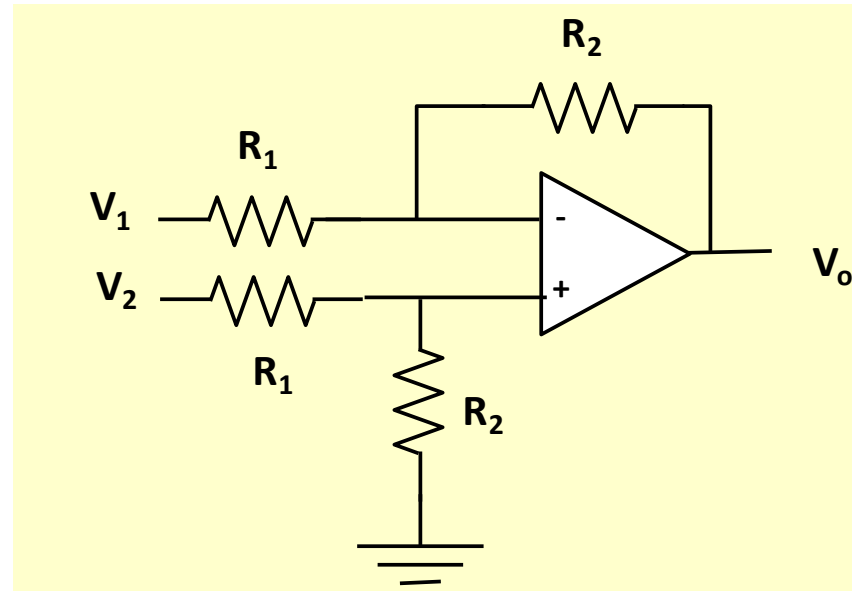


## Amplificador diferencial



### ANÁLISIS

- Cortocircuito virtual:  $v_+ = v_-$
- Principio de superposición

$$v_o|_{v_2} = -\frac{R_2}{R_1} v_1$$

Cartagena99

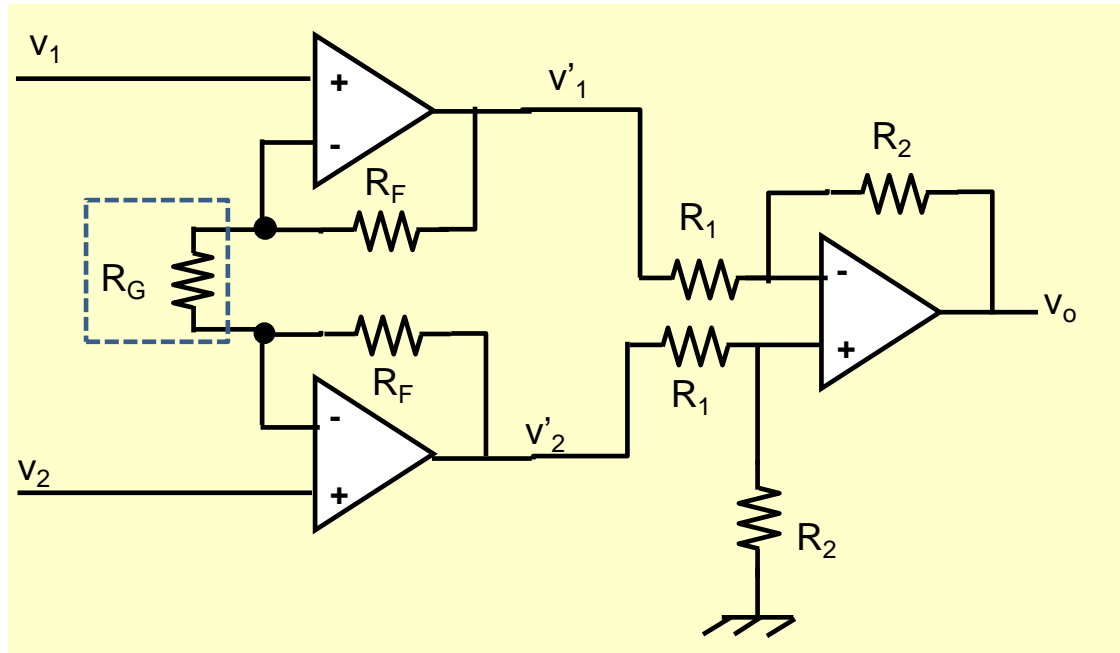
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$$\left( \frac{R_1}{R_1 + R_2} \right) \frac{R_1}{R_1 + R_2} v_2 + \left( \frac{R_2}{R_1 + R_2} \right) v_1$$

