AL-MUSTAQBAL UNIVERSITY COLLEGE

Department of Biomedical Engineering

Faculty of Engineering

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BME 322
Signals and Systems for BME

- 5 -
Filtres

Babylon - Iraq - May 2021

FILTERS

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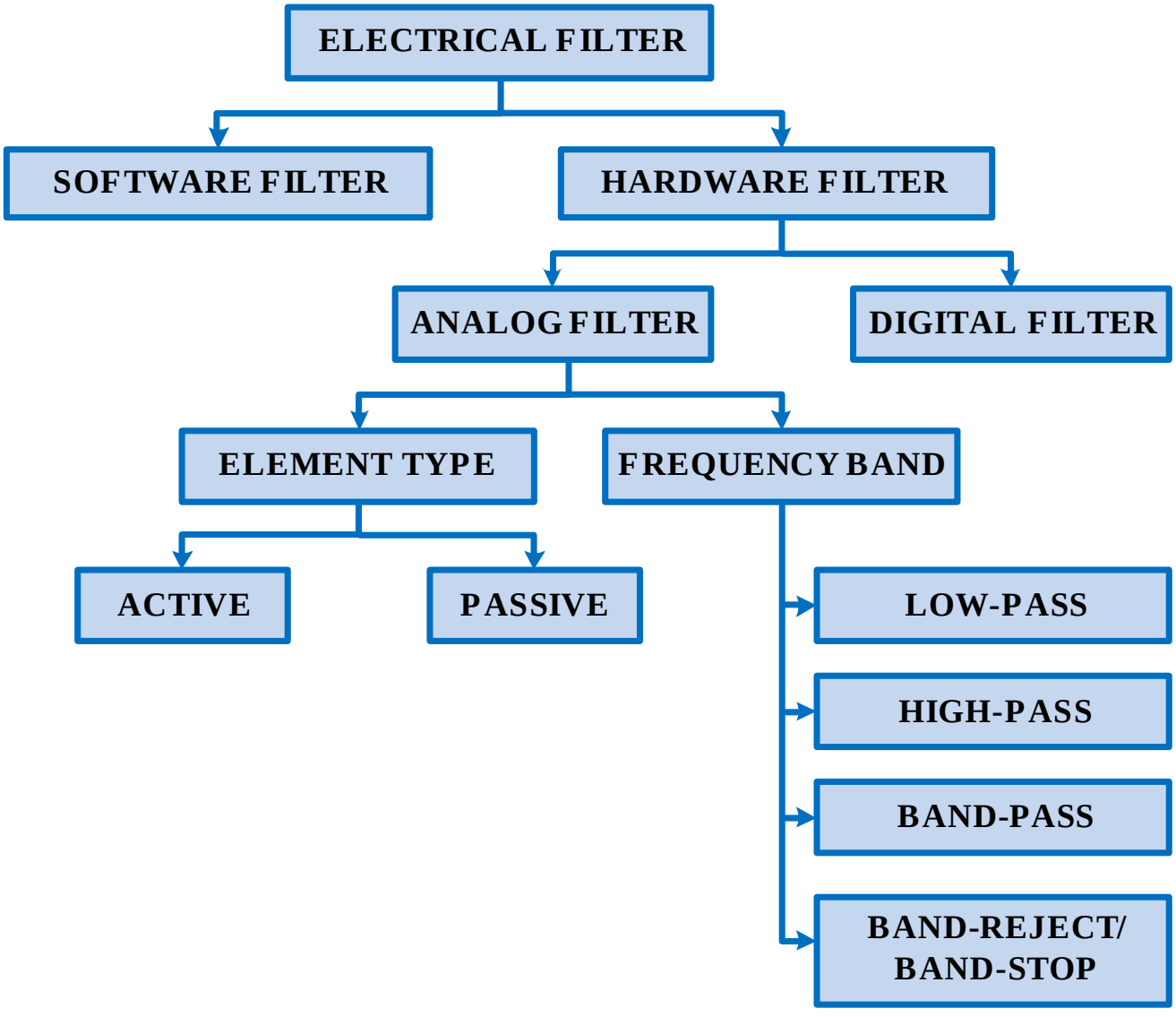
FILTERS

- A filter is a circuit that is designed to pass signals with desired frequencies and reject or attenuate others.

Classification of Filters



Types of filters

- Low pass filter: passes low frequencies and stops high frequencies.

