Osciloscopios

Osciloscopios

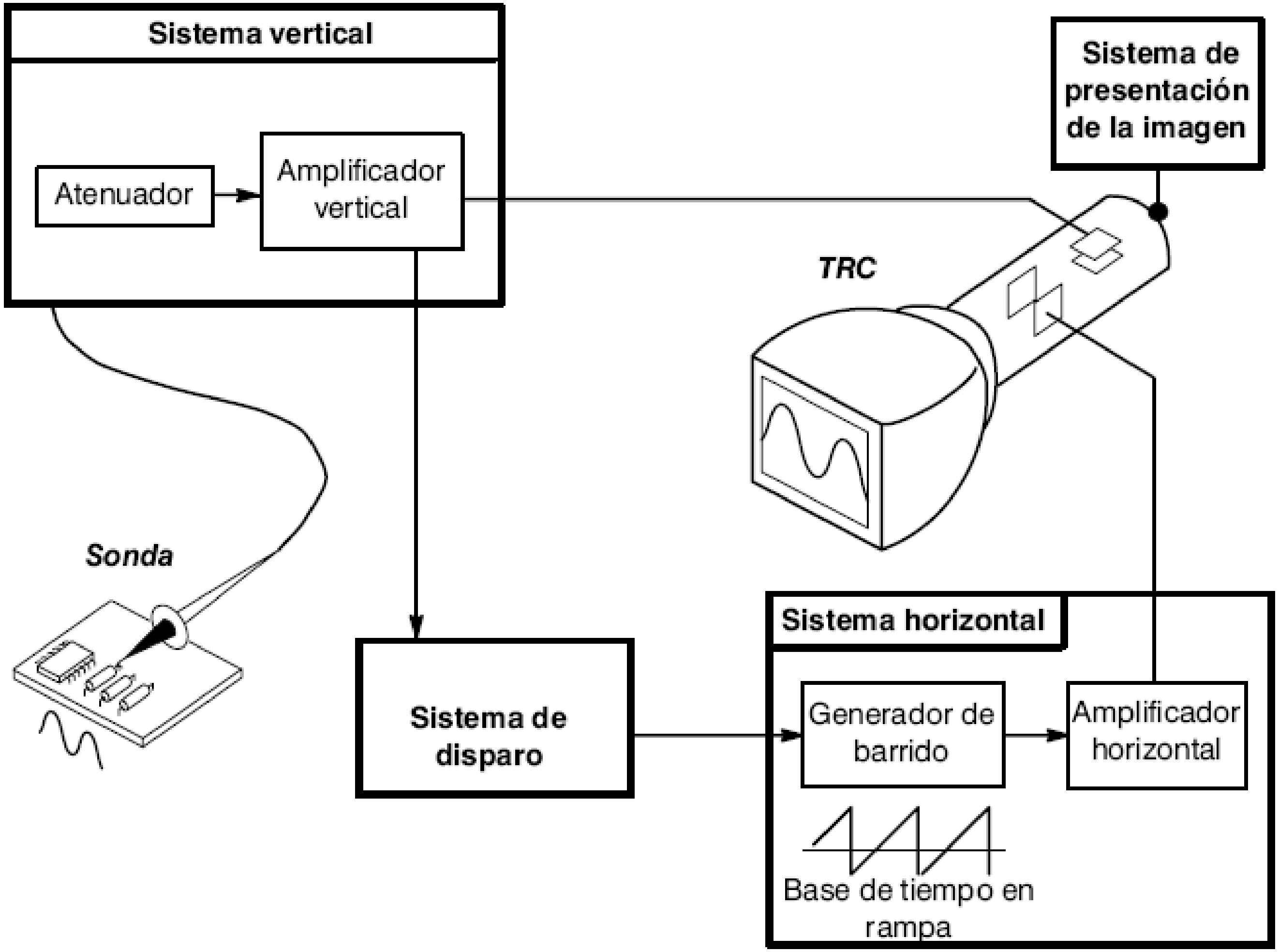
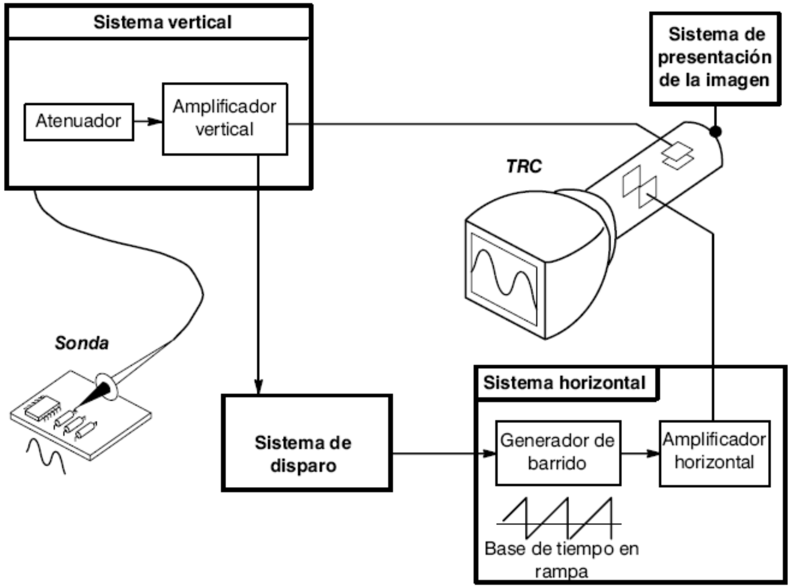
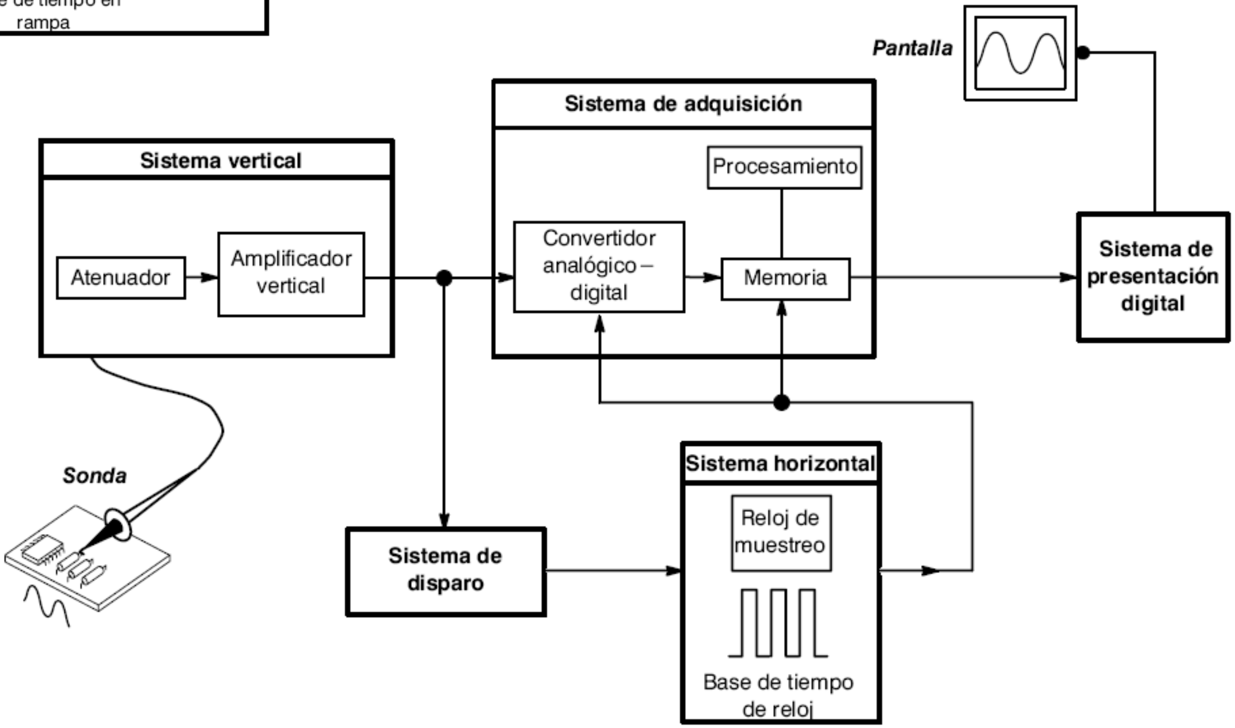


