AM/FM Radio Receiver

- A radio receiver consists of the following:
  - A Radio Frequency (RF) section
  - An RF-to-IF converter (mixer)
  - An Intermediate Frequency (IF) section
  - Demodulator
  - Audio amplifier

AM/FM Radio Receiver

- This is known as the “Superheterodyne” receiver
- Two stages: RF and IF

  (filtering and amplification)
- The receiver was designed by Armstrong

AM/FM Radio Receiver

- RF Section
  - Tunes to the desired RF frequency, f_c
  - Includes RF bandpass filter centered around f_c
  - The bandwidth B_{RF}
  - Usually not narrowband, passes the desired radio station and adjacent stations

AM/FM Radio Receiver

- The minimum bandwidth of RF filter:

$$B_{RF} > B_T$$

- Passes the desired radio channel, and adjacent channels

AM/FM Radio Receiver

- RF-IF converter:
  - Converts carrier frequency → IF frequency

- How can we convert signals with different RF frequencies to the same IF frequency?

AM/FM Radio Receiver

- Local oscillator with a center frequency f_{LO}
- f_{LO} is a function of RF carrier frequency

$$f_{LO} = f_c + f_{IF}$$

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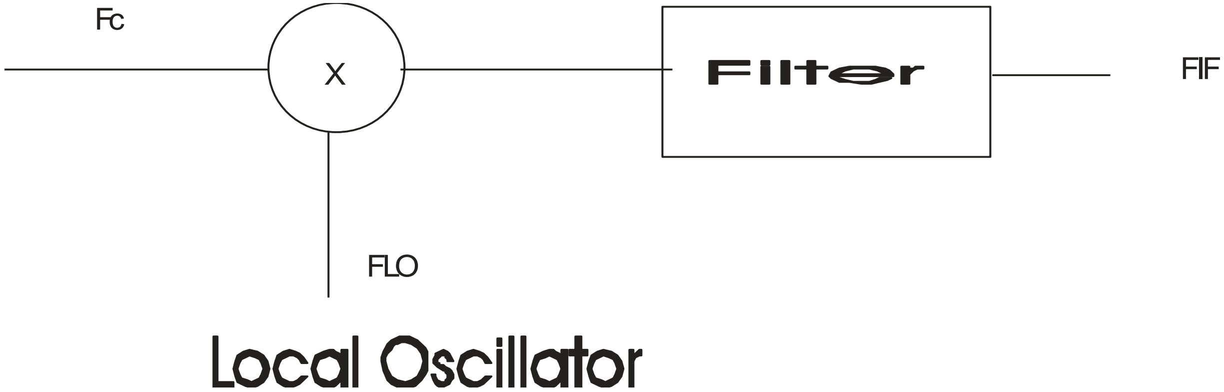
- RF-to-IF receiver includes:
  - An oscillator with a variable frequency f_{LO} (varies with RF carrier frequency)
  - By tuning to the channel, you are tuning the local oscillator and RF tunable filter at the same time.

AM/FM Radio Receiver

- All stations are translated to a fixed carrier frequency for adequate selectivity.



AM/FM Radio Receiver

- Two frequencies are generated at the output of product modulator:

$$f_{LO} + f_c = 2f_c + f_{IF}$$

$$f_{LO} - f_c = f_{IF}$$

- The higher frequency component is eliminated through filtering
- We are left with IF frequency

AM/FM Radio Receiver

- One problem with this receiver:

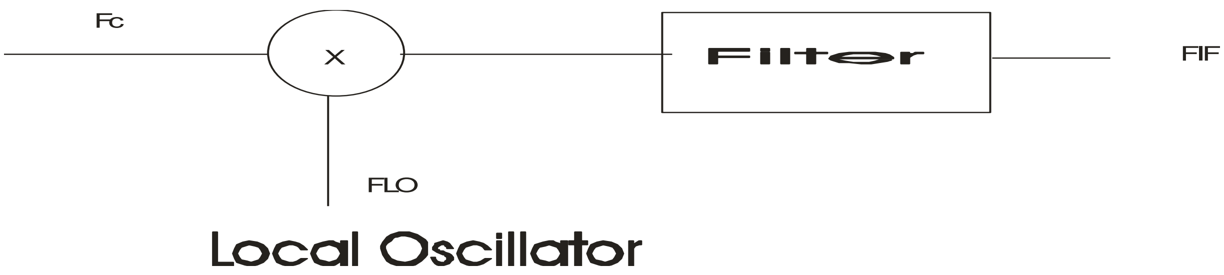
  "Image Signal"

- Image signal has a center frequency:

$$f_i = f_c + 2f_{IF}$$

AM/FM Radio Receiver

- If an "image signal" exists at the input of the "RF-to-IF" converter, then the output of the converter will include the desired signal + image signal



$$f_{LO} + f_i = (f_c + f_{IF}) + (f_c + 2f_{IF}) = 2f_c + 3f_{IF}$$

$$f_{LO} - f_i = (f_c + f_{IF}) - (f_c + 2f_{IF}) = -f_{IF}$$

AM/FM Radio Receiver

- Example: Incoming carrier frequency 1000 kHz,
- Local oscillator = 1000+455=1455 kHz
- Consider another carrier at 1910 kHz
- If this is passed through the same oscillator, will have a 1910-1455=455 kHz component
- Therefore, both carriers will be passed through RF-to-IF converter

AM/FM Radio Receiver

- Therefore, RF filter should be designed to eliminate image signals
- The frequency difference between a carrier and its image signal is: $2f_{IF}$
- RF filter doesn't have to be selective for adjacent stations, have to be selective for image signals
- Therefore,

$$B_T < B_{RF} < 2f_{IF}$$

AM/FM Radio Receiver

- IF filter:
  - Center frequency f_{IF}
  - Bandwidth approximately same as transmission bandwidth, B_T
  - For AM: $B_T = 2W$
  - For FM: $B_T = 2(D+1)W$

AM/FM Radio Receiver

- Depending on the type of the received signal, the output of “IF filter” is demodulated using AM or FM demodulators.
- For AM: envelope detector
- For FM: frequency discriminator