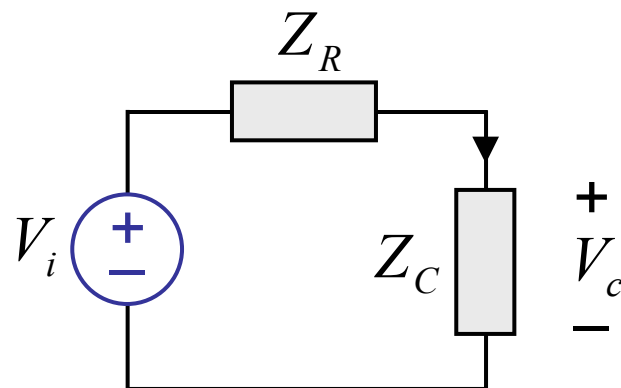
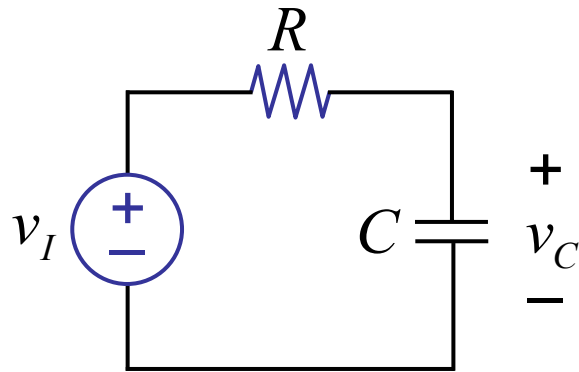


**6.002**

**CIRCUITOS Y  
ELECTRÓNICA**

# Filtros

# Repaso

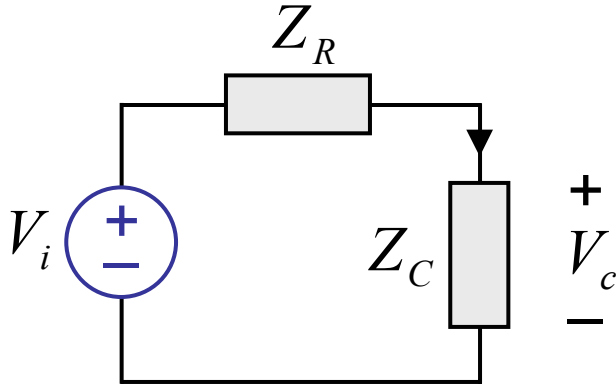


$$V_c = \frac{Z_C}{Z_C + Z_R} \cdot V_i$$

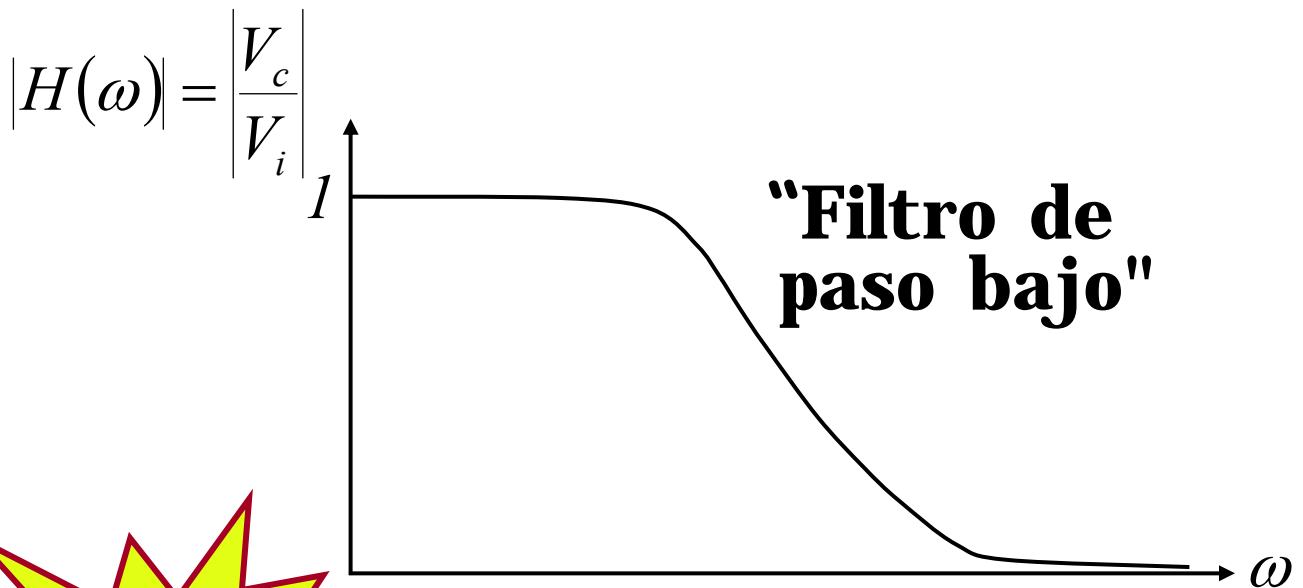
$$\frac{V_c}{V_i} = \frac{\frac{1}{j\omega C}}{\frac{1}{j\omega C} + R} = \frac{1}{1 + j\omega RC}$$

