HOJA N°

FECHA

Trabajo Práctico N° 1

1.1) - $T_1 = (25 \pm 1)°C$; $R_1 = (24,22 \pm 0,07)\,\Omega$

a) - $R_2 = 28,35\,\Omega$, $e_{R2} = \pm 0,3\,\%$

$$\Delta T = \frac{(R_2 - R_1) * (\alpha + T_1)}{R_1} = \frac{[(R_2 \pm E_{R2}) - (24,22 \pm 0,07\,\Omega)] * (\alpha + 25 \pm 1)}{24,22 \pm 0,07} =$$

$$= \frac{(R_2 - R_1 \pm (E_{R2} + E_{R1})) * (\alpha + T_1 \pm E_{T1})}{R_1 \pm E_{R1}} =$$

$$e_{R2} = \pm \frac{E_{R2}}{R_2} \Rightarrow E_{R2} = \pm\, e_{R2} \cdot R_2 = 0,3\,\% \cdot 28,35 = \pm 0,08$$

$$= \frac{(4,13 \pm 0,15) * (260 \pm 1)}{24,22 \pm 0,07} = \boxed{44,33 \pm 1,91}$$

$e_{rA} = 4,13 \pm 0,15 \rightarrow \dfrac{0,15}{4,13} = \pm 3,63\,\%$

$e_{rB} = 260 \pm 1 \rightarrow \dfrac{1}{260} = \pm 0,38\,\%$

$e_{rC} = 24,22 \pm 0,07 \rightarrow \dfrac{0,07}{24,22} = \pm 0,29\,\%$

$\Big\}\ e_{rT} = \boxed{\pm 4,3\,\%}$

$$E_{rt} = \pm\, e_{rt} \cdot \Delta T = \pm 4,3\,\% \cdot 44,33 = \pm 1,91$$

b) - Si Δt es chico $\rightarrow R_2 - R_1 \cong 0$ entonces $T_1 \cong T_2$

$$e_{rA} = \pm \frac{E}{R_2 - R_1} = \pm \frac{\text{acotado}}{\text{valor chico}} \rightarrow \pm\infty$$

NOTA

1.2). $R_x = 99,6$ $\quad e_R = \pm 0,1\,\%$

$R_1 = 100\,\Omega \quad e_{R1} = \pm\, 0,1\,\%$

$R_{P1} = 24,9\,K\Omega \quad e_{P1} = \pm\, 0,1\,\%$

$R_{P2} = 24,9\,K\Omega \quad e_{P2} = \pm\, 2\,\%$

Operador 1:

$$R_x = \frac{R_1 \times R_{P1}}{R_1 + R_{P1}}$$

$$E_{Rx} = \pm\left(\left|\frac{\partial R_x}{\partial R_1}\right| E_{R1} + \left|\frac{\partial R_x}{\partial R_{P1}}\right| E_{RP1}\right) =$$

$$= \pm\left(\left|\frac{R_{P1} \times (R_1 + R_{P1}) - R_{P1} \times R_1}{(R_1 + R_{P1})^2}\right| E_{R1} + \right.$$

$$\left. + \left|\frac{R_1 \times (R_1 + R_{P1}) - R_{P1} \times R_1}{(R_1 + R_{P1})^2}\right| E_{RP1}\right) =$$

$$= \pm\left(\left|\frac{24,9K\Omega \times (100 + 24,9K\Omega) - 24,9K\Omega \times 100\,\Omega}{(100 + 24,9K\Omega)^2}\right| . E_{R1} + \right.$$

$$\left. + \left|\frac{100\,\Omega \times (100 + 24,9K\Omega) - 24,9K\Omega \times 100\,\Omega}{(100 + 24,9K\Omega)^2}\right| . E_{RP1}\right) =$$

$$= \pm\left(0,9 . E_{R1} + 0,0 . E_{RP1}\right) \cong \pm\, 0,9 . \frac{0,1}{100} . 100\,\Omega = \pm\, 0,09$$

$R_x = (99,6 \pm 0,1)\,\Omega$

$$e_{Rx} = \pm\, \frac{0,1}{99,6} = \pm\, 0,1\,\%$$

Operador 2:

$R_x = (99,6 \pm 0,1)\,\Omega$

$e_{Rx} = \pm\, 0,1\,\%$

Esto es así porque el término E_{RP2} no tiene peso en la ecuación.

HOJA N°

FECHA

1.3) $U = I * (R_2 - R_1) = 0,1893\ V$

a) Amperímetro: $C = 0,1$ $a/c = 2A$ $200\ div$ $R_a = 0,2\ \Omega$

$I = 189,3\ div$

$I \rightarrow 200\ div$ — $2A$ $\quad I = 1,893\ A$

$189,3\ div$

$$E_I = \pm \frac{0,1}{100} \cdot 2A = \pm 0,002$$

$$e_I = \pm \left(\frac{0,002}{1,893} \cdot 100 \right) = 0,1\ \%$$

$$e_{R1} = \pm 0,1\ \% \qquad E_{R1} = \pm \frac{0,1}{100} \cdot 9998,9\ \Omega = \pm 9,999\ \Omega$$

$$e_{R2} = \pm 0,1\ \% \qquad E_{R2} = \pm \frac{0,1}{100} \cdot 9999,9\ \Omega = \pm 9,999\ \Omega$$

$$X = R_2 - R_1 = 1\ \Omega$$

$$e_x = \pm \frac{2 \cdot 9,999\ \Omega}{0,1} \cdot 100 = \pm 20000\ \%$$

$$U = I \cdot (R_2 - R_1)$$

$$U = \pm \left(\left| \frac{\partial U}{\partial I} \right| E_I + \left| \frac{\partial U}{\partial R_1} \right| E_{R1} + \left| \frac{\partial U}{\partial R_2} \right| E_{R2} \right) =$$

$$= \pm \left(\left| (R_2 - R_1) \cdot E_I \right| + \left| - I \cdot E_{R1} \right| + \left| I \cdot E_{R2} \right| \right) =$$

$$= \pm (0,1 \cdot 0,002 + 1,893 \cdot 9,998 + 1,893 \cdot 9,999)\ V =$$

$$= \pm 37,854$$

$$\boxed{U = (0,189 \pm 37,854)\ V}$$

NOTA

b)- $R_1 = (9998,9 \pm 0)\ \Omega$

$R_2 = (9998,9 + 0,1)\ \Omega$

$X = R_2 - R_1 = r_2 - r_1 = 0,1\ \Omega$

$$e_x = \pm \frac{E_{r2} + E_{r1}}{r_2 - r_1} * 100 = \frac{0,0001}{0,1} \cdot 100 = \boxed{\pm 0,1\%}$$

$$E_{r2} = \pm \frac{0,1}{100} \cdot 0,1\ \Omega = \pm 0,0001\ \Omega$$

$E_U = \pm(0,1 \cdot 0,002 + 1,893.)$

$U = U_m \pm E_U = (0,1893 \pm 0,0037)\ V$

1.4)- $U = U_m \left(\frac{R_2}{R_1}\right)$, $E_U = \pm(0,05\%\, U_m + 2\ dig)$, $R_V = 10\ M\Omega$

$U_m = 14,820\ V$ $\quad e_R = \pm 0,2\%$

$R_1 = R_c + R_1'$ $\quad E_U = \pm(0,05\%\ 14,820 + 0,002) = \pm 0,00941$

$R_2 = R_c + R_2'$

a)- $R_1 = (5 \times 100 + 7 \times 10 + 6 \times 1 + 1 \times 0,1)\ \Omega$

$R_2 = (4 \times 100 + 2 \times 10 + 1 \times 1 + 1 \times 0,1)\ \Omega$

R_2: $R_c = 421,1\ \Omega$ $\quad R_2' = 0\ \Omega$

R_1: $R_c = 421,1\ \Omega$ $\quad R_1' = 155,0\ \Omega$

$$E_U = \pm\left(\left|\frac{\partial U}{U_m}\right| E_{U_m} + \left|\frac{\partial U}{R_1}\right| E_{R1} + \left|\frac{\partial U}{R_2}\right| E_{R2}\right) =$$

$$= \pm\left(\frac{R_2}{R_1} \cdot E_{U_m} + U_m \cdot \frac{R_2}{R_1^2} \cdot E_{R1} + \frac{U_m}{R_2} \cdot E_{R2}\right)$$

o

$$U = U_m \left(\frac{R_c + R_2'}{R_c + R_1'}\right) \rightarrow E_U = \pm\left(\left|\frac{\partial U}{\partial U_m}\right| E_{U_m} + \left|\frac{\partial U}{\partial R_1'}\right| E_{R_1'} + \left|\frac{\partial U}{\partial R_2'}\right| E_{R_2'} + \left|\frac{\partial U}{\partial R_c}\right| E_{R_c}\right)$$

$$E_U = \pm\left(\left|\frac{R_c + R_2'}{R_c + R_1'}\right| E_{U_m} + \left|\frac{-U_m (R_c + R_2')}{(R_c + R_1')^2}\right| E_{R_1'} + \left|\frac{U_m}{R_c + R_1'}\right| E_{R_2'} + \left|\frac{U_m (R_c + R_1') - U_m (R_c +}{(R_c + R_1')^2}\right.\right.$$

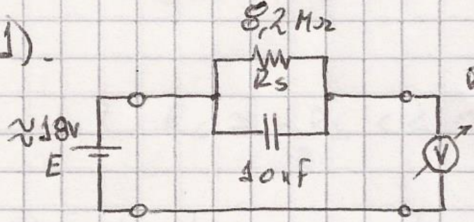
NOTA

sigue atrás

25/08/14

Gabinete TP N° 1

1).



$R_V = 10 M\Omega$

$e \approx \pm 1\%$

Errores: → fortuito (propio del instrumento)
→ Sistemático (propio del método)
↓
* Error de inserción.

Medición Directa:

YU-FUNG 1030:

3 1/2 digitos - indicación 1999

$U_m \approx 18V$. alcance 20 V.

Error fortuito: $E_v = \pm (0,8\% \cdot U_m + 1 \text{ dig.})$

$$E_v = \pm (0,8\% \cdot 18v + 0,01) = \pm 0,154 V$$

$$e_v = \pm \frac{0,154v}{18v} \cdot 100\% = \pm 0,86\%$$

—o—

$$U_m = E \cdot \frac{R_v}{R_v + R_s} = 9,89 V$$

$$E = \frac{U_m (R_v + R_s)}{R_v} = U_m + \frac{R_s}{R_v} U_m$$

$$\left.\begin{array}{l} E_S = U_m - E = -U_m \cdot \frac{R_s}{R_v} = -8,11 V \\ e_S = \frac{U_m - E}{E} = \frac{-R_s}{R_s + R_v} = -45\% \end{array}\right\}$$

1). Despreciable $e_s < \frac{e_F}{10}$

2). Desafectarlo $e_s \geq \frac{e_F}{10}$

$$E = U_m \left(1 + \frac{R_s}{R_v}\right) \leftarrow \text{Valor corregido.}$$

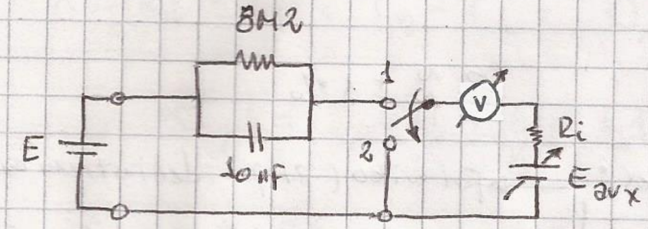
$$E_E = \pm \left(\frac{\partial F}{\partial U_m} \Delta U_m + \frac{\partial F}{\partial R_s} \Delta R_s + \frac{\partial F}{\partial R_v} \overset{=0}{\cancel{\Delta R_v}} \right) = \checkmark$$

$$= \pm \left[\left(1 + \frac{R_s}{R_v}\right) E_{U_m} + \frac{U_m}{R_v} \cdot E_{R_s} \right]$$

→

$$e_E = \pm\left(e_{Um} + \frac{R_s}{R_s+R_v}\, e_{R_s} \right)$$

Método de Oposición:



1_ llave en ①, ajusto E_{aux} para lograr "0" en el detector. ⊛

2_ Llave en ② mido sobre E_{aux} la tensión con V.

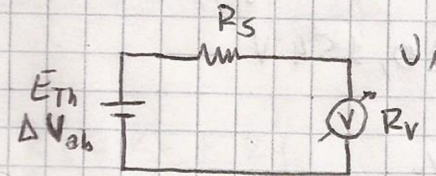
Se mide E con $\begin{cases} e = \pm\ 0{,}86\ \% \\ E = \pm\ 0{,}154\,V \end{cases}$

$E_i < E_E/10$

$E_i < 0{,}154/10$

$E_i < 0{,}0154\ V.$

⊛ Error de insensibilidad



$$U_{med} = \frac{\Delta U_{ab} \cdot R_v}{R_v + R_s}$$

$$\Delta U_{ab} = \frac{(R_v + R_s)\ \Delta U_{med}}{R_v}$$

$$\left.\begin{array}{l} \text{Si } \Delta U_{med} \rightarrow Res \\ \Delta U_{ab} \rightarrow E_i \end{array}\right\}\ E_i = \frac{R_v + R_s}{R_v}\ \Delta U_{res}$$

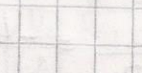
$$\Delta U_{Res} = \frac{0{,}0154 \cdot 10M\Omega}{10M\Omega + 8M\Omega} = 0{,}008\,V$$

① Alc. 20V $\longrightarrow$ 19,99 $\longrightarrow$ 0,01 $\quad Res = \frac{0{,}01}{2} = \pm 0{,}005\ V$

Alc. 2V $\longrightarrow$ 1,999 $\longrightarrow$ 0,001 $\quad Res = \frac{0{,}001}{2} = \pm\ 0{,}0005\ V.$

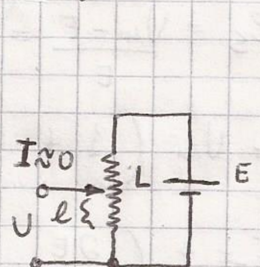
Finura de la fuente:

$\begin{cases} R_i << \\ E \begin{cases} 5V \\ 50V \end{cases} \\ \text{Finura} = 0{,}001V \end{cases}$



$y = f(x)$

$$\Delta y = \frac{\partial f}{\partial \ell} \cdot \Delta \ell$$



Ejemplo: $L = 30$ cm
$\Delta f = 2$ mm

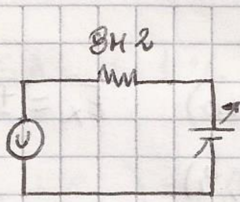
$$U = \frac{E \cdot \frac{\ell}{L} \cancel{R}}{\cancel{R}} \qquad \Delta U = \frac{E}{L}\, \Delta \ell \qquad \Delta U = E \cdot \frac{2\,mm}{300\,mm} = 30V \times \frac{2\,mm}{300\,mm} = 0{,}12\,V.$$

NOTA

HOJA N°

FECHA

Circuito final:



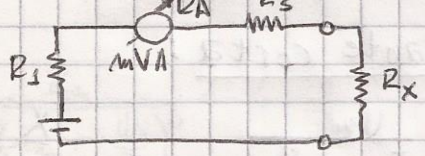
$e_s \simeq -\frac{R_i}{R_V} << 0{,}154$

2)- Mediciones de resistencias

Directo: Óhmetro

—o—

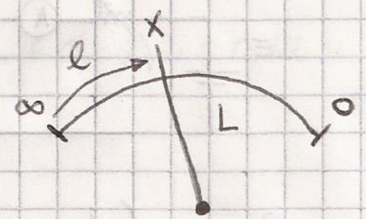
Óhmetro analógico



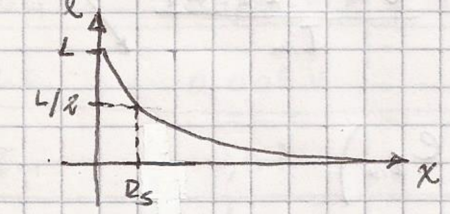
En corto: $I_{max} = \frac{E}{R_i + R_s + R} = \frac{E}{R_s} = K.L$

abierto $I = 0 \longrightarrow l = 0$

$I_x = \frac{E}{R_i + R_0 + R + R_x} = K.l$



$l = \frac{L}{1 + \frac{X}{R_s}}$



$C = \frac{\Delta l}{L}\ \%$

$\Delta l = \frac{L . R_s}{(R_s + X)^2} . \Delta X$

Si $X = R_s \rightarrow \boxed{e = \pm 4 e}$

$C = \frac{\Delta l}{L} = \frac{X . R_s}{-(R_s + X)^2} \left(\frac{\Delta x}{x}\right)$

$\boxed{e = \pm C \frac{(R_s + X)^2}{R_s . X}}$

$X \simeq 3\ \Omega$ $c = 2$ (SANWA 305-ZTR)

Alc. x1 $\rightarrow R_s = 34\ \Omega$

$e = \pm 2 \frac{(34+3)^2}{34.3} = \pm 27\%$

$E = \frac{3\ \Omega \times 27\%}{100} = \pm 0{,}8\ \Omega$ $(3{,}0 \pm 0{,}8)\ \Omega$

—o—

NOTA

Óhmetro digital:

$\underline{X = 3\ \Omega}$

YU-FUNG (YF-1030) $\quad E_X = \pm(1\%\, R_m + 2\ \text{dig})$

Alc. $200\ \Omega$ $(199,9)$

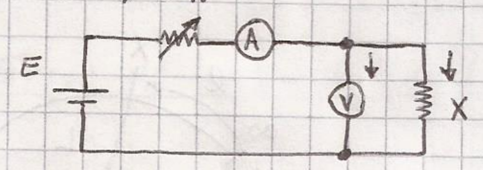
$$E_X = \pm(1\% \cdot 3 + 0,2) = \pm 0,23\ \Omega$$

$$X = (3,1 \pm 0,2)\ \Omega$$

$$e = \pm 7,7\ \%$$

Medición de R de una lámpara

12V / 5W

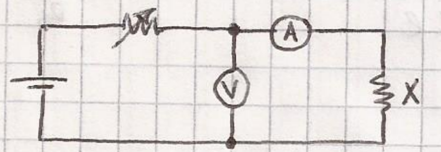


Variante corta

$$X = \frac{U_m}{I_m - \frac{U_m}{R_v}}$$

X chicas

$$e_X = \pm\left(1 + \frac{X}{R_v}\right)\left(e_{U_m} + e_{I_m}\right)$$



Variante larga

$$X = \frac{U_m - I_m \cdot R_a}{I_m}$$

X grandes

$$e_X = \pm\left(1 + \frac{R_a}{X}\right)\left(e_{U_m} + e_{I_m}\right)$$

$$R_c = \sqrt{R_V \cdot R_A} \qquad P = \frac{U^2}{R} \Rightarrow R = \frac{12^2\ V}{5\ W} = 29\ \Omega$$

Volt. YU-FUNG $10\ M\Omega$ (R_v)

Amp. YEW (1 A) $R_A = 0,06\ \Omega$

$$R_c = \sqrt{10\ M\Omega \cdot 0,06\ \Omega} = \underline{770\ \Omega}$$

Conexión corta: $\quad e_U = \pm \frac{[0,8 \cdot 14 + 0,01]}{14} = \pm 0,86\ \%$

$$C = \pm\frac{E_I}{Alc.} \cdot 100\% = 0,5\% \rightarrow E_I = \pm 0,005\ A$$

$\rightarrow$

$$e_I = \pm \frac{0{,}005A}{0{,}5A} = \pm 1\,\%$$

$$e_x = \pm\left(1 + \frac{x}{R_V}\right)\left(e_{U_m} + e_{I_m}\right) = \pm\left(0{,}86 + 1\right) = \pm 1{,}9\,\%$$

$E_x = \pm\, 0{,}55$ $\qquad \boxed{X = (29{,}2 \pm 0{,}6)\,\Omega}$

Incertidumbre:

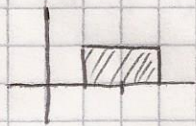
$$X = U_m \,/\, (I_m - U_m/R_V)$$

$$C_1 = \left.\frac{\partial F}{\partial U_m}\right|_x \quad , \quad C_2 = \left.\frac{\partial F}{\partial I_m}\right|_x$$

$$\mu_x = \sqrt{C_1^2\left(\mu_i^2 + \mu_{res}^2\right)^2 + C_2^2\left(\mu_U^2 + \mu_{res}^2\right)^2}$$

$$C_{U_m} = \frac{I_m}{\left(I_m - \frac{U_m}{R_V}\right)^2} = 2\ \frac{1}{A}$$

$$E = \pm(0{,}8\, I_m + 0{,}01) = \pm\, 0{,}12\ V$$

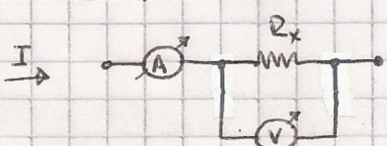


$$C_{I_m} = \frac{U_m}{\left(I_m - \frac{U_m}{R_V}\right)^2} = -60\ \frac{1}{A^2}$$

	Magnitud	Estimación	Incertidumbre	C	μ
U_m	U_m	14,00 V	$\frac{0{,}12}{\sqrt{3}}$	$2\ \frac{1}{A}$	$0{,}14\,\Omega$
	Res	0,005 V	$\frac{0{,}005}{\sqrt{3}}$		$0{,}0058\,\Omega$
I_m	I_m	0,5 A	$\frac{0{,}005}{\sqrt{3}}$	-60	$0{,}17\,\Omega$
	Res	$1\,\mu A$	$\frac{1\mu A}{\sqrt{3}}$		$0{,}035\,\Omega$
X					$0{,}22\,\Omega$

$$X_m \pm K\mu^2$$

Medición de pista de circuito impreso:



