UNIT-IV

Fundamentals of semiconductor devices and digital circuits

Lecture 36

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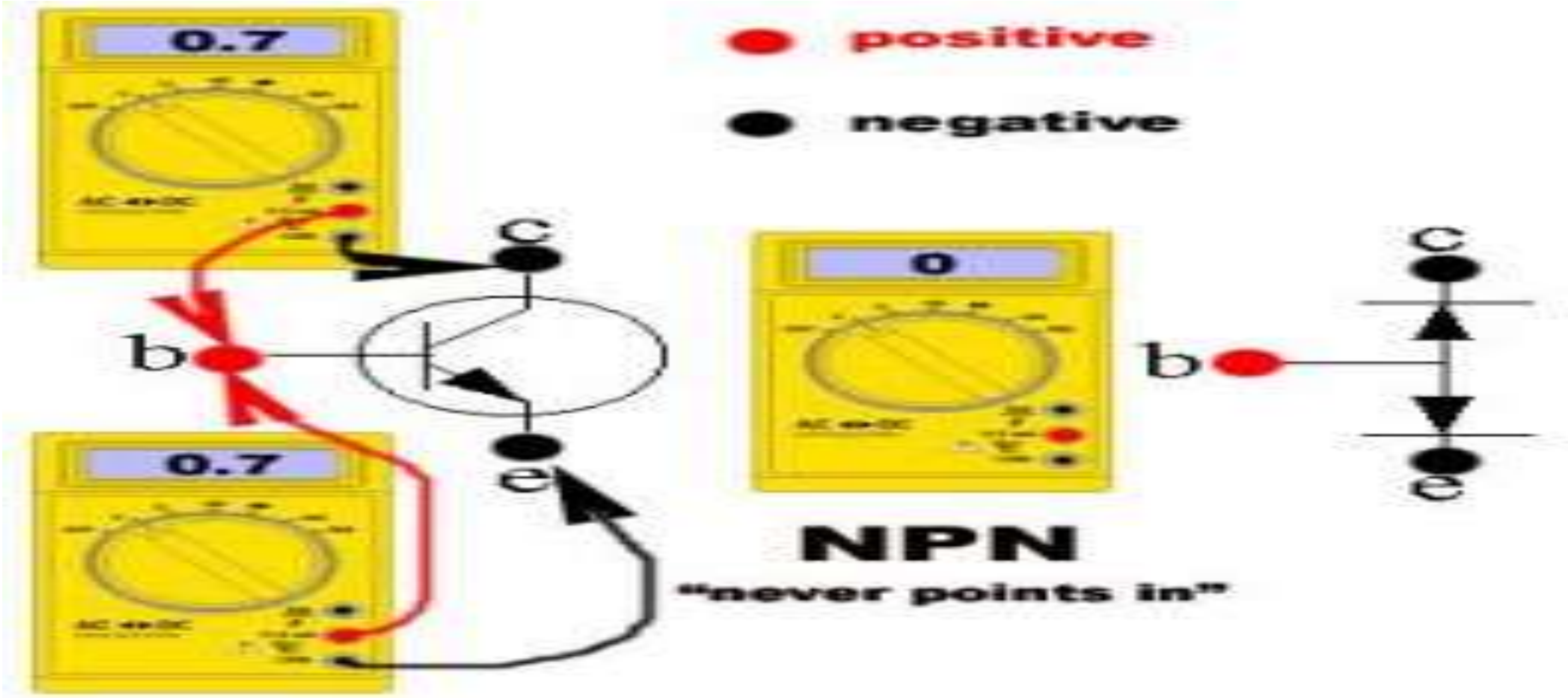
Procedure of a Transistor Tester Using a Digital Multimeter

- A digital multimeter is used to test the base to emitter and base to collector PN junction of the BJT. By using this test, you can also identify the polarity of an unknown device. PNP and NPN transistor can be checked using the digital multimeter.
- The digital multimeter consists of two leads: black and red. Connect the red (positive) lead to the base terminal of the PNP transistor, and the black (negative) lead to the emitter terminal of the transistor. The voltage of a healthy transistor should be 0.7V, and the measurement across the collector should read 0.0V. If the measured voltage is around 1.8V, then the transistor will be dead.

- Similarly, connect the black lead (negative) to the base terminal of the NPN transistor, and red lead (positive) to the emitter terminal of the transistor. The voltage of a healthy transistor should be 0.7V, and the measurement across the collector should read 0.0V. If the measured voltage is around 1.8V, then the transistor will be dead.



Integrated circuits

- An **integrated circuit**, or IC, is small chip that can function as an amplifier, oscillator, timer, microprocessor, or even computer memory. An IC is a small wafer, usually made of silicon, that can hold anywhere from hundreds to millions of transistors, resistors, and capacitors.
- **General types of integrated circuits(ICs) include the following:**
- Logic Circuits. These ICs are designed using logic gates-that work with binary input and output (0 or 1). ...
- Comparators. X. ...
- Switching ICs. ...
- Audio amplifiers. ...
- Operational amplifiers. ...
- Timer ICs.

Why are integrated circuits are important?

- Basically and integrated circuit as the name implies, is one (or many) circuit(s) within a circuit. So the most important thing of the IC is the form factor. Because we can include Millions and Billions of transistors into one Germanium and silicon chip, we can now reduce the size of our electronic devices.

Advantages of IC

- The entire physical size of IC is extremely small than that of discrete circuit.
- The weight of an IC is very less as compared entire discrete circuits.
- It’s more reliable.
- Because of their smaller size it has lower power consumption.
- It can easily replace but it can hardly repair, in case of failure.
- Temperature differences between components of a circuit are small.
- It has suitable for small signal operation.
- The reduction in power consumption is achieved due to extremely small size of IC.

