$\vec{v}_A = \frac{q\,\tau \vec{E}}{m} = \mu \vec{E}$ ('MOVILIDAD')

$I = \iint_A \vec{J}\, d\vec{s}$

$I(t) = \frac{dq}{dt} = n q A v_A$ $[I] = \frac{C}{s} = A$ $[\vec{J}] = A/m^2$

$\forall S'$ CERRADA $\Rightarrow \oint_{S'} \vec{J}\, d\vec{s} = 0 \vee \vec{\nabla}\vec{J} = 0$

$I // \vec{J} \Rightarrow |\vec{J}| = \frac{I}{A} \Rightarrow \vec{J} = \frac{n q^2 \tau \vec{E}}{m}$; $\sigma = \rho^{-1}$

$\sigma_1 < \sigma_2 \Rightarrow \rho_1 > \rho_2$

$\uparrow T \Rightarrow \downarrow \tau \Rightarrow \downarrow v_A \Rightarrow \downarrow I \Rightarrow \downarrow \sigma \Rightarrow \uparrow \rho$

$(\uparrow l \Rightarrow \uparrow R) \wedge (\downarrow A \Rightarrow \uparrow R)$ $R = \frac{\rho l}{A} = \frac{l}{A\sigma}$ $\Delta V = RI$ $[R] = \Omega$ $[P] = \frac{J}{s} = W$(ATTS)

$V_{PILA} = \mathcal{E} = \frac{C\Delta V^2}{2} = \frac{Q^2}{2C}$, $V_{CAPACITOR} = Q/C$, $V_{RESISTENCIA} = IR$

LEY DE NODOS $\rightarrow \sum_{i=1} I_i = 0$ (CON SIGNO)

LEY DE MALLAS $\rightarrow \sum \Delta V = 0$ (CON SIGNO)

TAMBIÉN SIRVE PARA COMPUTAR IMPEDANCIAS (Z_{eq}) DE DIF. COMPONENTES

$\exists \{R_1, \dots, R_n\} / R_1 \Sigma R_2 \Sigma \dots \Sigma R_n \Rightarrow R_{eq} = \sum_{i=1}^{n} R_i$

$\exists \{R_1, \dots, R_n\} / R_1 // R_2 // \dots // R_n \Rightarrow R_{eq}^{-1} = \sum_{i=1} R_i^{-1}$

$P_{PILA} = I V_{PILA}$

$P_{RESISTENCIA} = \frac{\Delta V_{RESISTENCIA}^2}{R}$

$P_{ENTREGADA} = P_{DISIPADA} + P_{ABSORBIDA} \Leftrightarrow$ SOLO CON EL CIRCUITO COMPLETO

$\Rightarrow \sum_{k=1}^{\alpha} I_k \mathcal{E}_k = \sum_{i=1}^{\beta} I_i^2 R_i + \sum_{j=1}^{\gamma} I_j \mathcal{E}_j$

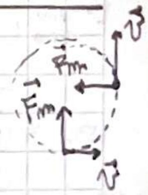
$V_{TIERRA} = 0 \Rightarrow I_{TIERRA} = 0$

ENTREGA

ABSORBE

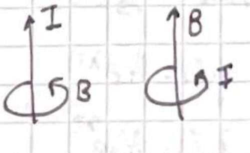
$I_A \Sigma I_B \Rightarrow I_A = I_B$ $E|_{[kWh]} = \text{POTENCIA}|_{[W]} \times \text{HORAS}/1000$

$\oint_S \vec{B}\, d\vec{s} = 0 \Rightarrow \vec{\nabla}\vec{B} = 0$ $\vec{F}_{m_{Aj}} = q(\vec{v} \times \vec{B}) / W_{\vec{F}_m} = 0 \wedge \vec{F}_m // \check{m}$



$\vec{F}_L = q\vec{E} + q(\vec{v} \times \vec{B})$ TRAYECTORIA HELICOIDE (MCU + MRU) $/ \vec{B} = B_0 \check{j}, \vec{v} = v_x \check{i} + v_y \check{j}$

$\vec{F}_m = I \int_p^q d\vec{l} \times \vec{B} = I\, |\vec{r}_p - \vec{r}_q|\, B_0\, \check{m} \Leftrightarrow \vec{B}$ UNIFORME



