

Five Band Audio Equalizer

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Presentation Structure

- ➊ Introduction
- ➋ Filter Design
- ➌ Other Circuits
- ➍ PCB Design

Component Selection Justification

① NE5532 Operational Amplifier

- **Low Noise:** $5 \text{ nV}/\sqrt{\text{Hz}}$ suitable for high-fidelity audio
- **Bipolar Input:** Ensures low offset and distortion in precision audio
- **Dual Channel:** Two op-amps per IC for compact design
- **High Slew Rate:** $9 \text{ V}/\mu\text{s}$ supports wide dynamic range
- **Wide Bandwidth:** 10 MHz gain-bandwidth product for audio applications
- **Wide Supply:** $\pm 3 \text{ V}$ to $\pm 20 \text{ V}$ operation for design flexibility
- **High Drive Capability:** Can directly drive 600Ω loads

② LM3915 Dot/Bar Display Driver

- Logarithmic 3 dB/step response for audio
- Direct LED drive without current-limiting resistors
- Simple setup with minimal external components
- Over-voltage protection ($\pm 35 \text{ V}$) on input

Component Selection Justification (Cont.)

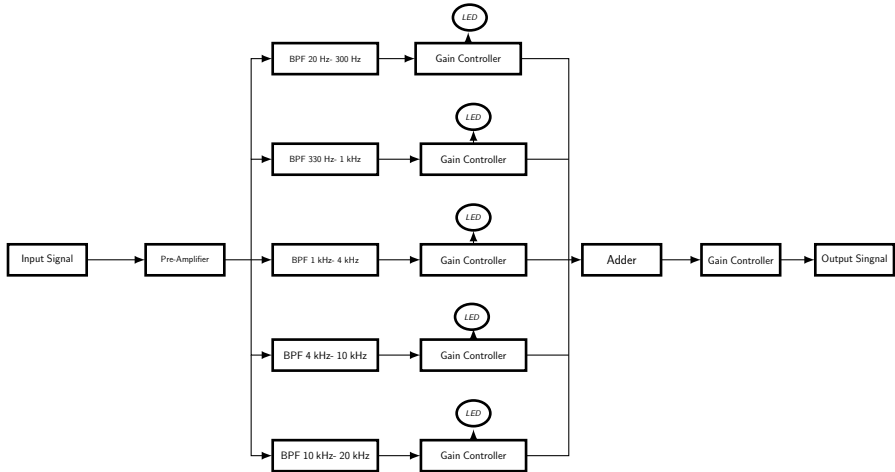


Figure: NE5532 Operational Amplifier



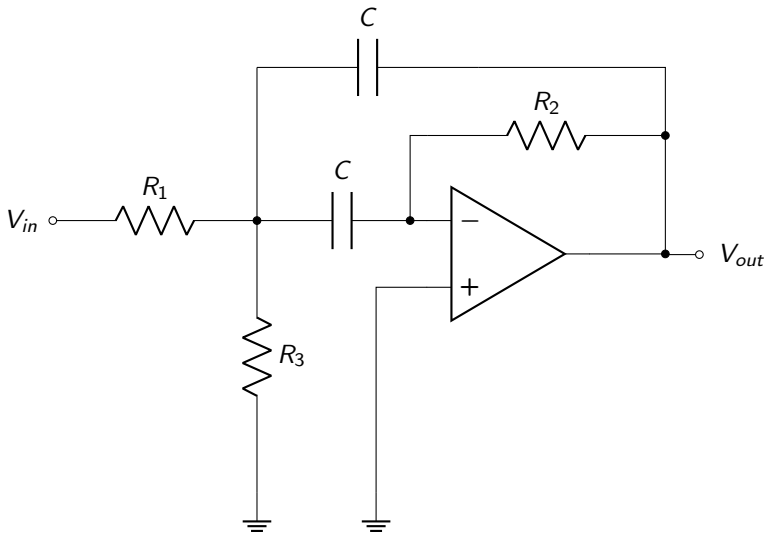
Figure: LM3915 Dot/Bar Display Driver

System Architecture



Filter Design

MFB Band-Pass Filter



MFB Band-Pass Filter (Cont.)