Disadvantages of IC

- Coils or indicators cannot be fabricated.
- It can be handle only limited amount of power.
- High grade P-N-P assembly is not possible.
- It is difficult to be achieved low temperature coefficient.
- The power dissipation is limited to 10 watts.
- Low noise and high voltage operation are not easily obtained.
- Inductors and transformers are needed connecting to exterior to the semiconductor chip as it is not possible to fabricate inductor and transformers on the semiconductor chip surface.
- Inductors cannot be fabricated directly.
- Low noise and high voltage operation are not easily obtained.

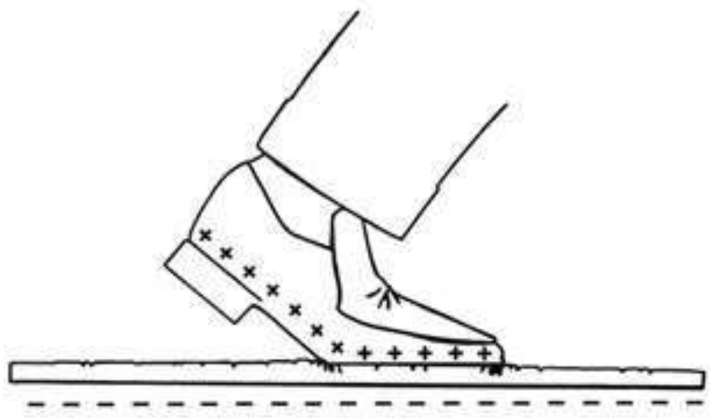
ESD

- Electrostatic discharge (**ESD**) is the sudden flow of electricity between two electrically charged objects caused by contact, an electrical short, or dielectric breakdown. A buildup of static electricity can be caused by tribocharging or by electrostatic induction.
- ESD (electrostatic discharge) is defined as the transfer of electric charge, which takes place when two objects which have been charged to different electric potentials are brought in contact with one another or when two objects which have different electric potentials due to static induction are brought in contact .

ESD Definition

ESD – Electrostatic Discharge: The transfer of an electrostatic charge between bodies at different electrical potentials.

- Also referred to as static electricity
- **Electrostatic charge is most commonly created by the contact and separation of two materials which results in Tribocharging**



Sources of ESD

The following items are examples of materials that generate and hold electrostatic charge.

- Vinyl binders
- Equipment covers
- Plastic document holders/sheet protectors
- Post-It™ notes
- Plastic pens
- Bubble wrap
- Plastic housings on equipment
- Paper, schematics, etc.
- Plastic work travelers
- Plastic spray bottles
- Personal items
  - –Purses
  - –Sweaters/jackets
  - –Insulated lunch totes
  - –Combs/brushes
  - –Lotion bottles

Common Causes of ESD

- Opening a common plastic bag
- Removing adhesive tape from a roll or container
- Walking across a floor and grabbing the door knob
- Transporting computer boards or components around in their trays on non- ESD carts
- Sliding circuit boards on a work bench

Why is ESD Important?

Electrostatic Discharge (ESD) can damage sensitive electronic devices, resulting in:

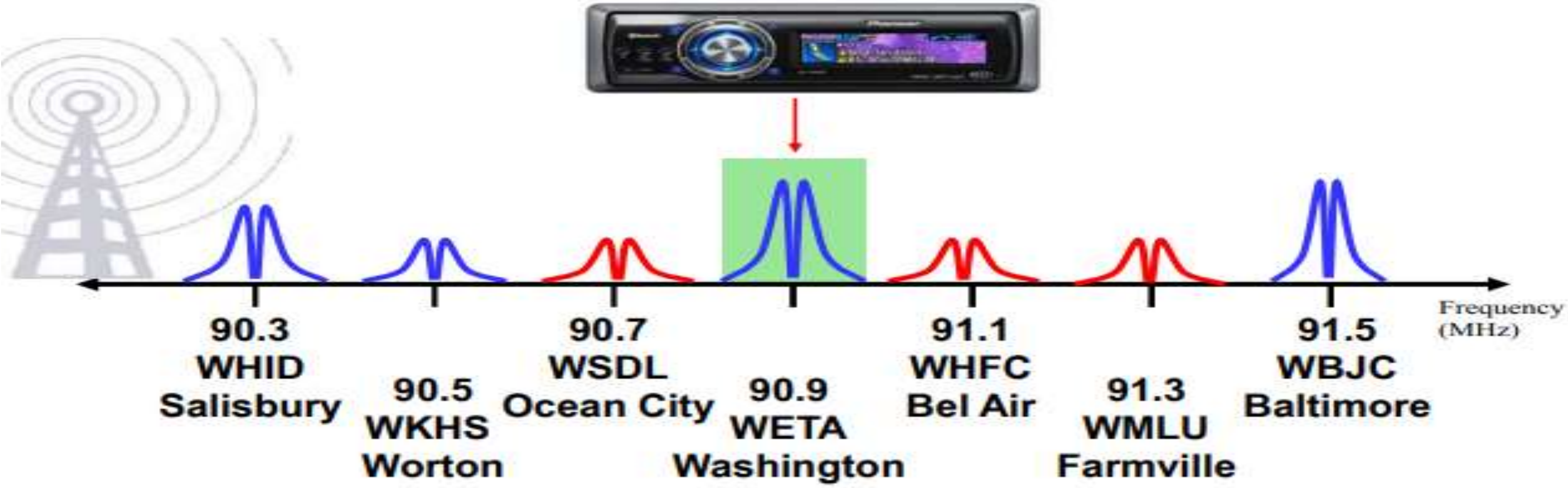
- Higher manufacturing costs
  - Rework
  - Repair
  - Scrap
- Lower production yields
- Unhappy customers
  - Shorter product life
  - Reduce product reliability

