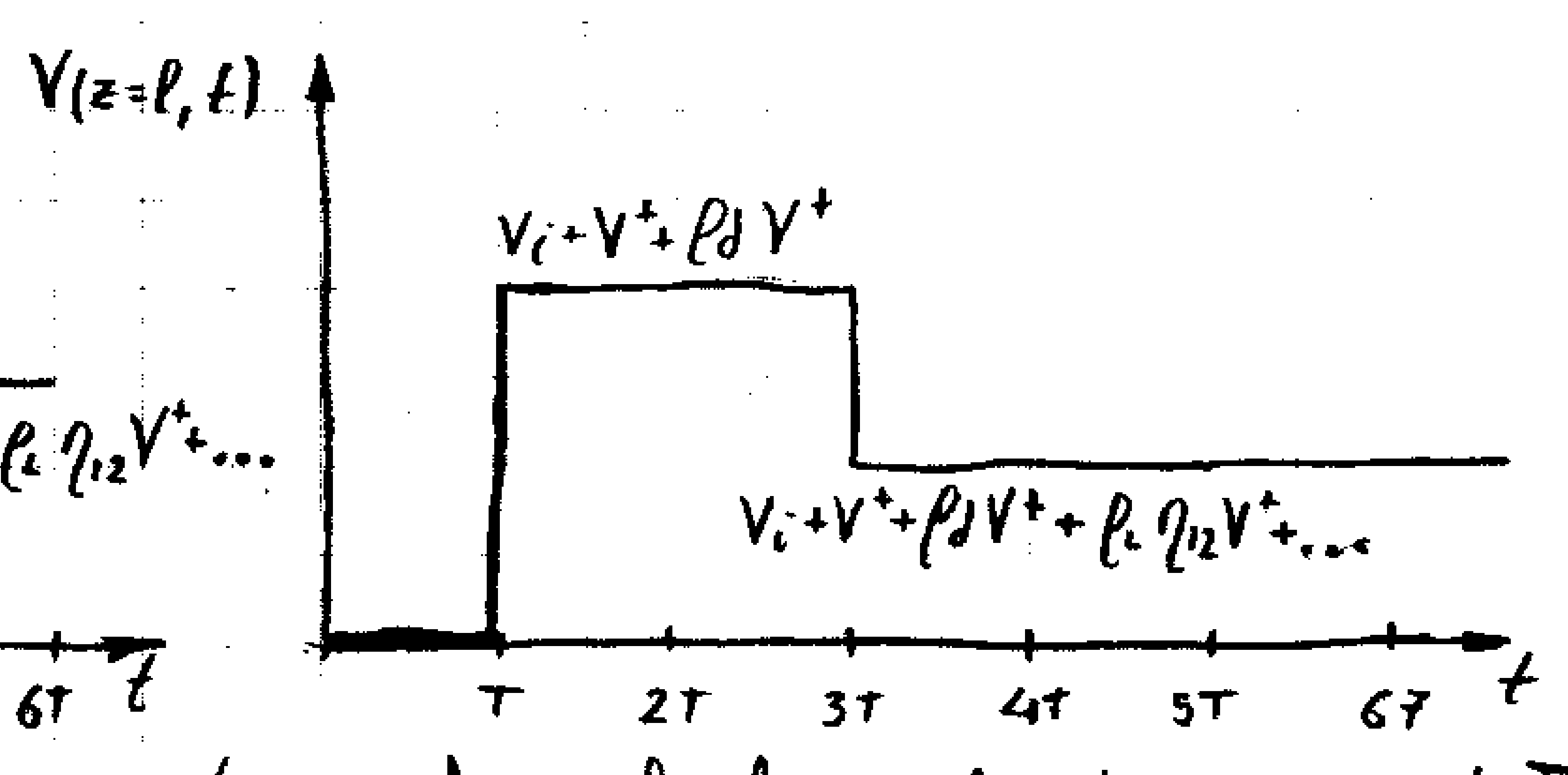
③ Dibujar el diagrama espacio-tiempo



Ejemplo para el caso $\rho_g = \rho_d' = 0$

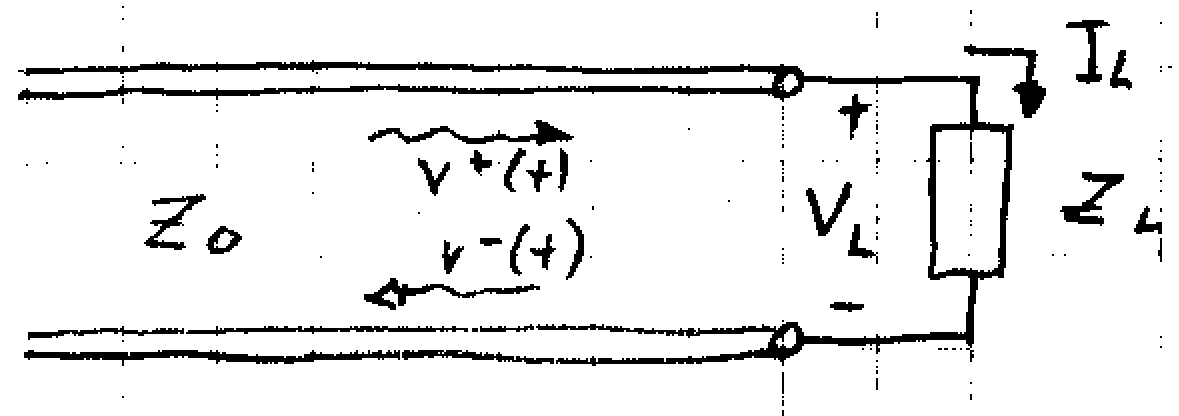
③ Particularizar para un z o t concretos





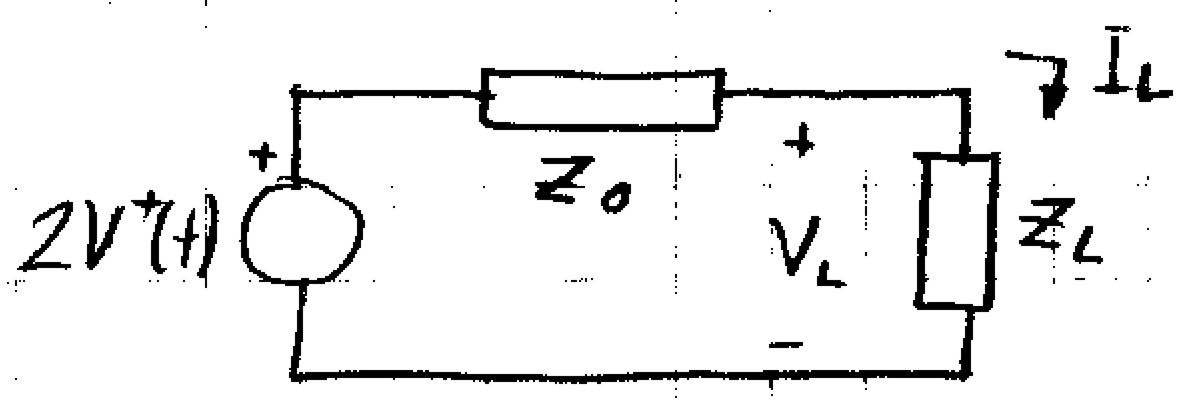
④ Se puede comprobar si para $t \to \infty$ los calculos coinciden con no L.T

- Reflexión en cargas reactivas



$$V_L(t) = V^+(t) + V^-(t)$$
$$I_L(t) = \frac{1}{Z_0}\left(V^+(t) - V^-(t)\right)$$
$$\boxed{2V^+(t) = V_L(t) + I_L(t) Z_0}$$

Circuito equivalente



$$Z_L = C \Rightarrow V_c(t) = V_g - (V_g - V_i)\, e^{-t/\tau} \qquad \tau = Z_0 C$$
$$Z_L = L \Rightarrow I_L(t) = I_g - (I_g - I_i)\, e^{-t/\tau} \qquad \tau = \frac{L}{Z_0}$$

$$\rho(t) = \frac{V^-(t)}{V^+}$$

- RPS EN L.T.