Diagrama en bloques simplificado de un Osciloscopio Analógico

Comparación

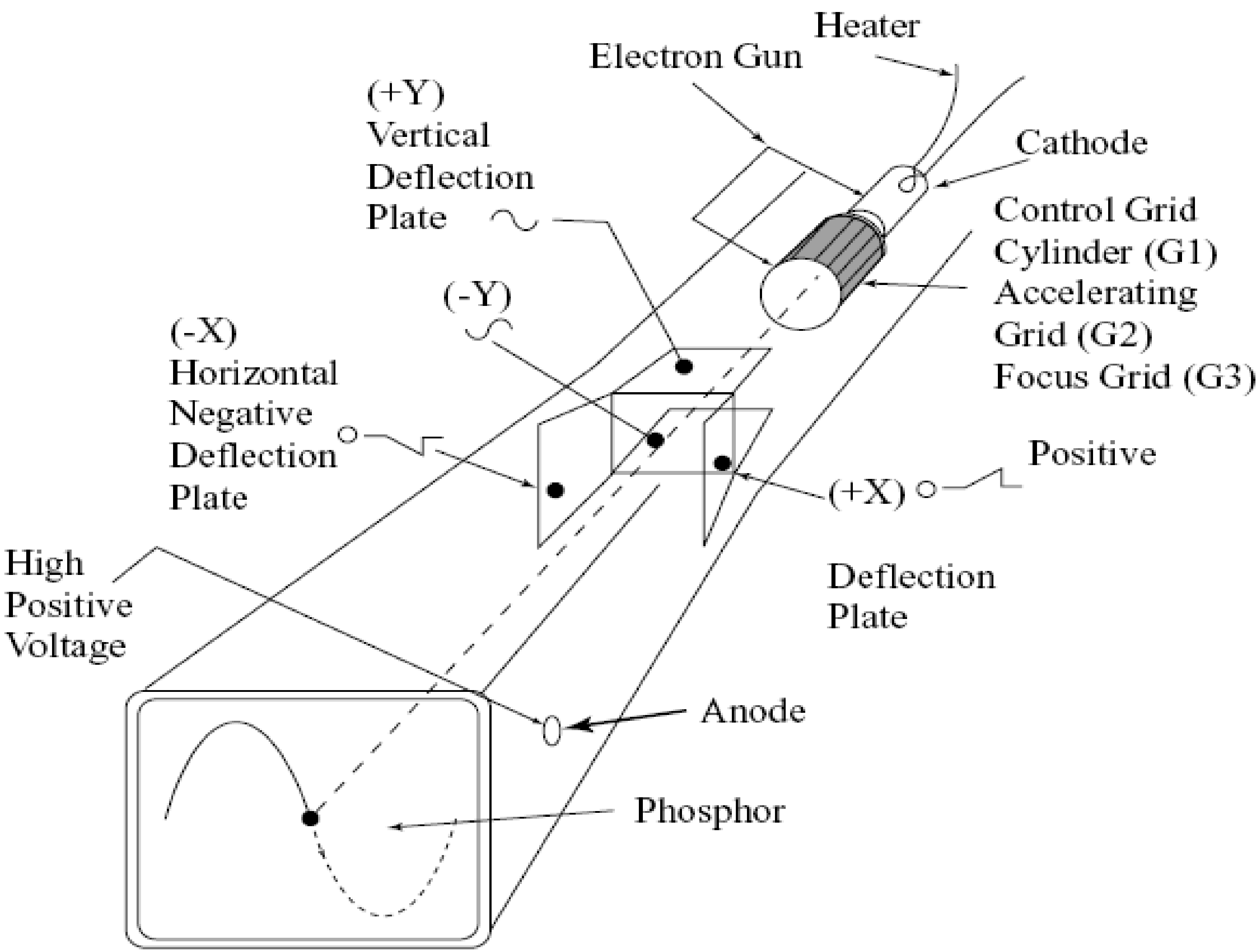


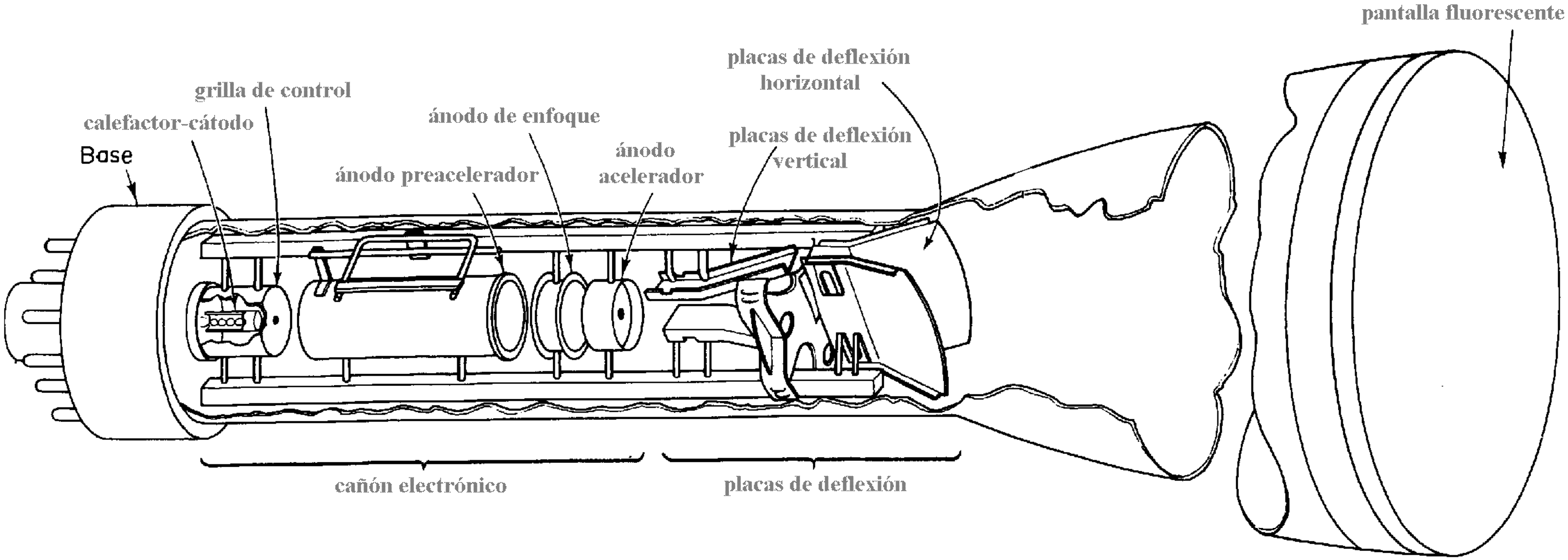
Osciloscopio Analógico

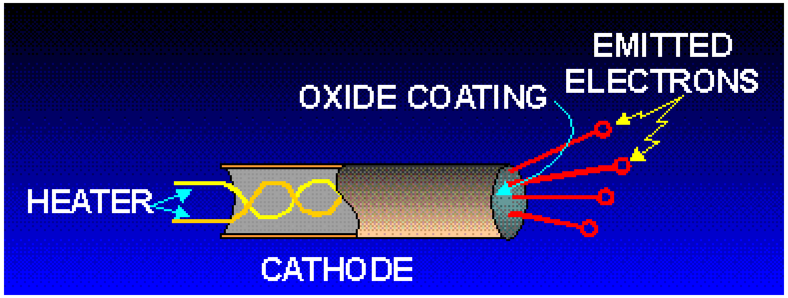


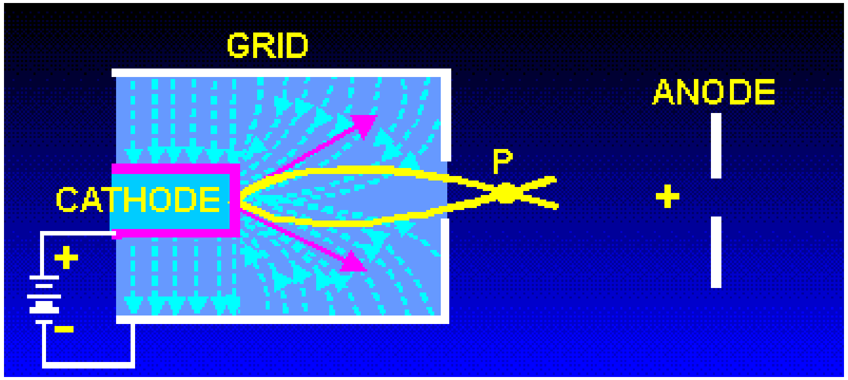
Osciloscopio Digital

Tubo de Rayos Catódicos (TRC o CRT)

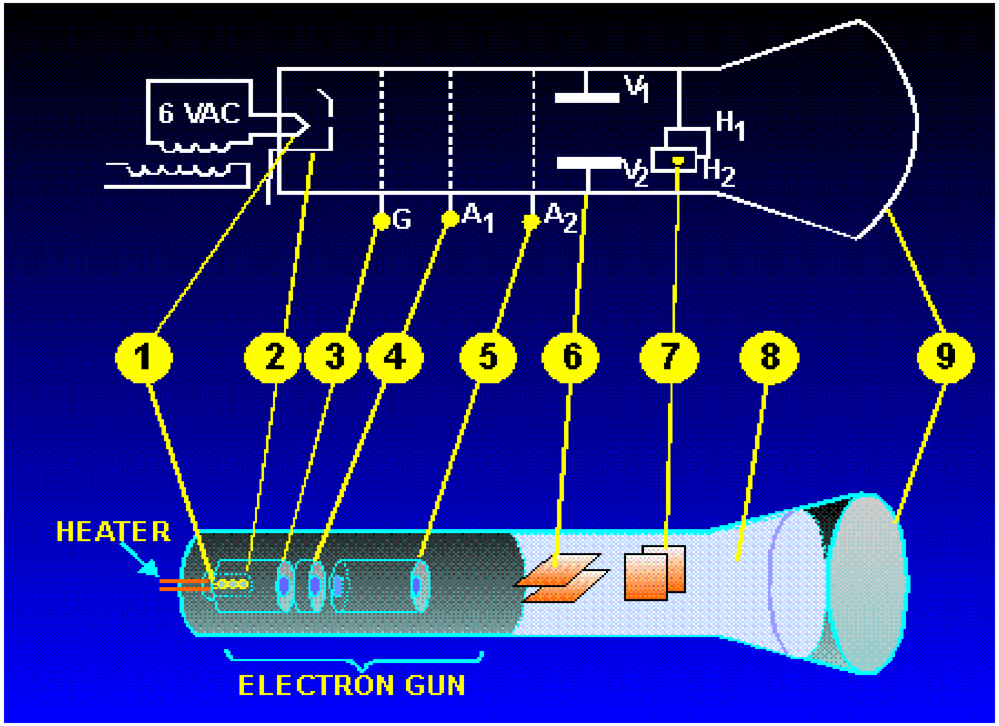


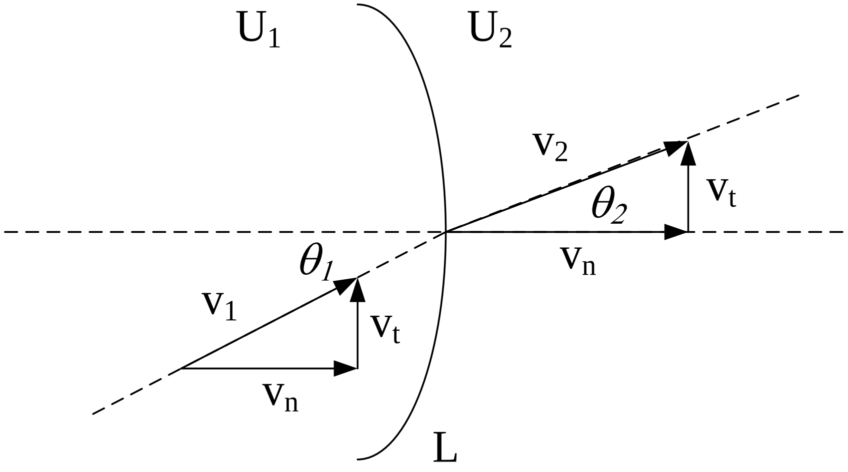






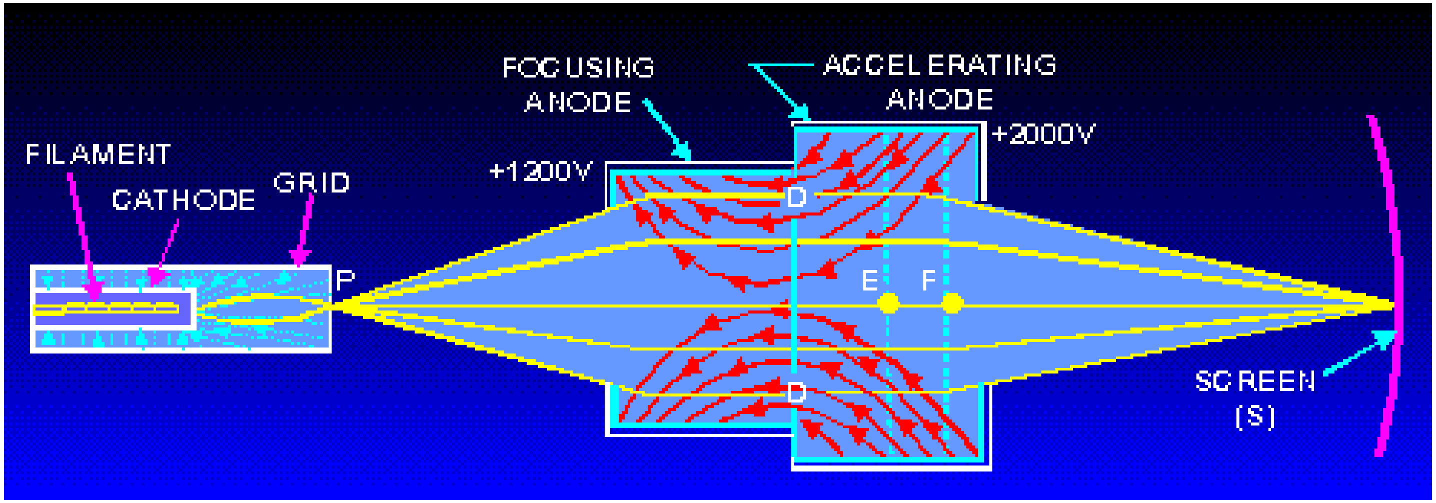
Cañón electrónico



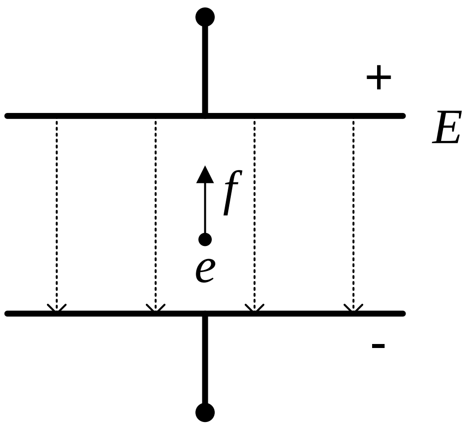


$$\frac{\operatorname{sen}\theta_1}{\operatorname{sen}\theta_2}=\sqrt{\frac{U_2}{U_1}}$$

