Project 2

5-Band Audio Equalizer

Team size: 2 students

Difficulty: ★★★★ (Challenging)

Core concepts: Active filters, frequency response, op-amp gain stages, Bode plots, superposition, filter tuning, capacitor tolerance.

Goal: design and build a **5-band active equalizer** using op-amp bandpass or multiple-feedback filters, capable of boosting or attenuating specific audio frequency bands (e.g., 100 Hz, 300 Hz, 1 kHz, 3.3 kHz, 10 kHz). The input is an audio signal (e.g., from a phone or function generator), and the output should drive a small speaker or audio amplifier.

Core features (must have)

- Five independent active filter stages, each centered at a specific frequency band.
- Adjustable gain (±10 dB typical) via potentiometer in each band.
- Buffering stage before and after filters.
- Optional summing amplifier to recombine the bands.
- Bypass switch for full flat response test.

Why diodes?

- **Clipping/limiting protection:** prevent overdrive by adding diodes at op-amp output.
- **Indicator rectifier:** optional LED peak meter using diode rectifier + RC filter.
- **Clamping:** protect input stage from high voltage audio signals.

Suggested circuit blocks & analysis tasks

1. **Input buffer / preamp**
    - Unity gain buffer or low-gain amplifier to drive the equalizer stages.
    - Analysis: input impedance, loading effects, bandwidth.
2. **Filter design**
    - Use multiple-feedback or Sallen–Key topology for each band.
    - Derive f_0, Q,and gain.
    - Verify via Bode plots (simulation + experimental).
3. **Summing stage**
    - Recombine filtered signals using op-amp adder.
    - Compute output impedance and effect of gain mismatch.
4. **Clipping/limiting**
    - Add diode limiter to prevent output saturation; analyze conduction threshold.

5. **Power and stability**
    - Use dual supply ±12V or single-supply bias network; verify DC biasing and coupling capacitors.

Testing & measurement tasks

- Plot magnitude response for each band (Bode plots).
- Measure gain/attenuation range and center frequency.
- Observe waveform distortion before/after clipping protection.
- Listen to equalized vs. flat sound (qualitative test).

Parts list

- 5× dual op-amps, resistors, capacitors (1% tolerance for accurate center frequencies), potentiometers, diodes, audio jack, speaker or small amplifier, ±12 V or single 9–15 V supply.

Milestones

1. **Week 1:** Filter design calculations and simulation.
2. **Week 2:** Build one band; measure frequency response.
3. **Week 3:** Build and test all bands; integrate summing stage.
4. **Week 4:** Final measurements and audio demo.

Assessment

- Theoretical design (25)
- Frequency response measurement & accuracy (25)
- Circuit implementation & clarity (25)
- Demo performance & sound quality (15)
- Report/presentation (10)