Estimates of actual cost of ESD damage to the electronics industry = $$$ Billions annually

UNIT - V

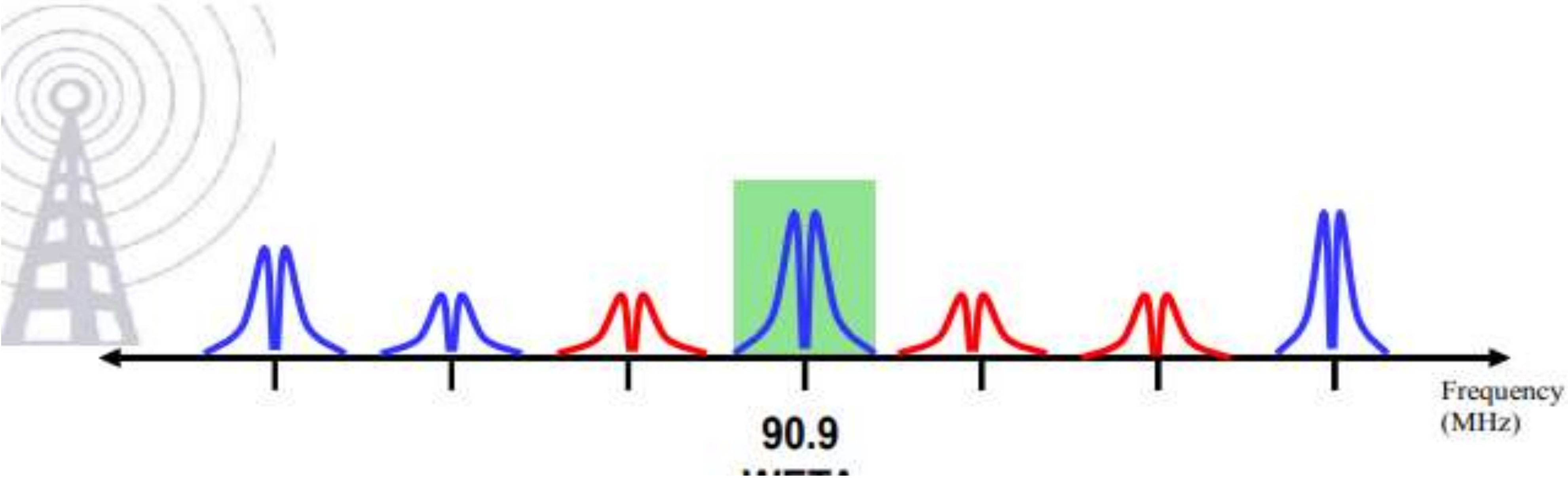
Tuning a Radio

- Consider tuning in an FM radio station.
- What allows your radio to isolate one station from all of the adjacent stations?



Filters

- A filter is a frequency-selective circuit.
- Filters are designed to pass some frequencies and reject others.



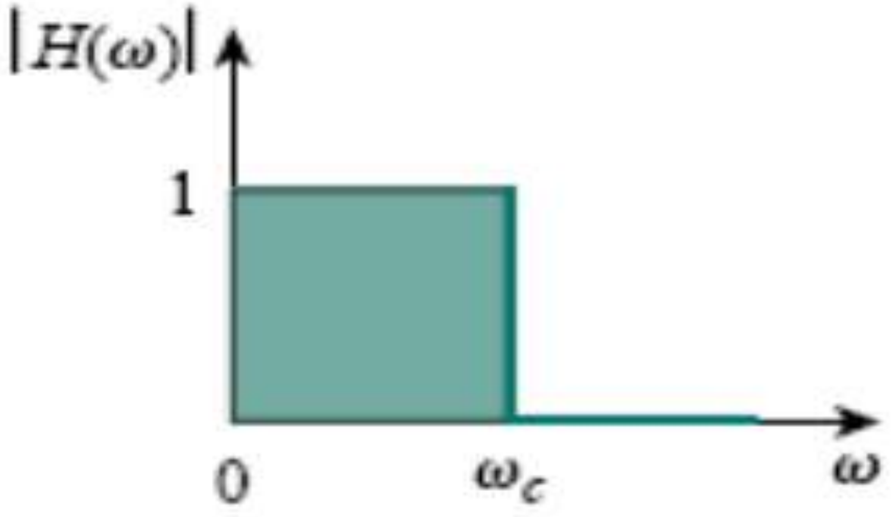
Active and Passive Filters

- Filter circuits depend on the fact that the impedance of capacitors and inductors is a function of frequency

- There are numerous ways to construct filters, but there are two broad categories of filters:
  - Passive filters are composed of only passive components (resistors, capacitors, inductors) and do not provide amplification.
  - Active filters typically employ RC networks and amplifiers (opamps) with feedback and offer a number of advantages.