### Amplificador de instrumentación



### ANÁLISIS

$$v'_1 - v'_2 = v(R_F) + v(R_G) + v(R_F)$$

$$\Rightarrow v'_1 - v'_2 = \frac{v_1 - v_2}{R_G} \cdot (R_F + R_G + R_F)$$

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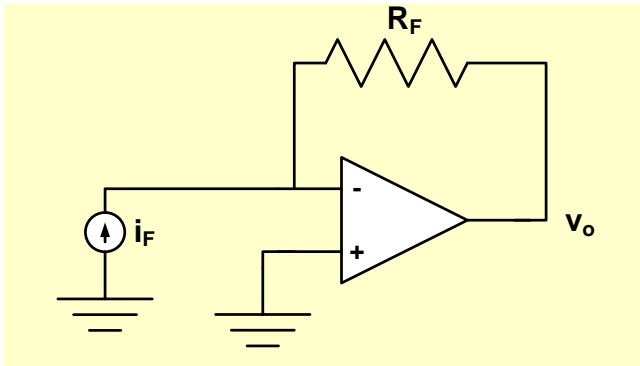
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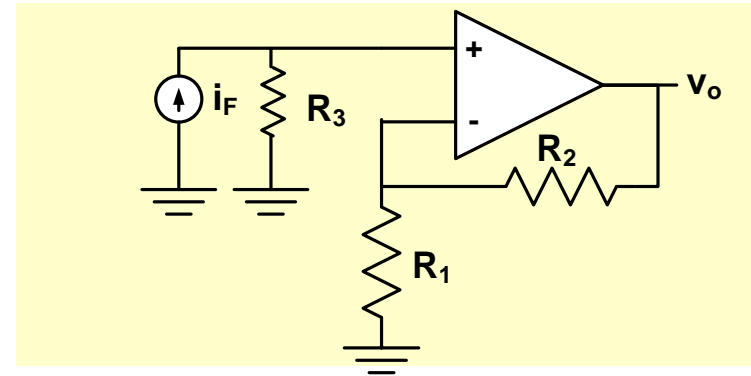
## Conversor corriente-tensión (Amplificador de transimpedancia)

### INVERSOR

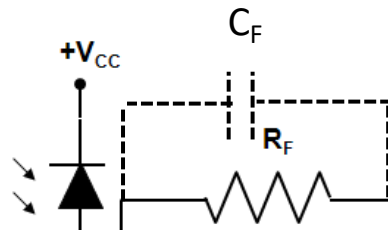


$$v_o = -R_F \cdot i_F$$

### NO INVERSOR



$$v_o = R_3 \cdot \left( 1 + \frac{R_2}{R_1} \right) \cdot i_F$$



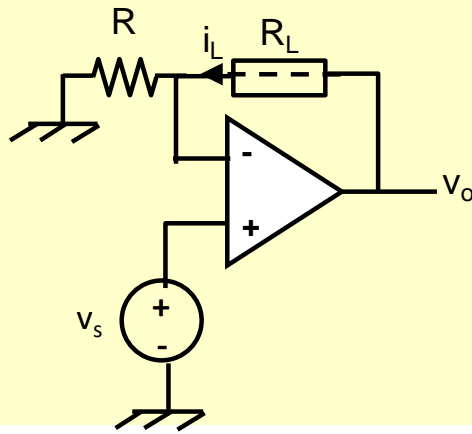
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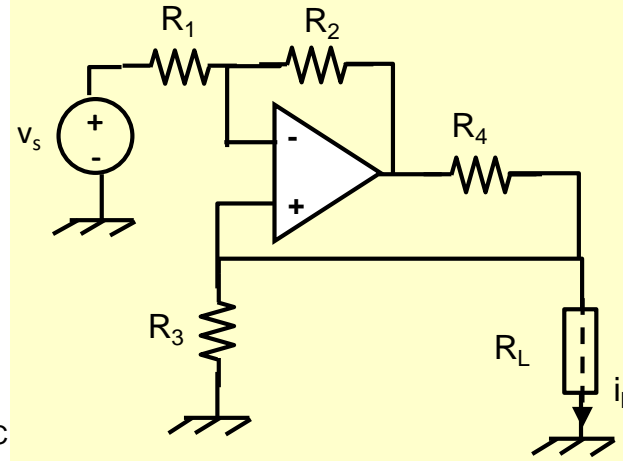
## Conversor tensión-corriente (Amplificador de transadmitancia)

### CARGA FLOTANTE



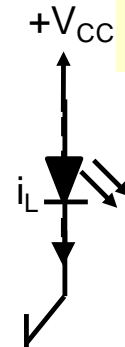
$$i_L = -\frac{v_s}{R}$$

### CARGA A TIERRA



$$\frac{R_2}{R_1} = \frac{R_4}{R_3}$$

$$i_L = -\frac{v_s}{R_3}$$



Driver LED

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## Amplificador operacional ideal: aplicaciones no lineales

- Amplificador logarítmico y antilogarítmico
- Rectificadores de precisión
- Comparador
- Disparador de Schmitt (comparador con histéresis)
- Oscilador de relajación

The logo for Cartagena99 features the text 'Cartagena99' in a stylized, dark green font. The '99' is significantly larger and more prominent than the 'Cartagena' part. The text is set against a light blue and white background with a subtle wave-like pattern.