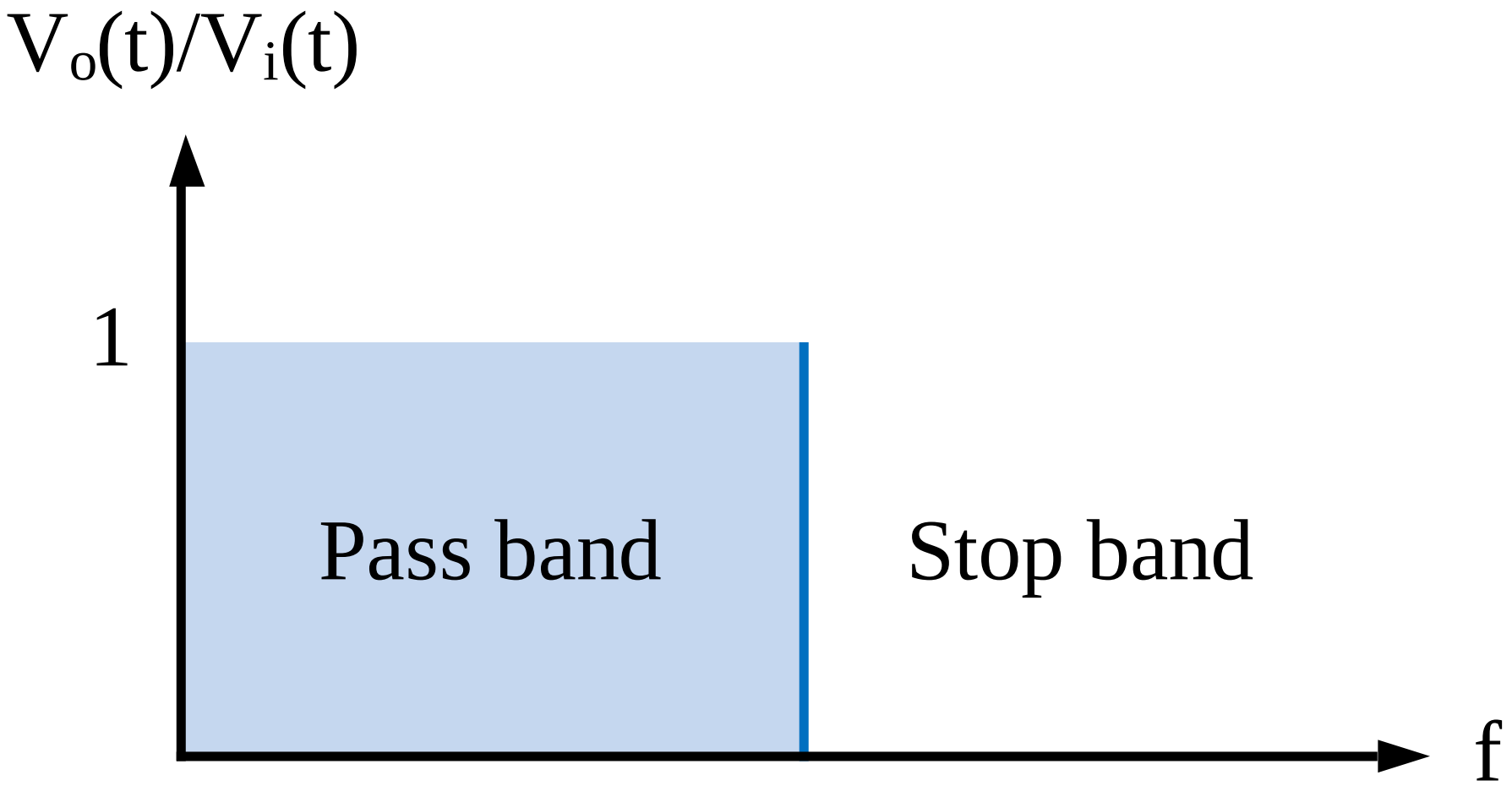
- High pass filter: passes high frequencies and rejects low frequencies.