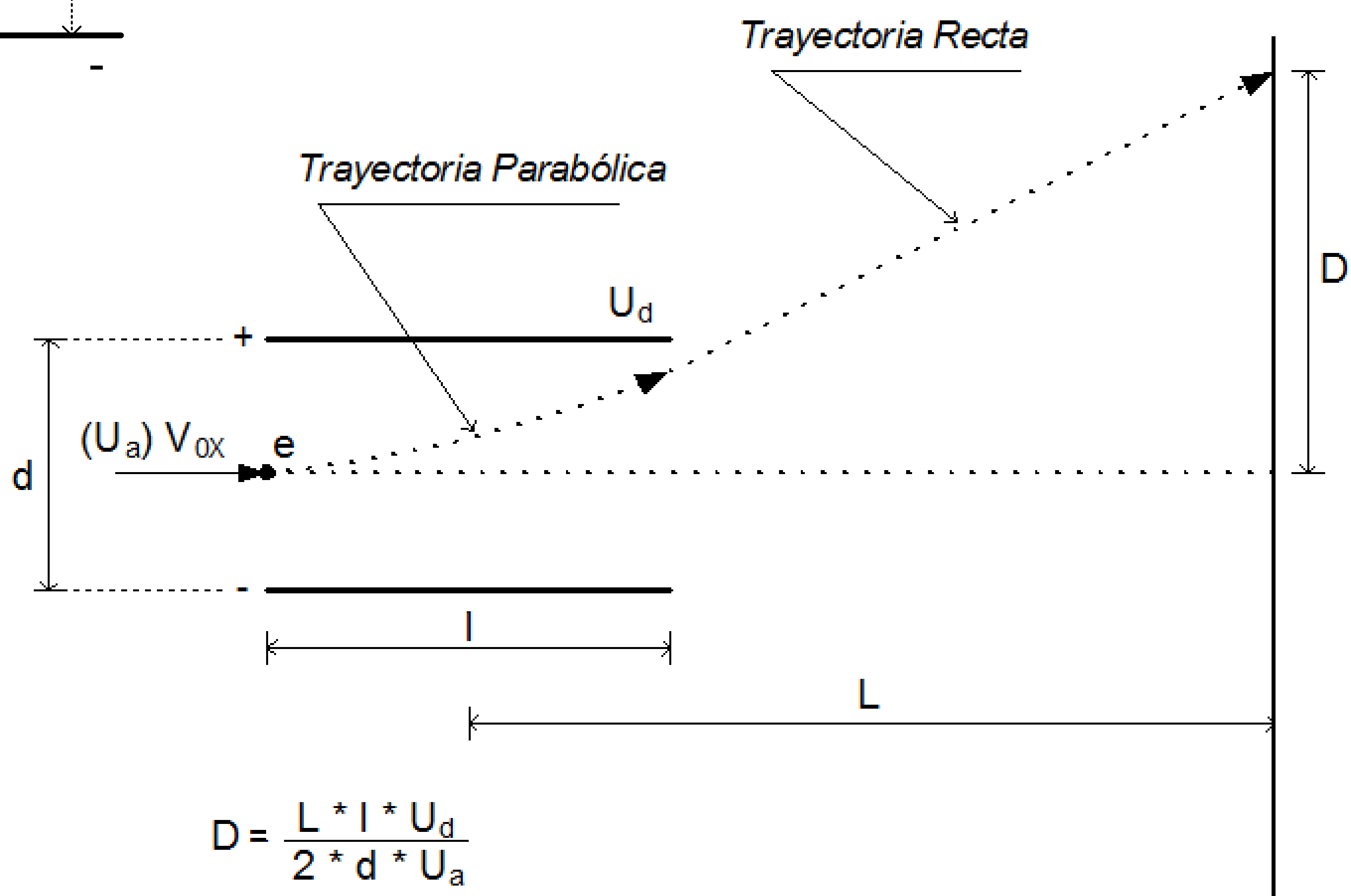
Ánodos de enfoque



Placas de Deflexión Vertical

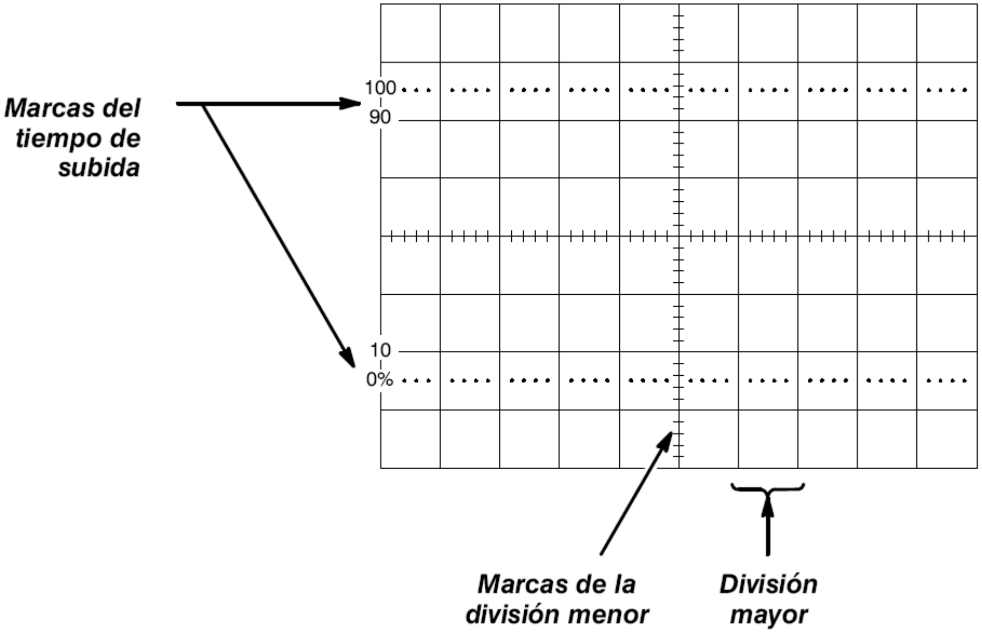


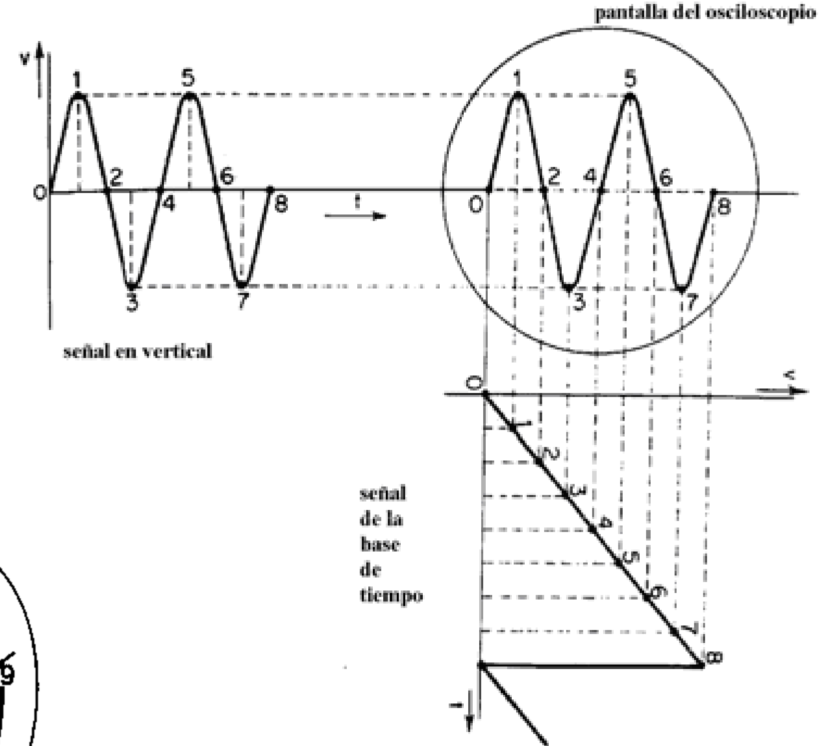
$$f = -e \,.\, E$$

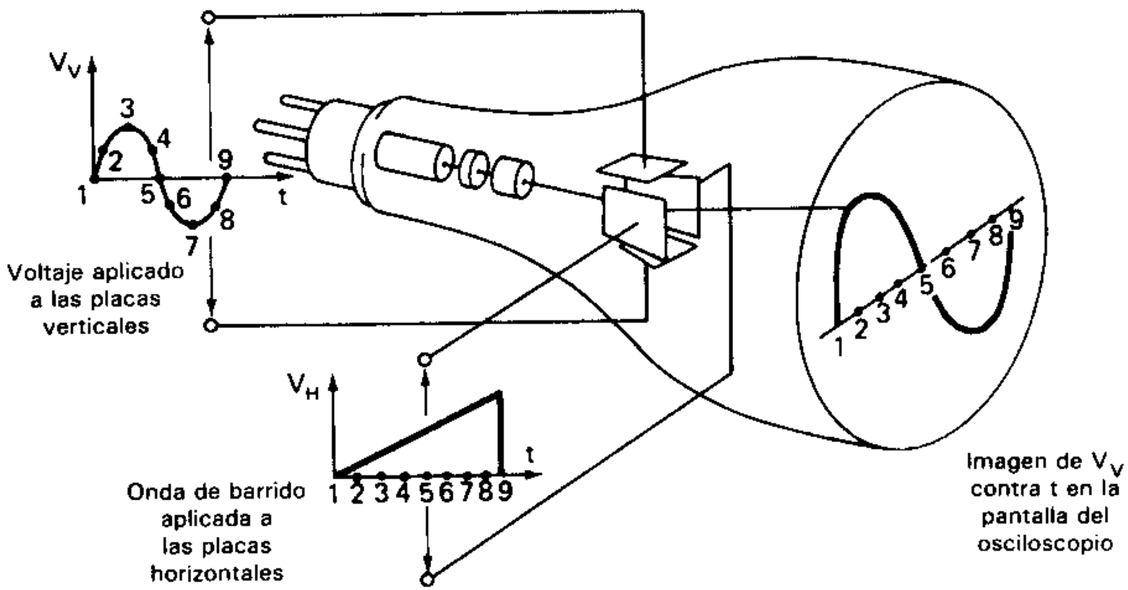


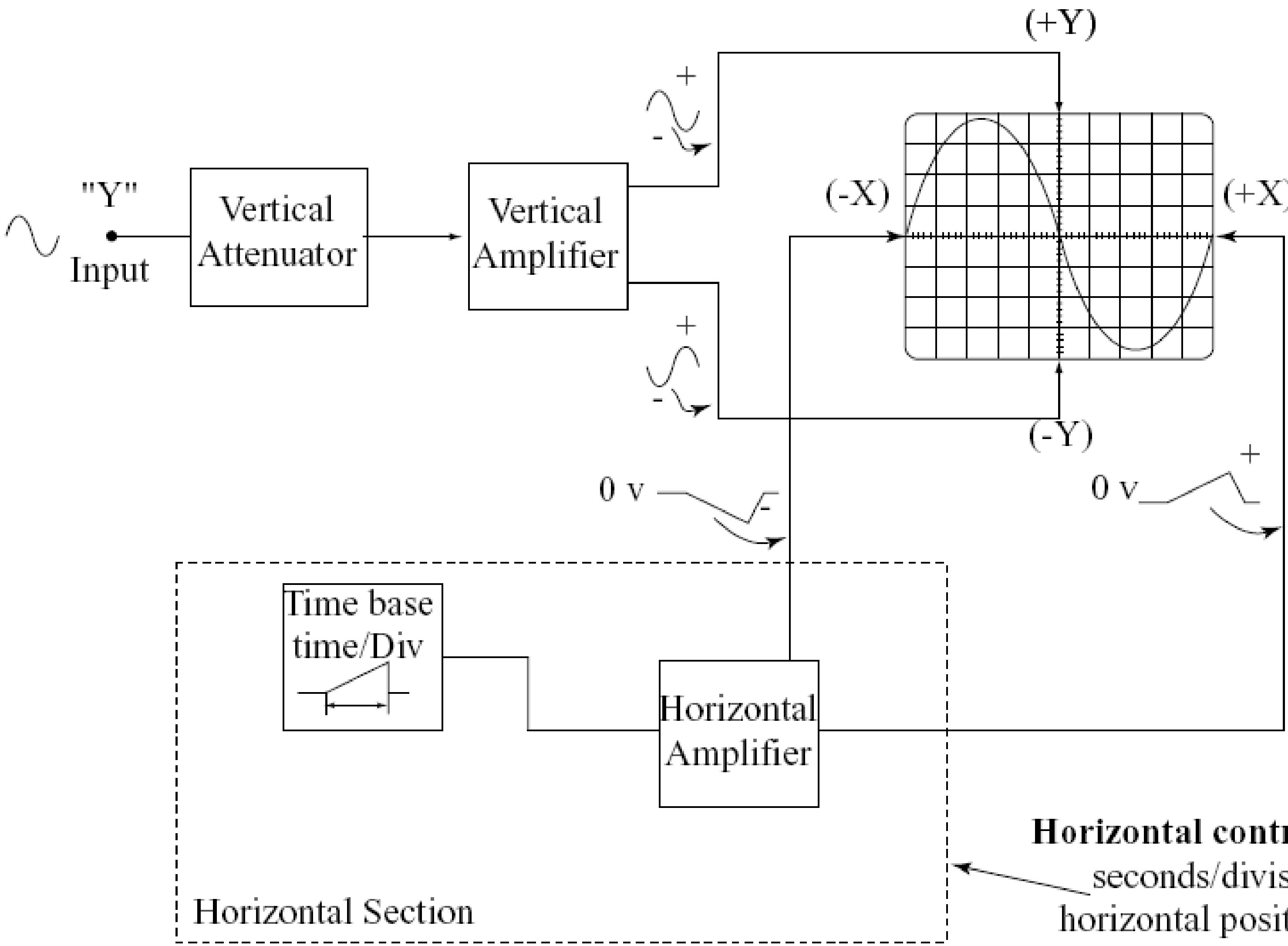
$$D = \frac{L * l * U_d}{2 * d * U_a}$$

Pantalla


Marcas del tiempo de subida
100
90
10
0%
Marcas de la división menor
División mayor


pantalla del osciloscopio
señal en vertical
señal de la base de tiempo

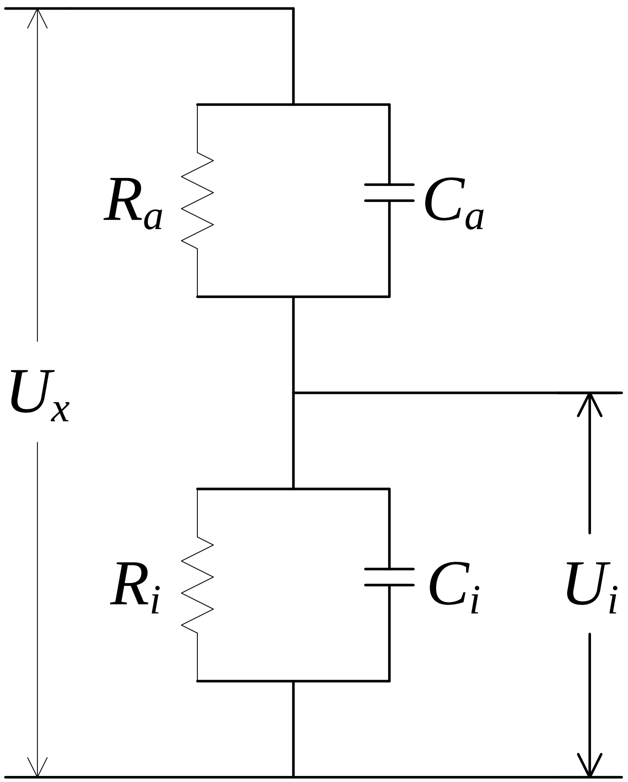

Voltaje aplicado a las placas verticales
Onda de barrido aplicada a las placas horizontales