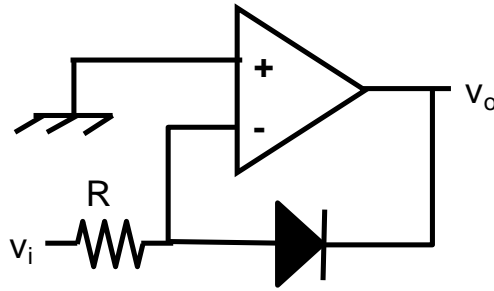
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## Amplificador logarítmico y antilogarítmico (exponencial)

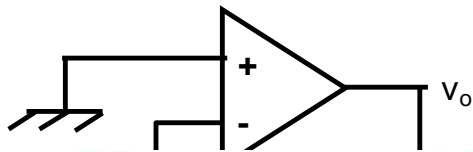
### LOGARÍTMICO



$$i_D = i_R = \frac{v_i}{R}$$

$$v_o = -v_D = -V_T \cdot \ln\left(\frac{i_D}{I_s}\right)$$

$$\Rightarrow v_o = -V_T \cdot \ln\left(\frac{v_i}{R \cdot I_s}\right)$$



$$i_R = i_D = I_s \cdot \exp\left(\frac{v_D}{V_T}\right) = I_s \cdot \exp\left(\frac{v_i}{V_T}\right)$$

$$v_o = -R \cdot i_R$$

$$\Rightarrow v_o = -R \cdot I_s \cdot \exp\left(\frac{v_i}{V_T}\right)$$

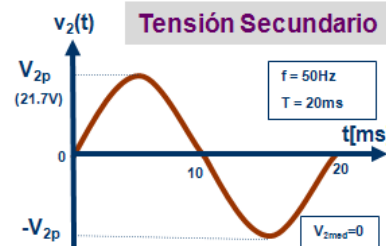
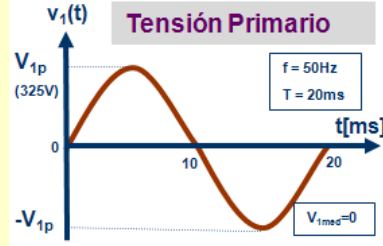
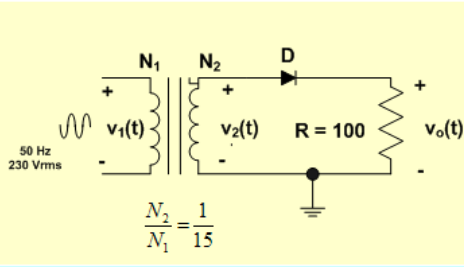
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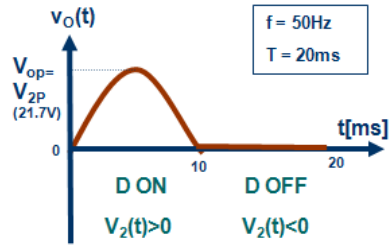
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## Rectificador de media onda

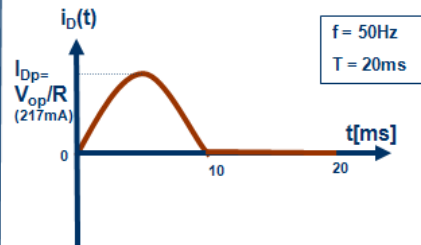


1ª Aproximación (Diodo ideal)

