Jules' Workshop

Standard

Unit 13 – ANSWERS

Q1 What are the three criteria for a receiver? Explain each criterion.

Sensitivity

Receiver sensitivity indicates how faint an input signal can be to be successfully received by the receiver. Sensitivity is defined as the receiver's ability to detect a signal at the input and give a signal-plus-noise ratio of 10dB above the noise output of the receiver.

Selectivity

Selectivity is an important parameter in any radio receiver. Selectivity is necessary for the receiver to be able to select the wanted signal from the unwanted adjacent signal.

Stability

Frequency stability means the receiver must stay "tuned" to the incoming radio signal and must not "drift" with time or temperature.

Q2 What is Thermal Noise?

Thermal noise or Thermal agitation noise is always present in the electrical equipment and is one of the major sources of noise that can affect the detection of weak signals.

Thermal noise occurs due to the vibration of charge carriers within an electrical conductor and is directly proportional to the temperature. Thermal noise cannot be eliminated but can be reduced by controlling the temperature of devices. The thermal noise power is proportional to the bandwidth and is effectively white noise.

~~Q3 What is the thermal noise voltage at 290deg K for a 10 kHz bandwidth and a 50-ohm load?~~

~~**0.089 uV**~~

Q4 Name and explain the three basic receiver configurations.

Tuned Radio Frequency Receiver (TRF). This receiver relies on the filters in the RF sections of the radio to provide selectivity. These are variable and often at a relatively high frequency. Selectivity can better be achieved by the other types of techniques.

Direct conversion receiver (DCR). The DCR is also known as homodyne, synchrodyne, or zero-IF receiver. The receiver demodulates the incoming radio signal using synchronous detection driven by a local oscillator. intended signal.

This is a simple circuit, but other issues arise. The DCR is unsuited to receiving AM and FM signals without implementing an elaborate phase locked loop. Improvements in technology and software have revived its use in certain areas including some consumer products.

Superheterodyne receiver. The superheterodyne radio receiver has been in widespread use for years, and it is still widely used for high performance applications. A variety of selectivity and filter requirements are applicable for superheterodyne receivers.

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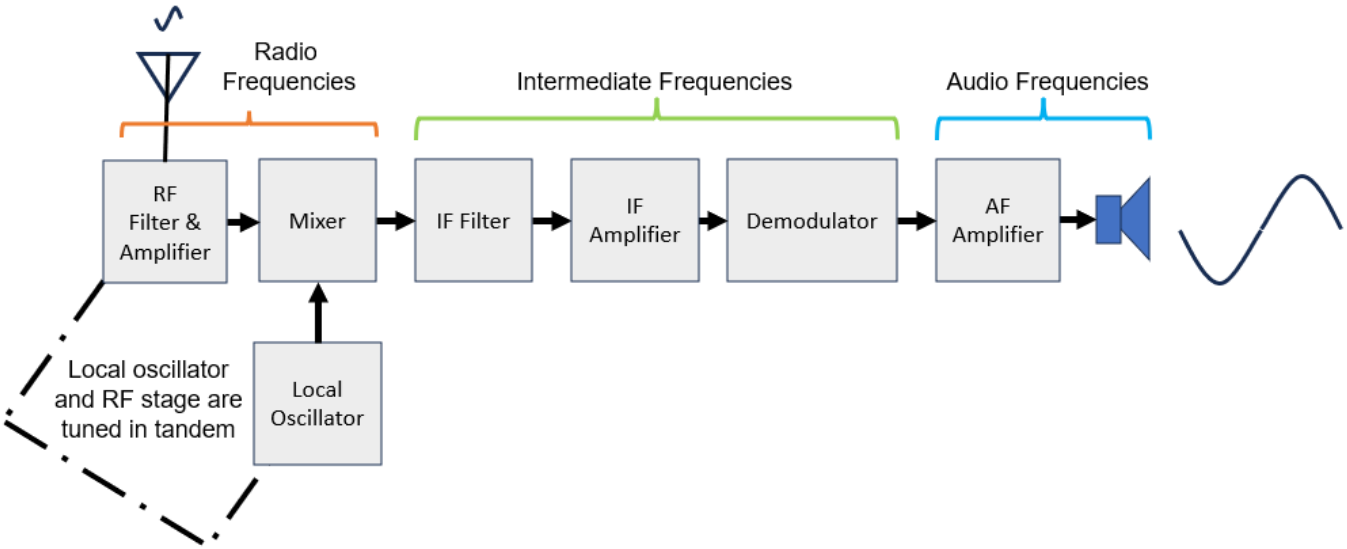
Selectivity of the front end is required to ensure sufficient image rejection, and the filters in the IF provide the main adjacent channel rejection.