Imagen de V_V contra t en la pantalla del osciloscopio



Horizontal controls
seconds/division
horizontal position
x 10 magnify, delayed sweep - delayed and x 10 magnify sweep is explained later

Atenuador Vertical

$$Z_a = \frac{R_a}{1 + j\,\omega R_a C_a} \quad ; \quad Z_i = \frac{R_i}{1 + j\,\omega R_i C_i}$$

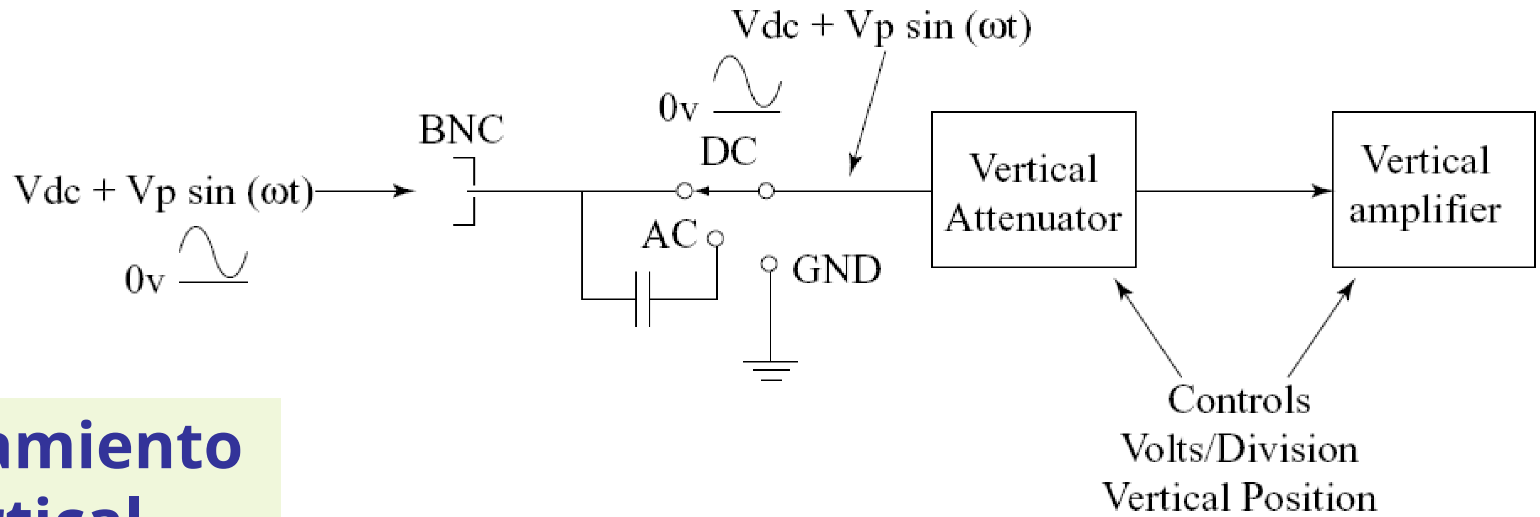


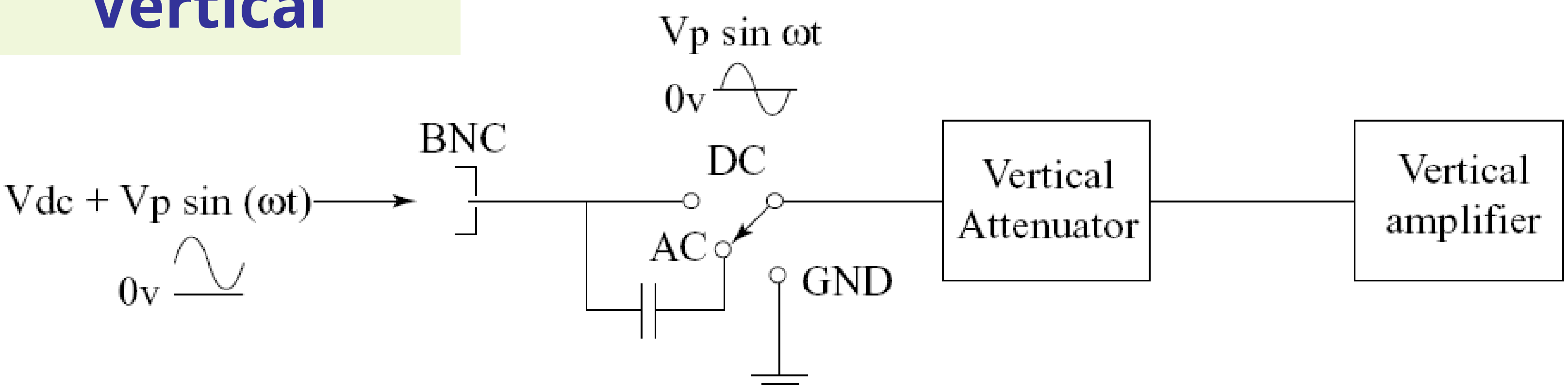
$$\frac{U_i}{U_x} = \frac{\dfrac{R_i}{1 + j\,\omega R_i C_i}}{\dfrac{R_a}{1 + j\,\omega R_a C_a} + \dfrac{R_i}{1 + j\,\omega R_i C_i}}$$

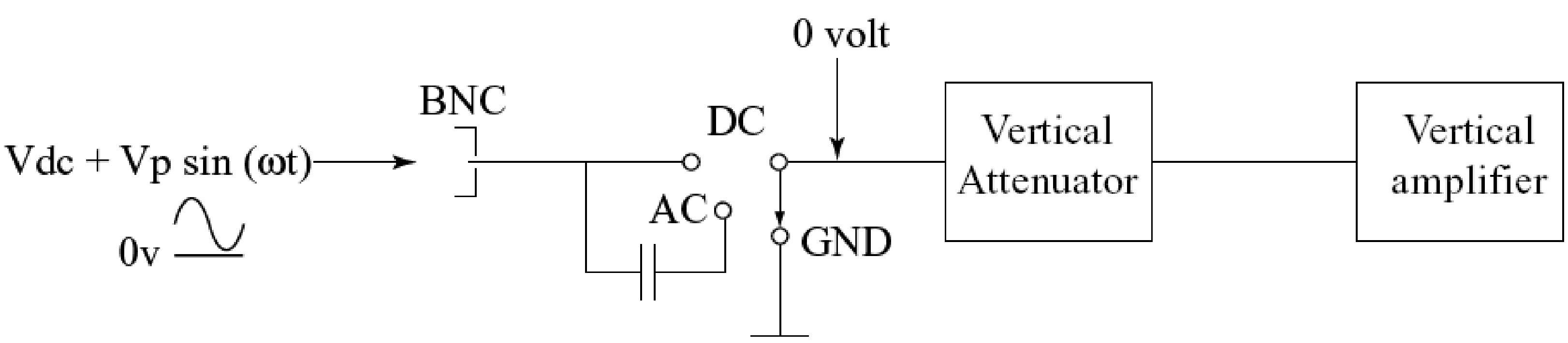
si $\quad R_i\ C_i = R_a\ C_a \quad \Rightarrow \quad 1 + j\,\omega R_a C_a = 1 + j\,\omega R_i C_i$