- mid-frequency: $f_m = \frac{1}{2\pi C} \sqrt{\frac{R_1 + R_3}{R_1 R_2 R_3}}$
- gain at f_m : $-A_m = \frac{R_2}{2R_1}$
- filter quality: $Q = \pi f_m R_2 C$
- bandwidth: $B = \frac{1}{\pi R_2 C}$

The MFB band-pass allows to adjust Q , A_m , and f_m independently. Bandwidth and gain factor do not depend on R_3 . Therefore, R_3 can be used to modify the mid frequency without affecting bandwidth, B , or gain, A_m . Furthermore,

$$R_1 = \frac{R_2}{-2A_m}, R_2 = \frac{Q}{\pi f_m C}, R_3 = \frac{-A_m R_1}{2Q^2 + A_m}$$

Fourth-Order Band-Pass Filter (Staggered Tuning)

In order to make Fourth-Order Band-Pass filter, we cascaded two MFB Band-Pass filters.

The mid frequency of filter 1 is:

$$f_{m1} = \frac{f_m}{\alpha}$$

the mid frequency of filter 2 is:

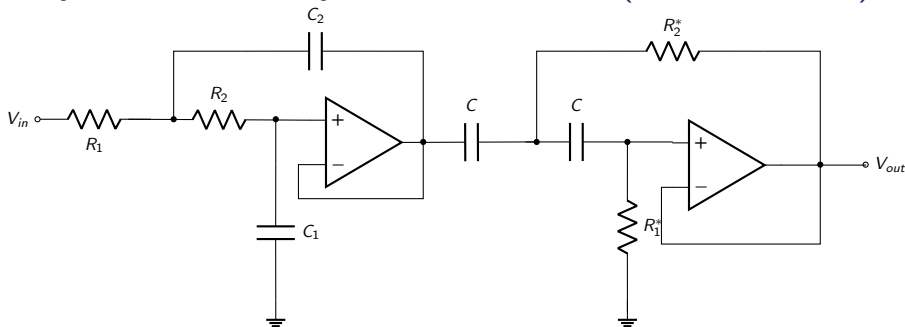
$$f_{m2} = f_m \cdot \alpha$$

with Q being the quality factor of the overall filter.

The individual gain (A_{mi}) at the partial mid frequencies, f_{m1} and f_{m2} , is the same for both filters:

$$A_{mi} = \frac{Q_i}{Q} \sqrt{\frac{A_m}{B_1}}$$

Unity-Gain Sallen-Key Band-Pass Filter (For 20-300 Hz)



For given C_1 and C_2 , the resistor values for R_1 and R_2 are calculated through:

$$R_{1,2} = \frac{a_1 C_2 \mp \sqrt{a_1^2 C_2^2 - 4b_1 C_1 C_2}}{4\pi f_c C_1 C_2}$$

For given C , the resistor values for R_1^* and R_2^* are calculated through:

$$R_1^* = \frac{1}{\pi f_c C a_1}, R_2^* = \frac{a_1}{4\pi f_c C b_1}$$

Resistor & Capacitor Values

Resistor & Capacitor values (For Frequency Range: 20 Hz – 300 Hz)

$$R_1 = 1.2 \text{ k}\Omega, R_2 = 2.2 \text{ k}\Omega, C_1 = 220 \text{ nF}, C_2 = 470 \text{ nF}, \\ R_1^* = 47 \text{ k}\Omega, R_2^* = 27 \text{ k}\Omega, C = 220 \text{ nF}$$

Resistor & Capacitor values for 1st MFB Filter

Frequency Range	R_1	R_2	R_3	C
300 Hz – 1 kHz	2.7 k Ω	10 k Ω	10 k Ω	100 nF
1 kHz – 4 kHz	2.7 k Ω	8.2 k Ω	15 k Ω	33 nF
4 kHz – 10 kHz	2.2 k Ω	6.8 k Ω	1.2 k Ω	15 nF
10 kHz – 20 kHz	1.8 k Ω	5.6 k Ω	470 Ω	10 nF