HOJA N°

FECHA

1.4)_ continuación

$$E_U = \pm\left(\frac{421,1}{421,1+155} \cdot 0,00941 + \frac{14,820(421,1)}{(421,1+155)^2} \cdot 0,31 + \cancel{\frac{14,820}{421,1+155} \cdot 0\,\Omega} + \right.$$

$$\left. + 14,820\left[\frac{(421,1+155)-(421,1)}{(421,1+155)^2}\right] \cdot 0,8422 \right) =$$

$$E_{R'_1} = \pm e_{R'_1} \cdot R'_1 = \pm \frac{0,2}{100} \cdot 155 = \pm 0,31$$

$$E_{R'_2} = \pm e_{R'_2} \cdot R'_2 = \pm \frac{0,2}{100} \cdot 0\,\Omega = \pm 0$$

$$E_{R_C} = \pm e_{R_C} \cdot R_C = \pm \frac{0,2}{100} \cdot 421,1 = \pm 0,8422$$

$$E_U = \pm\left(6,8782 \times 10^{-3} + 5,8290 \times 10^{-3} + 5,8291 \times 10^{-3}\right) =$$

$$= \boxed{\pm 0,0127\ V}$$

$$U = 14,820\left(\frac{421,1\,\Omega}{421,1+155}\right) = 10,833\ V$$

$$\boxed{U = 10,833 \pm 0,013}$$

c)_ $$E_U = \pm\left(\left|\frac{\partial U}{U_m}\right| E_{U_m} + \left|\frac{\partial U}{R_1}\right| E_{R_1} + \left|\frac{\partial U}{\partial R_2}\right| E_{R_2} \right) =$$

$$= \pm\left(\frac{R_2}{R_1} \cdot E_{U_m} + U_m \cdot \frac{R_2}{R_1^2} \cdot E_{R_1} + \frac{U_m}{R_2} \cdot E_{R_2} \right) =$$

$$= \pm\left(\frac{421,1}{576,1} \cdot 0,00941 + \frac{14,820 \cdot 421,1}{(576,1)^2} \cdot 0,8422 + \frac{14,820}{421,1} \cdot 1,1522 \right) =$$

$$= \pm 0,062\ V$$

$$\boxed{U = (10,833 \pm 0,062)\ V}$$

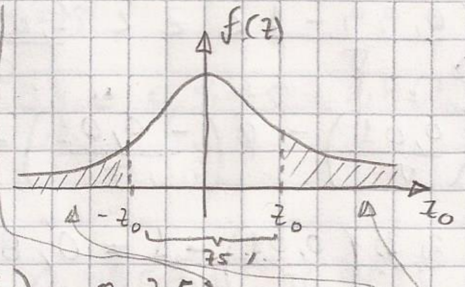
NOTA

1.5) -

a) - Valor medio: $\bar{u} = \sum_{i=1}^{N} \frac{U_i}{N} = \sum_{i=1}^{30} \frac{U_i}{30} = 15,9166$

Desviación normal: $\sigma = \sqrt{\sum_{i=1}^{30} \frac{(\bar{u} - U_i)^2}{30}} = 0,2547$

b). Defino $z = \frac{U - \bar{u}}{\sigma}$



$P(-z_0 < z < z_0) = 0,75$

$P\left(-z_0 < \frac{U - \bar{u}}{\sigma} < z_0\right) = 0,75$

$P(-z_0 \cdot \sigma + \bar{u} < U < z_0 \cdot \sigma + \bar{u}) = 0,75$

$P(-1,15 \cdot 0,2547 + 15,9166 < U < 1,15 \cdot 0,2547 + 15,9166) = 0,75$

$P(15,6237 < U < 16,2095) = 0,75$

Intervalo $[15,6 ; 16,2]$

$1 - 0,75 = 0,25$

$\frac{0,25}{2} = 0,125$

$z_0 = 0,875 \quad -z_0 = 0,125$

$z_0 = 1,15$

c) - $P(\bar{u} - \sigma < U < \bar{u} + \sigma) = P(15,9166 - 0,08 < U < 15,9166 + 0,08) =$

$= P(15,84 < U < 16,00)$

$z = \frac{U - \bar{u}}{\sigma} \rightarrow P\left(\frac{15,84 - 15,92}{0,2547} < U < \frac{16 - 15,92}{0,2547}\right) =$

$= P(-0,3141 < U < \underbrace{0,3141}_{z_0}) = P(z_0) - P(-z_0) =$

$= P(z_0) - 1 + P(z_0) = 2P(z_0) - 1 = 2\phi(0,3141) - 1 =$

$= 2 \, 0,6217 - 1 = 0,2434 \rightarrow \boxed{24\ \%}$

d) - $S(\bar{u}) = \frac{\sigma}{\sqrt{30}} = \frac{0,2547}{\sqrt{30}} = 0,0465$

$\phi(z) = 0,95 + \frac{0,05}{2} = 0,975 \qquad z = 1,96$

$E_U = K \cdot S(\bar{u}) = 0,0465 \cdot 2,04 = \boxed{0,095}$

$\boxed{U = 15,9 \pm 0,1}$

1.6)- $C = 1 \mu F$ $\quad E_c = \pm 0{,}01 \mu F$

15 % desecho $\quad \bar{C} = 1{,}000 \mu F$

a)- $P(\bar{C} - E_c < C < \bar{C} + E_c) = P(1 - 0{,}01 < C < 1 + 0{,}01) =$

$= P(0{,}99 < C < 1{,}01) = 0{,}85$

$$P\left(\frac{0{,}99-1}{\sigma} < Z < \frac{1{,}01-1}{\sigma}\right) = 0{,}85$$

$$\phi\left(\frac{0{,}01}{\sigma}\right) - \phi\left(-\frac{0{,}01}{\sigma}\right) = \phi\left(\frac{0{,}01}{\sigma}\right) - 1 + \phi\left(\frac{0{,}01}{\sigma}\right) =$$

$$\Rightarrow 2\phi\left(\frac{0{,}01}{\sigma}\right) - 1 = 0{,}85$$

$$\phi\left(\frac{0{,}01}{\sigma}\right) = \frac{0{,}85+1}{2} = 0{,}925 \rightarrow Z_0 = 1{,}44$$

$$Z_0 = \frac{0{,}01}{\sigma} = 1{,}44$$

$$\sigma = \frac{0{,}01}{1{,}44} = \boxed{6{,}94 \times 10^{-3}}$$

b)- $\bar{C} = 0{,}998 \mu F$

$P(0{,}998 - 0{,}01 < C < 0{,}998 + 0{,}01) =$

$= P(0{,}988 < C < 1{,}008) = 0{,}85$

$$P\left(\frac{0{,}988 - 0{,}998}{\sigma} < Z < \frac{1{,}008 - 0{,}998}{\sigma}\right) = 0{,}85$$

$$\phi\left(\frac{0{,}01}{\sigma}\right) - \phi\left(-\frac{0{,}01}{\sigma}\right) = 2\phi\left(\frac{0{,}01}{\sigma}\right) - 1 = 0{,}85$$

$$\phi\left(\frac{0{,}01}{\sigma}\right) = \frac{0{,}85+1}{2} = 0{,}925$$

$$\boxed{\sigma = 6{,}94 \times 10^{-3}}$$

c)- $\phi\left(\frac{0{,}01}{\sigma}\right) = \frac{0{,}995+1}{2} = 0{,}9975 \rightarrow Z_0 = 2{,}81$

$Z_0 = \frac{0{,}01}{\sigma} = 2{,}81 \quad \sigma = \frac{0{,}01}{2{,}81} = \boxed{3{,}55 \times 10^{-3}}$

NOTA

HOJA N°

FECHA

d)_ $c = \bar{c} \pm E_c$; 99,5%

$$P(\bar{c} - E_c < c < \bar{c} + E_c) = 0,995$$

$$P(-z_0 < z < z_0) = 0,995$$

$$P\left(-z_0 < \frac{c - \bar{c}}{\sigma} < z_0\right) = 0,995$$

$$P\left(-z_0 \cdot \sigma + \bar{c} < c < z_0 \cdot \sigma + \bar{c}\right) = 0,995 = 2P(z_0) - 1$$

$\sigma = 0,0035$ $\quad \bar{c} = 1 \mu F$

$$2P(z_0) - 1 = 0,995 \rightarrow P(z_0) = \frac{0,995 + 1}{2} = 0,9975 \rightarrow z_0 = 2,81$$

$$P(-2,81 \cdot 0,0035 + 1 < c < 2,81 \cdot 0,0035 + 1) =$$

$= P(0,99 < c < 1,01)$ intervalo: $[0,99 ; 1,01]$

$$\boxed{c = (1,00 \pm 0,01) \mu F}$$

1.7)_ $n = 30 \times 100 = 3.000$ mediciones

$\bar{U} = 220,3 V$ $\quad \sigma = 2,1 V$

$U_{min} = 185 V$ $\quad P(210) = ?$

<u>Usuario 1</u>: $P \approx 0$ para $U_{min} = 1,85 V$

Supongo una medición $\longrightarrow$ $U \sim N(\mu, \sigma^2)$

$N(220.3, 2,1^2)$

$$P(U < 185) = P\left(Z < \frac{185 - 220,3}{2,1}\right) = P(Z < -16,80) =$$

$$= 1 - \phi(16,8) \approx 0$$

$$P(U < 210) = P\left(Z < \frac{210 - 220,3}{2,1}\right) = P(Z < -4,905) =$$

$$= 1 - \phi(4,905) \approx 0$$

NOTA

1.8)- $X = \bar{X} \pm K.\sigma$

a)- $\mu = \int_{-\infty}^{\infty} x . f(x) \, dx = \int_{a}^{b} x . \frac{1}{b-a} \, dx = \frac{1}{b-a} . \frac{x^2}{2}\Big|_a^b = \checkmark$

$= \frac{1}{b-a} \frac{b^2}{2} - \frac{a^2}{2} = \boxed{\frac{b+a}{2}}$

$\sigma^2 = \int_{-\infty}^{\infty} (x-\mu)^2 f(x) \, dx = \int_a^b \left(x - \frac{b+a}{2}\right)^2 \frac{1}{b-a} \, dx = b$

$= \frac{1}{b-a} \int_a^b x^2 + (b+a)x + \left(\frac{b+a}{2}\right)^2 dx = \checkmark$

$= \frac{1}{b-a} \left[\frac{x^3}{3} + (b+a).\frac{x^2}{2} + \left(\frac{b+a}{2}\right)^2 x \right]\Big|_a^b = \checkmark$

$= \frac{1}{b-a} \left[\frac{b^3}{3} - \frac{a^3}{3} + (b+a).\frac{(b-a)^2}{2} + \left(\frac{b+a}{2}\right)^2 (b-a) \right] = \checkmark$

$= \frac{1}{b-a} \left[\frac{b^3-a^3}{3} - \frac{(b-a)^2 (b+a)}{2} + \frac{(b+a)^3}{4} \right]$

$\rightarrow \boxed{\sigma = \frac{b-a}{3\sqrt{2}}}$

b)- $P(\mu - \sigma < x < \mu + \sigma) = \int_{\mu+\sigma}^{\mu+\sigma} \frac{1}{b-a} \, dx = \frac{1}{b-a} . x \Big|_{\mu-\sigma}^{\mu+\sigma} = \checkmark$

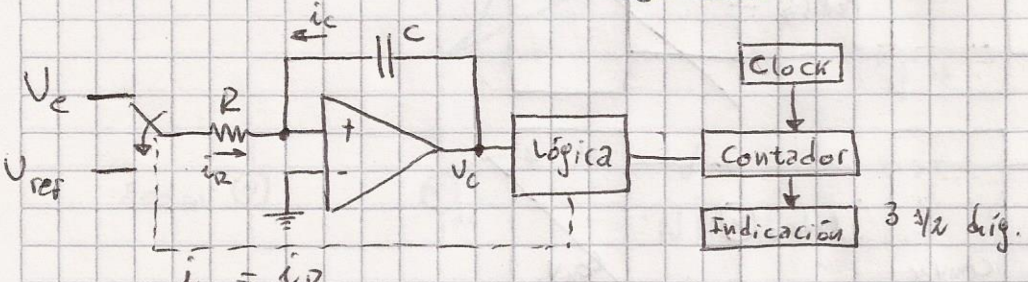
$= \frac{1}{b-a} \left[\cancel{\mu} + \sigma - \cancel{\mu} - \sigma \right] = \boxed{\frac{2\sigma}{b-a} = P}$

NOTA

08/09/14

Gabinete TP N° 2

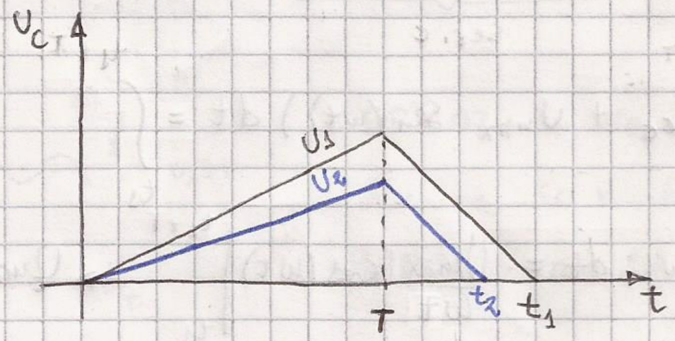
Conversor doble rampa (integrador):



$i_c = i_R$

$$V_c = \frac{1}{C}\int i_c\,dt = \frac{1}{RC}\int_0^T V_e\,dt = \frac{1}{RC}\cdot V_e \cdot T$$

$$i_c = i_R = \frac{V_e}{R}$$

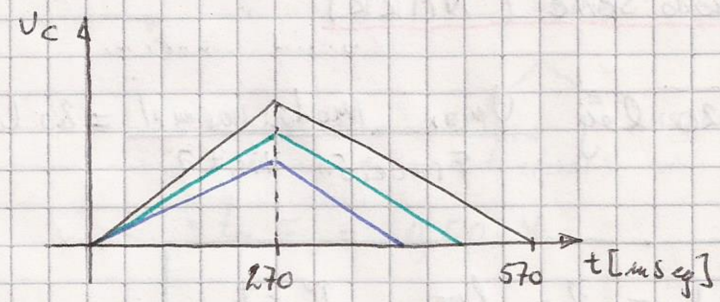


$$\frac{1}{\cancel{CR}}\cdot V_e \cdot T = \frac{1}{\cancel{CR}} V_{ref}\cdot t$$

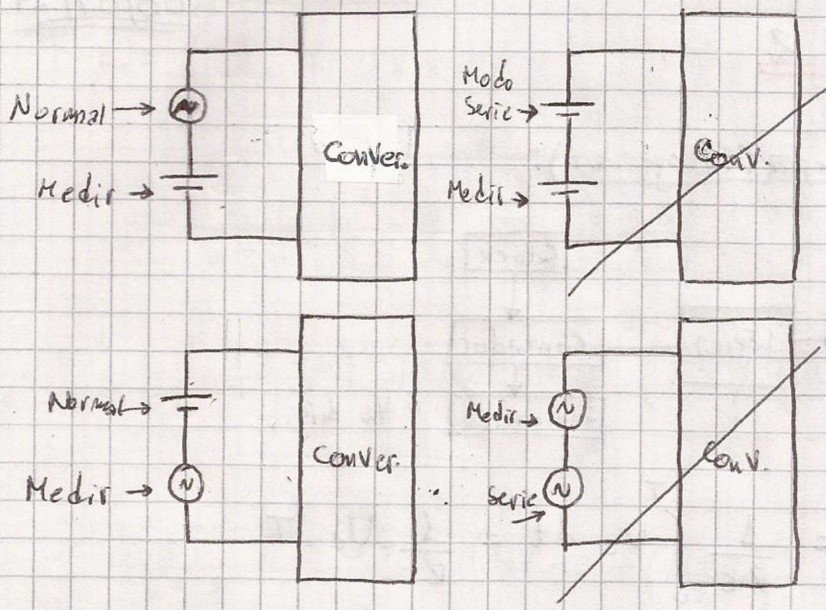
$$V_e = V_{ref}\cdot\frac{t}{T}$$

$V_e = 110$ mV ; $T = 270$ mSeg ; $t = 300$ mSeg.

$$V_{ref} = V_e\cdot\frac{t}{T} = 110\text{ mV}\cdot\frac{300\text{ ms}}{270\text{ ms}} = 100\text{ mV}$$



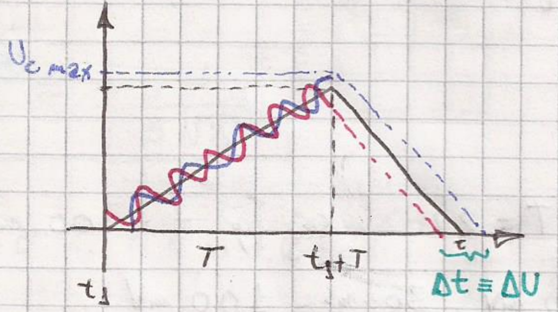
Señales de modo normal ó serie



$$U_e = V_{cc} + \underbrace{U_{max} \cdot \text{sen}(wt)}_{\text{serie}}$$

$$U_c \propto \frac{1}{T} \int_{t_1}^{t_1+T} \left(U_{cc} + U_{max} \cdot \text{sen}(wt) \right) dt$$

$$K \cdot U_c = \int_{t_1}^{t_1+T} U_{max} \cdot \text{sen}(wt)\, dt = \frac{U_{max}}{wT} \cos(wt) \Big|_{t_1}^{t_1+T} \rightarrow U_{c\,max} = \frac{U_{max}}{\pi f t} \text{sen}(\pi f t)$$



Rechazo de modo serie (NMRR)

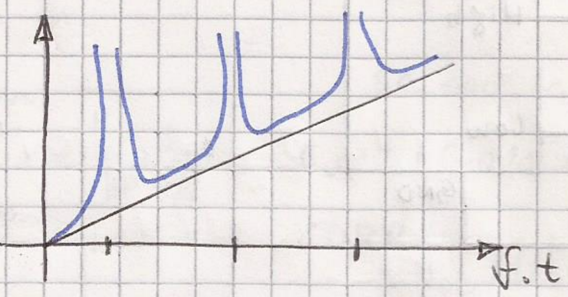
$$NMRR = 20 \log \frac{U_{max} \text{ modo normal}}{\text{Fracción vista}} = 20 \log \frac{\cancel{U_{max}}}{\frac{\cancel{U_{max}}}{\pi f t} \text{sen}(\pi f t)}$$

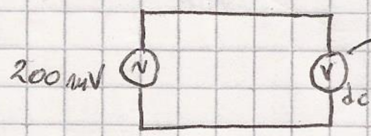
$$\boxed{NMRR = 20 \log \frac{\pi f t}{\text{sen}(\pi f t)}}$$

NOTA

HOJA N°

FECHA





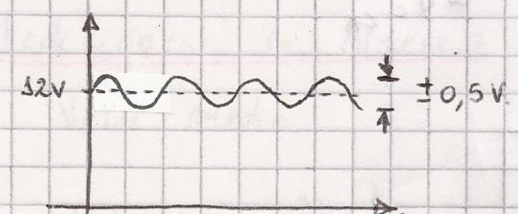
$\rightarrow U_m$ = fracción vista

$$NMRR = 20 \log \frac{U_{max}}{U_m}$$

$$U_m = \begin{cases} +0,5 \text{ mV} \\ -0,5 \text{ mV} \end{cases} \qquad NMRR = 20 \log \frac{\sqrt{2}\,200 \text{ mV}}{0,5 \text{ mV}} \cong 55 \text{dB}$$

Ejemplo:

1).



HP 974 50.000 cuentas

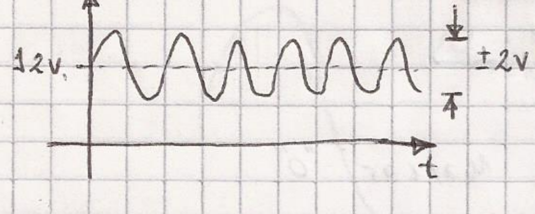
Alcance 50 V. $E_v = \pm(0,025\% U_m + 2 \text{ díg})$

$NMRR > 60$ dB

Mido 12V : $E_v = \pm(0,025\% . 12V + 2 . 0,001) = \pm 0,005$ V.

$$U_{vista} = \frac{U_{max}}{10^{\frac{NMRR}{20}}} = \frac{0,5 \text{ V}}{1000} = 0,0005 \text{ V.} \rightarrow \text{No AFECTA}$$

2).



$$U_{vista} = \frac{2V}{1000} = 0,002 \text{ V.} \rightarrow \text{AFECTA}$$

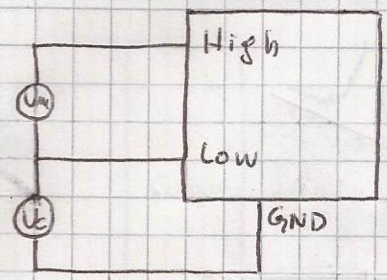
Considero a U_{vista} como un error adicional

instrumento mejor

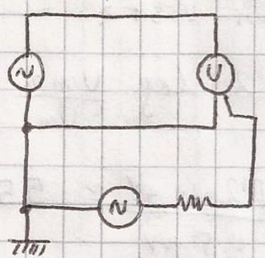
$\rightarrow E_v = \pm 0,007$ V.