Ec. del telegrafista en RPS

$$\boxed{\frac{\partial^2 V(z)}{\partial z^2} = \gamma^2 V(z)}$$

$$\boxed{\frac{\partial^2 I(z)}{\partial z^2} = \gamma^2 I(z)}$$

$\gamma^2 = Z \cdot Y$ Cte de propagación

$Z = R + j\omega L$
$Y = G + j\omega C$

$$\boxed{\gamma = \sqrt{(R+j\omega L)(G+j\omega C)} = \alpha + j\beta}$$

α: Cte de atenuación

β: Cte de fase

$$\boxed{\begin{aligned} V(z) &= V^+ e^{-\gamma z} + V^- e^{\gamma z} \\ I(z) &= I^+ e^{-\gamma z} + I^- e^{\gamma z} \end{aligned}}$$

$$\boxed{\begin{aligned} V^+ &= Z_0 I^+ \\ V^- &= -Z_0 I^- \end{aligned}} \qquad \boxed{Z_0 = \sqrt{\frac{R+j\omega L}{G+j\omega C}}}$$

- Atenuación de la L.T = $\alpha \cdot l$ [Nep] $\quad \boxed{1\,\text{Nep} = 8'686\,\text{dB}}$

* L.T IDEAL $\quad R = G = 0$

$$\boxed{Z_0 = \sqrt{L/C}} \qquad \boxed{\alpha = 0} \boxed{\beta = \omega\sqrt{LC}} \qquad \boxed{v_g = \frac{1}{\sqrt{LC}}}$$

$$\beta = \frac{2\pi f}{v_g} = \frac{2\pi}{\lambda}$$

* L.T ECUALIZADA (SIN DISTORSIÓN)

↳ La atenuación α no depende de la frecuencia

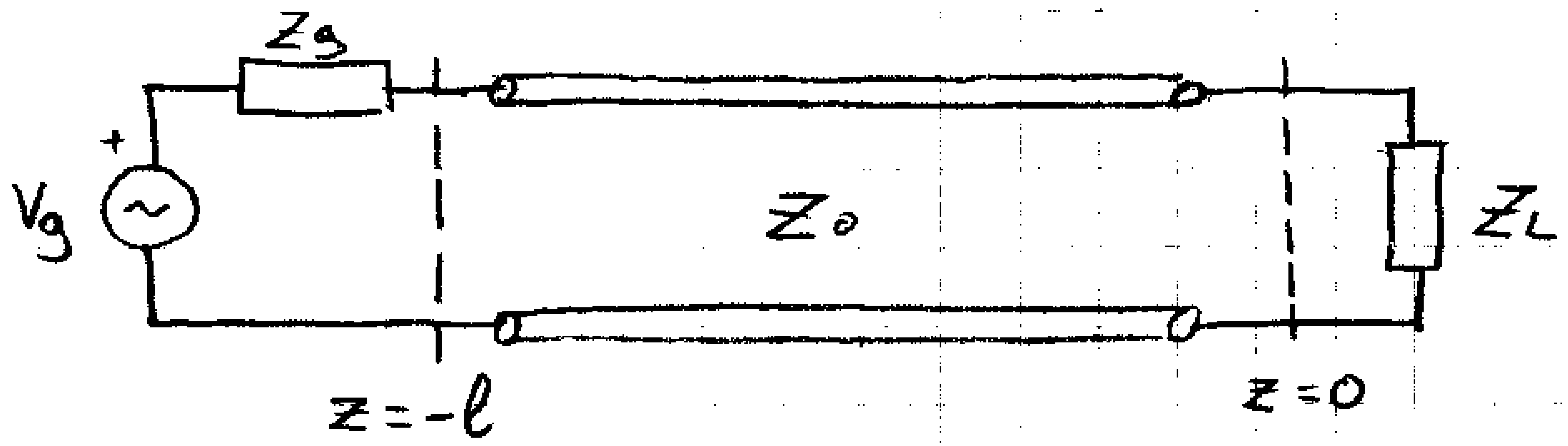
$$\boxed{\frac{R}{L} = \frac{G}{C}} \qquad \boxed{\alpha = R\sqrt{C/L}} \boxed{\beta = \omega\sqrt{LC}}$$

$$\boxed{Z_0 = \sqrt{L/C}} \qquad \boxed{v_p = \frac{1}{\sqrt{LC}}}$$

* L.T de bajas perdidas

$$\boxed{\frac{R}{\omega L} << 1} \qquad \boxed{\frac{G}{\omega C} << 1} \quad \Rightarrow \quad \boxed{Z_0 \approx \sqrt{L/C}}$$

$$\boxed{\beta \simeq \omega\sqrt{LC}} \qquad \boxed{\alpha \simeq \frac{R}{2Z_0} + \frac{GZ_0}{2}} = \frac{R}{2}\sqrt{\frac{C}{L}} + \frac{G}{2}\sqrt{\frac{L}{C}}$$



$$\boxed{\rho_L = \rho(z=0) = \frac{Z_L - Z_0}{Z_L + Z_0}} \qquad \boxed{\rho(z) = \rho_L e^{2\gamma z}}$$

no se usa

$$\cancel{V^+ = V_g \frac{Z_{ent}}{Z_{ent}+Z_g} \frac{e^{-\gamma\ell}}{1+\rho_L e^{-2\gamma\ell}}} \qquad \boxed{Z(z) = Z_0 \frac{1+\rho(z)}{1-\rho(z)}}$$

$$\boxed{V^- = \rho_L V^+}$$

* CARGA ADAPTADA $\quad Z_L = Z_0 \quad \Rightarrow \rho_L = 0, \; Z_{ent} = Z_0$

$$\boxed{V^+ = V_g \frac{Z_0}{Z_0 + R_g} e^{-\gamma\ell}}$$

* GENERADOR ADAPTADO $\quad Z_g = Z_0$

$$\boxed{V^+ = \frac{1}{2} V_g e^{-\gamma\ell}}$$

* POTENCIA EN UNA L.T.

$$P(z) = \frac{|V^{+}|^2}{Z_0} e^{-2\alpha z} \left(1 - |\rho(z)|^2\right) = P^{+}(z) - P^{-}(z)$$

$$P^{+}(z) = \frac{|V^{+}|^2}{Z_0} e^{-2\alpha z} \qquad P^{-}(z) = \frac{|V^{-}|^2}{Z_0} e^{+2\alpha z}$$

- L.T. sin perdidas $\quad \alpha = 0 \quad \Rightarrow P(z) = P^{+}(1 - |\rho_L|^2)$

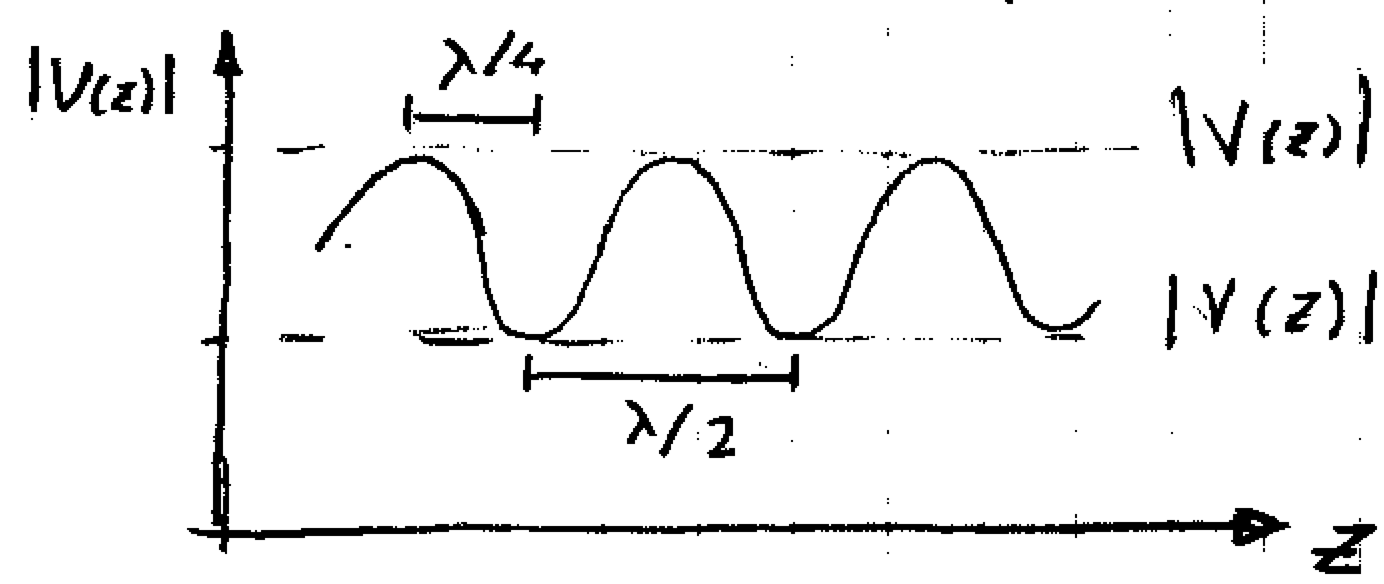
Si el generador esta adaptado a la carga:

$$\boxed{P^{+}(z=-\ell) = P^{+}(z) = P_{disp} = \frac{V_g^2}{4R_g}}$$

* L.T. IDEAL

$$\boxed{\rho(z) = \rho_L e^{j2\beta z} = \rho_L e^{j2\frac{2\pi}{\lambda}z} = \rho_L e^{j\frac{4\pi}{\lambda}z}} \qquad \lambda = v_p/f$$

