The Basic FM Transmitter

Cleveland State University
Nathanael Dolesh, Patrick Donnelly, Oliver Tiber, Ryan Walsh.
Advisor: Dr. Charles Alexander

Intro

Edwin Howard Armstrong was the inventor of the wide band FM (Frequency Modulation). After he threatened to take his invention to Europe, the FCC finally let him construct a 42-50 MHz transmitter tower in Alpine, New Jersey in the late 1930's. Armstrong then gave licenses to General Electric along with Zenith to begin manufacturing FM receivers. In 1942 there were 50 FM radio stations airing and approximately 500,000 FM receivers in use. However, the FCC took the 43-45 MHz frequency being used for radio, and made it into the emergency frequency, thus the 50 radio stations along with the half million receivers were useless. Today, the frequency reserved for FM radio transmission is between 88 MHz and 108 MHz. Frequencies for TV channels 2 to 13 occupy 54 to 216 MHz, but the FM radio occupies channels 6 and 7. FM radio frequencies have a better overall sound quality, less static, than AM (amplitude modulation) frequencies. However, AM can cover a much greater area. Now FM transmitters are used for many different applications, such as playing music from your iPod/MP3 player into your car stereo system. They are also very easily attainable and inexpensive; you can find cheap ones for under $10.

Abstract

The Basic FM Transmitter
Patrick J. Donnelly, HSDG, Nathanael Dolesh, HSDG, Oliver Tiber, HSDG, Ryan Walsh, HSDG
Fenn College of Engineering, Cleveland State University

This poster is about the components and elements in a basic FM transmitter, as well as how it works. FM means Frequency Modulation, which is when the input voltage in a circuit is adjusted and the output frequency of the circuit changes in direct proportion to the voltage change. A basic FM transmitter uses capacitors, inductors, transistors, amplifiers, and oscillators in order to create a signal that is then transmitted through an antennae. There are many different elements to even a circuit as small and simple as this one. In fact there are several different circuits that can perform the job as a FM transmitter. This particular circuit uses a Colpitts oscillator in order to amplify the signal. Along with the many different components and elements to this circuit there is also many different mathematical equations that can help to explain how the circuit works. For example the equation for the voltage gain of the self-biased amplifier in this circuit is listed below and shows what the change in the voltage is in the circuit. This particular transmitter has the ability to broadcast for approximately 300 meters in the open air, and can even broadcast through apartment walls.

List of Equations

Inductors:

$i_L = 1/L \int_{t0}^{t} v(t)\,dt + i(t0)$

$v_L = L(di/dt)$

Capacitors:

$i_C = C(dv/dt)$

$v_C = 1/C \int_{t0}^{t} I\,dt + v(t0)$

Self-Biased Amplifier:

$v_l/v_s = (r_{in}/(r_s+r_{in}))A_v(R_L/(R_L+r_d||R_D))$

Colpitts Oscillator:

$f_0 = 1/2\pi\sqrt{(LC/2)}$

Hartley Oscillator:

$f_0 = 1/2\pi\sqrt{(2LC)}$

A Basic FM Transmitter Circuit

Figure 1

The Electret Microphone

The electret microphone is a permanently charged dielectric. The microphone uses a slice of ceramic material, which has been made into an electrostatic equivalent of a permanent magnet, as a part of the dielectric of a capacitor in the microphone. Sound going into the microphone creates sound pressure, which then moves one of the plates in the capacitor. Thus the capacitance is changed. The electret capacitor is then connected to an FET amplifier.

Diagram of Circuit

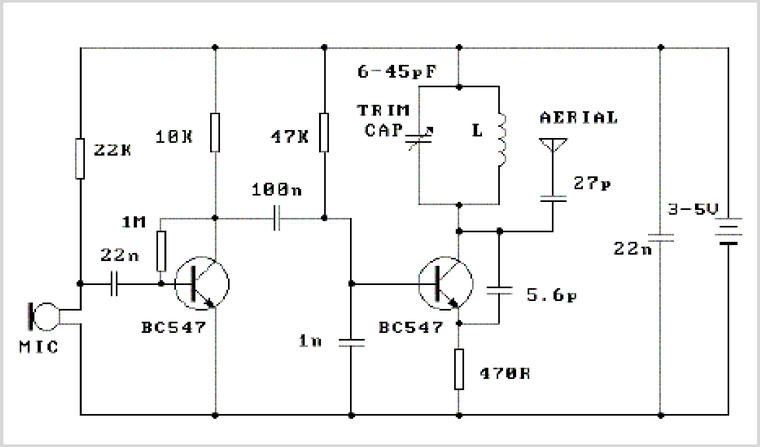

Figure 2

Audio Amplifier Stage

In order for a signal to be created for broadcast, first there needs to be a sine wave. A sine wave is created using the sound taken from the microphone, and then transferring it through a capacitor and inductor in parallel. This sine wave is then amplified into a powerful signal using transistors. At the first amplifier in the circuit, the 22nF capacitor isolates the microphone from the base voltage of the transistor and strictly allows only AC current to pass. The signal then goes through the LC tank circuit which is part of the Colpitts oscillator that sends the signal to the antenna.

List of Components

Resistors:	Capacitors:	Voltage Source:
1MΩ	1nF	3 – 5V
47KΩ	5pF	
22KΩ	22nF	
10KΩ	27pF	
Inductor:	**Transistors:**	**Variable Capacitor:**
5 turn coil	BC547, 548	6 – 45pF

Circuit Elements

Jumper Wire: Used to transfer a signal across a gap between two contact points.

Varicap Diode: Diode containing a variable capacitance.

Diode: This component is used to tune radio frequency oscillations.

Resistor: This component dissipates power flowing through the circuit.

Capacitor: This item can be used to filter out interference and create a smother output, or select a particular frequency.

Trim Potentiometer: A trim potentiometer is used to divide voltages that are applied to it.

Trim Capacitor: This capacitor allows for adjustment of the capacitance of the parallel combination of the system.

Transistor: This device amplifies the electric signal.

Electret Microphone: This microphone uses a permanently charged material.

Calibration

In order for a receiver to pick up this particular transmitter's signal, the circuit must first be calibrated. This specific transmitter has a broadcasting range of approximately 10ft, and the receiver must be set to somewhere between 89 and 90 MHz. The circuit is then calibrated by giving power to it and turning the trim cap from 6pF to 45pF. The FM dial on the receiver may be turned up and down after each turn on the trim cap, in order to better receive the signal.

Conclusion

From the equations and terminology above, we can conclude that a FM transmitter is not as simple as it appears to be. There are many different components and elements all with different purposes that work together in order to create a signal with a high enough frequency to be broadcast. Just by looking at the diagram we can see that this particular circuit is fairly small, but at the same time can be very complicated. We now understand the general process of how sound is put into the mike, and then transferred through the circuit, and then amplified to a frequency which can be broadcast from an antenna. This basic circuit is just the one of many different types of circuits found in everyday electronics.