Final Design Report

EEL 4924 Electrical Engineering Design

Wireless Speakers

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Project Abstract

Our project is to design and construct a 2.4 GHz wireless system, to transmit stereo audio from a 3.5 mm jack to play on a pair of speakers. The transmitter will convert the audio from analog to digital with an Analog-to-Digital Converter (ADC) and transmit this digital data via a 2.4GHz transmitter. The receiver will receive the digital data with minimal loss, and reconstruct the analog signal with a Digital-to-Analog Converter (DAC). The receiver will pass this audio signal through an audio equalizer to control the frequency response of the low, mid and high bands. A power amplifier will then be used to amplify the audio signal and play it though passive speakers. The project will also include an audio visualizer synchronized with the audio signal. The audio visualizer will be controlled via bandpass filters in series with peak detectors for each band of the audio visualizer. The receiver system will be stationary while the transmitter will be aimed for portability.

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Project Features/Objective

The purpose of this project is to allow the wireless transmission of stereo audio from a 3.5mm source, (ie. mp3 player, phone, computer, etc) to a pair of passive speakers. This project will also include an audio equalizer to boost/cut low, mid, and high bands of the audio to match the frequency response of the speakers, and the user's personal tastes at the receiver. The receiver end of the wireless speakers will also include an audio visualizer rendered in real time and synchronized with the audio played through the speakers.

The main objectives for this project are:

- Effectively transmit and receive high quality audio (128 kbps) from a 3.5mm jack and play through speakers wirelessly
- Low power transmitter so that it can be powered with 9V battery and be small and portable
- Design an audio equalizer that can weaken and strengthen low, mid and high frequency bands by at least +/-10 dB, by passing the audio signal through 3 parallel active filters and then a summer to restore the audio signal.
- Produce enough power to speakers to have "loud" music while limiting noise and distortion
- Design an audio visualizer that will be controlled by the MSP430 using analog band pass filters and peak detectors.

System Overview

The system will first convert the analog music to digital using a stereo audio codec (TLV320AIC3204). This data will be transmitted wirelessly to the receiver. The receiver will then convert the digital data back to an analog signal. The low, mid and high frequencies will be adjusted by a 3 band equalizer and passed in parallel to the power amplifier and visualizer, so that adjustments in the audio can be heard and seen simultaneously.

