Five Band Audio Equalizer

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Presentation Structure

Component Selection Justification

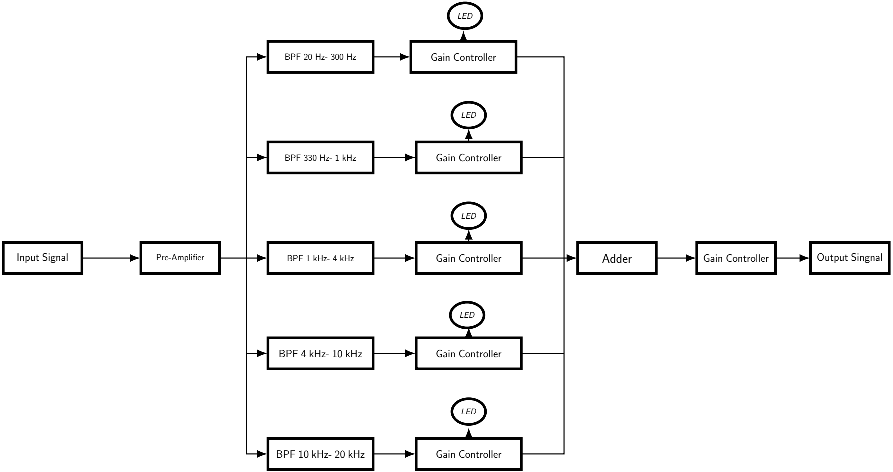
1. **NE5532 Operational Amplifier**
   - **Low Noise**: $5\,\mathrm{nV}/\sqrt{\mathrm{Hz}}$ suitable for high-fidelity audio
   - **Bipolar Input**: Ensures low offset and distortion in precision audio
   - **Dual Channel**: Two op-amps per IC for compact design
   - **High Slew Rate**: $9\,\mathrm{V}/\mu\mathrm{s}$ supports wide dynamic range
   - **Wide Bandwidth**: $10\,\mathrm{MHz}$ gain-bandwidth product for audio applications
   - **Wide Supply**: $\pm 3\,\mathrm{V}$ to $\pm 20\,\mathrm{V}$ operation for design flexibility
   - **High Drive Capability**: Can directly drive $600\,\Omega$ 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$35V) on input

Component Selection Justification (Cont.)

Figure: NE5532 Operational Amplifier

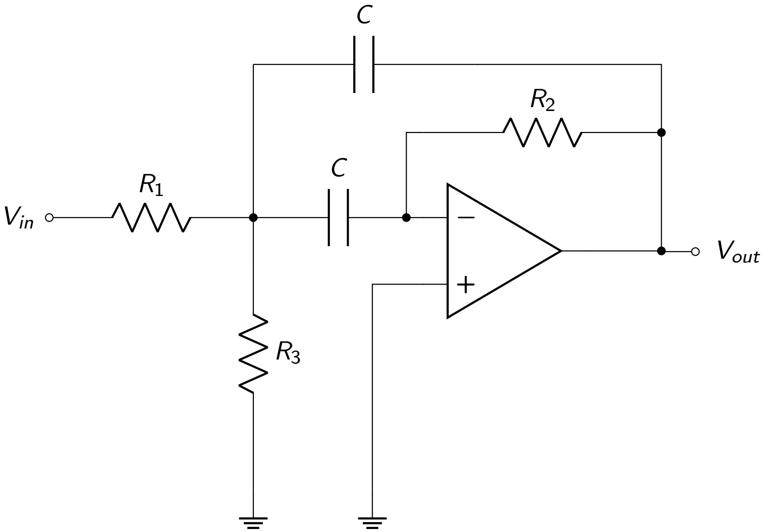
Figure: LM3915 Dot/Bar Display Driver

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:

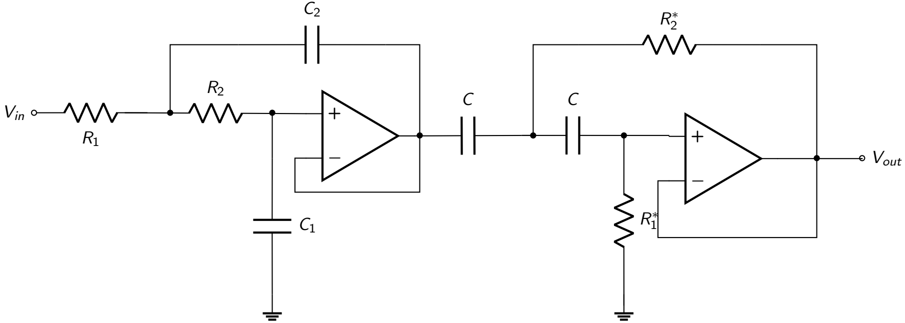
$$f_{m2} = f_m \cdot \alpha$$

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:

