Reverse Engineering of FM radio Receiver.

Title: Reverse Engineering of FM radio Receiver.

Students: Soham Gaonkar and Srivatsha Maruveda

Team: Plant Power (6111C)

Location: Raleigh, NC, USA

Entry for : VRC Middle School - Reverse Engineering Challenge 2023

Video Link:

https://www.youtube.com/watch?v=Gd9xr9ai33I

Introduction:
FM Radio is such an interesting topic!
I can't clearly hear my mother talking to me from the kitchen. Some of it is part of selective hearing, especially if she is asking about homework.
But I can hear someone singing live from across the country. Explain that!

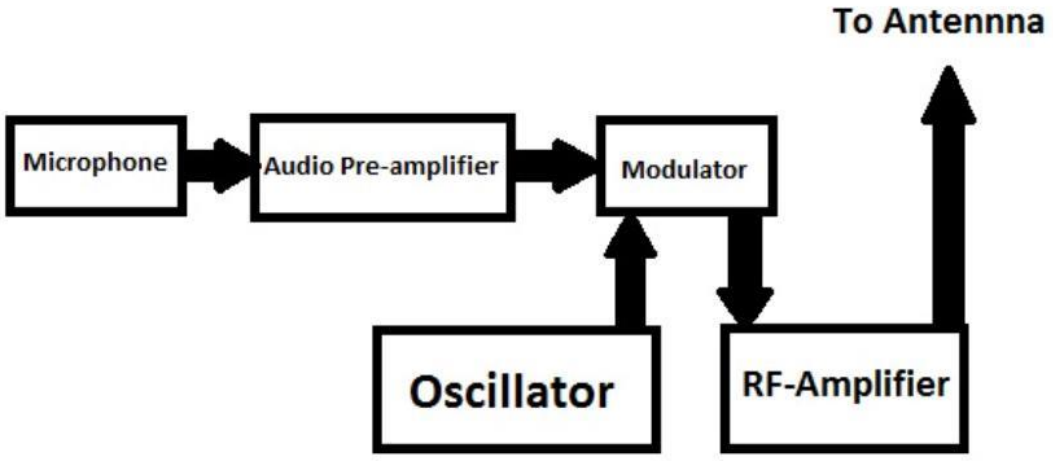
We, Srivastha and Soham, are both music students.So the sound transmitting over the radio waves was obviously a fascinating subject. How does a sound transmit without losing its quality over such long distances?

Theory : We read the theory as sound waves are first modulated by Amplitude or Frequency (AM or FM) and then transmitted using a high power antenna. The FM receiver is a tiny electronics circuit,capable of receiving the FM signal, removing the noise, then amplifying it and converting it to audio range that humans can hear. We wanted to try to build it from scratch and test ourselves how it works.

What is an FM transmitter?

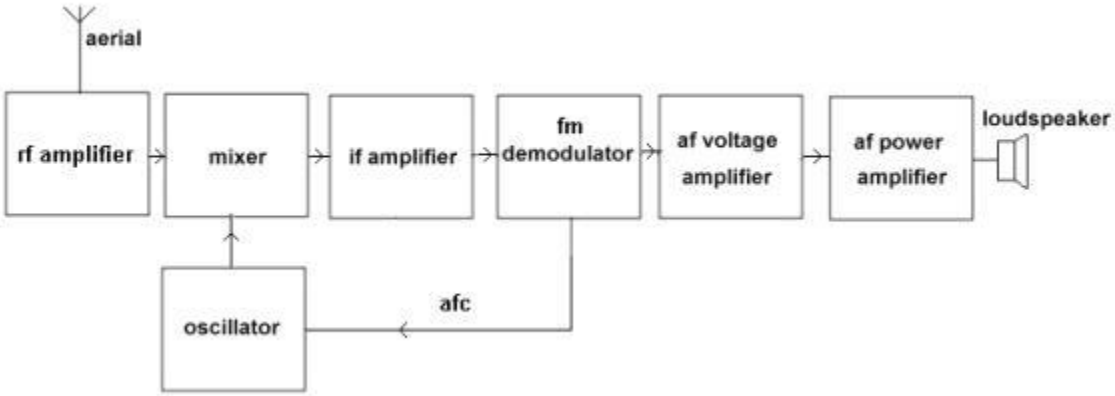
The FM transmitter is a circuit that uses a very low power to operate and uses (Frequency Modulation) FM Waves to transmit the sound. With the help of such FM transmitters we can easily transmit the audio signals through the carrier waves with different frequencies over long distance. This is what radio stations/Towers do.