Types of filters

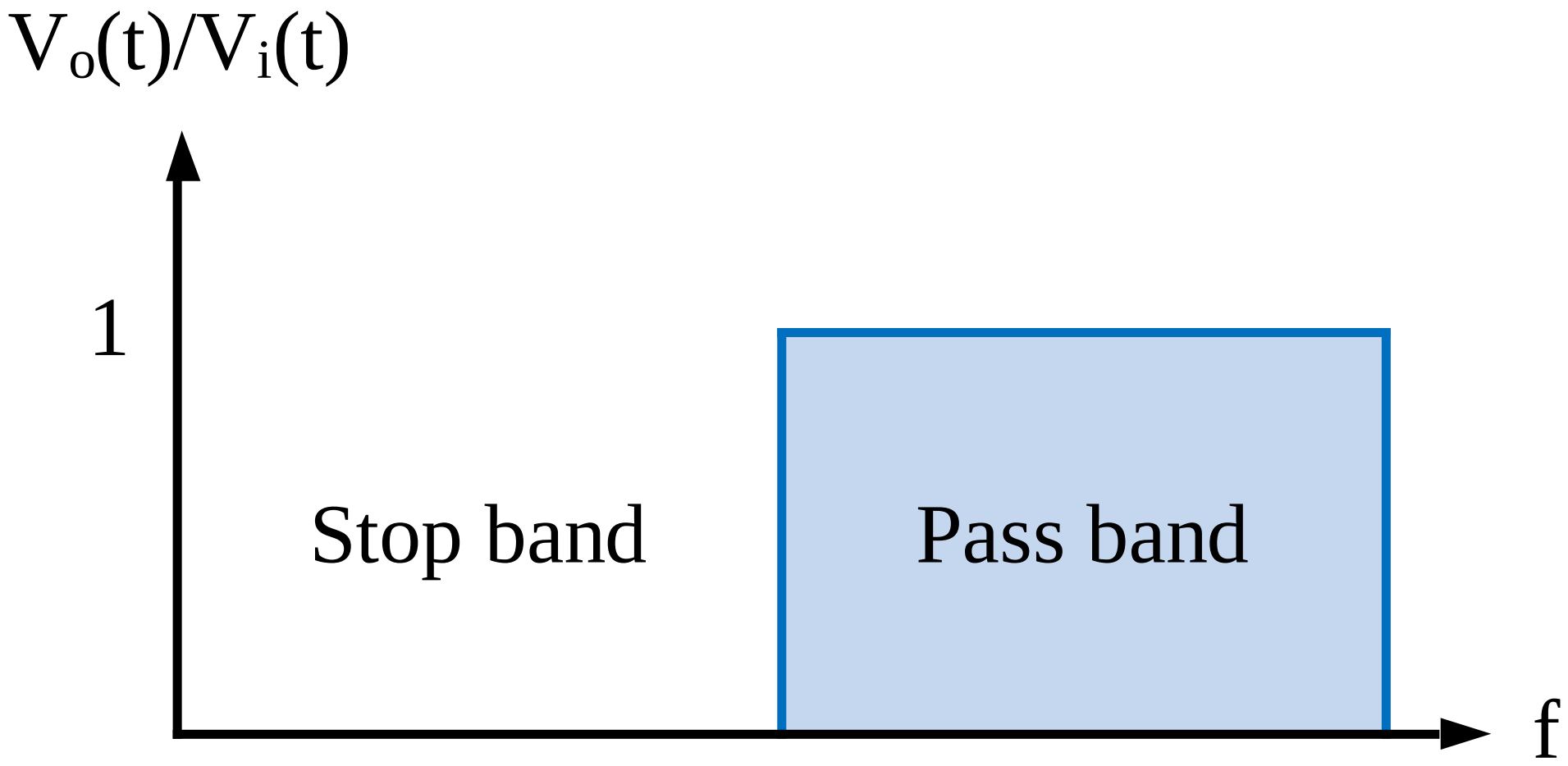
- Band pass filter: passes frequencies within a frequency band and blocks or attenuates frequencies outside the band.

- Band stop filter: passes frequencies outside a frequency band and blocks or attenuates frequencies within the band.