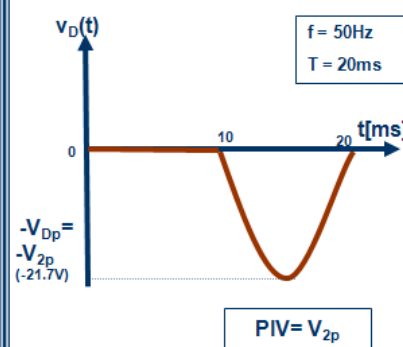
Tensión Salida



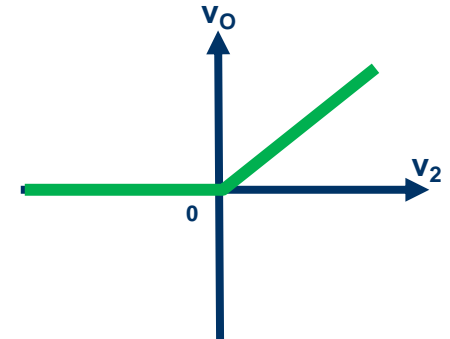
Corriente Diodo



Tensión Diodo



## Función de transferencia



$$v_o = \frac{V_{op}}{\pi}$$

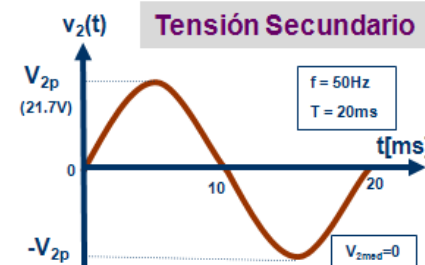
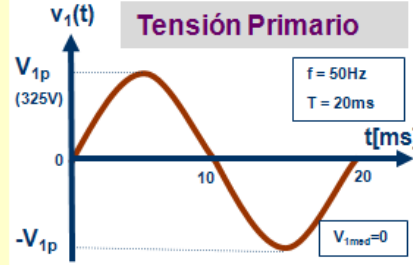
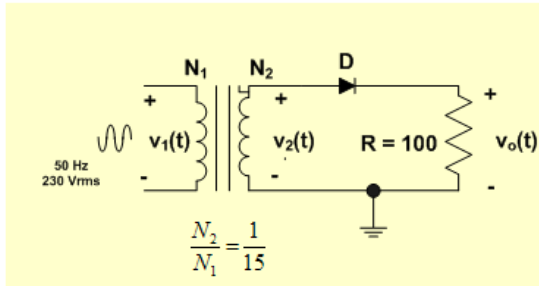
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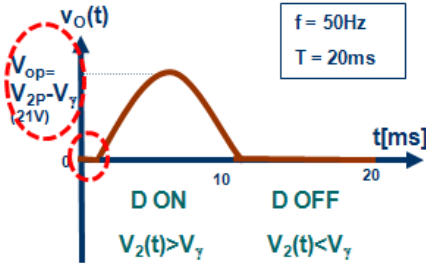
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## Rectificador de media onda

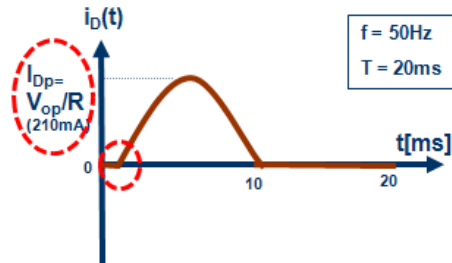


2ª Aproximación ( $V_\gamma = 0.7\text{V}$  en directa)

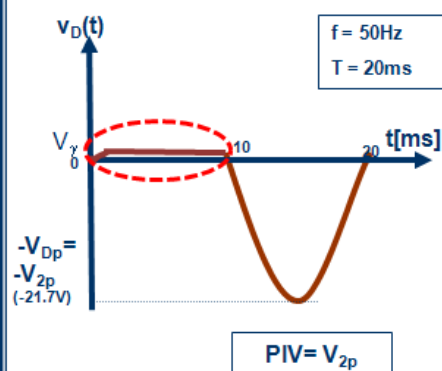
**Tensión Salida**



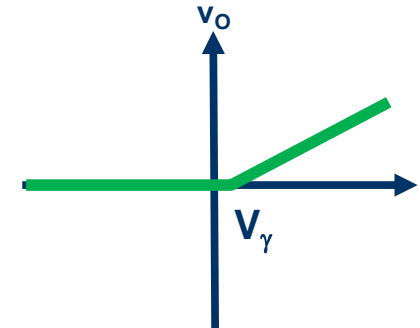
**Corriente Diodo**



**Tensión Diodo**



**Función de transferencia**



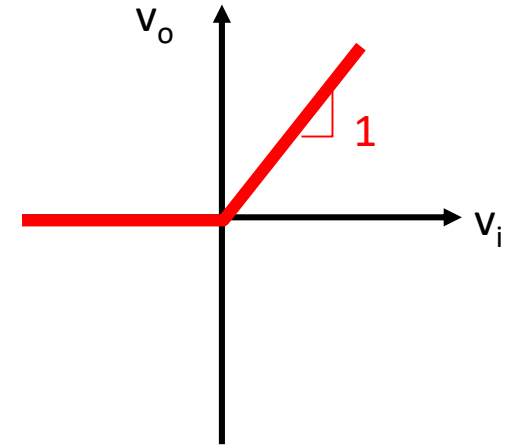
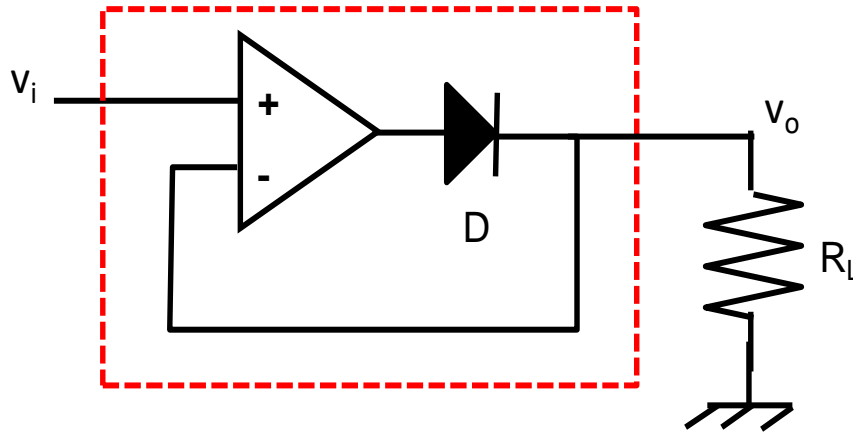
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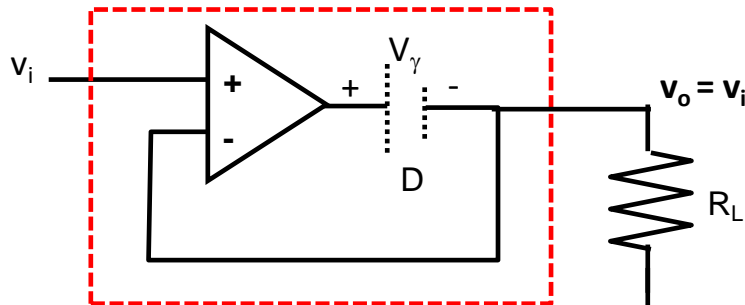
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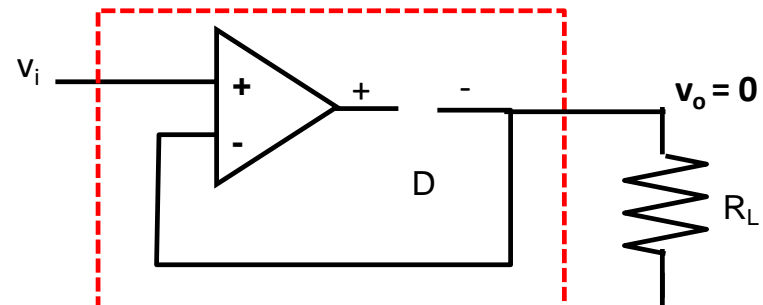
## Rectificadores de precisión



