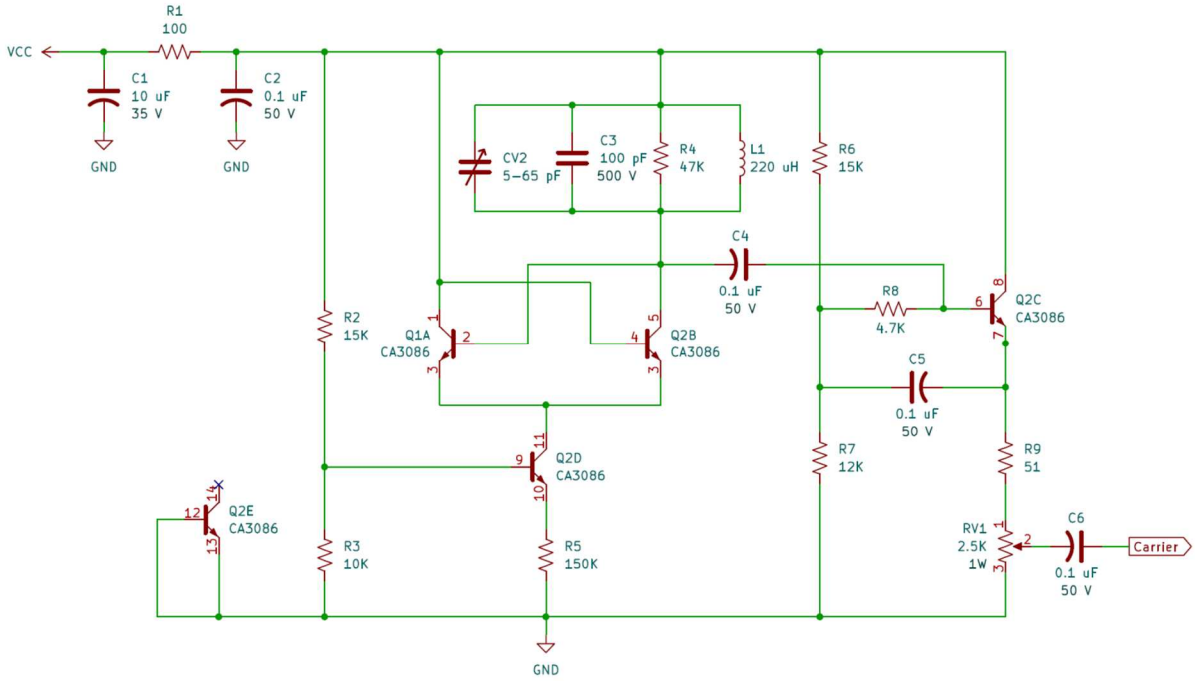
EE 423: Communication Electronics
Prof. Mohammed Hawa

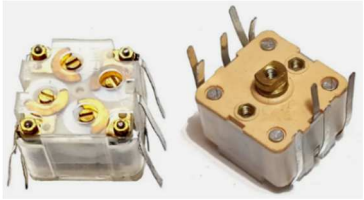
Project: AM Transmitter (Hardware)

In this project, you are required to **understand, build and test** the AM transmitter circuit shown below and **get it to work**. The first part of the circuit is a cross-coupled quadrature harmonic oscillator that generates a sinusoidal carrier with frequency around 1 MHz. Both the frequency and amplitude of the output signal from the oscillator are controllable via the variable capacitor and variable resistor, respectively.



For the variable capacitor, you can use a 5-65 pF (or any wider range) variable capacitor, or alternatively you can salvage a ganged capacitor from an old AM/FM radio, which contains multiple capacitors, some of which cover the desired range (and beyond).

Variable capacitor (trimmer)



Ganged capacitor (AM/FM radio)