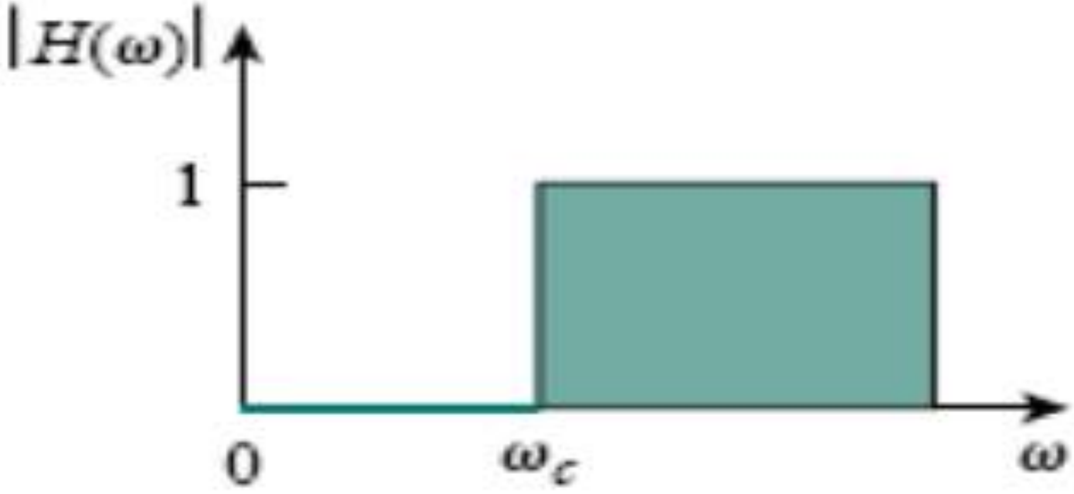
Passive Filters

- There are four basic kinds of filters:
  - **Low-pass filter** - Passes frequencies below a critical frequency, called the *cutoff frequency*, and attenuates those above.



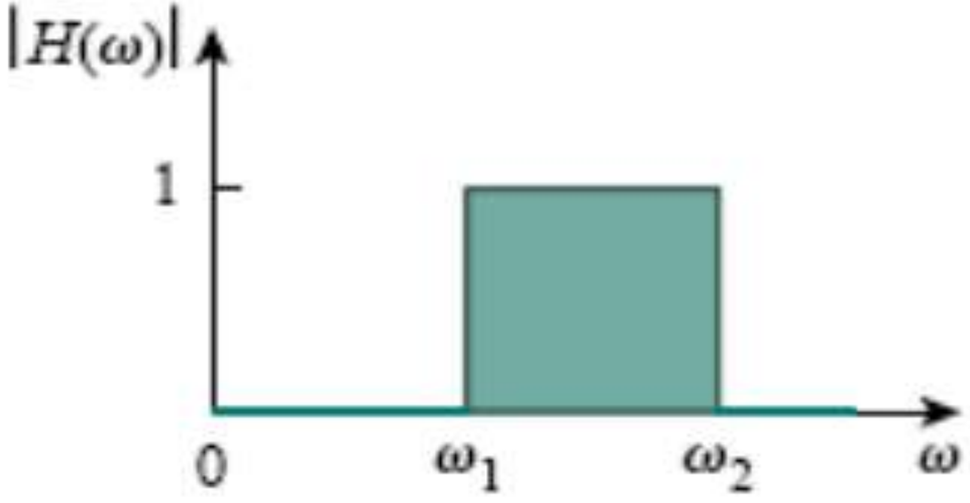
Passive Filters

- There are four basic kinds of filters:
  - **High-pass filter** - Passes frequencies above the critical frequency but rejects those below.



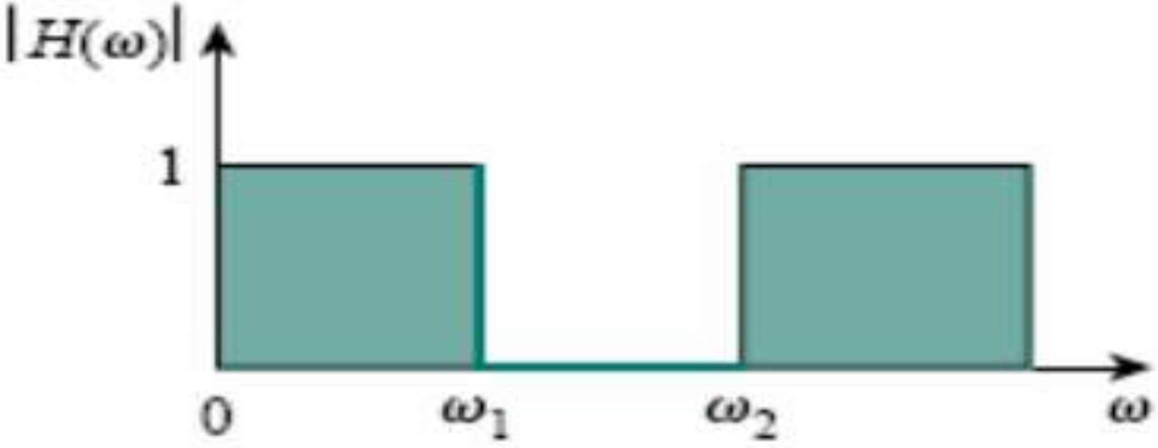
Passive Filters

- There are four basic kinds of filters:
  - **Bandpass filter** - Passes only frequencies in a narrow range between upper and lower cutoff frequencies.