**D ON**



**D OFF**



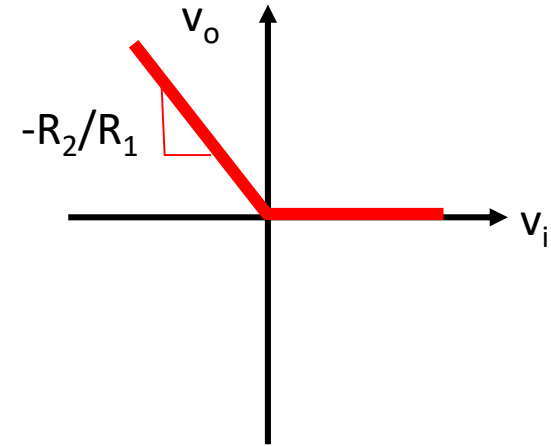
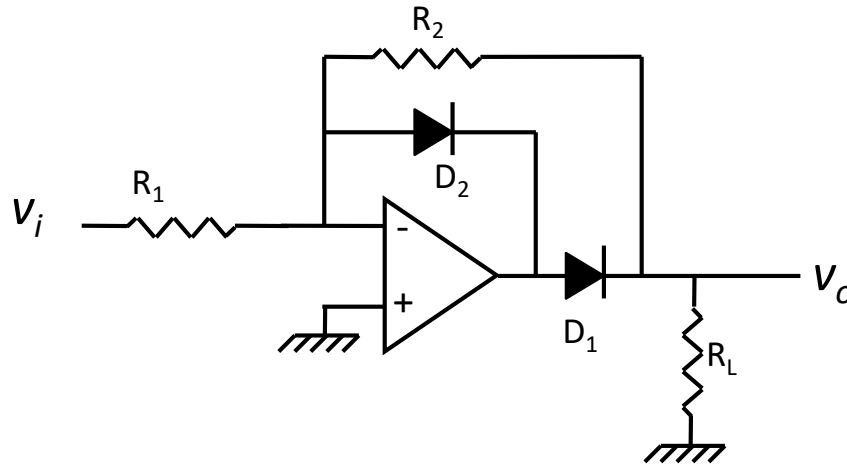
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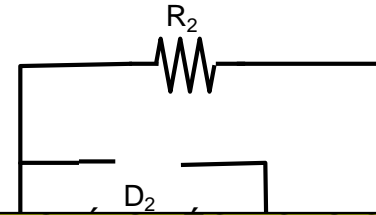
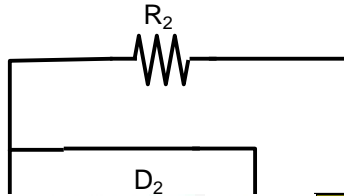
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### Rectificadores de precisión



$$v_i > 0 \Rightarrow \begin{cases} D_2 & \text{ON} \\ D_1 & \text{OFF} \end{cases}$$

$$v_i < 0 \Rightarrow \begin{cases} D_2 & \text{OFF} \\ D_1 & \text{ON} \end{cases}$$