**Lectura:** secciones 14.5, 14.6, 15.3 de A & L.

# Un filtro

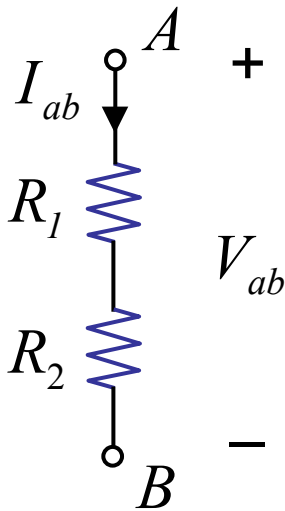


$$V_c = \frac{Z_C}{Z_C + Z_R} \cdot V_i = \frac{1}{1 + j\omega RC}$$

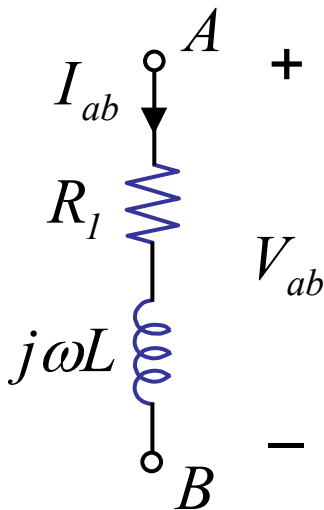


# Repaso rápido a las impedancias-

Simplemente:



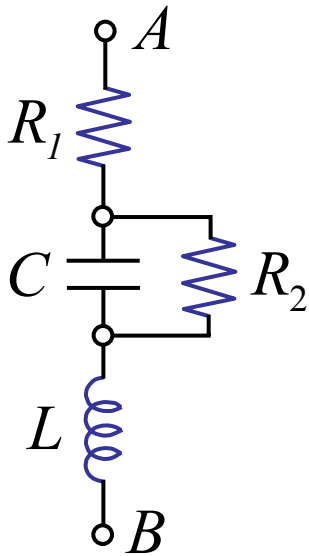
$$R_{AB} = \frac{V_{ab}}{I_{ab}} = R_1 + R_2$$



$$Z_{AB} = \frac{V_{ab}}{I_{ab}} = R_1 + j\omega L$$

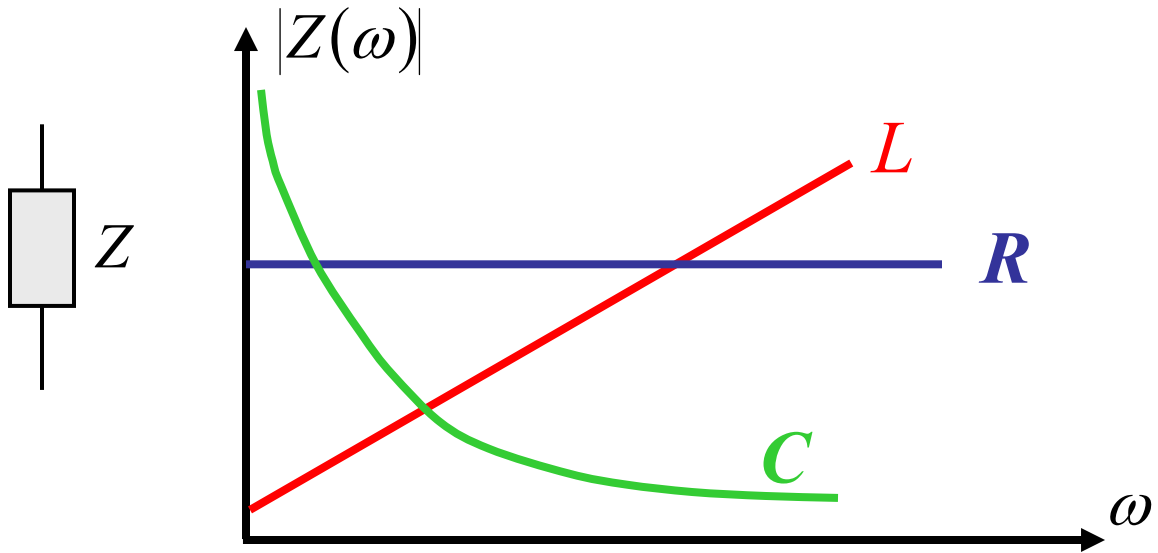
# Rápido repaso de impedancias

De forma similar:

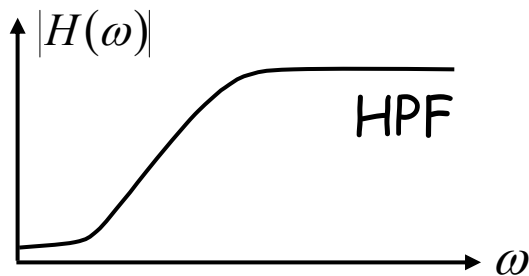
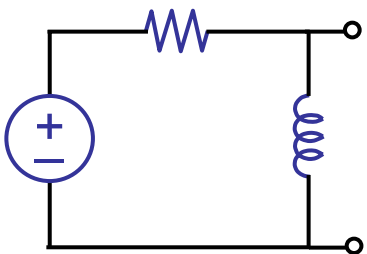
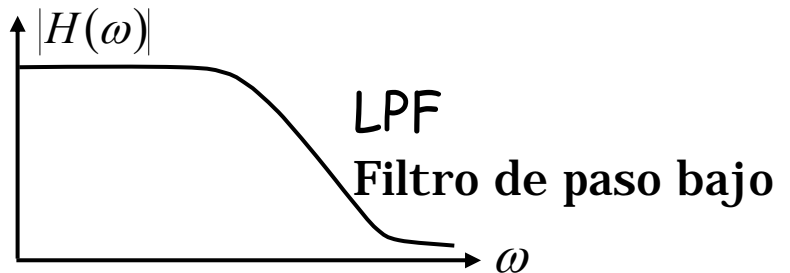
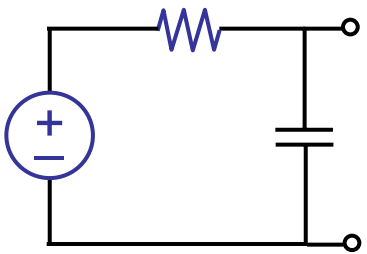
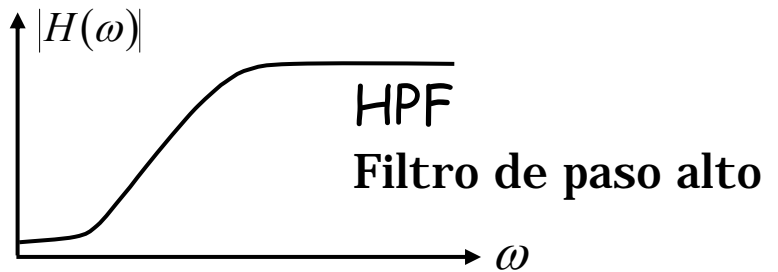
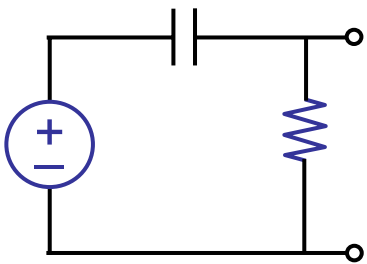
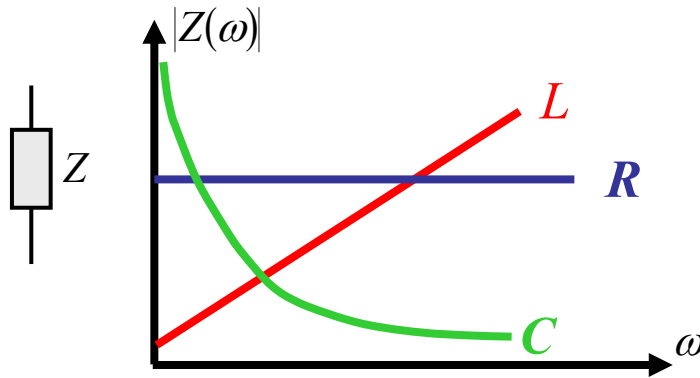


$$\begin{aligned} Z_{AB} &= R_1 + Z_C \parallel R_2 + Z_L \\ &= R_1 + \frac{Z_C R_2}{Z_C + R_2} + Z_L \\ &= R_1 + \frac{R_2}{1 + j\omega C R_2} + j\omega L \end{aligned}$$

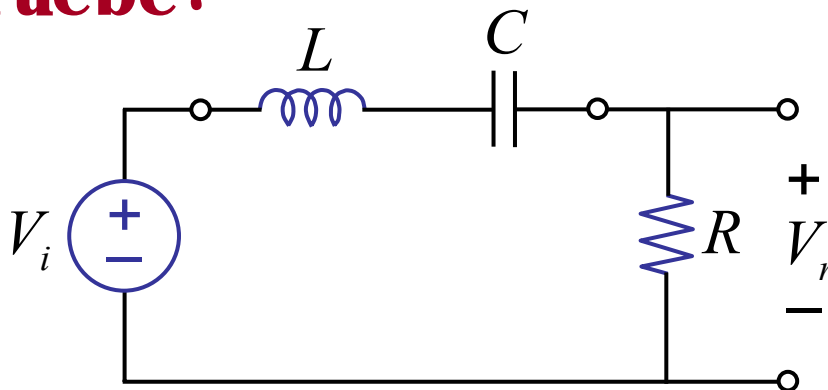
# Podemos construir otros filtros combinando impedancias