$|I(z)|, |V(z)| \Rightarrow \lambda/2$ periódicas



$$|V(z)|_{max} = |V^{+}|(1 + |\rho_L|)$$

$$|V(z)|_{min} = |V^{+}|(1 - |\rho_L|)$$

* RELACIÓN DE ONDA ESTACIONARIA (ROE)

$$\boxed{ROE = \frac{|V|_{max}}{|V|_{min}} = \frac{1 + |\rho_L|}{1 - |\rho_L|}} \qquad 1 \leq ROE < \infty$$

$$\boxed{|\rho_L| = \frac{ROE - 1}{ROE + 1}}$$

* PERDIDAS POR RETORNO

$$\boxed{L_{ret} = -20 \log |\rho_L|} \ (dB)$$

Resolución de problemas en líneas de bajas pérdidas

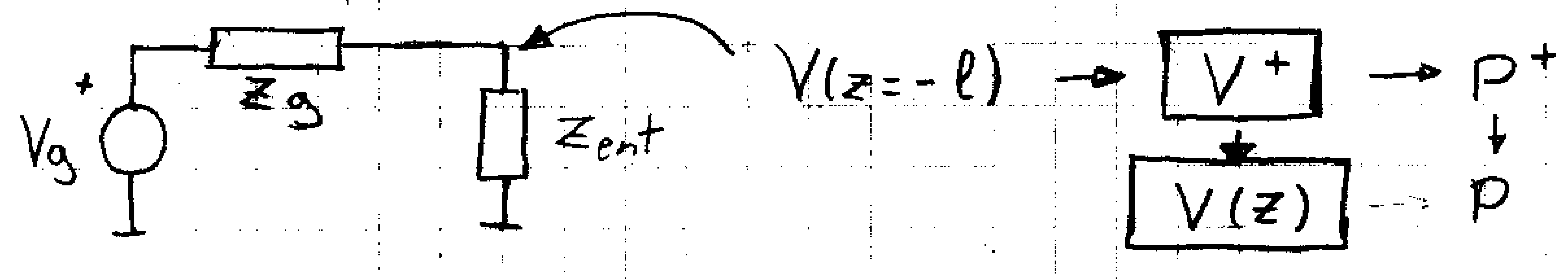
① Comprovar si la carga o generador estan adaptados si lo estan, aplicaremos las formulas simplificadas

$$Z_g = Z_0 \Rightarrow V^+ = \frac{1}{2} V_g e^{-\gamma \ell} \quad ; \quad P^+ = P_{disp} = \frac{V_g^2}{4R_g}$$

$$Z_L = Z_0 \Rightarrow V^+ = V_g \frac{Z_0}{Z_0 + R_g} e^{-\gamma \ell} \quad ; \quad P^- = 0$$

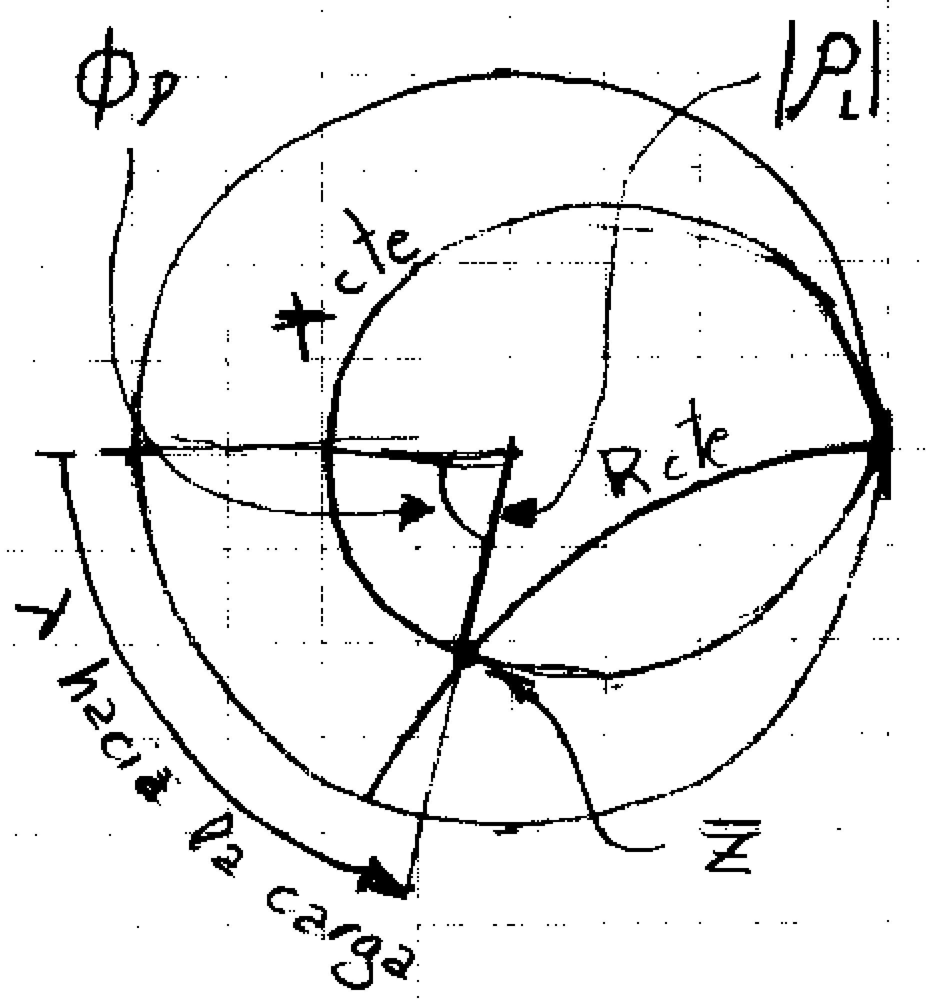
② Si ninguna de las dos estan adaptadas

- Tension a la entrada: $V(z=-\ell) = V^+ e^{-\gamma z} \left(1 + \rho_L e^{2\gamma z}\right)$
- Impedancia de entrada: $\rho_{ent} = \rho_L e^{-2\gamma \ell}$; $Z_{ent} = Z_0 \dfrac{1 + \rho_{ent}}{1 - \rho_{ent}}$
- Circuito equivalente :



$$I(z) = \frac{1}{Z_0} V^+ e^{-\gamma z} \left(1 - \rho_L e^{2\gamma z}\right)$$

- LA CARTA DE SMITH



Formulas útiles

$$\boxed{\overline{Z}(l) = \frac{Z(l)}{Z_0}} \qquad \boxed{\rho = \frac{\overline{Z}-1}{\overline{Z}+1} = -\frac{\overline{Y}-1}{\overline{Y}+1}}$$

$$\boxed{ROE = \frac{|V|_{max}}{|V|_{min}} = \frac{1+|\rho|}{1-|\rho|}} \qquad \boxed{|\rho| = \frac{ROE-1}{ROE+1}}$$

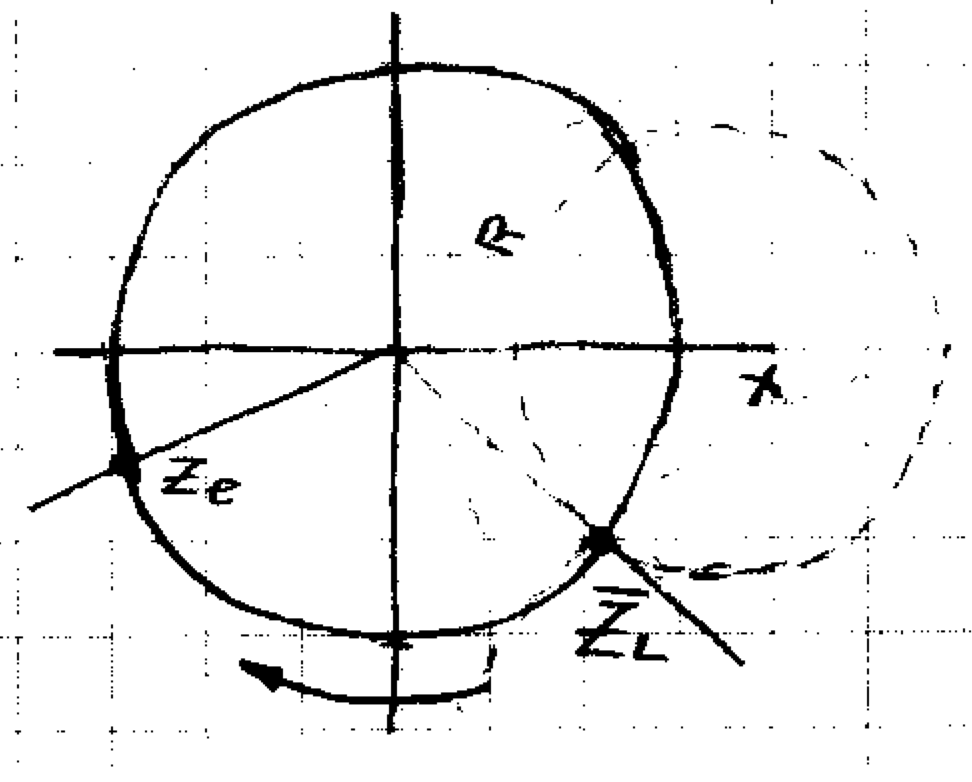
$$\boxed{\begin{array}{l} ROE = \overline{Z}_{max} \Rightarrow |V|_{max} \\ 1/ROE = \overline{Z}_{min} \Rightarrow |V|_{min} \end{array}}$$