NOTA

Señales de modo común



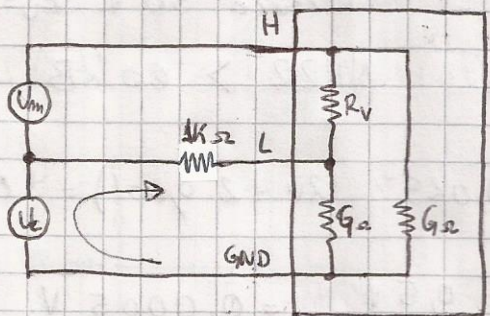
— o —



— o —

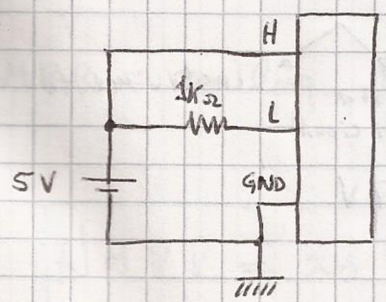
$U_{m\,DC} \rightarrow U_{c\,DC},\ U_{c\,AC}$

$U_{m\,AC} \rightarrow U_{c\,DC},\ U_{c\,CA}$



$$\boxed{CMRR = 20 \log \frac{U_{\text{modo común}}}{U_{\text{visto}}}}$$

desbalance 1 KΩ en <u>LOW</u>



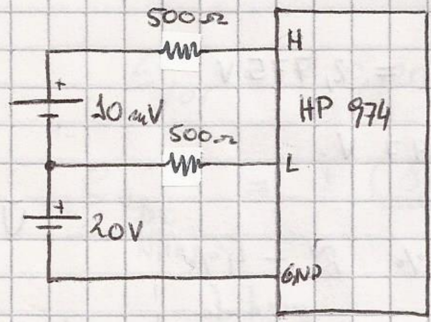
Debería marcar "0"

U_m = Fracción vista = 0,5 mV

$$CMRR = 20 \log \frac{5V}{0{,}5mV} = 80\,dB \Big|_{1k\Omega}$$

NOTA

Ejemplo:



50.000 cuentas

$E_V = \pm (0{,}025\% \cdot V_m + 2 \text{ dig})$

CMRR

→ V_{DC}: 120 dB dc, 50, 60 Hz (1kΩ)

V_{AC}: 60 dB dc, 50, 60 Hz

$E = \pm (0{,}025\% \, 10\,mV + 2 \times 0{,}0001\,mV) =$

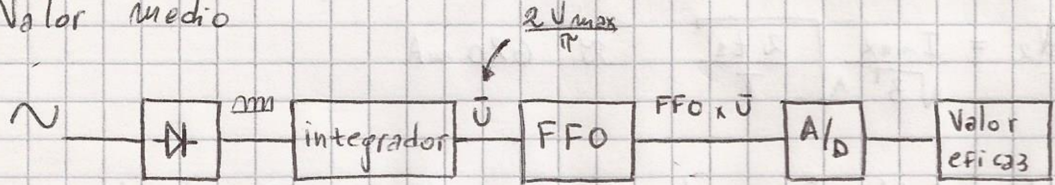
$= \pm 0{,}0045\,V.$

$V_V = \dfrac{20V}{10^6} = 0{,}02\,mV$

para 500Ω $V_{vista} = 0{,}01\,mV$

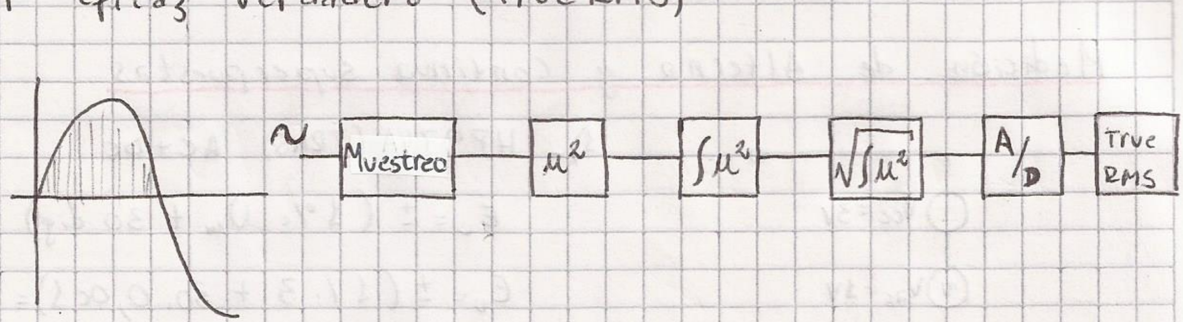
Mediciónes en Alterna

1.- Valor medio



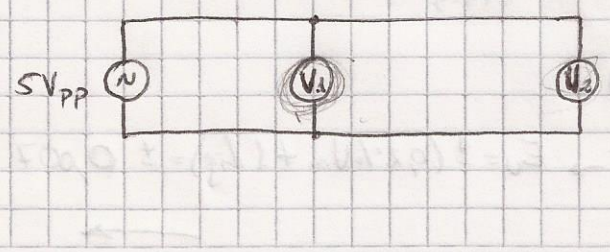
$FFO = \dfrac{U_{ef}}{\bar{U}} = 1{,}11$

2.- Valor eficaz verdadero (True RMS)



Laboratorio:

1).-



U_1 = Valor medio

U_2 = True RMS

U_{1m} = acotado

U_{2m} = acotado

2)_ señal triangular 5 Vp

U_1 : $\bar{U} = \frac{U_{max}}{2}$

$U_1 = 1,11 \cdot \bar{U} = 1,11 \cdot \frac{U_{max}}{2} = 2,775\,V$

$U_2 = \frac{U_{max}}{\sqrt{3}} = \frac{5\,V}{\sqrt{3}} = 2,887\,V.$

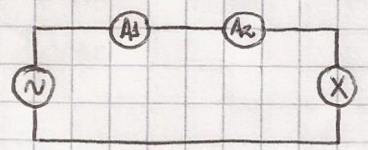
$e = \frac{2,775 - 2,885}{2,885} = -3,88\% \approx -4\%$ medido

$\bar{U} = \frac{2\,U_{max}}{\pi}$

$\frac{U_{max}}{V_{ef}} = \sqrt{2}$

$FFO = \frac{U_{ef}}{V_m}$

3)_



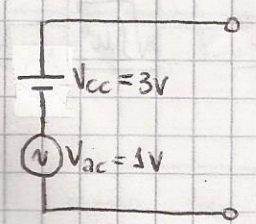
$U_2 = \frac{I_{max}}{\sqrt{3}} \sqrt{\frac{2\,t_1}{T}} \approx 620\,mA$

$U_1 = 1,11 \cdot I_{max} \cdot \frac{t_1}{T} = 340\,mA$ ← Alc. de 10 A.

$FC = 3$

TrueRMS → alc. 500 mA → $I_{max} = FC \cdot Alc = 3 \times 500 = 1,5\,A.$

Medición de Alterna y Continua superpuestas



1)_ HP974A (TRMS) AC+DC

$E_v = \pm(1\% \cdot U_m + 30\,dig)$

$E_v = \pm(1\% \cdot 3 + 30 \cdot 0,001) = \pm\,0,033\,V.$

$e = \pm \frac{0,033\,V}{3,1\,v} = \pm 1\%$

$U_{ef} = \sqrt{3^2 + 1^2} = 3,1\,V$ 3,0990 V TRMS.

2)_ HP 472A (4000 cuentas)

Mido U_{DC} : alc 4 V. → $E_v = \pm(0,2\% U_m + 1\,dig) = \pm\,0,007\,V.$

→

NOTA

HOJA N°

FECHA

$$NMRR = 60\ dB \rightarrow \text{fracción vista} = 0{,}001\ V.$$

$$E_{TOT} = \pm\ 0{,}008\ V.$$

$$e_{U_{DC_{NMRR}}} = \pm\ \frac{(0{,}007 + 0{,}001)V}{3V} = \pm\ 0{,}27\ \%$$

<u>Medir AC:</u> $E = \pm\ (1\% \cdot U_m + 3\ dig) = \pm\ 0{,}013\ V.$

$$e_{U_{AC}} = \pm\ 1{,}3\ \%$$

$$U_{ef} = \sqrt{U_{DC}^2 + U_{AC}^2}$$

$$e_{U_{ef}} = \pm \left(\frac{U_{DC}^2}{U_{DC}^2 + U_{AC}^2} \cdot e_{U_{DC}} + \frac{U_{AC}^2}{U_{DC}^2 + U_{AC}^2} \cdot e_{U_{AC}} \right) = \pm\ 0{,}37\ \%$$

NOTA

1.10)-

U_i [V]	12,32	12,40	12,28	12,40	12,33	12,42	12,37
I_i [A]	1,325	1,331	1,315	1,329	1,328	1,337	1,322

Tipo A:

$$\bar{U} = \frac{1}{N} \sum_{i=1}^{N} U_i = 12,36 \text{ [V]} \qquad \sigma_U = 0,0513$$

$$\bar{I}_i = \frac{1}{N} \sum_{i=1}^{N} I_i = 1,3267 \text{ [A]} \qquad \sigma_I = 6,993 \times 10^{-3}$$

desviación típica

$$\sigma = \sqrt{\sum_{i=1}^{7} \frac{\bar{R} - R_i}{n-1}}$$

TIPO A: - Su única fuente surge del análisis estadístico
- Es la desviación típica de la media

TIPO B: - Error límite en el amperímetro y en el voltímetro
- Resolución del amperímetro y del voltímetro.

$$R_i = \frac{U_i}{I_i}$$

R_i [Ω]	9,298	9,316	9,338	9,330	9,284	9,289	9,357

$\bar{R} = 9,316\ \Omega \qquad S_R = 0,027 \rightarrow$ desviación típica

$$S_{\bar{R}} = \frac{S_R}{\sqrt{n}} = \frac{0,027}{\sqrt{7}} = 0,01$$ ← desviación típica de la media

$$\boxed{\mu_1 = 0,010}$$

Tipo B:

Amperímetro: $S_A = \frac{0,002 \text{ A}}{\sqrt{3}} = 0,0011 \text{ A} = \mu_{2(I)}$

Resolución: $\mu_{3(I)} = \mu_{resolución} = \frac{0,0005}{\sqrt{3}} = 2,88 \times 10^{-4}$

NOTA

HOJA N°

FECHA

Voltímetro: $u_{4(V)} = \frac{0,01V}{\sqrt{3}} = 5,77 \times 10^{-3}$

Resolución: $u_{5(V)} = \frac{0,005}{\sqrt{3}} = 2,88 \times 10^{-3}$

Coeficientes de sensibilidad:

$$C_V = \frac{\partial R}{\partial V} = \frac{1}{\bar{I}} = \frac{1}{1,3267} = 0,753$$

$$C_I = \frac{\partial R}{\partial I} = \frac{\partial}{\partial I}\left(\frac{U}{I}\right) = \frac{-\bar{U}}{\bar{I}^2} = \frac{-12,36}{(1,3267)^2} = -7,022$$

$$u(R) = \sqrt{\sum_{i=1}^{5} (C_i \cdot u_i)^2} = \sqrt{C_1^2 u_1^2 + C_I^2[u_2^2 + u_3^2] + C_V^2[u_4^2 + u_6^2]} =$$

$$= \sqrt{0,01^2 + 7,022^2(0,0011^2 + (2,88 \times 10^{-4})^2) + 0,753^2[(5,77 \times 10^{-3})^2 + (2,88 \times 10^{-3})^2)} = 0,0136$$

$$V_{eff} = \frac{u^4(R)}{\sum_{i=1}^{N} \frac{u_i^4(R)}{v_i}} = \frac{(0,0136)^4}{\frac{u_A^4}{6} + \frac{u_B^4}{\infty}} = \frac{(0,0136)^4 \cdot 6}{(0,01)^4} = 20,53$$

→ considero 20

$u(R) = K \cdot u(R)$ y para un 95% de probabilidad $K = 2,09$

$u(R) = 2,09 \cdot 0,0136 = 0,0284$

$$\boxed{R = (9,32 \pm 0,03)\ \Omega}$$

NOTA

1.11)- Amp. 3 ½ dig. 1999 Alc. 10 A

$U_1 = \pm (0,05\% \cdot I_a + 2\,mA)$ $I = 10,000$ A.

a)- Tipo A:

$\bar{I} = \frac{1}{5} \sum_{i=1}^{5} I_i = 10,038$ A.

$\sigma_I = 0,0238$ A

$\sigma_{\bar{I}} = \frac{\sigma}{\sqrt{5}} = \frac{0,0238\,A}{\sqrt{3}} = \boxed{1,37 \times 10^{-2} = \mu_{A1}(I)}$

b)-

calibrador:

$U_I = \pm \left(\frac{0,05}{100} \cdot 10 + 0,002 \right) = \pm 0,007$ A.

$U_I = K \cdot \mu_2(I) \rightarrow \mu_2(I) = \frac{U_I}{K} = \frac{0,007}{2,58} = \boxed{2,71 \times 10^{-3}}$

Con tabla normal $\phi(z) = 0,995 \rightarrow K = 2,58$

Amperímetro:

$\mu_3(I) = \mu_{resolución} = \frac{0,0005}{\sqrt{3}} = \boxed{2,88 \times 10^{-4}}$

$\mu_B(I) = \sqrt{(\mu_2^2 + \mu_3^2) \cdot c}$ con $c = 1$

$\mu(I) = \sqrt{(1,37 \times 10^{-2})^2 + (2,71 \times 10^{-3})^2 + (2,88 \times 10^{-4})^2} \cong 1,37 \times 10^{-2}$

$\mu_{total}(I) \simeq \mu_A(I)$ se puede despreciar la

$\mu_{total}(I) =$ - del tipo B.

c)- $\nu = 5 - 1 = 4 \rightarrow$ Tipo A.

$\nu_{effectivos} = \nu_A$

Elijo una probabilidad del 95 %

$U(I) = K \cdot \mu(I) \longrightarrow K = 1,96$ $\phi(K) = 0,9744$

$\boxed{I = (10,038 \pm 0,027)\,A}$

NOTA

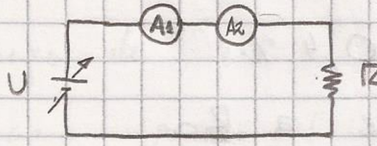
HOJA N°

FECHA

1.12)_ $I_1 \Rightarrow C = 1 \quad A_{LC} = 5A \quad esc\ 25\ div.$

a)_ Verificaría el fondo de escala ya que el error es mínimo (de igual valor a la clase)

b)_

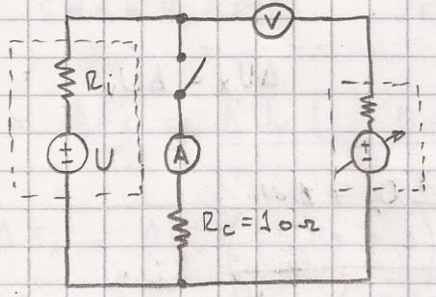


c)_ Variando U hasta q' $I_R = 5A$ en A de contraste
Medir a fondo de escala con A de control y determinar el error de medida.

d)_ Puedo asegurar que el error en otro punto de la escala sea < el error límite.

1.13)_ $U = 10V$. $I = 1A$. $U_R = 100mV$

a)_ $e = 1\%$



Fuente de tensión variable (6.1)

• Fuentes de error: Error del voltímetro y error de insensibilidad.

$$e_m = \pm(e_v + e_i) < 1\%$$

Como $E_m = E_v + E_i < 1\ mV$.

NOTA

Elijo el multímetro (2.4) en el Alc = 200 mV, 3 1/2 dig.

$$E_U = \pm [0{,}5\% \, U_m + 1 \text{ dig}]$$

Si mido 100 mV

$$E_U = \pm \left(\frac{0{,}5}{100} \cdot 100 \text{ mV} + 0{,}1 \text{ mV} \right) = \pm 0{,}6 \text{ mV}$$

$$e_U = \pm \frac{0{,}6 \text{ mV}}{100 \text{ mV}} = \pm 0{,}6\%$$

$$e_m = \pm (e_U + e_i) < 1\%$$

$$\hookrightarrow e_i < 0{,}4\%$$

Supongo R_i despreciable frente a R_c

$$\frac{U}{R_i + R_c} = I \longrightarrow \frac{U}{R_c} = 1 \text{ A}$$

Ajusto R_c hasta que I sea igual a 1 A.

<u>Error de insensibilidad:</u>

$$\frac{U_V}{R_V} = \frac{U_x - U_{Aux}}{R_V + R_{i1} + R_{i2}} \Rightarrow \Delta U_V = \frac{R_V}{R_V + \underbrace{R_{i1} + R_{i2}}_{\ll R_V}} \cdot \Delta U_x$$

$$U_V = \frac{R_V \cdot U_x}{R_V + R_{i1} + R_{i2}} - \cancel{\frac{R_V U_{Aux}}{R_V + R_{i1} + R_{i2}}}^{=0} \qquad \frac{dU_V}{dU_x} \qquad \Delta U_x = \frac{\cancel{R_V}}{\cancel{R_V}} \cdot \Delta U_V$$

$$e_i = \frac{0{,}1 \text{ mV}}{100 \text{ mV}} = 0{,}001\%$$

$$\Delta U_x = E_{ins} = \pm 0{,}1 \text{ mV} \qquad \Delta U_x = \Delta U_V$$

b)- $e_m = \pm (0{,}6 + 0{,}1) \text{ mV} = \pm 0{,}7\%$

$$\boxed{U_m = (100{,}000 \pm 0{,}007) \text{ mV}}$$

c)-

$$u_{1\,FTV} = \frac{0{,}6 \text{ mV}}{\sqrt{3}} \qquad u_{3\,det} = \frac{0{,}05 \text{ mV}}{\sqrt{3}}$$

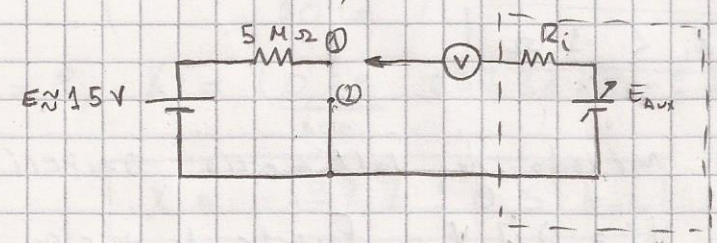
$$u_{2\,Res} = \frac{0{,}05 \text{ mV}}{\sqrt{3}}$$

NOTA

HOJA N°

FECHA

1.14)_ 4000 cuentas, $E_v = \pm(0,2\,\%\cdot U_m + 1\text{ dig})$, $R_v = 10\,M\Omega$



a)_ Primero hay que colocar la llave en ① y buscar el cero en el voltímetro ajustando E_{aux}, con el rango de 4 V.

Luego paso el voltímetro al alcance de 40 V y la llave a la posición ②. El valor indicado es el valor de E.

b)_ La finura de la fuente debería ser 2 mV.

c)_ Error fortuito del instrumento:

$$E_v = \pm\left[\frac{0,2}{100}\cdot 15 + 0,01\right] = \pm 0,04\,V$$

Error de insensibilidad:

$$\frac{U_v}{R_v} = \frac{E - E_{Aux}}{5\,M\Omega + R_v + R_i} \quad \frac{\partial}{\partial E_x} \Rightarrow \quad \frac{\Delta U_v}{R_v} = \frac{\Delta E_x}{5\,M\Omega + R_v + R_i}$$

$$R_i \ll 5\,M\Omega + R_v$$

$$E_{ins} = \Delta E_x = \frac{\Delta U_v\,(5\,M\Omega + 10\,M\Omega + R_i)}{R_v}$$

$$\Delta E_x = \Delta U_v\cdot\left(\frac{5\,M\Omega}{R_v} + 1\right) = 1\,mV\cdot 1,5 = \boxed{\pm 1,5\,mV}$$

$\Delta U_v = 1\,mV$ $\qquad E_v = \pm 41,5\,mV$

$$\boxed{U = (15,00 \pm 0,04)\,V}$$

d)_ Puedo despreciar el error de inserción si es al menos 10 menor que el del instrumento.

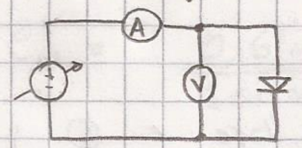
NOTA

$$|e_{\text{inserción}}| = \frac{R_i}{R_V} < \frac{1{,}5\,mV}{15\,V}$$

$$\therefore R_i < 1 \times 10^{-7} \cdot R_V$$

$$\boxed{R_i < 1\,\Omega}$$

1.15)_ Utilizo el método de voltímetro amperímetro.



$V_\gamma = 0{,}7\ V.$ Fuente de tensión regulable hasta $I_m = 1\ A$.

$$R_d = \frac{U_m}{I_m - I_V} = \boxed{\frac{U_m}{I_m - \frac{U_m}{R_V}} = R_d} = 0{,}7\,\Omega$$

$$e = \pm\left(1 + \frac{R_d}{R_V}\right)\cdot\left(e_{I_m} + e_{U_m}\right)$$

1.16)_ Voltímetro - Amperímetro conexión corta

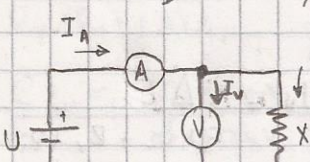
Voltímetro: $4\,1/2$ dig.; $Alc = 1000\ V$; Ind: $248{,}2V$; $R_V = 10\,M\Omega$

$$E_U = \pm(0{,}04\%\,U_m + 1\text{ dig})$$

Amperímetro: $4\,1/2$ dig; $Alc = 2\ mA$; Ind: $1{,}8321\ mA$

$$E_I = \pm(0{,}3\%\,I_m + 2\text{ dig})$$

a)_



$$X = \frac{U_x}{I_x} = \frac{U_m}{I_m - I_V} = \frac{U_m}{I_m - \frac{U_m}{R_V}} = \frac{248{,}2\,V}{1{,}8321\,mA - \frac{248{,}2\,V}{10\,M\Omega}} =$$

$$\underline{\underline{X = 137{,}33\,K\Omega}}$$

$$e_x = \pm\left(1 + \frac{X}{R_V}\right)\left(e_U + e_I\right)$$

$$E_U = \pm\left(\frac{0{,}04}{100}\cdot 248{,}2 + 0{,}1\right)V = \pm 0{,}19928\,V$$

$$e_U = \frac{E_U}{U_m} = \frac{\pm 0{,}19928}{248{,}2} = \pm 0{,}08\%$$

$$E_I = \pm\left(\frac{0{,}3}{100}\cdot 1{,}8321 + 0{,}0002\right) = \pm 0{,}0057\ A.$$

$$e_I = \frac{E_I}{I_m} = \frac{\pm 0{,}0057}{1{,}8321} = \pm 0{,}31\%$$

NOTA

HOJA N°

FECHA

$$e_X = \pm\left(1 + \frac{137{,}33\,K\Omega}{10\,M\Omega}\right)(0{,}08 + 0{,}31) = \pm\,0{,}39\,\%$$

$$E_X = e_X \cdot X = \pm\frac{0{,}39}{100} \cdot 137{,}33\,K\Omega = \pm\,535{,}6\,\Omega$$

$$\boxed{X = (137{,}3 \pm 0{,}5)\,K\Omega}$$

b)_ calculo la resistencia crítica:

$$X_C = \sqrt{R_a \cdot R_V} \quad y \quad R_a = \frac{0{,}3\,V}{2\,mA} = 150\,\Omega$$

$$X_C = \sqrt{10\,M\Omega \cdot 150\,\Omega} = 38{,}7\,K\Omega$$

$X > X_C$ se debió utilizar la conexión larga, aunque debido a que la diferencia es de solo 10 ordenes de magnitud no va a haber diferencia entre los dos métodos.