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

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)

$R_1 = 1.2$ kΩ, $R_2 = 2.2$ kΩ, $C_1 = 220$ nF, $C_2 = 470$ nF,
$R_1^* = 47$ kΩ, $R_2^* = 27$ kΩ, $C = 220$ nF

Resistor & Capacitor values for 1st MFB Filter

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

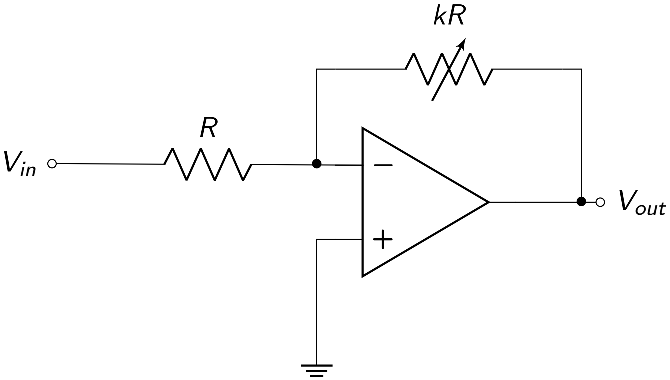
Resistor & Capacitor Values (Cont.)

Resistor & Capacitor values for 2nd MFB Filter

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

Other Circuits

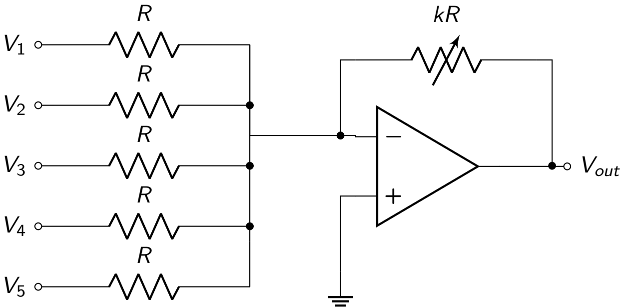
Gain Controller



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

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

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

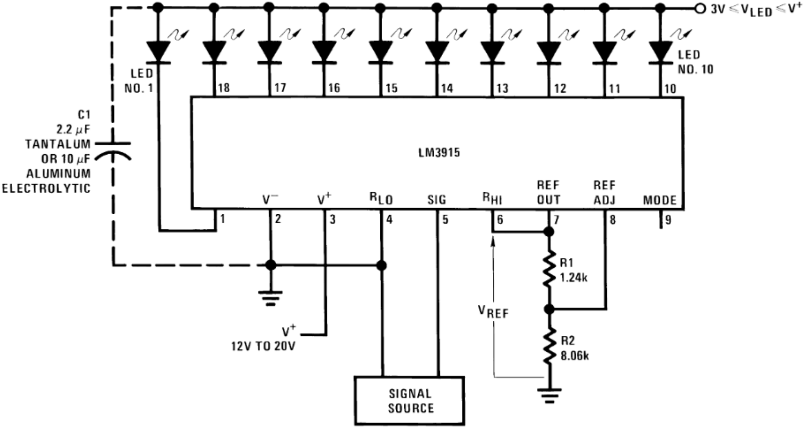
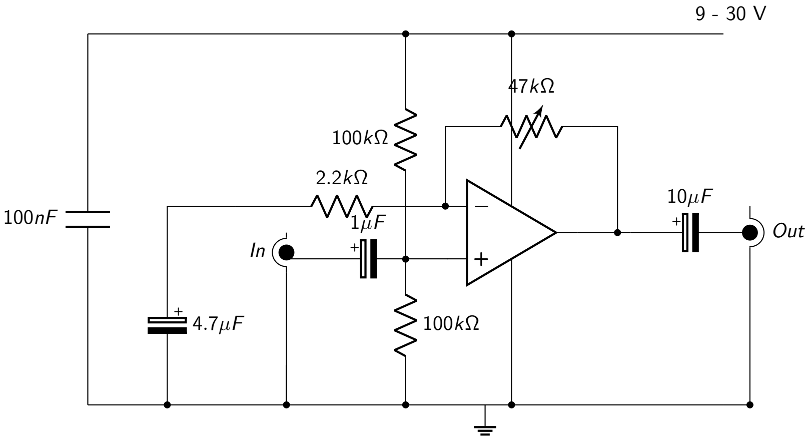