The frequency of the carrier wave would be the same as for the audio signal with an amplitude. The FM Transmitter produces a range of VHF from 88 HZ to 108 MHZ.



FM receiver

FM receiver is our individual small electronic unit. It is designed to receive the FM transmitted radio signals and then demodulate, amplify signal, Noise reduction to audio signals that we can hear. This is the unit that converts the Radio signals which are not in our hearing range back to audio that we can hear with human ears as crystal clear sound.



Selection of Kit

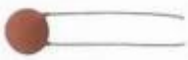
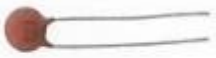
We selected a FM radio kit based on the RDA5807FP chip that supports a global frequency range of 76 Mhz - 108Mhz.

Specifications:

- based on IC RDA5807FP
- Voltage: DC 3V, Current:19mA
- Frequency:76-108Mhz
- Output impedance:32 ohm
- Temperature:-40℃~85℃
- Humidity:0%~95%RH
- Size :57*32*20mm

Summary Of Components (parts list):

The kit has 19 electronic components and a circuit board. As listed below:

NO.	Picture	Name	Marker	Parameter	QTY
1		Resistor	R1	30K	1
2		Inductor	L1	0.1uH	1
3		Inductor	L2, L3	1uH	2
4		Crystal Oscillator	Y1	32.768KHz	1
5		Ceramic Capacitor	C1	24pF	1
6		Ceramic Capacitor	C2	0.01pF(103)	1
7		Ceramic Capacitor	C3	0.022pF(223)	1
8		Switch	S1-S5	6*6*5mm	5
9		Electrolytic Capacitor	C4, C5	100uF/16V	2
10		Audio Jack	J1	3.5mm	1
11		IC chip SOP-16	U1	RDA5807FP	1
12		Battery Box		AA*2	1
13		Straps		6mm/2.36in	3
14		PCB Board		56*30*1.6mm	1

IC : The main component of this kit is RDA5807FP Integrated Circuit or IC. This is the only active electronic component in this kit. RDA5807FP has different modules integrated inside. Such as, Low noise amplifcation, noise removal, Frequency demodulation, Programmable gain control, Digital signal Processors, High Fidelity Digital to analog converters.

Capacitors: They store electrical charge. Unit is Farad.There are 3 ceramic capacitors and two Electrolytic capacitors. Ceramic capacitors provide low capacitance in picofarad range and have lower voltage lange. Electrolyte capacitors provide capacitance in microfarad range and even higher. They have a higher voltage range. They can also store larger charges.

Resistor: They provide resistance to current. Unit is in Ohms. There is only one ceramic resistor used.

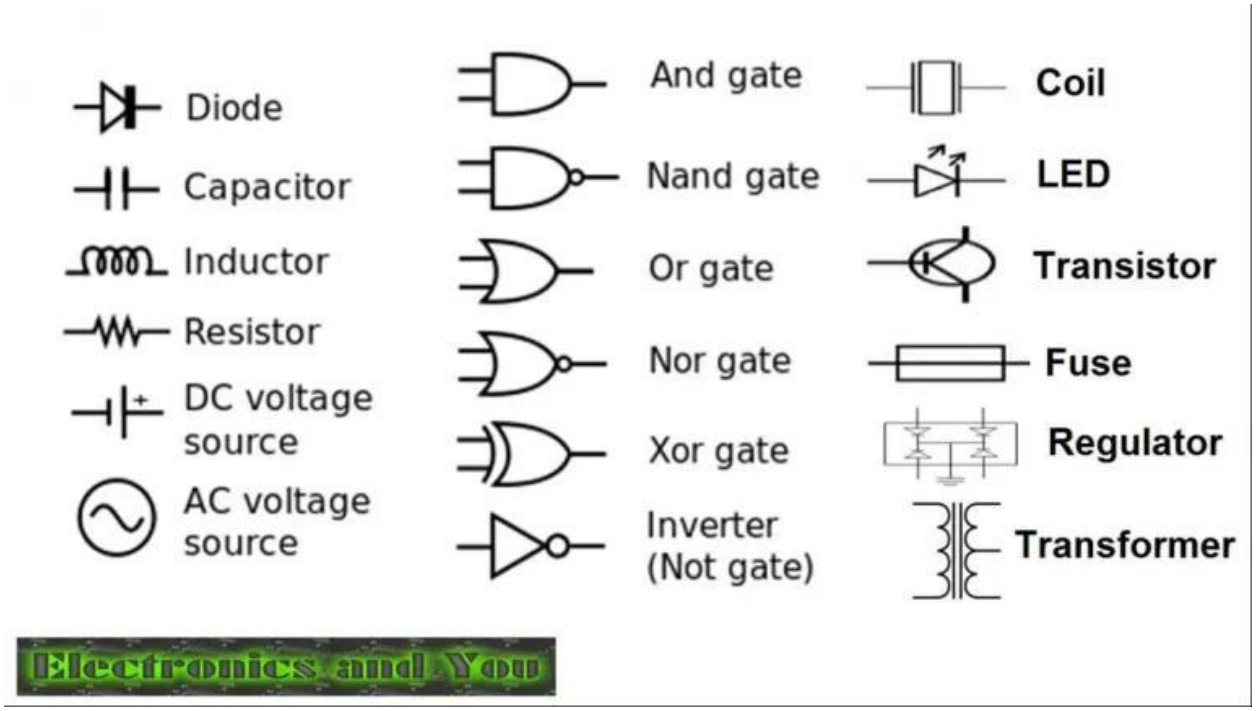
Inductor or Coils: They provide oscillation and magnetic feld. Unit is Henry. There are 3 inductors used in this circuit.