K_m: 'CONSTANTE MAGNÉTICA' $= \frac{\mu_0}{4\pi} \Rightarrow \vec{B}(\vec{r}) \overset{\text{DISCRETO}}{=} \frac{\mu_0 q}{4\pi} \frac{\vec{v} \times (\vec{r} - \vec{r}')}{|\vec{r} - \vec{r}'|^3}$

$$\begin{cases} R = \frac{m v_\perp}{q B_0} \\ T = \frac{2\pi}{\omega} = \frac{2\pi m}{q B_0} \\ h = \frac{v_{//} 2\pi m}{q B_0} \end{cases}$$

$$\vec{B}(\vec{r}) = \begin{cases} K_m \int I \frac{d\vec{l} \times (\vec{r} - \vec{r}')}{|\vec{r} - \vec{r}'|^3} & \leftarrow 1D \\ K_m \iint \vec{k} \frac{d\vec{s} \times (\vec{r} - \vec{r}')}{|\vec{r} - \vec{r}'|^3} & \leftarrow 2D \\ K_m \iiint \vec{J} \frac{d\vec{v} \times (\vec{r} - \vec{r}')}{|\vec{r} - \vec{r}'|^3} & \leftarrow 3D \end{cases}$$

LEY DE AMPERE $\rightarrow \oint \vec{B}(\vec{r})\, d\vec{l} = \mu_0 I_{ENC}$

LEY DE AMPERE GENERALIZADA $\xrightarrow{\text{LIH}}$ $\begin{cases} \vec{B} = \mu_0 (\vec{H} + \vec{M}) \\ \vec{M} = \chi_m \vec{H} = \mu_0 \mu_r \vec{H} \end{cases}$

$I // \check{m} \Rightarrow +I$

$I \not// \check{m} \Rightarrow -I$

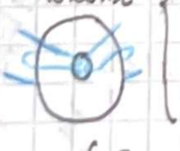
LEY DE AMPERE (PARA CORRIENTES ESTACIONARIAS) $\rightarrow \oint_{C} \vec{B}\, d\vec{l} = \mu_0 \{\Sigma I_{S(C)}\}$

$\vec{B}(\vec{r})|_{\text{ALAMBRE INFINITO}} = \frac{\mu_0 I}{2\pi r} \check{\varphi}$

n: 'DENSIDAD DE ESPIRAS' $= \frac{N}{L} \Rightarrow IN = I_{ENC} = \vec{B}_S(\vec{r}) = \int \cdots \int \vec{B}_{ESPIRA}(\vec{r})\, d\vec{l}\, N$ $\left\{ \vec{\nabla} \times \vec{E} = -\frac{d\vec{B}}{dt} \right\}$

$[\vec{B}] = T$ (ESLA) $[\vec{H}] = [\vec{M}] = A/m$ $\mu = \mu_r \mu_0 \wedge \mu_r|_{VACÍO} = 1$

TOROIDE $\begin{cases} \vec{B} = \frac{\mu_0 \mu_r N I}{2\pi r} \\ L = \frac{\mu_0 \mu_r N^2 S}{2\pi r} \end{cases}$



SOLENOIDE $\begin{cases} \vec{B} = \mu_0 \mu_r N I \check{z} / h \\ L = \mu_0 \mu_r N^2 S / (h r^2) \\ M = \mu_0 \mu_r N_1 N_2 S_{1/2} / l \end{cases}$

CILINDRO HUECO $\vec{B}$

$$\begin{cases} \mu_0 I_1 r \check{\varphi} / 2 & \leftarrow r < R_a \\ \mu_0 I_1 R_a^2 \check{\varphi} / 2r & \leftarrow R_a < r < R_b \\ \mu_0 [I_1 R_a^2 + I_2 (r^2 - R_b^2)] \check{\varphi} / 2r & \\ \mu_0 [I_1 R_a^2 + I_2 (R_c^2 - R_b^2)] \check{\varphi} / 2r & \leftarrow r > R_c \end{cases}$$

$R_b < r < R_c$

$\oint \vec{B}(\vec{r})\, d\vec{l} = \mu_0 (I_r + I_m) = \mu_0 \left(\oint \vec{H}(\vec{r})\, d\vec{l} + \oint \vec{M}(\vec{r})\, d\vec{l} \right) = \mu_0 (\vec{H} + \vec{M})$

