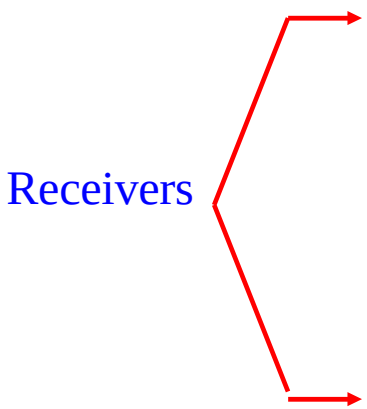
Chapter-06

Radio Receiver

Generalized Receivers

- Two types of receivers:



Tuned Radio Frequency (TRF) Receiver:
Composed of RF amplifiers and detectors.
No frequency conversion
It is not often used.
Difficult to design tunable RF stages.
Difficult to obtain high gain RF amplifiers

Superheterodyne Receiver:
Downconvert RF signal to lower IF frequency
Main amplifixcation takes place at IF

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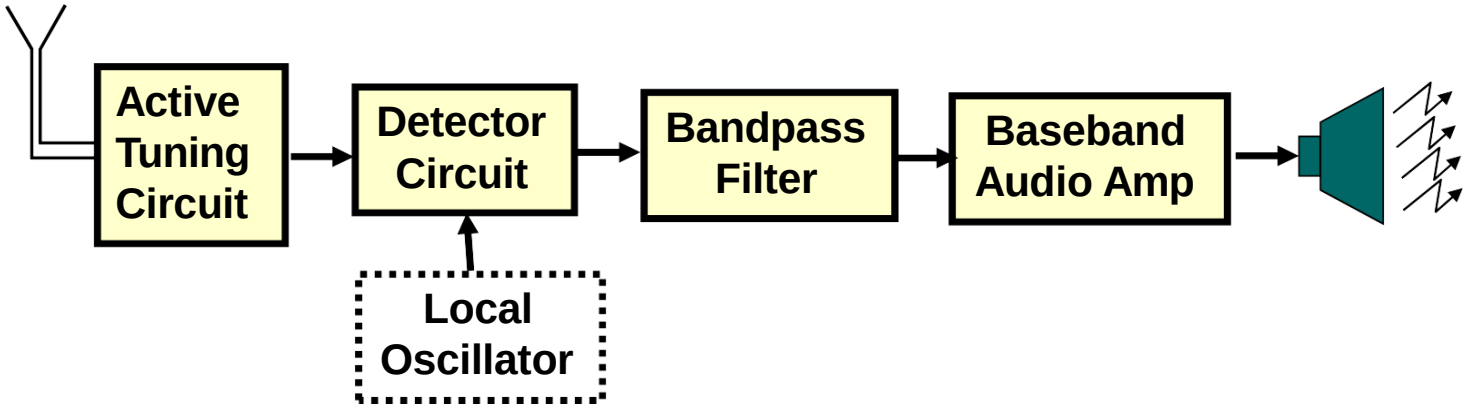
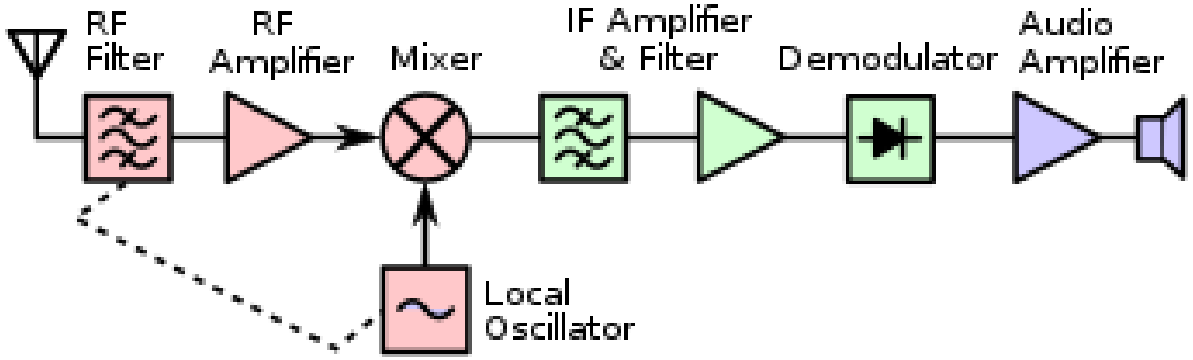
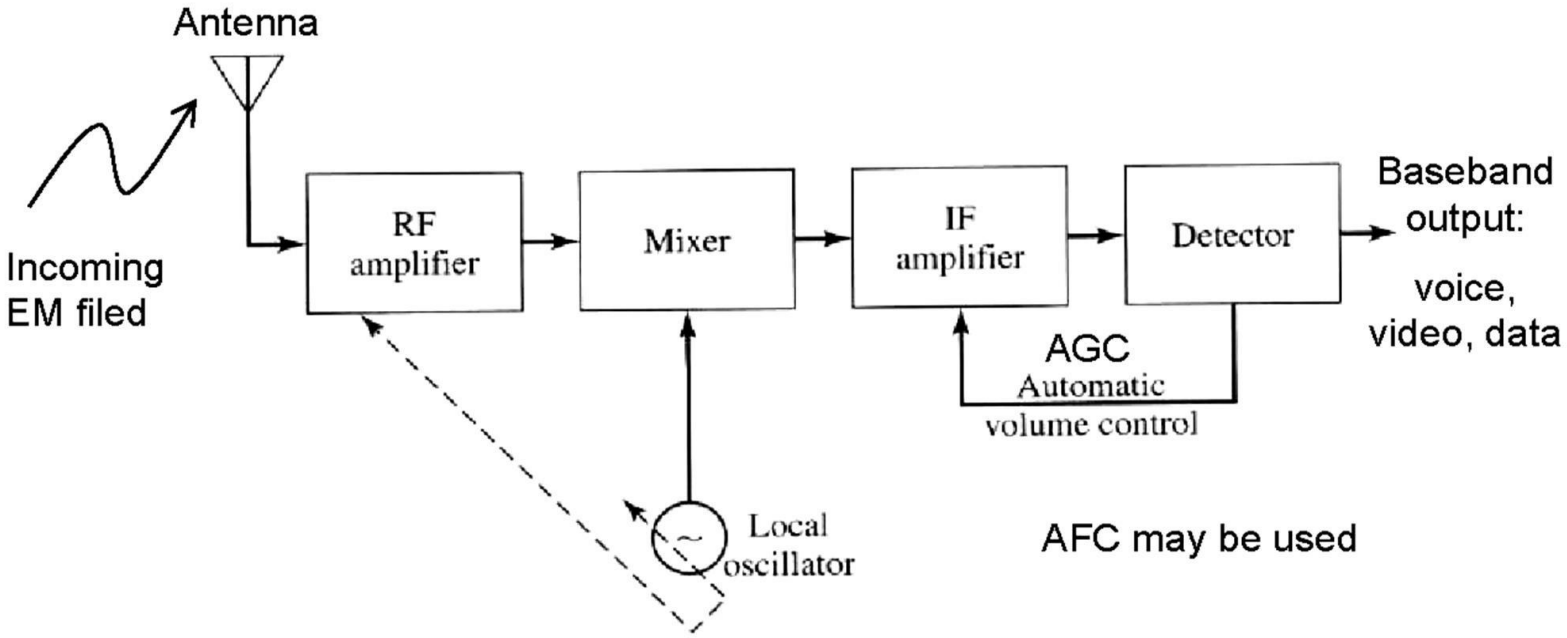


