

TOPIC 3 – Analog and Digital Signals

3.4 Filters

- **Filters are devices which alter the frequency characteristics of an electronic signal.**
- **Filters may be designed to be either passive or active.**
- **Filters are designed from capacitors, inductors and resistors.**
- **There are several common types of filters such as: low-pass, high-pass, band-pass and notch.**

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BLOCK DIAGRAM



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Remember Impedance:

- Electrical components have responses that vary with frequency.
- This frequency response is known as impedance, Z .
- Impedance has both a real and a complex part and is of the form:
 $Z = R + jX$ where X is called Reactance.
- So the following relationships hold:
 - Resistor: $Z = R + 0*j = R$
 - Capacitor: $Z = 0 - j/\omega C = 1j/\omega C$
 - Inductor: $Z = 0 + \omega L = \omega L$
 - Where $\omega = \text{omega} = 2 * \text{Pi} * \text{frequency in Hz}$

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Low Pass Filter (LPF) Circuits

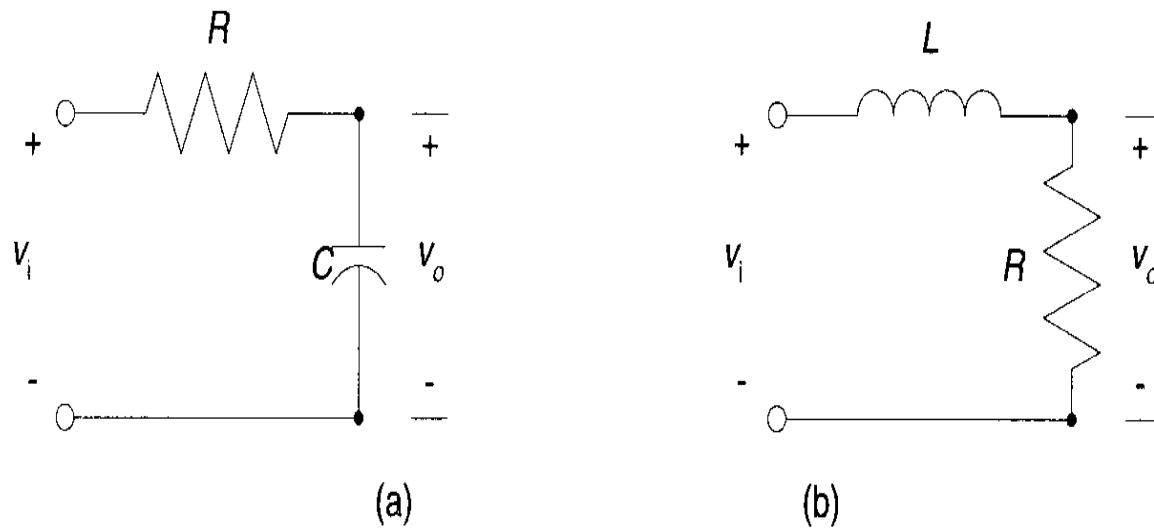


Figure 2.37 Low-pass filter. (a) RC circuit. (b) RL circuit.

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Low Pass Filter (LPF) Response

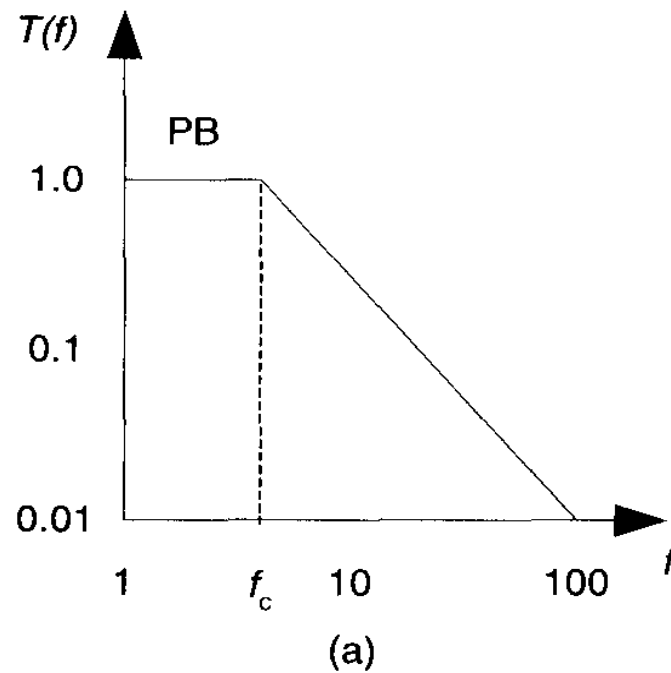
Filter response, $T(\omega)_{\text{out}}$ for either the RC circuit or the RL circuit is:

- $T(\omega)_{\text{out}} = 1/(1+j \omega/\omega_c)$
- Where the ω_c = cutoff frequency is:
 - $\omega_c = 1/RC$ for the RC circuit and
 - $\omega_c = R/L$ for the RL circuit

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Low Pass Filter (LPF) Response



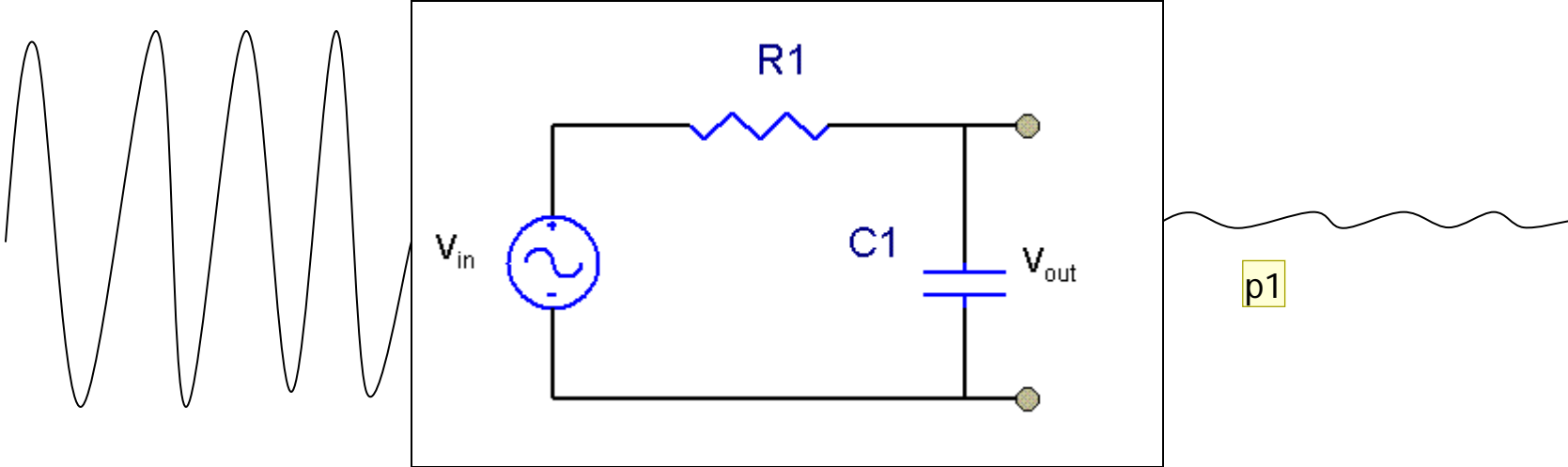
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Low Pass Filter (LPF) Uses

- Typical use in bioinstrumentation; remove RF interference from an EKG signal.
- Source of RF: unshielded leads or long connecting wires/cables.
- Typical cutoff frequency is 150 Hz

Low Pass RC Filters



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Changes.

pcourtoi, 12/20/2004

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High Pass Filter (HPF) Circuits