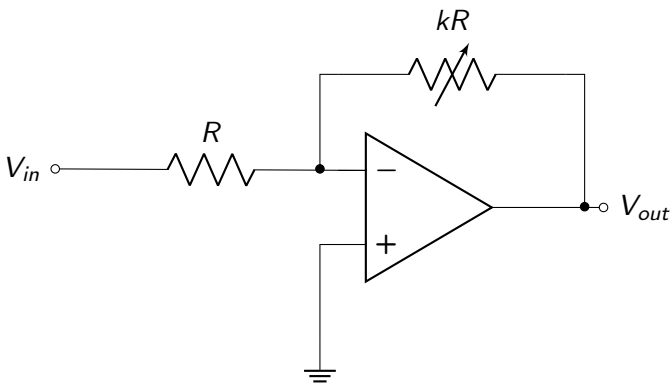
Resistor & Capacitor Values (Cont.)

Resistor & Capacitor values for 2nd MFB Filter

Frequency Range	R_1	R_2	R_3	C
300 Hz – 1 kHz	8.2 k Ω	27 k Ω	27 k Ω	10 nF
1 kHz – 4 kHz	2.2 k Ω	8.2 k Ω	15 k Ω	10 nF
4 kHz – 10 kHz	2.2 k Ω	6.8 k Ω	1.2 k Ω	6.8 nF
10 kHz – 20 kHz	1.5 k Ω	3.9 k Ω	390 Ω	6.8 nF

Other Circuits

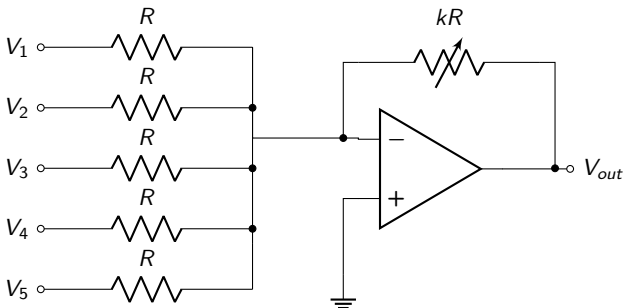
Gain Controller



$$\frac{V_{in} - 0}{R} = \frac{0 - V_{out}}{kR}$$

$$V_{out} = -kV_{in}$$

Adder & Volume Controller



$$\sum_{i=1}^5 \frac{V_i - 0}{R} = \frac{0 - V_{out}}{kR}$$

Hence,

$$V_{out} = -k \sum_{i=1}^5 V_i$$

LED Display

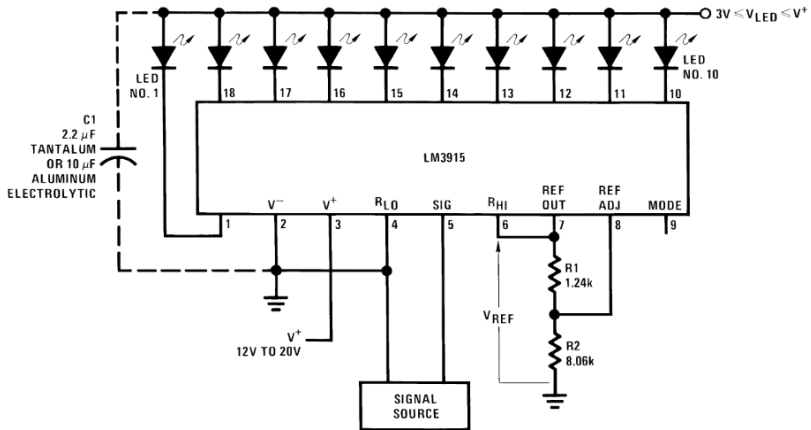
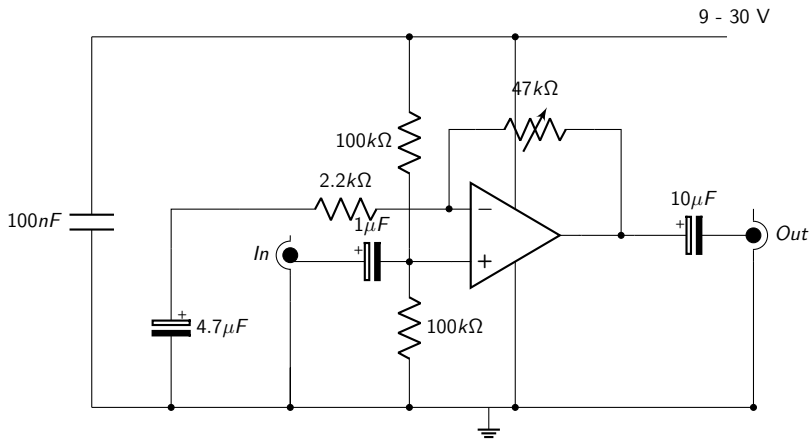


