FM Transmitter

LAB REPORT

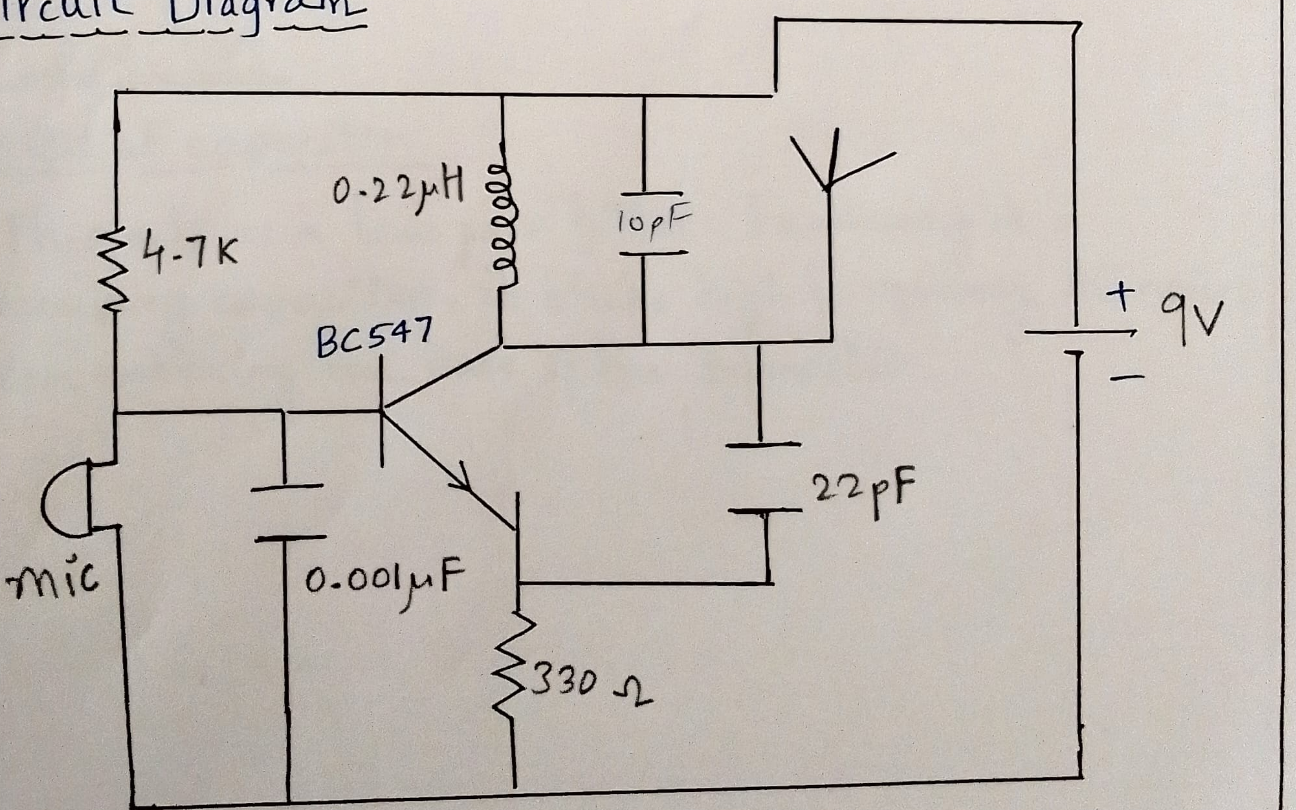
Dhanush V Nayak
EE23BTECH11015

Aim: The aim of this expeuiment is to build FM Transmitter circuit using BC547 Transistor. Also we aim to understand principles of FM modulation.

Components:

1) Condenser Mic
2) BC547 Transistor
3) Antenna (single Stranded wire)
4) 0.22μH indutor
5) 330Ω and 4.7KΩ resistor

Circuit Diagram



Working:

1) Tap Microphone

It works on the principle of piezoelectric effect. Therefore when we tap microphone, it converts the mechanical stress/energy into eletric signal.

- This signal represents the sound of the tap and is typically in form of rapid oscillations of voltage.

2) Base Band Signal Processing

- AC signal from the microphone is sent to the base terminal of the transistor BC547.
- This signal represents our baseband signal.

