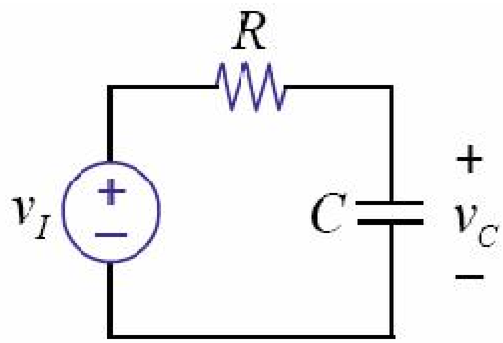
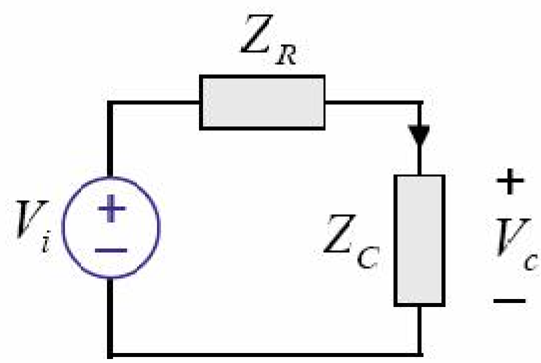
滤波器

复习



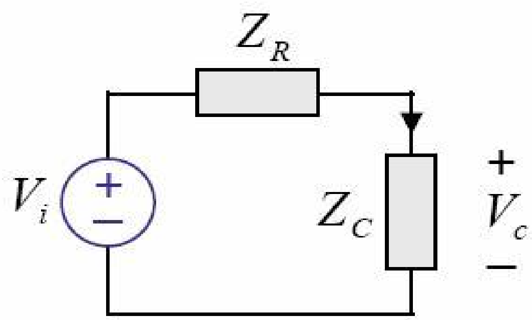


$$V_c = \frac{Z_C}{Z_C + Z_R} \cdot V_i$$

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

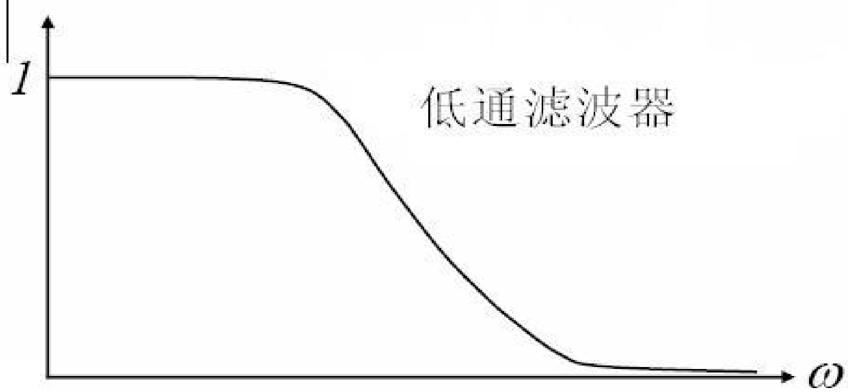
阅读A和L的14.5，14.6，15.

滤波器



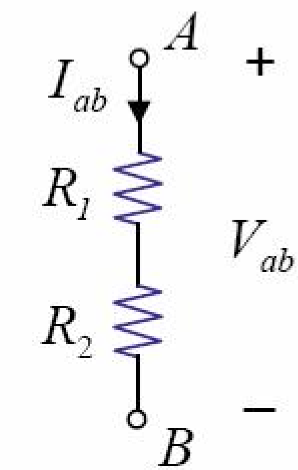
$$V_c = \frac{Z_C}{Z_C + Z_R} \cdot V_i = \frac{1}{1 + j\omega RC}$$