Heterodyning



Superheterodyne Receivers

- Most popular type of a radio receiver so far.
- Used for AM/FM & TV broadcasting, cellular & satellite systems, radars, GPS etc.
- Main idea: downconvert RF signal to some fixed lower (intermediate) frequency, then amplify it and detect.



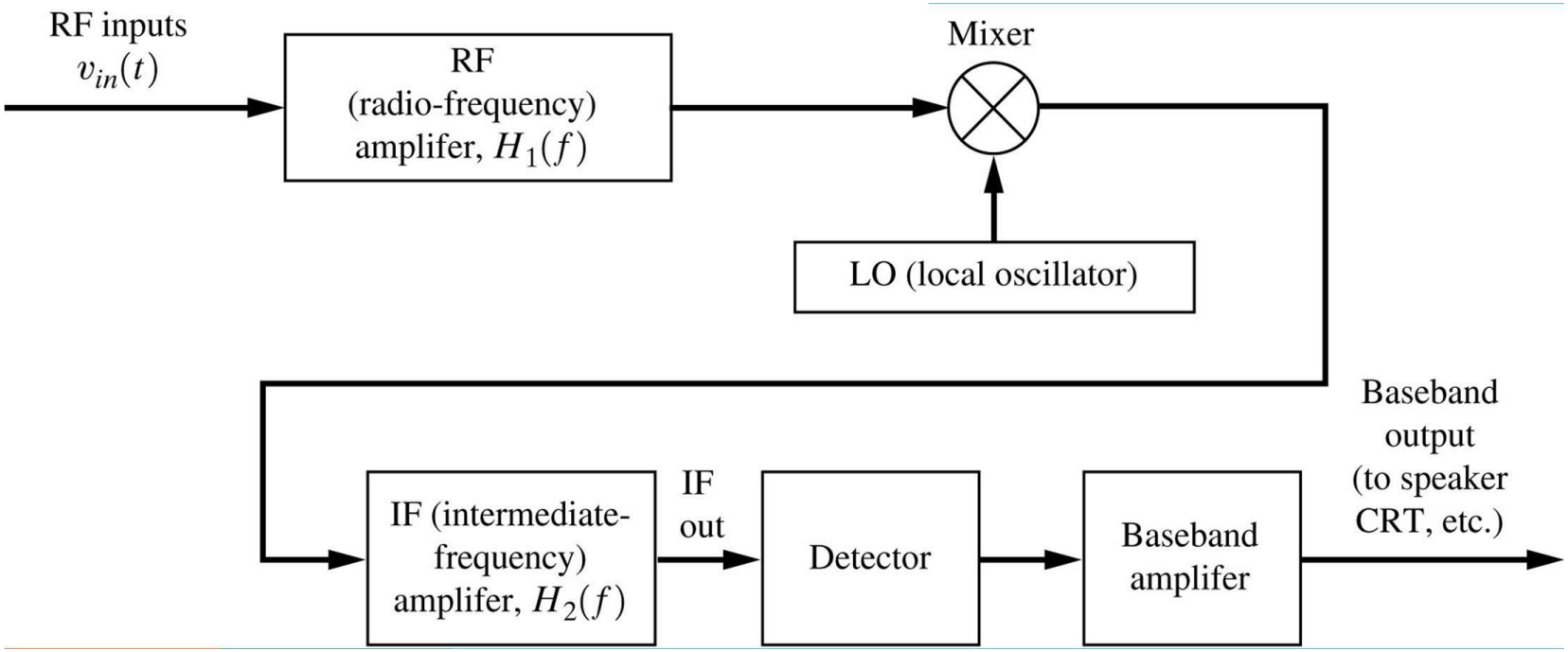
Superheterodyne Receiver Diagram

Superheterodyne Receiver

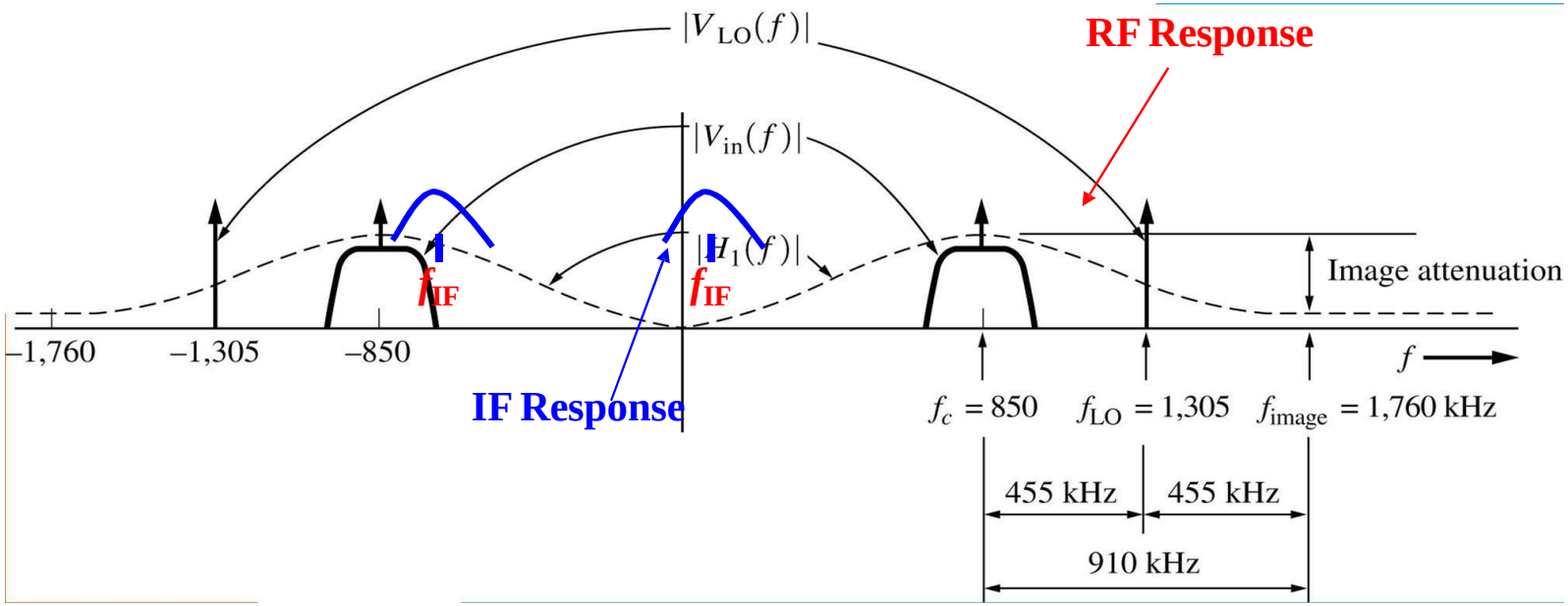
- RF amplifier: amplifies a weak RF signal coming out of the antenna. Rejects the image frequency. Bandwidth: much wider than the signal bandwidth.
- Mixer: together with the local oscillator downconverts the RF signal to the IF frequency band.
- IF amplifier: amplifies the IF signal significantly (up to 10^6) and rejects adjacent channel signals and interference (frequency selectivity). Its bandwidth is the same as the signal bandwidth.
- Detector (demodulator): demodulates (recovers) the message signal.
- AGC: adjusts the IF amplifier gain according to the signal level (to keep the average signal amplitude almost constant)
- Local oscillator: allows tuning the receiver to a desired channel (frequency).

Superheterodyne Receivers

 The RF and IF frequency responses $H_1(f)$ and $H_2(f)$ are important in providing the required reception characteristics.



Superheterodyne Receivers



Superheterodyne Receivers

TABLE 4–4 SOME POPULAR IF FREQUENCIES IN THE UNITED STATES.

IF Frequency	Application
262.5 kHz	AM broadcast radios (in auto
455 kHz	AM broadcast radios
10.7 MHz	FM broadcast radios
21.4 MHz	FM two-way radios
30 MHz	Radar receivers
43.75 MHz (video carrier)	TV sets
60 MHz	Radar receivers
70 MHz	Satellite receivers

Superheterodyne Receiver Frequencies

- IF must be such that the image response is rejected by RF amplifier.

up-side conversion

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

down-side conversion

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

- Image response: the same effect as that of the desired signal -> must be rejected!
- Image frequency: up-side conversion

