CHAPTE 2

LITERATURE REVIEW

2.1   Introduction

I have performed with high expectation to complete this final year project for the title FM Telephone Transmitter. By considering this project can be done for in good result and the output can be perform at FM radio smoothly. This chapter will review some similar project and studies, the solutions of the project related, overview on different approaches made by previous researchers and make a comparison between my final year project and those similar projects.

2.2   Frequency Modulation (FM)

Frequency Modulation (FM) is the method of varying a carrier wave's frequency proportionally to the frequency of another signal, in our case the human voice. This compares to the other most common transmission method, Amplitude Modulation (AM). AM broadcasts vary the amplitude of the carrier wave according to an input signal. Standard FM broadcasts are based in the 88 - 108 MHz range; otherwise known as the RF or Radio Frequency range.

However, they can be in any range, as long as a receiver has been tuned to demodulate them. Thus the RF carrier wave and the input signal can't do much by themselves they must be modulated. That is the basis of our transmitter. An example is useful to illustrate what is actually going on. If we were to broadcast a 100MHz signal and tune a radio into that frequency, we would hear nothing. That 100MHz signal has locked or

captured that spot and simply produces a DC value. Now if we were to move the incoming signal +/-100KHz in either direction at a frequency of 1000Hz, then we would hear a 1000Hz signal on the radio. If we only moved +/-10Khz then the sound from the radio would be 1/10th the original in loudness.

Thus the rate or frequency at which we change the RF carrier produces the audible frequency that we hear, and the further from the main RF carrier we move, the louder the output will be. This is the basis of all FM transmitters. We will now look at how this is achieved by examining the basic circuit.

2.3   Inductance of an Air Core Coil

Self-made inductor has a value determined by its radius r, length x and number of wire turns n.
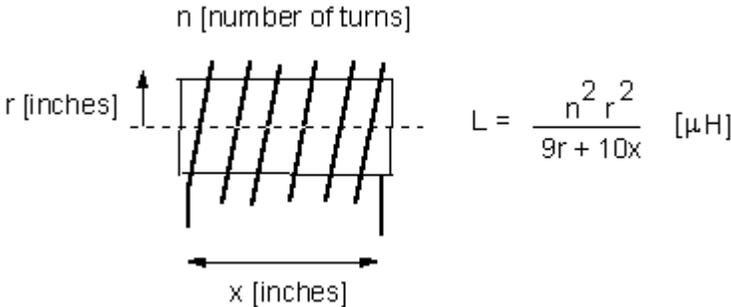

$$L = \frac{n^2 r^2}{9r + 10x} \ [\mu H]$$

Figure 2.1:   Calculations of inductor value

For inductor, $r = 0.1325$ inches, $x = 0.25$ inches and $n = 6$ turns and results in $L = 0.171$ microHenry or 0.000000171 Henry.

2.3.1 Frequency

The specific frequency, f generated is now determined by the capacitance C and inductance L measured in Farads and Henry respectively:

$$C \text{ [Farads]} \quad L \text{ [Henry]} \quad f = \frac{1}{2\pi \sqrt{LC}} \text{ [Hz]}$$
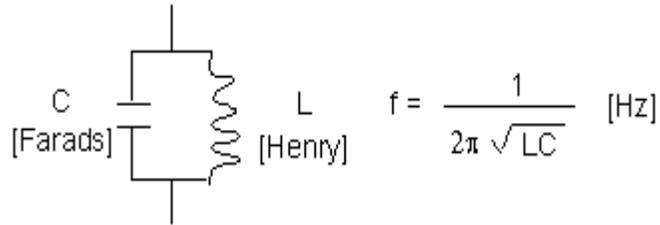
Figure 2.2:   Calculations of frequency value

2.4   Resonant Frequency of a Parallel LC Circuit

FM radio stations operate on frequencies between 88 and 108 MHz. The variable capacitor and self-made inductor constitute a parallel LC circuit. It is also called a tank circuit and will vibrate at a resonant frequency, which will be picked up the FM radio.

In tank circuits, the underlying physics is that a capacitor stores electrical energy in the electric field between its plates and an inductor stores energy in the magnetic field induced by the coil winding. The mechanical equivalent is the energy balance in a flywheel; angular momentum (kinetic energy) is balanced by the spring (potential energy). Another example is a pendulum where there's a kinetic versus potential energy balance that dictates the period (or frequency) of oscillations.