$$\Rightarrow \quad \frac{U_i}{U_x} = \frac{R_i}{R_a + R_i}$$

Acoplamiento Vertical

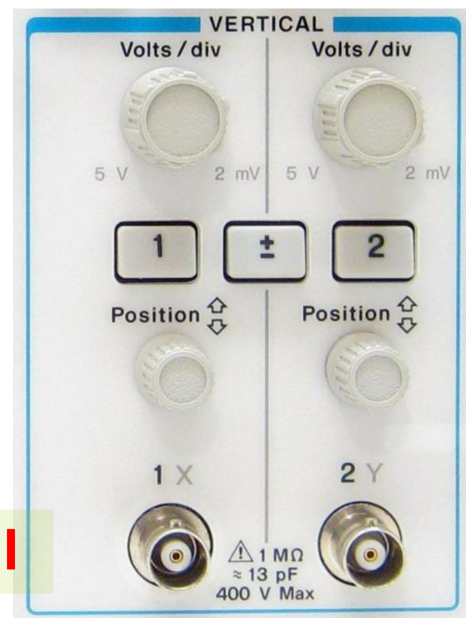




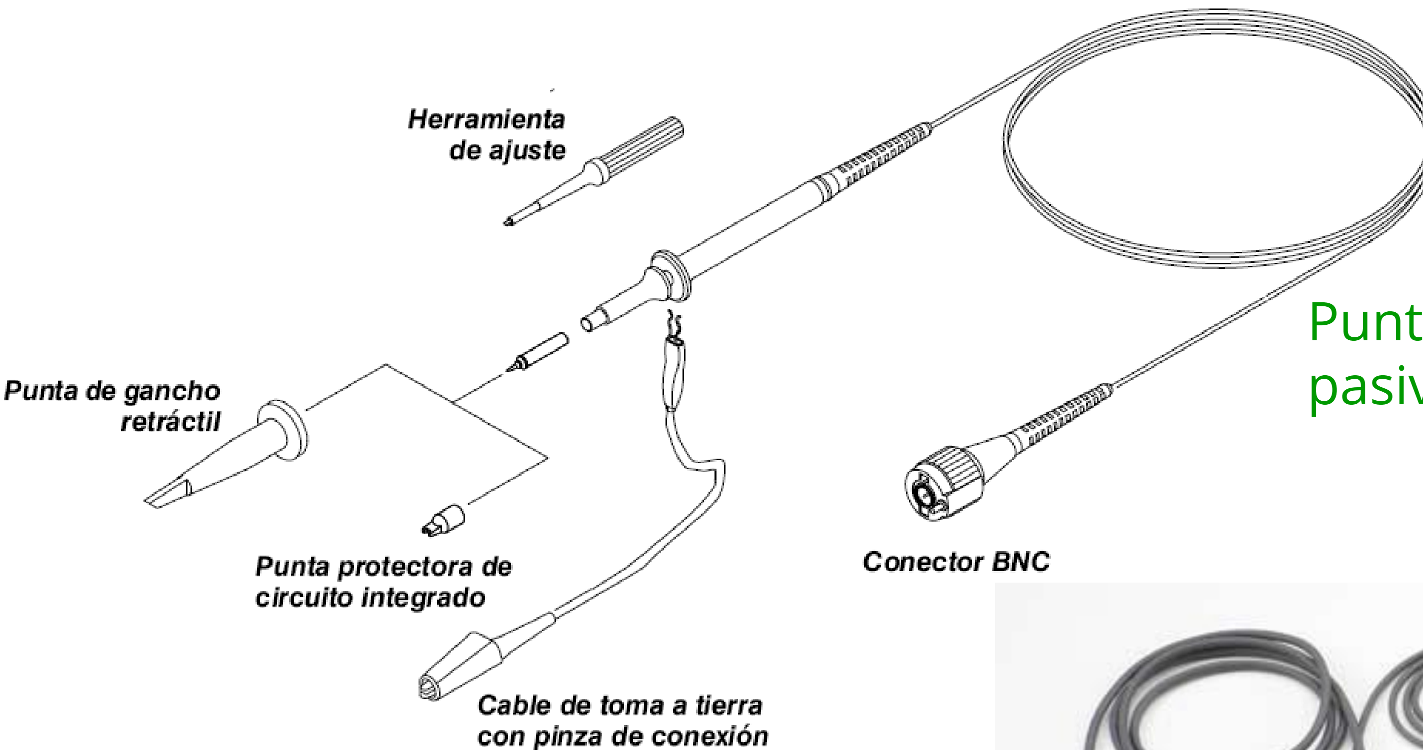


Controles Verticales

Osciloscopio Analógico



Osciloscopio Digital

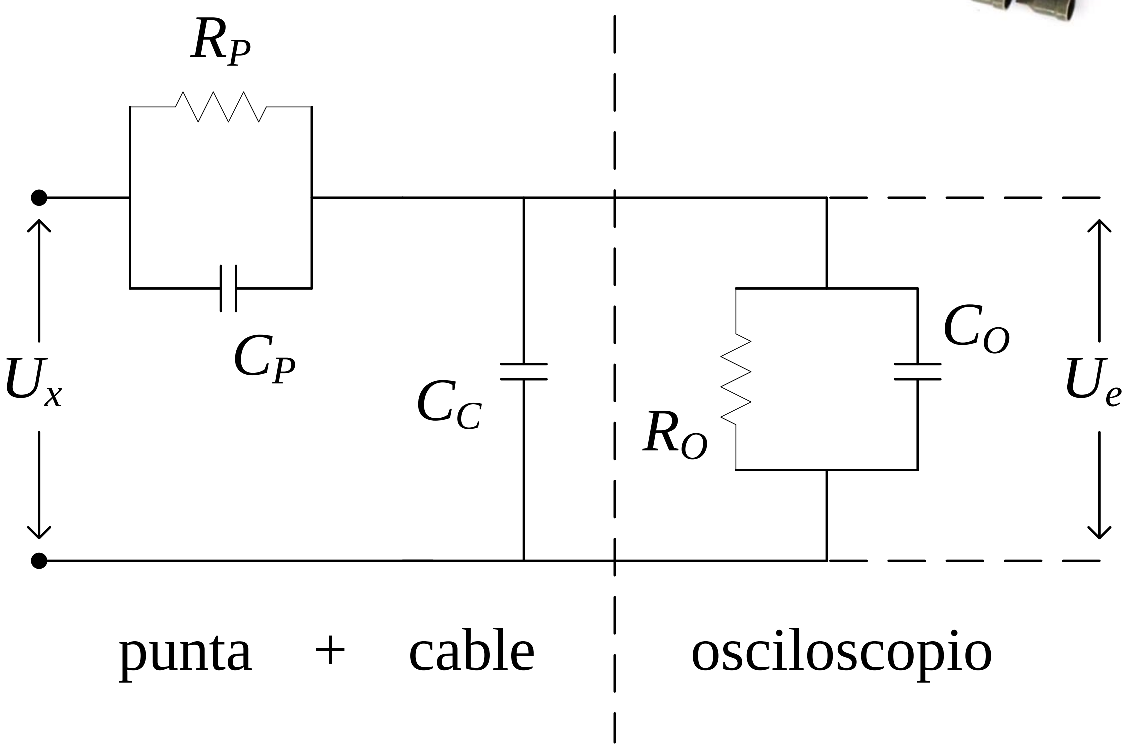


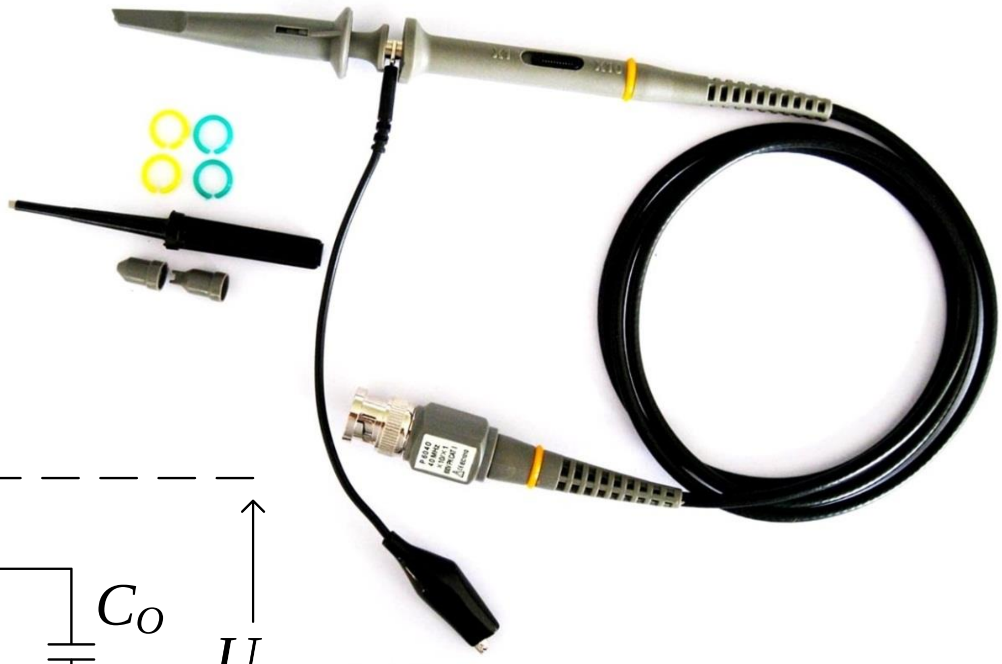
Punta atenuadora pasiva de tensión

Puntas de Prueba

Punta de corriente

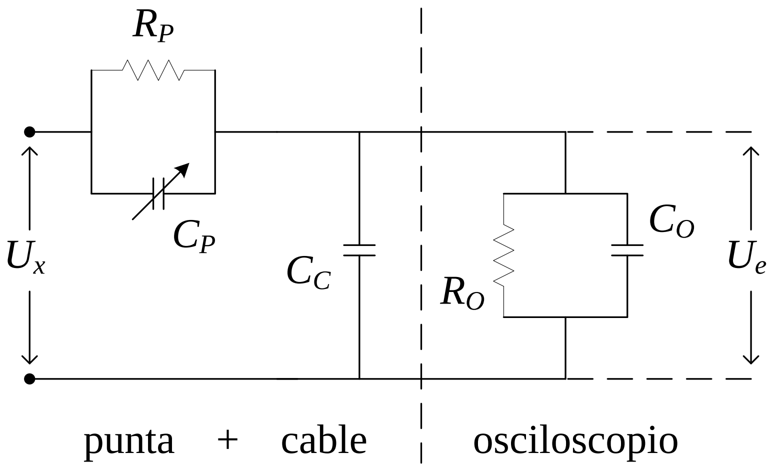
Puntas Atenuadoras
Pasivas de Tensión



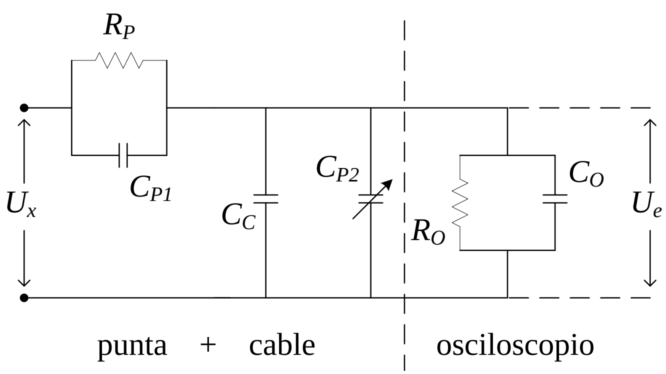


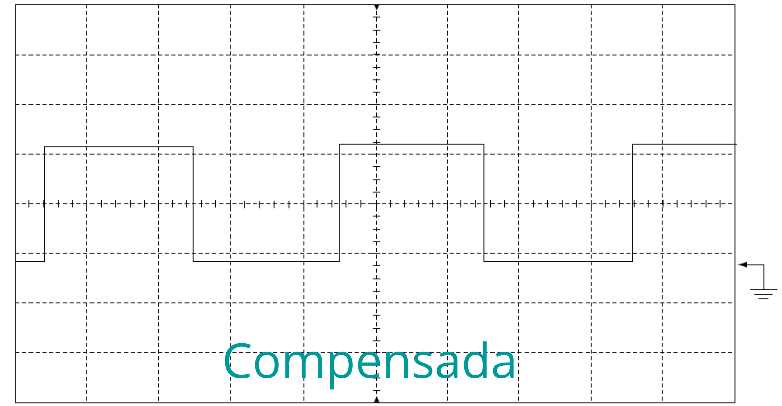
$$R_P\ C_P = R_O\ (C_C + C_O) \quad \Rightarrow \quad \frac{U_e}{U_x} = \frac{R_O}{R_P + R_O}$$