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

down-side conversion

$$f_{image} = f_{LO} - f_{IF} = f_c - 2f_{IF}$$

image rejection ->

$$\Delta f_{RF} < 2f_{IF}$$

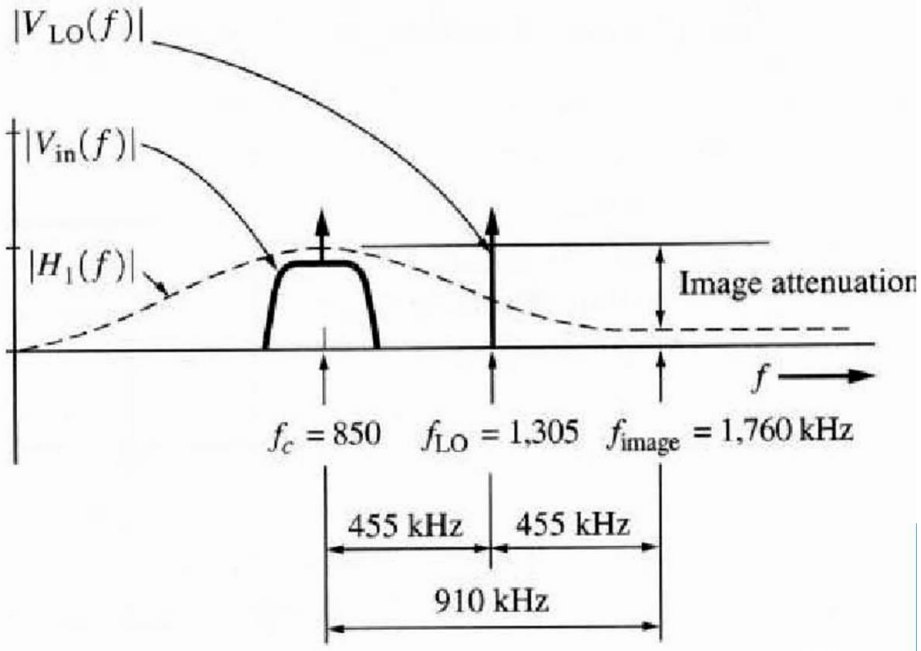
Superheterodyne Receiver Frequencies

- Incoming RF signal: $f_c = 850$ kHz IF signal: $f_{IF} = 455$ kHz
- Up-side conversion: $f_{LO} = f_c + f_{IF} = 1305$ kHz
- Image frequency: $f_{image} = f_{LO} + f_{IF} = f_c + 2f_{IF} = 1760$ kHz

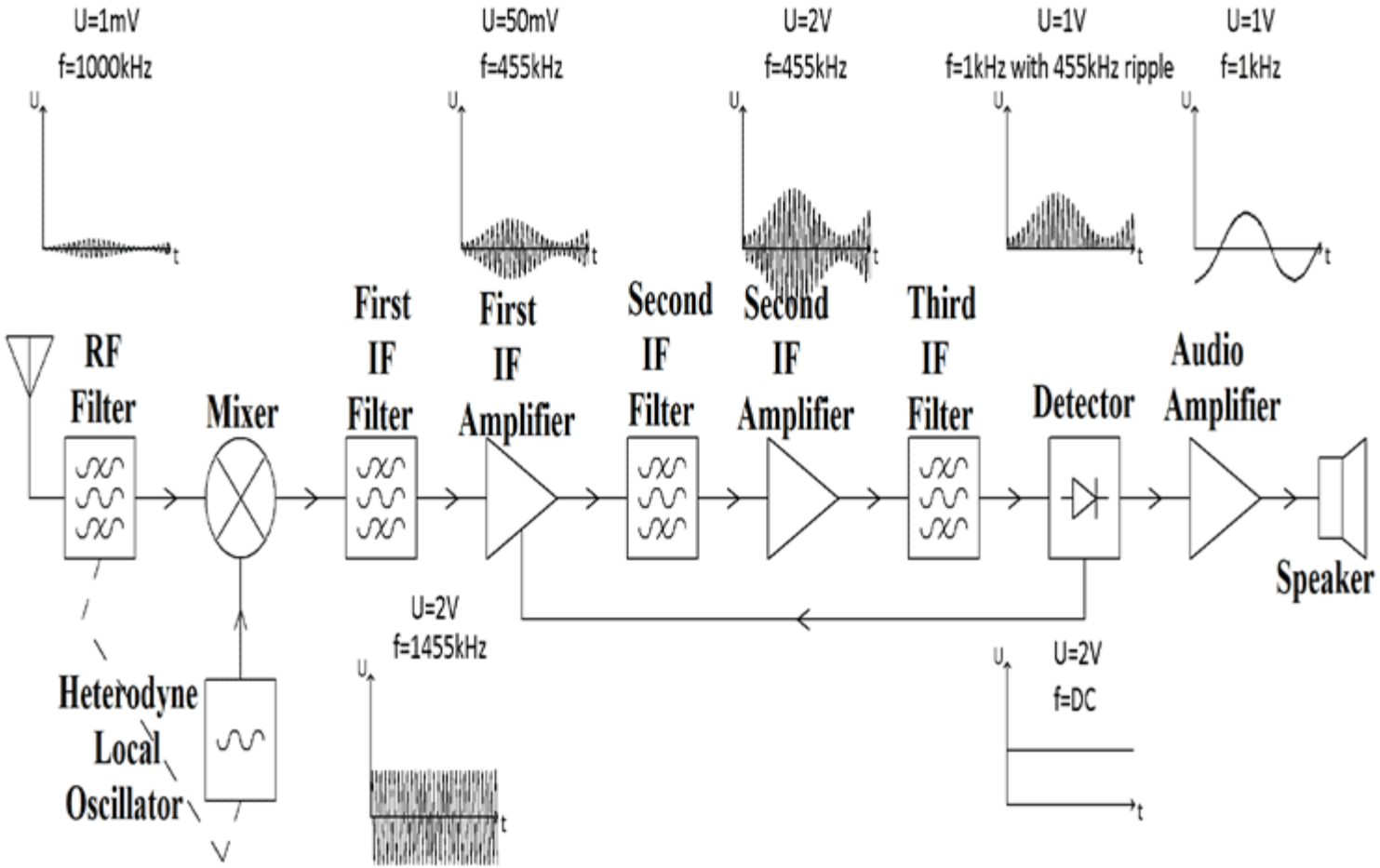
Note: image rejection is due to RF amplifier only!

