AM Receiver - 1) TRF Receiver
2) Superhetrodyne Receiver

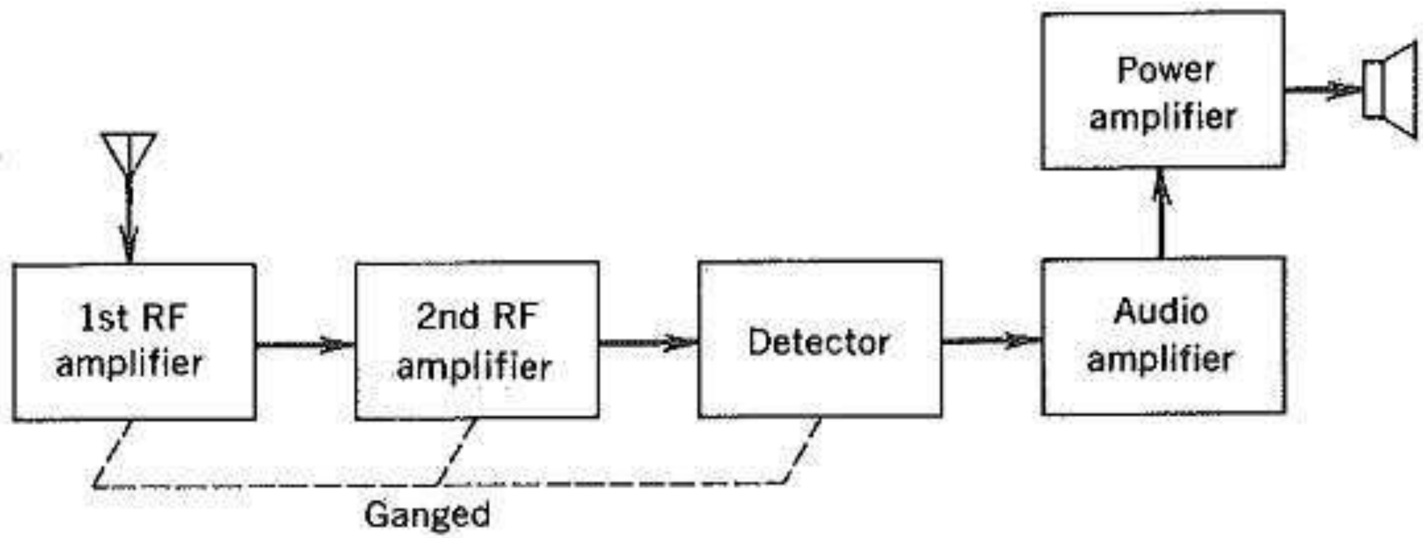


FIGURE 6-1 The TRF receiver.

Disadvantages of TRF

- It is very difficult to design at high frequency.

➢ Difficult to design tunable RF stages.

➢ Difficult to obtain high gain RF amplifiers

➢ It has poor audio quality.

