6.101 Final Project Proposal

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AM Radio Transmission

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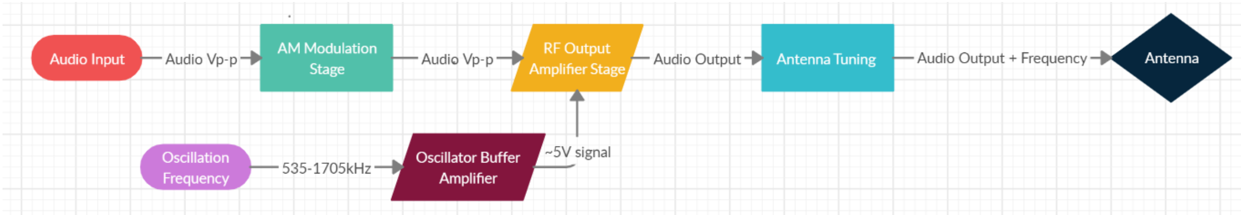
Abstract:

Amplitude modulation (AM) radio transmissions are commonly used in commercial and private applications, where the aim is to broadcast to an audience - communications of any type, whether it be someone speaking, Morse code, or even ambient noise. In AM radio frequencies (RF) transmissions, the amplitude of the wave is modulated and encoded with the transmitted sound, while the frequency is kept the same. Furthermore, AM radio transmissions can occur on different frequencies, with broadcasts of the same frequency interfering with each other. Therefore, it is important to select a unique – or as unique as possible – frequency band in order to transmit clean, interference free, communications. And currently, many 1-way and 2-way radios, with transmission ability have some digital component in order to improve different aspects of the radio. Thus, for my 6.101 final project, I plan to build a fully analog circuit, in keeping with the theme of the class, that can be used to broadcast to specific AM frequencies. Thus, the goal is to broadcast as far as possible while minimizing the power consumed. Moreover, I plan to be able to receive these AM transmissions through an existing receiver or one built alongside this project. I expect to run into difficulties when extending the reception range as it may arise from the antenna length, the RF transmission power, and the number of transistor stages. I also expect noise to be an issue, since the message is stored in the amplitude and any type of noise will distort the communication.

Block Diagram:



Testing and Build:

For this project, I plan to first test and construct the modules in LTSpice. Once the modules are verified through hand calculations and LTSpice simulation, I will construct a PCB board that will be purchased in order to physically construct the system. If I were testing this system physically, I might have used a field strength meter in order to determine the strength of the sent signal. However, since debugging will primarily be done through LTSpice, I can make use of the projected signal that LTSpice shows, whether they are static or dynamic.

In simplicity, the oscillator buffer stage, AM modulation stage, and RF output amplifier stage can be accomplished with one BJT. While, I do hypothesize that I will use one device per stage for power efficiency, I will continue to explore to see which configuration minimizes power consumption while maximizing signal strength. I am doing this as I plan to physically build the system once the circuit is tested and verified, in order to demo the project when school resumes.

Power Dynamics:

Since my inspiration for this project is LoRa, developed by Semetech, a low power long range communication device. I believe it appropriate to attempt at lowering the power draw from the power source.

Power optimization across my whole circuit will be a big focus for me since I am creating a portable system. In transmitting long ranges, it really comes down to how much power goes through the final amplifier stage in your transmitter as that is the signal coming from the device. Thus for that reason, I may not use the typical parts we often used in lab, but find more power efficient parts available.

In addition to the power optimization, I will also be making the system portable. Depending on how efficient the system is, I would not like to have to buy batteries often when using this device. Thus, I am going to a rechargeable battery circuit that can either be charged via a USB or solar panel, as detailed in the objectives portion.

Signal Amplification:

As noted as part of my inspiration, I am also attempting to make this device energy efficient. And, this may seem contradictory as signal amplification is in part due to power output across the final stage. However, this problem can be circumvented. I will do that by increasing the antenna size and increasing the power across the final stage.

The antenna plays a large role when it comes to transmitting far distances. There are two types of antennas I can use a whip and a stub. And, I will be using a whip antenna as a stub antenna may reduce your range by 30%. While inconvenient to transport compared to a stub antenna, it provides much greater range.

As stated previously, optimizing the power in the circuit is a main priority and becomes increasingly critical in the final stage of the device where the signal is transmitting. Understandably, the more power at that point the farther the signal the travels and the more penetrating power it has to go through difficult objects such as metal.

As a side note, it should be noted that typical AM signals (535 – 1705kHz) transmit farther than FM (88 – 108MHz) signals. Not because of how they are modulated, but because AM signals are typically transmitted below 2MHz, whereas FM signals are usually transmitted over 2MHz. When a signal has a frequency below 2MHz, it can be reflected off the Earth's atmosphere and travel beyond the horizon – which can be hundreds of miles away for a radio station.

Transmission and Reception:

The transmitter will be able to broadcast on the full AM band, 535 – 1705kHz. Therefore, the transmitter should be heard on any normal AM radio receiver. I will do this by using a tunable capacitor and inductor instead of crystal oscillator. The pros of this method is that I will be able to sweep the AM band. The con is that I will not have the clean stability of an oscillator crystal.

Time permitting, I will also create a much simpler AM radio receiver, such as the one in lab, so that I can verify the results without any additional components. However, this receiver will also be able to sweep the same band as the transmitter. Furthermore, the receiver circuit will be connected an amplifier in order to broadcast the sound through either an earpiece or speaker.

Timeline and Final Project:

Since we have a slightly shortened time frame due to the COVID-19 situation, I will adjust my projected timeline beginning the week of the 20th of April 2020 ending the week of the 11th of May 2020, leaving us a little less than 3.5 weeks. Importantly, I have been working on the design prior to the start of my first stated week.

In the first week, April 20th – 24th,

- I expect finalize my AM transmitter design before the presentation.
- On either Tuesday or Thursday, I will present my project to the class and receive feedback.
- I plan to calculate the expected values for each connection of the entire circuit by hand.

In the second week, April 27th – May 1st,

- Once values are verified by hand calculations, I will simulate the model in LTSpice.
- When the base model works, I will start on the expected and reach goals:
  - Battery charger circuit
  - Solar panel connection
  - 535 – 1705kHz range AM transmitter
  - Etc…

In the third week, May 4th – 8th,

- I intend to write my final report detailing the steps and processes that I used to bring my project to fruition due May 12, 2020.

Objectives:

Basic

- Stable 1 frequency AM transmitter
- Replaceable battery connection
- Having at least a 10m reception range

Expected

- A 535 – 1705kHz AM transmitter
- USB rechargeable battery IC circuit
- Having at least a 50m reception range
- Use a switch to turn the device on and off

Stretch

- Solar panel and USB connection to the rechargeable battery
- Custom built battery charger circuit
- User friendly
- Matching AM receiver circuit
- Having at least a 100m Reception range
- Include the transmitter and receiver on the same PCB
    - Use a switch to toggle between transmitter and receiver
- Using an amplifier circuit in order to play music or use different microphones