$\mathcal{E}_{FEM} = -\frac{d\phi}{dt} = -\frac{d}{dt} \iint \vec{B}\, d\vec{s} = i_{IND} \cdot R$

$\frac{dB}{dt} > 0 \Rightarrow \frac{d\phi}{dt} > 0 \Rightarrow \mathcal{E} < 0 \Rightarrow \text{SIGN}(i_{IND}) = -\text{SIGN}(i)$

$\mathcal{E} < 0 \Rightarrow I_{IND} < 0 \Rightarrow$ LA CORRIENTE INDUCIDA VA EN LA DIRECCIÓN CONTRARIA QUE YO ASUMÍ

$\frac{dB}{dt} < 0 \Rightarrow \frac{d\phi}{dt} < 0 \Rightarrow \mathcal{E} > 0 \Rightarrow \text{SIGN}(i_{IND}) = \text{SIGN}(i)$

$\left\{ \tan(\varphi_i) = R\left(\omega C - \frac{1}{\omega L}\right) \right\}$

$\left\{ \bar{B} \in \text{ENTRANTE} \wedge \begin{array}{l} \left|\frac{d\phi}{dt}\right| > 0 \Rightarrow \bar{E} \in \text{SALIENTE} \\ \left|\frac{d\phi}{dt}\right| < 0 \Rightarrow \bar{E} \in \text{ENTRANTE} \end{array} \right.$ $\left\{ \bar{B} \in \text{SALIENTE} \wedge \begin{array}{l} \left|\frac{d\phi}{dt}\right| > 0 \Rightarrow \text{ENTRANTE} \\ \left|\frac{d\phi}{dt}\right| < 0 \Rightarrow \text{SALIENTE} \end{array} \right.$

$M = M_{12} = M_{21}$

$\mathcal{E}_{total} = N \cdot \mathcal{E}_{individual}$

$$\begin{cases} \mathcal{E}_{11} = -\frac{N_1 \phi_{11}}{dt} = -\frac{N_1 \phi_{11}}{di_1} \cdot \frac{i_1}{dt} = -L \frac{i_1}{dt} \\ \mathcal{E}_{21} = -\frac{N_2 \phi_{21}}{dt} = -\frac{N_2 \phi_{21}}{di_1} \cdot \frac{i_1}{dt} = -M \frac{i_1}{dt} \end{cases}$$

$U = \frac{LI^2}{2}$ $\quad \frac{df}{dt} \cong \frac{\Delta f}{\Delta t} = \frac{f(t_1) - f(t_0)}{t_1 - t_0} \Leftrightarrow \exists t_0, t_1, f(t_0), f(t_1)$

$[m] = N/L$

BORNES HOMÓLOGOS
$$\begin{cases} \mathcal{E} = -(L_1 + L_2 + 2M)\frac{di}{dt} \\ \mathcal{E}_1 = -L_1 \frac{di_1}{dt} - M \frac{di_2}{dt} \\ \mathcal{E}_2 = -L_2 \frac{di_2}{dt} - M \frac{di_1}{dt} \end{cases}$$

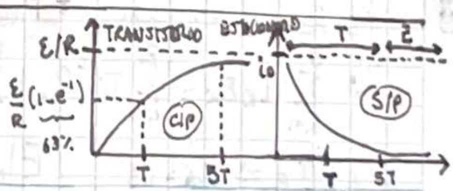
BORNES NO HOMÓLOGOS
$$\begin{cases} \mathcal{E} = -(L_1 + L_2 - 2M)\frac{di}{dt} \\ \mathcal{E}_1 = -L_1 \frac{di_1}{dt} + M \frac{di_2}{dt} \\ \mathcal{E}_2 = -L_2 \frac{di_2}{dt} + M \frac{di_1}{dt} \end{cases}$$