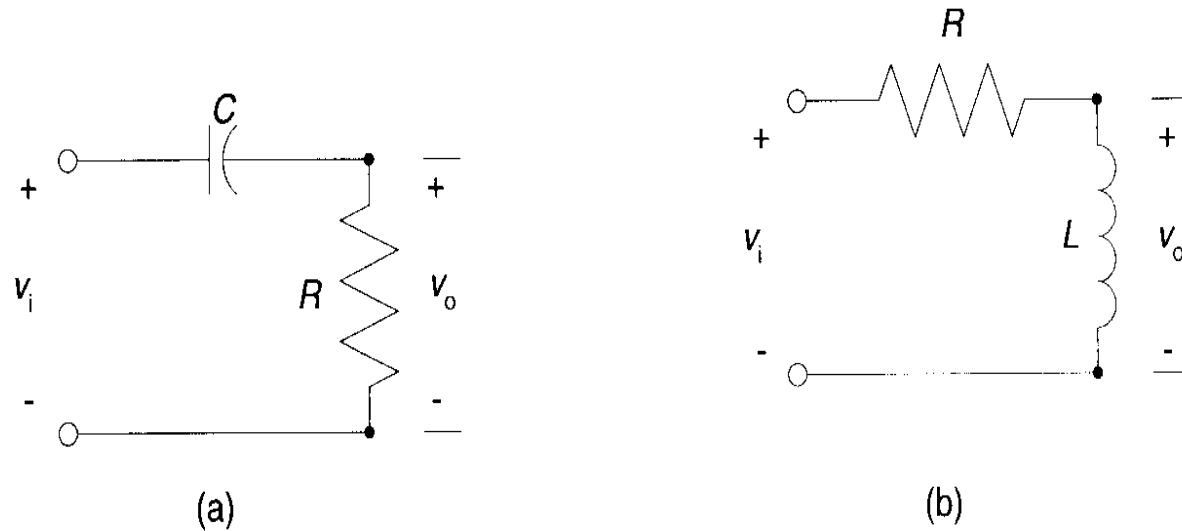


Figure 2.38 High pass filter. (a) RC circuit. (b) RL circuit.

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High Pass Filter (HPF) Response

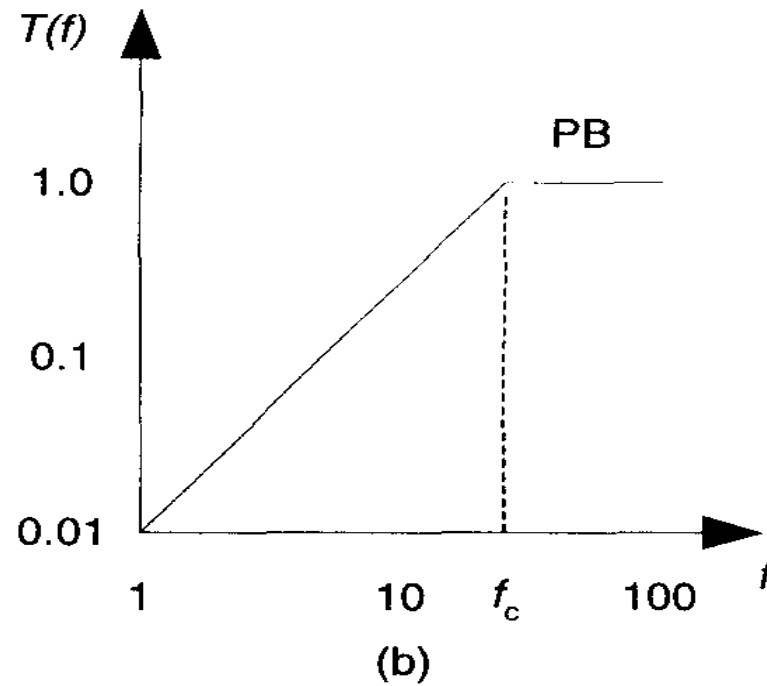
Filter response, $T(\omega)_{out}$ for either the RC circuit or the RL circuit is:

- $T(\omega)_{out} = 1/(1-j \omega_c/\omega)$
- Where ω_c = cutoff frequency is:
 - $\omega_c = 1/RC$ for the RC circuit and
 - $\omega_c = R/L$ for the RL circuit

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High Pass Filter (LPF) Response