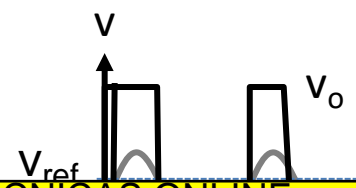
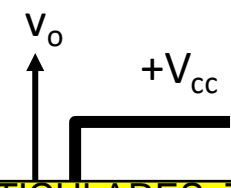
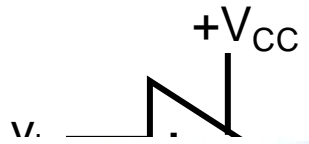
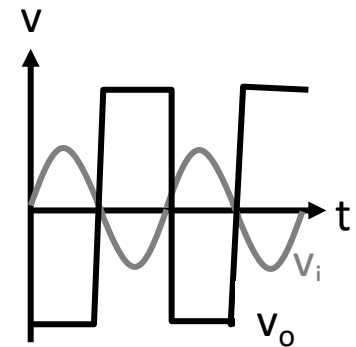
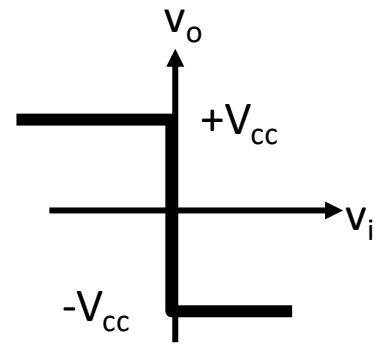
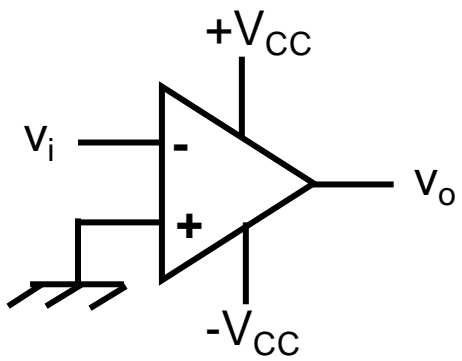
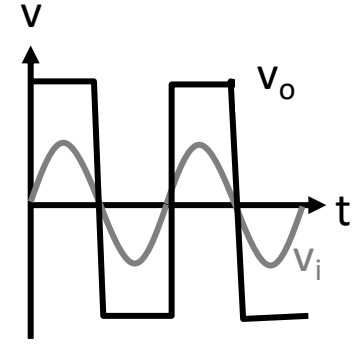
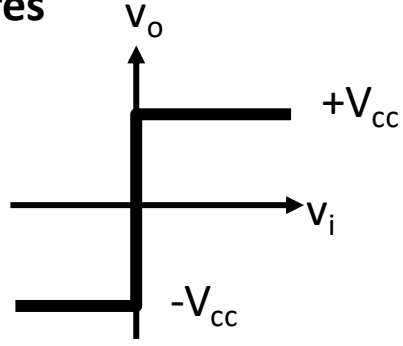
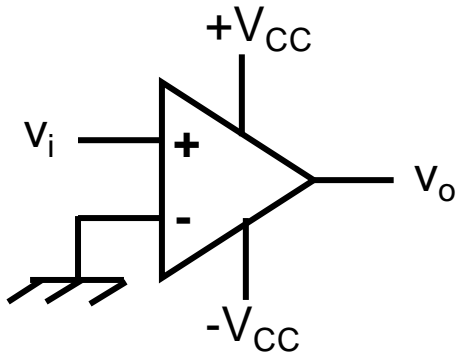
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**Comparadores**



**Cartagena99**

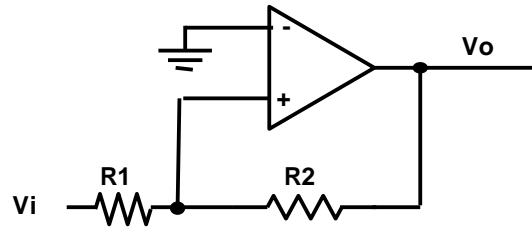
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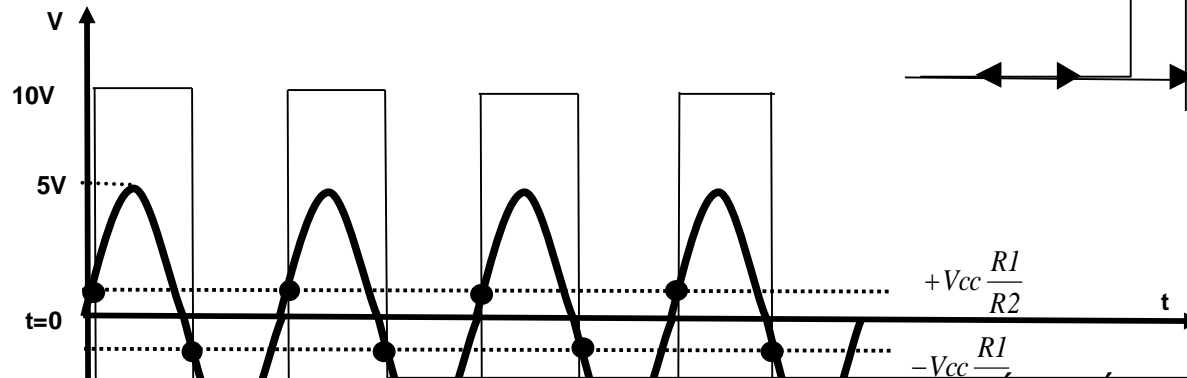
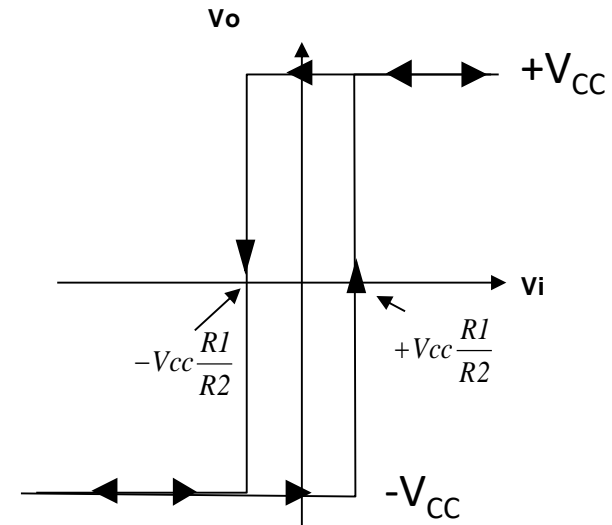
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## Disparador de Schmitt