- **Resolución cálculo impedancia de entrada**

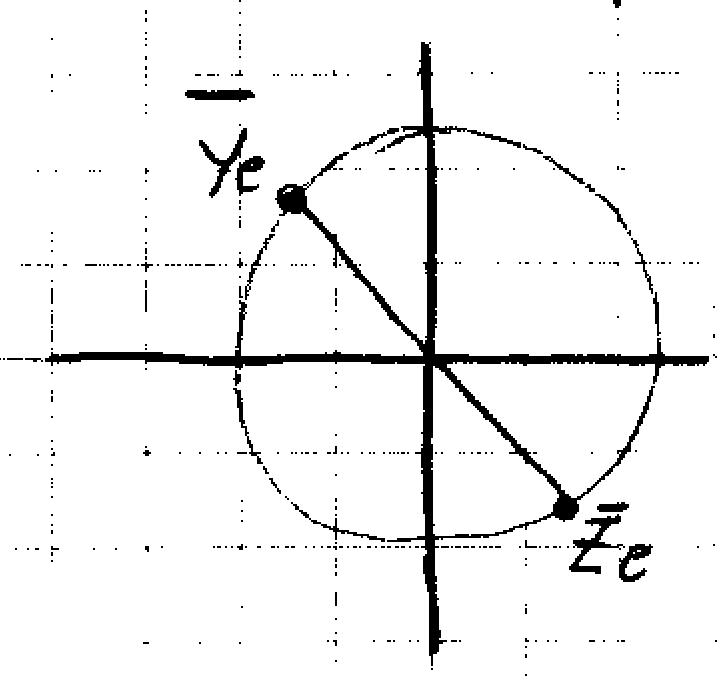
① Dibujamos la impedancia normalizada de la carga.

② Nos desplazamos l longitudes de onda $[\lambda]$ hacia el generador, y en ese punto tenemos $\overline{Z}_e$

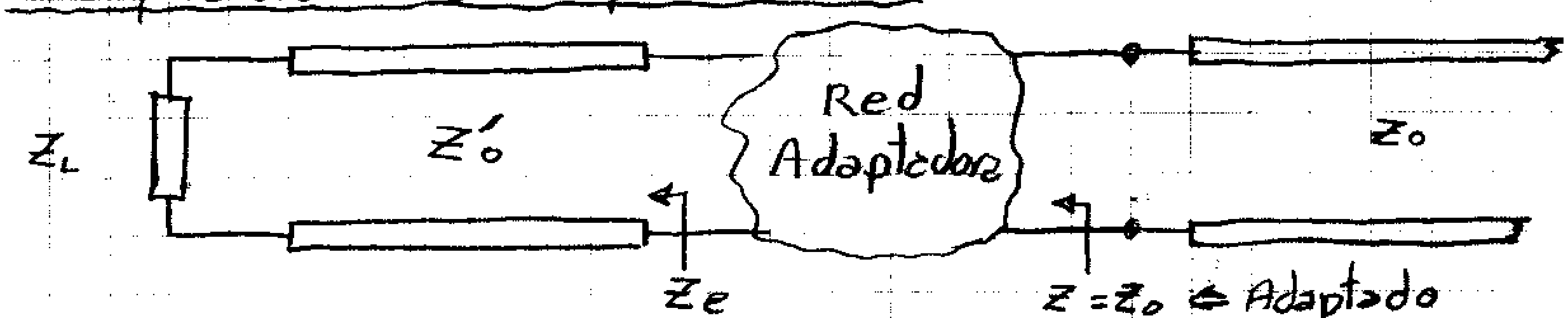
③ Desnormalizamos la impedancia de entrada.



Para calcular $\overline{Y}_e$ desplazamos 180° $\overline{Z}_e$



- **Adaptación de impedancias**



① Calcular $\overline{Z}_e$ (para adaptar con componentes en serie)
" " $\overline{Y}_e$ (" " " paralelo)

② De la circumferencia de las posibles $\overline{Z}_e$, $\overline{Y}_e$ seleccionamos los dos valores que intersecten con la circumferencia $R=1$

③ Seleccionamos uno de los dos puntos en función de si adaptamos con $\begin{cases} C \Rightarrow X<0 \ ; \ B>0 \\ L \Rightarrow X>0 \ ; \ B<0 \end{cases}$

Tema 3: Guias de onda

- En una guia de ondas solo se propagan los modos TE, TH.

Modos TE ($E_z = 0$)

$$\boxed{\beta = \sqrt{k^2 - k_c^2} = k\sqrt{1-\left(f_c/f\right)^2}}$$

$\boxed{f_c < f}$ para que haya propagación

Superposición ondas en la guia — Onda incidente — Ondas propagables en la guia (segun geometria)

$$\boxed{\lambda_g = \frac{2\pi}{\beta}} \qquad \boxed{\frac{1}{\lambda^2} = \frac{1}{\lambda_c^2} + \frac{1}{\lambda_g^2}} \qquad \boxed{k = \omega\sqrt{\mu\varepsilon}} \qquad \boxed{\eta = \sqrt{\mu/\varepsilon}}$$

$\eta_0 = 120\pi$

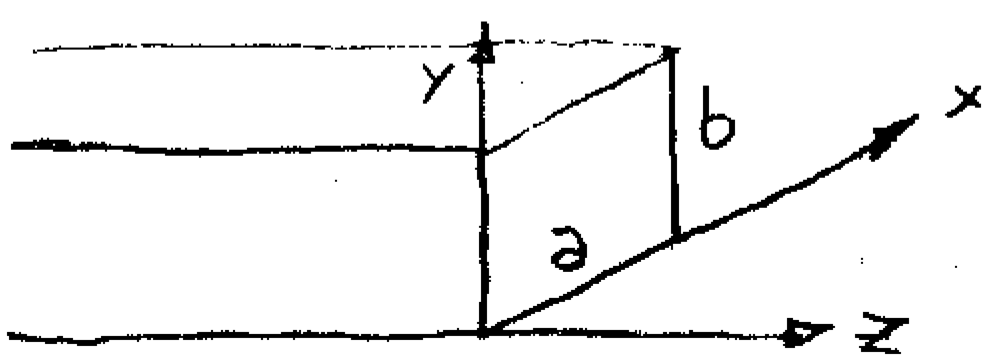
$$\boxed{Z_{TE} = \frac{\omega\mu}{\beta} = \frac{\eta}{\sqrt{1-\left(f_c/f\right)^2}}}$$

Impedancia de la guia

Modos TM (Todo IDEM TE)

$$\boxed{Z_{TM} = \frac{\beta}{\omega\mu} = \frac{\sqrt{1-\left(f_c/f\right)^2}}{\eta}}$$

* Guia rectangular



$a > b$

$$k_c^2 = k_x^2 + k_y^2$$

$$k_x = \frac{m\pi}{a} \qquad k_y = \frac{n\pi}{b}$$

$$\boxed{K_{c_{mn}} = \sqrt{\left(\frac{m\pi}{a}\right)^2 + \left(\frac{n\pi}{b}\right)^2}} \qquad f_{c\,mn} = \frac{v_p}{2\pi}\sqrt{\left(\frac{m\pi}{a}\right)^2 + \left(\frac{n\pi}{b}\right)^2}$$

