

# Assignment : Passive Filter Design

**Deadline: 26/09/2025 @11.59pm**

## Background

Headphones and speaker systems both rely on crossover networks to divide the audio spectrum into different frequency ranges that can be handled by dedicated drivers (woofer, midrange, tweeter). These filters ensure that each driver only processes the frequencies it is designed for, thereby improving sound quality and reducing distortion.

The figure below shows the datasheet frequency response of a 3-way crossover filter network. The response illustrates how the woofer (W), tweeter (T), and midrange (M) drivers share the frequency spectrum. The roll-off slopes are provided in dB/octave, and cutoff points are indicated at the  $-3$  dB marks.

Your task is to analyze this datasheet, extract the necessary parameters, and redesign the crossover filters for improved performance using LTspice.

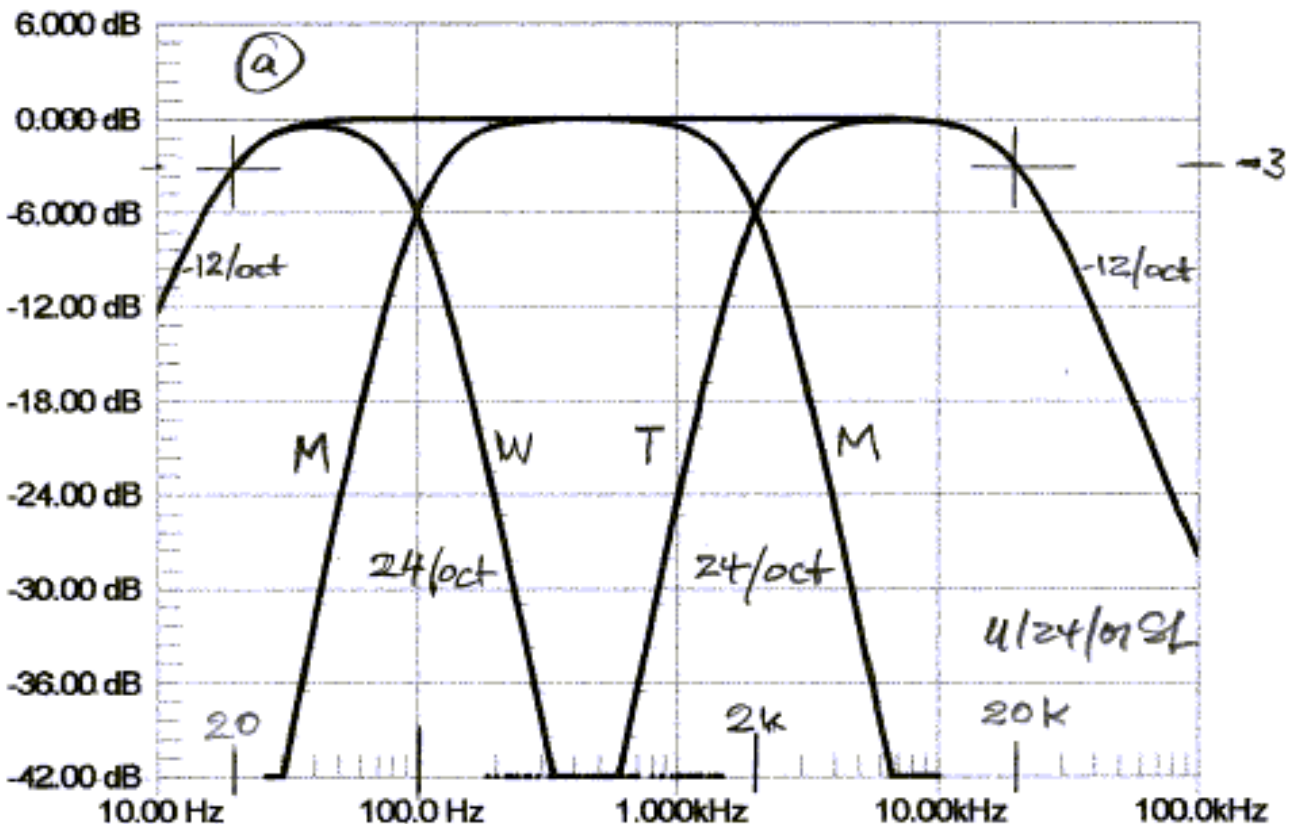


Figure: Frequency response of a 3-way crossover network showing woofer (W), tweeter (T), and midrange (M) filter sections with cutoff points and roll-off slopes.

## Questions

Q1. From the datasheet plot, determine the order of each filter by analyzing the roll-off slopes:

- Woofer low-pass section,
- Tweeter high-pass section,
- Midrange band-pass section.

Q2. Estimate the cutoff frequencies ( $-3$  dB points) for the woofer, tweeter, and midrange sections from the datasheet response.

Q3. Redesign the system using Butterworth filters (low-pass, high-pass, and band-pass) with the following specifications:

- Passband tolerance: 3 dB,
- Attenuation: 90 dB at  $5 \times$  cutoff frequency.
  - (a) Write the transfer functions of the redesigned filters (no need to simplify).
  - (b) Use LTspice to simulate and plot the Bode responses.
  - (c) Compare the LTspice responses with the datasheet plot and calculate the reduction in transition regions (in Hz).*Assume source resistance = load resistance =  $50\ \Omega$ .*

Q4. For the woofer section only, design a Chebyshev Type I filter with:

- Passband ripple: 0.5 dB,
- Attenuation: 90 dB at  $5 \times$  cutoff frequency.
  - (a) Write the transfer function.
  - (b) Simulate and plot the frequency response in LTspice.
  - (c) Compare the Chebyshev and Butterworth woofer responses.

Q5. Based on your results, recommend which filter type (Butterworth or Chebyshev) is more suitable for this application. Provide a clear justification.

## Submission Instructions

Your submission must include:

1. Step-by-step solutions to all questions.
2. LTspice schematics for each filter (with all component values labeled).
3. Bode plots for each filter (axes clearly marked).

**Note:** Copying is strictly prohibited. Identical submissions will result in reduced marks for all involved.

**Additional Note for Students:** In the provided datasheet frequency response, the woofer (LP) and tweeter (HP) responses show an initial  $-12$  dB/oct slope before reaching their passbands. For simplicity in this assignment, you may ignore this effect and assume the passbands are flat.