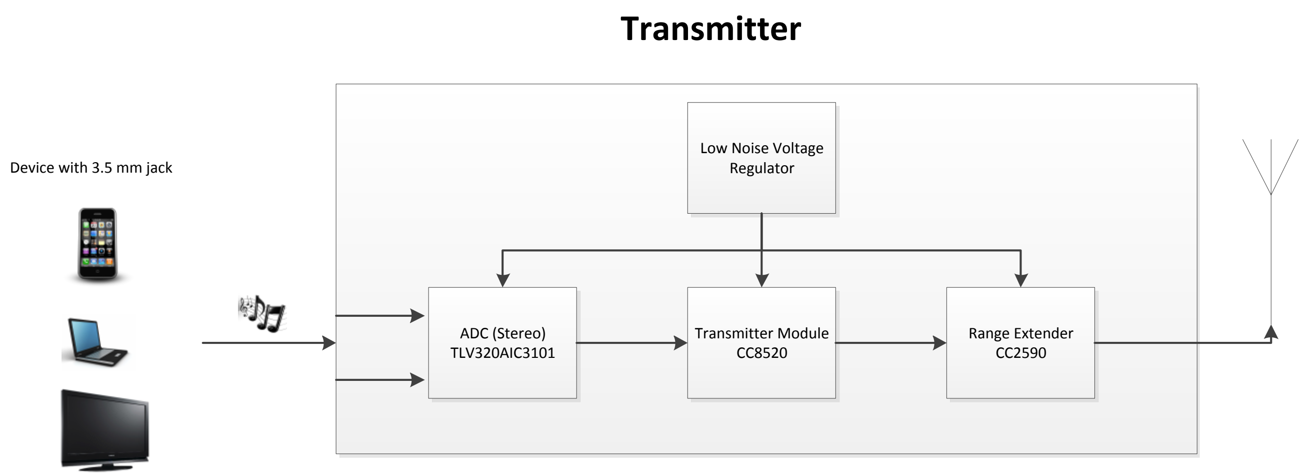


FIGURE 1 - TRANSMITTER DESIGN

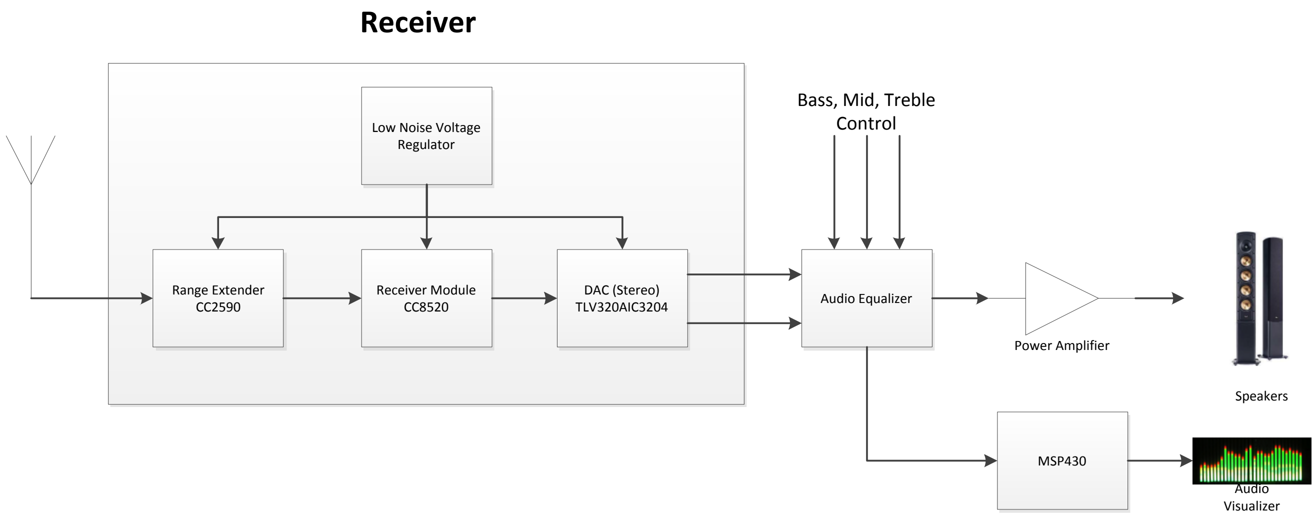


FIGURE 2 - OVERALL RECEIVER DESIGN

Wireless Link:

The wireless link between the transmitter and receiver will use Texas Instrument's PurePath Wireless Audio Solution. The transmitter and receiver will use TI's CC8520 System-on-a-Chip (SoC) to stream stereo audio to speakers. Other possible solutions to wireless stream audio are Nordic Semiconductor's nRF24Z1 or Xbee RF modules. The TI solution was chosen based on its higher range and faster streaming capabilities.

Pros:

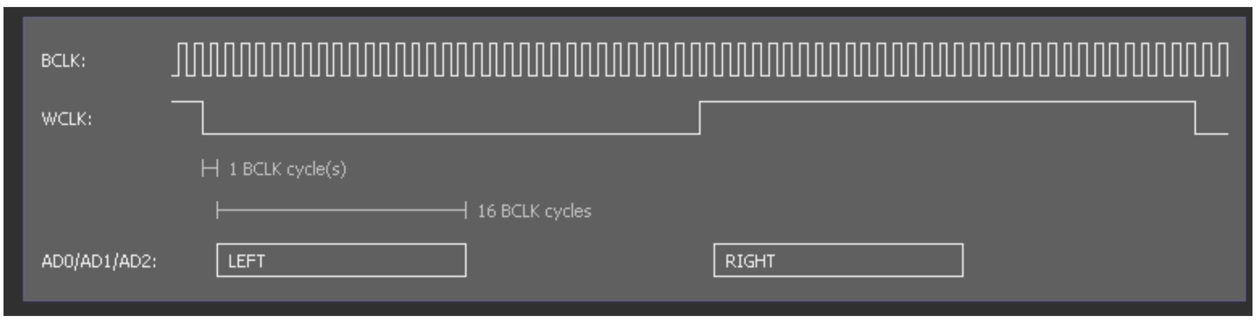
- Faster streaming rate
- Has an longer range with increased transmit power and sensitivity from FEM
- Made for streaming audio – frequency hopping, bit error correction, coexistence with other 2.4 GHz standards
- Can operate autonomously – lower cost and less real estate on board design

The CC8520 can communicate through SPI or I^2C to the stereo audio codec, ADC/DAC, (TLV320AIC3204) and generate the clocks for the I^2S protocol to stream the audio.

ADC/DAC

The TLV320AIC3204 is used to convert the audio into digital and back again. The audio codec also has a built in headphone amplifier, so we can use this to create an extra pair of wireless headsets.

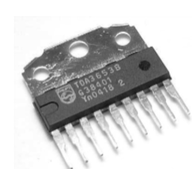
The audio codec uses the I^2S protocol to transfer the music signal. The left channel is sent on the low of the WCLK and the right channel is sent on the high of the WCLK.



The TL1936A-33 is used as the voltage regulator for both the transmitter and receiver. The low noise and ability to use a high input voltage (+20V) is needed, because the power amplifier requires a large voltage.

Audio Amplifier:

The audio amplifier is constructed using a chip amplifier. The chip amplifier produces the best sound per area. The goals of the amplifier are to provide sufficient power to 8 ohm speakers.



- TDA 1517
  - Pros: Simplicity (few external components), single rail low power requirement, small heat sink requirement, reasonably low THD
  - Cons: Little flexibility, low power output (6W), high THD at max output

The layout of the audio amplifier required special attention to the signal paths and the grounding, noise can be easily introduced.

Audio Equalizer

The audio equalizer is made with active bandpass filters and a summer to boost/cut the low, mid, and high frequencies. There is an input buffer to increase the stability and the boost/cut is adjusted with a potentiometer (knob). The rotational potentiometer is chosen because it will give a more intuitive feel for adjusting the frequencies and seeing them on the visualizer versus a digital one with buttons. A sliding potentiometer was also considered, but it is redundant with the visualizer.

Audio Visualizer

The audio visualizer design will not consist of a LCD but a 7 column LED panel. We plan on using the MSGEQ7 IC, which detects peaks of 7 different frequency bands and outputs a DC representation of the amplitude to a multiplexer that is strobed. We used the MSP430 to send the strobe and reset signals to the MSGEQ7. We then used the MSP430 to trigger darlington pairs to turn on different LED drivers at different times to display each band. Below is a overview of the design.