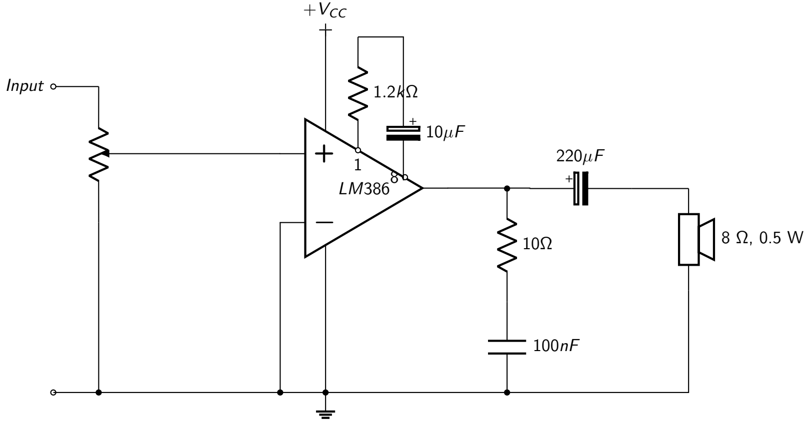
Figure: Circuit connection for LED display[2]

Pre-Amplifier Circuit[1]



[1] https://www.homemade-circuits.com

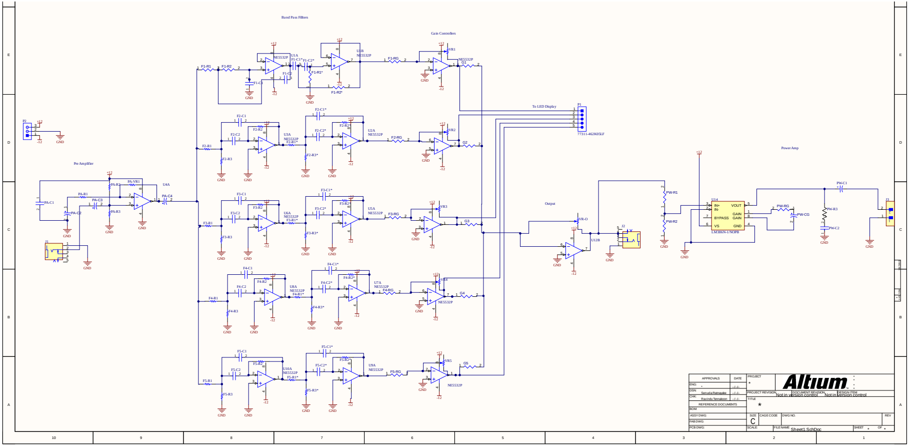
Power Amplifier Circuit[2]



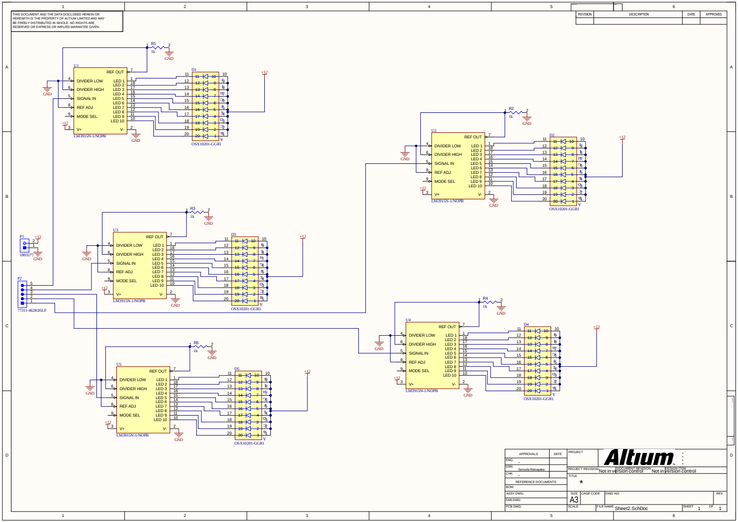
[2] https://www.eleccircuit.com/lm386-audio-amplifier-circuit/

PCB Design

PCB for Main Circuit



PCB for LED Display Circuit



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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!