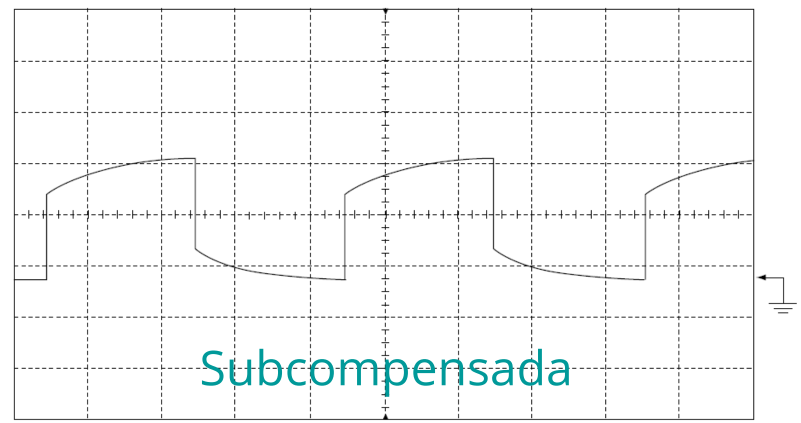
Compensación de Puntas Atenuadoras de Tensión

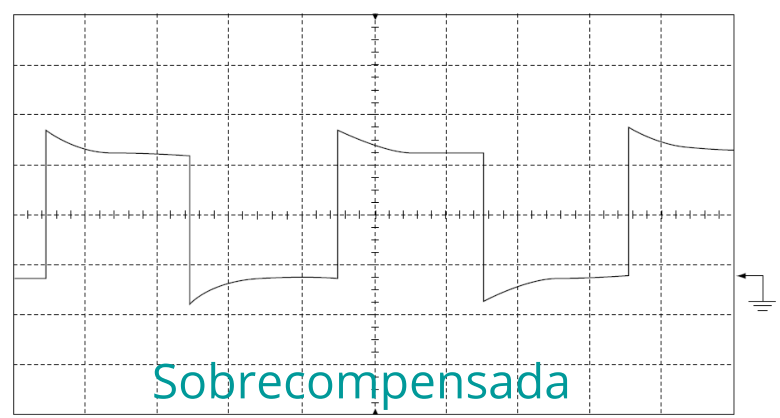


$$R_P\ C_P = R_O\ (C_C + C_O)$$

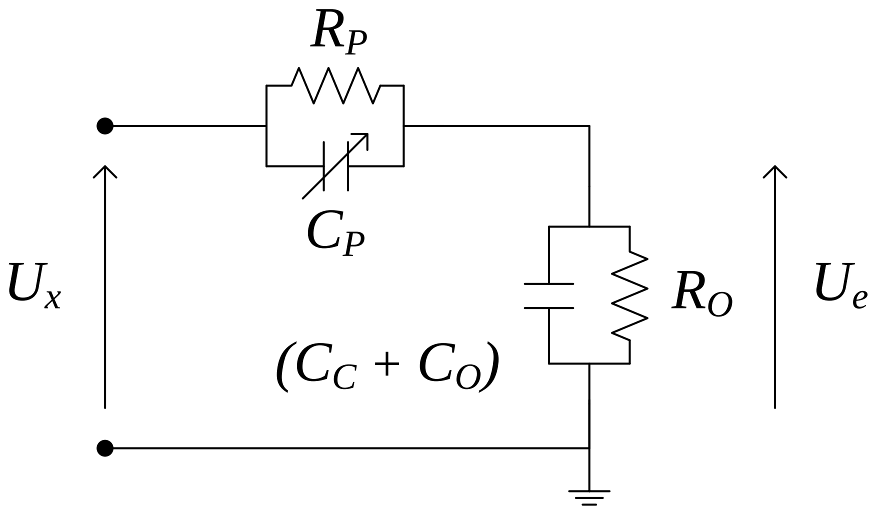








Ejemplo de compensación de una Punta de Tensión 10X, con R_O= 1 MΩ, C_O = 30 pF y C_C = 100 pF



$$\frac{U_e}{U_x} = \frac{R_O}{R_P + R_O} = \frac{1}{10}$$

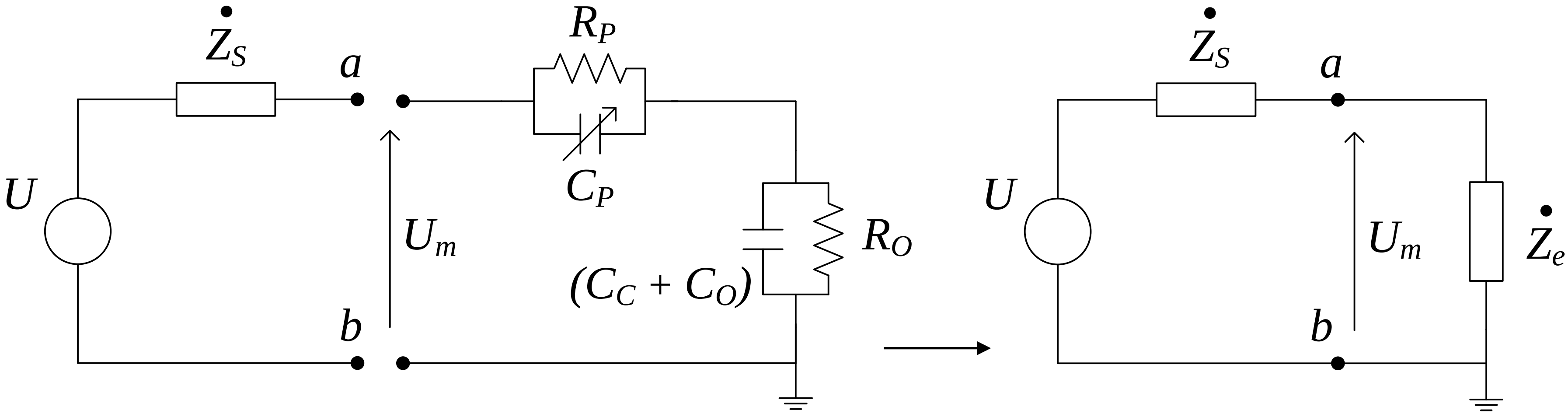
$$\Rightarrow R_P = 9\,R_O = 9\,M\Omega$$

Además: $R_P\ C_P = R_O\ (C_C + C_O)$

$$\Rightarrow C_P = \frac{R_O\ (C_C + C_O)}{R_P} = \frac{1\ M\Omega\ (100 + 30)\ pF}{9\ M\Omega}$$

$$= 14{,}4\ pF$$

Error de inserción:



$$e_i = \frac{|U_m| - |U|}{|U|} = \frac{\left|\dfrac{U \cdot \dot{Z}_e}{\dot{Z}_e + \dot{Z}_S}\right| - |U|}{|U|}$$

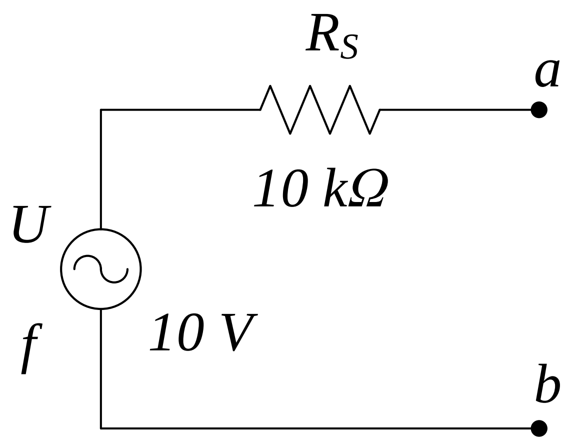
$$\Rightarrow \quad e_i = \frac{|\dot{Z}_e|}{|\dot{Z}_e + \dot{Z}_S|} - 1$$

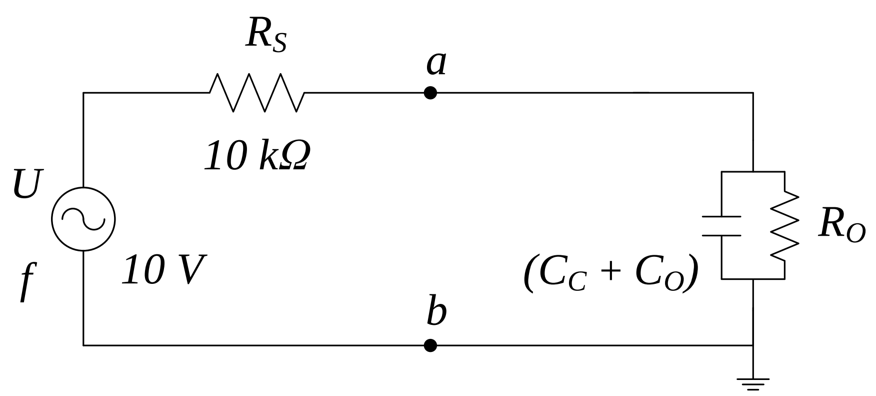
Ejemplo: Se pretende visualizar la forma de onda entre los bornes ***a*** y ***b*** del circuito de la figura, en dos casos, a saber:

1) f = 50 Hz y **2)** f = 50 kHz

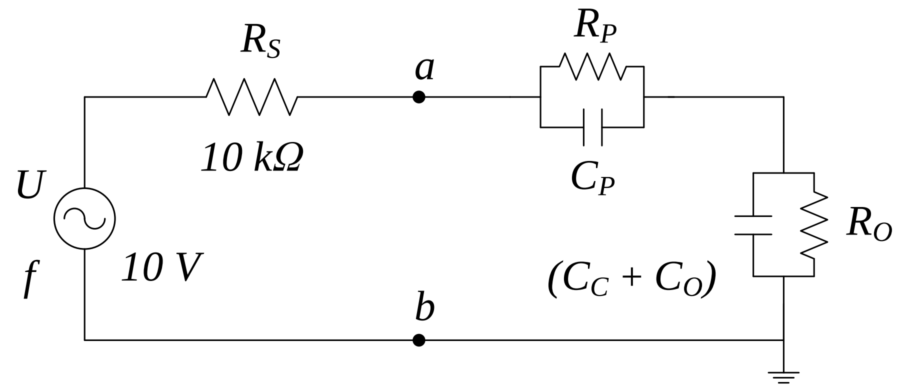
¿Qué punta atenuadora elegiría (1X o 10X)?

$R_O = 1\ M\Omega$; $C_O = 30\ pf$; $C_C = 100\ pf$





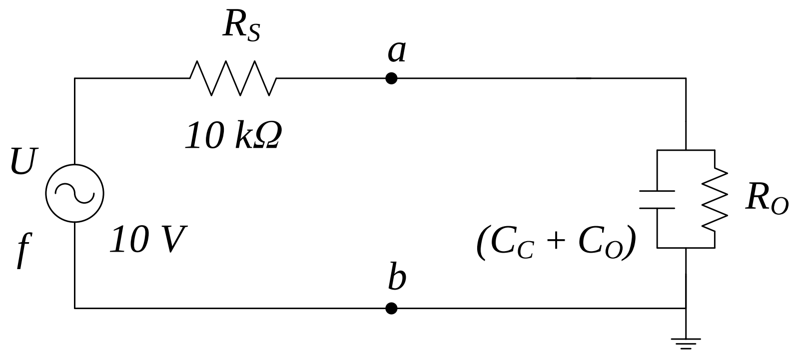
Circuito equivalente para punta 1X



Circuito equivalente para punta 10X

Punta 1X

$$C_C + C_O = 130pF \qquad R_O = 1\ M\Omega$$



Caso 1) f = 50 Hz

$$X_{(C_C + C_O)} = 24{,}5\, M\Omega \quad >> \quad R_O$$

$$\Rightarrow e_i \approx -100 * \frac{R_S}{R_O} \quad \approx -1\ \%$$

Caso 2) f = 50 kHz

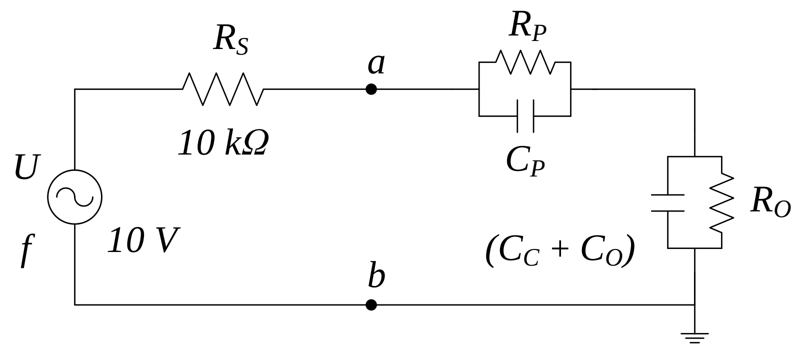
$$X_{(C_C + C_O)} = 24{,}5\, k\Omega \quad << \quad R_O$$

$$\Rightarrow e_i \approx 100 \ * \left[\frac{X_{(C_C+C_O)}}{\left| R_S + j X_{(C_C+C_O)} \right|} - 1 \right] \approx -7\ \%$$