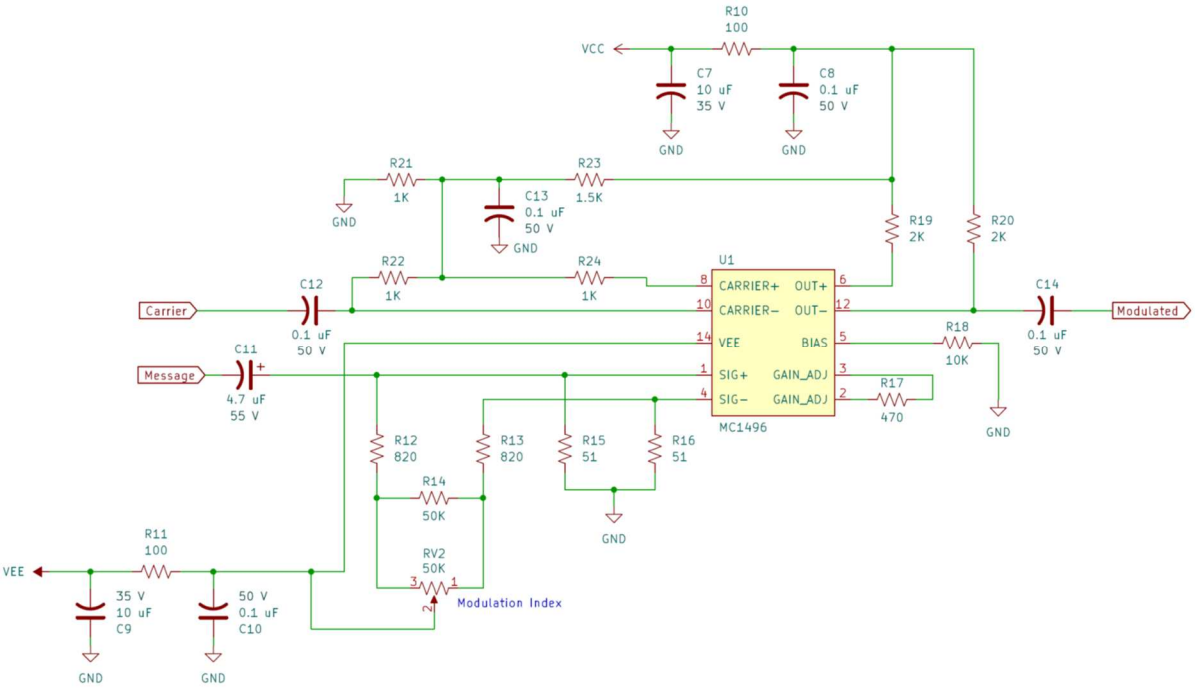
For the variable resistor you can use a rotary potentiometer (for easier manual control) or a trimmer or preset potentiometer (if you want a less expensive option).

Rotary potentiometer

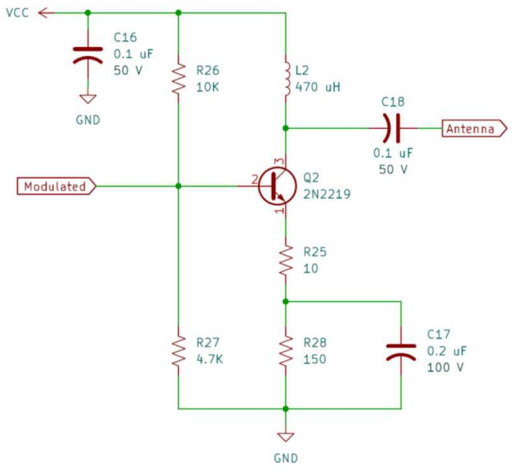
Trimmer potentiometer

Preset potentiometer

The second part of the circuit is a mixer that multiplies the sinusoidal carrier with the message signal. The message is supposed to be the output from an mp3 player, cell phone, PC audio card, etc, that plays an audio file. We want to test multiple audio files with different signal bandwidths. The mixer is a Gilbert cell, hence the use of the MC1496 chip. You can control the AM modulation index using the 50 kΩ potentiometer, to utilize critical modulation (or slightly under modulation).

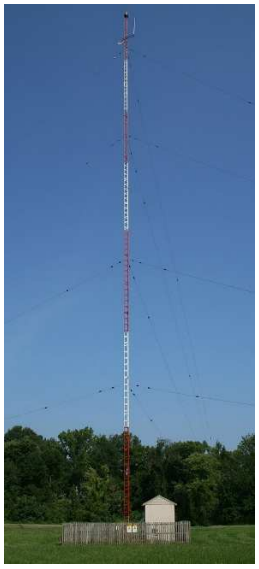


The third stage is a single-transistor RF power amplifier that amplifies the modulated signal before being sent to the antenna.



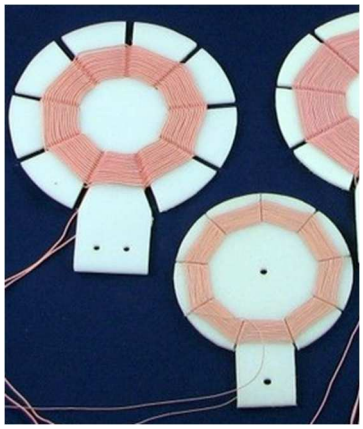
At 1 MHz, the half wavelength of the modulated signal is $\lambda/2 \approx 150$ m, which means a monopole antenna would be around 75 m long. Typical AM radio stations employ long mast radiators (i.e., radiating towers). However, this is impractical for hobbyists, who often use a loop antenna or a spider wire ham radio antenna. You can build one of those yourself, if you want, using a long piece of wire, but you are *not* required to do so. Rather, for this

project, just use one meter of wire or salvage an FM telescopic aerial antenna from an old radio, since we do not need nor want to transmit for long distances.