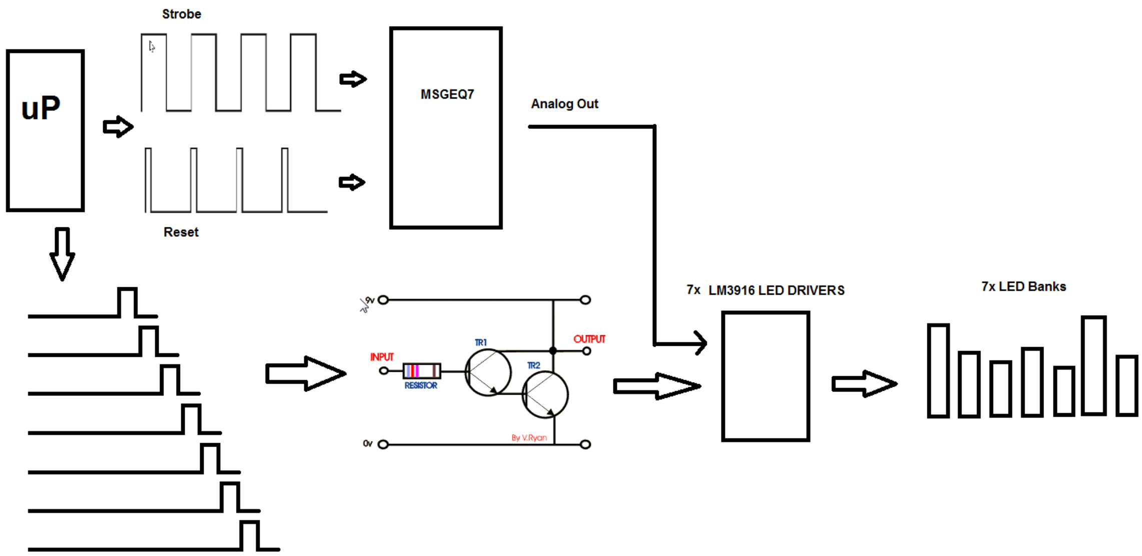
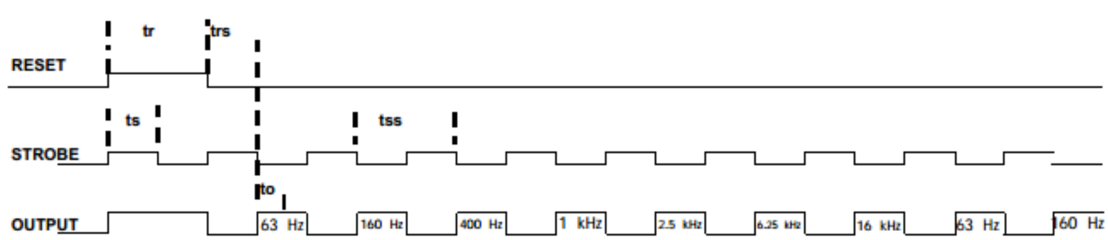
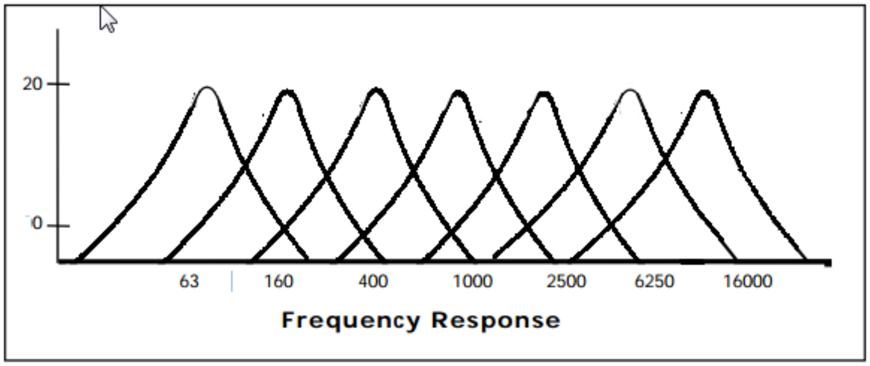