- This is mainly due to

➢ Instability
➢ Variation in BW
➢ Poor Selectivity

Merits

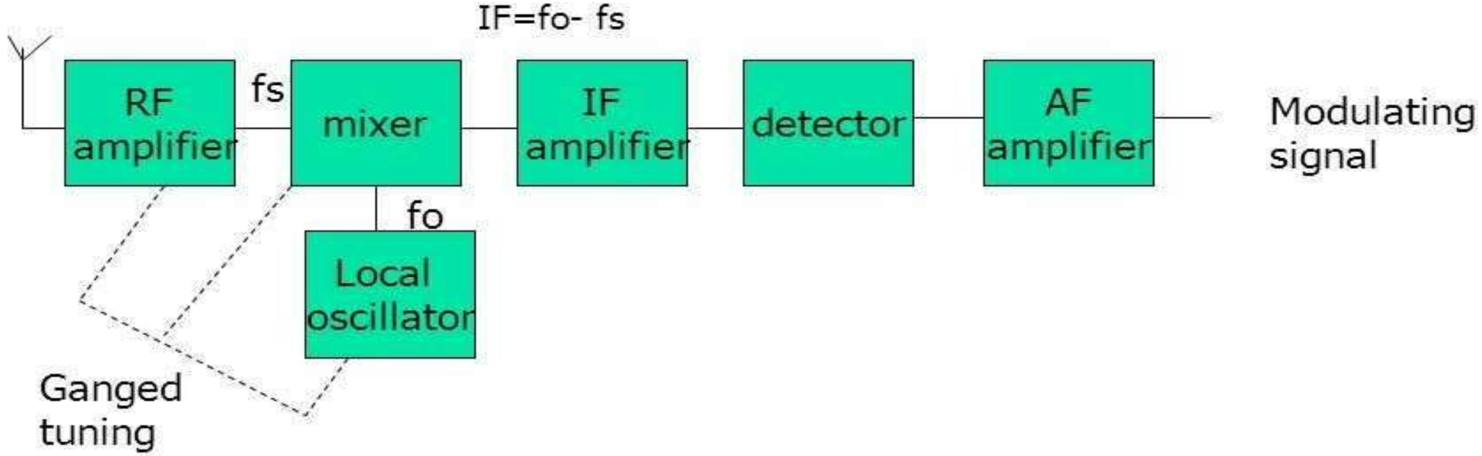
- TRF receivers are simple to design.
- TRF has high sensitivity.
- ability to drive the speaker to an acceptable level (to amplify)

Demerits

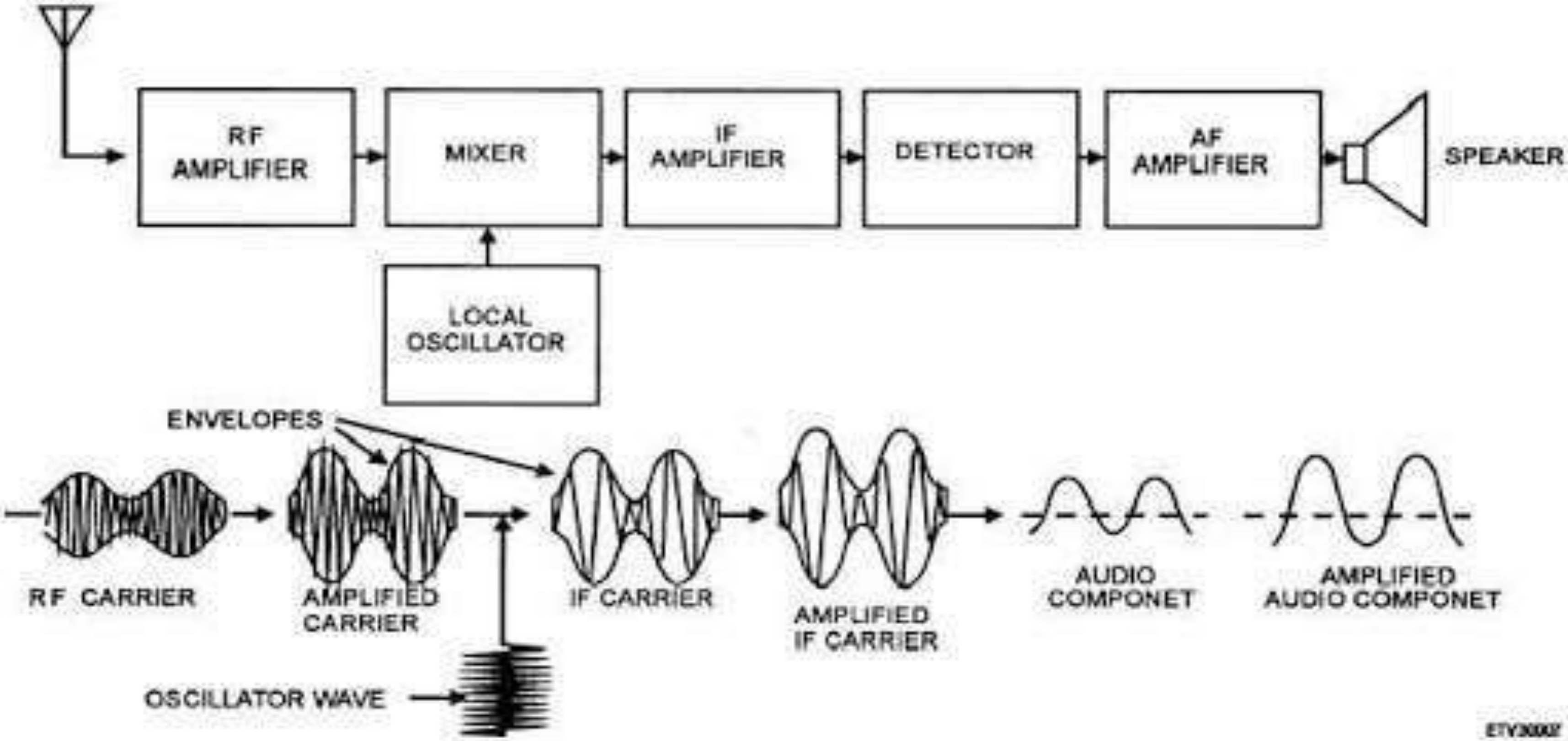
- It allow the broadcast frequency 535 KHz to 1640 KHz. But at the higher frequency, it produces difficulty in design.
- Problem of instability.
- It has poor audio quality.