C/P = CON PILA

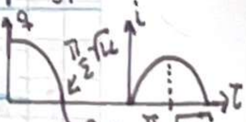
S/P = SIN PILA

$V_{\text{INDUCTANCIA}, L} = L \frac{di}{dt}$

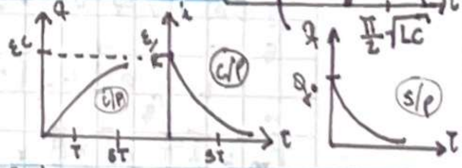
$[RL]$
$$\begin{cases} \text{C/PILA} \ \{ i(0) = 0, \quad i(t) = \frac{\mathcal{E}}{R}(1 - e^{-\frac{R}{L}t}) \\ \text{S/PILA} \ \{ i(0) = i_0, \quad i(t) = i_0 e^{-\frac{R}{L}t} \end{cases} , \ T = \frac{L}{R}, \ U_L = LI^2/2, \ U_E = U_L + U_R, \ U_R = \frac{i_0^2 L (1 - e^{-\frac{2t}{T}})}{2}$$



$[LC]_{\text{SIN PILA}} \{ q(0) = Q_0, \ i(0) = 0, \ q(t) = Q_0 \cos(\frac{t}{\sqrt{LC}}), \ i(t) = \frac{Q_0}{\sqrt{LC}} \sin(\frac{t}{\sqrt{LC}}), \ f = \frac{1}{\sqrt{LC}}, \ U(t) = U_0 = \frac{Q_0^2}{2C}$



$[RC]$
$$\begin{cases} T = RC \\ U_{\mathcal{E}}(t) \xrightarrow{5T} C\mathcal{E}^2 \\ U_R(t), U_C(t) \xrightarrow{5T} C\mathcal{E}^2/2 \end{cases} \quad \begin{array}{l} \text{C/PILA} \ \{ q(0) = 0, \ q(t) = \mathcal{E}C(1 - e^{-\frac{t}{RC}}), \ i(t) = \frac{\mathcal{E}}{R}(e^{-\frac{t}{RC}}) \\ \text{S/PILA} \ \{ q(0) = Q_0, \ q(t) = Q_0 e^{-\frac{t}{RC}}, \ i(t) = \frac{Q_0}{RC} e^{-t/RC} \end{array}$$



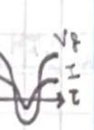
$[RLC]$
$$\begin{cases} q(0) = Q_0 & q(t) = Ae^{\lambda t} \\ i(0) = 0 & i(t) = A\lambda e^{\lambda t} \end{cases} \quad \lambda = \frac{-R \pm \sqrt{R^2 - 4\frac{L}{C}}}{2L}$$

$\Delta < 0 \Rightarrow q(t) = Q_0 e^{-\frac{R}{2L}t} \cos(\frac{\sqrt{-\Delta}}{2L})$, SUBAMORTIGUADO

$\Delta > 0 \Rightarrow q(t) = Q_0 e^{-\frac{R}{2L}t} \cos(\frac{\sqrt{\Delta}}{2L})$, SOBREAMORTIGUADO

$\Delta = 0 \Rightarrow q(t) = Q_0 e^{-\frac{Rt}{2L}}$, AMORTIGUAMIENTO CRÍTICO

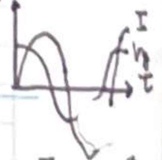
RESISTIVO PURO: $i(t) = \frac{V_0}{R}\cos(\omega t + \varphi_V)$, $i_0 = \frac{V_0}{R}$, $\varphi_i = \varphi_V$, $\varphi_{iV} = 0$



$V_g(t) = V_0 \cos(\omega t + \varphi_V)$, $\omega = 2\pi f$

CAPACITIVO PURO: $q(t) = CV_0 \cos(\omega t + \varphi_V)$, $i_0 = CV_0\omega$, $\varphi_{iV} = \pi/2$, $i(t) = CV_0\omega \cos(\omega t + \varphi_V + \frac{\pi}{2})$, $X_C = (\omega C)^{-1}$

INDUCTIVO PURO: $i(t) = \frac{V_0}{L\omega}\cos(\omega t + \varphi_V - \frac{\pi}{2})$, $i_0 = \frac{V_0}{L\omega}$, $\varphi_{iV} = -\frac{\pi}{2}$, $X_L = \omega L$



PSEUDO LEY DE OHM $\rightarrow V_g = IZ \rightarrow V_0 e^{j\varphi_V} = i_0 e^{j\varphi_i} Z \Rightarrow \{ V_0 = i_0 |Z| \wedge \varphi_V = \varphi_i + \varphi_Z \Rightarrow \varphi_Z = -\varphi_{iV}$