Punta 10X

$$C_C + C_O = 130pF \qquad R_O = 1\ M\Omega$$

$$C_P = 14{,}4\ pF \qquad R_P = 9\ M\Omega$$



Caso 1) f = 50 Hz

$$\left.\begin{array}{l} X_{(C_C + C_O)} = 24{,}5\,M\Omega \;\; >> \;\; R_O \\ X_{C_P} = 221\ M\Omega \;\; >> \;\; R_P \end{array}\right\} \Rightarrow Z_e \approx R_P + R_O$$

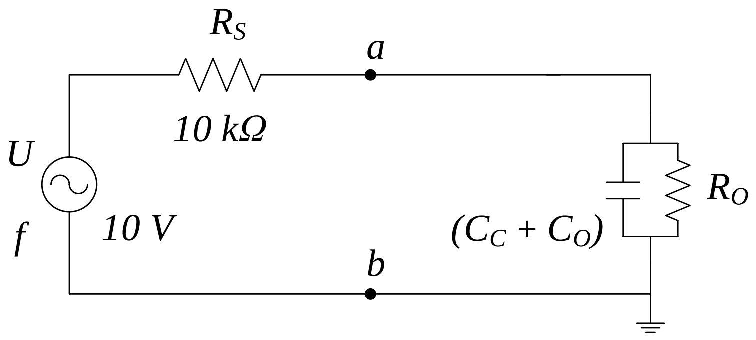
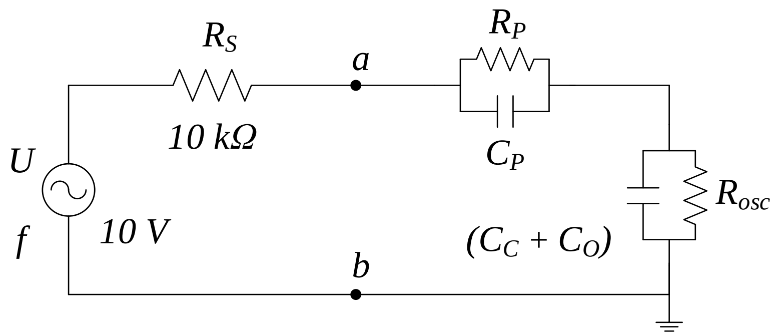
$$\Rightarrow e_i \approx -100 * \frac{R_S}{R_P + R_O} \approx -0{,}1\ \%$$

Caso 2) f = 50 kHz

$$\left.\begin{array}{l} X_{(C_C + C_O)} = 24{,}5\,k\Omega \;\; << \;\; R_O \\ X_{C_P} = 221\,k\Omega \;\; << \;\; R_P \end{array}\right\} \Rightarrow Z_e \approx X_{C_P} + X_{(C_C + C_O)}$$

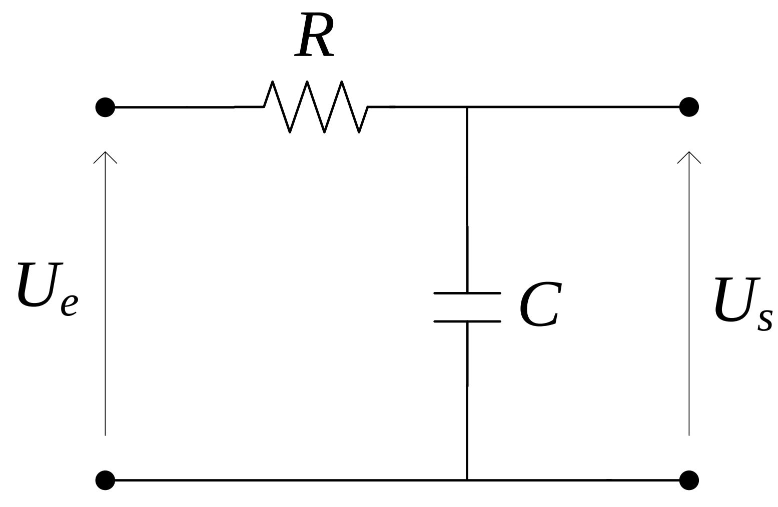
$$\Rightarrow e_i \approx 100 * \left[\frac{X_{C_P} + X_{(C_C+C_0)}}{\left| R_S + j\left(X_{C_P} + X_{(C_C+C_0)}\right)\right|} - 1 \right] \approx -0{,}08\ \%$$

Resumiendo:

	Caso 1) f = 50 Hz	**Caso 2)** f = 50 kHz
 Punta 1X	$e_i \approx -1\ \%$	$e_i \approx -7\ \%$
 Punta 10X	$e_i \approx -0{,}1\ \%$	$e_i \approx -0{,}08\ \%$

Conclusiones

Ancho de Banda *(BW)*

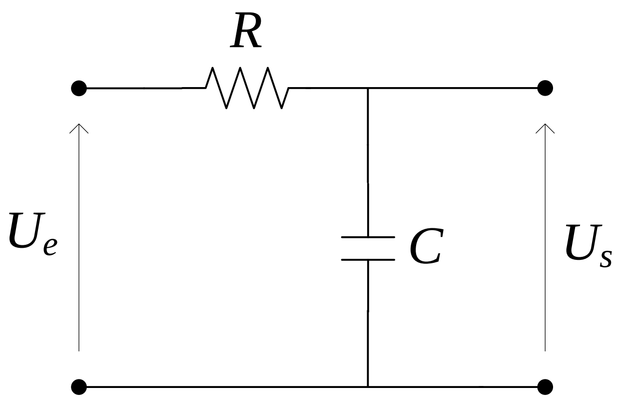


$$\frac{U_e}{R + \dfrac{1}{j\omega C}} = \frac{U_s}{\dfrac{1}{j\omega C}}$$

$$\Rightarrow \quad \frac{U_s}{U_e} = \frac{1}{1 + j\,\omega R C} = \frac{1}{1 + j\,2\pi\, f\, R C}$$

$$\left.\begin{aligned} \frac{U_s}{U_e} &= A \\ \frac{1}{2\pi R C} &= f_{cs} \end{aligned}\right\} \quad \Rightarrow \quad A = \frac{U_s}{U_e} = \frac{1}{1 + j\,\dfrac{f}{f_{cs}}}$$

$$A = \frac{U_s}{U_e} = \frac{1}{1 + j\dfrac{f}{f_{cs}}}$$



$$\begin{cases} f = 0 & \Rightarrow \quad |A| = 1 \\ f = f_{cs} & \Rightarrow \quad |A| = \dfrac{1}{|1 + j1|} = 0{,}707 \end{cases}$$

En la realidad, se tiene:

$$\frac{U_s}{U_e} = A = \frac{A_0}{1 + j\dfrac{f}{f_{cs}}} \qquad \Rightarrow \qquad \frac{A}{A_0} = \frac{1}{1 + j\dfrac{f}{f_{cs}}}$$