Super Heterodyne Receiver

- The shortcomings of the TRF receiver are overcome by the invention of the super heterodyne receiver.
- A super heterodyne receiver converts all incoming radio frequency (RF) signals to a lower frequency known as an intermediate frequency (IF).



Superhetrodyne Receiver



Superhetrodyne Receiver

- Superhetrodyn receivers convert all incoming signals to a lower frequency, known as **the intermediate frequency (IF),** at which a single set of amplifiers is used to provide a fixed level of selectivity and sensitivity.
- The key circuit is the **mixer** – act as a simple amplitude modulator to produce sum and difference frequencies.
- Heterodyne means to **mix** two frequencies together in a nonlinear device or to **translate** one frequency to another using nonlinear mixing.

▪ RF section

▫Consists of a pre-selector and an amplifier.

▫Pre-selector - broad-tuned band pass filter with an adjustable center frequency used to reject unwanted radio frequency and to reduce the noise bandwidth.

▫RF amplifier – amplifies the signal. It also determines the sensitivity of the receiver.

- **Mixer/converter section**

- Consists of a radio-frequency oscillator and a mixer.
- Choice of oscillator depends on the stability and accuracy desired.
- Mixer is a nonlinear device to convert radio frequency to intermediate frequencies (i.e. heterodyning process).
- The shape of the envelope, the bandwidth and the original information contained in the envelope remains unchanged although the carrier and sideband frequencies are translated from RF to IF.

- **IF section**

- Consists of a series of IF amplifiers and bandpass filters to achieve most of the receiver gain and selectivity.
- The bandpass filter band limits the IF signal .

- The IF is always lower frequency than the RF because it is easier and less expensive to construct high-gain, stable amplifiers for low frequency signals.

- IF amplifiers are also less likely to oscillate than their RF counterparts.

- **Detector section**
  - To convert the IF signals back to the original source information (demodulation).
  - Can be as simple as a single diode or as complex as a PLL or balanced demodulator.

- **Audio amplifier section**
  - Comprises several cascaded audio amplifiers and one or more speakers

- **AGC (Automatic Gain Control)**

  - Adjust the IF amplifier gain according to signal level (to the average amplitude signal almost constant).

  - AGC is a system by means of which the overall gain of radio receiver is varied automatically with the variations in the strength of received signals, to maintain the output constant.

Drawbacks Overcomed

- Stability – As high frequency is down converted to IF the reactance of stray capacitances will affect and cause oscillations.
- No variation in BW- Bandwidth remains constant over the entire frequency range.
- Better selectivity & Sensitivity - As no adjacent channels are picked due to variation in BW.