$$|H(\omega)| = \left|\frac{V_c}{V_i}\right|$$

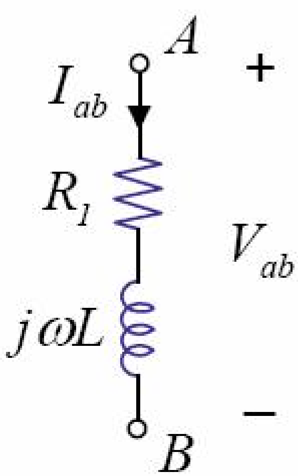


阻抗电路的快速回顾

如



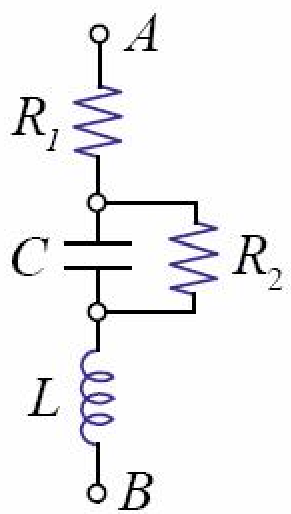
$$R_{AB}=\frac{V_{ab}}{I_{ab}}=R_1+R_2$$



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

阻抗电路的快速回顾

类似的

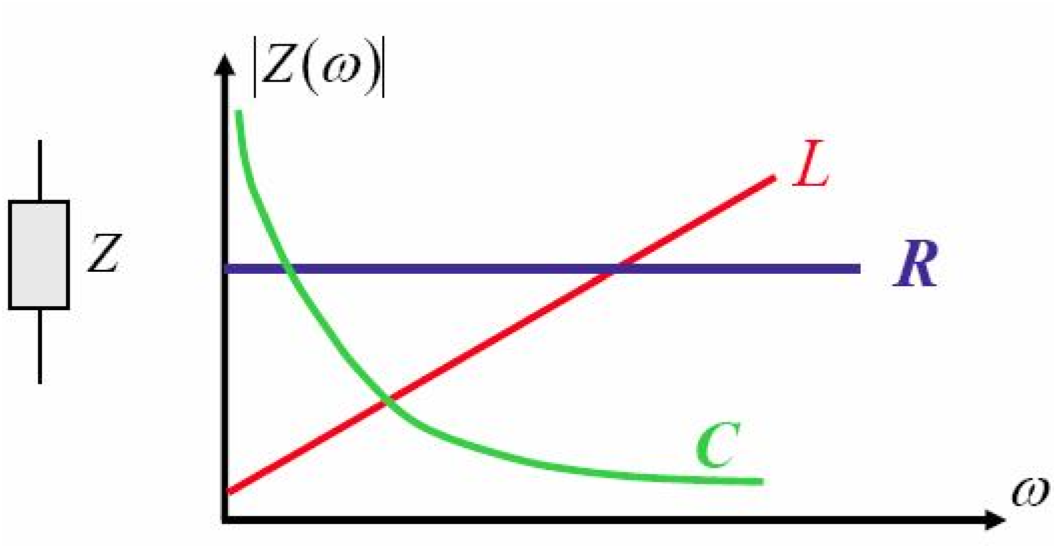


$$Z_{AB} = R_1 + Z_C \,||\, R_2 + Z_L$$

$$= R_1 + \frac{Z_C R_2}{Z_C + R_2} + Z_L$$

$$= R_1 + \frac{R_2}{1 + j\omega C R_2} + j\omega L$$

我们也可以利用不同阻抗组合来搭建其它滤波器电路