Comparador con histéresis no inversor



Función de transferencia



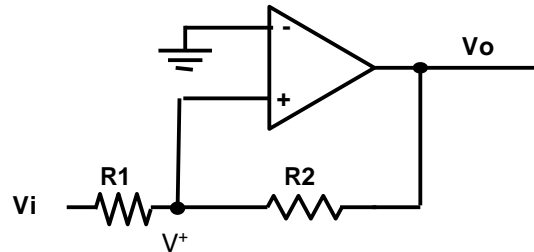
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## Disparador de Schmitt

Comparador con histéresis no inversor



$$v^+ = v_o \cdot \frac{R_1}{R_1 + R_2} + v_i \cdot \frac{R_2}{R_1 + R_2}$$

$$v^+ = \pm V_{cc} \cdot \frac{R_1}{R_1 + R_2} + v_i \cdot \frac{R_2}{R_1 + R_2}$$

Si  $v_o = +V_{cc}$

Se produce la comparación cuando se cumple que  $v^+$  pasa ser menor que cero:

$$0 \geq +V_{cc} \cdot \frac{R_1}{R_1 + R_2} + v_i \cdot \frac{R_2}{R_1 + R_2} \Rightarrow v_i \leq -V_{cc} \cdot \frac{R_1}{R_2}$$

Si  $v_o = -V_{cc}$

Se produce la comparación cuando se cumple que  $v^+$  pasa ser mayor que cero:

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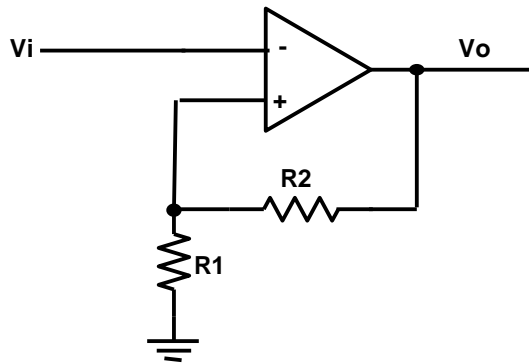
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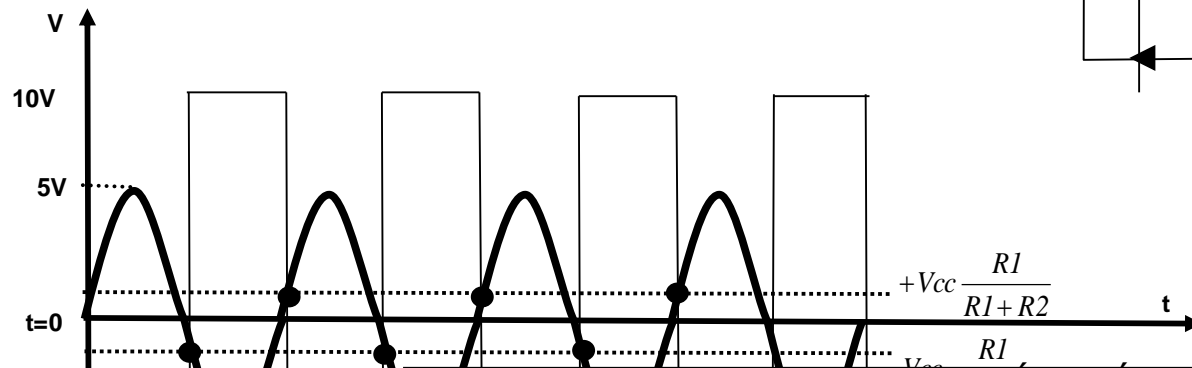
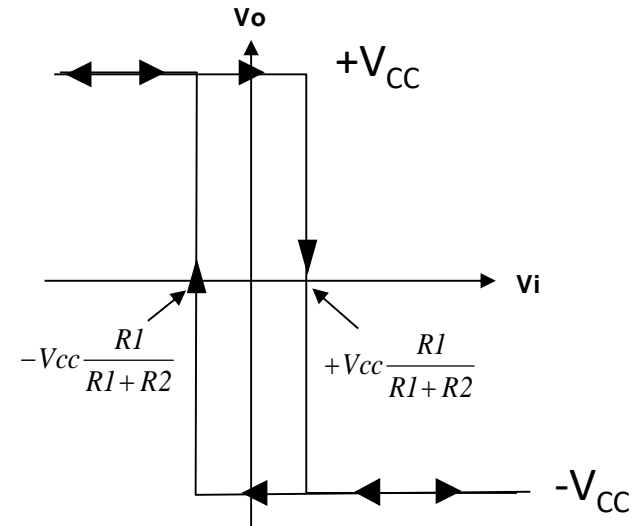
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## Disparador de Schmitt