Unidad Temática N° 2

2.1)_ Voltimetro 1: $3\,1/2$ digitos; 2000 cuentas; FFO = 1,11 ; $E_V = \pm[0{,}5\%\,V_m + 1\,dig]$ 45 Hz − 1 KHz ; $R_V = 10\,M\Omega$

Voltimetro 2: $3\,1/2$ digitos; 2000 cuentas; TRMS ; $E_V = \pm[0{,}8\,\%\cdot V_m + 2\,dig]$ 40 Hz − 2 KHz ; Fc = 10 ; $R_V = 10\,M\Omega$

BW = 200 KHz pasa bajo.

a)_ $$\bar{U} = \frac{1}{T^*}\int_0^{T^*} u(t)\,dt = \frac{1}{10\,ms}\left[\int_0^{5ms} \frac{200}{5ms}\,t\,dt + \int_{5ms}^{10ms} -\frac{200t}{5ms} + 400\,dt\right]$$

$$T^* = \frac{T}{2} = 10\,mSeg$$

$$= \frac{1}{10ms}\left[\int_0^{5ms} 40t\,dt + \int_{5ms}^{10ms} -40t+400\,dt\right] = 100\,V$$

a)_ $U_{ind} = \bar{U} \cdot FFO = 100V \cdot 1{,}11 = \boxed{111\,V}$

$$E_U = \pm\left[\frac{0{,}5}{100} \cdot 111V + 0{,}1\right] = \pm 0{,}655\,V$$

b)_ Hay errores sistematico (forma de onda) y fortuito

$$U_{ef} = \sqrt{\frac{1}{T}\int_0^T u(t)^2\,dt} = \sqrt{\frac{1}{10ms}\int_0^{5ms}(40t)^2\,dt + \int_{5ms}^{10ms}\left(\frac{-400t}{10m}+400\right)^2 dt} =$$

$$= \boxed{115{,}47V}$$

$$e_{U_{FFO\%}} = \left(\frac{U_{ef,m} - U_{ef,v}}{U_{ef,v}}\right) = \frac{111 - 115{,}47}{115{,}47} \cdot 100 = \boxed{-3{,}87\%}$$

<u>VM</u>: $e_U = \frac{\pm 0{,}655V}{115{,}47V} \cdot 100 = \boxed{\pm 0{,}56\%}$ $U_m = (111{,}0 \pm 0{,}6)\,V$

Sin desafectar error de FFO

<u>TRMS</u>: $E_U = \pm\left[\frac{0{,}8}{100} \cdot 115{,}47 + 0{,}2\right] = \pm 1{,}124\,V$

$e_U = \frac{\pm 1{,}124V}{115{,}47V} \cdot 100 = \boxed{\pm 0{,}9\%}$ $\boxed{U_m = (115{,}5 \pm 1{,}0)\,V}$

$$E_{sist} = e_{U_{FFO\%}} \cdot \frac{111\,V}{100} = -\frac{3{,}87}{100} \cdot 111V = -4{,}29\,V$$

<u>VM</u>: $U_m = 111V + 4{,}29\,V \pm 0{,}655V = \boxed{(115{,}3 \pm 0{,}6)\,V}$

c)_ El más apropiado para realizar la medición es el de valor eficaz verdadero por ser más práctico.

d)_ No debido a que el ancho de banda permite medir bien.

NOTA

HOJA N°

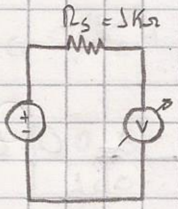
FECHA

2.2)_ 3 1/2 dig. ; FFO = 1,11 ; desacople DC ; $R_V = 10 M\Omega$

$C_V = 25 pF$; $E_U = \pm(0,5\% \, U_m + 2 \, dig)$ [45 Hz - 2 kHz]

$U = \sqrt{2} \cdot (220 \cdot sen(\omega t) + 10 \cdot sen(3\omega t))$, $\omega = 314 \, r/s$

$R_S = 1 K\Omega$



$$e_{ins} = \frac{-R_S}{R_S + R_V} \cdot 100 = \frac{-1 K\Omega}{10 M\Omega} \cdot 100 = -0,01\%$$

↳ es despreciable

$$T = 20 \, mSeg = \frac{2\pi}{\omega}$$

a)_ $$\bar{U} = \frac{1}{T^*} \int_0^{T^*} u(t) \, dt \qquad T^* = \frac{1}{2} T = 10 \, mSeg$$

$$\bar{U} = \frac{\sqrt{2}}{10 mS} \int_0^{10 mSeg} (220 \cdot sen(\omega t) + 10 \cdot sen(3\omega t)) \, dt =$$

$$= \frac{\sqrt{2}}{10 mS} \left[1,40 + 0,021 \right] = 200,95 \, V.$$

$$U_{med} = \bar{U} \cdot FFO = 200,95 \cdot 1,11 = \boxed{223,06 \, V}$$

$$U_{verd} = \sqrt{U_{ef_{f_0}}^2 + U_{ef_3}^2} = \sqrt{220 V^2 + 10 V^2} = 220,3 \, V.$$

b)_ $$e_{\% \, FFO} = \left(\frac{U_{med} - U_{ver}}{U_{ver}} \right) \cdot 100 = \left(\frac{223,06 - 220,3}{220,3} \right) \cdot 100 = \boxed{+1,25\%}$$

Es posible despreciarlo, dependiendo del

$$E_U = \pm \left[\frac{0,5}{100} \cdot 223,06 + 2 \, dig \right] V = \pm 3,11$$

$$e_U = \pm \frac{3,11}{223,06} \cdot 100 = \pm 1,39\%$$

Es posible desafectar el error de forma de onda, ya que es cte y conocido.

NOTA

2.3)_

Voltímetro: 3 1/2 dígitos ; 3200 cuentas

$E_U = \pm\left[0{,}5\%\, U_m + 1 \text{ dig}\right]$; $R_V = 10\,M\Omega \,//\, C_V = 30\,pF$

$NMRR = 50\,dB$ @ $100\,Hz$

$CMRR = 90\,dB$ @ $100\,Hz$ c/ $1\,K\Omega$ en LOW.

a)_ $NMRR = 20\log\left(\frac{U_{max}}{U_{vista}}\right)$

$$U_{vista} = \frac{U_{max}}{10^{\frac{NMRR}{20}}} = \frac{5V}{10^{\frac{50}{20}}} = 0{,}016\,V$$

$$E_U = \pm\left[\frac{0{,}5}{100}\cdot 220 + 0{,}1 \text{ dig}\right] = \pm 1{,}2\,V$$

Como $U_{vista} << E_U \rightarrow$ se puede despreciar

$$\boxed{U_m = (220{,}0 \pm 1{,}2)\,V}$$

b)_ $U = U_s - U_e = 221{,}0\,V - 218{,}0\,V = 3\,V$

$$E_U = \pm\left[\left|\frac{\partial U}{\partial U_e}\right|\cdot \Delta U_e + \left|\frac{\partial U}{\partial U_s}\right|\cdot \Delta U_s\right] = \pm(\Delta U_e + \Delta U_s) =$$

$$\left.\begin{aligned}\Delta U_e &= \pm\left(\frac{0{,}5}{100}\cdot 221{,}0 + 0{,}1\right) = \pm 1{,}205\,V\\ \Delta U_s &= \pm\left(\frac{0{,}5}{100}\, 218{,}0 + 0{,}1\right) = \pm 1{,}19\,V\end{aligned}\right\} \boxed{E_U = \pm 2{,}395\,V}$$

Además en este caso hay una superposición de una alterna sobre una continua medida

$$U_{vista}\Big|_{entrada} = U_{vista}\Big|_{salida} = 0{,}016\,V \leftarrow \text{despreciable}$$

$$\boxed{U = (0{,}003 \pm 0{,}002)\,KV}$$

$$e_{\%} = \pm\frac{0{,}002}{0{,}003}\cdot 100 \cong \boxed{67\,\%}$$

NOTA

$\frac{10000}{20.00}$

HOJA N°

FECHA

c)_ Si repito el instrumento puedo considerar en corto término:

$$U_e = U_c + u_e \qquad U_c = 218\,V \rightarrow U_e = 218V + 3V$$
$$U_s = U_c + u_s \qquad\qquad\qquad\qquad U_s = 218V + 0V$$

$$U = U_e - U_s = \cancel{U_c} + u_e - \cancel{U_c} - u_s = \underline{u_e - u_s = 3\,V}$$

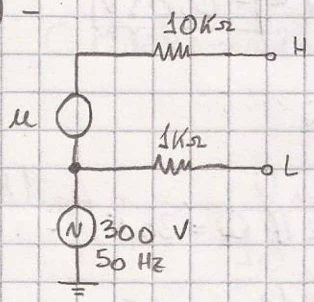
$$E_{u_e} = \pm\left[\frac{0,5}{100}\cdot 3V + 0,1V\right] = \pm 0,115V$$

$$E_{u_s} = 0$$

$$\boxed{U = (3,0 \pm 0,1)\,V}$$

$$e_U = \pm\frac{0,1}{3}\cdot 100 = \boxed{\pm 3,3\ \%}$$

2.4)_



a)_ Fuentes de error:

- Error de inserción
- Error del instrumento
- Error de señal de modo común
- Error de señal de modo normal

b)_ Error fortuito del instrumento:

$$E_U = \pm\left[0,5\%\cdot U_m + 10\ dig\right]$$

$$U_{ef} = \sqrt{\frac{1}{10ms}\left[\int_0^{5ms}\left(\frac{20}{5ms}t\right)^2 dt + \int_{5ms}^{10ms}\left(-\frac{20t}{5ms} + 40\right)^2 dt\right]} = \checkmark$$

$$= \sqrt{\frac{1}{10ms}\left[0,67 + 0,67\right]} = \boxed{11,57\ V}$$

$$E_U = \pm\left[\frac{0,5}{100}\cdot 11,57 + 0,001 \times 10\right] = \boxed{\pm 0,06\ V}$$

NOTA

Error de modo común:

CMRR > 60 dB

$$20 \log\left(\frac{U_{máx}}{U_{visto}}\right) > 80\ dB$$

$$U_{Vista} < \frac{U_{máx}}{10^{\frac{80}{20}}} \Rightarrow U_{vista} < \frac{300V}{10^4} = 0,03\ V$$

$$E_{U_{vista}} = \pm\left[\frac{0,5}{100} \cdot 0,03V + 0,001 \times 10\right] = \boxed{\pm 0,01\ V}$$

Error de modo normal:

No hay error de modo serie.

Error de inserción:

$$e_{ins} = \frac{Z_{th}}{Z_V} = -\frac{1100\Omega}{10 M\Omega} = \boxed{-1,1 \times 10^{-3}}$$

$$\rightarrow = -0,11\ \%$$

$$E_{ins} = -1,1 \times 10^{-3} \cdot 11,57 = \boxed{-0,01V}$$

2.5) $V_p \cong 75V$ $V_{rms} \cong 15V$

Voltímetro: 3 ½ dig - TRMS - $R_V = 10 M\Omega$ // $C_V = 30pF$

$E_U = \pm[0,8\ \% U_m + 3\ dig]$ - CMRR = 90 dB en CC

FC = 3

$$FC = \frac{U_p}{U_{ef}} = \frac{75V}{15V} = 5$$

$$U_p < FC \cdot U_{ef}$$

$$75V < 3 \cdot A_{ec}$$

$$\frac{75V}{3} < A_{ec} \rightarrow A_{ec} > 25\ V.$$

Se selecciona el alcance de 200 V.

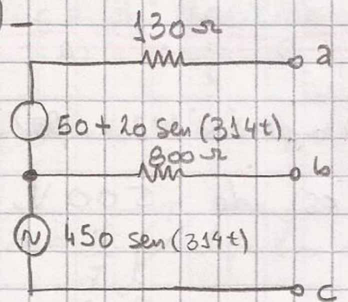
$$E_U = \pm\left[\frac{0,8}{100} \cdot 15V + 0,3\right] = \pm 0,42\ V.$$

$$\boxed{U = (15,0 \pm 0,4)\ V}$$

HOJA N°

FECHA

2.6)_



Fuentes de error:

1)_ Error modo normal

2)_ Error de modo común

3)_ Error fortuito.

a)_ 1 9999

- Error fortuito:

Alc. = 200V

$$E_U = \pm \left[\frac{0{,}03}{100} \cdot 50 + 0{,}02 \right] = \pm\, 0{,}035\ V.$$

- Error modo común:

CMRR > 90 dB

$$CMRR = 20 \log \left(\frac{U_{max}}{U_{vista}} \right)$$

$$U_{vista} = \frac{U_{max}}{10^{\frac{CMRR}{20}}} = \frac{450V.}{10^{90/20}} = 0{,}014\ V.$$

$$\frac{800\Omega}{1\ K\Omega} = \frac{U_{vista}}{0{,}014} \rightarrow U_{vista} = 0{,}014 \cdot \frac{800}{1K} = 0{,}011\ V$$

- Error modo normal:

NMRR > 60 dB

$$NMRR = 20 \log \left(\frac{U_{max}}{U_{vista}} \right)$$

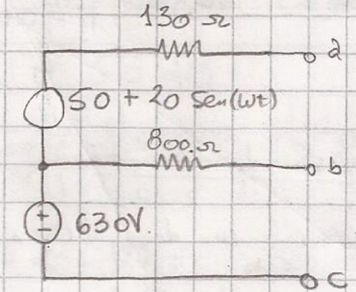
$$U_{vista} = \frac{U_{max}}{10^{60/20}} = \frac{20}{10^{60/20}} = 0{,}02$$

$$e_{\%} = \frac{0{,}035v + 0{,}011v + 0{,}02v}{50v.} \cdot 100 = \boxed{0{,}13\ \%}$$

La medición se puede realizar con un error menor al 0,3 %.

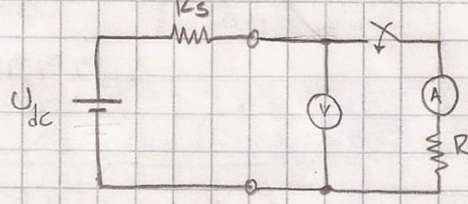
NOTA

b)



No se puede calcular debido a que la especificación máxima para el CMMRR es de 500 V.

2.7)



$e_{U_V - U_C} < 0,5\,\%$

$I_m = 0,5\ A$

1999

<u>Ripple:</u> Medido de forma directa en AC

$$E_U = \pm\left[\frac{0,8}{100} \cdot 2\,mV + 0,02\right] = \pm 0,036\,mV$$

$$U_{Ripple} = (2,00 \pm 0,04)\,mV$$

<u>Tensión en vacío:</u> dC Alc = 200 V.

$$E_U = \pm\left[\frac{0,1}{100} \cdot 125\,V + 0,1\right] = \pm 0,225\,V. \qquad e_{\%} = \pm\frac{0,225}{125\,V} = \pm 0,18\,\%$$

$$U_{vista} = \frac{U_{max}}{10^{\frac{NMRR}{20}}} = \frac{2\,mV}{10^{60/20}} = 2\,\mu V$$ ← se puede despreciar.

<u>Tensión en plena carga:</u>

$$E_U = \pm\left[\frac{0,1}{100} \cdot 0,995 \cdot 125 + 0,1\right] = \pm 0,224\,V.$$

$$e_{\%} = \pm\frac{0,224\,V}{0,995 \cdot 125} = \pm 0,18\,\%$$

$$e_T = \pm(e_{U_V} + e_{U_C}) = \pm 2 \times 0,18\,\% = \boxed{\pm 0,36\,\%}$$

NOTA

20/10/14

Práctica 3: Medición de Potencia

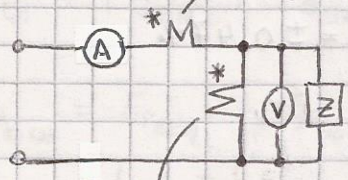
Instrumentos Electrodinámicos

$$\delta = \frac{K}{T}\int_0^T i_F \cdot i_m \, dt$$

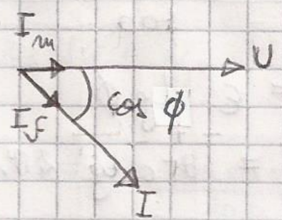
Si bobinas en serie $i_f = i_m \rightarrow \delta = \frac{K}{T}\int_0^T i^2 \, dt$

Vatímetro

bobina fija (amperométrica)



bobina de tensión

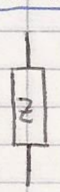


$$\delta = K \cdot P = K \cdot U \cdot I \cdot \cos\phi$$

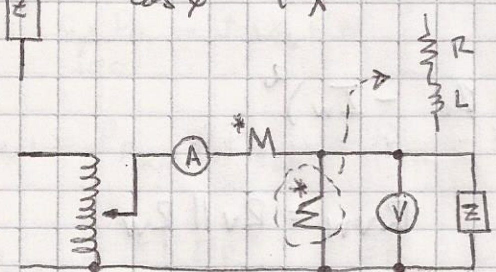
índice de clase: $c = \frac{E}{P_F}$ $\qquad P = U_m \cdot I_m \cdot \cos\phi_m$

- Error por consumo propio
- Error de fase ε

Caracterización de una impedancia



Z, $\cos\phi$ $\left\{ \begin{array}{l} R \\ X \end{array} \right.$ $\qquad Z = \frac{|U|}{|I|}$ $\qquad \cos\phi = \frac{P}{|U||I|}$



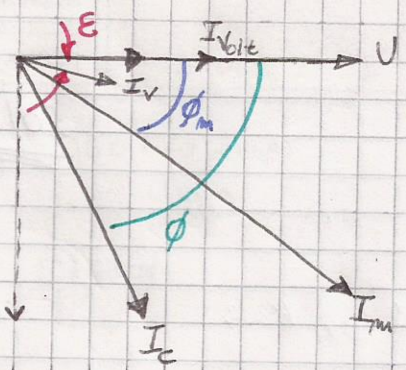
$Z \approx 60\Omega \;\angle 70°$ $\qquad 1\,A$ @ $50\,Hz$

A: $c = 0{,}5$; $A_{ec} = 1{,}5\,A$.

V: $c = 1{,}5$; 15/30/75 V. ; $R_V = 1000\,\Omega/V$

W: $U = 75/150\,v$, $I = 2{,}5/5\,A$. ; $\cos\phi_n = 0{,}2$; $L = 0{,}041\,Hy$; $c = 0{,}25$

$R_W = 1524\Omega / 3048\Omega$



$U_m \approx 60\ V$

$P_m \approx 20\ W$

$C = \frac{E}{X_f}$

A: $\frac{0,5}{100} 1A = \pm 0,005 A \quad e_A = \pm 0,5\%$

V: $\frac{1,5 \times 75}{100} V = \pm 1,1 V \quad e_U = \pm 1,9\%$

W: $\frac{0,25 \times 75V \times 2,5A \times 0,2}{100} = \pm 0,09 W \quad e_p = \pm 0,47\%$

$e = \varepsilon \ tg \phi$

$\varepsilon = arc\ tg \frac{2\pi .50 . 0,041 Hy}{1524 \Omega} = 0,00084\ rad$

$\boxed{e = + 0,23\ \%}$ Hay que desafectarlo

error de fase

error por consumo propio:

$P_{VW} = \frac{U^2}{R_{VW} // R_V} = \frac{(60V)^2}{1494 \Omega} = 2,4 W \longrightarrow$ desafectar

$P_c = P_m - \frac{U^2}{R_{VW} // R_V} - \frac{\varepsilon . tg \phi . P_m}{100}$

$P = U_m . I_m . \cos \phi_m$

$I_c^2 = (I_m . \text{sen}\, \phi_m)^2 + (I_m . \cos \phi_m - I_w)^2$

$I_c = \sqrt{I_m^2 - \frac{2 \phi_m}{R_{VW}} + \frac{U^2}{R_{VW}^2}} \quad R_{VW} = R_V // R_W$

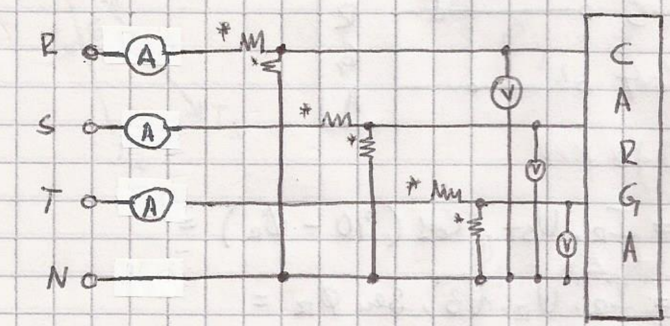
$Z = \frac{U_c}{I_c} \quad \cos \phi = \frac{P_c}{I_c . U_c}$

NOTA

HOJA N°

FECHA

Medición de Potencia en sistema trifásico



$$P_{Total} = P_{R_{RN}} + P_{S_{SN}} + P_{T_{TN}}$$

$$E_{P_{Total}} = E_{P_{RRN}} + E_{P_{SSN}} + E_{P_{TTN}} = 3 . E = 3 \times 16,5\ W$$

$$W: \begin{cases} C = 1,5 \\ I_N = 5\ A. \\ U_N = 220\ V\ /\ 380\ V \\ \cos \phi_n = 1 \end{cases} \qquad C = \frac{E}{P_F} \longrightarrow E = \frac{C \times U_n \times I_n \times \cos\phi_n}{100} = \pm 16,5\ W$$

Ejemplo:

$P_{R_{RN}} = 0,43\ KW \rightarrow I_R = 2\ A \rightarrow U_R = 220\ V.$

$P_{S_{SN}} = 0,16\ KW \rightarrow I_S = 2,3\ A. \rightarrow V_S = 220\ V.$

$P_{T_{TN}} = 0,29\ KW \rightarrow I_T = 3,60\ A \rightarrow U_T = 220\ V.$

$P_W = \frac{(220)^2}{12 K\Omega} = 4\ W$ No es despreciable.