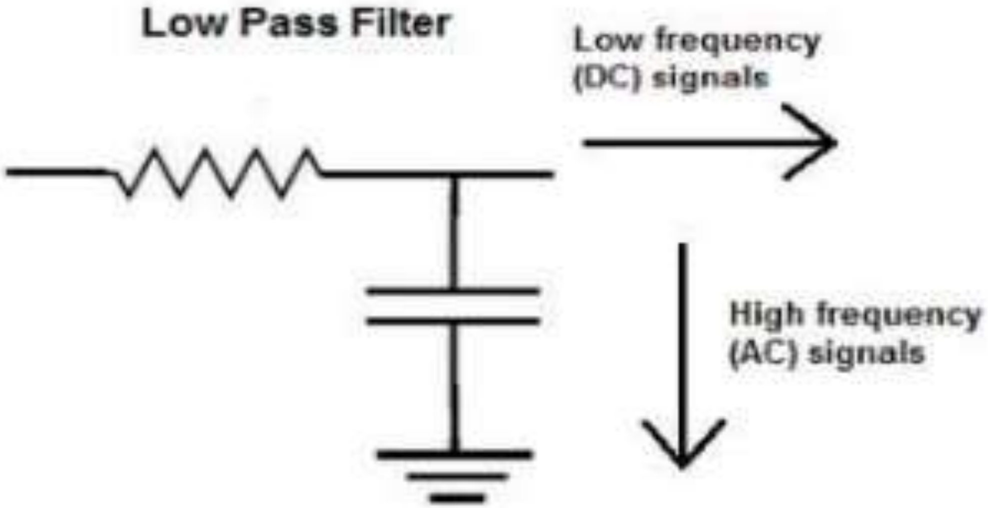


Passive Filters

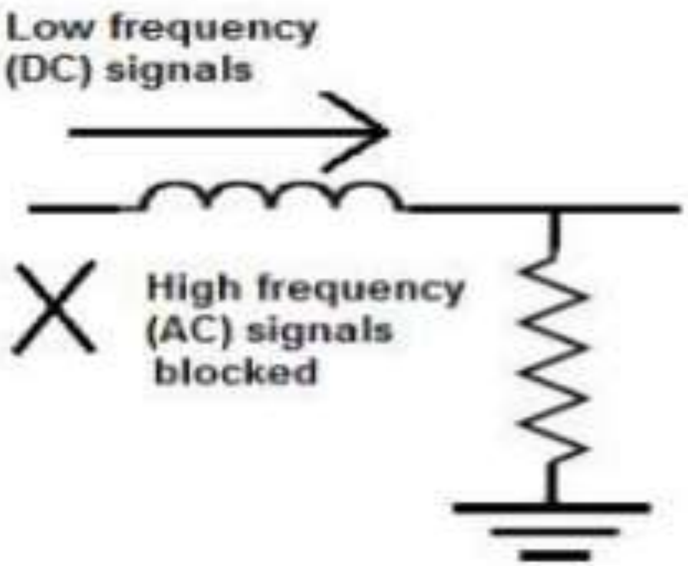
- There are four basic kinds of filters:
  - **Band-reject filter** - Rejects or stops frequencies in a narrow range but passes others.



Low Pass Filters



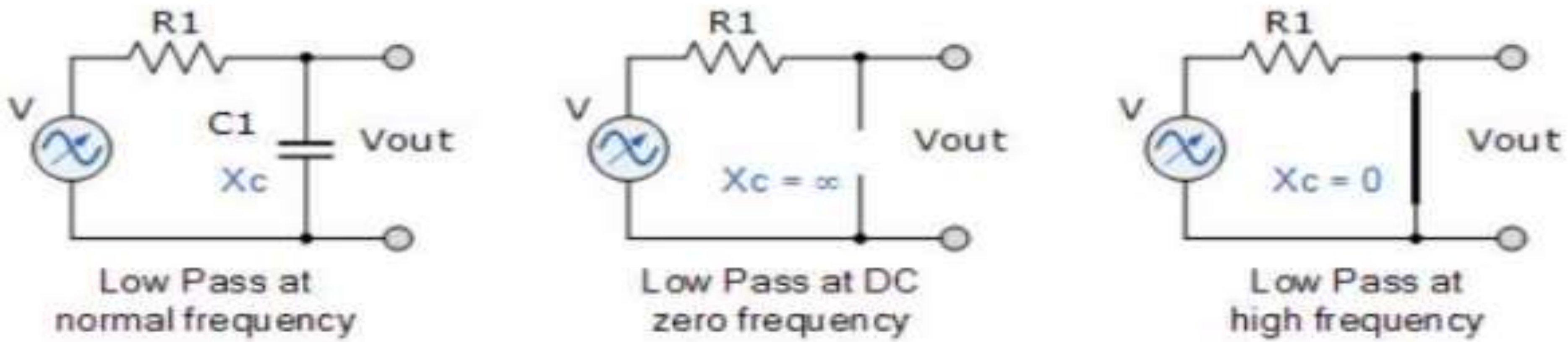
RC low-pass filter



RL low-pass filter

- RC low pass filter works based on the principle of *capacitive reactance*, while RL low pass filter works on the principle of *inductive reactance*

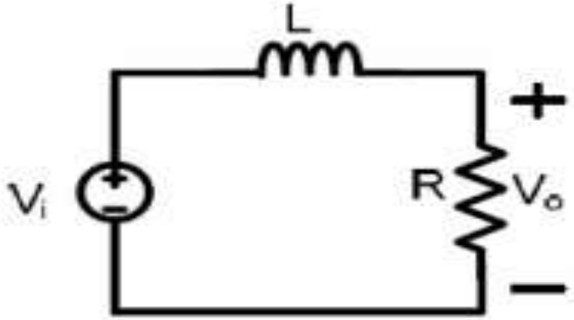
Capacitive Reactance



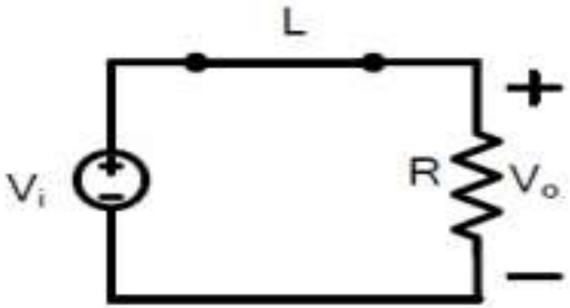
- *Capacitive Reactance (Xc)* varies with the applied frequency.
  - As the frequency applied to the capacitor increases, its effect is to decrease its reactance (measured in ohms).
  - Likewise as the frequency across the capacitor decreases its reactance value increases.