2.5   Antenna Length

The antenna either with a piece of solid strand 22 gauge wire 30 inches long or used a telescopically extendable antenna. Its length should be approximately 1/4 the FM wavelength; recall that multiplying frequency and wavelength equals the speed of light. It's most probably be operating the transmitter near 108 MHz, as such:

$$\text{Speed of light} = \text{frequency} \times \text{wavelength} = 300\,000\ \text{km/sec}$$

$$\text{wavelength} = \frac{300\,000\ \text{km/s}}{108\ \text{MHz}} = 2.78\ \text{meters}$$

$$\text{antenna length} = 0.25 \times \text{wavelength} = 0.69\ \text{meters}$$

$$\text{Thus antenna should be } 27.3\ \text{inches}$$

Figure 2.3:   Calculations of antenna length

2.6   Wireless FM Transmitter

2.6.1   Schematic
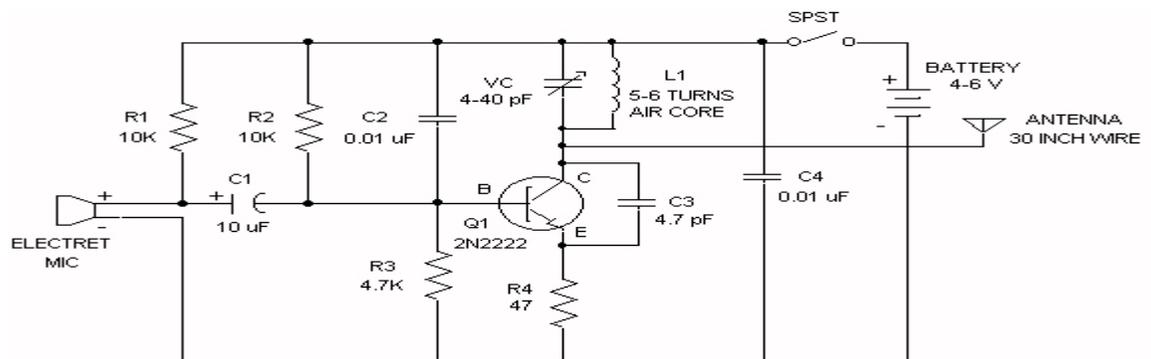
NOTE 1:   L1: length = 0.25 inch
diameter = 0.265 inch
5 to 6 turns yields apx. 0.17 uH
NOTE 2:   VC set at 12.5 pF yields 108.8 MHz

Figure 2.4:   Schematic of Wireless FM Transmitter

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2.6.2 Fixed Capacitors

In theory, as long as there is a supply voltage across the parallel inductor and variable capacitor, it should vibrate at the resonant frequency indefinetely. Referring to the schematic, *C2* and *C4* act as decoupling capacitors and typically *0.01 uF* (or *0.1 uF*) are used. *C4* attempts to maintain a constant voltage across the entire circuit despite voltage fluctuations as the battery dies. A capacitor can be thought of as a frequency-dependent resistor (called reactance). Speech consists of different frequencies and the capacitor *C1* impedes them. The net effect is that *C1* modulates the current going into the transistor.

Using a large value for *C1* reinforces bass (low frequencies) while smaller values boost treble (high frequencies). The *C3* capacitor across the 2N2222A transistor serves to keep the tank circuit vibrating. In reality however, the frequency decays due to heating losses. *C3* is used to prevent decay and the 2N2222A spec sheet suggests a capacitance between *4* to *10 pF*

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2.6.3 Resistor for Electret Mic

The spec sheet for the Jameco #136573 electret microphone says the maximum current is *0.5 mA*. When battery powered at *6V*, then the voltage drop across *R1* is *V1 = 1.92V*. The resulting current through the microphone is below the rated maximum since

$I1 = (6\text{-}1.92)V / 10000\ Ohms = 0.41\ mA$

2.6.4   Resistors and the 2N2222A

The 2N2222A transistor has rated maximums thus demanding a voltage divider made with *R2* and *R3* and emitter current limiting with *R4*. The 2N2222A's maximum rated power is *Pmax = 0.5 W*. This power ultimately affects the distance you can transmit. Overpowering the transistor will heat and destroy it. To avoid this, one can calculate that the FM transmitter outputs approximately *124 mW* and is well below the rated maximum.

2.6.5   Conclusion

The literature review begins with a discussion on frequency modulation (FM), that are very important for this project. Standard FM broadcasts are based in the 88 - 108 MHz range; otherwise known as the RF or Radio Frequency range. Next, it discusses about the main electronic components in the electronic circuit that function to generate a frequency for broadcasting and the parameter related with the electronic components.

In this chapter I also discusses about Wireless FM Transmitter circuit. Using this circuit I studied about the main electronic component related such as capacitor, inductors and resistors, which inculudes their functioning and operations.