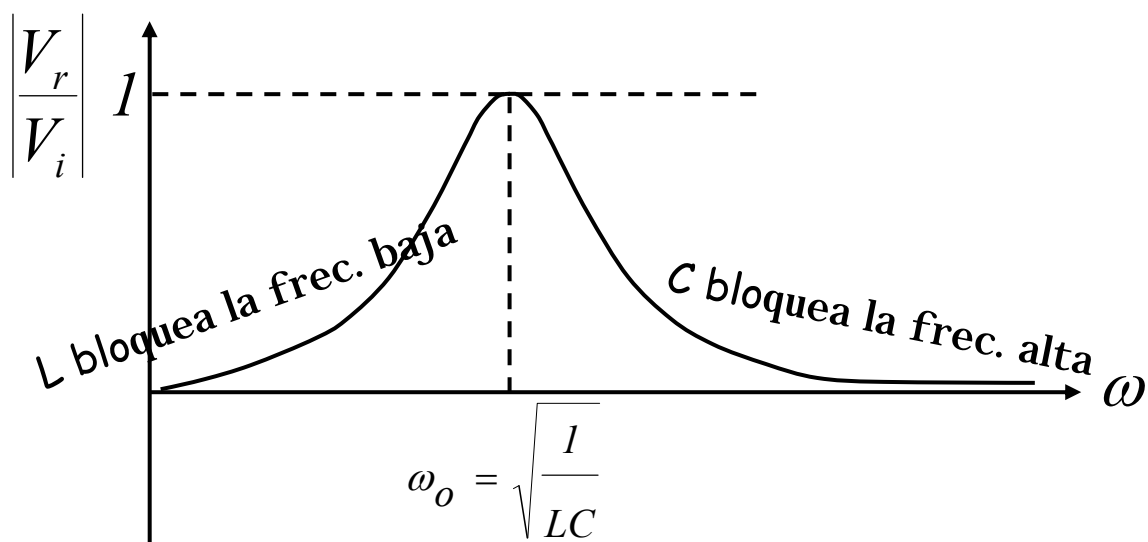
# Podemos construir otros filtros combinando impedancias



# Compruebe:




Por intuición:



$$\frac{V_r}{V_i} = \frac{R}{j\omega L + \frac{1}{j\omega C} + R}$$

$$= \frac{j\omega RC}{1 - \omega^2 LC + j\omega RC}$$

$$\left| \frac{V_r}{V_i} \right| = \frac{\omega RC}{\sqrt{(1 - \omega^2 LC)^2 + (\omega RC)^2}}$$

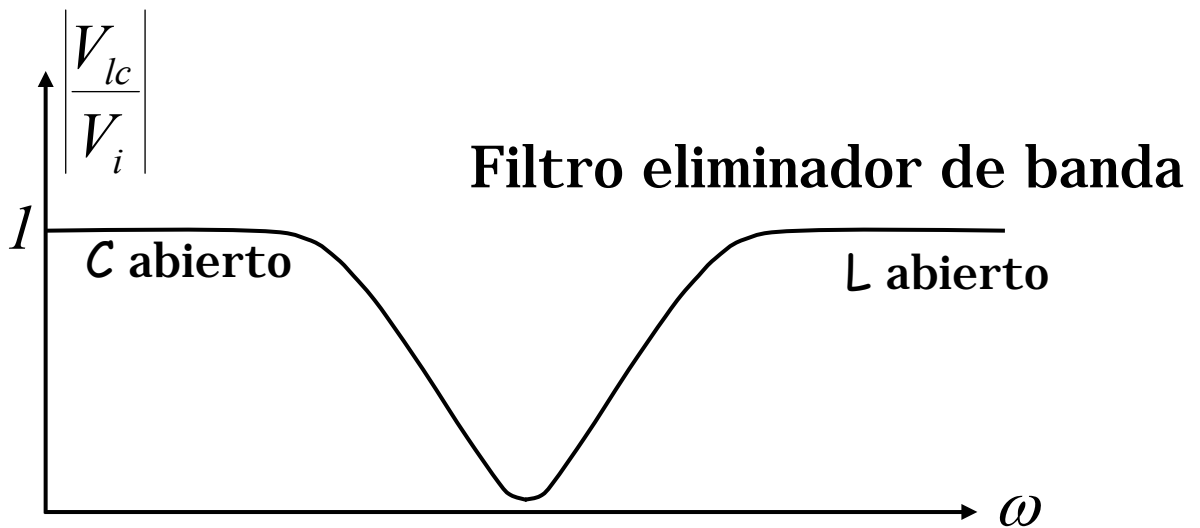
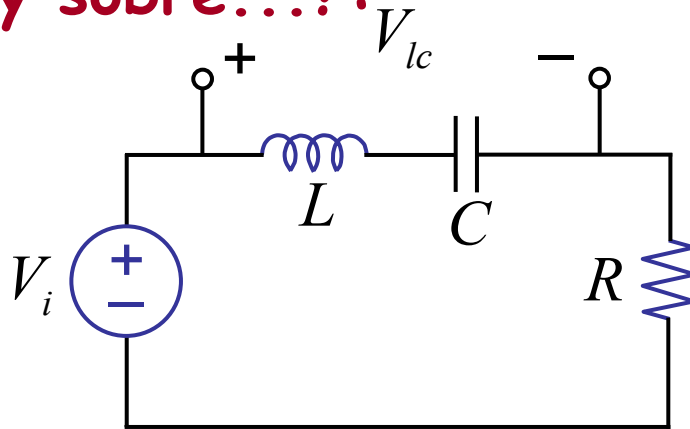
 **En resonancia,**  
 $\omega = \omega_0$