3) Capacitors

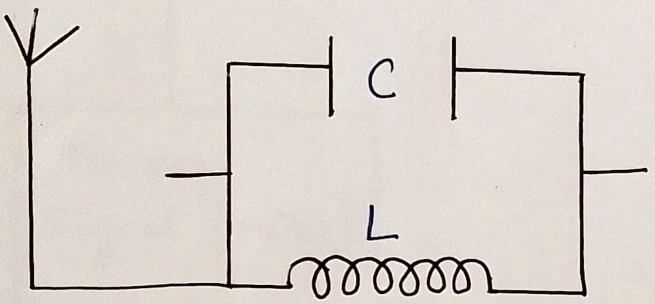
0.001 µF capaciton

- This acts as a low pass filter. Funtioning as a decoupling capacitor, it blocks high frequency AC noises from entering the base of the transistor.

4) LC Tank Circuit

- The Tank Circuit consists of the inductor and a ceramic capacitor. It acts like a electric resonator.

- This part of circuit is responsible for generating carrier frequency.



$$\boxed{f = \frac{1}{2\pi\sqrt{LC}}}$$

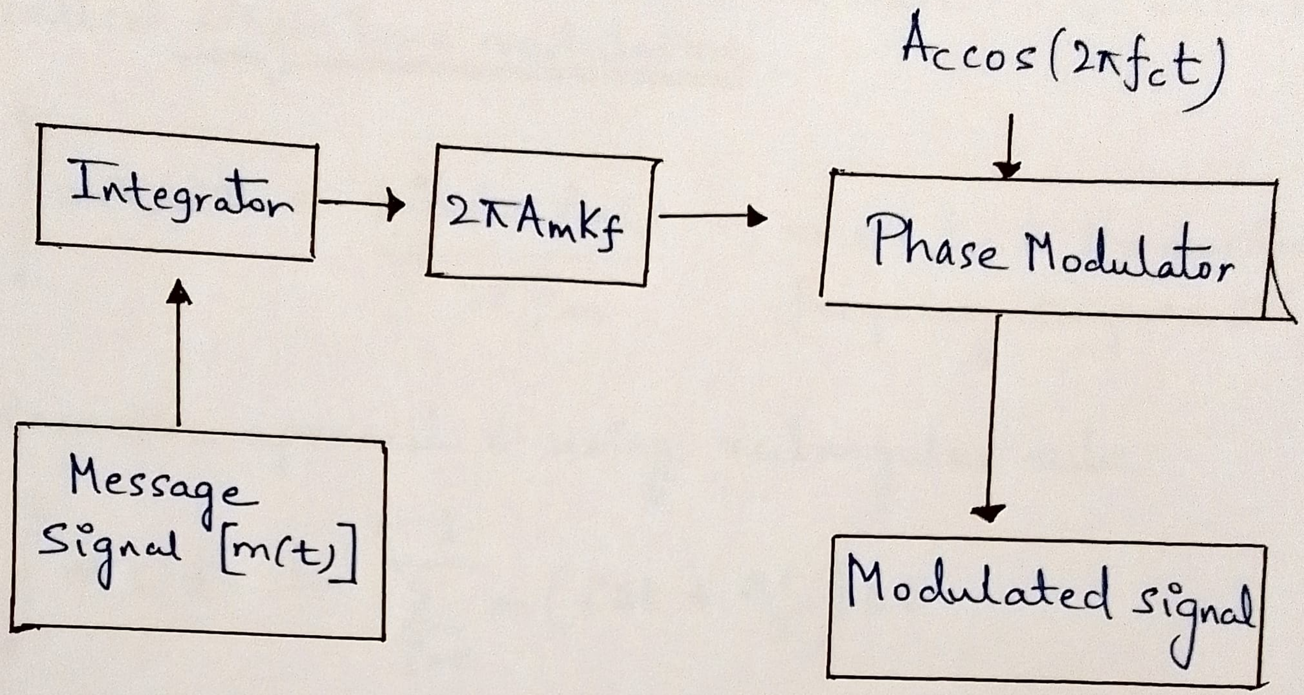
- When the circuit is powered on, current oscillates back and forth between inductor and capacitor at this resonant frequency.

- Here the capacitor should not be electrolytic as both sides of the capacitor the charging should take place. If we use electrolytic capacitor, the leads get polarised.

- The transistor here amplifies the weak audio signals. The amplified audio signal is coupled and circuit oscillates at its resonant frequency.

- The antenna radiates the modulated FM signal as radio waves.

FM Modulation:→



A_m → amplitude of modulating signal
K_f → sensitivity of frequency modulator
f_c → carrier frequency.

Modulated signal is given by:

$$\boxed{y(t) = A_c \cos\left(2\pi f_c t + 2\pi f_\Delta \int_0^t m(\tau)\,d\tau\right)}$$

$f_\Delta = A_m K_f$

where f_Δ is the frequency deviation.