$$(Xc = {}^{1}/_{2\pi f c})\ \text{ohms}$$

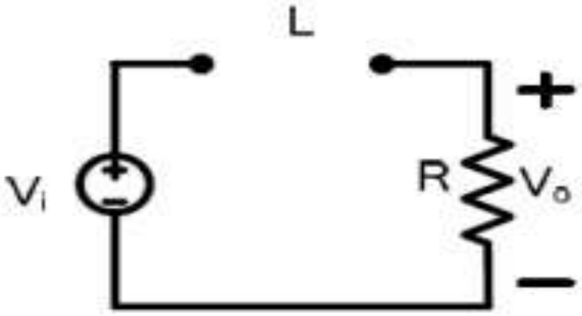
Inductive Reactance



RL low-pass filter



RL low-pass filter
at low frequencies
$\omega = 0$

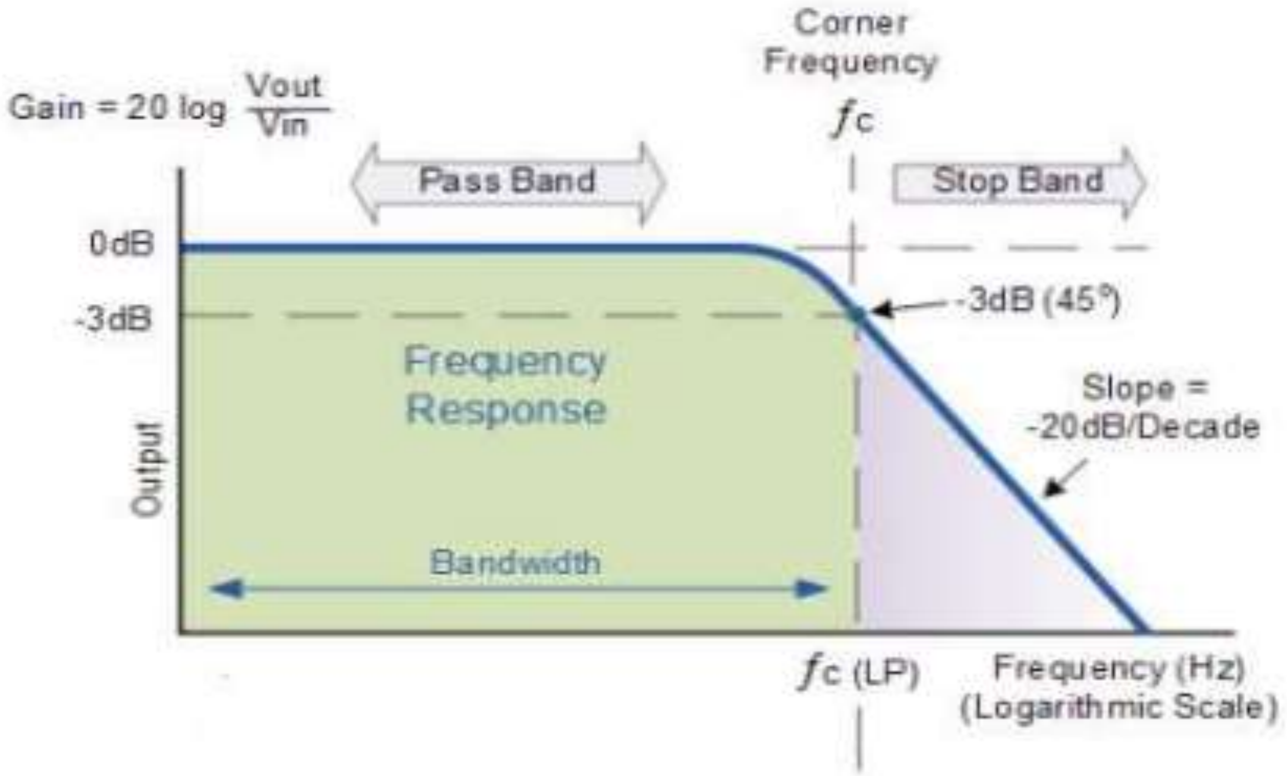


RL low-pass filter at
high frequencies
$\omega = \infty$

- *Inductive Reactance (X_L)* varies with the applied frequency.
  - To high frequency signals, inductors offer high resistance thus blocks high frequencies
  - As frequencies decrease, the inductor offers low resistance so low frequencies pass