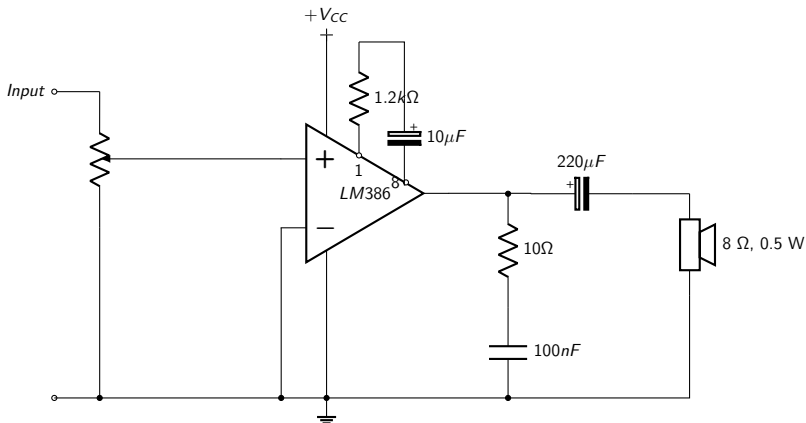
Figure: Circuit connection for LED display[2]

Pre-Amplifier Circuit¹



¹<https://www.homemade-circuits.com>

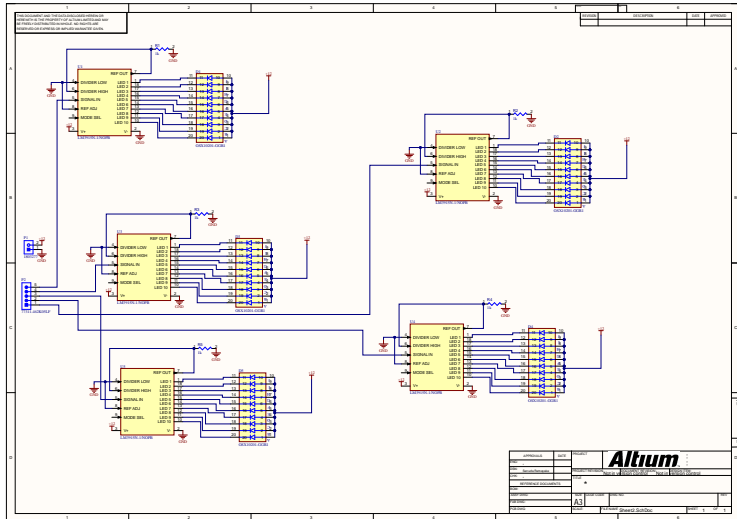
Power Amplifier Circuit²



²<https://www.eleccircuit.com/lm386-audio-amplifier-circuit/>

PCB Design

PCB for LED Display Circuit



References



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Texas Instruments. *LM3915 Dot/Bar Display Driver Datasheet*, SNVS740C. Revised Mar. 2013. [Online]. Available: <https://www.alldatasheet.com/datasheet-pdf/view/558236/TI/LM3915.html>

Thank You!