$E = \frac{C \times P_n}{100} = \pm 16,5\ W$

$$P_{Total} = P_{R_{RN}} + P_{S_{SN}} + P_{T_{TN}} - 3 \times P_W = 0,868\ KW$$

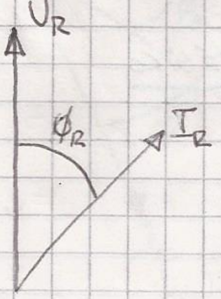
$$E_{P_{TOTAL}} = \pm \left[E_{P_{RRN}} + E_{P_{SSN}} + E_{P_{TTN}} + 3 \times 2 \times \frac{U}{R_W} . E_U \right] = ✓$$

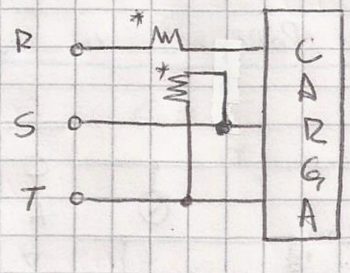
$$= \pm \left(3 \times 16,5 W + 6 \times \frac{220 V}{12 K\Omega} \right) = \pm 0,05\ KW$$

$$\boxed{P = (0,87 \pm 0,05)\ KW} \quad \boxed{e = \pm 5,7\ \%}$$

NOTA

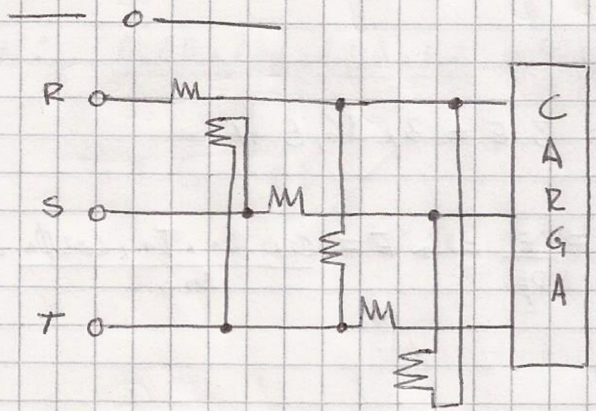
Potencia Reactiva





$P_{R_{ST}}$

$$P_{R_{ST}} = I_R \cdot U_{ST} \cdot \cos(90 - \phi_R) =$$
$$= I_R \cdot U_R \cdot \sqrt{3} \cdot \operatorname{sen} \phi_R =$$
$$= \sqrt{3} \cdot Q_R$$



$$Q_{TOTAL} = \frac{1}{\sqrt{3}} \left(P_{R_{ST}} + P_{S_{RT}} + P_{T_{RS}} \right)$$

$P_{R_{ST}} = 0,8$ KVA

$P_{S_{RT}} = -0,44$ KVA

$P_{T_{SR}} = 0,76$ KVA

$$Q_{TOTAL} = \frac{1}{\sqrt{3}} \cdot \left(0,80 - 0,44 + 0,76 \right) = 0,647 \text{ KVAR}$$

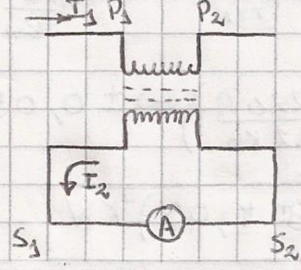
$$E_Q = \frac{1}{\sqrt{3}} \left(E_{P_{RST}} + E_{P_{SRT}} + E_{P_{RS}} \right)$$

En el laboratorio:

$E_P = \pm (1\% \, P_m + 1 \text{ dig})$

$E_Q = \pm (1\% \, Q_m + 1 \text{ dig})$

Transformadores

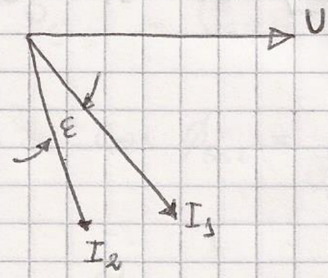


5A

Relación I_1 / I_2

Clase c

S_n



$$I_1 = K \cdot I_2$$

$$e_{I_1} = \pm\left(\mu + e_{I_2}\right)$$

μ: error de relación ($\pm$)

$$P_1 = K \cdot P_2$$

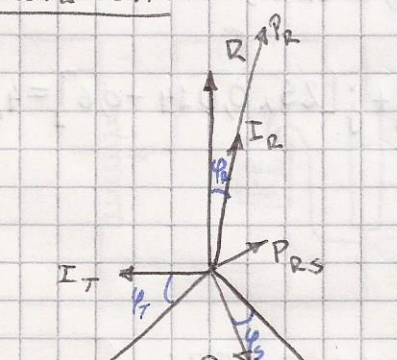
$$e_{P_1} = \pm\left(\mu + \varepsilon \cdot tg\, e_1 + e_{P_2}\right)$$

ε: error de Fase

Manejo de tabla

	% I_n			
	5	20	100	120
0,2			0,2	0,2
0,5			0,5	0,5

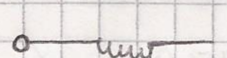
<u>Laboratorio:</u>



$P_{R_{PT}}$ $\quad$ $P_{S_{ST}}$

$$P_{TOTAL} = P_{R_{RT}} + P_{S_{ST}} = \checkmark$$

$$= I_R\, V_{RT} \cdot \cos(\phi_R - 30°) + I_S \cdot V_{ST} \cdot \cos(\phi_S + 30°)$$



Ejemplo: $P_{2_{RRT}} = 1{,}20\ kW$; $P_{2_{SST}} = 0{,}20\ kW$; $I_{2R} = 3{,}5\ A$

$T_A = 15/5$; $C = 0{,}5$; $S_n = 10\ VA$; $U_{RT} = U_{ST} = 380\ V$.

$$P_{RRT} = 3 \times 1{,}20 = 3{,}60\ kW$$

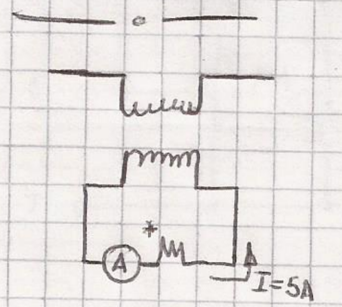
$$P_{SST} = 3 \times 0{,}20 = 0{,}60\ kW$$

$$P_{TOTAL} = 3{,}60 + 0{,}60 = 4{,}20\ kW$$

$$E_{P_{TOT}} = \pm \left[E_{P_{RRT}} + E_{P_{SST}} \right]$$

$$e_{P_{RRT}} = \pm \left(\eta + \varepsilon\, tg\, \phi_{RRT} + e_{P_{2RRT}} \right)$$

$$e_{P_{SST}} = \pm \left(\eta + \varepsilon \cdot tg\, \phi_{SST} + e_{P_{2SST}} \right)$$



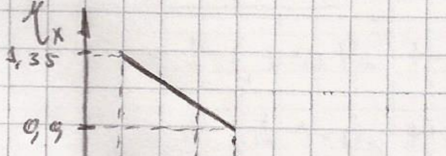
$25\% < S < 100\%$

Vatímetro $\rightarrow \begin{cases} R = 0{,}13\ \Omega \\ XL = 2\pi 50 \cdot 0{,}14\ mH_y \end{cases}$

Amperímetro $\rightarrow \left. \begin{array}{l} P = 0{,}8\ W \\ Q = 0{,}6\ VAR \end{array} \right\} I_{max}(5A)$

$$S = \left[(5)^2 (0{,}13) + 0{,}8 \right] + j \left[25 \times 0{,}014 + 0{,}6 \right] = 4{,}4\ VA$$

$$\frac{I_2}{I_{2N}} = \frac{3{,}5\ A}{5\ A} = \underline{\underline{70\%}}$$



$$\frac{0{,}75 - 0{,}5}{80} = \frac{X}{30} \qquad X = 0{,}0935$$

$$\eta = 0{,}5 + 0{,}0435 = $$

$$\frac{1{,}35 - 0{,}9}{80} = \frac{X}{30} \qquad \varepsilon_x = 1{,}07$$

$$P_{RRT} = U_{RT} \cdot I_R \underline{\cos \phi_{RRT}}$$

$$\cos \phi_{RRT} = \frac{P_{RRT}}{U_{RT} \cdot I_R} \Rightarrow tg\ \phi_{RRT} = 0{,}48$$

NOTA

$$P_{S_{ST}} = U_{ST} \cdot I_S \cdot \cos \phi_{S_{ST}}$$

$$\cos \phi_{SST} = \frac{P_{SST}}{U_{ST} \cdot I_S} \rightarrow tg\, \phi_{SST} = 6{,}6$$

$$e_{P_{2\,RRT}} = \frac{C \times 380 \times 5 \times 1}{1{,}20} = \pm 2{,}4\ \%$$

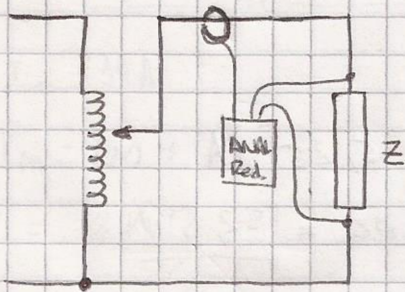
$$e_{P_{2\,SST}} = \pm 14\ \%$$

$$e_{P_{RRT}} = \pm (0{,}59 + 1{,}07 \cdot 0{,}48 + 2{,}4) = \pm 3{,}9\ \%$$

$$e_{P_{SST}} = \pm (0{,}59 + 1{,}07 \cdot 6{,}6 + 14) = \pm 22\ \%$$

$$e_{P_T} = \frac{3{,}5\% \cdot 3{,}80 + 22\% \cdot 0{,}60}{4{,}2} = \pm 6{,}1\ \%$$

Caracterización de Impedancia (220V)



$U_m = 220V$

$I_m = 30{,}0\ A\ (0{,}3\ A)$

$P_m = 4{,}40\ KW\ (44{,}0\ W)$

$S_m = 6{,}62\ KVA\ (66{,}2\ VA)$

$Q_m = 4{,}70\ KVAR\ (47{,}0\ VAR)$

$P_F = 0{,}66$

$$Z = \frac{U_m}{I_m} = 723\ \Omega \qquad R_{eq} = |Z| \cdot F_P = 484\ \Omega$$

$$X_{eq} = |Z| \cdot \sqrt{1 - F_P^2} = 550\ \Omega$$

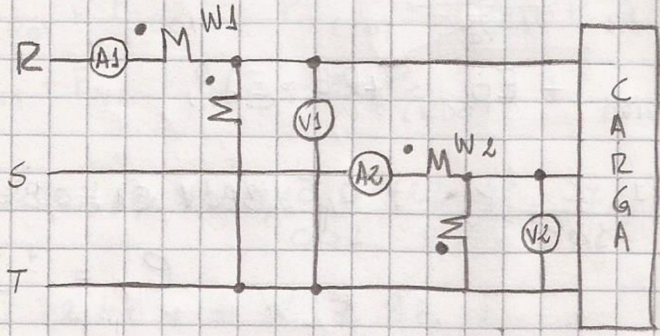
$$E_U = \pm (0{,}5\ \% U_m + 2\ dig) \Rightarrow e_U = \pm 1{,}4\ \%$$

$$E_I = \pm (0{,}5\% \cdot I_m + 3\ dig) \Rightarrow e_I = \pm 1{,}52\ \%$$

Unidad Temática N° 3

3.2)- $e = 5\%$ $S \cong 2\,kVA$ $FP = 0{,}1$ (ind)

3 x 380V
50Hz



A_1 y A_2: $A\ell c = 5A$ - $C = 0{,}5$ - Consumo @ 5A = 1 VA - FP = 0,7

V_1 y V_2: $A\ell c = 400V$ - $C = 0{,}5$ - $133\ \Omega/V$

W_1 y W_2: $U_M = 220/380$ - $I_M = 5A$ - $C = 0{,}5$ - $R_{VW} = 56\ \Omega/V$

a)- $P_T = P_{R(RT)} + P_{S(ST)}$ $\cos\varphi = 0{,}1 \rightarrow \varphi = 84{,}3°$

$P_{R(RT)} = I_R \cdot U_{RT} \cdot \cos(U_{RT} \hat{.} I_R)$

$P_{S(ST)} = I_S \cdot U_{ST} \cdot \cos(U_{ST} \hat{.} I_S)$

Como se trata de una carga balanceada:

$P_{R(RT)} = I_R \cdot U_{RT} \cdot \cos(\varphi - 30°)$

$P_{S(ST)} = I_S \cdot U_{ST} \cdot \cos(30° + \varphi)$

$S = 2\,kVA = \sqrt{3}\, U_L \cdot I_f \longrightarrow I_f = \dfrac{2\,kVA}{\sqrt{3} \cdot 380V} = 3{,}04\ A$

$R_V = 380\,V \cdot 133\,\frac{\Omega}{V} = 50{,}5k$

Indicación W1: $P_{R(RT)} + \dfrac{U_1^2}{R_V \| R_{VW}} = P_{M1}$ $R_{VW} = 380\,V \cdot 56\,\frac{\Omega}{V} = 21{,}28$

$P_{R(RT)} = 3{,}04A \cdot 380V \cdot \cos(84{,}3° - 30°) = 674{,}1\ W$

$\dfrac{U_1^2}{R_V \| R_{VW}} = \dfrac{380^2}{14{,}98 K\Omega} = 9{,}64\,W$

Indicación W2: $P_{S(ST)} - \dfrac{U_2^2}{R_V \| R_{VW}} = P_{M2}$

$P_{S(ST)} = 3{,}04A \cdot 380V \cdot \cos(30° + 84{,}3°) = -475{,}4\ W$

$\boxed{P_{Total}} = P_{R(RT)} + P_{S(ST)} - 2 \cdot \dfrac{U^2}{R_V \| R_{VW}} = 674{,}1W - 475{,}4W + 2 \cdot 9{,}64W = \boxed{179{,}42}$

Errores:

$$P_T = \left(P_{M1} + \frac{U_1^2}{R_V \| R_{VW}} \right) - \left(P_{M2} - \frac{U_2^2}{R_V \| R_{VW}} \right)$$

$$P_T = P_{M1} - P_{M2} + 2 \cdot \underbrace{\frac{U^2}{R_V \| R_{VW}}}_{P_C}$$

$$E_{P_T} = \pm \left(E_{P_{R(RT)}} + E_{P_{S(ST)}} + 2 E_{P_C} \right)$$

$$E_{P_{R(RT)}} = E_{P_{S(ST)}} = \pm \frac{C}{100} \cdot P_f = \pm \frac{0,5}{100} \cdot 380V \cdot 5A \cdot 0,8 = \pm 7,6\ W$$

$$e_\% = \frac{\pm 7,6 VA}{179,42} \cdot 100 = \checkmark$$

$$\boxed{e_\% = 4,2\%}$$

$$E_{P_T} = \pm \left(2 \cdot 7,6W + 2 \cdot 2 \cdot \frac{U}{R_V \| R_{VW}} \cdot E_U \right)$$

$$E_U = \pm \frac{0,5}{100} \cdot 400V = \pm 2\ V$$

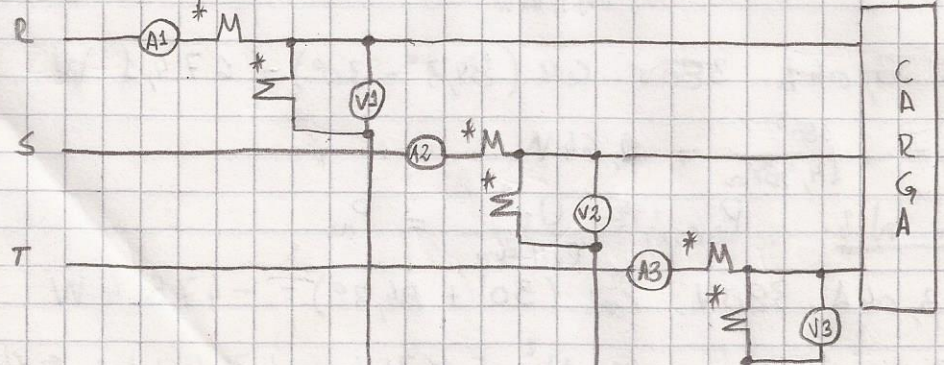
$$E_{P_T} = \pm \left(2 \cdot 7,6 W + 4 \cdot \frac{380}{14,98 k\Omega} \cdot 2 \right) = \pm 15,40$$

$$e_{P_T} = \frac{\pm 15,40}{179,42} \cdot 100 = \boxed{\pm 8,6\%}$$

$$\boxed{P = (179,4 \pm 15,4)\ W}$$

b) – No, porque no logro medir mejor que al 8,6 %

Propongo el circuito: (Menor error en carga reactiva)



NOTA

HOJA N°

FECHA

Conviene usar los tres vatímetros con alcance: $\begin{cases} U_M = 220V \\ I_M = 5A \\ \cos\varphi = 0,2 \end{cases}$

$$P_T = P_{R(R_0)} + P_{S(S_0)} + P_{T(T_0)} = (P_{W1} - P_{c1}) + (P_{W2} - P_{c2}) + (P_{W3} - P_{c3}) = d$$

$$= P_{W1} + P_{W2} + P_{W3} - 3 . P_c$$

$$P_{W1} = 220V . 3,04A . 0,1 + \frac{(220V)^2}{8,7K\Omega} = 72,44 W$$

$$P_T = 3 \times 72,44 W = 217,33 W$$

$$E_{P_T} = \pm \left(E_{P_{W1}} + E_{P_{W2}} + E_{P_{W3}} + 3 . E_{P_c} \right)$$

$$E_{P_{W1}} = E_{P_{W2}} = E_{P_{W3}} = \pm \frac{C}{100} . 220V . 5A . 0,2 = \pm 1,1 W$$

$$E_{P_c} = \pm \left(3 . \frac{2 . 220V . 2V}{8,7K\Omega} \right) = \pm 0,3 W$$

$$E_{P_T} = \pm (3 \times 1,1 W + 0,3 W) = \boxed{\pm 3,6 W}$$

$$e_r = \frac{\pm 3,6 W}{210,32 W} . 100 = \boxed{\pm 1,7 \%}$$

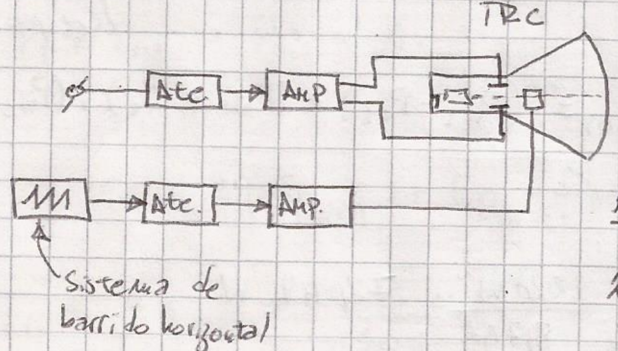
$$\boxed{P = (217,3 \pm 3,6) W}$$

NOTA

Práctica 4: Osciloscopios Analógicos y Digitales

10/11/14

Osciloscopio Analógico

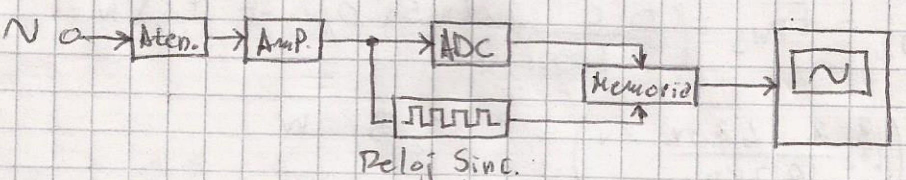


1)_ Modo x, y

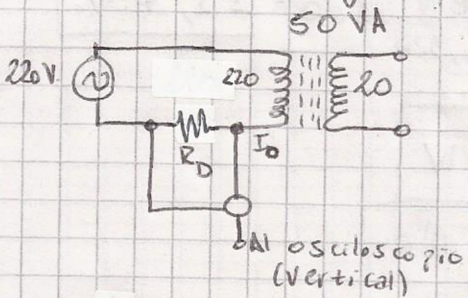
2)_ $u(t)$ → Visualizar tensiones [Repetitiva] en función del tiempo.

3)_ $u(t)$ → Disparo único (memoria) [No repetitiva]

Osciloscopio Digital



1)_ Visualizar y medir una corriente vacío de un trafo.

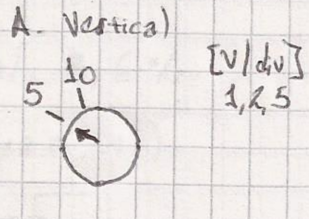


$I_N = \frac{50\ VA}{220\ V} = 230\ mA$

$I_0 \approx 0{,}1 \cdot I_N = 23\ mA$. ← Corriente de Vacío.

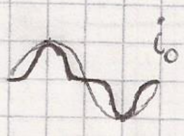
$R_D = ?$ $2\ mV/div$ ó $\underline{5\ mV/div}$

$\hat{U}_{RD} = 5\frac{mV}{div} \cdot 5\ div = 25\ mV$



$\hat{I}_0 = 23\ mA \cdot \sqrt{2} = 28{,}2\ mA$ (sup. que sea senoidal)

$R_D \approx \frac{25\ mV}{28{,}2\ mA} \approx 0{,}9\ \Omega$.



$U_{RD} << 220\ V$.

$U_{RD} \approx \frac{220\ V}{100} \approx 2{,}2\ V$

$i = U \cdot R_D$

$R_D = 56\ \Omega$ $e_{R_D} = \pm 5\%$

$\hat{U}_{RD} = 56\ \Omega \cdot 23\ mA \cdot \sqrt{2} = 1{,}8\ V$

NOTA

HOJA N°

FECHA

$$e_i = \pm(e_U + e_{Ro})$$

Error en el osciloscopio:

$$U = \delta\,(div) \times K\left(\frac{Volt}{div}\right)$$

$$e_U = \pm(e_\delta + e_K)$$

↑ error del atenuador vertical $\simeq \pm 3\%$

$$e_\delta = \frac{\Delta\delta}{\delta} \cdot 100$$

$$\Delta\delta \begin{cases} 1/10 \\ 1/20 \\ 1/50 \end{cases} div$$

$$e_U = \frac{1/20}{10_{div}} \cdot 100 = \frac{100}{200} \cdot 100 = \pm 0{,}5\%$$

$$e_i = \pm(\underset{e_\delta}{0{,}5\%} + \underset{e_K}{3\%} + \underset{e_{Ro}}{5\%}) = \pm 8{,}5\% \simeq \pm 9\%$$

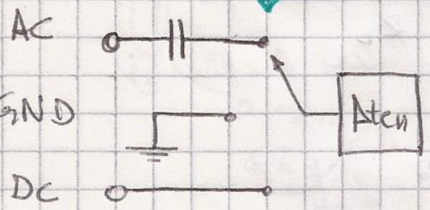
Sistema Vertical
- ganancia (V/div) → $23mA \cdot \sqrt{2} \cdot 56\Omega \simeq 1{,}8V$
- Acoplamiento (DC)

$U_{Mpp} = 3{,}6V$

$$\frac{3{,}6V}{10\,div} = 0{,}36\,V/div$$

Ajuste de 0,5 V/div → 5V pantalla

Se ven 7,2 div.