From computation perspective the baseband signal can be approximated as a sinosodual wave. This method is called <u>single tone modulation</u>.

$$\int_0^t m(\tau)\,d\tau = \frac{\sin(2\pi f_m t)}{2\pi f_m}$$; where f_m is the maximum frequency component.

alternative approach is using rectangular rule.

$$\int_0^t m(\tau)\,d\tau = \sum_{i=0}^{N-1} m\left(i\Delta t + \frac{\Delta t}{2}\right)\Delta t$$

$N \rightarrow$ number of intervals ; $\Delta t = t/N \longrightarrow$ time step

<u>Using these techniques:</u>

$$\boxed{y(t) = A_c \cos\left(2\pi f_c t + 2\pi A_c k_f \cdot \sum_{i=0}^{N-1} m\left(i\Delta t + \frac{\Delta t}{2}\right)\Delta t\right)}$$

Carson's Rule states that nearly 98% of the power of a frequency-modulated signals lies in its Bandwidth.

Consider computing fourier transform of $y(t)$; using DFT.

$$\boxed{Y(K) = \sum_{n=0}^{N-1} y(n)\, e^{-j2\pi kn/N}}$$

Power Spectral Density:

$$PSD = |Y(k)|^2$$

After computing PSD of modulated signal; we apply a masking function for better results and accuracy of spectral density.

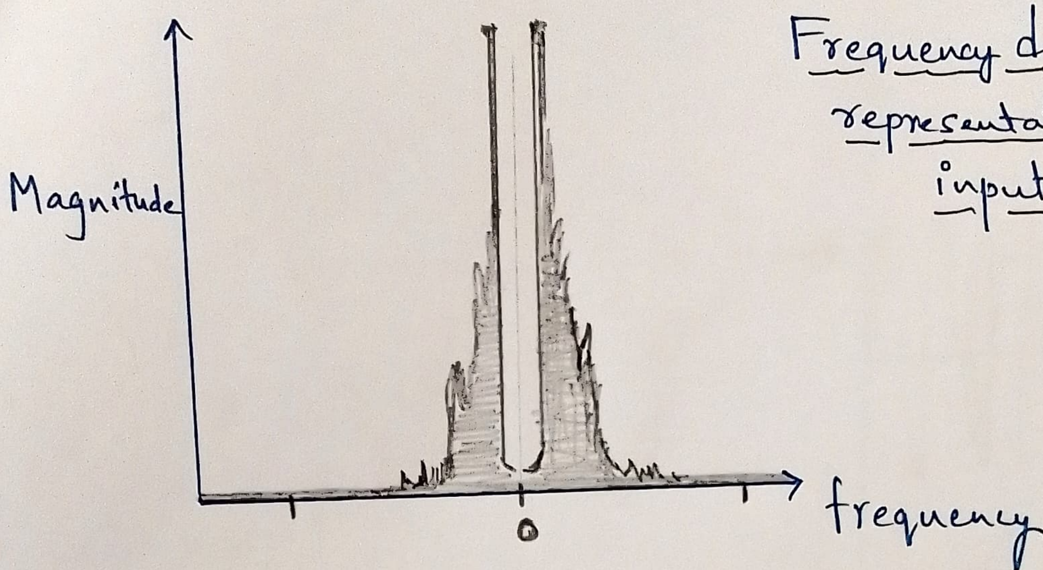
Masking Function; its like creating a threshhold and selecting frequencies above it.