$$X_L = 2\pi f L \text{ ohms}$$

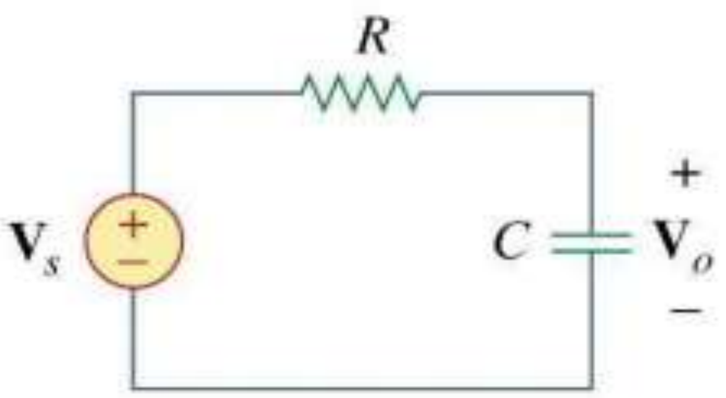
RC Low-Pass Filter – Frequency Response



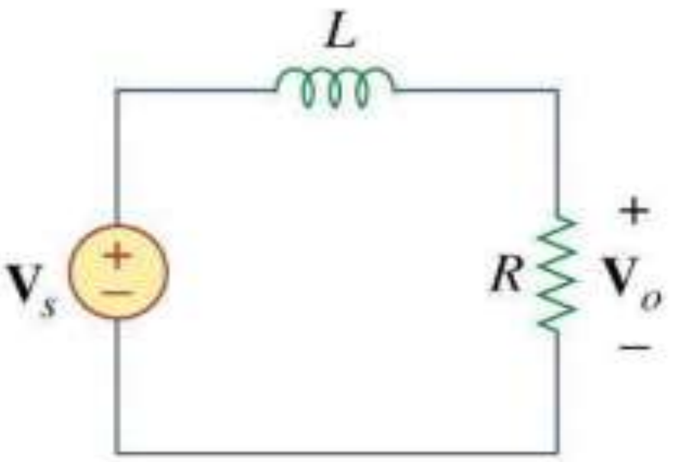
- The cutoff frequency is the frequency at which capacitive reactance and resistance are equal (R = Xc), therefore $f_c = {}^{1}/_{2\pi Rc}$
- At cutoff, the output voltage amplitude is 70.7% of the input value or –3 dB (20 log (Vout/Vin))

Filters

Notice the placement of the elements in RC and RL low-pass filters.



RC low-pass filter

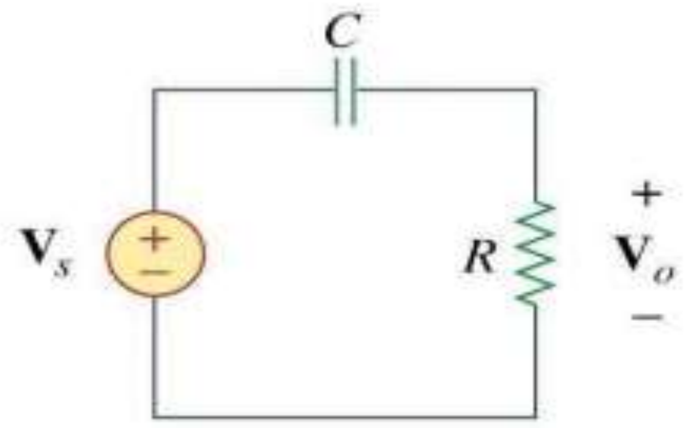


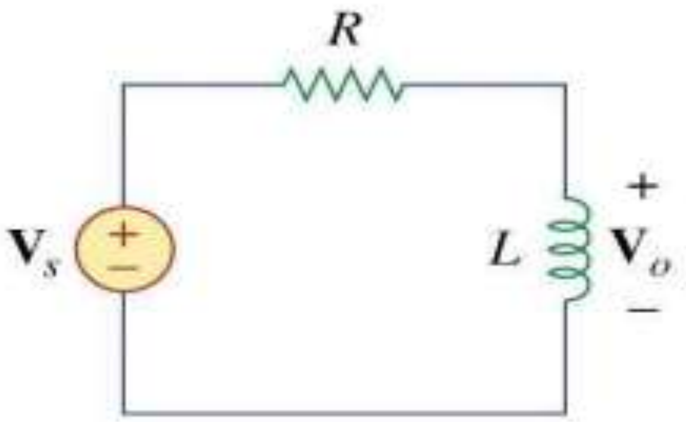
RL low-pass filter

What would result if the position of the elements were switched in each circuit?