AM radio tower

Loop antenna

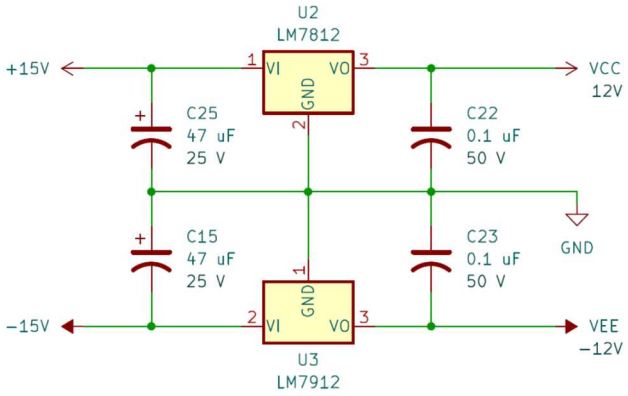


Spider wire antenna

FM telescopic aerial antenna

The circuit requires a heavily-regulated +12V and -12V DC sources (V_{CC} and V_{EE}). The easiest way to obtain such voltages is to use a switching power supply unit from an old PC, which provides you with +12V, -12V, +5V, and 3.3V. If you do not have an old PC, you can find cheap PC power supplies nowadays (their cost is about that of two 9V batteries). There are more expensive options, of course, but those are more efficient supplies that deliver high power suitable for gaming PCs. The circuit in this project requires very little power, and the cheapest power supply you can find should suffice. If you want to use two separate 12V power adaptors that you already own, then make sure you add the circuit below (with the +12V and -12V voltage regulators), since typical power adopters are not usually well regulated. Most PC power supplies, on the other hand, do *not* require the use of extra regulators.

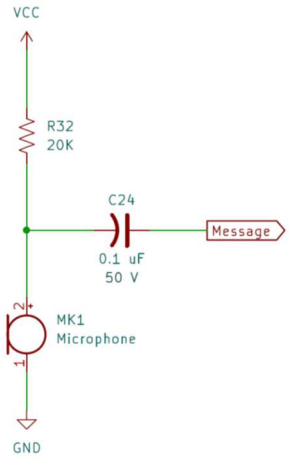
PC power supply unit



Voltage regulator circuit

Optionally, you might want to send your voice over AM radio. In this case, you can use an electret microphone, and connect it using the following circuit. However, you are still required to test different audio files from an audio player.

Electret MIC

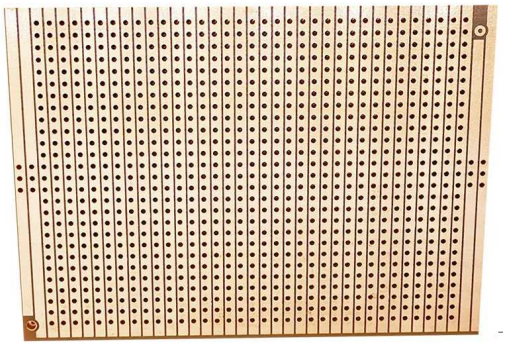


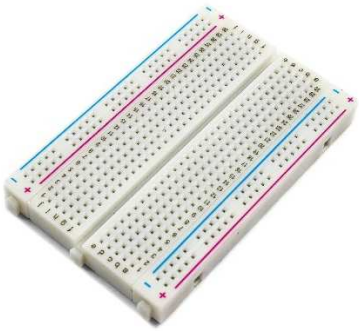
Biasing circuit for the MIC

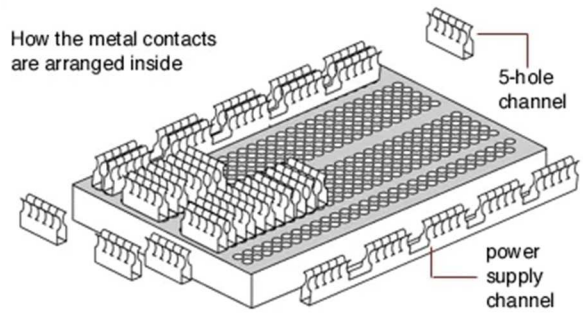
For this project, the modulated signal should be transmitted at an appropriate AM frequency so that we can hear it on a regular AM radio device within a range of few meters.

You are required to build your circuit on top of a stripboard, not a breadboard. The metal strips inside breadboards can cause undesirable parasitic capacitance at higher frequencies. Though a breadboard can sometimes work at 1 MHz, it is safer to just use a stripboard. You are not required, nor allowed, to build a PCB for this project in case we need to tweak the design later.

The design of the circuit is modular, so you can build different parts of the circuit on different small stripboards (and also test each part individually), then connect the different parts of the circuit using wires. Each module can be built by one team member. However, all team members should understand the whole design and be able to answer questions about the details of every part of the circuit.







Stripboard Breadboard

For best results, use a mica capacitor for the 100 pF / 500 V capacitor, use electrolytic capacitors for the 4.7 µF and 47 µF capacitors, and use tantalum capacitors for the rest. If such capacitors are not available or very expensive, you can try other capacitor types, but you have to be aware of their RF performance and tolerances. Remember that electrolytic and tantalum capacitors are polarized, so pay attention to their terminal polarity when connecting them. Follow the polarity in the schematic.

Mica capacitors

Tantalum capacitors

Electrolytic capacitor

At the time of **project submission** please:

- Make sure that you understand how the different parts of the circuit work.
- Test multiple audio files and hear them over AM radio.
- Be prepared to answer questions about AM hardware in general and this transmitter circuit in particular.