Q5 Draw the block diagram of a superheterodyne receiver.



Q6 Why must the local oscillator and RF stage be tuned in tandem?

They need to be tuned together so the front end can block near frequencies and the oscillator mixes with the frequency to provide the correct IF.

Q7 If the RF signal is fc and the oscillator frequency is fo, what are the two possibilities at the output of the mixer?

Fc + fo and fc - fo

Q8 What is an image frequency?

Image frequency is the unwanted signal frequency that could also produce the same IF frequency.

Q9 What is an IF frequency and why is it used?

This section basically amplifies the output of the mixer. IF amplifier provides sensitivity(gain) and selectivity (bandwidth requirement) to the receiver. The sensitivity and selectivity are uniform and does not show variations as in the case of TRF receivers because IF amplifiers are independent of that of the received signal frequency. The IF has a narrow bandwidth and rejects all other frequencies, reducing the risk from interference.

Q10 Name the seven types of demodulators?

- Amplitude modulation (AM) — Envelope detector or synchronous detector
- Morse code (CW) — Product detector
- Frequency modulation (FM) — Slope detector, Foster-Seely discriminator, Ratio detector or Quadrature detector.
- Single Side Band (SSB) — Product detector.

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Q11 Explain the slope detector?

In the FM slope detector, the frequency of the tuned circuit formed by the transformer secondary and C1 is slightly higher than the incoming frequency. The converts the signal from FM to AM. The envelope detector is then used to demodulate the signal.

The downfall of this detector is that it is susceptible to amplitude spikes and the signal strength is reduced.

Q12 Why use a double superheterodyne receiver?

The double conversion superhet has two IF stages. These improve image rejection and adjacent channel rejection.

~~Q13 What is the signal to noise ratio of a 50 uV signal and the noise level of 1 uV?~~

~~**16.9 dB**~~

Q14 What is AGC and how does it work?

Automatic gain control (AGC) is closed-loop feedback regulating circuit in an amplifier. The purpose of the AGC is to maintain a suitable signal amplitude at its output, despite variation of the signal amplitude at the input. The average or peak output signal level is used to dynamically adjust the gain of the amplifiers. AGC is used in most radio receivers to equalise the average volume (loudness) of different radio stations due to differences in received signal strength, as well as variations in a single station's radio signal due to fading. Without AGC the sound emitted from an AM radio receiver would vary to an extreme extent from a weak to a strong signal; the AGC effectively reduces the volume if the signal is strong and raises it when it is weaker. In a typical receiver the AGC feedback control signal is usually taken from the detector stage and applied to control the gain of the IF or RF amplifier stages.

Q15 What is an S meter and what level is required for S9?

An S meter or signal strength meter is an indicator often provided on communications receivers, such as amateur radio or shortwave broadcast receivers. The scale markings are derived from a system of reporting signal strength from S1 to S9 as part of the R-S-T system. The term S unit refers to the amount of signal strength required to move an S meter indication from one marking to the next.

Analogue S meters are sensitive microammeters. The standard is that a reading of S9 corresponds to a 50 µV signal at the antenna input to the receiver.

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Q16 Why is a limiter needed?

A limiter is a circuit that allows signals below a specified input power or level to pass unaffected while attenuating (lowering) the peaks of stronger signals. Limiting is any process by which the amplitude of a signal is prevented from exceeding a predetermined value.

Limiters are common as a safety device in live sound and broadcast applications to prevent sudden volume peaks from occurring.

Q17 What is phase noise?

Reciprocal mixing occurs because of the phase noise which appears on all signals to a greater or lesser degree. The major problem for a receiver is that the phase noise spreads out either side of the local oscillator signal.

Phase noise consists of small random variations in the phase of the signal. These variations are effectively phase modulation and noise sidebands are generated. These spread out either side of the main signal and can be plotted on a spectrum analyser as single sideband phase noise.

Q18 What is a low noise amplifier?

