ISSN: XXXX -XXXX
Veridian Publication
Veridian Journal of Engineering and Applied Sciences
International Peer Reviewed Journal
www.veridianjournal.org
Volume 1 – Issue 1; December 2025

Received: 01/09/2025; Accepted: 28/10/2025; Published: 22/11/2025

Radio Receivers and their role in Communication Systems

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Abstract

We know that in a communication system, a radio transmitter radiates or transmits a modulated carrier signal. This modulated carrier signal travels down the channel i.e. transmission medium and reaches at the input of radio receiver. This means that the modulated carrier signal is picked up by the antenna of the radio receiver. This modulated signal so received is generally very weak. Therefore, inside the receiver this weak signal is first amplified in an R.F. (Radio frequency) amplifier stage of the radio receiver. Also, since the received modulated signal contains a lot of noise or unwanted signals at adjacent frequencies, it must be selected and the noise must be rejected. Finally, in receiver, the R.F. carrier or modulated signal must be demodulated to get back the original modulating or baseband signal. Further, since the demodulated or detected signal (i.e. audio signal in case of broadcast receiver) is generally weak, it has to be amplified in one or more stages of audio amplifier.

1. Introduction

From the above discussion, we can summarize the main function of a radio receiver as:

(i) Intercept the incoming modulated signal (i.e. electromagnetic waves) by the receiving antenna.

(ii) Select the desired signal and reject the unwanted signals.

(iii) Amplify this selected R.F. signal.

(iv) Detect the modulated signal to get back the original modulating or baseband signal.

(v) Amplify the modulating frequency signal.

This means that a radio receiver is electronic equipment which picks up the desired signal, rejects the unwanted signals, amplifies the desired signal, demodulates the modulated signal to get back the original modulating frequency signal.

2. Classification Radio Receivers

We can classify the radio receiver in two ways as under:

2.1 Depending upon the applications, the radio receivers may be classified as follows:

(i) Amplitude Modulation (A.M.) Broadcast Receivers: These receivers are used to receive the broadcast of speech or music transmitted from amplitude modulation broadcast transmitters which operate on long wave, medium wave or short wave bands.

(ii) Frequency Modulation (F.M.) Broadcast Receivers: These receivers are used to receive the broadcast programmers from F.M. broadcast transmitters which operate in VHF or UHF bands.

(iii) Communication Receivers: Communication receivers are used for reception of telegraph and short wave telephone signals. This means that communication receivers are used for various purposes other than broadcast services.

(iv) Television Receivers: Television receivers are used to receive television broadcast in VHF or in UHF bands.

(v) Radar Receivers: Radar receivers are used to receive Radar (i.e. Radio detection and ranging) signals.

2.2 Depending upon the fundamental aspects, the radio receivers may also be classified as under:

(i) Tuned Radio Frequency (TRF) Receivers

(ii) Superheterodyne Receiver

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In fact, various forms of receivers have been proposed from time to time. However, only two of them became popular for commercial applications. These are Tuned Radio frequency (TRF) receiver and superheterodyne receiver. Presently, the superheterodyne receiver is the most popular and most widely used. The TRF receiver was used earlier in the 1940s. The TRF receiver had some inherent drawbacks which were removed in superheterodyne receiver. Therefore, we shall start our discussion with TRF receiver and then come to the superheterodyne receiver.

3. Tuned Radio Frequency (TRF) Receiver

Tuned radio frequency (TRF) receiver is the simplest radio receiver. Figure 8.1 shows the block diagram of a tuned radio frequency receiver. The very first block of this receiver is an RF stage. This stage generally contains two or three RF amplifiers. Actually, these RF (radio frequency) amplifiers are tuned RF amplifiers i.e. they have variable tuned circuit at the input and output sides. At the input of the receiver, there is a receiving antenna as shown in figure 8.1. At this antenna signals from different sources (i.e. stations) are present. However, with the help of input variable tuned circuit of RF amplifiers the desired signal (i.e. station) is selected. But this selected signal is usually very weak of the order of μV. This selected weak signal is amplified by the RF amplifier (i.e. R.F stage).

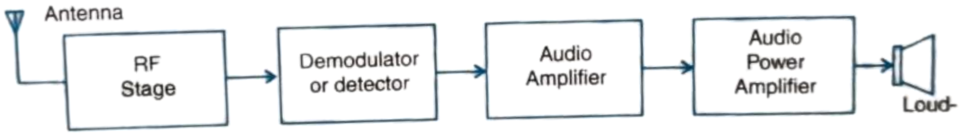

Figure 3.1 Block Diagram of a TRF Receiver

Thus the function of RF stage is to select the desired signal and amplify it. After this, the amplified incoming modulated signal is applied to the demodulator. The demodulator or detector demodulates the modulated signal and thus at the output of the demodulator, we get modulating or baseband signal (i.e. audio signal). This audio signal is amplified by audio amplifier. After that, this audio signal is further amplified by a power amplifier upto desired power level to drive the loudspeaker. The last stage of this receiver is the loudspeaker. A loudspeaker is a transducer which changes electrical signal into sound signal.

3.1 Drawbacks of TRF Receiver

As discussed above, although TRF receiver is cheaper and the simplest one, it has certain drawbacks as under:

(i) The TRF receiver suffers from a tendency to oscillate at higher frequencies from the multistage RF amplifiers with high gain and operating at same

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frequency. If such an amplifier has a gain of 20,000 then if a small portion of the output leaked back to the input of the RF stage, then positive feedback and oscillation will result. This type of leakage could result from power supply coupling, stray capacitance coupling, radiation coupling or coupling through any other element common to the input and output stages. Definitely, this type of condition is undesirable for a good receiver.