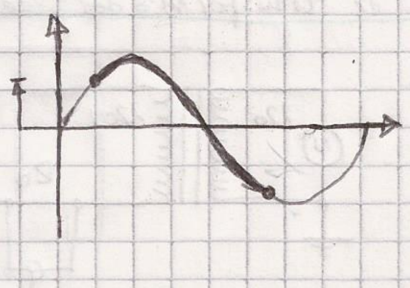


Base de tiempo (Horizontal)
- ej) 10 mS/div - Pantalla = 10 mS/div . 10 div = 100 mSeg
- Para T=20 mSeg : $K_{BT} = \frac{20\,mS}{10\,div} = 2\,mS/div$

Disparo:

Modo
- Auto
- Normal
- Single

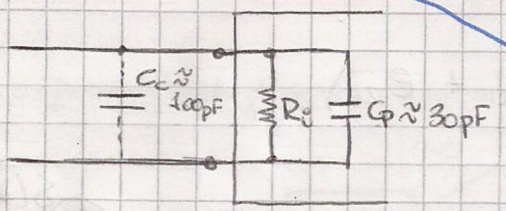
Source
- INT → Level + −
- EXT
- LINE

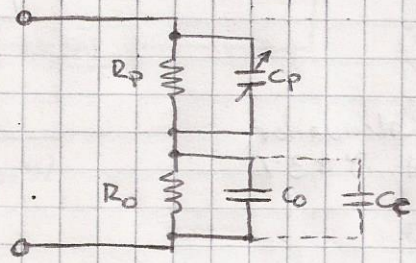


Puntas Atenuadoras:

→ Aumentar el alcance

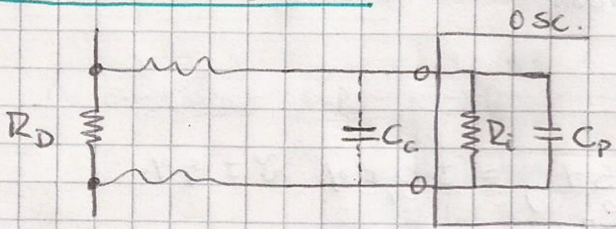
→ Disminuir el e_{ins}





$$R_p \cdot C_p = R_{os}\,(C_o + C_e)$$

Error de Inserción:



$R_i = 10\ M\Omega$

$X_c \approx 24\ M\Omega\ (50\ Hz)$

$\Downarrow$

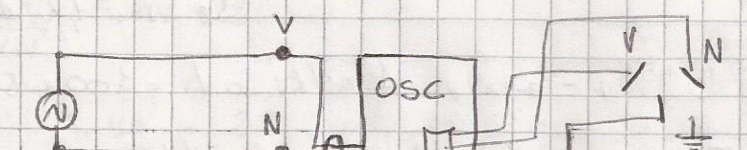
$Z_i \approx 1\ M\Omega$

$$e_i = \frac{U_{osc} - U_{RD}}{U_{RD}} \cdot 100$$

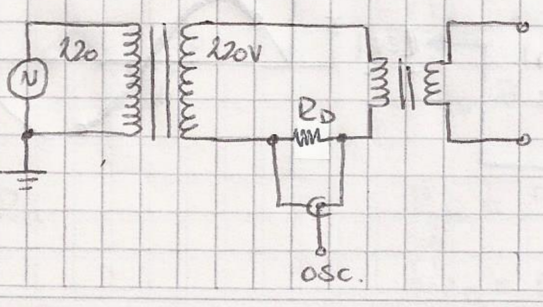
$$e_i \simeq \frac{i \cdot R_D \| Z_{oi} - i \cdot R_D}{i \cdot R_D} = \frac{R_D \| Z_i - R_D}{R_D}$$

$$R_D \| 1\ M\Omega \approx 55{,}497\ K\Omega$$

$$e_i \approx -0{,}005\%$$

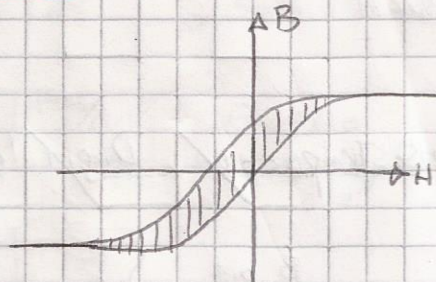


Uso de transformador de aislación:



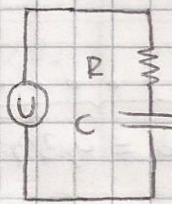
Medición del ciclo de Histeresis (modo x, y):

$$H = \frac{N \cdot I}{L} \qquad H \equiv i_0$$



$$e_2 = N_2 \cdot \frac{d\phi}{dt} = N_2 \cdot S \cdot \frac{dB}{dt}$$

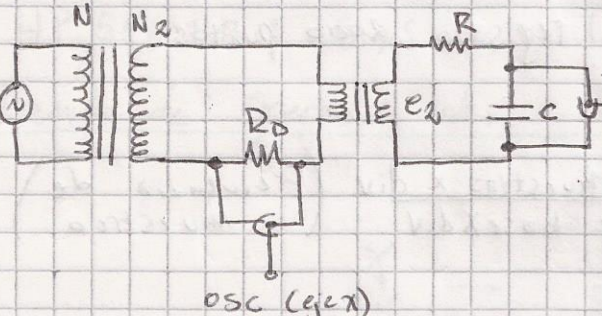
$$B = \frac{1}{N_2 \cdot S} \int e_2 \, dt$$



$$u_c = \frac{1}{C} \int i \, dt$$

$$u_c = \frac{1}{RC} \int U \, dt$$

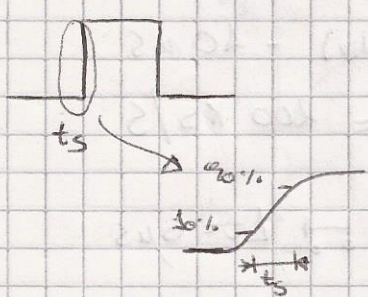
$$R \gg X_c$$

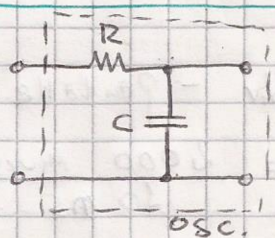


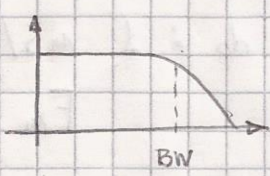
$$B = \frac{C \cdot R}{N_2 \cdot S} \, u_c$$

$$\left.\begin{array}{l} R = 90\,K\Omega \\ C = 1\,\mu F \end{array}\right\}$$

Medición del tiempo de Subida de una Señal Cuadrada:







$$t_r = 2{,}2\ RC \qquad F_{es} = \frac{1}{2\pi RC}$$

$$t_r = \frac{0{,}35}{BW} \approx 35\ nS$$

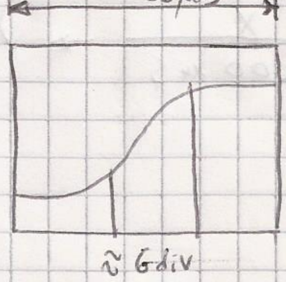
$BW \rightarrow 10\ MHz$

$$ts_{visto} = \sqrt{ts_{os}^2 + ts_{señal}^2} = \sqrt{(35\,nS)^2 + (6\,\mu S)^2} \approx 6\,\mu S$$

Señal cuadrada 6 μS

Barrido ≈ 1μS/div

Ajusto level a cero ("0")

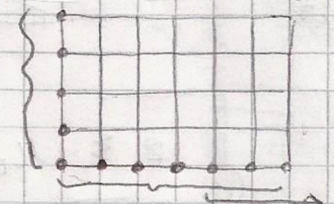


Barrido Retardado:

Señal

Osciloscopios Digitales

8 bit
256 niveles



11 bits (2048 puntos); $\Delta t = 50\ ns$

Resolución: $1/256 \cdot 100 = 0{,}39\%$

Disparo único: 20 Ms/s registro 2000 puntos

Barrido repetitivo: 10 Gs/s

Disparo único: $F_m = \dfrac{N^o\ muestras}{time\ base \times div}$ (Frecuencia de muestreo)

$$Max\ F_m = 20\ Ms/s$$

$$\frac{1}{Max\ F_m} = \frac{1}{20M} = 50\ ns$$

ej) Barrido: 1 ms/div - pantalla (10 div) - 10 ms

$$F_m = \frac{2000\ muestras}{10\ ms} = 200\ KS/S$$

$$\frac{1}{F_m} = \frac{1}{200\ ks/s} = 5\mu S \quad \therefore \Delta t = 5\mu s$$

ej) Barrido: 500 ns/div - Pantalla (10 div) - 5000 ns

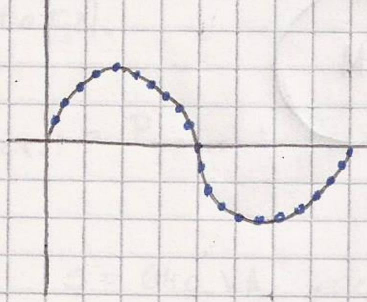
$$F_m = \frac{2000\ muestras}{5000\ ns} = 400\ \cancel{MS}/s \rightarrow !$$

$$20\ Ms/s = \frac{X}{5000\ ns} \rightarrow X = 20\ \frac{Ms}{s} \cdot 5000\ ns = 100\ puntos$$

NOTA

Aliassing:

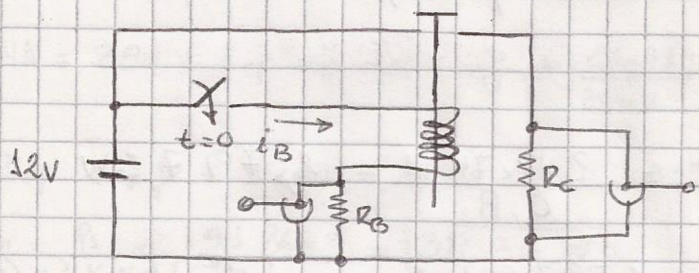
$500\ ns/div \xrightarrow{pantalla} 5000\ ns \rightarrow 100$ pto

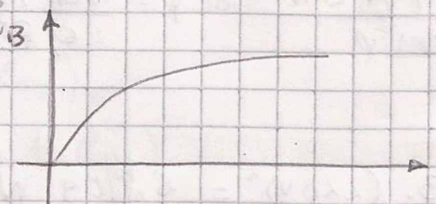


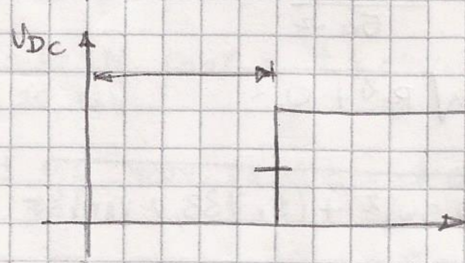
$F_{señal}$	T	Ptos/ciclo	Fenómeno
1 MHz	1000 ns	20	"Correcta"
3 MHz	333 ns	6,7	Máximos
7 MHz	142,8 ns	2,9	Aliassing
18 MHz	55,5 ns	1	Aliasing

HP 54603 B: 5 ns/div x 10 div = 50 ns/pantalla

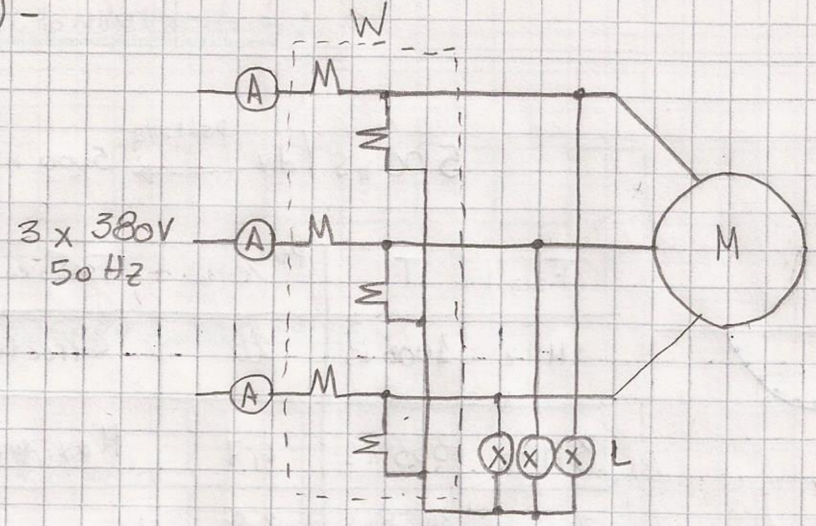
Tiempo de Operación de un Relé:







3.3)-



M: $U_M = 380\,V$; $P_M = 3\,HP$; $\eta = 0{,}8$; $\cos\varphi = 0{,}85$

$\hookrightarrow \varphi = 31{,}79°$

L: Carga resistiva , $50\,\Omega$

a)- Si, es adecuada ya que cumple el teorema de Blondel.

b)-

$$P_{eléctrica} = \frac{P_M}{\eta} = \frac{3\,HP \times 746\,W}{0{,}8} = 2.797{,}5\,W$$

$$Q = S \cdot \operatorname{Sen}\varphi = \frac{2.797{,}5\,W}{\cos\varphi} \operatorname{Sen}\varphi = \frac{2.797{,}5\,W}{0{,}85} \cdot \operatorname{Sen}(31{,}79°) =$$

$$= 1.733{,}7\,VAr$$

$$P_{L1,L2,L3} = 3 \times \frac{U^2}{R} = 3 \cdot \frac{(220\,V)^2}{50\,\Omega} = 2.904\,W$$

Carga total: $S_T = \sqrt{P_T^{\,2} + Q_T^{\,2}}$

$$S_T = \sqrt{(2904\,W + 2797{,}5\,W)^2 + (1.733{,}7\,VAr)^2} = 5.959{,}25\,VA$$

$$\cos\varphi = \frac{P_T}{S} = \frac{2904\,W + 2797{,}5\,W}{5.959{,}25\,VA} = 0{,}95$$

Indicación: $P_{Total} = 2904\,W + 2797{,}5\,W = \boxed{5.701{,}5\,W}$

NOTA

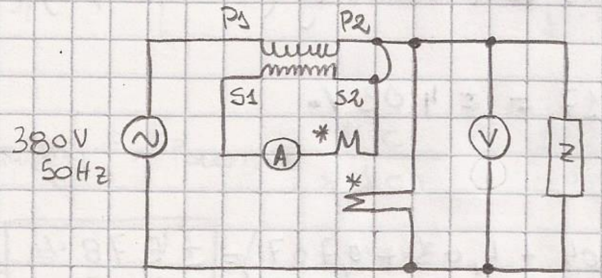
HOJA N°

FECHA

c)_ Si, la indicación del vatímetro será la potencia total.

$$P_{total} = P_{motor} + P_{L1,L2} = 2797,5\,W + \frac{(380\,V)^2}{2\cdot 50\Omega} = \boxed{4.239,5\,W}$$

3.4)_ $S = 640\ VA$; $\cos\varphi = 0,3$ Ind.



$$P = K_{I_n} \cdot P_2$$

$$S = 640\,VA = 380\,V \cdot I_{ef} \Longrightarrow I_{ef} = \frac{S}{U} = \frac{640\,VA}{380\,V} = 1,683\,A.$$

$$P = U \cdot I_{ef} \cdot \cos\varphi = 380V \cdot 1,683\,A \cdot 0,3 = 191,862\,W$$

$$P_2 = \frac{P_1}{K} = \frac{191,862\,W}{5} = \boxed{38,36\,W}$$

$$e_p = \pm\left(e_{K_{I_n}} + e_{P_2}\right)$$

$$e_p = \pm\left(\eta + e_{fase} + e_{P_2}\right)$$

$$e_{P2} = \frac{\pm E_{P2}}{P_2} = \frac{\pm 0,4\,W}{38,36\,W} \cdot 100\% = \pm 1,04\%$$

$$E_{P2} = \pm \frac{c}{100} \cdot P_f = \pm \frac{0,5}{100} \cdot 400V \cdot 1A \cdot 0,2 = \pm 0,4\,W$$

$$\eta: \frac{I_f}{I_{1n}} \cdot 100 = \frac{1,683\,A}{5\,A} \cdot 100 = 33,6\%\ I_n$$

$$\frac{100-20}{0,5-0,75} = \frac{100-33,6}{0,5-\eta} \Longrightarrow \eta = -\frac{100-33,6}{100-20} \cdot (0,5-0,75) + 0,5$$

$$-320 = \frac{66,4}{0,5-\eta} \qquad \boxed{\eta = \pm 0,707}$$

NOTA

e_{fase} :
$$\frac{100-20}{0{,}9-1{,}35} = \frac{100-33{,}6}{0{,}9-\varepsilon}$$

$$-177{,}78\,(0{,}9-\varepsilon) = 66{,}4$$

$$-0{,}9+\varepsilon = +\frac{66{,}4}{177{,}78}$$

$$\varepsilon = \frac{66{,}4}{177{,}78} + 0{,}9 = \pm 1{,}273$$

$$e_{fase} = \pm\,\varepsilon \cdot tg\,\varphi = \pm 1{,}273 \text{ centiradian} \cdot tg(\arccos 0{,}3) =$$

$$= \pm 1{,}273\,\% \cdot 3{,}17 = \pm 4{,}03\,\%$$

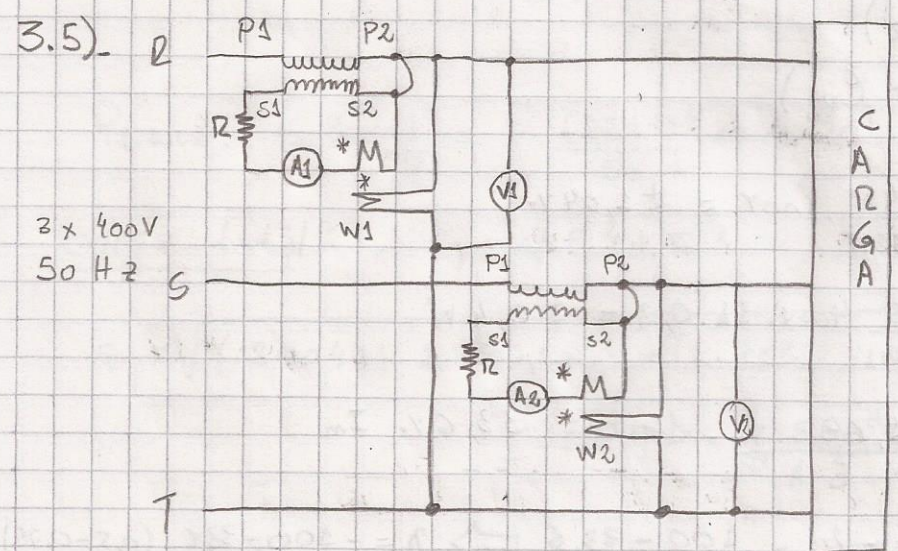
$$e_p = \pm(\eta + e_{fase} + e_{p2}) = \pm(1{,}04 + 4{,}03 + 0{,}707) = \boxed{\pm 5{,}78\,\%}$$

$$E_p = \pm\frac{5{,}78\,\%}{100} \cdot 191{,}86\,W = \pm 11{,}1\,W$$

$$P_V = \frac{(380\,V)^2}{\underbrace{100\,\frac{\Omega}{V} \cdot 500\,V \,\|\, 15\,K\Omega}_{11{,}54\,K\Omega}} = 12{,}51\,W$$

No es despreciable

3.5)



indicaciones:
- W1 : 100 div
- W2 : 86,6 div
- V1 = V2 = 100 div
- A1 = A2 = 100 div

$$R_{cable} = \frac{Cu \cdot l}{S} = \frac{0{,}0175\,\Omega \cdot mm^2/m \cdot 10\,m}{6\,mm^2} = 0{,}02917\,\Omega$$
$$= 29{,}2\,m\Omega$$

$$S = (5\,A)^2 \cdot \underbrace{[0{,}029 + 0{,}056\,\Omega + 0{,}028\,\Omega + j314\,(0{,}18\,mHy + 90\,\mu Hy)]}_{0{,}113 + j\,0{,}0848} = 3{,}53\,VA \quad \varphi = 36°$$
$$\cos\varphi = 0{,}81$$

NOTA

$$S = (3{,}53\,VA / 10\,VA) \cdot 100 = \boxed{35{,}3\,\%}$$

HOJA N°

FECHA

a).-

$$P_{Total} = P_{R(RT)} + P_{S(ST)} = K \cdot P_{R2(RT)} + K \cdot P_{S2(ST)} =$$

$$P_N = I_N \cdot U_N = 400V \cdot 5A = 2.000\,W$$

$$100\ div \_\_\_ 2000\,W$$
$$86{,}6\ div \_\_\_ = 1.732\,W$$

$$P_{Total} = 2 \cdot \left[2000\,W + 1732\,W \right] = \boxed{7.464\,W}$$

$$E_{P_{R2(RT)}} = E_{P_{S2(ST)}} = \frac{\pm c}{100} \cdot P_f = \pm \frac{0{,}5}{100} \cdot 400V \cdot 5A = \pm 10\,W$$

$$E_{P_{cons.}} = \frac{U^2}{R_{VW} \,//\, R_V} = \frac{(400V)^2}{33{,}3\frac{\Omega}{V} \cdot 400V \,//\, 133\frac{\Omega}{V} \cdot 400V} = \frac{(400V)^2}{\underbrace{13{,}32\,K\Omega \,//\, 53{,}2\,K\Omega}_{10{,}653\,K\Omega}} =$$

$$= 15{,}2\,W$$

$$e_{P_{R2(RT)}} = \pm \frac{10\,W}{2000\,W} \cdot 100 = \pm 0{,}5\% \qquad e_{P_{S2(ST)}} = \pm \frac{10\,W}{1732\,W} \cdot 100 = \pm 0{,}58\%$$

$$e_{P_{R(RT)}} = \pm \left(\eta + e_{Fase} + e_{P_{R2(RT)}} \right) = \pm (0{,}65\% + 0{,}5\%) = \pm 1{,}15\%$$

$$\eta = \frac{I_f}{I_{fN}} \cdot 100 = \frac{5A}{10A} \cdot 100 = 50\%\ I_N$$

$$\frac{100-20}{0{,}5-0{,}75} = \frac{100-50}{0{,}5-\eta}$$

$$-320 = \frac{50}{0{,}5-\eta} \rightarrow +\eta = +\frac{50}{320} + 0{,}5 = \pm 0{,}65\%$$

e_{Fase} :

$$\frac{100-20}{0{,}9-1{,}35} = \frac{100-50}{0{,}9-\varepsilon} \rightarrow \varepsilon = \frac{50}{177{,}78} + 0{,}9 = \pm 1{,}18\ \text{centirad}$$

$$e_{Fase} = \pm \varepsilon \cdot tg\,\varphi = \pm 1{,}18 \cdot tg(\arccos 1) = \pm 0\%$$

$$\cos \varphi = \frac{P_m}{I_m \cdot U_m} = \frac{2000\,W}{5A \cdot 400V} = 1$$

NOTA

$P_{TOTAL} = 7464\,W - 2 \cdot 15,2\,W = 7433,6\,W$

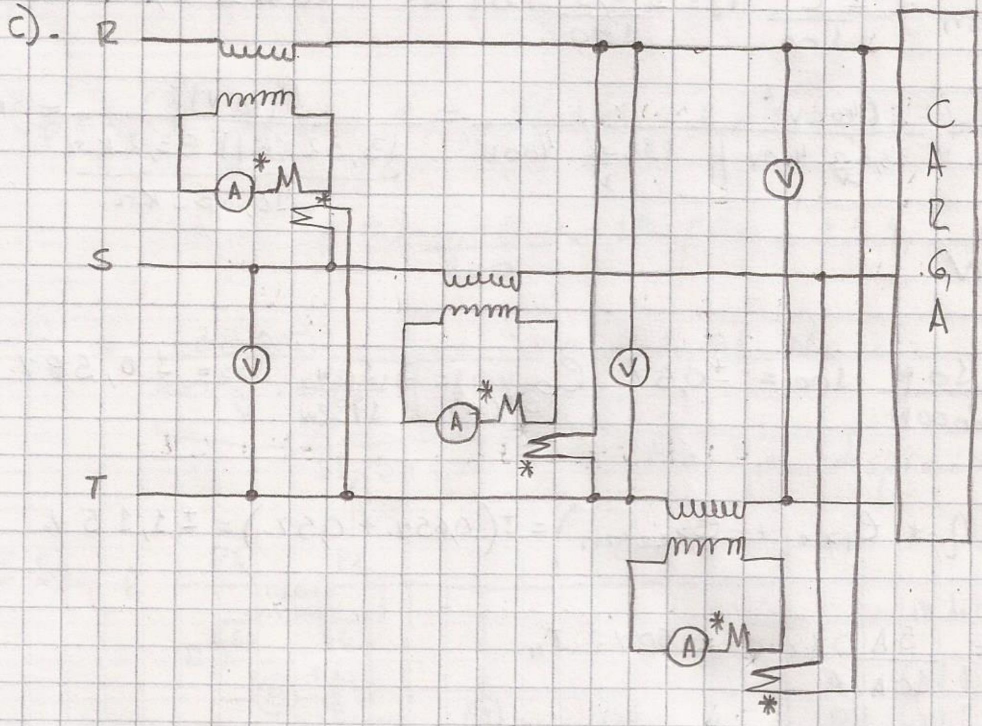
$e_T = \pm 2 \cdot 1,15\% = \pm 2,3\%$ $\qquad e_T = \pm \frac{E}{P_T} \cdot 100$