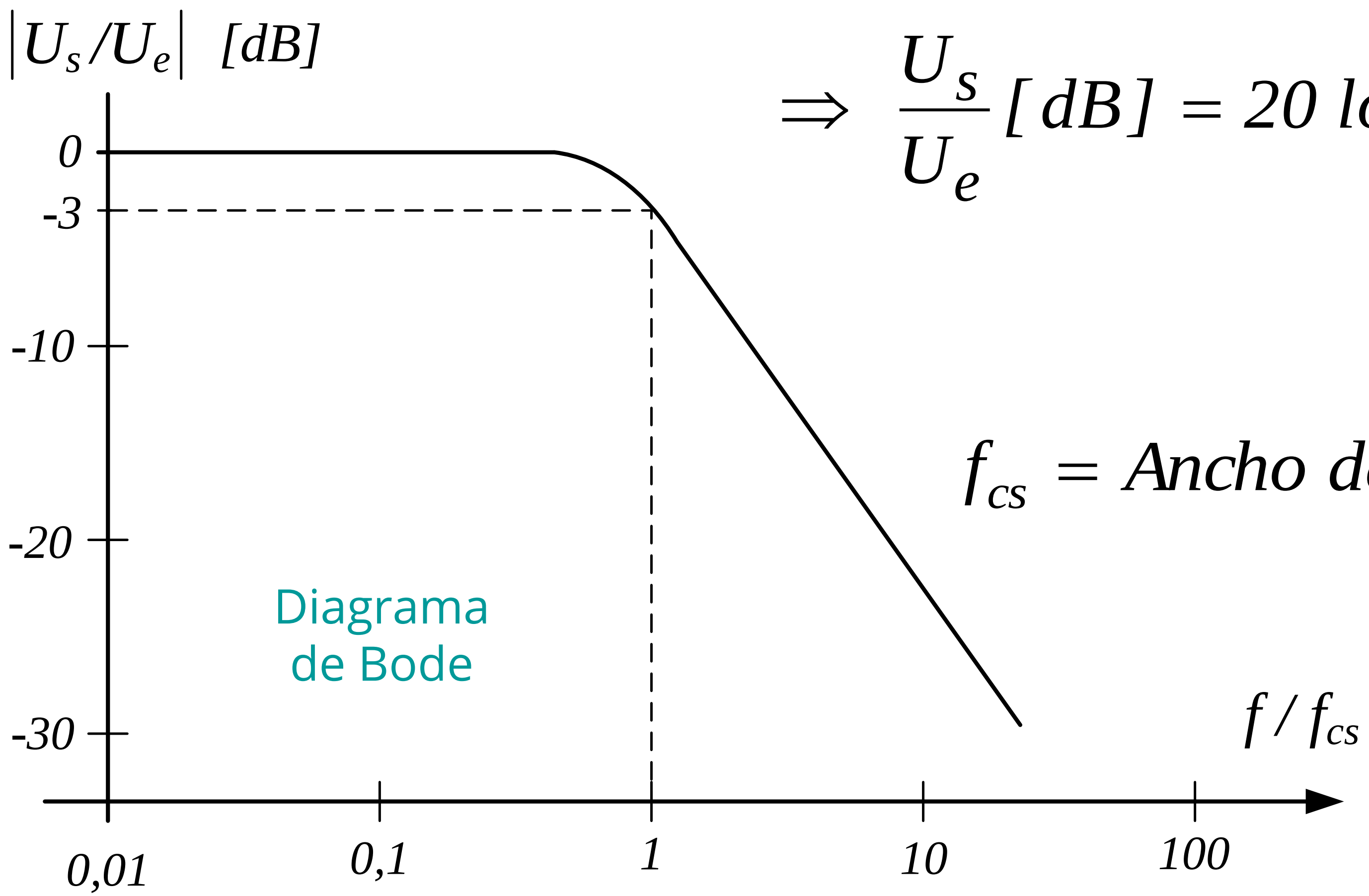
Expresión en *dB*

$$\frac{A}{A_0} = \frac{1}{1 + j\,\frac{f}{f_{cs}}}$$

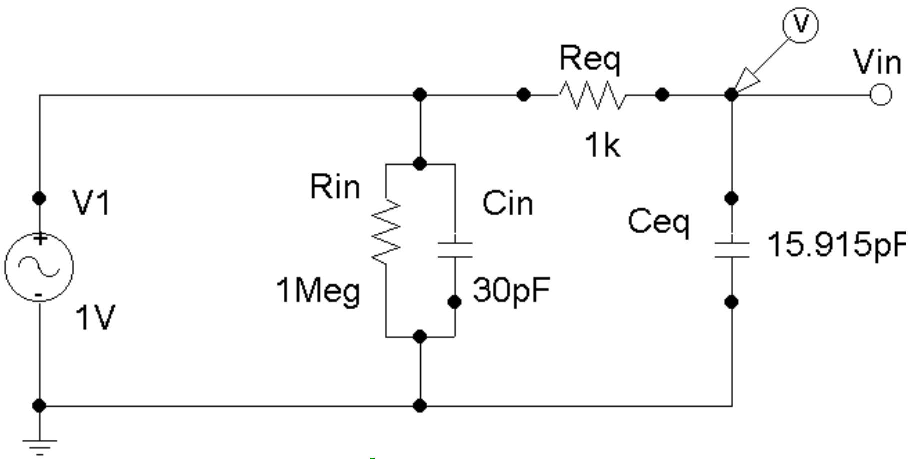
$$A\,[dB] = 20 \log \frac{A}{A_0}$$

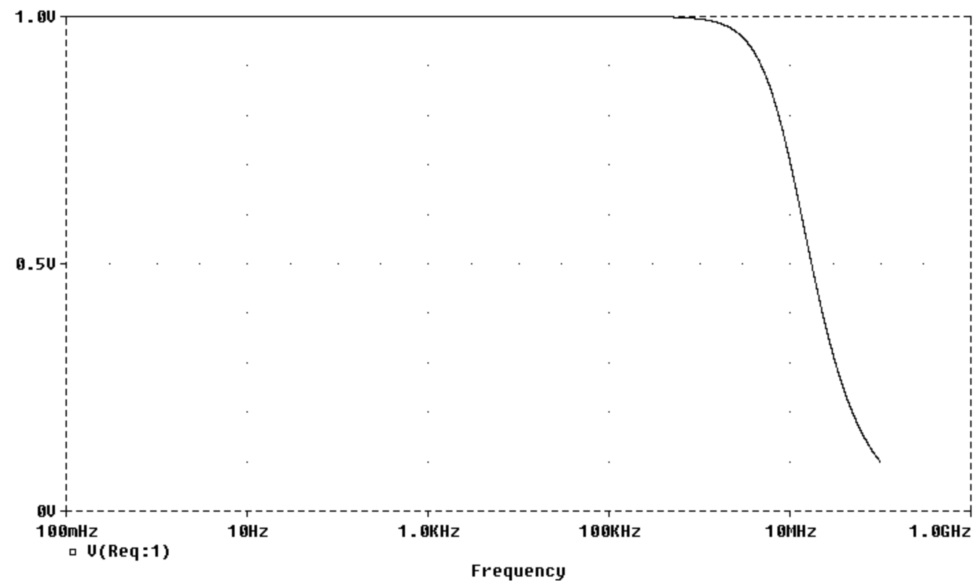
$$\Rightarrow \frac{U_s}{U_e}[dB] = 20 \log \frac{1}{1 + j\,\frac{f}{f_{cs}}}$$

$$f_{cs} = \text{Ancho de banda}\,(BW)$$

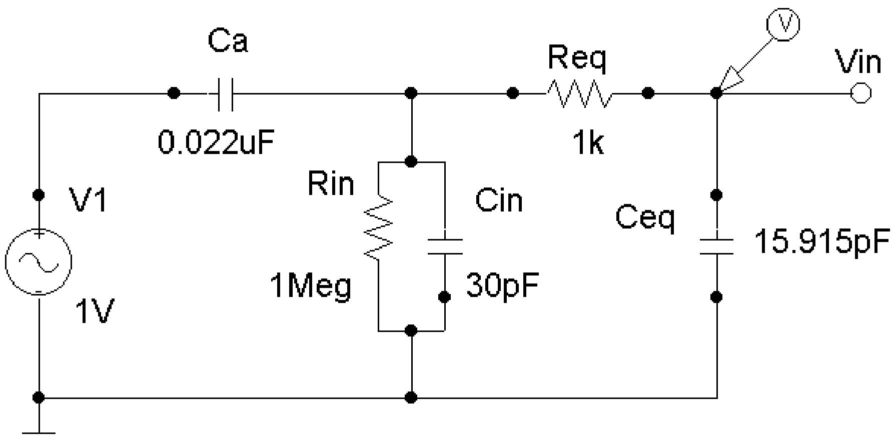


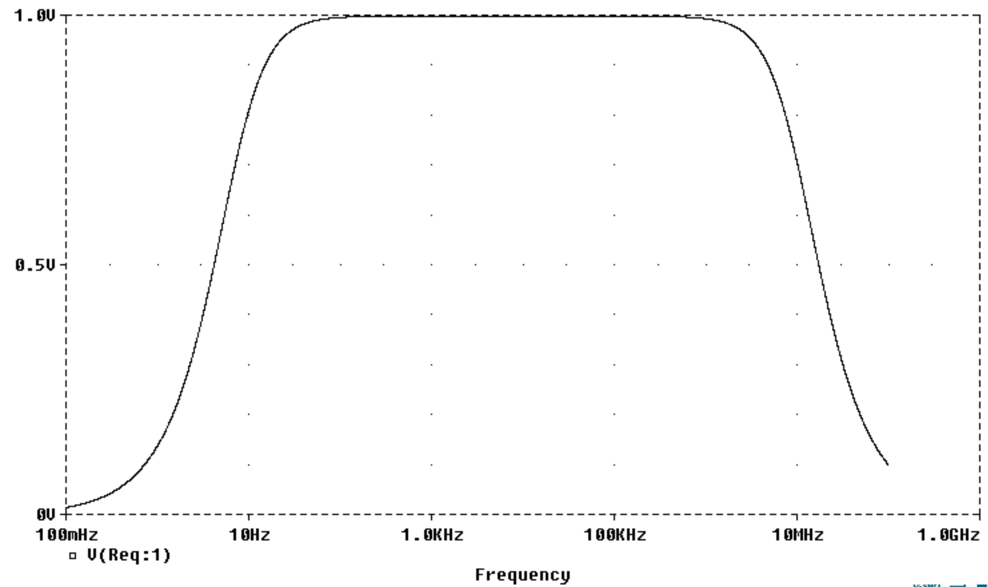
Ejemplo de un osciloscopio con $BW = 10\ MHz$





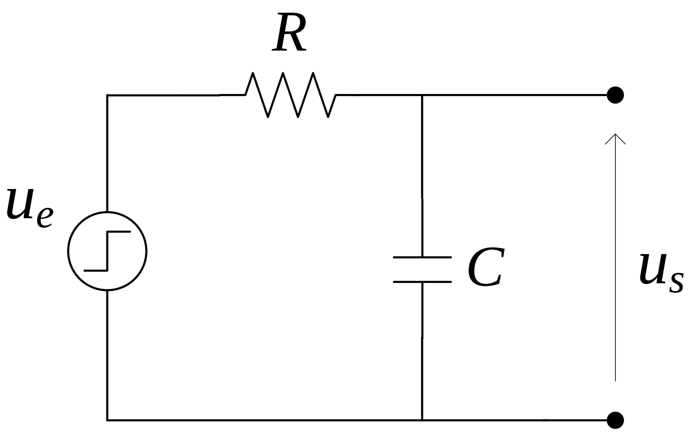
Acoplamiento DC

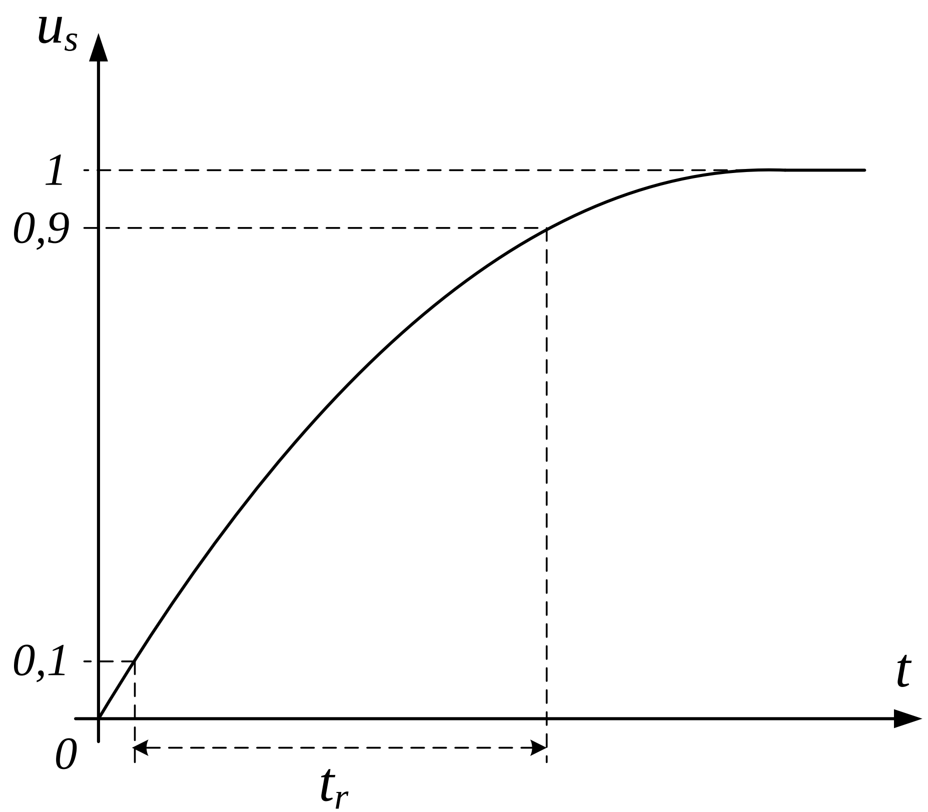




Acoplamiento AC

Tiempo de Subida (t_r)





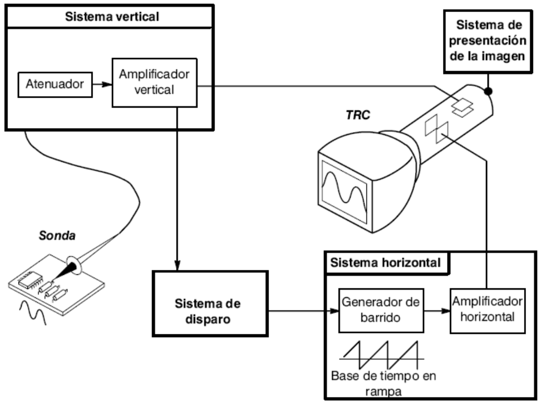
$$u_s = u_e \left(1 - e^{-\frac{t}{RC}} \right)$$

$$\Rightarrow \quad t_r = 2{,}2\,RC$$

Con $$RC = \frac{1}{2\pi f_{cs}}$$

$$\Rightarrow \quad t_r = \frac{2{,}2}{2\pi f_{cs}} = \frac{0{,}35}{f_{cs}} = \frac{0{,}35}{BW}$$

Tiempo de Subida de un Sistema de Medida



$$t_{r_{medido}} = \sqrt{t^2_{r_{señal}} + t^2_{r_{punta}} + t^2_{r_{osciloscopio}}}$$

o también: $$t_{r_{medido}} \approx \sqrt{t^2_{r_{señal}} + t^2_{r_{osciloscopio}}}$$

Ejemplos:

a) $$t_{r_{osciloscopio}} = \frac{t_{r_{señal}}}{5}$$

$$\Rightarrow t_{r_{medido}} = t_{r_{señal}} \sqrt{1 + \frac{1}{25}} = 1{,}02\ t_{r_{señal}}$$

b) $$t_{r_{osciloscopio}} = \frac{t_{r_{señal}}}{3} \qquad \Rightarrow t_{r_{medido}} = 1{,}05\ t_{r_{señal}}$$