This problem is also termed as instability of the receiver.

(ii) The selectivity of a receiver is its ability to distinguish between a desired signal and an undesired signal. The selectivity of TRF receiver is poor. In fact, it is difficult to achieve sufficient selectivity at high frequencies due to the enforced use of single-tuned circuits.

(iii) Another problem associated with the TRF receiver is the bandwidth variation over the tuning range. For example, in AM broadcast system, let us consider that a tuned circuit is required to have a bandwidth of 10 kHz at a frequency of 540 kHz.

4. Superheterodyne Receiver: Basic Elements

Figure 8.2 shows the block diagram of a superheterodyne receiver. All the drawbacks in TRF receiver have been removed in a superheterodyne receiver. The basic superheterodyne receiver is most widely used. This means that the superheterodyne principle is used in all types of receiver like television receiver, radar receiver, etc.

In a superheterodyne receiver, the incoming RF signal frequency is combined with the local oscillator signal frequency through a mixer and is converted into a signal of lower fixed frequency.

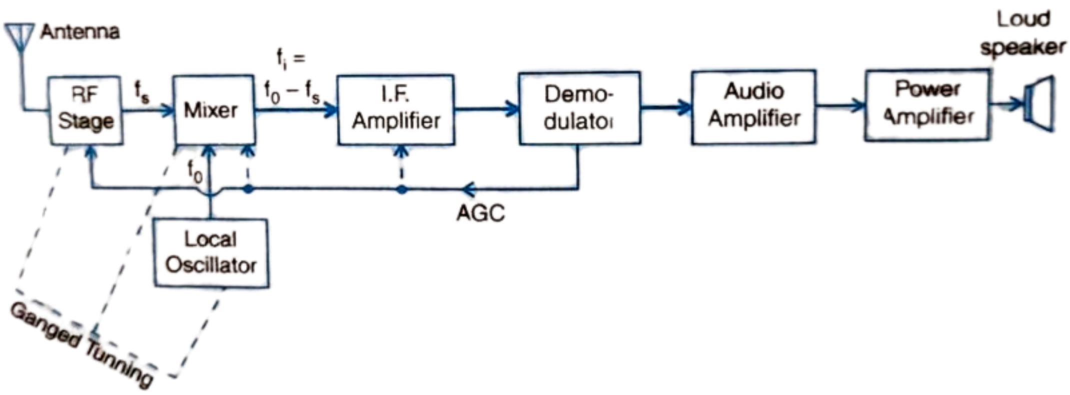

Figure 4.1 Block Diagram of superheterodyne Receiver

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This lower fixed frequency is known as intermediate frequency. However, the intermediate frequency signal contains the same modulation as the original signal. This intermediate frequency signal is now amplified and demodulated to reproduce the original signal.

The word heterodyne stands for mixing. Here we have mixed the incoming signal frequency with the local oscillator frequency. Therefore this receiver is called superheterodyne receiver.

Thus, in a superheterodyne receiver, a constant frequency difference is maintained between the local oscillator signal frequency and incoming RF signals frequency through capacitance tuning in which the capacitances are ganged together and operated by a common control knob. The intermediate frequency (IF) amplifier generally contains a number of transformers each consisting of a pair of mutually coupled tuned circuits. Thus, with this large number of double-tuned circuits, operating at a specially chosen frequency, the IF amplifier provides most of the gain (i.e. sensitivity) and bandwidth requirements (i.e. selectivity) of the receiver. This means that the IF amplifier determines the sensitivity and selectivity of the superheterodyne receiver.

Also, since the characteristics of the IF amplifier are independent of the incoming frequency to which the receiver is tuned, the selectivity and sensitivity of the superheterodyne receiver are quite uniform throughout its tuning range and not subject to the variations like a TRF receiver. Further since the I.F. amplifier works at a fixed I.F. frequency, the design of this system is quite easy to provide high gain and constant bandwidth.

Because of its narrow bandwidth, the I.F. amplifier rejects all other frequencies except intermediate frequency (I.F.). Actually, this rejection process reduces the risk of interference from other stations or sources. In fact, this selection process is the key to the superheterodyne receiver’s exceptional performance.

After the I.F. amplifier, the signal is applied at the input of demodulator which extracts the original modulating signal (i.e. audio signal). This audio signal is amplified by an audio amplifier to get a particular voltage level. This amplified audio signal is further amplified by a power amplifier to get a specified power level so that it may activate the loudspeaker. The loudspeaker is a transducer which converts this audio electrical signal into audio sound signal and thus the original signal is reproduced i.e. the original transmission is received.

The advantages of the superheterodyne receiver make it the most suitable for the majority of radio receiver applications like AM, FM, communications, single-sideband, television and even radar receiver; all use superheterodyne principle. This means that it can be considered as today’s standard form of radio receiver.

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5. Conclusion

The superheterodyne receiver has the advantages as (i) No variation in bandwidth. The BW remains constant over the entire operating range. (ii) High sensitivity and selectivity. (iii) High adjacent channel rejection.

Frequency Parameters of AM Receiver, the AM receiver has the following frequency parameters:

(i) Two frequency bands: Medium wave (MW) band and short wave (SW) band.(ii) RF carrier range (MW band) : 535 kHz to 1650 kHz (SW band) : 5 to 15 MHz. (iii) Intermediate frequency IF: 455 kHz. (iv) IF bandwidth B: 10 kHz.

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