$E_T = \frac{e_T}{100} \cdot P_T = \frac{\pm 2,3\%}{100\%} \cdot 7433,6\,W = \pm 170,97\,W$

$$\boxed{P = (7433,6 \pm 170,97)\,W}$$

b)- Si, el metodo es general.

c).-



$Q_T = Q_R + Q_S + Q_T \qquad Q = U \cdot I \cdot \operatorname{Sen} \varphi$

$Q_R = U_R \cdot I_R \cdot \operatorname{Sen} \varphi$

$U_{ST} \cdot I_R \cdot \operatorname{Cos}(90 - \varphi) = \sqrt{3} \cdot U_R \cdot I_R \cdot \operatorname{Sen} \varphi = \sqrt{3} \cdot Q_R$

$U_{RT} \cdot I_S \cdot \operatorname{Cos}(90 + \varphi) = -\sqrt{3} \cdot U_R \cdot I_S \cdot \operatorname{Sen} \varphi = \sqrt{3}\, Q_S$

$U_{SR} \cdot I_T \cdot \operatorname{Cos}(90 - \varphi) = -\sqrt{3} \cdot U_R \cdot I_T \cdot \operatorname{Sen} \varphi = \sqrt{3}\, Q_R$

$$\boxed{Q = \frac{K_I}{\sqrt{3}} \left[P_{m1} + P_{m2} + P_{m3} \right]}$$

NOTA

HOJA N°

FECHA

3.8)- $P = \sqrt{3} \cdot U_L \cdot I_{ef} \cdot \cos\varphi$

$P_A = \sqrt{3} \cdot U_L \cdot I_{eA} \cdot \cos\varphi_A$

$I_{ef_A} = 3{,}8\ A = \dfrac{5\ kW}{\sqrt{3} \cdot 380 \cdot \cos\varphi}$

$I_{ef_B} = 76\ A. = \dfrac{40\ kW}{\sqrt{3} \cdot 380 \cdot 0{,}8}$

Corriente	$\cos\varphi$	error [%]
$0{,}05 \cdot I_b$	1	$\pm 2{,}5\ \%$
1 $0{,}1\ I_b$ a I_{max}	1	$\pm 2{,}0\ \%$
$0{,}1\ I_b$	0,5 Ind 0,8 Ind	$\pm 2{,}5\ \%$
2 $0{,}2\ I_b$ a I_{max}	0,5 Ind 0,8 Ind	$\pm 2\ \%$

A: $I_b = 5\ A \Rightarrow \left.\begin{array}{l} 0{,}1\ I_b = 0{,}5\ A \\ 0{,}2\ I_b = 1\ A \end{array}\right\}$ I_{max} 40 A $0{,}05 I_b = 0{,}25\ A$

B: $I_b = 15\ A \Rightarrow \left.\begin{array}{l} 0{,}1 \cdot I_b = 1{,}5\ A \\ 0{,}2 \cdot I_b = 3\ A \end{array}\right\}$ $I_{max} = 120\ A$ $0{,}05 I_b = 0{,}25\ A$

C: $I_b = 1{,}5\ A \Rightarrow \left.\begin{array}{l} 0{,}1 \cdot I_b = 0{,}15\ A \\ 0{,}2 \cdot I_b = 0{,}3\ A \end{array}\right\}$ $I_{max} = 120\ A$ $0{,}05 \cdot I_b = 0{,}075\ A$

Transf. A: $I_{ef,A} \Rightarrow \dfrac{5}{150} \cdot 3{,}8\ A = 0{,}13\ A.$

$I_{ef,B} \Rightarrow \dfrac{5}{150} \cdot 76\ A = 2{,}53\ A$

Transf. B: $I_{ef,A} \Rightarrow \dfrac{1}{150} \cdot 3{,}8\ A = 0{,}025\ A.$

$I_{ef,B} \Rightarrow \dfrac{1}{150} \cdot 76\ A = 0{,}51\ A$

Transf. C: $I_{ef,A} \Rightarrow \dfrac{5}{200} \cdot 3{,}8\ A = 0{,}095\ A$

$I_{ef,B} \Rightarrow \dfrac{5}{200} \cdot 76\ A = 1{,}9\ A$

NOTA

Con ninguno logro estar en 1 para las corrientes A

$\rightarrow$ Voy a necesitar estar en $0{,}05 . I_b \rightarrow$ tampoco puedo

Si no uso transformador:

Uso medidor B:

$$\left.\begin{array}{l} \Rightarrow 3{,}8\,A \in [0{,}1\, I_b ; I_{max}] \\ 3{,}8A \in [1{,}5\,A ; 120\,A] \\ \Rightarrow 76\,A \in [0{,}2 . I_b ; I_{máx}] \\ 76A \in [3\,A ; 100\,A] \end{array}\right\} \text{Uso el medidor B}$$

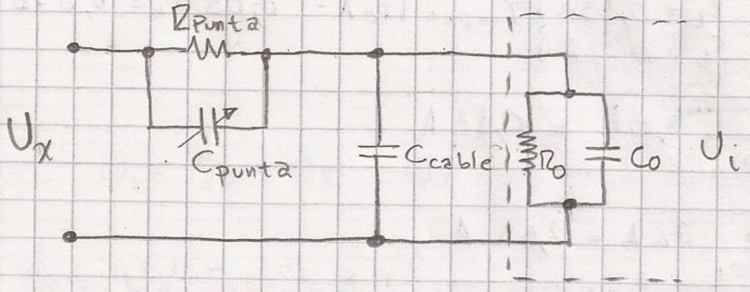
Unidad Temática Nº 4

1)_ El control que se varió fue el de acoplamiento del vertical (AC-GND-DC). En la figura 1 se seleccionó GND, en la figura 2 DC y en la 3 el modo de AC.

2)_ 10 MHz , $Z_{in} = 1\,M\Omega \parallel 30pF$

1 m. cable de $100pF = C_c$

a)_



$$\frac{U_i}{U_x} = \frac{R_0}{R_0 + R_p}$$ cuando las capacidades están correctamente ajustadas.

Punta 1 = Punta 2 = Punta 3:

$$\frac{U_i}{U_x} = \frac{1\,M\Omega}{9\,M\Omega + 1\,M\Omega} = \frac{1}{10} \rightarrow \text{punta } \times 10$$

NOTA

HOJA N°

FECHA

Punta 4 = Punta 5 = Punta 6:

$$\frac{U_i}{U_x} = \frac{1\,M\Omega}{1\,M\Omega + 99\,M\Omega} = \frac{1}{100} \longrightarrow \text{punta } X100$$

En continua puede usarse cualquier punta, ya que los capacitores son circuitos abiertos y por lo tanto la atenuación solo depende de las resistencias.

$$\frac{U_i}{U_x} = \frac{\frac{R_0}{1 + sC_0R_0}}{\frac{R_0}{1+sC_0R_0} + \frac{R_P}{1+sC_PR_P}}$$

$$R_0 C_0 = R_p \cdot C_p$$

b)- Para saber si son adecuadas voy a ver si se pueden compensar las capacidades para que la atenuación no dependa de la frecuencia:

Punta 1 = Punta 2 = Punta 3: $(R_p = 9\,M\Omega)$

$$C_p = \frac{R_0 \cdot C_T}{R_p} = \frac{1\,M\Omega \cdot 130\,pF}{9\,M\Omega} = 14{,}4\,pF$$

↳ solo sirve la punta (3)

Punta 4 = Punta 5 = Punta 6: $(R_p = 99\,M\Omega)$

$$C_p = \frac{R_0 \cdot C_T}{R_p} = \frac{1\,M\Omega \cdot 130\,pF}{99\,M\Omega} = 1{,}30\,pF$$

↳ sirve sola la punta (4)

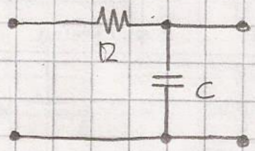
c)- Si no se puede compensar $\frac{U_i}{U_x} \in \mathbb{C}$

$\frac{U_i}{U_x} \longrightarrow |\,|\angle\phi$ Hay un desplazamiento de fase y se modifica el módulo.

Si, se pueden medir periodos, con la precaución de que la frecuencia de la onda no supere los 2 MHz aproximadamente, para no tener problemas con el BW.

NOTA

d).-



$$\frac{U_s}{U_i} = \frac{1}{1 + j\omega RC} = \frac{1}{1 + j\, f/f_0}$$

$$f_0 = \frac{1}{2\pi RC}$$ (Frec. de corte superior)

$$f_0 = 10\ \text{MHz}$$

$$\left|\frac{U_s}{U_i}\right| = \frac{1}{\sqrt{1^2 + (f/f_0)^2}}$$

$$1 - \left|\frac{U_s}{U_i}\right| < 0{,}003$$

$$1 - \frac{1}{\sqrt{1^2 + (f/f_0)^2}} < 0{,}003$$

$$1 - 0{,}003 < \sqrt{\frac{1}{(f/f_0)^2 + 1}}$$

$$(1 - 0{,}003)^2 < \frac{1}{(f/f_0)^2 + 1}$$

$$(f/f_0)^2 + 1 < \frac{1}{(1 - 0{,}003)^2}$$

$$f/f_0 < \frac{1}{(1 - 0{,}003)^2} - 1$$

$$\underbrace{f < \left(\frac{1}{(1 - 0{,}003)^2} - 1\right) f_0}_{f < 60{,}271\ \text{KHz}}$$

$$f_{max\,(93\,\%)} = 60\ \text{kHz}$$

$$\text{Fase} = -\,\text{arc tg}\left(f/f_0\right) \begin{cases} f = f_{max} \rightarrow \text{fase} = -6 \times 10^{-3} \\ f = f_0 \rightarrow \text{fase} = -\pi/4 \end{cases}$$

NOTA

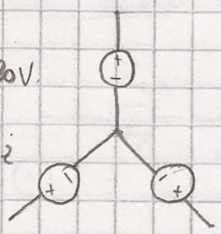
HOJA N°

FECHA

3)

$|V_m| = 220V$

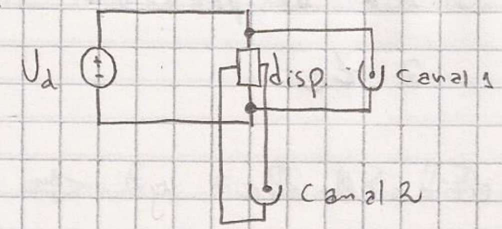
$f_0 = 50 Hz$



OSCILOSCOPIO:

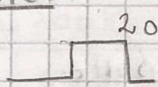
- Puntas x 10
- Uso el amplificador vert. en 5 V/div
- Base de tiempos 5 mseg/div.
- Uso 2 transformadores de aislación 1/1.

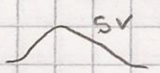
5)



Como el osciloscopio no puede tener 5KV en la entrada, utilizo puntas X10 para la tensión de disparo y X1000 para la salida del dispositivo.

Atenuadores verticales:

Canal 1:  → 50 mV/div

Canal 2:  → 1 V/div

Acoplamiento de ambos canales DC.

Disparo:

Fuente de disparo: Canal 1, Single (disparo único)

Pendiente positiva (+)

Nivel de disparo 1 V.

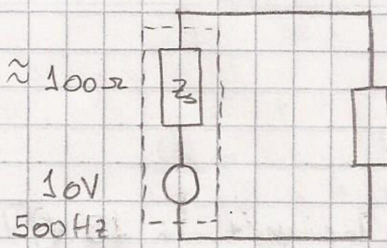
Base de tiempo:

Quiero ver 50/60 μS → con 5 μS/div

Puedo medir t_1, t_2 y U_c midiendo en la pantalla y U_c multiplicando por 1000.

NOTA

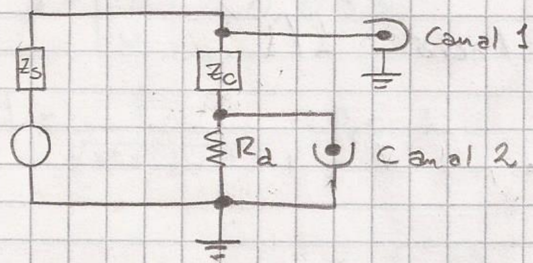
4.4)-



$Z_C \approx 100 K\Omega$

$\varphi \approx 45°$ (inductivo)

a)- Circuito propuesto:



- Osciloscopio de 2 canales.
- $R_a \approx 100\Omega$ para que sea despreciable frente a Z_C.

En el canal 1 veo la tensión en Z_C y en el canal 2 veo la corriente por Z_C dividida por R_a.

$$I = U_{C2}/R_a$$

$$|Z_C| = \frac{U_{C1}}{U_{C2}/R_a}$$

$$\text{fase } Z_C = \frac{360°}{\cancel{2\pi}} \cdot \cancel{2\pi} \cdot \Delta t \cdot 500\text{Hz}$$

Para medir la fase, determino la diferencia de tiempo entre la señal de tensión y la de corriente.

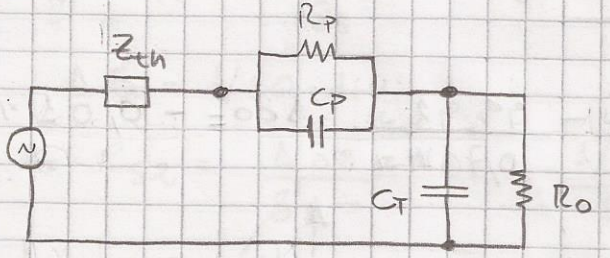
Para determinar que puntas usar analizo los errores de inserción. Como la caída de tensión en R_a será muy pequeña uso punta x1 en el canal 2.

NOTA

HOJA N°

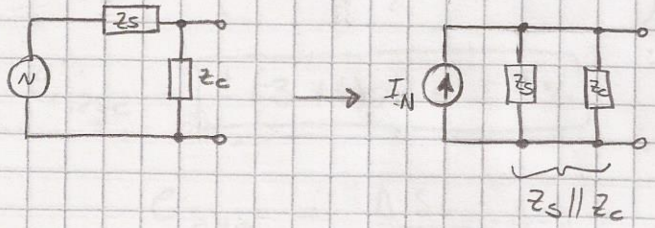
FECHA

Punta x10:



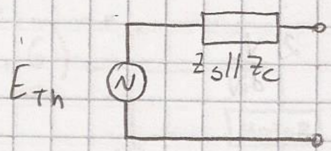
$Z_C = 100\,k\Omega \angle 45° =$

$= 70710{,}7 + j\,70710{,}7\ \Omega$



$I_N = \dfrac{10V}{Z_S}$

$\Longrightarrow E_{Th} = I_N \cdot (Z_S // Z_C)$



$E_{Th} = \dfrac{10V}{Z_S} (Z_S // Z_C) = \dfrac{10V}{\cancel{Z_S}} \cdot \dfrac{Z_S \cdot Z_C}{(Z_S + Z_C)} =$

$= 10V \dfrac{Z_C}{(Z_S + Z_C)}$

$(Z_S // Z_C) = \dfrac{100\Omega \cdot 100\,k\Omega \angle 45°}{100\Omega + 100\,k\Omega \angle 45°} = 99{,}92 + j\,0{,}0706\ \Omega$

$\rightarrow 99{,}92 \angle 0{,}04°$

$X_{\underbrace{(C_C + C_0)}_{C_T}} = \dfrac{1}{2\pi f (C_C + C_0)} = \dfrac{1}{2\pi\, 500\,Hz \cdot 130\,pF} = 2{,}45\ M\Omega$

$X_{C_T} \gg R_0$? ← es comparable

$X_{CP} = \dfrac{1}{2\pi f\, C_P} = \dfrac{1}{2\pi \cdot 500\,Hz \cdot 14{,}4\,pF} = 22{,}1\ M\Omega$

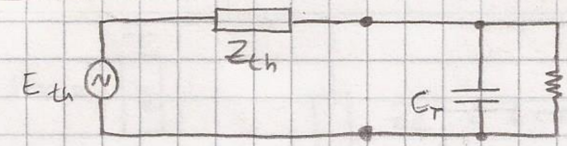
$X_{CP} \gg R_P$? ← no se puede despreciar

$Z_{eq} \cong (X_{C_T} // R_0) + (R_P // X_{C_P}) = 7{,}1\ M\Omega$

$e_i = -\dfrac{Z_{th}}{Z_{eq}} \cdot 100 = -\dfrac{99{,}92\,\Omega}{7{,}1\,M\Omega} \cdot 100 = \boxed{-0{,}001\ \%}$

NOTA

Punta 1x:



$$e_i \cong -\frac{Z_{th}}{Ze} \cdot 100 = -\frac{99,92\,\Omega}{0,71\,M\Omega} \cdot 100 = -0,01\,\%$$

$$Ze \cong (X_{C_T} \,||\, R_0) = 0,71\,M\Omega$$

elijo punta 1_x

b)- Controles Osciloscopio:

Vertical:

$f = 500\,Hz \longrightarrow T = 2\,m\,seg$

$U \cong 10\,V$ $\quad I \cong \frac{10\,V}{100\,K\Omega} = 0,1\,mA \quad U = 0,1\,mA \cdot 100\,\Omega = 10\,mV$

Canal 1: $\frac{10\,V}{8\,div} = 1,25\,V/div \longleftarrow 2\,\frac{V}{div}$

Canal 2: $\frac{10\,mV}{8\,div} = 1,25\,mV/div \longleftarrow 2\,\frac{mV}{div}$

Acoplamiento de ambos canales

Horizontal:

$$\frac{2\,m\,seg}{10\,div} = 200\,\mu s/_{div} \longleftarrow 500\,\mu s/_{div}$$

c)-

$$|Z_c| = \frac{U_{c1}}{U_{c2}/R_d}$$

$$e_{Z_c} = \pm(e_{c1} + e_{c2} + e_{R_d}) =$$

$$= \pm(e_{\delta 1} + e_{K1} + e_{\delta 2} + e_{K2} + e_{R_d})$$

$$e_{S1} = \frac{\Delta S1}{S1} \cdot 100 = \frac{1/50\,div}{5\,div} \cdot 100 = \pm 0,4\,\%$$

$$\Delta S = 1/50\ div$$

$$e_{S2} = \frac{\Delta S2}{S2} \cdot 100 = \frac{1/50\ div}{5\,div} \cdot 100 = \pm 0,4\,\%$$

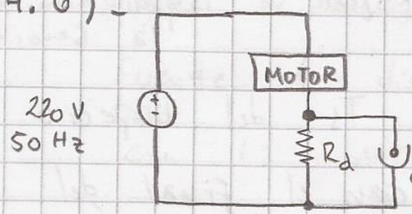
$$e_{Z_{ci}} = \pm\left(2 \cdot (0,4 + 3) + 1 \right) = \pm\ 7,8\,\% \simeq \boxed{\pm\ 8\,\%}$$

$$e_{fase} = \boxed{\pm (3+4)\,\% = \pm\, 7\,\%}$$

$$e_{S\,hor} = \frac{\Delta S_h}{S_h} \cdot 100 = \frac{1/50\ div}{0,5\ div} \cdot 100 = \pm 4\,\%$$

$$\Delta t = 250\,\mu seg$$

4.6) –



$$P = 2 \times 736\,W = 1472\,W = U_{ef} \cdot I_{ef} \cdot \cos\varphi$$

$$\cos\varphi = \frac{P}{U_{ef}\ I_{ef}} = \frac{1472\,W}{220\,V \cdot 14\,A} = 0,48$$

$$R_{(motor)} = \frac{U_{ef}}{I_{ef}} \cdot \cos\varphi = \frac{220\,V}{14\,A} \cdot 0,48 = 7,4\,\Omega$$

Elijo $R_d = 0,1\,\Omega$ de modo tal que la corriente del sistema no varíe. También el error de inserción será pequeño ya que $R_d << |Z_{osc}|$

Las puntas pueden ser 1x (si se usarán 10x ó 100x la atenuación sería muy grande)

Si $R_d = 0,1\,\Omega \rightarrow U_{c1} = 1,4\,V$ en funcionamiento

$\rightarrow U_{c1} = 10\,V$ en el arranque

Atenuador vertical: $\frac{10\,V}{8\,div} = 1,25\ V/div \longrightarrow \underbrace{2\ V/div}$

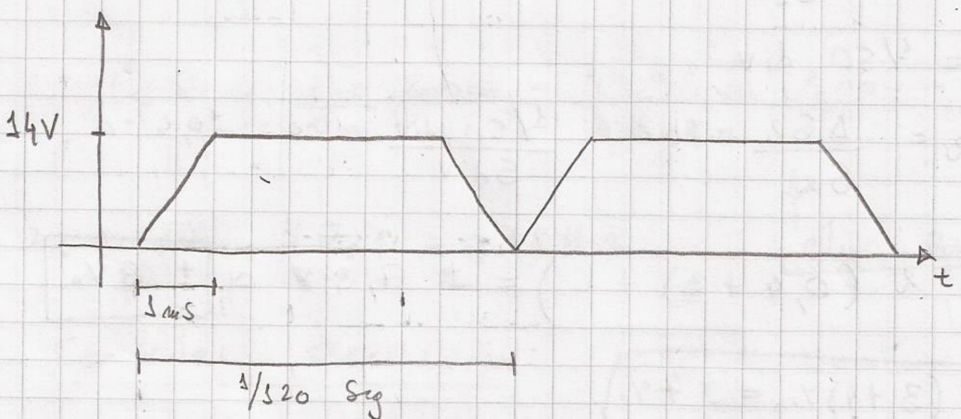
Atenuador Horizontal: $\frac{2\ Seg}{10\ div} = \underbrace{200\ ms/div}$

NOTA

Disparo: disparo unico - Fuente: Canal 1

Flanco ⨍, Level: 0V.