A low-noise amplifier (LNA) is an amplifier that boosts very low-power signal without significantly degrading its signal-to-noise ratio (SNR). Any amplifier will increase the power of both the signal and the noise present at its input, but the amplifier will also introduce some additional noise. LNAs are designed to minimise that additional noise, by choosing special components, operating points, and circuit topologies. Minimising additional noise must balance with other design goals such as power gain and impedance matching. A typical LNA may supply a power gain of 100 (20 decibels (dB)) while decreasing the SNR by less than a factor of two (a 3 dB noise figure (NF)). Although LNAs are primarily concerned with weak signals that are just above the noise floor, they must also consider the presence of larger signals that cause intermodulation distortion.

Q19 What is de-emphasis?

Pre-emphasis is undertaken in the transmitter and the de-emphasis is undertaken at the receiver. The purpose is to improve the signal-to-noise ratio for FM reception. A time constant of 75µs is specified in the RC or L/Z network for pre-emphasis and de-emphasis. De-emphasis performs the following functions.

- **Applies a low-pass filter to the received signal.**
- **Attenuates or reduces the boosted high frequencies.**
- **Rolls-off highs above 2-3 kHz**
- **Restores original frequency spectrum.**
- **Reduces noise and distortion picked up during transmission**.

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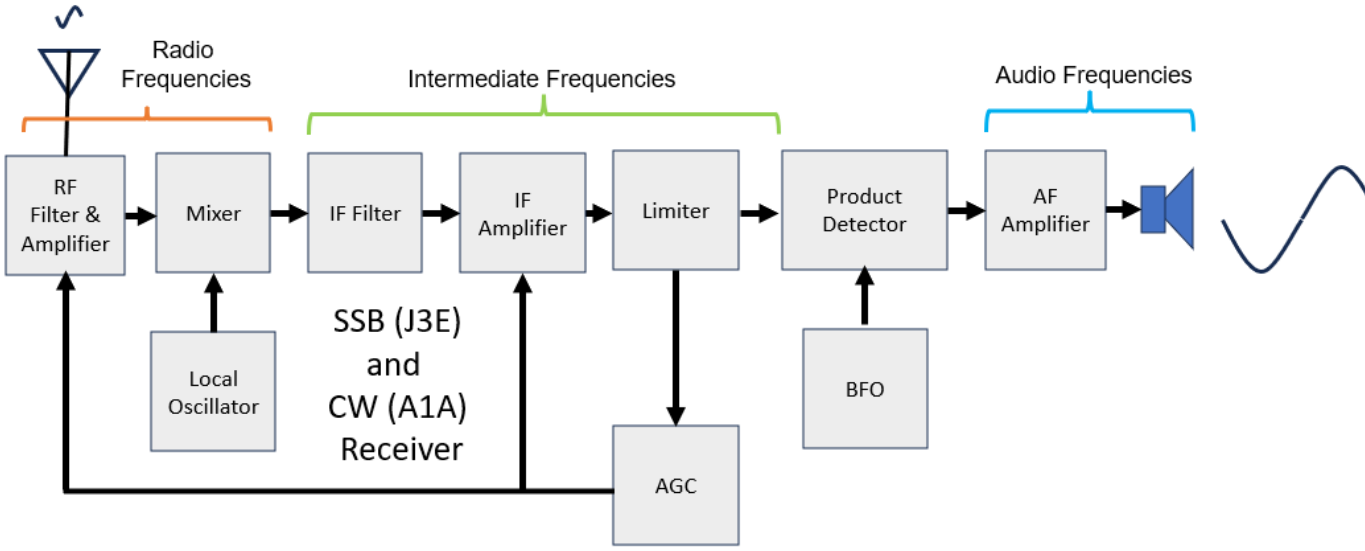
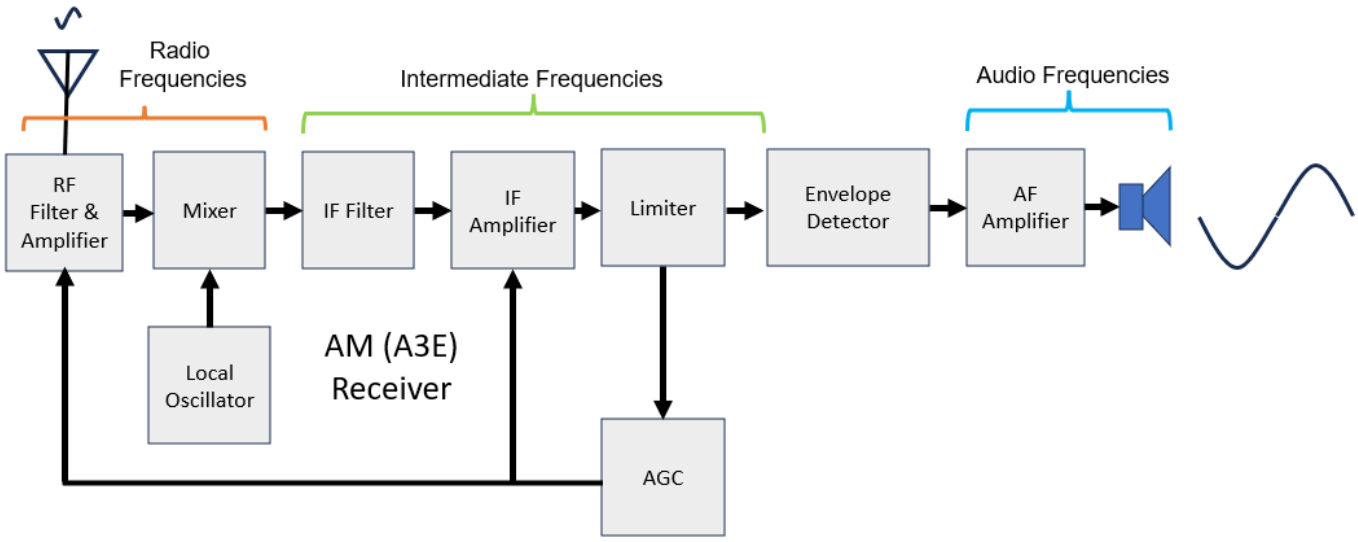
Q20 Draw block diagrams for the following receivers.