$Z = Z_R + Z_L + Z_C = R + j\omega L + (-j\frac{1}{\omega C})$, $V_{EF} = \frac{V_0}{\sqrt{2}}$, $i_{EF} = i_0/\sqrt{2}$ $\quad [P] = W, [Q] = VAR, [S] = VA$

$$\begin{cases} 0 < \varphi < \frac{\pi}{2} \Rightarrow \text{capacitivo} \\ -\frac{\pi}{2} < \varphi < \frac{\pi}{2} \Rightarrow \text{inductivo} \end{cases}$$

POTENCIAS
"ACTIVA O INSTANTÁNEA"
$P = V_{EF} i_{EF} \cos(\varphi_Z) = i_{EF}^2 R$, $\varphi_Z = \pm\frac{\pi}{2} \Rightarrow P = 0$

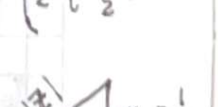
"REACTIVA"
$Q = V_{EF} i_{EF} \sin(\varphi_Z) = i_{EF}^2 (X_L - X_C)$, $\varphi_Z = 0 \Rightarrow Q = 0$

"APARENTE"
$S = \sqrt{P^2 + Q^2} = V_{EF} i_{EF}$ $\quad \boxed{\frac{X_L - X_C}{R} = \frac{V_L - V_C}{V_R} = \frac{Q}{P}}$

FACTOR DE POTENCIA: $\cos(\varphi_Z)$

FRECUENCIAS DE CORTE: $P = \frac{P_{MAX}}{2}$

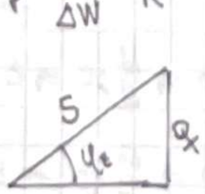
CAPACITIVO $\begin{cases} X_L < X_C, \ Q < 0 \\ \varphi_Z < 0, \ \varphi_{iV} > 0 \end{cases}$ INDUCTIVO $\begin{cases} X_L > X_C, \ Q > 0 \\ \varphi_Z > 0, \ \varphi_{iV} < 0 \end{cases}$



CIRCUITO EN RESONANCIA
$$\begin{cases} \omega_r = (LC)^{-1/2} \\ i_{MAX} = V_0/R \\ P = V_{EF}^2/R \end{cases}$$

FACTOR DE MÉRITO: $Q = \frac{\omega_r}{\Delta\omega} = \frac{L}{R}\omega_r$

$\omega_{1,2} = \pm\frac{CR + \sqrt{C^2R^2 + 4LC}}{2LC}$ (EN RESONANCIA)



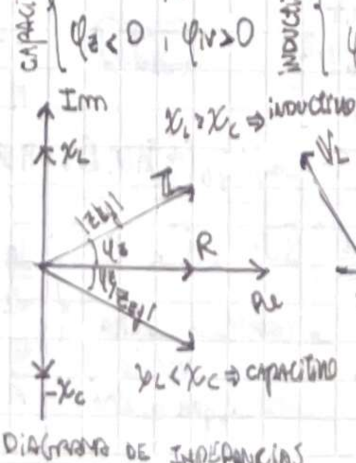


DIAGRAMA DE IMPEDANCIAS

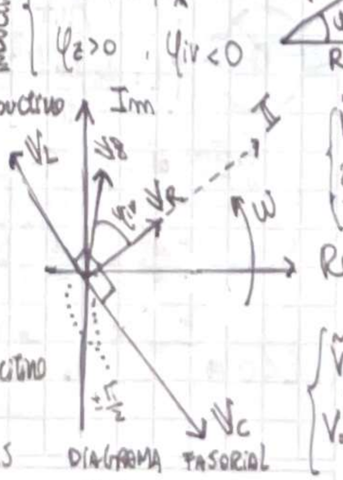


DIAGRAMA FASORIAL

$\begin{cases} \tilde{V}_\gamma = Z_\gamma \tilde{I} \\ \gamma \in \{L, C, R\} \end{cases}$

$\begin{cases} \tilde{V}_g = \tilde{I} Z_{eq} \\ V_0 = I_0 |Z_{eq}| \end{cases}$

$\{ X_L = \omega L, \ X_C = \frac{1}{\omega C} \}$

$\{ I(t) = |I| \cos(\omega t + \varphi_i) \ / \ |I| = |V_g| / |Z| \}$