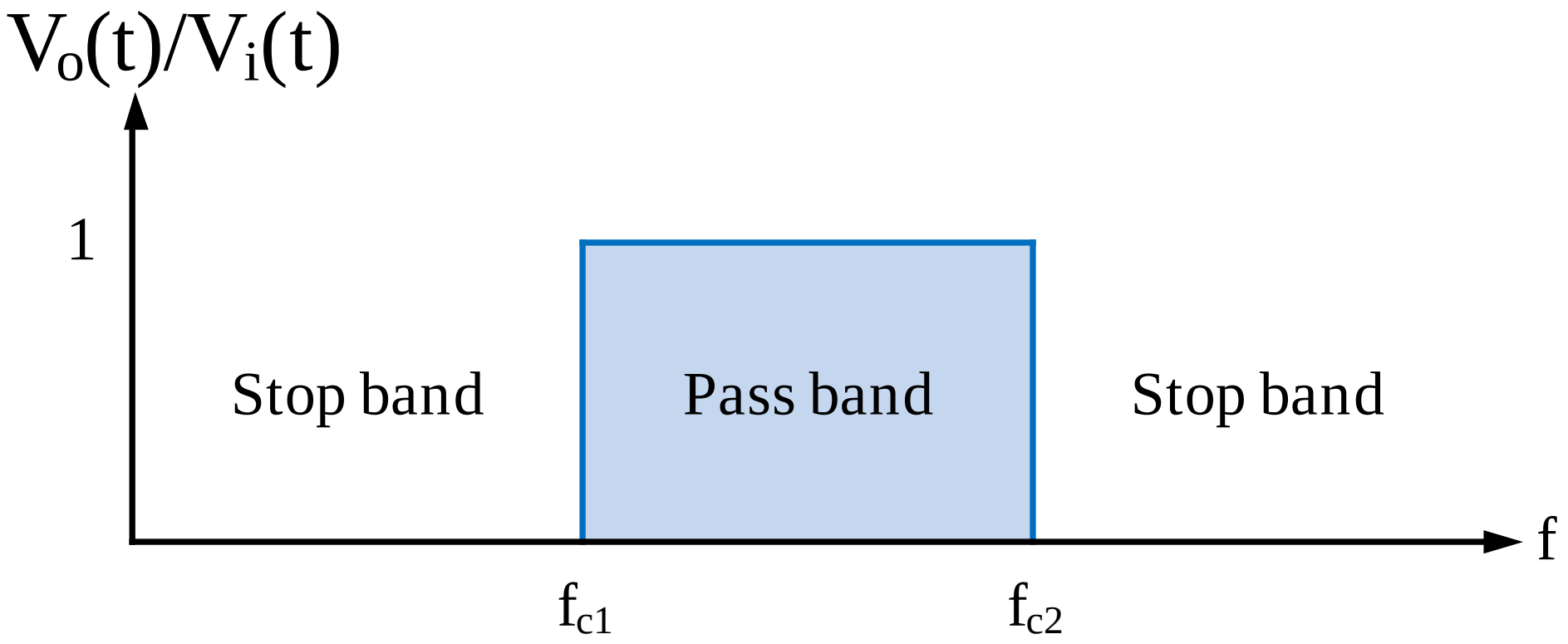
Ideal Low Pass Filter



Ideal High Pass Filter

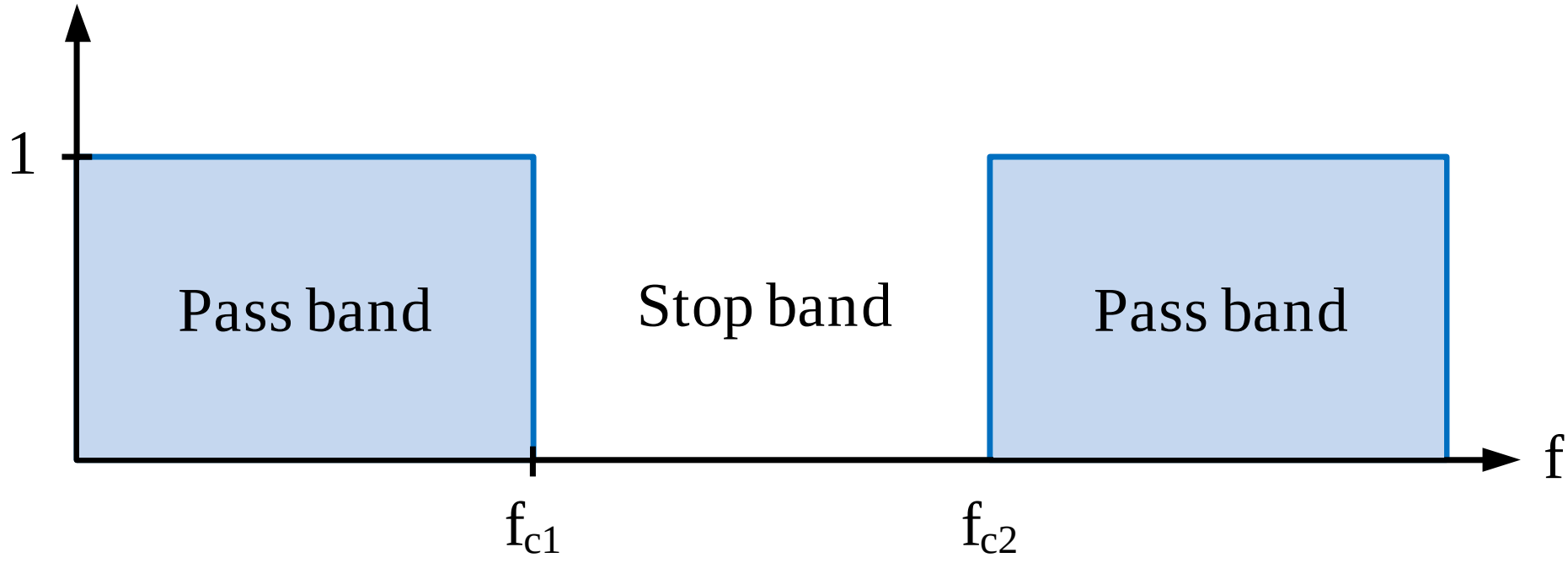


Ideal Band Pass Filter

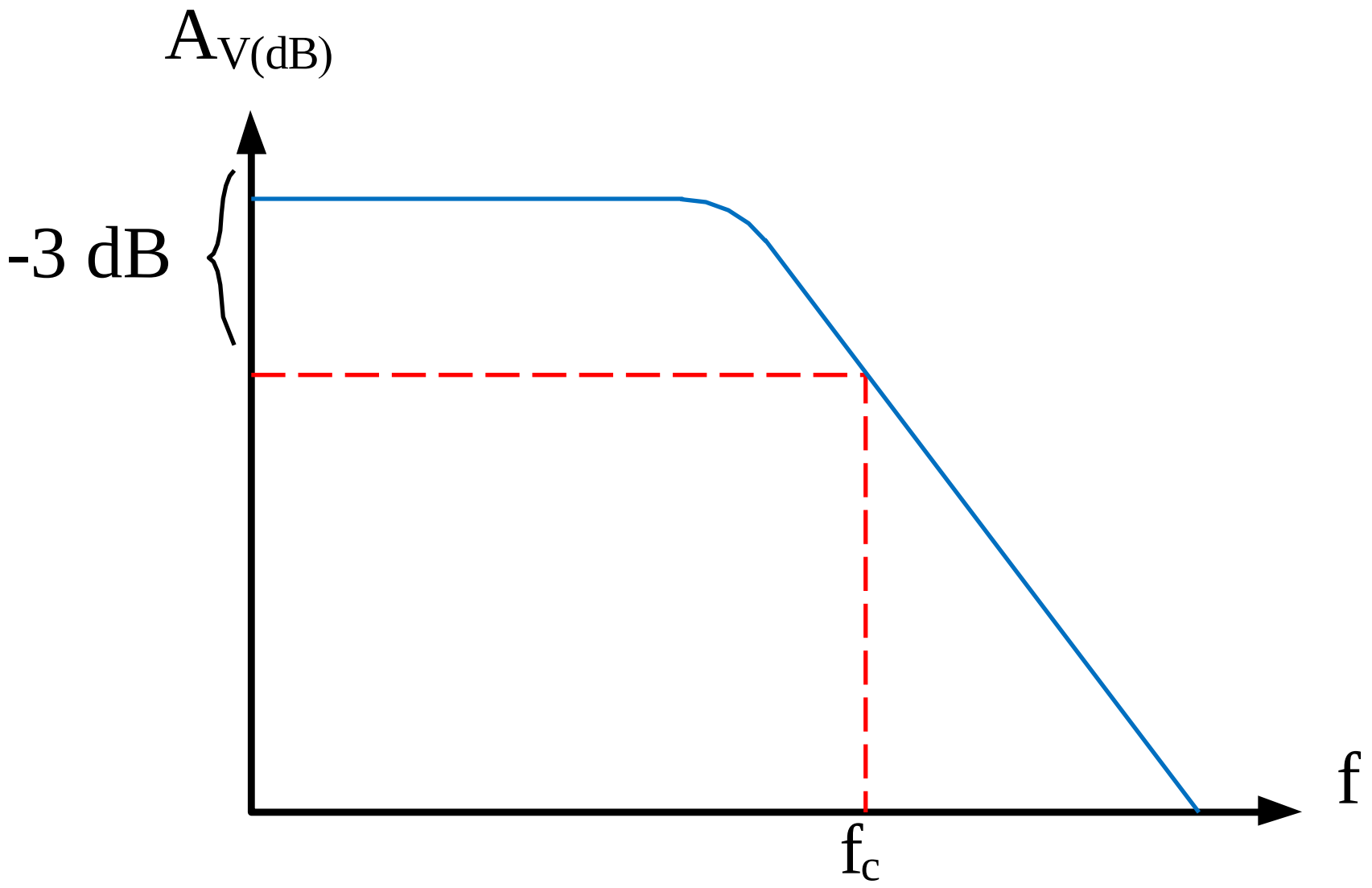


Ideal Band Stop Filter

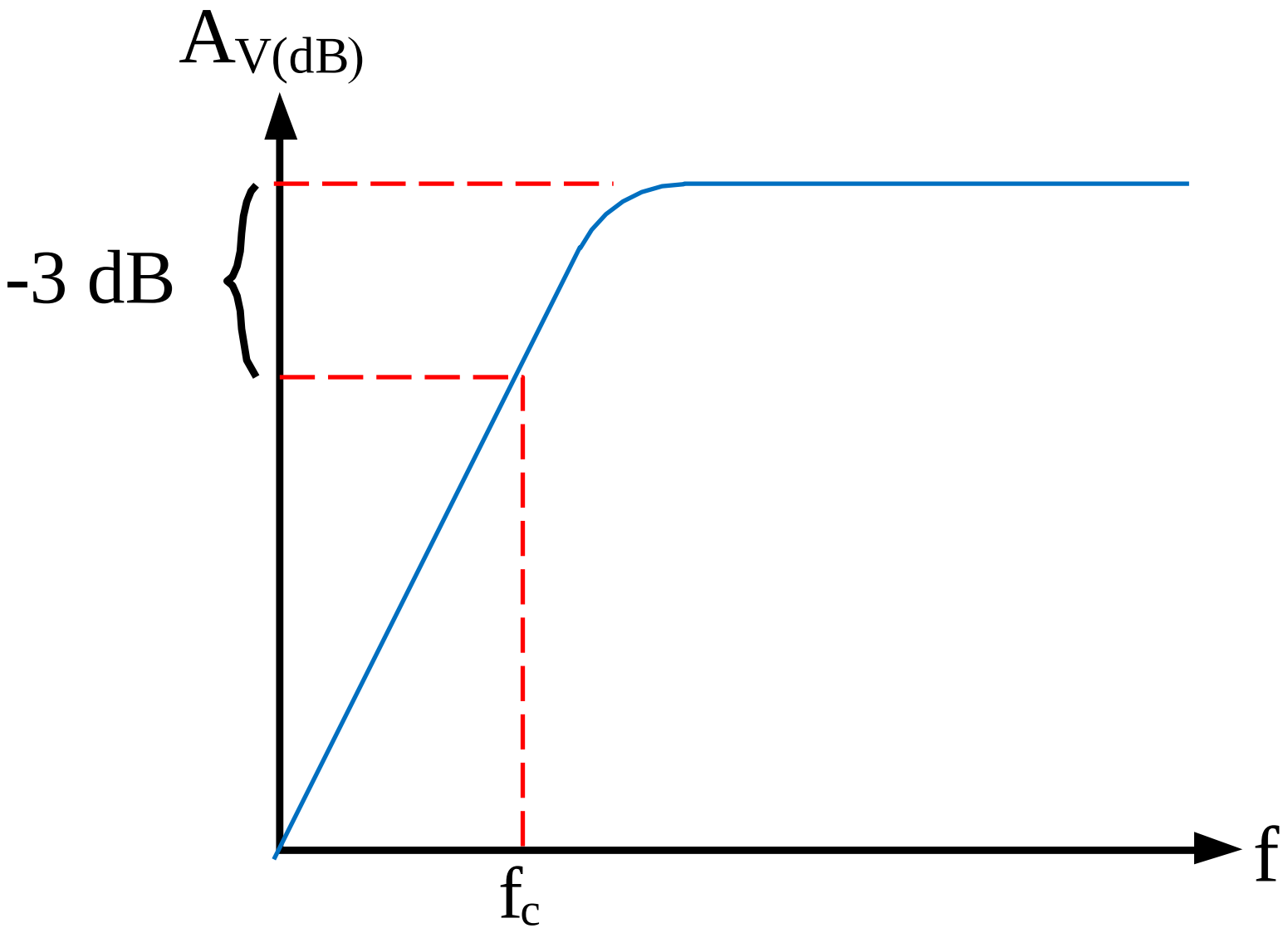
$V_o(t)/V_i(t)$



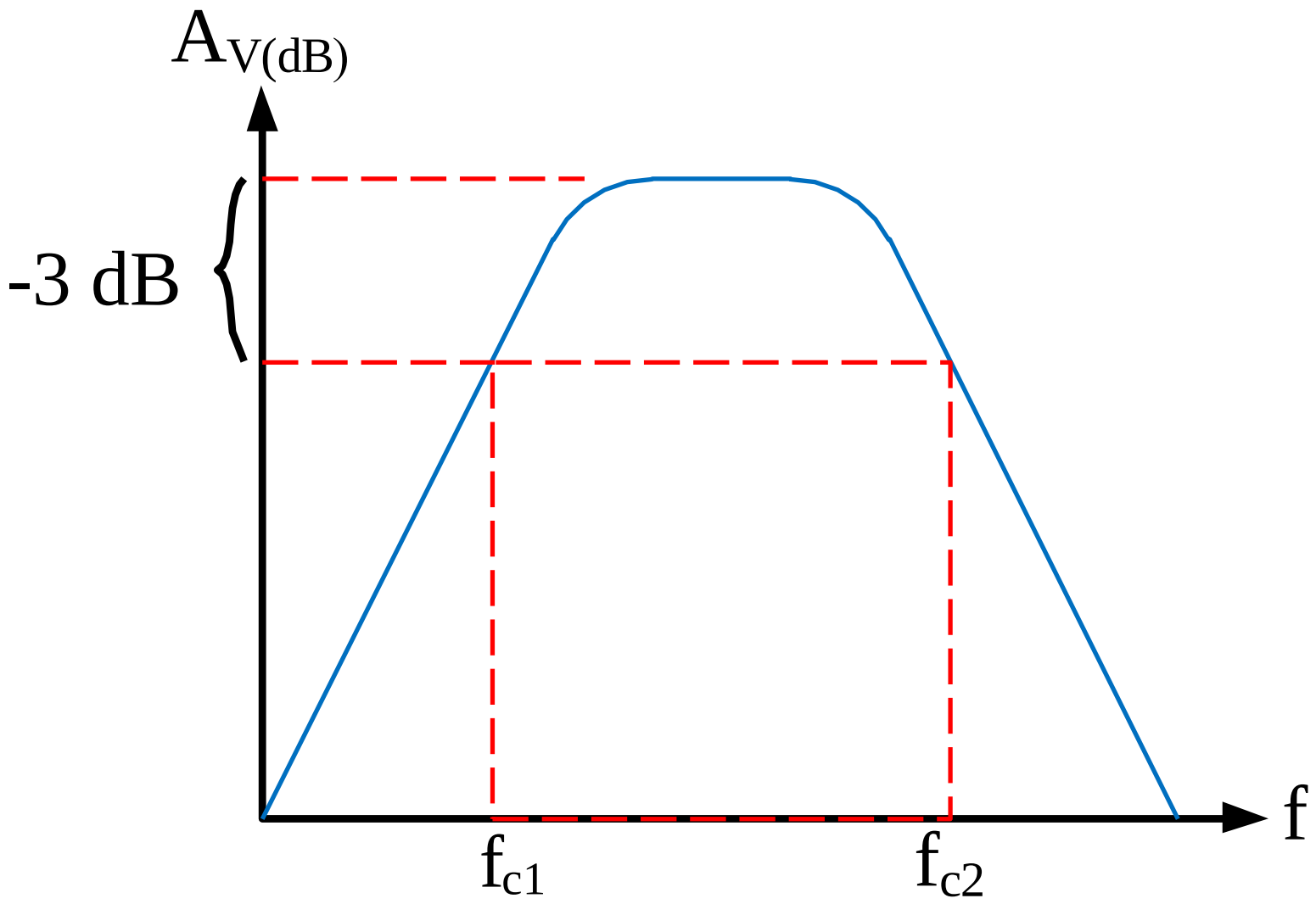
Practical Low Pass Filter



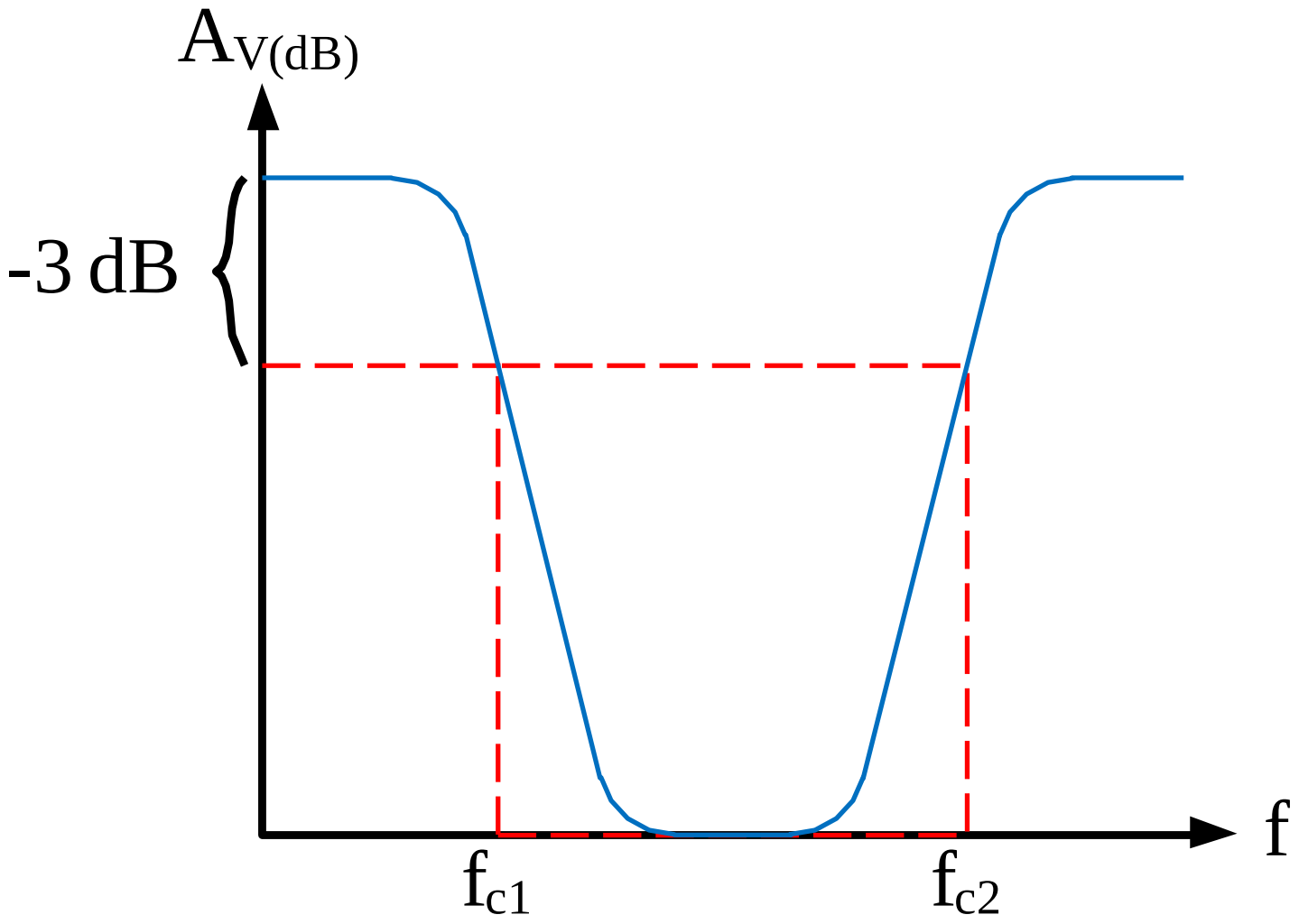
Practical High Pass Filter



Practical Band Pass Filter



Practical Band Stop Filter



Analog Filters