y

$Z_L + Z_C = 0$ ,  
**por tanto  $V_i$  sólo**  
**ve  $R$**

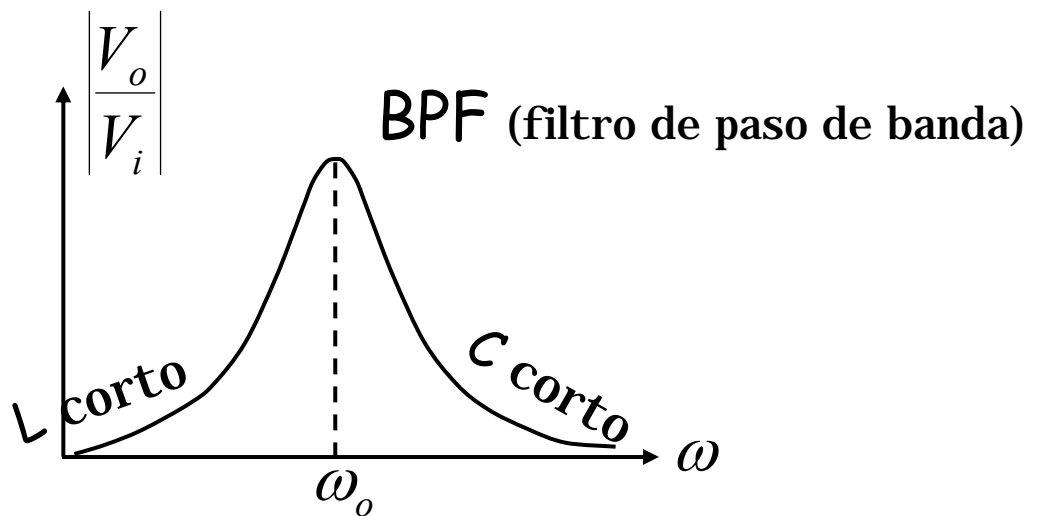
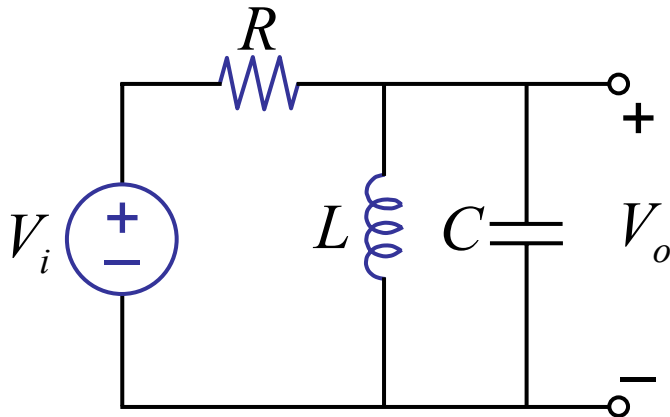
*Más adelante más.*

¿Qué hay sobre...?:



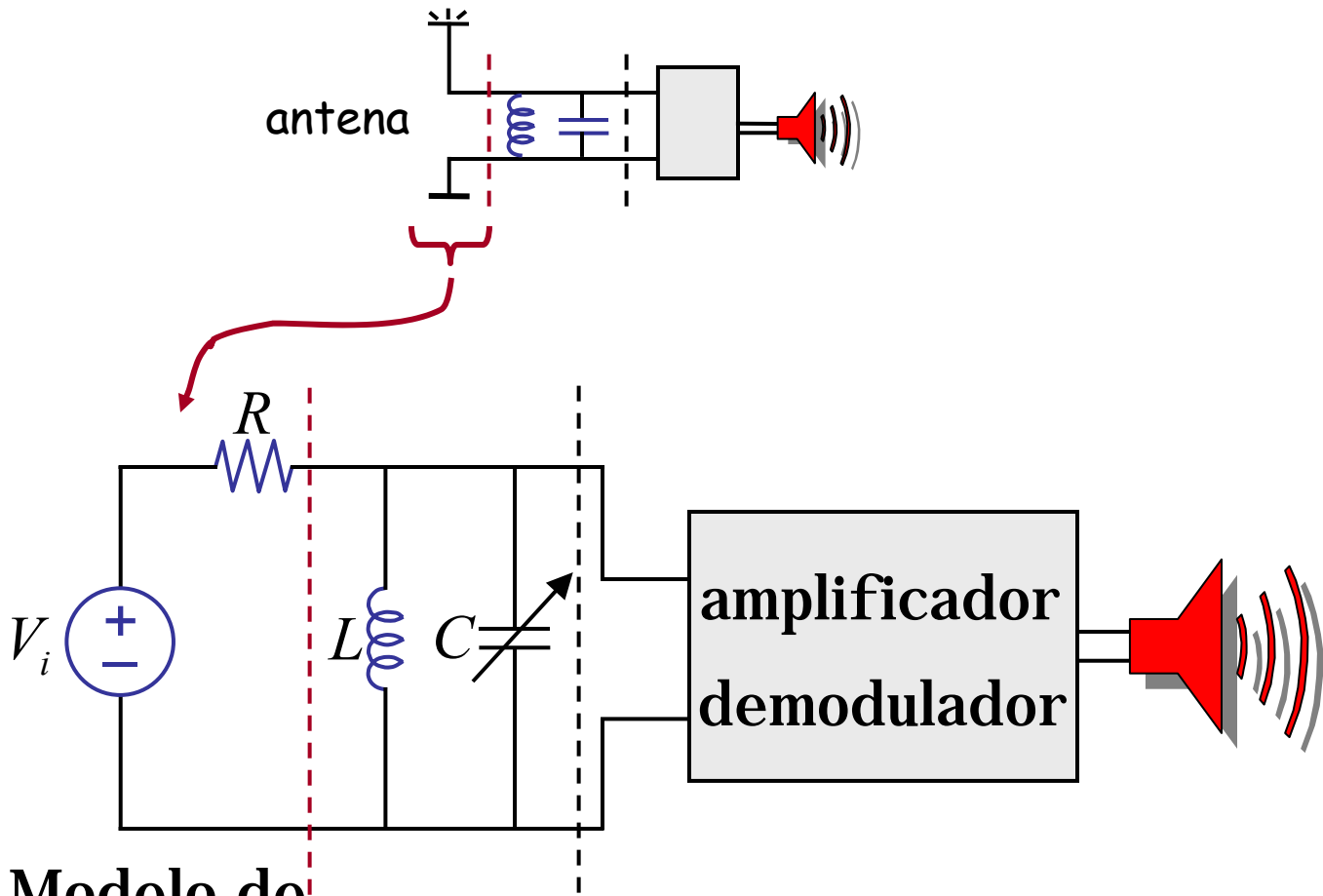
Compruebe  $V_l$  y  $V_c$  en la práctica.

## Otro ejemplo:



Aplicación: véase la radio AM (en breve).