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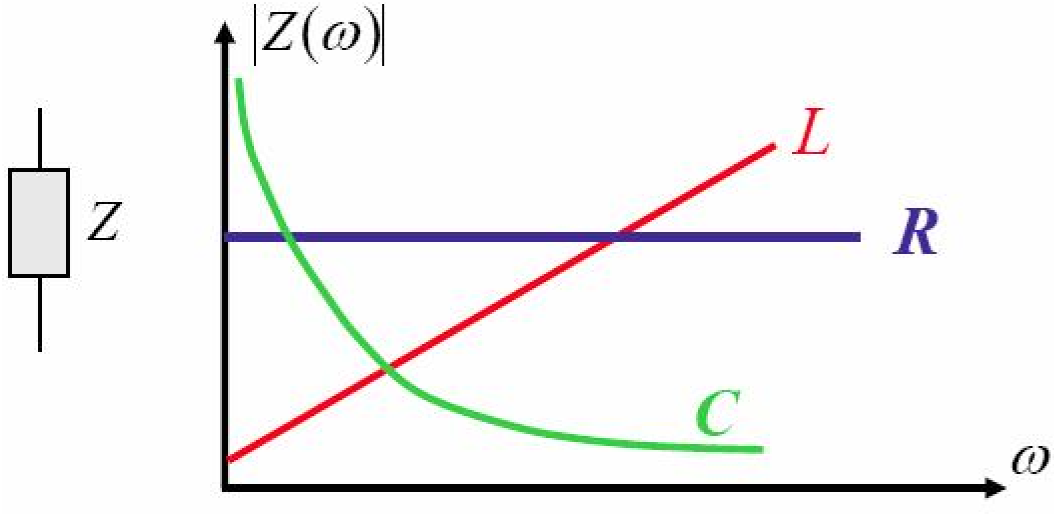
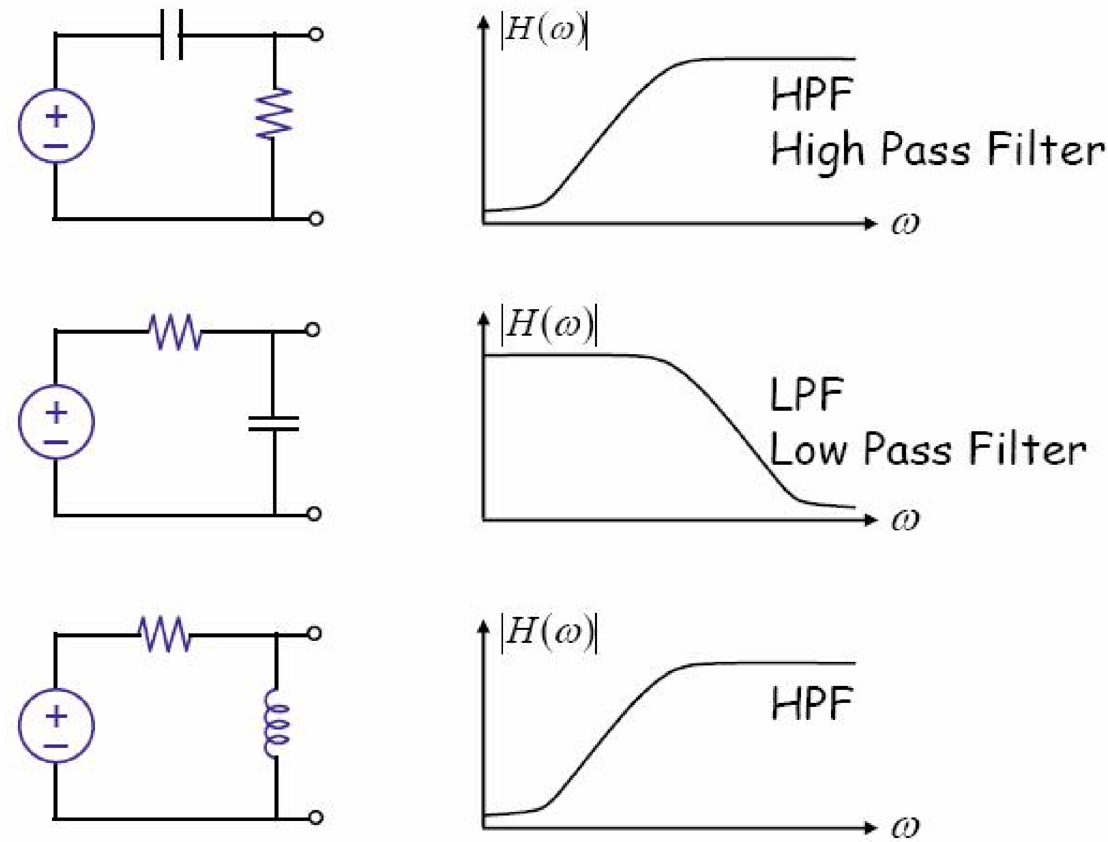
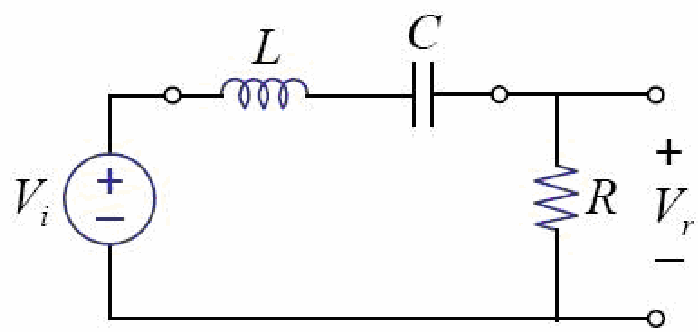
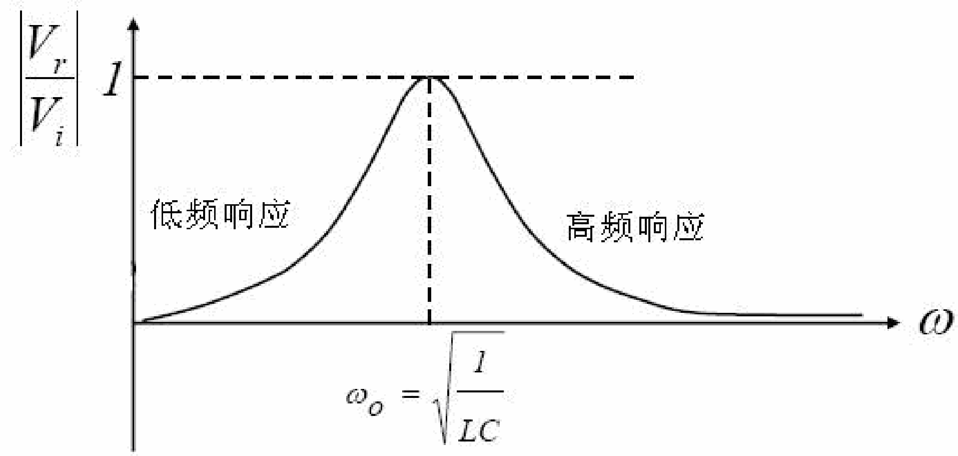