- Analog filters process continuous-time signals.
- Analog filters are circuits built from components like resistors, capacitors, and inductors.
- Their operation is quite sensitive to the change in the value of the components used.
- Redesigning analog filters requires completely rebuilding the circuits.
- Higher order analog filters require more components which deal with higher component tolerance.

Digital Filters

- Digital filters process discrete-time signals
- The behaviour of digital filters are defined by a list of numerical coefficients and not by the hardware.
- Digital filters can be redesigned by redefining the coefficients.

Recursive Digital Filters

- Recursive digital filters are filters which rely on both inputs and past outputs.
- Difference equation for recursive digital filters:

$$y[n] = -\sum_{k=1}^{N} a_k y[n-k] + \sum_{k=0}^{M} b_k x[n-k]$$

a_k and b_k are the filter coefficients

Example 1

A digital filter has the difference equation:

$$y[n] = 0.5\, y[n-1] + x[n]$$

(a) Determine type of filter (recursive or Nonrecursive).

(b) Determine the filter coefficients.

Example 1 (solution)

(a) Since the output, $y[n]$ depends on both the inputs, x[n] and past output $y[n-1]$, the digital filter is recursive.

(b) Rewrite the difference equation:

$$y[n] - 0.5y[n-1] = x[n]$$

$$a_0 = 1.0, a_1 = -0.5; \quad b_0 = 1.0$$

Nonrecursive Digital Filters

- Nonrecursive digital filters are filters which rely only on inputs and not on past outputs
- Difference equation for nonrecursive digital filters:

$$y[n] = \sum_{k=0}^{M} b_k x[n-k]$$

b_k are the filter coefficients

Example 2

A digital filter has the difference equation:

$$y[n] = 0.5\,x[n] - 0.3x[n-1]$$

(a) Determine type of filter (recursive or Nonrecursive)

(b) Determine the filter coefficients.

Example 2 (solution)

(a) Since the output, y[n] does not depend on the past output, y[n−k], the digital filter is nonrecursive.

(b) The filter coefficients:

$$a_0 = 1.0; \quad b_0 = 0.5, \; b_1 = -0.3$$