- El primer modo posible es el TE_{10}, TM_{10}

- Equivalencia con una línea de transmisión

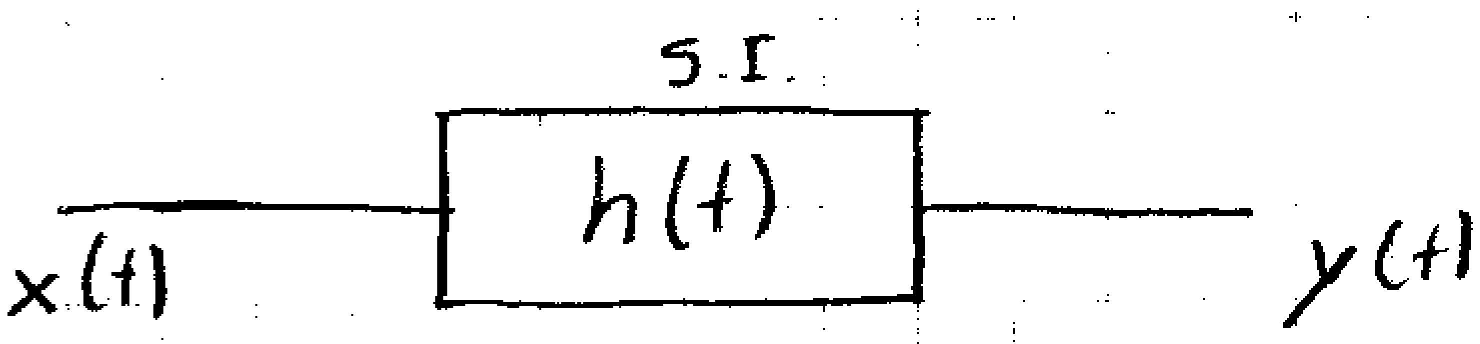
$$E_y = E_y^+ + E_y^- = E_0^+\,(1+\rho(z))\sin\frac{\pi x}{a}\,e^{-j\beta z}$$

$$\boxed{\rho(z) = \rho(0)\,e^{j2\beta z}} \qquad \boxed{\rho(0) = \rho_L = E_0^-/E_0^+}$$

$$\boxed{P_L = P^+ - P^- = P^+\left(1-|\rho_L|^2\right)} \qquad \boxed{P^+ = \frac{1}{2}\,ab\,\frac{|E_0^+|^2}{Z_{TE_{10}}}}$$

- Resto formulas IDEM linea transmisión

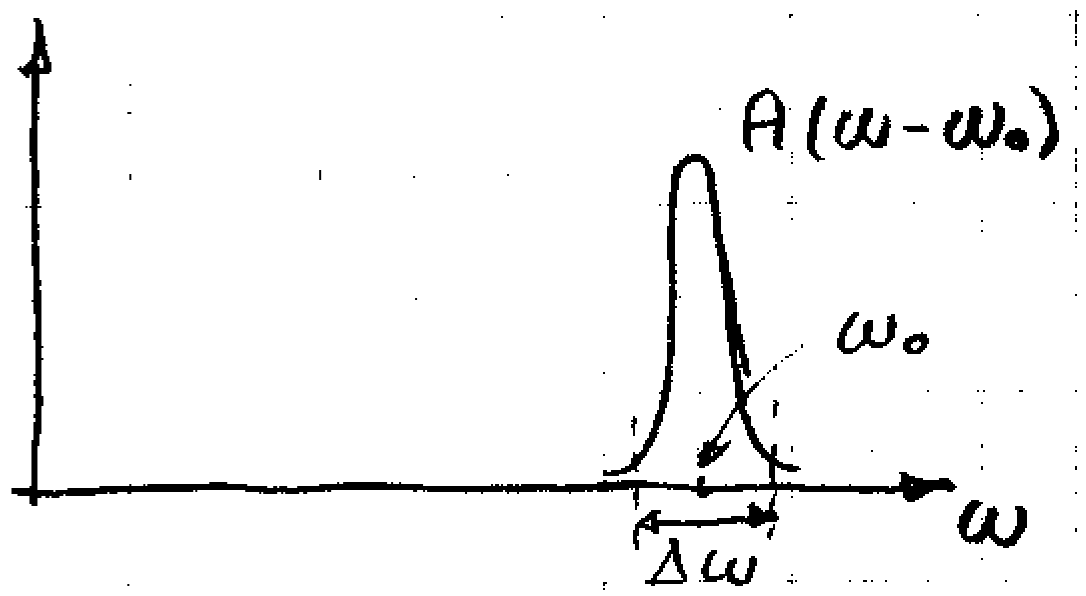
- DISPERSIÓN EN GUIAS DE ONDA



$H(\omega) = |H(\omega)|\, e^{-j\beta(\omega) z}$

No distorsion $\Rightarrow \begin{cases} |H(\omega)| = cte \\ \beta(\omega) \propto \omega \end{cases}$

- Señales de bda limitada en Guias de onda:



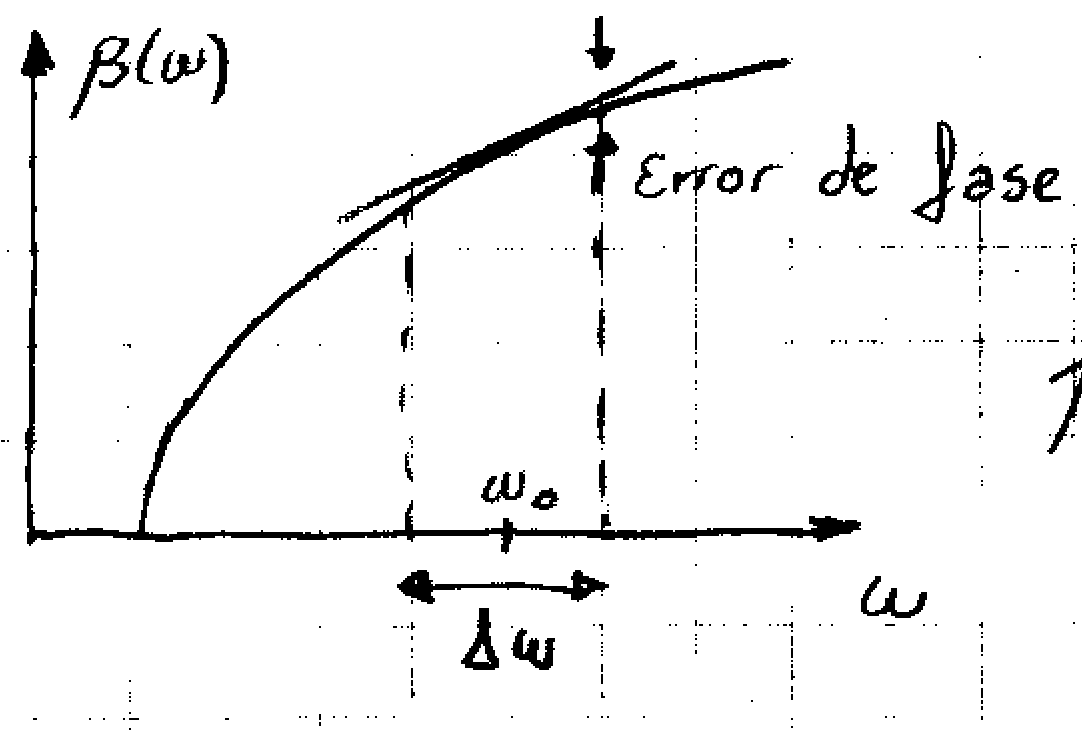
$\Delta\omega \ll \omega_0$

$$\boxed{\vec{E}(\vec{r},t) = \vec{E}_R(x,y)\, a(t - z/v_g)\cos(\omega_0 (t - z/v_f))}$$

Vel. de grupo $\boxed{v_g = \dfrac{1}{\left.\dfrac{d\beta}{d\omega}\right|_{\omega=\omega_0}} = v_p\sqrt{1-(f_c/f_0)^2}}$

Vel. de fase $\boxed{v_f = \left.\dfrac{\omega}{\beta}\right|_{\omega=\omega_0} = \dfrac{v_p}{\sqrt{1-(f_c/f_0)^2}}}$

- Dispersión de fase



$$\beta(\omega) = \beta_0 + \beta_1 \cdot (\omega - \omega_0) + \frac{1}{2}\beta_2 (\omega - \omega_0)^2$$

Long. de dispersión

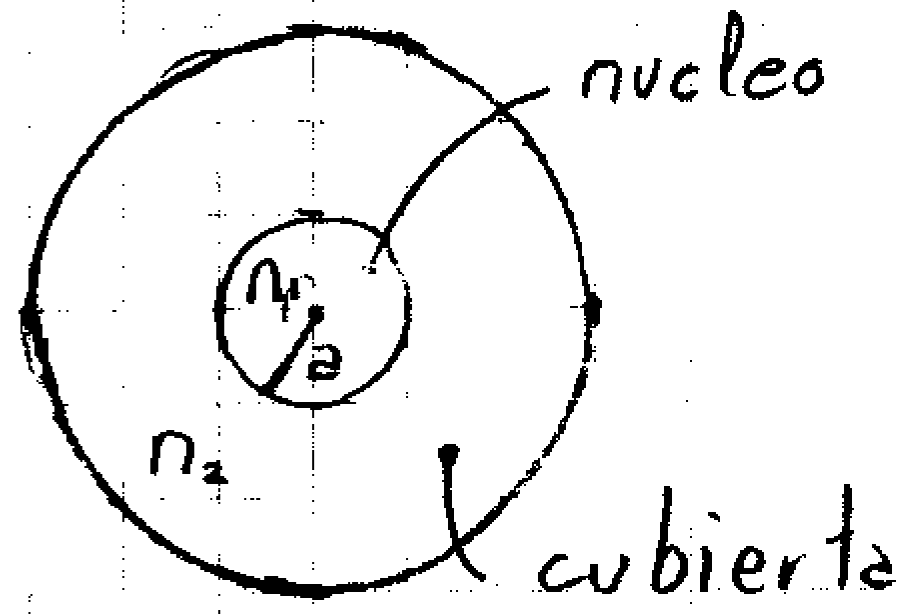
$\frac{1}{2}\beta_2 (\omega - \omega_0)^2 \cdot L_D \ll 1\,rad \Leftarrow$ Dispersión despreciable