COMPARISON

TRF Receiver

- No frequency conversion
- No IF frequency
- Instability , variation in BW and poor selectivity due to high frequencies
- Difficult to design tunable RF stages.
- Rarely used

Super hetrodyne Receiver

- Frequency conversion
- Downconvert RF signal to lower IF frequency
- No instability, variation in BW and poor selectivity as IF introduced.
- Main amplifixcation takes place at IF
- Mostly used

Advantages/disadvantages

Advantages of Amplitude Modulation, AM

There are several advantages of amplitude modulation, and some of these reasons have meant that it is still in widespread use today:

- It is **simple** to implement
- it can be demodulated using a circuit consisting of **very few components**
- AM receivers are **very cheap** as no specialized components are needed.

Disadvantages of amplitude modulation

Amplitude modulation is a very basic form of modulation, and although its simplicity is one of its major advantages, other more sophisticated systems provide a number of advantages. Accordingly it is worth looking at some of the disadvantages of amplitude modulation.

- It is not **efficient in terms of its power usage**
- It is not **efficient in terms of its use of bandwidth**, requiring a bandwidth equal to twice that of the highest audio frequency
- It is prone **to high levels of noise** because most noise is amplitude based and obviously AM detectors are sensitive to it.

Characteristics of AM Radio Receiver

The performance of radio receiver is determined by its characteristics/ parameters.

- These are of three types.