IF must be high enough to reject the image response.

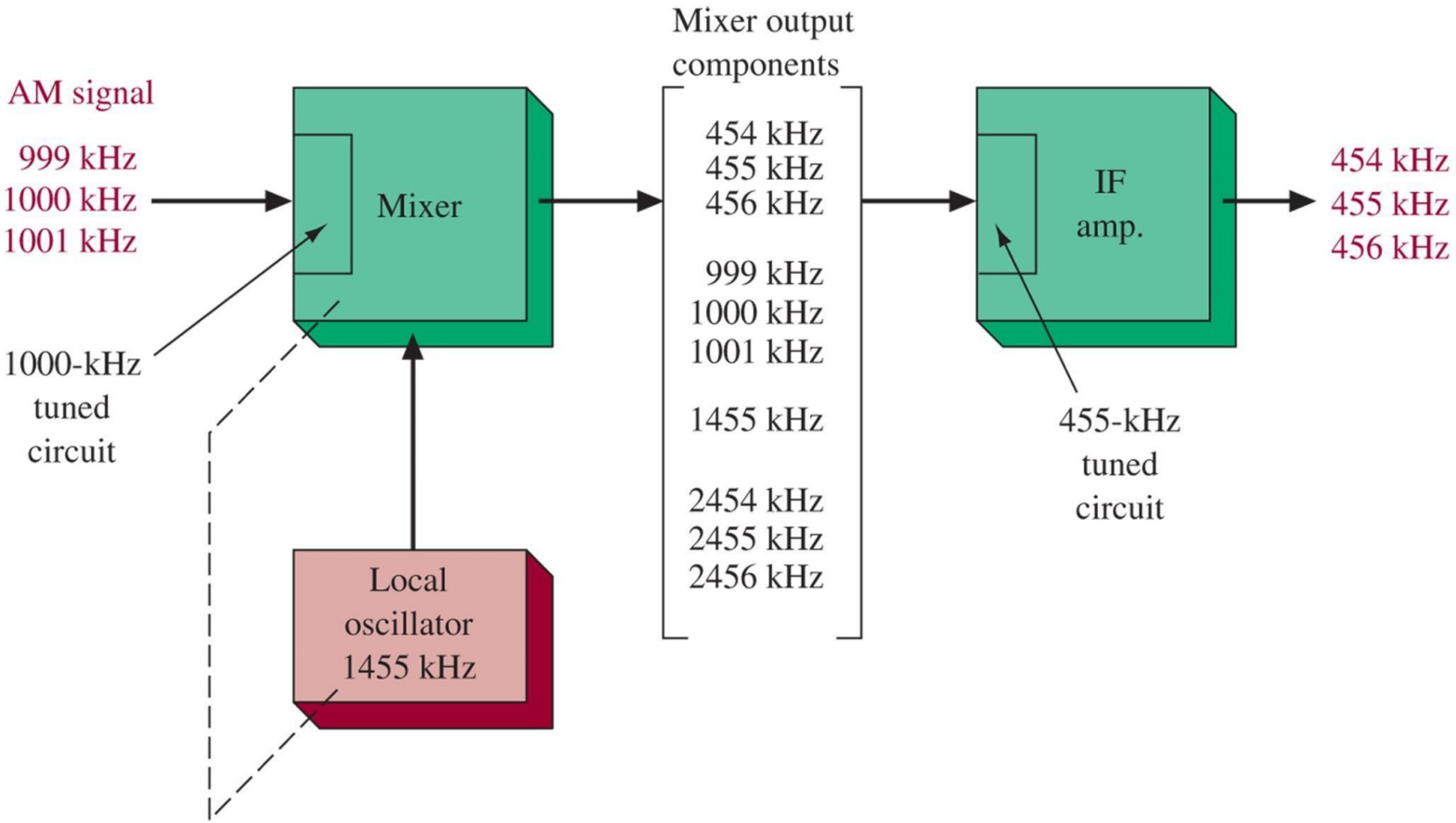
On the other hand, IF must be low enough to provide large gain and adjacent channel rejection.