$$\boxed{L_D = \frac{2}{\beta_2 (\Delta\omega/2)^2}}$$

$l_{max} \ll L_D$

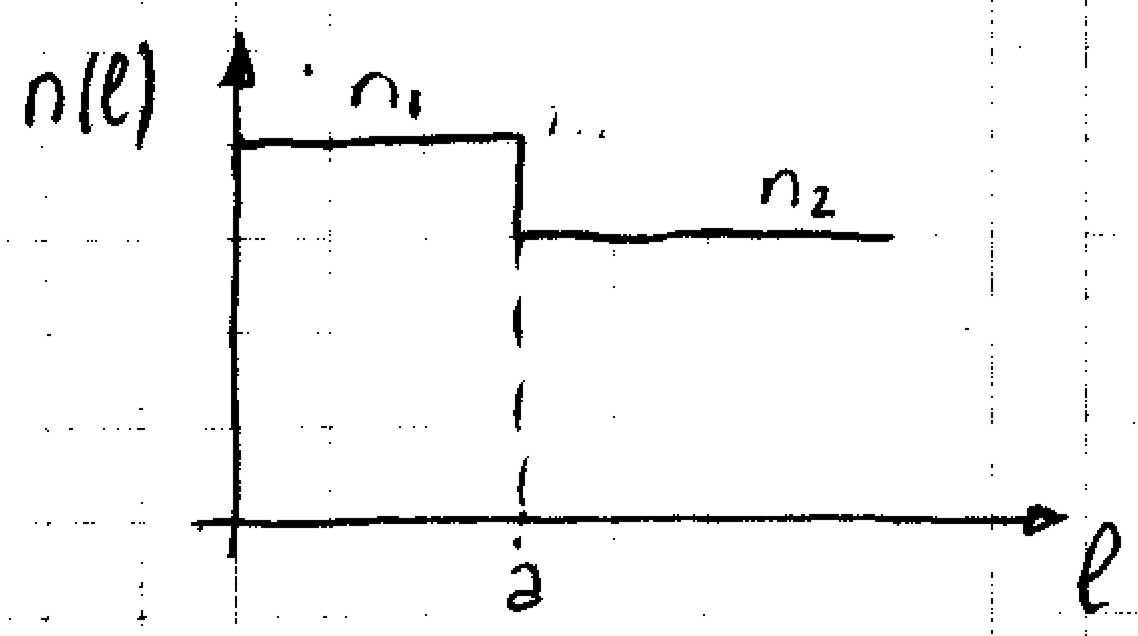
$$\beta_2 = \left.\frac{d^2\beta}{d\omega^2}\right|_{\omega=\omega_0} = \frac{1}{\beta_0 v_p^2}\left(1 - \frac{\omega_0^2}{\beta_0^2 v_p^2}\right)$$

FIBRAS ÓPTICAS

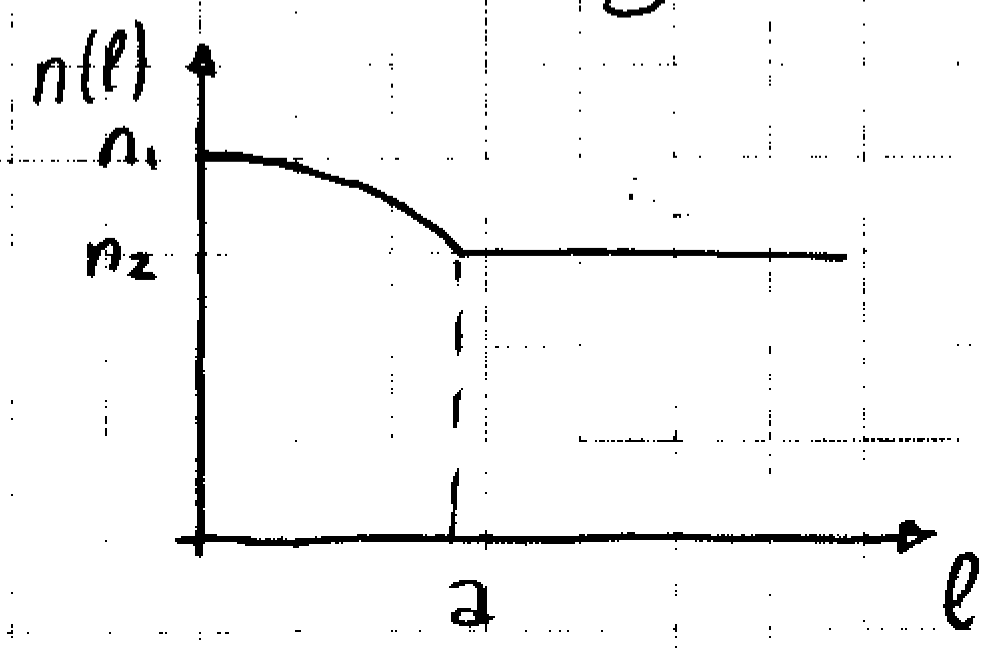


Reflexion total si $n_1 > n_2$

- Fibra de salto de índice



- Fibra de gradiente de índice



$$\boxed{\Delta = \frac{n_1^2 - n_2^2}{2n_1^2}}$$

$$n^2(\ell) = n_1^2\left[1 - (\ell/a)^{\ell}\Delta\right]$$

FREC. NORMALIZADA $\Rightarrow$ $\boxed{V = K_0 a\sqrt{n_1^2 - n_2^2}}$

MODO FUNDAMENTAL $\Rightarrow$ $\boxed{V < 2'408}$

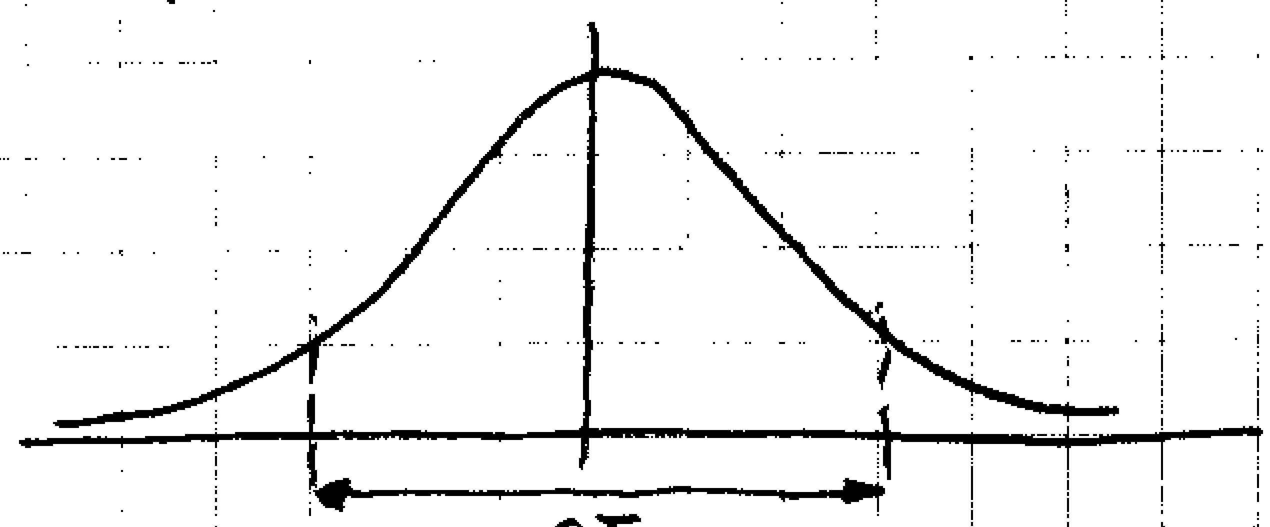
- Potencia en fibras ópticas

$$\boxed{\frac{w}{a} = 0'65 + \frac{1'619}{V^{3/2}} + \frac{2'879}{V^6}}$$

$$\boxed{\frac{P_{NUCLEO}}{P_{TOTAL}} = 1 - e^{-2(a/w)^2}}$$

Atenuación $\Rightarrow$ $\boxed{P(z) = P(0)e^{-2\alpha z}}$

- Dispersión en fibras monomodo



Pulsos gausianos $\sigma_0 = \frac{T_0}{\sqrt{2}}$

$$\boxed{\Delta f = -\frac{c}{\lambda^2} \Delta\lambda}$$

• Ancho del pulso recibido (T_1)

$$\boxed{T_1^2 = T_0^2 + \left(\frac{\beta_2 L}{T_0}\right)^2}$$

$$\boxed{\beta_2 = \frac{\lambda^2}{2\pi c} D} \qquad \boxed{D = \frac{d}{d\lambda}\left(\frac{1}{v_g}\right)} \qquad D = \frac{\beta_2}{T_0 \Delta\lambda}$$