Crystal : It provided a constant frequency oscillation. Unit is in Hertz.

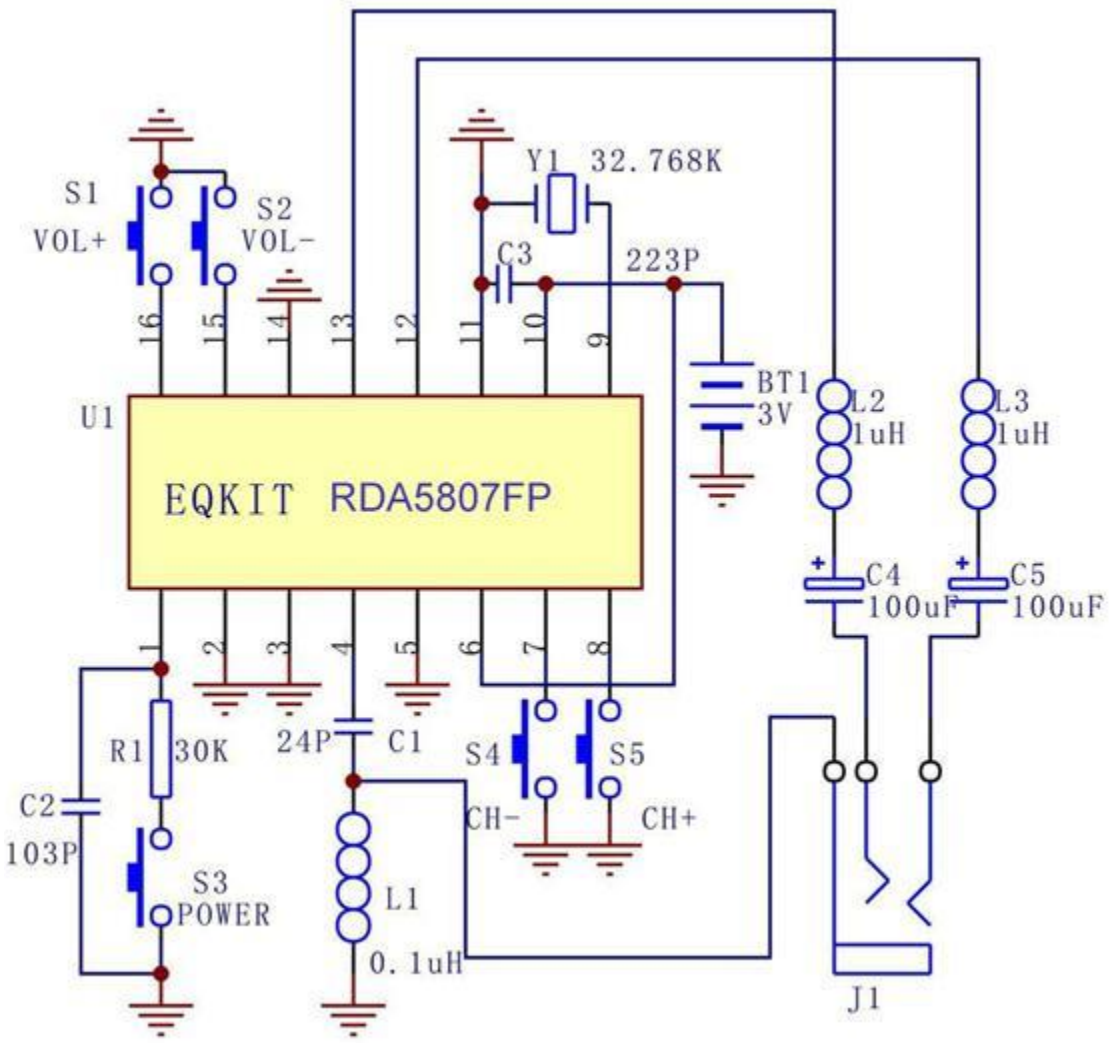
Switches: There are 5 switches that provide ON-OFF pulses to the IC to provide a digital input that changes the Output. Such as ON-OFF of the unit, volume high-low, Frequency UP-Down.