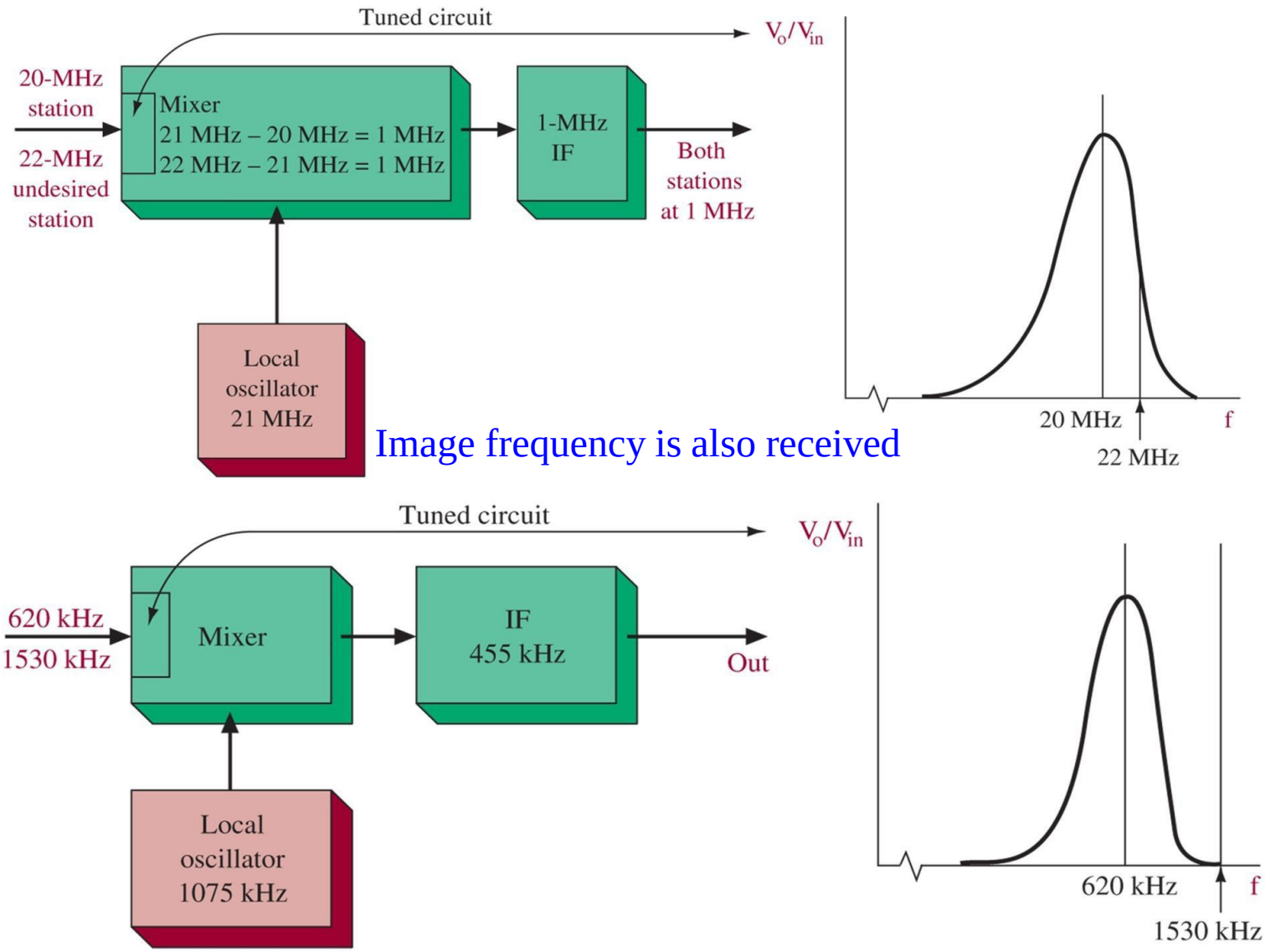


Block Diagram of Superheterodyne AM Receiver

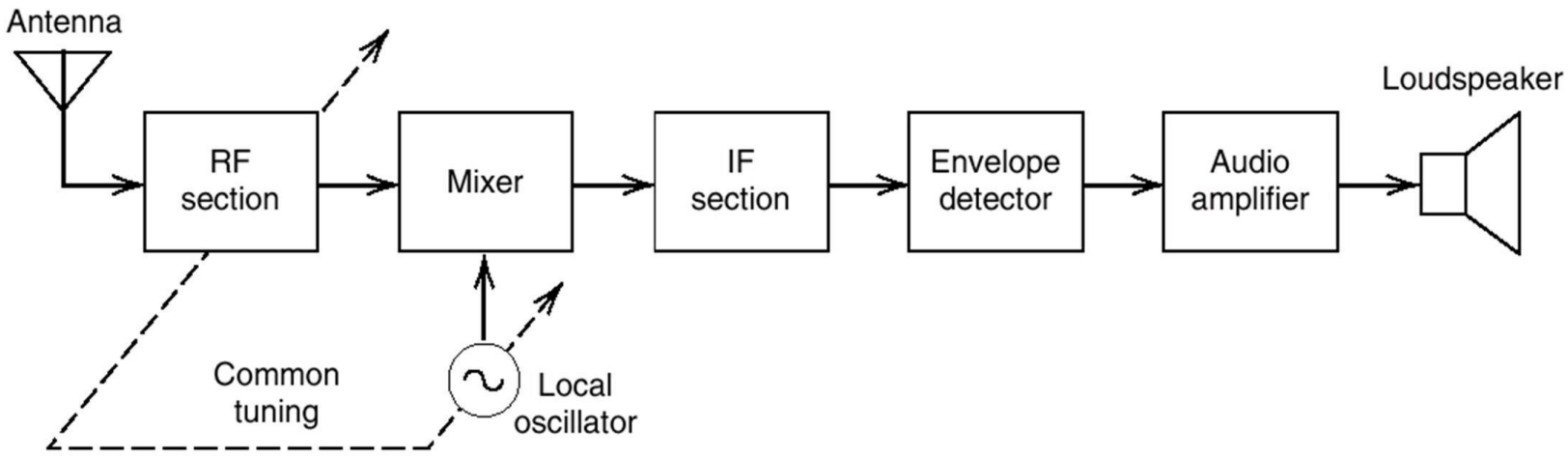


Frequency Conversion Process

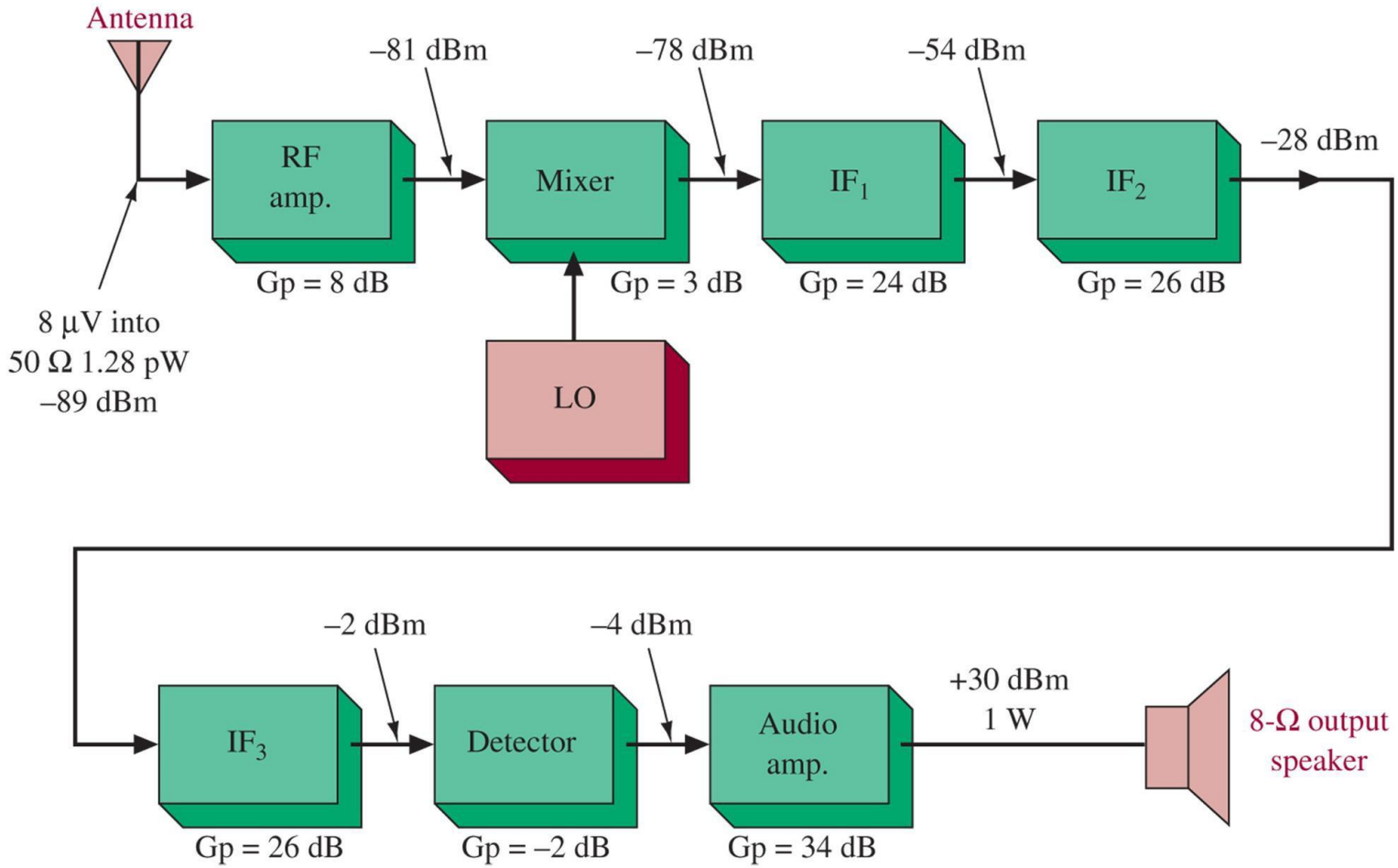



Tuned circuit
V_o/V_{in}
20-MHz station
22-MHz undesired station
Mixer
21 MHz – 20 MHz = 1 MHz
22 MHz – 21 MHz = 1 MHz
1-MHz IF
Both stations at 1 MHz
Local oscillator 21 MHz
20 MHz
22 MHz
f
Image frequency is also received
Tuned circuit
V_o/V_{in}
620 kHz
1530 kHz
Mixer
IF 455 kHz
Out
Local oscillator 1075 kHz
620 kHz
1530 kHz
f