• Fuente de luz no ideal

$$\boxed{\delta\omega = 2W_s}$$

$$\boxed{T_1^2 = T_0^2 + \left(\frac{\beta_2 z}{T_0}\right)^2 \left[1 + \left(\frac{W_s}{W_0}\right)^2\right]}$$

• Maxima velocidad de transmisión

$$\boxed{T_{bit} = 4\sigma_1}$$

TEMA 4: PARÁMETROS DE ANTENAS

- PARÁMETROS DE ANTENAS EN TRANSMISIÓN

$$\boxed{Z_L = (R_r + R_\Omega) + jX_L}$$

R_r : Resistencia de radiación
R_Ω : " " perdidas

$$\boxed{\eta_L = \frac{P_{RADIADA}}{P_L} = \frac{R_r}{R_r + R_\Omega}}$$

Eficiencia de la antena

$$\boxed{\mathcal{P}(\theta,\phi) = \frac{|E_\theta|^2 + |E_\phi|^2}{\eta}}$$

$$\boxed{P_{rad} = \int_S \mathcal{P}(\theta,\phi)\, dS = \int_0^{2\pi}\int_0^{\pi} \mathcal{P}(\theta,\phi)\, r^2 \sin\theta \, d\theta\, d\phi}$$

◦ Diagrama de radiación de una antena

$$\boxed{t(\theta,\phi) = \left.\frac{\mathcal{P}(\theta,\phi)}{\mathcal{P}_{max}}\right|_{r=cte}}$$

- Representación:

PLANO E
- Dirección $\mathcal{P}_{max}$
- Dirección $\vec{E}$

PLANO H
- $\perp$ Plano E
- Dirección de $\vec{H}$

Directividad $\boxed{D(\theta,\phi) = \frac{\mathcal{P}(\theta,\phi)}{P_{rad}/4\pi r^2}}$ $\boxed{D = \frac{\mathcal{P}_{max}}{P_{rad}/4\pi r^2} = \frac{4\pi}{\Delta\theta_{E-3dB} \cdot \Delta\theta_{H-3dB}}}$

$$\boxed{G(\theta,\phi) = \eta_L D(\theta,\phi)}$$

Ganancia de la antena

- Polarización de las antenas

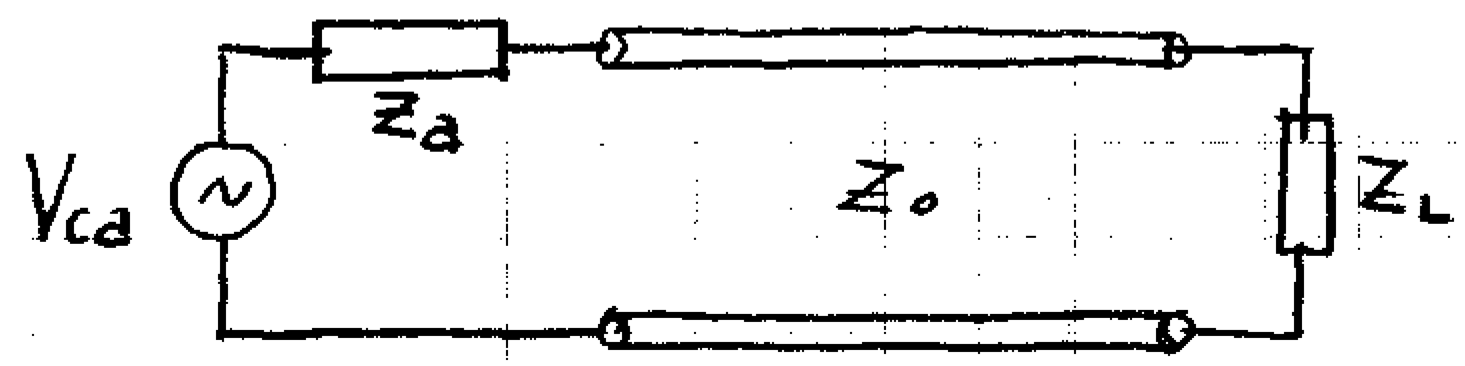
◦ La polarización de una antena se define como la polarización de la onda radiada en la dirección del máximo.

◦ Coef. de perdidas por polarización

$$\boxed{C_p = |\hat{e}_T \cdot \hat{e}_R|^2}$$

$\hat{e}_R$: Pol. señal recibida
$\hat{e}_T$: Pol. antena RX (si transmitiera)

- PARAMETROS DE ANTENAS EN RECEPCIÓN



$$\boxed{P_{Lmax} = \frac{|V_{ca}|^2}{4R_a}}$$ Todo adaptado

$$\boxed{C_a = \frac{4R_a R_L}{(R_a+R_L)^2+(X_a+X_L)^2}}$$ Coef. de desadaptación

$$\boxed{P_L = P_{Lmax}\cdot C_a}$$
Caso $Z_L = Z_o$

$$\boxed{P_L = P_L(1-|\rho|^2)}$$
Caso $Z_a = Z_o$

$$\boxed{A_{ef} = \frac{P_{Lmax}}{\mathcal{P}} = \frac{|V_{ca}|^2/4R_a}{|E|^2/\eta} = \frac{\lambda^2}{4\pi}D}$$
Area efectiva

$$\boxed{L_{ef} = \frac{|V_{ca}|}{|E|}}$$
long. Efectiva

$$\boxed{\mathcal{P}(\theta,\phi) = \frac{P_{rad}\cdot D(\theta,\phi)}{4\pi r^2} = \frac{P_{ent}\cdot G(\theta,\phi)}{4\pi r^2} = \frac{PIRE}{4\pi r^2}}$$

$$\boxed{P_L = \frac{P_{rad}\cdot D_{TX}}{4\pi r^2}\cdot A_{ef_{RX}}}$$ Ec. de transmisión de Fris

Perdidas en transmisión (Fórmula ampliada)

$$\boxed{\frac{1}{L} = \frac{P_L}{P_{rad}} = \left(\frac{\lambda}{4\pi r}\right)^2 D_T D_R C_p C_a C_m \eta_L}$$

- ECUACIÓN DEL RADAR

$$\boxed{\sigma = \frac{P_{reflejada}}{P_{incidente}}}$$ Sección recta radar

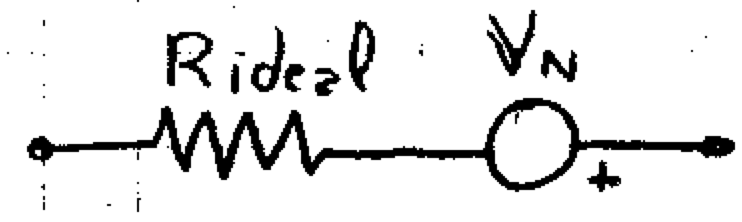
PIRE

$$\boxed{P_L = \left(\frac{P_{rad}D_T}{4\pi R_1^2}\right)\sigma\frac{1}{4\pi R_2^2}A_{ef_R}}$$

Radar monoestático
$R_1 = R_2$

– Ruido en el Receptor

- Resistencia ruidosa:



$$\boxed{P_N = K\,T_a\,B}$$

- Atenuador ruidoso

$$\boxed{P_N = K\,T_{amb}\left(1-\frac{1}{L}\right)B}$$

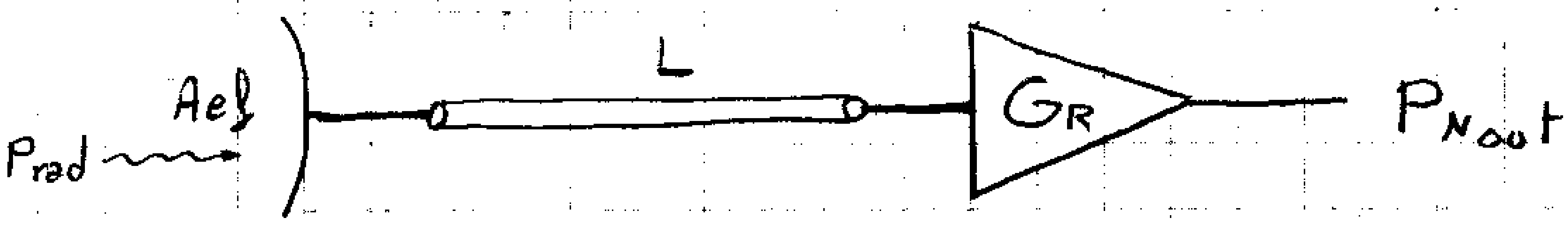
linea transmisión $\frac{1}{L} = \eta_L$