验证电路



直观表示



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

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

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

谐振时

$$\omega = \omega_o$$

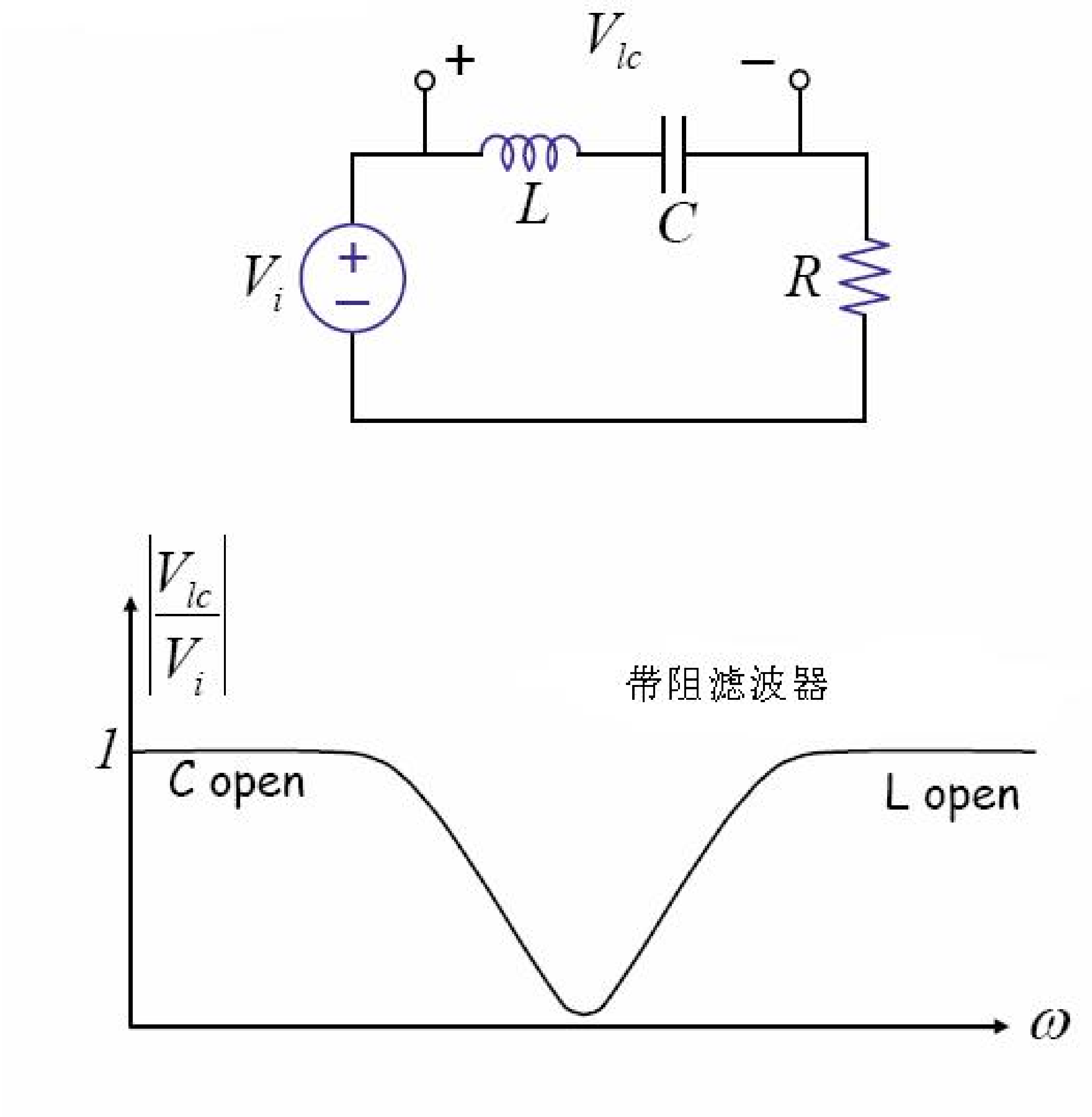
同时

$$Z_L + Z_C = 0,$$

因此 对 V_i 来说，

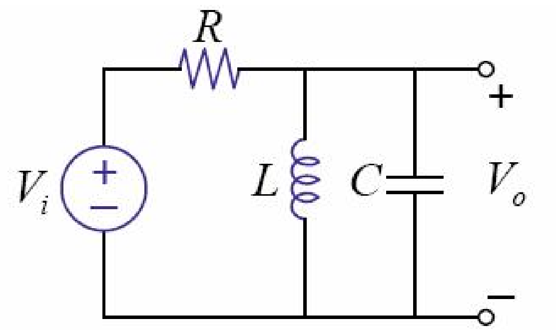
电路仅相当于 一个电阻

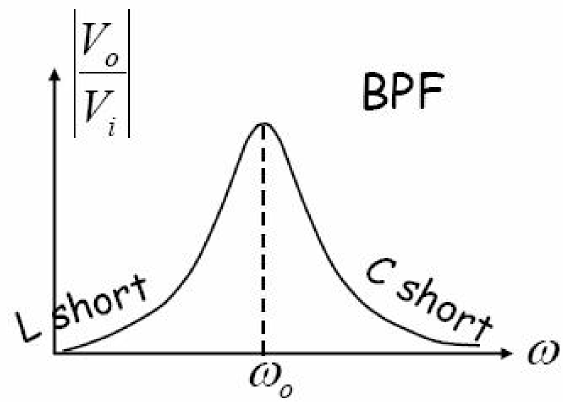
带阻滤波器



在实验室中验证V_l和V_c

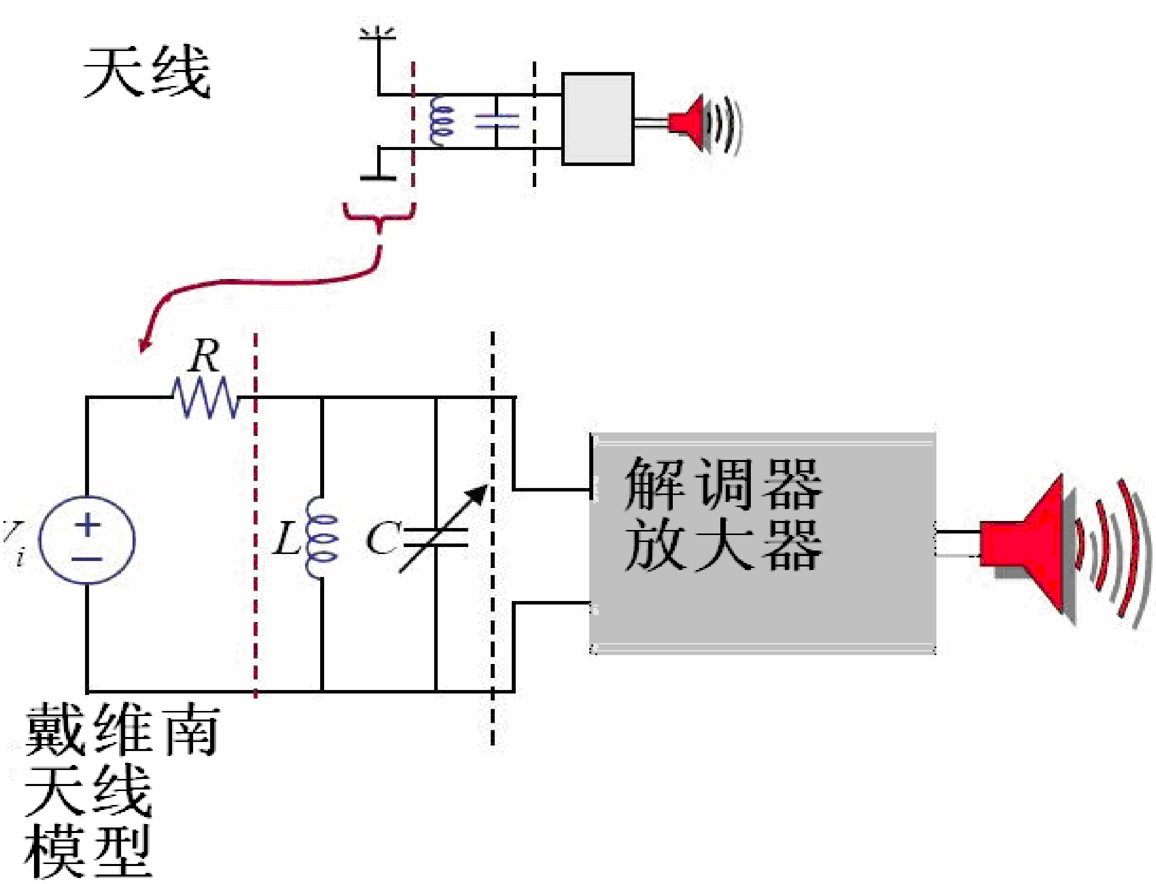
另外一个例子