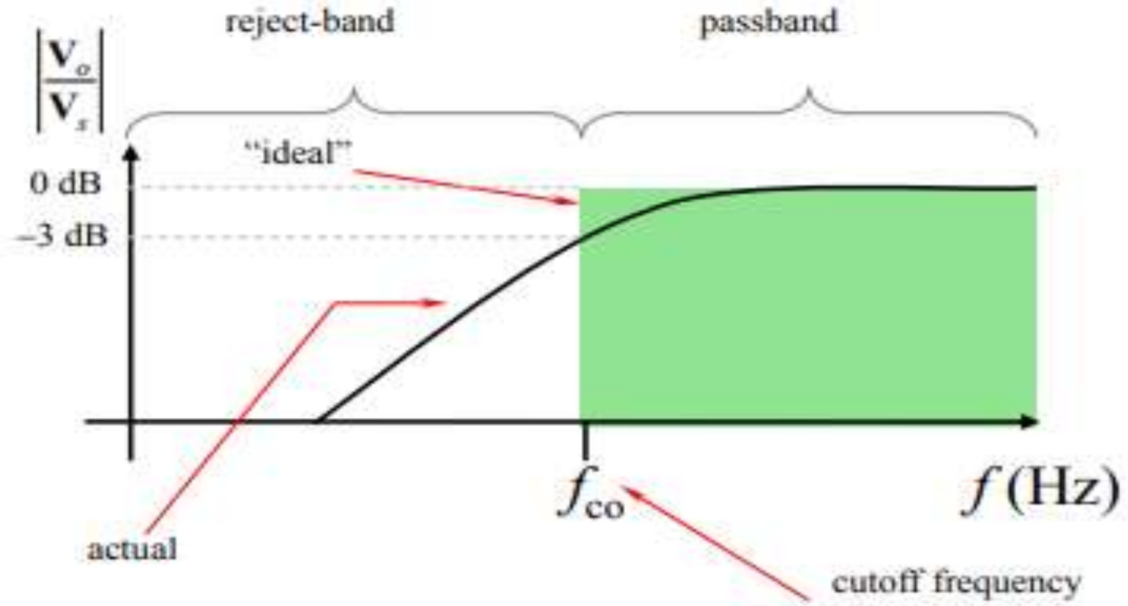
RC and RL High-Pass Filter Circuits

Switching elements results in a **High-Pass Filter**.





$$f_{co} = \frac{1}{2\pi RC} \quad \text{or} \quad f_{co} = \frac{R}{2\pi L} \quad \text{[Hz]}$$



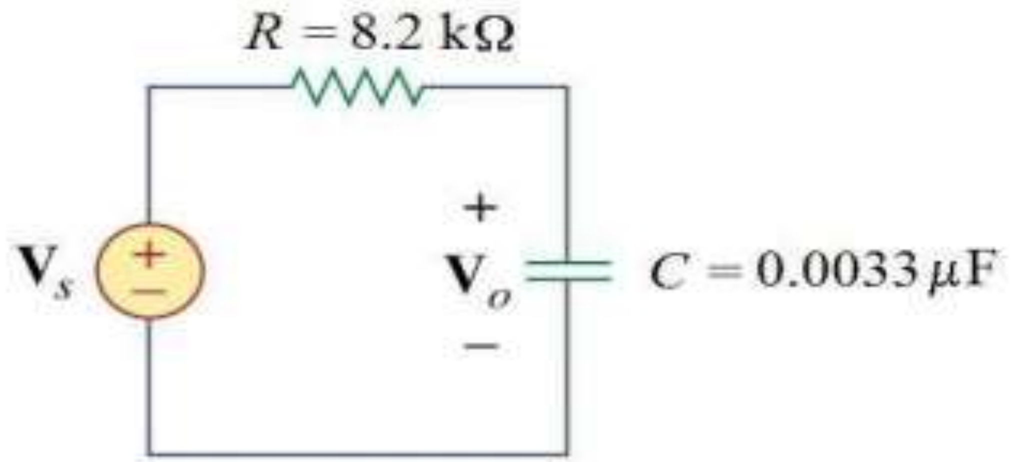
Example

What is the cutoff frequency for this filter?

<u>Given:</u>

$$R = 8.2k\Omega$$
$$C = 0.0033\mu F$$

$$\omega_{co} = \frac{1}{RC}$$



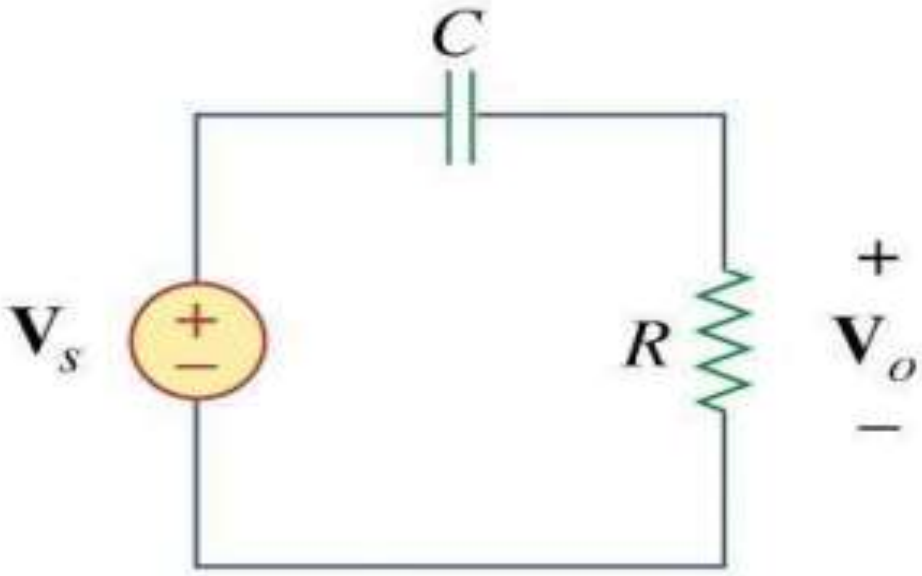
or $\boxed{f_{co} = \frac{1}{2\pi RC}}$ [Hz]

$$f_{co} = 5.88 \text{ kHz}$$

Example

What resistor value *R* will produce a cutoff frequency of 3.4 kHz with a 0.047 *m*F capacitor? Is this a high-pass or low-pass filter?

This is a High-Pass Filter



$$f_{co} = \frac{1}{2\pi RC} \quad [\mathrm{Hz}]$$

$$\Rightarrow \mathrm{R} = \frac{1}{2\pi C f_{co}}$$

$$R = 1004\,\Omega$$

Quick Quiz (Poll 1)

- What is a filter?

a) Frequency selective circuit
b) Amplitude selective circuit
c) Frequency damping circuit
d) Amplitude damping circuit

Quick Quiz (Poll 2)

- What are filters created by using resistors and capacitors or inductors and capacitors called?

  a) Active filters
  b) Passive filters
  c) Continuous filters
  d) Differential filters