Characteristics of Radio Receiver

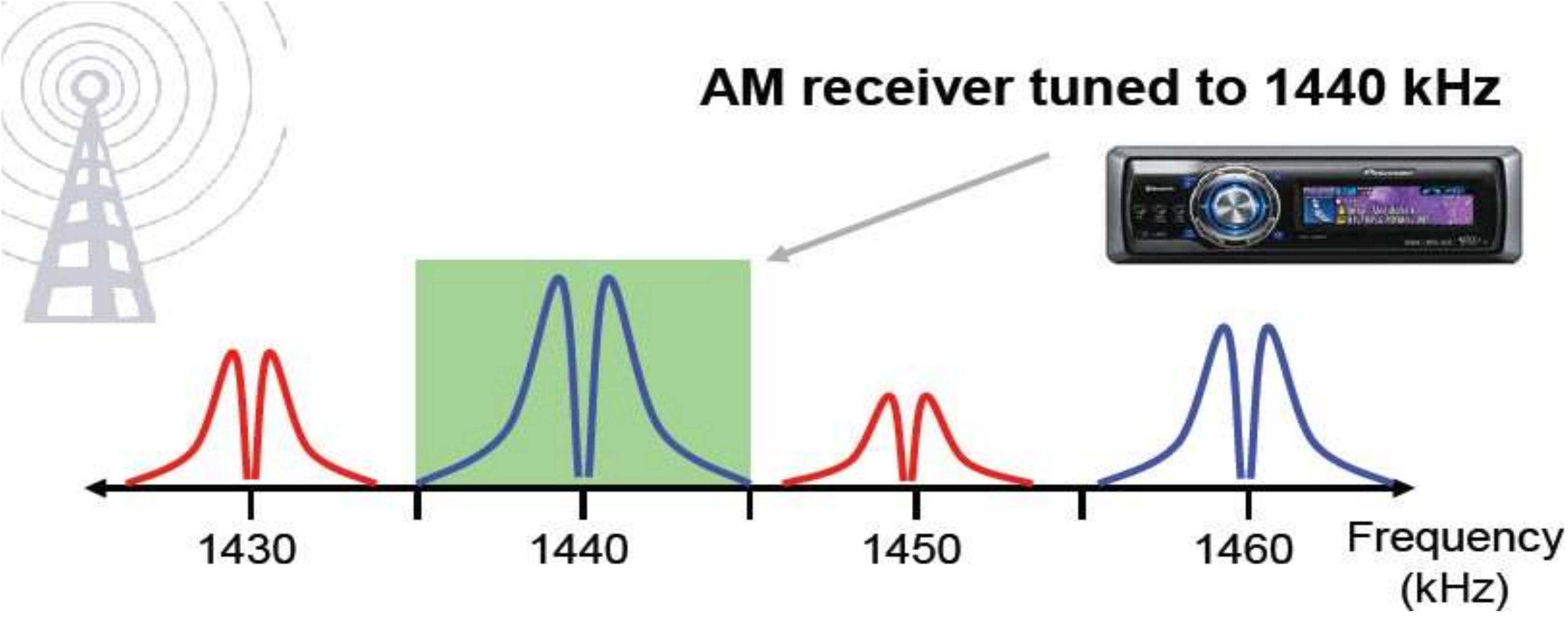
Sensitivity Selectivity Fidelity

Sensitivity

- Ability to amplify weak signals.
- Minimum RF signal level that can be detected at the input to the receiver and still produce a usable demodulated information signal.
- Broadcast receivers/ radio receivers should have reasonably high sensitivity so that it may have good response to the desired signal
- But should not have excessively high sensitivity otherwise it will pick up all undesired noise signals.
- It is function of receiver gain and measures in decibels.

Selectivity

- Selectivity of radio receiver is its ability to differentiate desired signal from unwanted signals.



Fidelity

- Ability of a communication system to produce an exact replica of the original source information at the output of the receiver.

- Radio receiver should have high fidelity or accuracy.

- For high fidelity, it is essential to have a flat frequency response over a wide range of audio frequencies when amplified.

Image Frequency

- Generally, local oscillator frequency is equal to the sum of signal frequency and intermediate frequency.

$$f_o = f_s + f_i$$

- When f_s and f_o are mixed, the difference frequency is equal to f_i which is the only one passed and amplified by the IF stage.

Image Frequency

- Suppose an undesired frequency $f_{si} = f_o + f_i$ reaches the mixer.
- The two frequency components will now be f_o (local oscillator) and f_{si} (undesired freq)
- And the harmonics will be f_o, f_{si}, f_o+f_{si}, f_o-f_{si}
- Substituting the value of f_{si}, the difference frequency is again f_i.