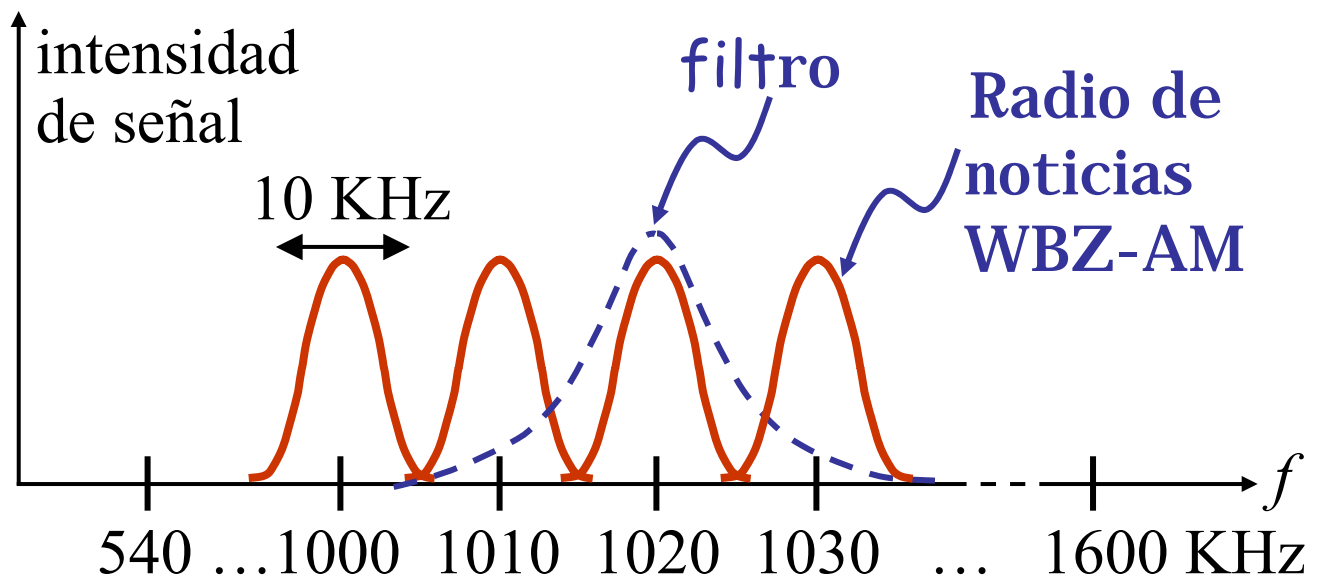
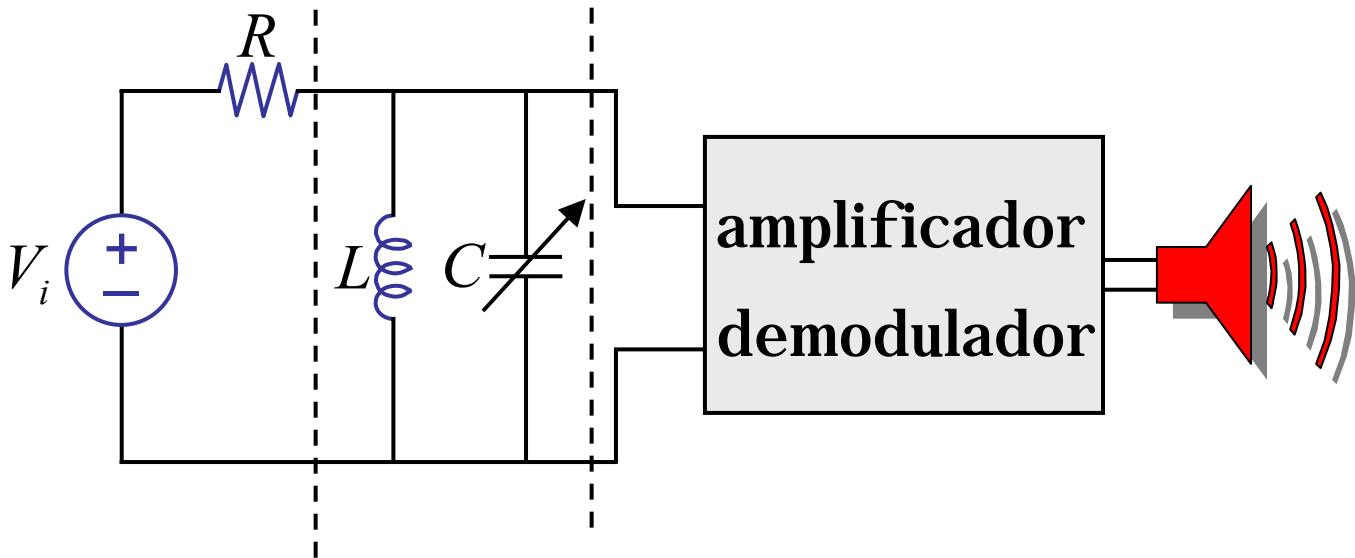
# Receptor de radio AM