Modulation Index:→ $h = \dfrac{\Delta f}{f_m}$

$h \ll 1$; narrow band FM

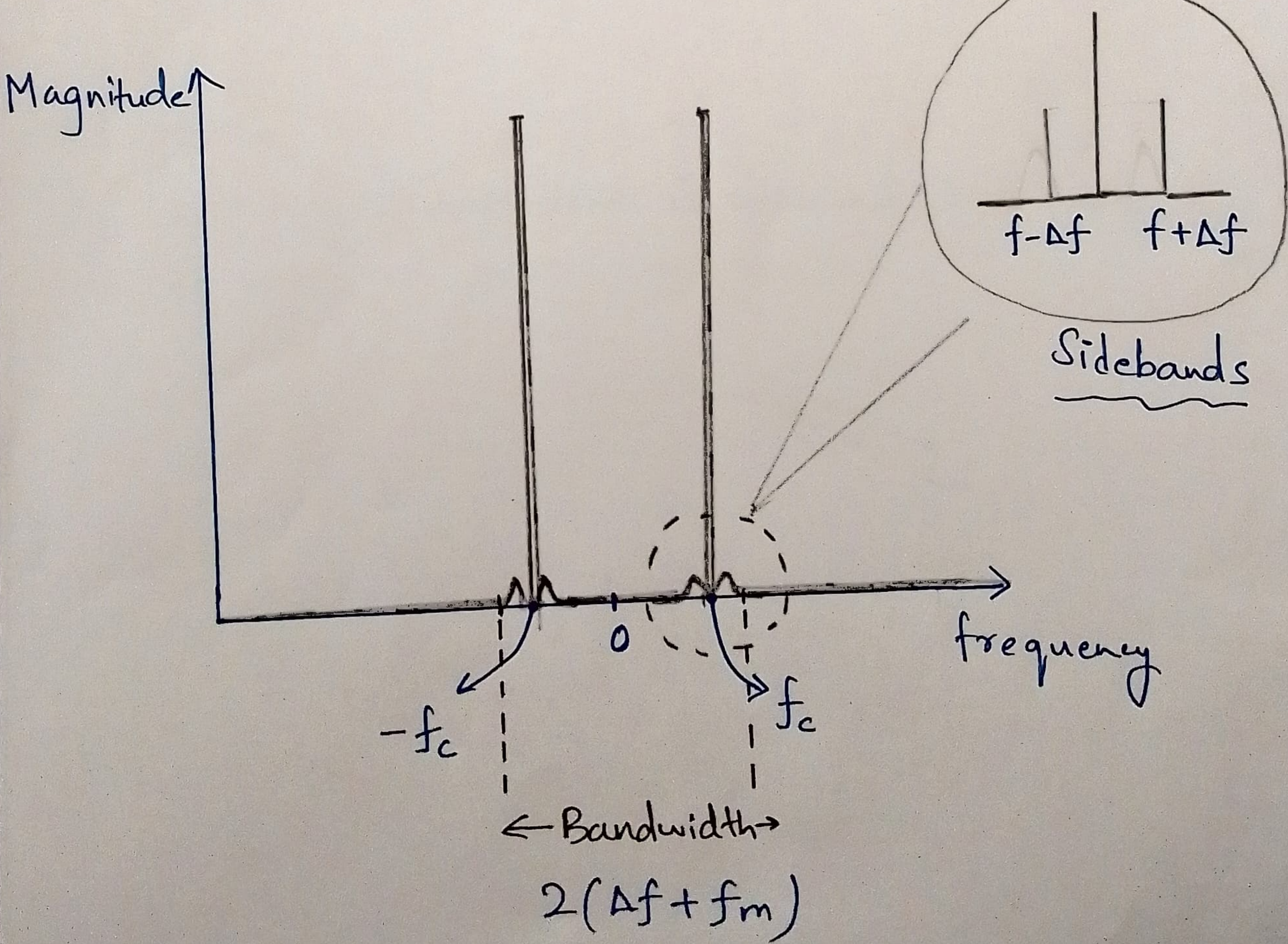
$h \gg 1$; wideband FM

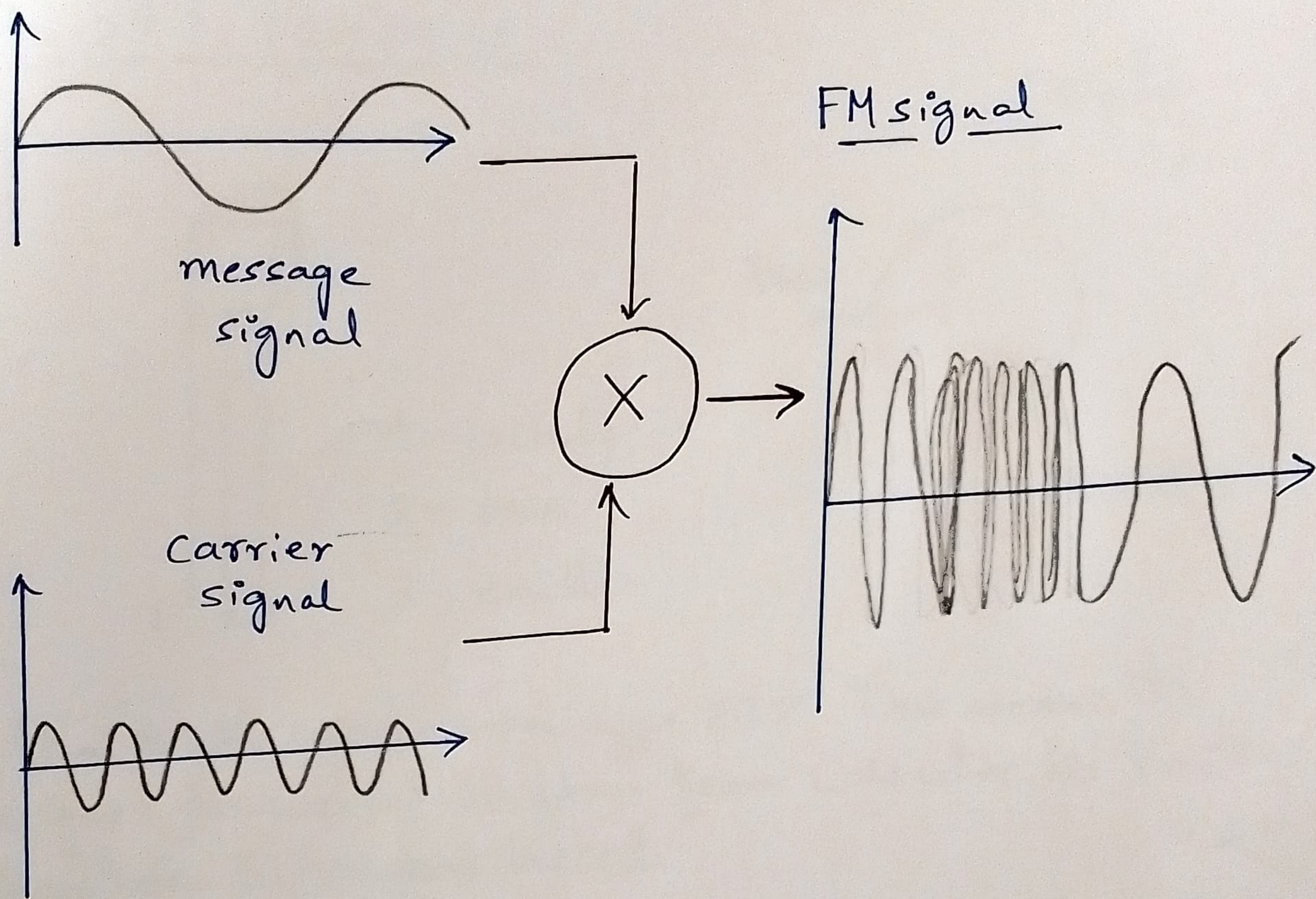
Sample input signal. (m(t))



Frequency domain representation of input signal.

Y(k) representation.

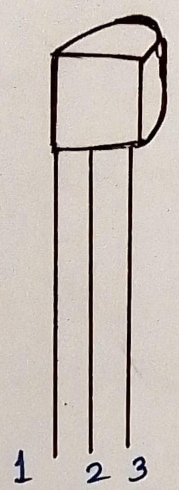




Observations:

The frequency transmission is observed at a frequeny 97.3 MHZ.

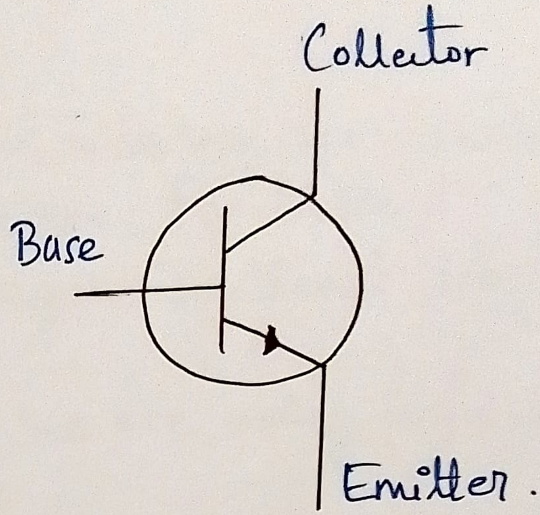
BC 547 Transistor



1– collector

2– base

3 – emitter



- The BC547 is an NPN type BJT. This means it's designed for current to flow from Collector to Emitter when base is forward biased.

- When a positive voltage is applied to base relative to emitter the base-emitter junction the base emitter junction becomes forward biased. This allows majority charge carriers from emitter to flow into base region.

- Even though base current is small due to thin base region, it creates strong electric feild. The feild significatly effects the depletion region around base-collector junction.

Precautions :-

1) Placement and Orientation of the antenna are crucial for optimal transmission performance. For better transmission make sure that length is atleast $\lambda/4$.

2) Ensure that the power supply we are using for circuit should be stable and regulated.

3) Make sure to use less number of connecting wires to prevent noise.

Conclusion :

We were succesfully able to demonstrate the working of FM Transmitter. The bandwidth of the transmitted signal can be modified by changing or make some changes in the tank circuit.