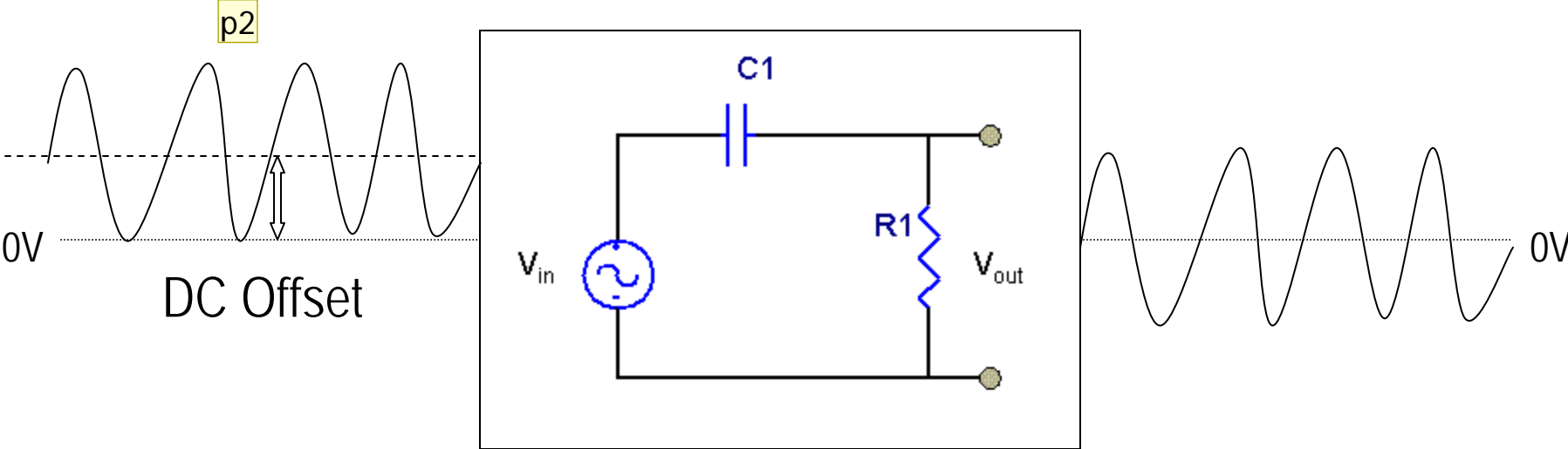
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High Pass Filter (HPF) Uses

- Typical use in bioinstrumentation: remove dc offset and other low frequency interference from an EKG signal.
- Typical cutoff frequency: .5 Hz

High Pass RC Filters



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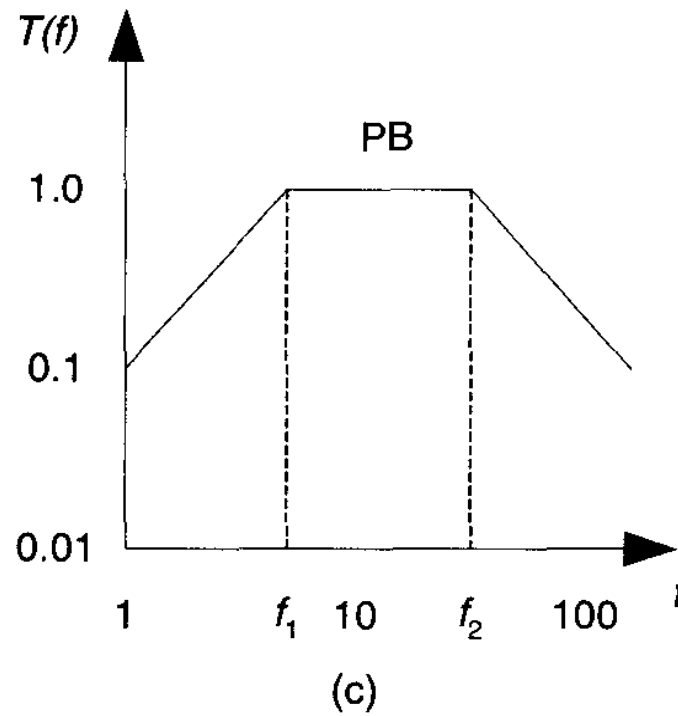
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Bandpass Filter (BPF) Response



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Notch (Bandstop) Filter (NPF) Response