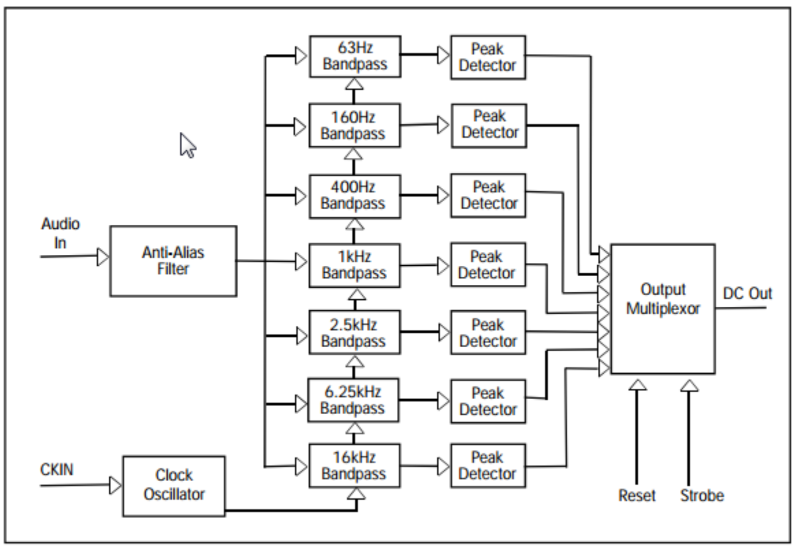
Figure 3 - Visualizer Design

The main gripe that we had about the visualizer design was how we were turning on the LEDS. I would of liked to use the darlington pair array to turn on certain LED segments each clock, but the LED drivers were diretly connected to the anodes of the LEDs, which made it impossible to turn on the LED segments individually. Therefore, we had to turn on the LED drivers individually, which added an extra 6 ICs to the schematics. This design was very inefficient and drew a lot more current. There was also additional leakage current which made the LED segments flicker quite a bit. Overall though, the performance of the visualizer worked out well, and displayed all the frequencies correctly.

MSGEQ7:




20
0
63
160
400
1000
2500
6250
16000
Frequency Response


Audio In
Anti-Alias Filter
63Hz Bandpass
160Hz Bandpass
400Hz Bandpass
1kHz Bandpass
2.5kHz Bandpass
6.25kHz Bandpass
16kHz Bandpass
Peak Detector
Peak Detector
Peak Detector
Peak Detector
Peak Detector
Peak Detector
Peak Detector
Output Multiplexor
DC Out
CKIN
Clock Oscillator
Reset
Strobe