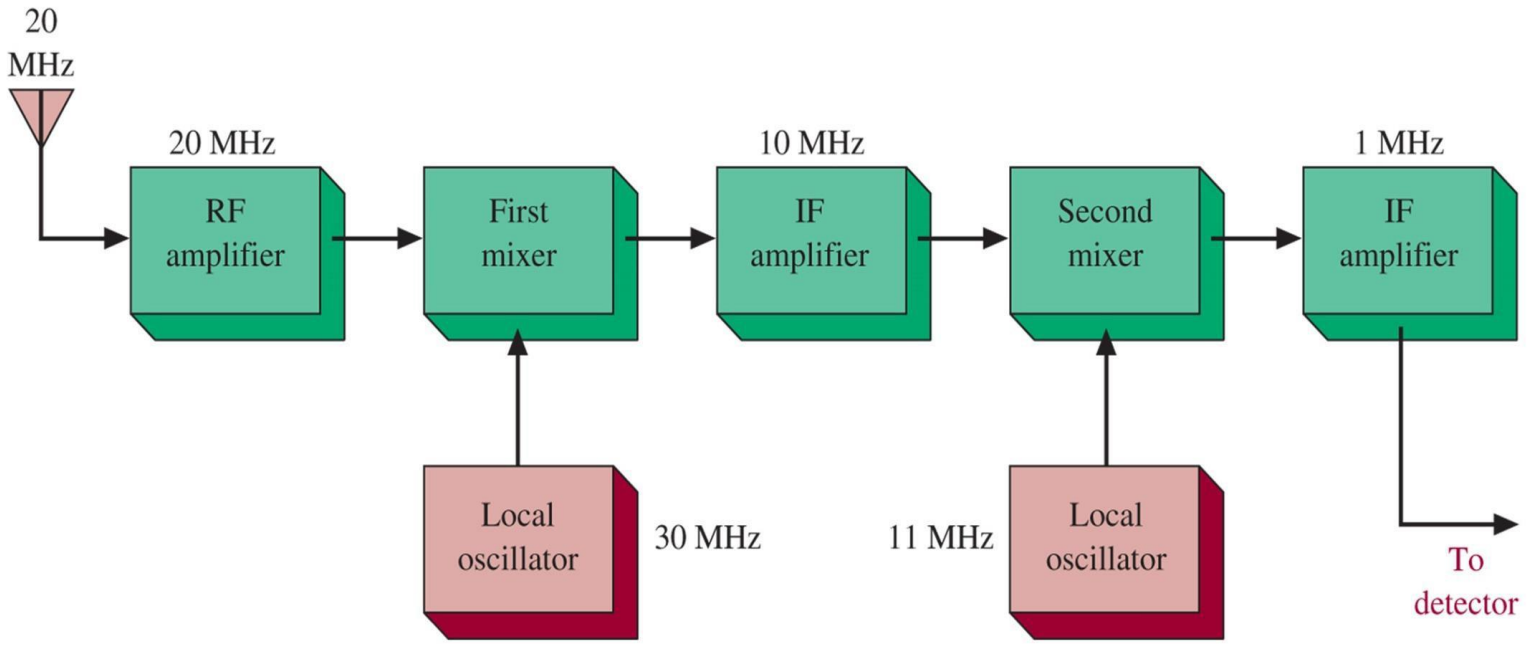
AM Radio Receiver



Superheterodyne Receiver Typical Signal Levels



Double-conversion block diagram.



The parameters of the AM Receivers are Sensitivity, Selectivity, Fidelityetc. some of which are explained below:

Selectively

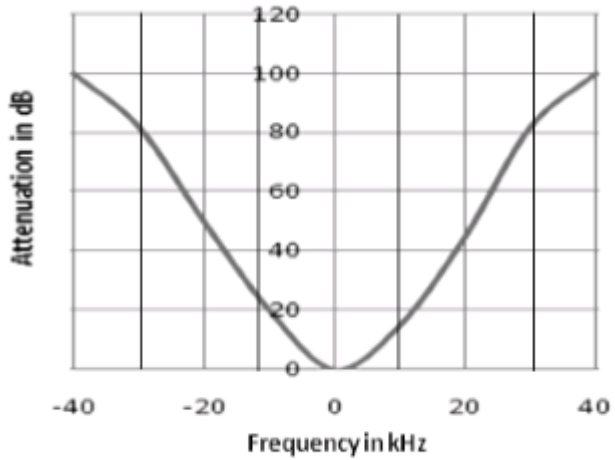
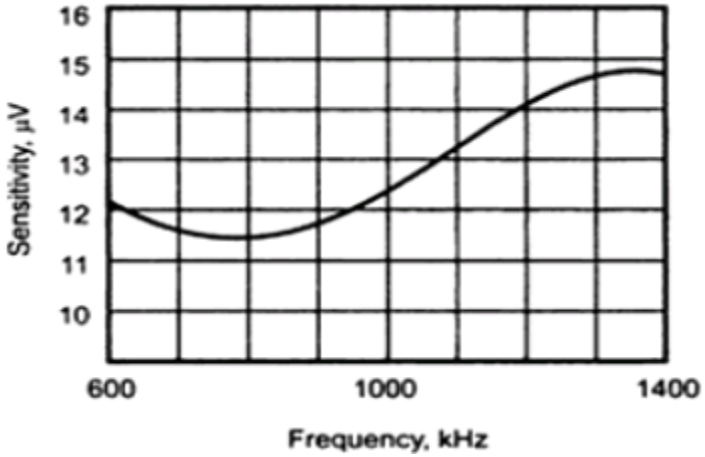


Fig1. Selectivity curve

✓ The selectivity of an AM receiver is defined as its ability to accept or select the desired band of frequency and reject all other unwanted frequencies which can be interfering signals.
✓ Adjacent channel rejection of the receiver can be obtained from the selectivity parameter.
✓ Response of IF section, mixer and RF section considerably contribute towards selectivity.
✓ The signal bandwidth should be narrow for better selectivity.
✓ Graphically selectivity can be represented as a curve shown in Fig1. below, which depicts the attenuation offered to the unwanted signals around the tuned frequency.

2. Fidelity



✓ Fidelity of a receiver is its ability to reproduce the exact replica of the transmitted signals at the receiver output.

✓ For better fidelity, the amplifier must pass high bandwidth signals to amplify the frequencies of the outermost sidebands, while for better selectivity the signal should have narrow bandwidth. Thus a trade off is made between selectivity and fidelity.

✓ Low frequency response of IF amplifier determines fidelity at the lower modulating frequencies while high frequency response of the IF amplifier determines fidelity at the higher modulating frequencies.

3. Sensitivity

✓ Sensitivity of a receiver is its ability to identify and amplify weak signals at the receiver output.
✓ It is often defined in terms of voltage that must be applied to the input terminals of the receiver to produce a standard output power which is measured at the output terminals.
✓ The higher value of receiver gain ensures smaller input signal necessary to produce the desired output power.
✓ Thus a receiver with good sensitivity will detect minimum RF signal at the input and still produce utilizable demodulated signal.
Sensitivity is also known as receiver threshold.
✓ It is expressed in microvolts or decibels.
Sensitivity of the receiver mostly depends on the gain of IF amplifier.
✓ It can be improved by reducing the noise level and bandwidth of the receiver.
Sensitivity can be graphically represented as a curve shown in Fig2. Below, which depicts that sensitivity varies over the tuning band.


Any
Questions


THANK YOU
FOR YOUR
ATTENTION