Modelo de  
antena  
Thévenin

demo de radio de cristal

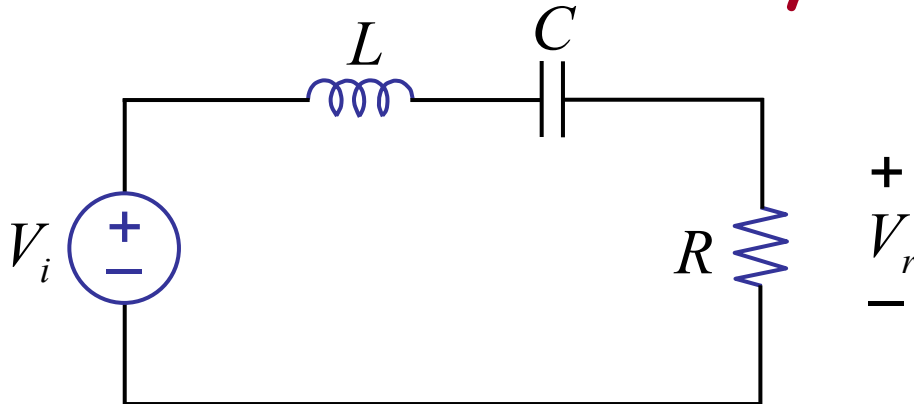
# Receptor AM



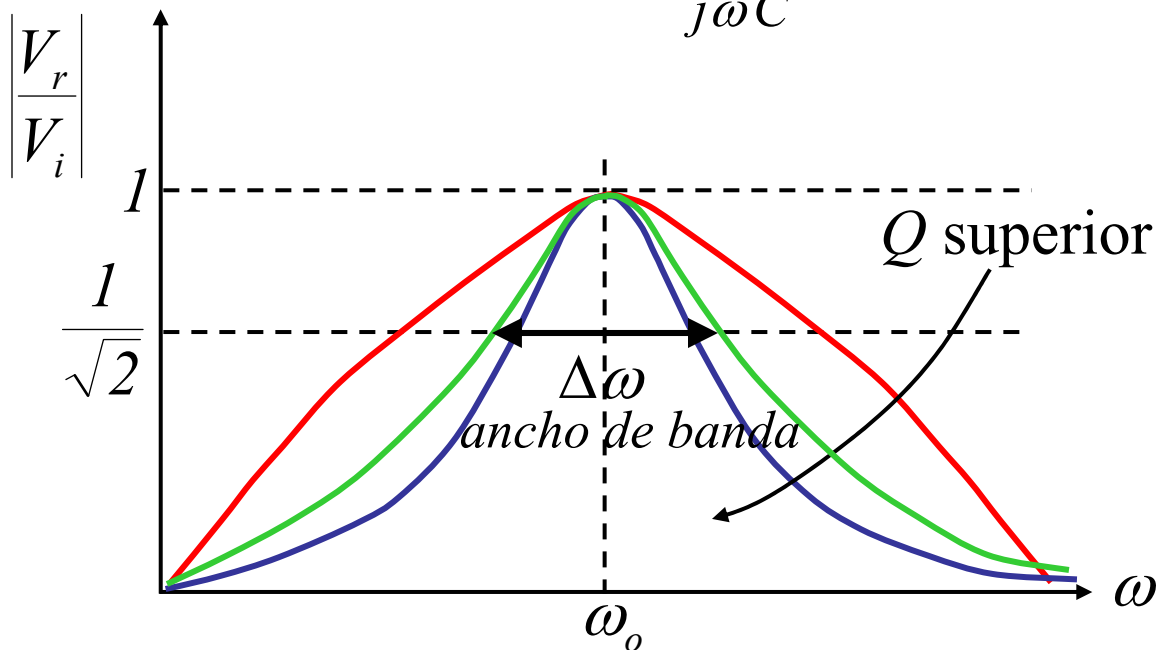
La "selectividad" es importante — hace referencia a un parámetro "Q" para el filtro. A continuación,...

# Selectividad:

Estudie las series RLC en mayor detalle



Recuerde, 
$$\frac{V_r}{V_i} = \frac{R}{R + j\omega L + \frac{1}{j\omega C}}$$



Defina  $Q = \frac{\omega_0}{\Delta\omega}$  *factor de calidad*

$Q$  alto  $\Rightarrow$  más selectivo

# Factor de calidad $Q$

$$Q = \frac{\omega_o}{\Delta\omega}$$

$\omega_o$ :

$$\frac{V_r}{V_i} = \frac{R}{R + j\omega L + \frac{1}{j\omega C}} = \frac{1}{1 + j\left(\omega \frac{L}{R} - \frac{1}{\omega CR}\right)}$$

$\underbrace{\hspace{10em}}_{\text{en } \omega_o = 0}$

$$\omega_o = \frac{1}{\sqrt{LC}}$$

$\Delta\omega$ ?

# Factor de calidad $Q$

$$Q = \frac{\omega_o}{\Delta\omega}$$

$\Delta\omega$  :

Observe que la magnitud de abstr. es  $\frac{1}{\sqrt{2}}$

cuando 
$$\frac{V_r}{V_i} = \frac{1}{1 + j\left(\omega \frac{L}{R} - \frac{1}{\omega CR}\right)} = \frac{1}{1 \pm j1}$$

es decir, cuando 
$$\frac{\omega L}{R} - \frac{1}{\omega CR} = \pm 1$$

$$\omega^2 \mp \frac{\omega R}{L} - \frac{1}{LC} = 0$$

Examinando las raíces de las dos ecuaciones,

$$\omega_1 = \frac{R}{2L} + \frac{1}{2} \sqrt{\frac{R^2}{L^2} + \frac{4}{LC}} \quad \omega_2 = -\frac{R}{2L} + \frac{1}{2} \sqrt{\frac{R^2}{L^2} + \frac{4}{LC}}$$

$$\Delta\omega = \omega_1 - \omega_2 = \frac{R}{L}$$

## *Factor de calidad $Q$*

$$Q = \frac{\omega_o}{\Delta\omega}$$

$$Q = \frac{\omega_o}{R} = \frac{\omega_o L}{R}$$

$$\omega_o = \frac{1}{\sqrt{LC}}$$

**Cuanto menor sea  $R$  (para las series  $R$ ), más marcado será el pico.**

# *Factor de calidad $Q$*

Otra forma de considerar  $Q$  :

$$Q = 2\pi \frac{\text{energía almacenada}}{\text{energía perdida por ciclo}}$$

$$= 2\pi \frac{\frac{1}{2} L |I_r|^2}{\frac{1}{2} |I_r|^2 R \frac{2\pi}{\omega_0}}$$

$$Q = \frac{\omega_0 L}{R}$$