Schematics

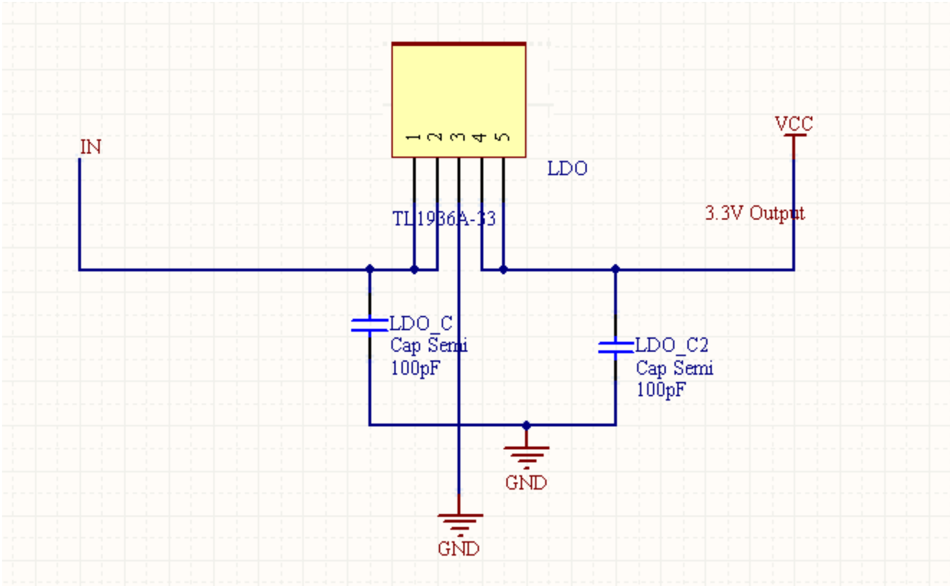


FIGURE 4 - VOLTAGE REGULATOR SCHEMATIC

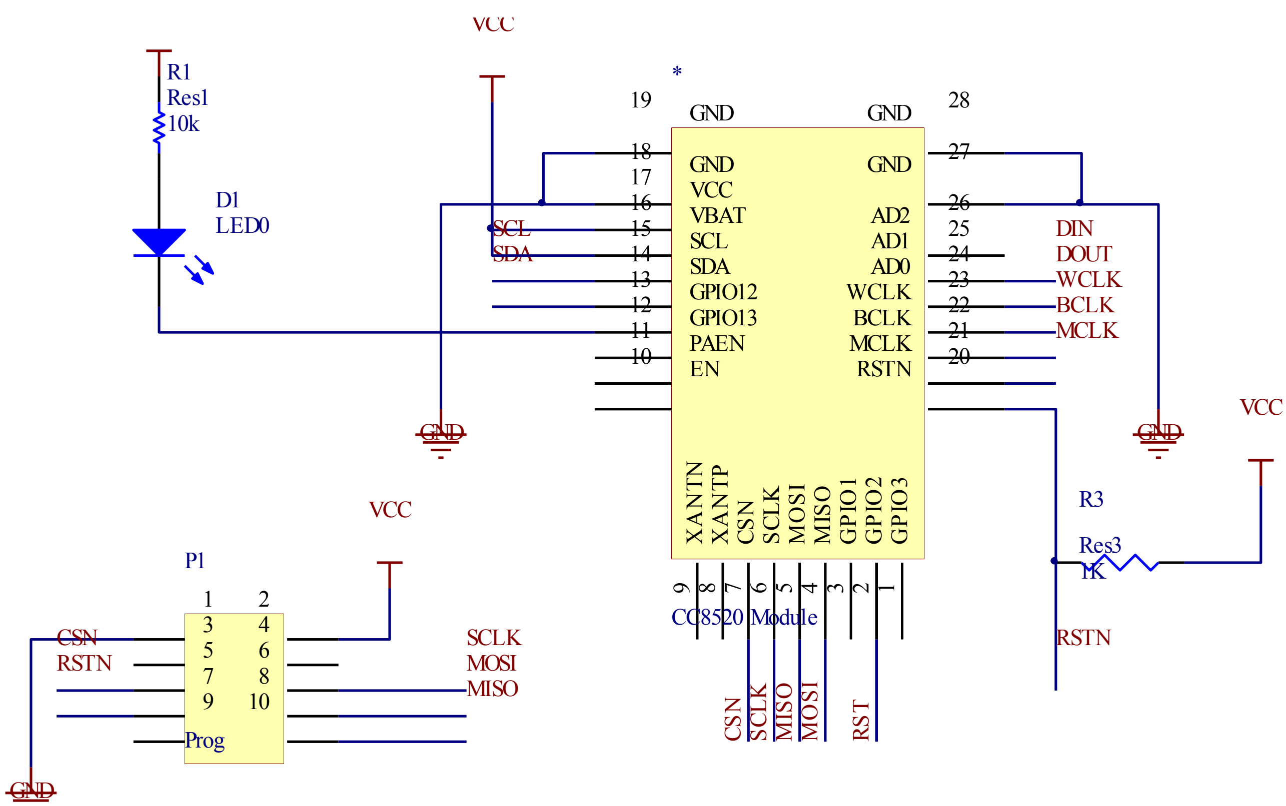


FIGURE 5 - WIRELESS SCHEMATIC

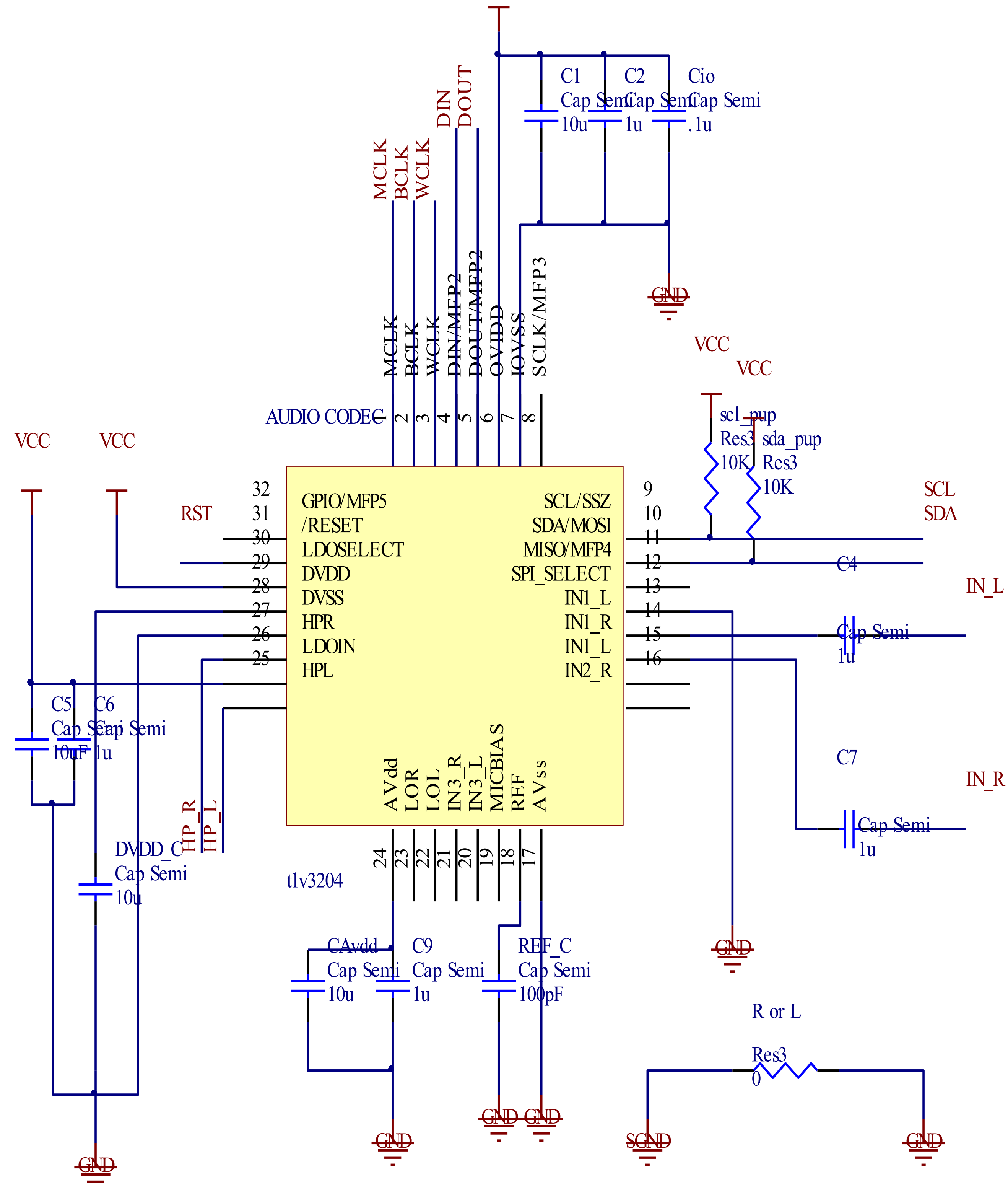


Figure 6 - Audio Codec

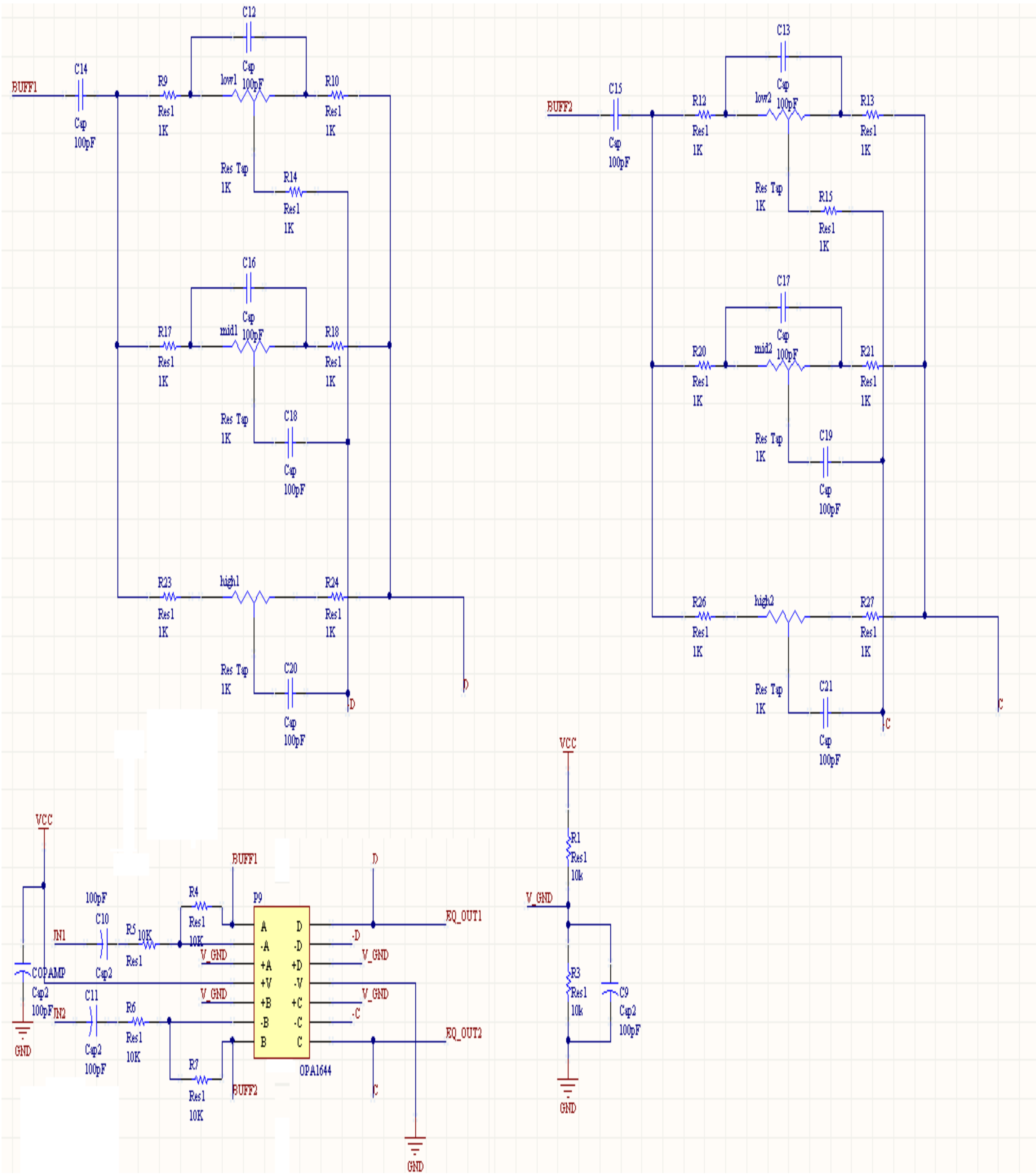


FIGURE 7 - EQUALIZER SCHEMATIC

P9 IS NOT A HEADER SCHEM PART, ITS OWN CUSTOM MADE SCHEM PART

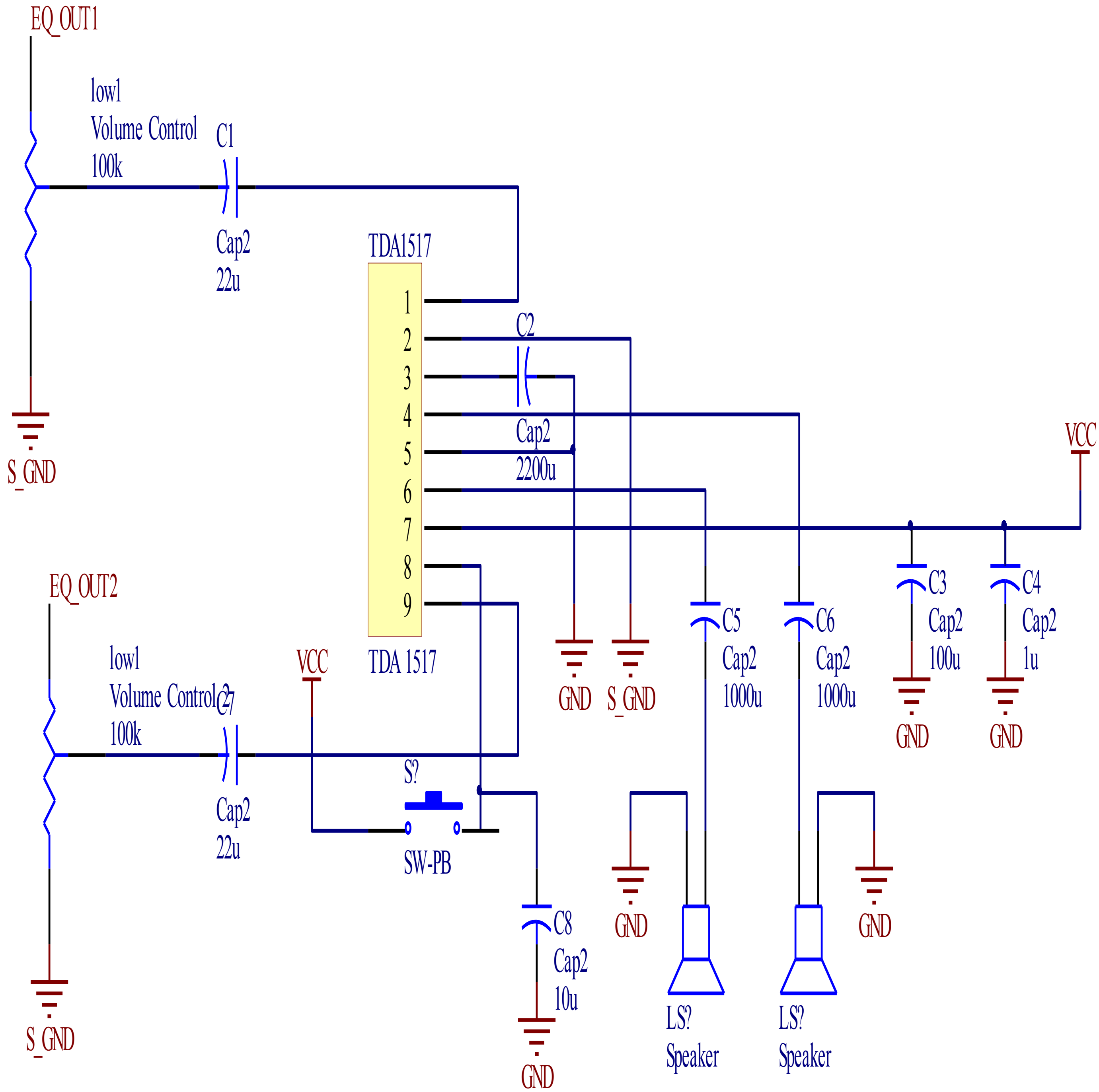


Figure 8 - Power Amplifier

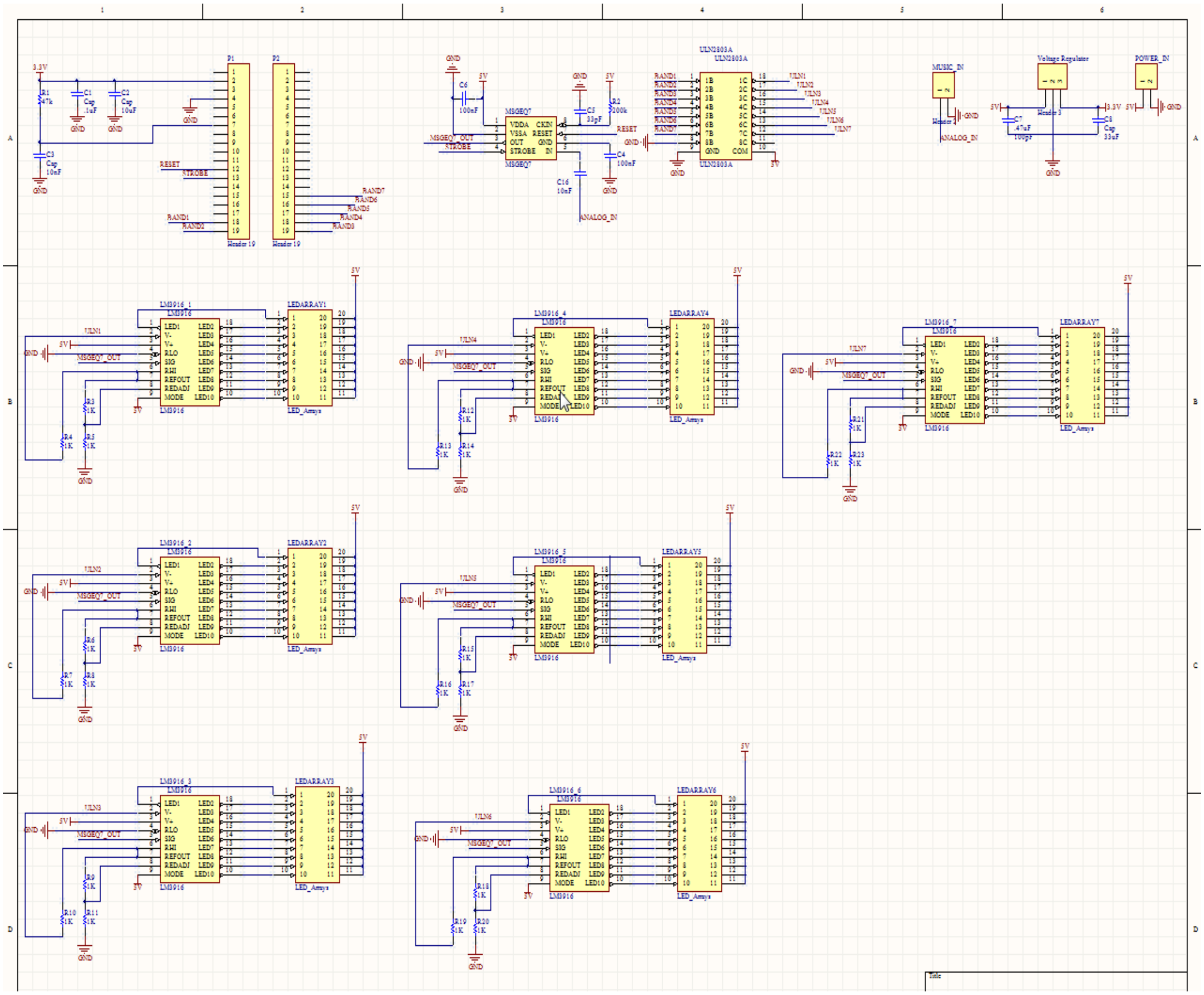


FIGURE 9 - AUDIO VISUALIZER