Other components: There is one Printed Circuit Board (PCB) that can hold all the components. The components needed to be soldered on the PCB as per the circuit diagram. There is one 3V battery box that will hold 2 AA batteries. One 3mm audio jack, where we can connect headphones.

Basic Symbols of electronics components.



Circuit Diagram



Pin 9 received the crystal clock oscillation.
Pin 10 is for 3V power input.
Pin 12 and 13 are audio output via inductor and electrolyte capacitor to audio jack.
Pin 4 is FM input. The FM input signal is provided via an Inductor and a capacitor.
Pin 1 is for Power On-OFF signal
Pin 15 and 16 are for changing the volume.
Pin 7 and 8 are for changing the channel.

Building Process

After understanding the theory of how the IC is supposed to work and how different electronic components will fit together on the circuit board, we were very excited to solder the components. Our coach showed us how the soldering process works and how we should be taking precautions with eye goggles and gloves. It is fun to solder components on PCB. We were so excited to build it from scratch. We did not know if we were making any mistakes and the only way to verify it was after building the kit.

Testing Process. After soldering all the components, we put in 2 fresh AA batteries and connected the headphone to the audio jack. We were so excited to see if we had really built a FM radio. Will it work? We tried to listen to the audio and we were very disappointed to know that it did not work. Our Coach instructed us to Debug the build. We did not know what it meant. Coach explained to us that you have to use a tool called Digital Multimeter. DM helps us to test connections by measuring the resistance between 2 points. It also measures voltage between 2 points and can also test current flowing between 2 points. We started with the Battery. The Battery box has 3V as shown by the DM. But the pin 10 of the IC did not have 3V. We noticed that the soldering on that point was weak. The coach explained that as a “Dry Solder” problem. We redid the soldering to pin 10 and we checked the voltage again and it was 3v at pin 4. Now we tried the headphone again, Hurray! We were able to hear crystal clear FM radio stations. It was so exciting and so fulfilling to build something from scratch and see it working as expected.

Conclusion and Lessons Learned.: It was such a learning experience to understand how a song transmitted hundreds of miles away can be received as a crystal clear sound by using just a few electronics components. We as students emerged deep in different types of electronics. Phone, TVs, Video games, Laptops, Internet to name a few. We always look at it as a black box. We gave them power as input and they provided. This is the first time we learned what goes inside an electronic device. Soldering was a cool experience. We felt like a mechanic working on rebuilding a car engine. Debugging was a vital experience. We learned that nothing works as expected right off the bat. Engineering builds are iterative processes that need a few steps forward and sometimes few steps backwards.

We learned about the block diagrams of FM transmitter and Receiver and the theory of Radio transmission, Frequency modulation and FM receiver.

We also learned about different electronics components and properties and measurement Units of them and the symbols of different components. How different components play different roles and fit in together as analogous to symphony orchestra. All coming in together at the right place, playing the part at the right time, right amplitude, to create beautiful music. .

Credits

https://datasheet.lcsc.com/lcsc/1809102009_RDA-Microelectronics-RDA5807FP_C77689.pdf

https://www.etechnog.com/2019/10/fm-transmitter-block-diagram-working.html

https://www.electronicsandyou.com/basic-electronic-components-types-functions-symbols.html https://www.hobbyprojects.com/block_diagrams/fm_receiver.html

https://electronics.howstuffworks.com/radio.htm

https://www.explainthatstuff.com/antennas.html

.