4.8)_

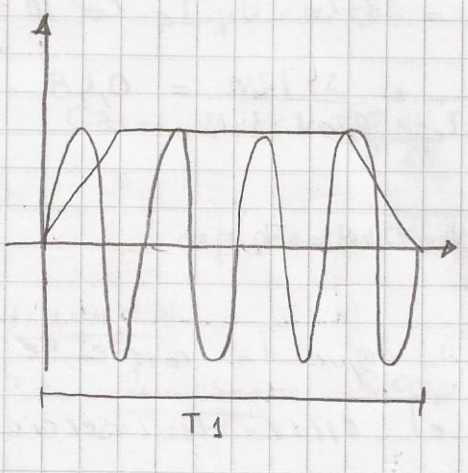


Generador de funciones $f = K.50\,Hz$, $\pm 1\%$.

error base osciloscopio $= \pm 3\%$.

Quiero una $f = K.50Hz = K_1.120\,Hz$

$\rightarrow 600\,Hz = f \rightarrow T = \frac{1}{600Hz}$ $\frac{1/120}{1/600} = 5$ → entran 5 periodos de la senoidal.



Hago que T_1 del trapecio coincida con el final del 5to ciclo de la onda senoidal.

El error será del 1% + error del osciloscopio.

base de tiempo es de $5\,\frac{mS}{div}$ $\rightarrow e_{g_{hor}} = \frac{1/50\,div}{8,2\,div} 100 = \pm 0,24\%$.

$$e = \pm(3 + 1 + 0,24) \cong \boxed{\pm 4\%}$$

4.9)-

a)- Lo que haría es utilizar el generador de frecuencia variable como disparo externo. Conecto el tren de pulsos al osciloscopio y uso la función de disparo externo.

Como disparo externo uso una onda de frecuencia $\frac{1}{T_R}$, con condición de disparo 0 V, pendiente positiva.

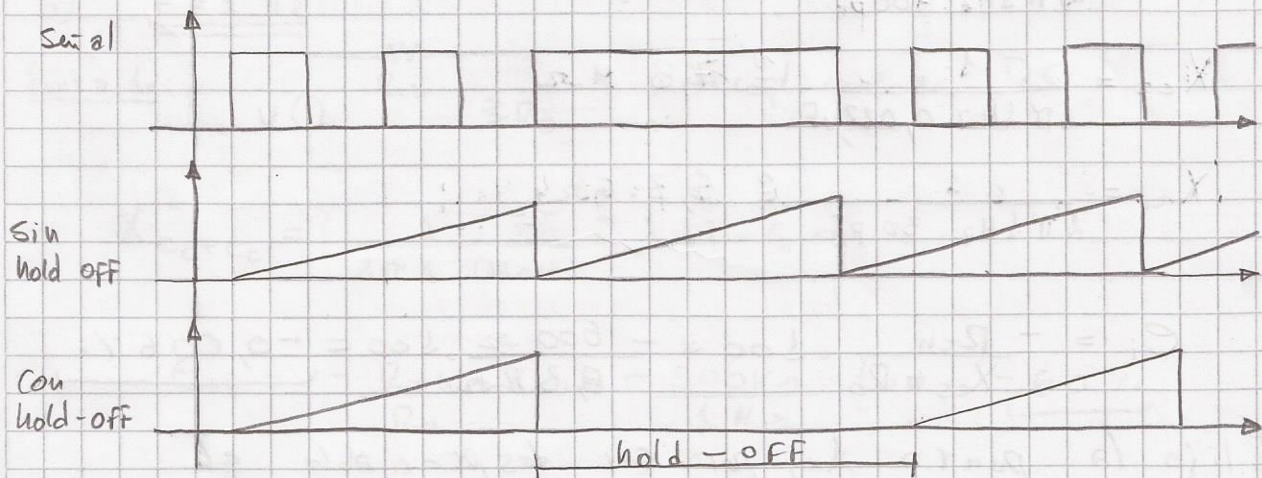
La base temporal la coloco en $\frac{5 ms}{10 div} = 500 \mu V/div$.

b)- Si el osciloscopio tiene memoria pongo el nivel de disparo en 0 V., pendiente positiva, fuente de disparo canal 1, modo simple.

Con la misma base de tiempo.

c)-

4.10)- Lo que se varió fue el hold-OFF, que en (a) no se estaba utilizando y en (b) se seteó de forma correcta.



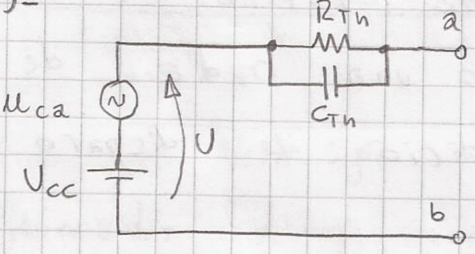
Con el hold-off puedo ver los dos primeros pulsos.

NOTA

4.11)_ Conviene usar barrido retardado, con el disparo indicado y el retardo t_1.

La base retardadora la pondría en 1 ms/div, y la retardada en 0,2 ms/div para ver la señal de 10 kHz.

4.7)_

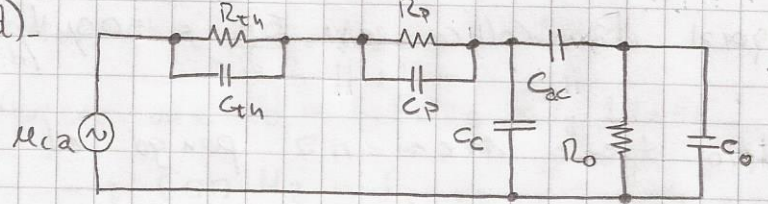


$u_{ca} = 0,5 . \text{Sen}(\omega t)$

$U_{cc} = 12V.$

$R_{th} \cong 500\,\Omega \quad C_{Th} \cong 20\,pF$

a)_

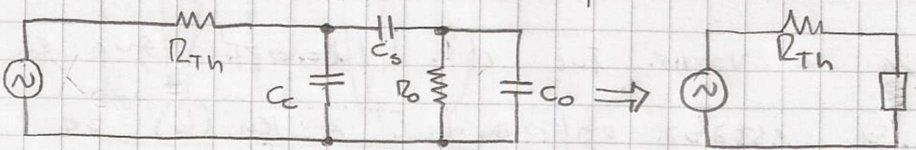


* Acoplamiento AC

$\underline{f = 1\,Hz}$

Punta 1x:

$$X_{C_{Th}} = \frac{1}{2\pi f\, C_{Th}} = \frac{1}{2\pi\, 1Hz .\, 20pF} \cong 8\,G\Omega >> R_{Th}$$



$X_{cs} + R_o \rightarrow \approx 8,3\,M\Omega$

$$X_{cc} = \frac{1}{2\pi 1Hz .\, 100pF} \cong 1,6\,G\Omega$$

$$X_{cs} = \frac{1}{2\pi\, 1Hz\, 0,022\mu F} \cong 7,3\,M\Omega$$

$$X_{co} = \frac{1}{2\pi\, 1Hz .\, 30\,pF} \cong 5,3\,G\Omega$$

$$e_i = -\frac{R_{th}}{X_{cs} + R_o} . 100 = -\frac{500\,\Omega}{8,3\,M\Omega} . 100 = \underbrace{-0,006\,\%}$$

Elijo la punta 1x, por ser despreciable el error de inserción.

NOTA

HOJA Nº

FECHA

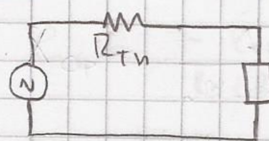
<u>Controles:</u> ganancia vertical : $\frac{500\ mV}{8\ div} = 62{,}5\ mV/div \rightarrow \boxed{0{,}1\ \frac{V}{div}}$

base de tiempo: $\frac{1\ seg}{10\ div} = \boxed{100\ ms/div}$

<u>$f = 100\ Hz$</u>

<u>Punta 1x:</u>

$$X_{C_{Th}} = \frac{1}{2\pi \cdot 100 \cdot 20pF} \cong 79\ M\Omega \gg R_{Th}$$



$X_{cs} + R_o \simeq 1\ M\Omega$

$$X_{cc} = \frac{1}{2\pi\, 100 \cdot 100pF} \cong 15{,}9\ M\Omega$$

$$X_{cs} = \frac{1}{2\pi \cdot 100 \cdot 0{,}022\mu F} \cong 72{,}3\ K\Omega$$

$$X_{co} = \frac{1}{2\pi\, 100 \cdot 30pF} \cong 53{,}0 M\Omega$$

$$e_i = -\frac{R_{th}}{X_{cs} + R_o} \cdot 100 = -\frac{500\Omega}{1M\Omega} \cdot 100 = \underline{-0{,}05\ \%}$$

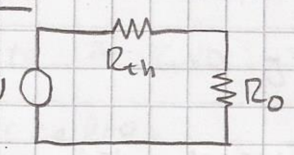
Elijo la punta $\underline{1x}$.

<u>Controles:</u> ganancia vertical: $\boxed{0{,}1\ V/div}$

base tiempo: $\frac{10\ ms}{10\ div} = \boxed{1\ mS/div}$

b)_ <u>$f = 1\ Hz$</u>

<u>Punta 1x:</u>



Acoplamiento DC

$$X_{c_o + c_c} = \frac{1}{2\pi \cdot 1 \cdot (130pF)} \cong 1{,}22\ G\Omega$$

$$e_i = -\frac{R_{th}}{R_o} \cdot 100 = -\frac{500K\Omega}{1M\Omega}\ 100 = \underline{-50\ \%}$$

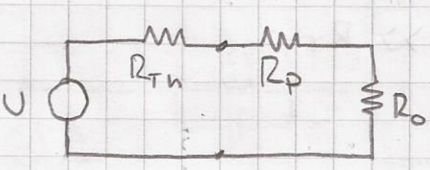
NOTA

Punta 10x:

$$C_P \cdot R_P = C_T \cdot R_o$$

$$C_P = \frac{C_T \cdot R_o}{R_P} = \frac{130pF \cdot 1M\Omega}{9M\Omega} = 14,4\ pF$$

$$X_{CP} = \frac{1}{2\pi \cdot 1 \cdot 14,4pF} \cong 11\ G\Omega$$



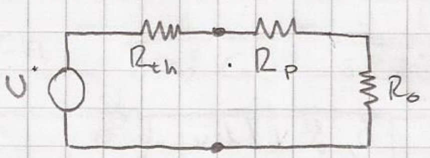
$$e_i = -\frac{R_{Th}}{R_p + R_o} \cdot 100\% = -\frac{500k\Omega}{10M\Omega} \cdot 100 = \underline{-5\%}$$

Punta 100x:

$$C_p \cdot R_p = C_T \cdot R_o$$

$$C_p = 130pF \cdot \frac{1M\Omega}{99M\Omega} = 1,31\ pF$$

$$X_{CP} = \frac{1}{2\pi \cdot 1 \cdot 1,31pF} \cong 381\ G\Omega$$



$$e_i = -\frac{R_{Th}}{R_p + R_o} \cdot 100\% = -\frac{500k\Omega}{100M\Omega} \cdot 100\% = \underline{-0,5\%}$$

Elijo la punta 100x

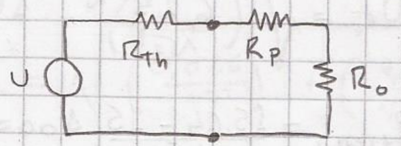
Controles: ganancia Vertical: $\frac{125\ mVp}{8\ div} = 15\ mV/div \rightarrow \boxed{20mV/div}$

base tiempo: $\boxed{100\ ms/div}$

$\underline{f = 100 \text{ Hz}}$

Punta 10x:

$$X_{cp} = \frac{1}{2\pi\, 100 \cdot 14{,}4\,pF} \cong 110\ M\Omega$$

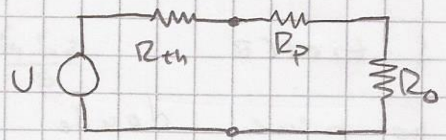


$$X_{co} = \frac{1}{2\pi \cdot 100 \cdot 130\,pF} \cong 12{,}2\ M\Omega$$

$$e_i = \frac{-R_{th}}{R_p + R_o}\, 100\% = -\frac{500\,k\Omega}{10\ M\Omega} \cdot 100 = \underline{-5\%}$$

Punta 100x:

$$X_{cp} = \frac{1}{2\pi\, 100 \cdot 1{,}31\,pF} \cong 1{,}2\ G\Omega$$



$$X_{co} = \frac{1}{2\pi \cdot 100 \cdot 130\,pF} \cong 12{,}2\ M\Omega$$

$$e_i = -\frac{R_{th}}{R_p + R_o}\, 100\% = -\frac{500\,k\Omega}{100\,M\Omega} \cdot 100\% = \underline{-0{,}5\%}$$

Elijo la punta 100x

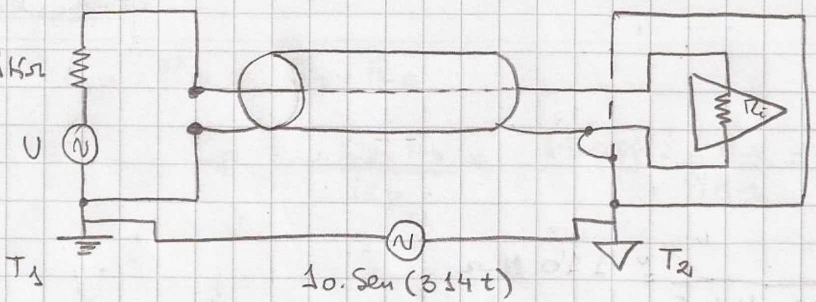
Controles: ganancia vertical: $\boxed{20\ mV/div}$

base tiempo: $\boxed{1\ ms\ /div}$

Para medir U_{cc} lo primero que hago es mover el acoplamiento a GND y llevar la referencia al cero del osciloscopio.

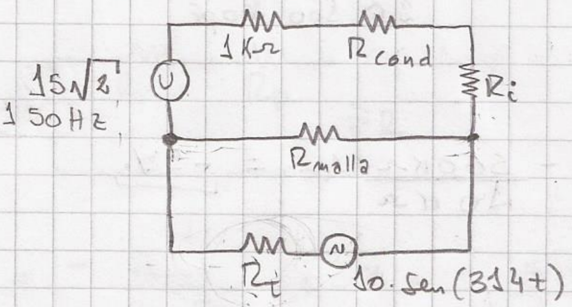
Luego paso el acoplamiento a DC y veo la superposición de las dos señales.

4.12).-



$R_i = 10\,M\Omega$

$$U_{ef} = \sqrt{\left(\frac{6,25}{\sqrt{2}}\right)^2 + 15^2} = 15,64\,V.$$



$$e_{tierra} = \frac{15,64 - 15}{15}\,100 = \underline{+4,2\,\%}$$

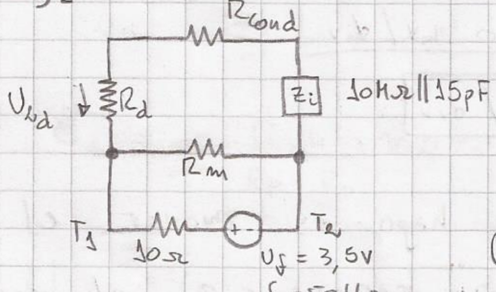
$$U_{R_{malla}} = \frac{10V}{R_t + R_{malla}} \cdot R_{malla} = \frac{10V}{5\Omega + 3\Omega} \cdot 3\Omega = 3,75\,V.$$

→ tengo que eliminar 1 tierra

Quito la guarda G y no tiene donde cerrarse el lazo → $I_t \approx 0$

De esta forma $|U_t| \approx \left(\frac{15.\sqrt{2}}{1k\Omega + 10\Omega + 10M\Omega}\right) . 3\Omega < 1\,V$

4.13).-



1 A ——— 3 V/Km

3V ——— 1 Km

0,075V ——— 0,025 Km

$\boxed{R_m = 0,075\,\Omega}$

$$U_{R_m\,diff} = \frac{3,5 \cdot R_m}{R_m + 10\Omega} = 0,026\,V.$$

$$|U_{Rd}| = \frac{U \cdot R_d}{R_d + Z} = \frac{500 \cdot 0,1\,\Omega}{10\Omega + 0,1\Omega} \simeq 4,95\,V \qquad U_{Rd_{ef}} = \frac{4,95V}{\sqrt{2}} = 3,50V.$$

• Fuentes de Error:
- Intrínseco del instrumento → 2%.
- Error de inserción → despreciable
- Error por tensión de tierra
- Error en la RD → despreciable

$$e_{ins} = \frac{-R_{th}}{10\,M\Omega \,||\, 15\,pF} \cdot 100 \cong \boxed{-0\ \%}$$

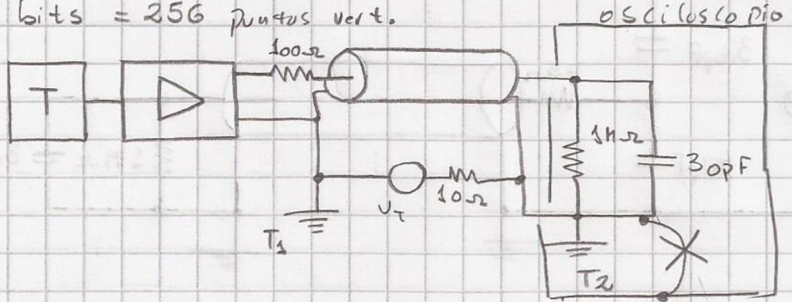
$$R_{Th} = \frac{10\,\Omega \cdot 100\,M\Omega}{10\,\Omega + 100\,M\Omega} = 0{,}099\,\Omega$$

$$U_{ef} = \sqrt{\left(\frac{0{,}026}{\sqrt{2}}\right)^2 + \left(\frac{4{,}9}{\sqrt{2}}\right)^2} = 3{,}46\,V$$

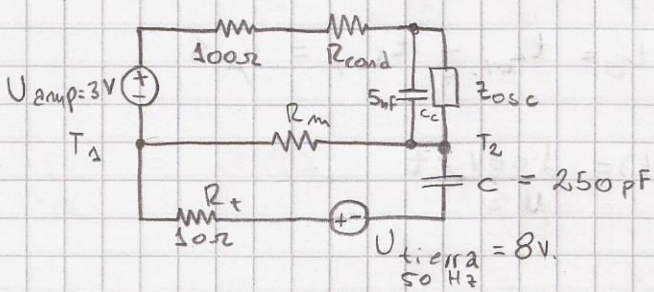
$$e_{tierra} = \frac{3{,}5\,V - 3{,}5\,V}{3{,}5\,V} \cdot 100\,\% = \boxed{0\ \%}$$

4.14)_ 8 bits = 256 puntos vert.

$1\ \frac{GS_a}{s}$



a)_



$$R_m = \frac{30\,m\Omega}{m} \cdot 50\,m = 1{,}5\,\Omega$$

$$\underset{\text{peor caso}}{|U_{Rm}|} = \left| 8\,V \, \frac{R_m}{R_m + 10\,\Omega + X_c} \right| = \frac{8 \cdot 1{,}5}{1{,}5 + 10 + \frac{1}{2\pi \cdot 250 \cdot 250\,pF}} = \boxed{4{,}72\,\mu V}$$

$$\underset{50\,KHz}{X_{cc}} = \frac{1}{2 \cdot \pi \cdot 50\,KHz \cdot 5\,nF} = 636{,}62\,\Omega$$

$$Z_{eq_{c+o}} \cong 636{,}62\,\Omega \qquad R_{cond} \to 0$$

$$\underset{MAX}{|U_{Zosc}|} = \frac{3\,V \cdot 636{,}62\,\Omega}{100\,\Omega + 636{,}62\,\Omega} = 2{,}59\,V.$$

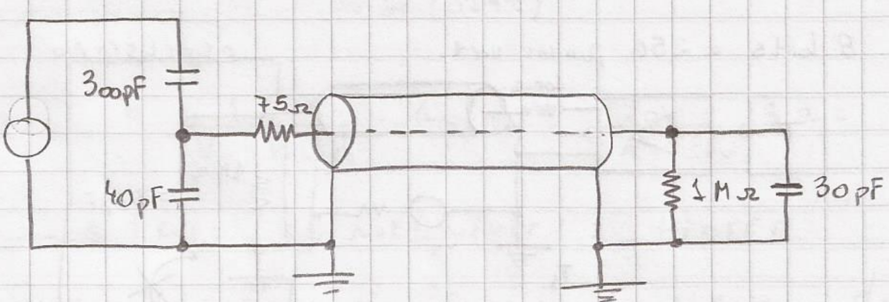
$$e_{Tierra} = -\frac{1,83 - 1,83}{1,83} \cdot 100\% = \underline{0\%}$$

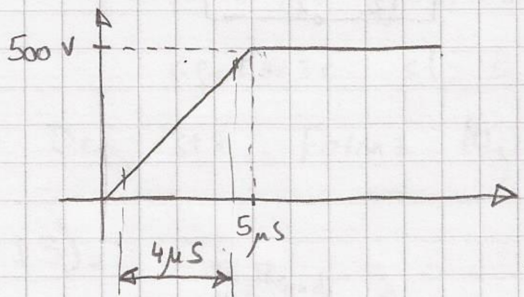
$$U_{ef} = \sqrt{\left(\frac{4,72\mu V}{\sqrt{2}}\right)^2 + \left(\frac{2,59}{\sqrt{2}}\right)^2} = 1,83\ V_{ef}$$

Tengo que medir <u>quitando</u> la guarda

$$U_{T2_{(2)}} = i \cdot R_m = \frac{3V}{100\Omega + 636\Omega + 1,5} \cdot 1,5 = 0,006\ V$$

4.15)-





Voy a calcular un ts

$$t_S = t_{90\%} - t_{10\%} = 4\mu S$$

$$u(t) = \frac{100V}{\mu S} \cdot t$$

a)- Habría que analizar si el error de tierra es grande.

Uso $t_S = \frac{0,35}{f_{c4}} \rightarrow f_{c4} = \frac{0,35}{4\mu S} = 87,5\ KHz$

Quizas convenga quitar una de las tierras porque en el transitorio la tensión sería muy alta.

No hay error de armado.

b)-