Project Responsibilities

The following breaks down project responsibilities for the team.

	Lawrence Pham	Baotung Tran
PCB Design	70%	30%
Audio Amplifier	80%	20%
Audio Equalizer	70%	30%
Audio Visualizer	20%	80%
Assembly and Construction	50%	50%
Testing and Debugging	50%	50%
Housing	20%	80%

FIGURE 10 - PROJECT RESPONSIBILITIES

Projected Timeline

The following is a tentative schedule for the project

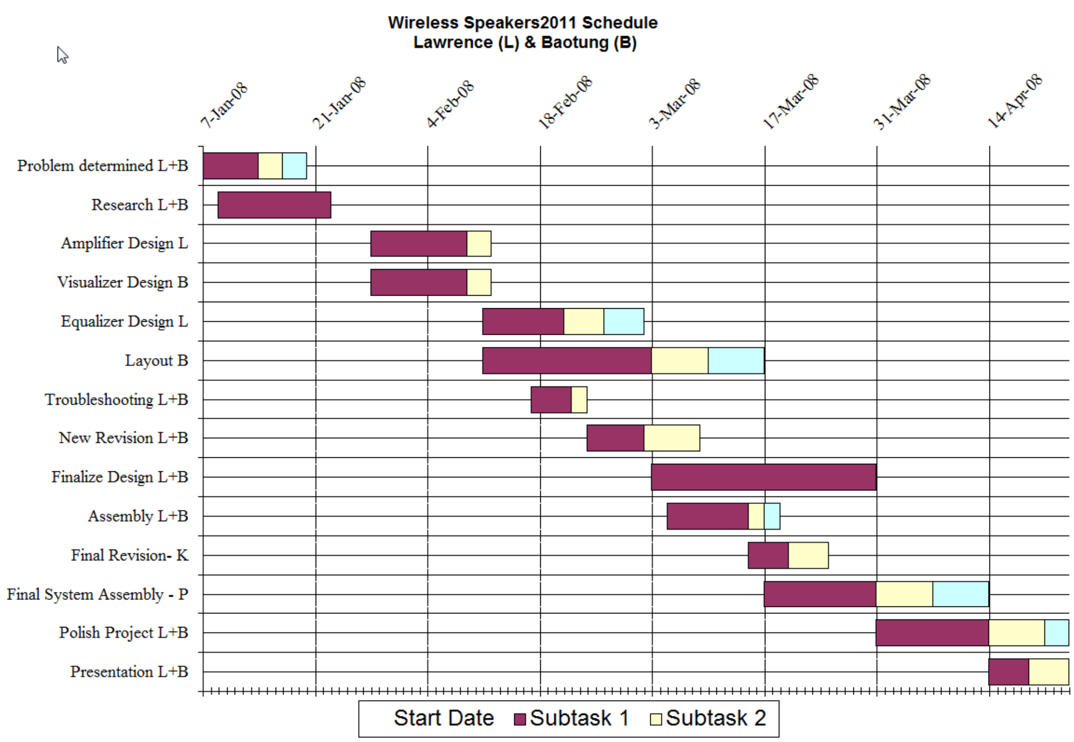


FIGURE 11 - GNATT CHART

Cost of Project

The total cost of the materials of the project is 50 dollars.

- LEDs: 5 dollars
- RF Module: 5 dollars
- Housing: 10 dollars
- Amplifier/OpAmps: 5 dollars
- Discrete Components (R,C,etc) : 15 dollars

Conclusion

•Project completed successfully

•Not very user friendly, need to adjust volume on both amplifier and audio source accordingly

•Equalizer is spotty, need to adjust design

•Extra boards (old)+ headphone amplifier so also have wireless headphones (extra boards have a small spur problem so a little bit extra noise)

•Visualizer has some leakage current going from breadboard to pcb. Slight dim of LEDs that are not supposed to be on.

Future Work

•Use of CC853X for 2.1 or quadrophonic audio streaming

•Use CC2591 (FEM) to increase sensitivity and range

•Use of differential line audio output on TLV320AIC3204

•Use rechargeable Lithium Ion batteries

•4 layer pcb design with better layout and use of audio detect pins

•Use of different method for driving LEDs. Very inefficient the way the design is currently implemented.