CW

SSB



AM



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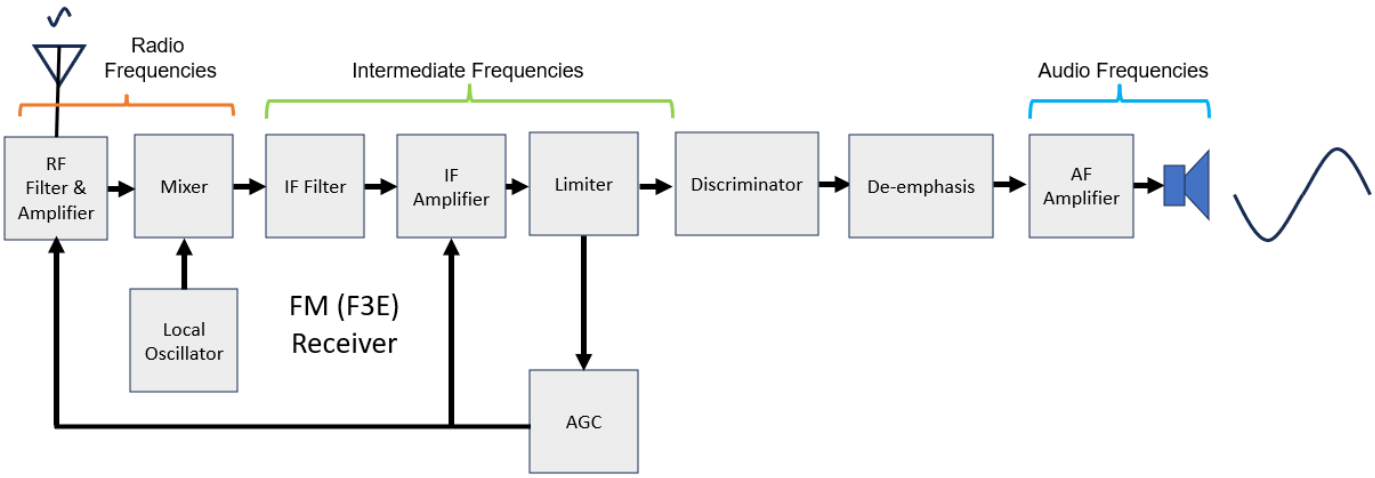
FM



Q21 Why do aircraft communications use AM and not FM?

Radio communications between aircraft use AM to prevent the capture effect impacting weaker signals. The pilots need to hear all transmissions on the same channel.

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