Comparador con histéresis inversor



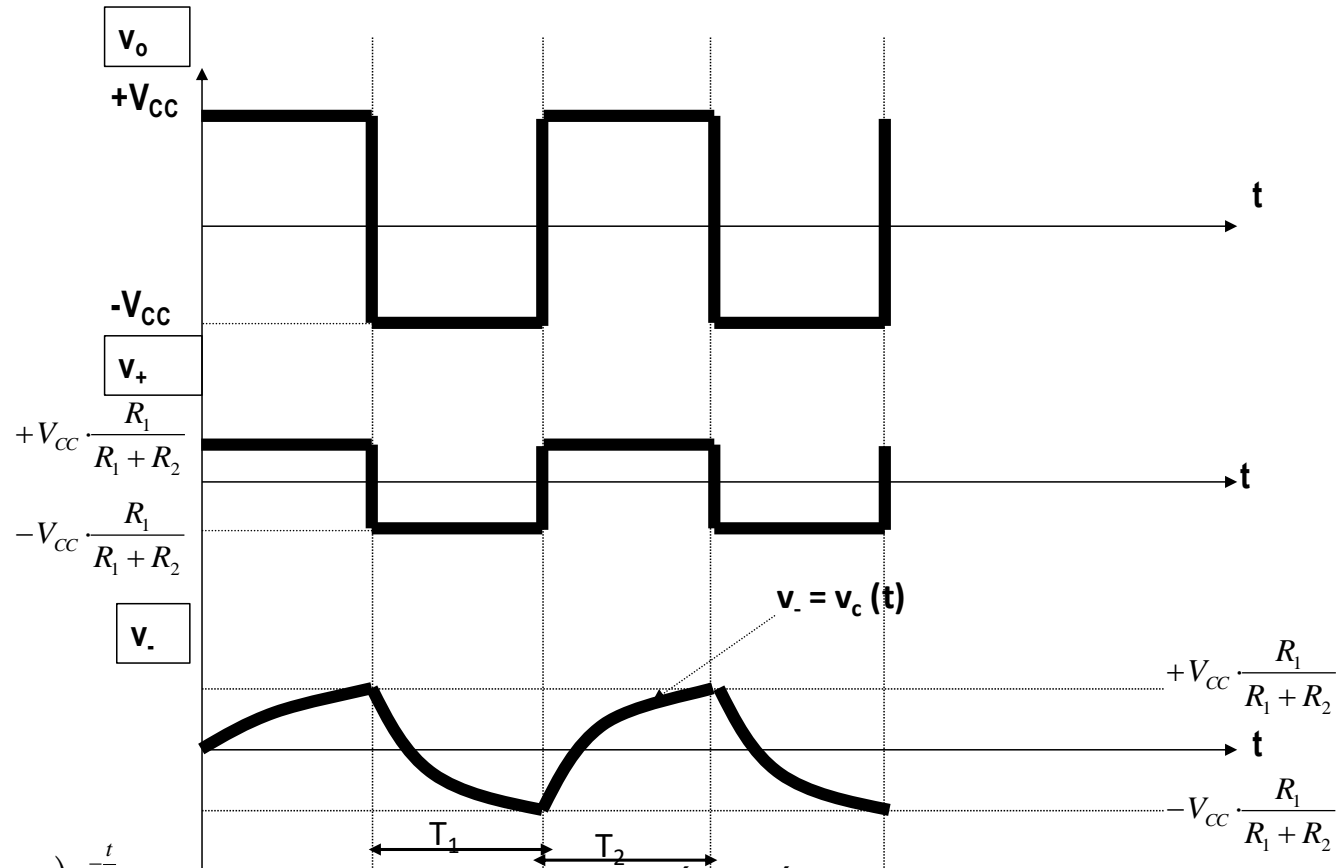
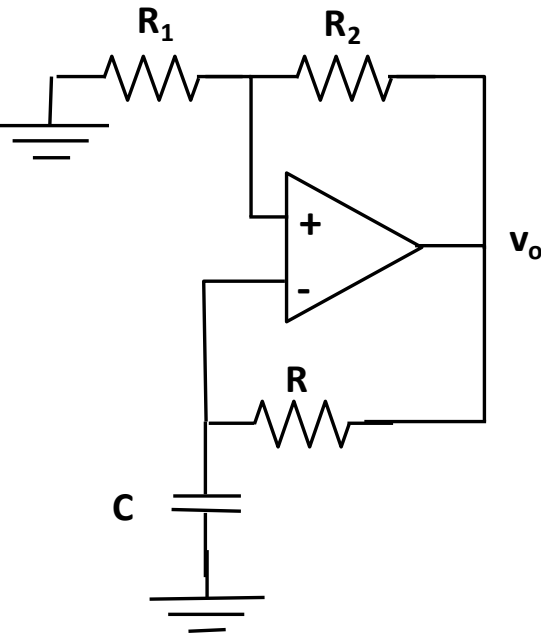
Función de transferencia



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### Oscilador de relajación



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