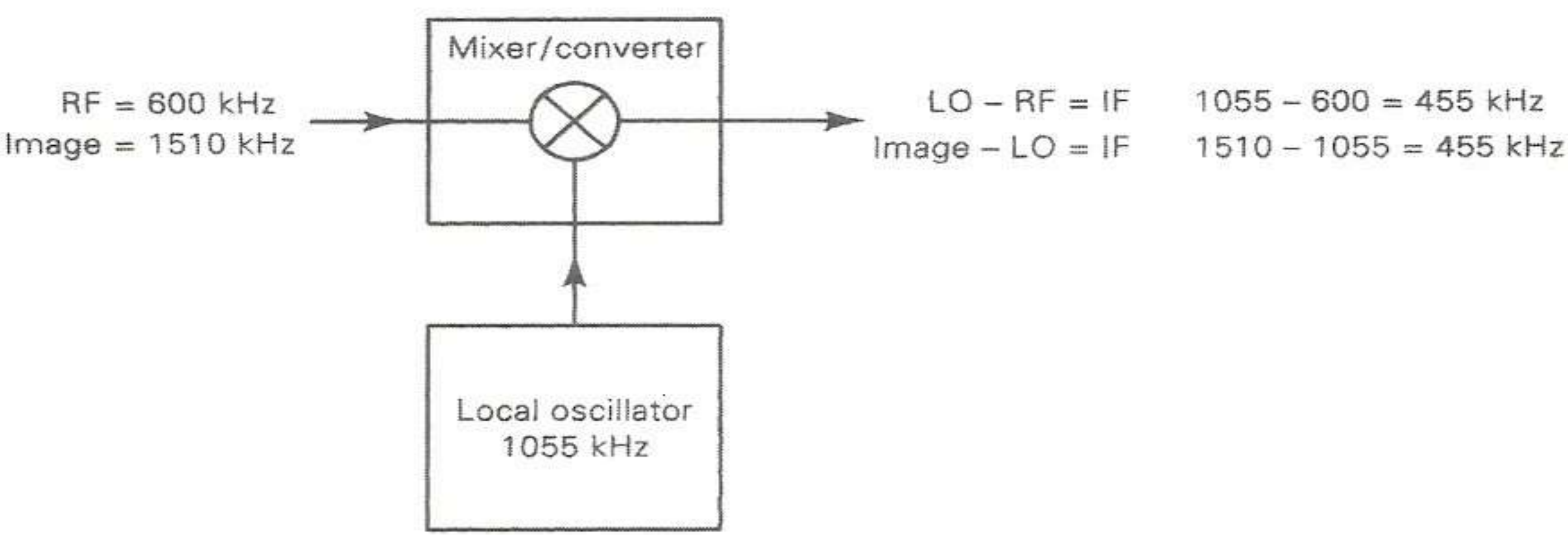
Image Frequency

- This IF signal will also be amplified by the IF stage and provide interference.
- This has the effect of two stations being received simultaneously.
- The term f_{si} is called the image frequency and is defined as the signal frequency plus twice the intermediate frequency.

$$f_{si} = f_s + 2f_i$$

Image Frequency

- Once an image frequency is down-converted to IF, it cannot be removed. In order to reject the image frequency, it has to be blocked prior to the mixer stage.



Choice of Intermediate Frequency

- High IF – Better image frequency rejection

Difficult to build stable amplifiers.

- Low IF – Stability since low frequency is used

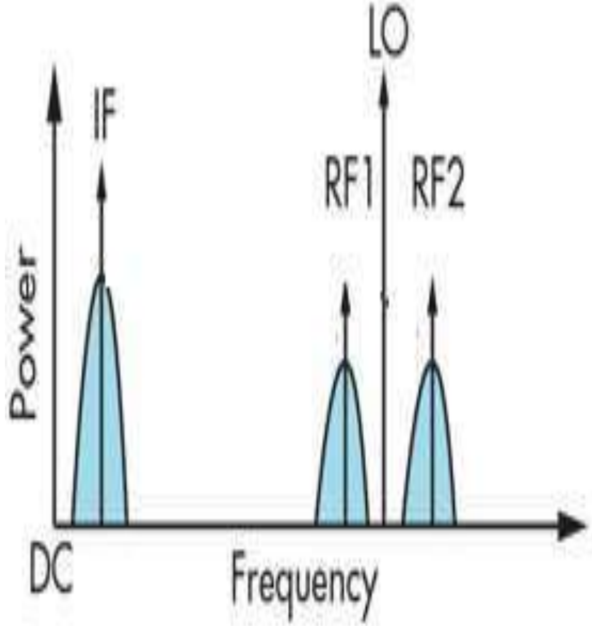
Poor image frequency rejection

Trade off between image frequency rejection and stability.

Double Spotting

- Same stations get picked up at two different nearby points, on the receiver dial.
- Due to inadequate image frequency rejection.
- Harmful, since a weak station can be masked by the reception of a strong station at the same point.
- Can be reduced by increasing front end selectivity of the receiver.
- Including the RF amplifier stage helps in avoiding double spotting.

RF1 -- Desired
RF2 -- Image



IF = LO - RF1 (Desired)
IF = RF2 - LO (Image)

Image Frequency rejection Ratio

$$IFRR = \alpha = \frac{Gain at signal freq}{Gain at image freq} = \sqrt{1+Q^2\rho^2}$$

Where Q= Loaded Q of the tuned ckt.

$$\rho = \frac{fsi}{fs} - \frac{fs}{fsi}$$

If two tuned ckts are there then

$$IFRR = \alpha 1 * \alpha 2$$

Superheterodyne Receiver Frequencies

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

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.