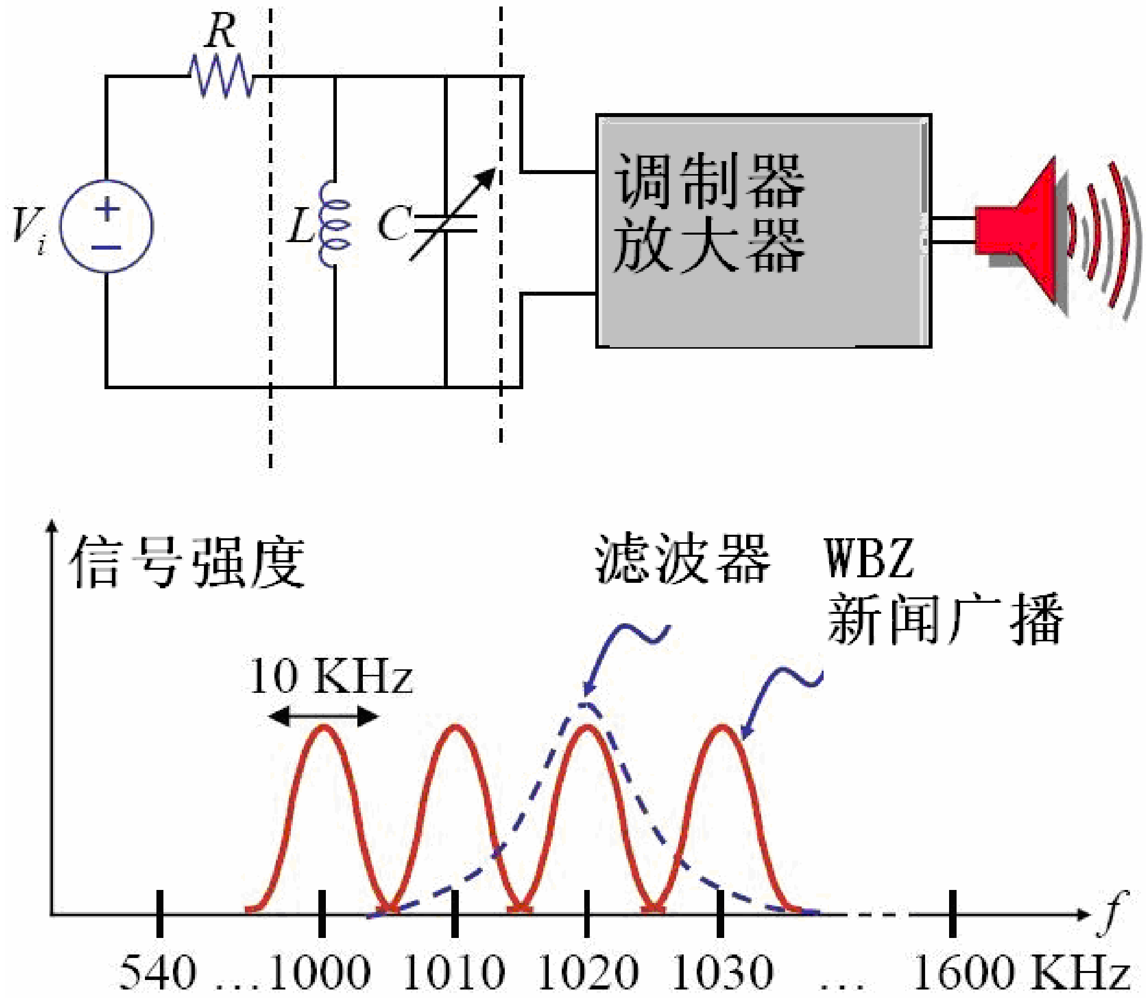


应用：见马上就要学习的AM广播系统

AM广播接收器



AM 广播接收器

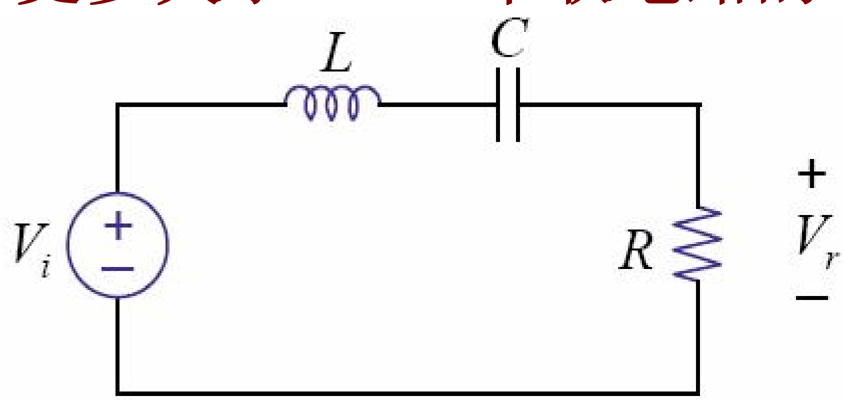


“选择性”的重要---

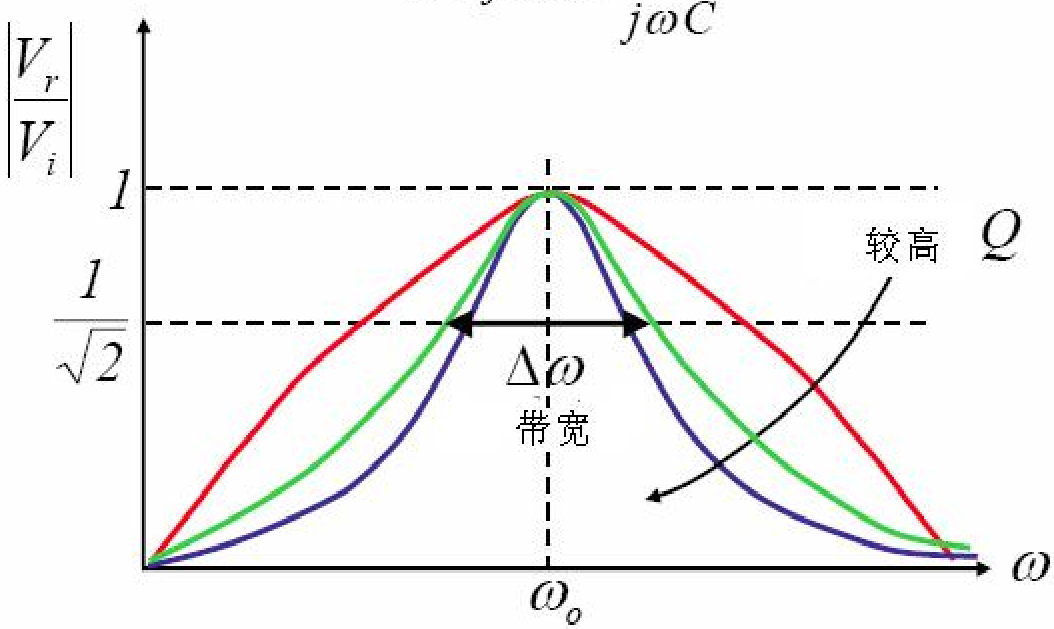
对于滤波器来说涉及到一个参数 *Q*。下面…

选择性：

了解更多关于 RLC 串联电路的细节



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



定义 $$Q = \frac{\omega_o}{\Delta\omega}$$ 质量因素

品质因数

Q 值越大 $\Rightarrow$ 选择性越强

品质因数 Q

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

ω_o:

$$\frac{V_r}{V_i} = \frac{R}{R + j\omega L + \frac{1}{j\omega C}} = \frac{1}{1 + j\underbrace{\left(\omega\frac{L}{R} - \frac{1}{\omega CR}\right)}_{\omega_o \;=0}}$$

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

$\Delta\omega$?

品质因数 *Q*

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

$\Delta\omega$:

注意abs的幅值为 $\frac{1}{\sqrt{2}}$

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

当 $$\frac{\omega L}{R} - \frac{1}{\omega CR} = \pm 1$$ 时

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

以下为两个等式的根：

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

品质因数 *Q*

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

$$Q = \frac{\omega_o}{\frac{R}{L}} = \frac{\omega_o L}{R} \qquad \omega_o = \frac{1}{\sqrt{LC}}$$

R（串联）值越低，则 Q 的值越大，峰越陡。

品质因数 *Q*

从另一方面看品质因数：

$$Q = 2\pi \frac{\text{energy stored}}{\text{energy lost per cycle}}$$

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

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