- Amplificador ruidoso

$$\boxed{P_N = G\,K\,T_o(F-1)\,B}$$

$T_o = 290K$

* *Ejemplo*



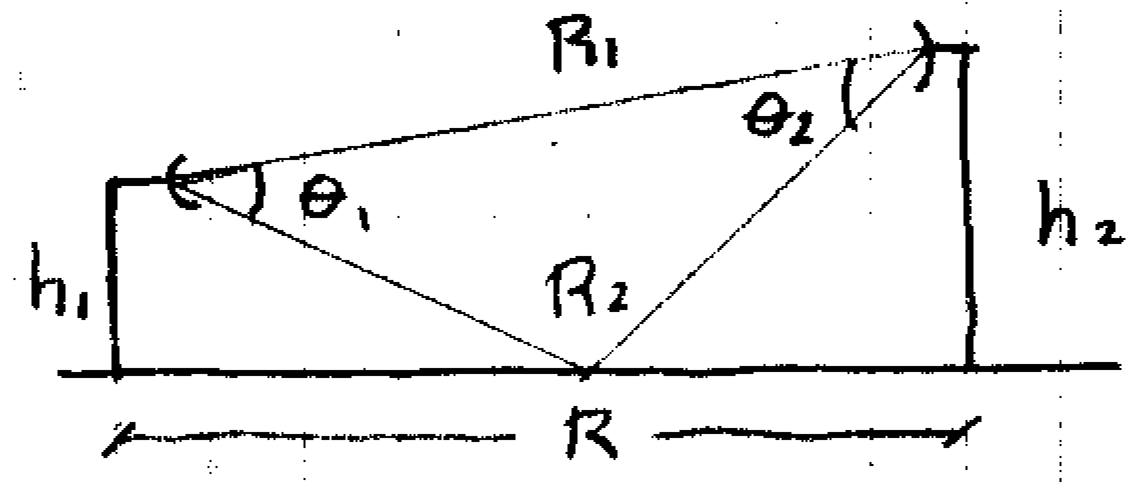
$$\boxed{S_{out} = \frac{P_{rad}\cdot D_T}{4\pi r^2} A_{ef_R}\cdot\frac{1}{L}\cdot G_R}$$

$$\boxed{N_{out} = G_R\,K\,B\left[T_a\frac{1}{L} + T_{amb}\left(1-\frac{1}{L}\right) + T_o(F_R-1)\right]}$$

$$\boxed{\left(S/N\right)_{dB} = 10\log\frac{S_{out}}{N_{out}}}$$

TEMA 5: PROPAGACIÓN

- REFLEXIÓN EN TIERRA PLANA



Si $R \gg h$ $\quad \theta_1 \approx \theta_2 \approx 0$

$$R_1 \simeq R + \frac{(h_2-h_1)^2}{2R}$$

$$R_2 \simeq R + \frac{(h_2+h_1)^2}{2R}$$

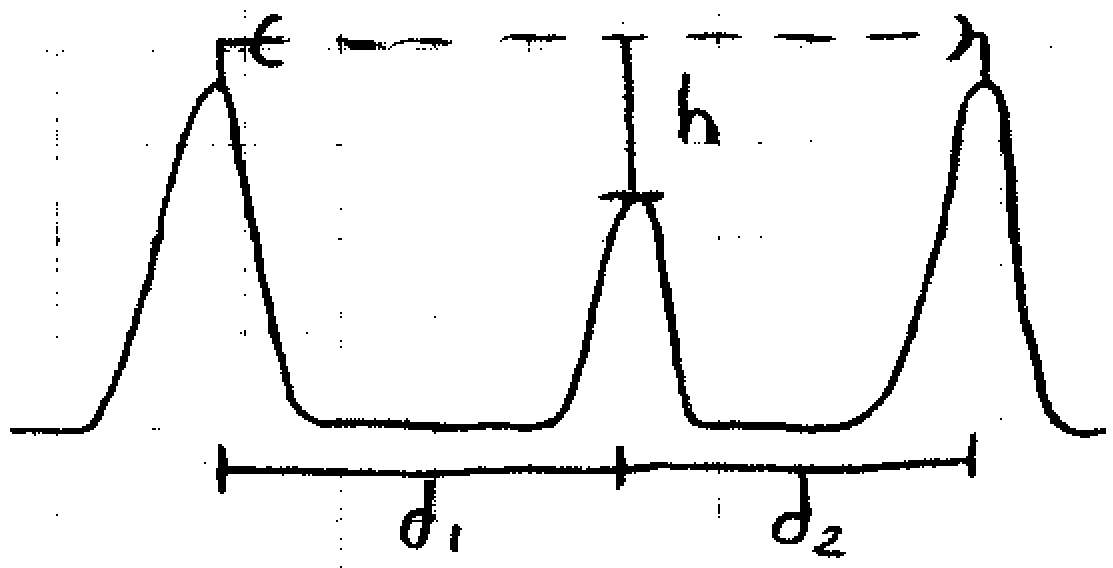
$$\boxed{\frac{V_{ca}}{V_{ca}^{d}} = 1 + \sqrt{\frac{D_1(\theta_1)\,D_2(\theta_2)}{D_1(0)\,D_2(0)}}\;\underbrace{|\rho|\,e^{j\varphi}}_{\text{coef. reflexión tierra} \approx -1}\;e^{-jk(R_2-R_1)}}$$

$V_{ca} = V_{ca}^{directo} + V_{ca}^{reflejado}$

$$\boxed{\left|\frac{V_{ca}}{V_{ca}^{d}}\right| \simeq 2\left|\sin \frac{k h_1 h_2}{R}\right|}$$

Formula aproximada para $h \ll R$

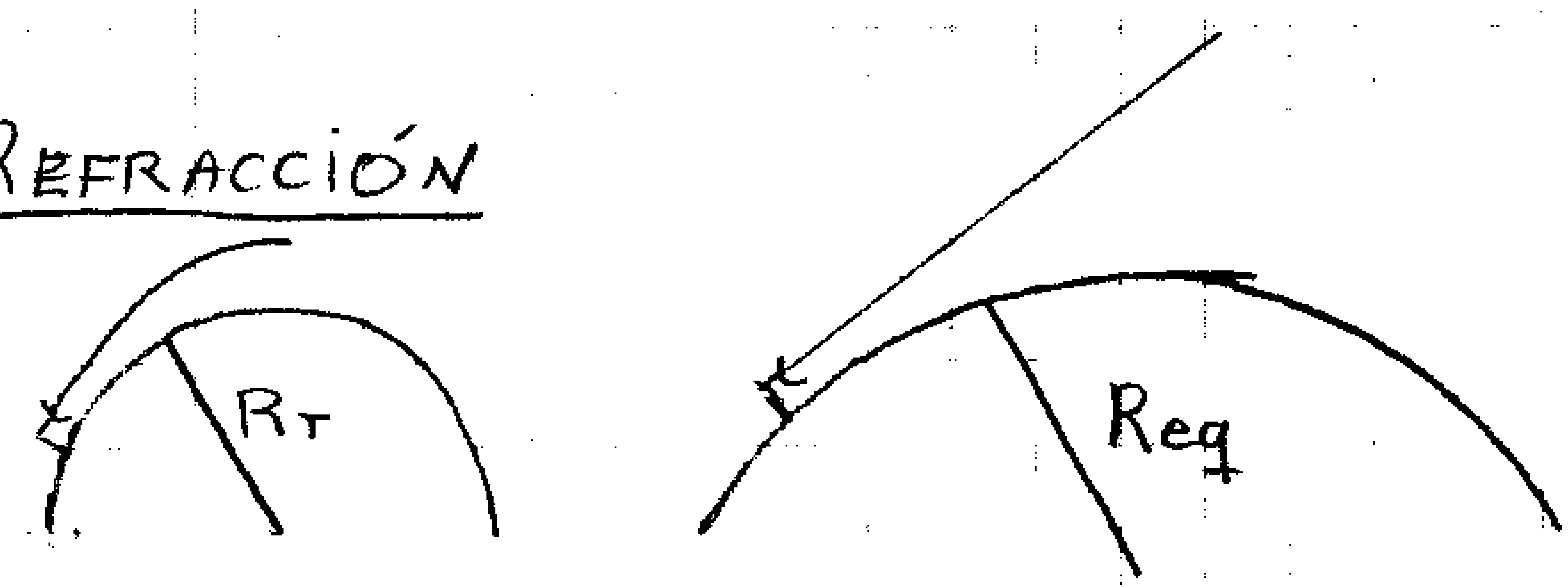
- DIFRACCIÓN



$$\boxed{R_1 = \sqrt{\lambda \frac{d_1\, d_2}{d_1 + d_2}}} \qquad \boxed{L_{DIF}\left(h/R_1\right)}$$

- En las tablas encontramos la atenuación L en función de h/R_1
- h negativo si sobrepasa la trayectoria

- REFRACCIÓN



$$\boxed{R_{eq} = \frac{4}{3} R_T \simeq 8500\,\text{Km}}$$

- Utilizando una Tierra de radio mayor al real podemos obviar el efecto de refracción