Jules' Workshop

Standard

Unit 13

RECEIVERS

ACMA Syllabus February 2024

Contents

Receivers 4
Receiver Configurations 4
Receiver Rating 4
Sensitivity 4
Dynamic Range 5
Selectivity 5
Stability 5
Receiver Configurations Groups 6
Direct conversion receiver (DCR). 6
Tuned Radio Frequency Receiver (TRF). 6
Superheterodyne Receiver. 7
Crystal radios. 7
Direct Conversion/Software-Defined Radios (SDR) 8
Superheterodyne Receiver in Detail. 9
Double Conversion Superhet 10
Mixer Frequencies and Image Frequencies 11
Mixer Frequencies 11
Image Frequency 12
Image rejection 13
Noise 14
Thermal Noise (Voltage) 14
Thermal Noise (Power) 14
SINAD 14
Signal to Noise Ratio 15
Band noise. 15
Narrowband noise 15
Noise density. 15
White Noise 15
Bandwidth 16
Signal Reports 17

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Common Receiver Terms 18
Audio amplifier 18
Automatic Gain Control 18
Blocking 18
Capture Effect 18
Cross modulation 18
Emphasis 19
Desensitisation 19
Intermodulation 19
Limiter 19
Low Noise Amplifier 19
Reciprocal mixing [phase noise] 20
S Meter 20
Squelch 20
Demodulators 21
Modulation Types 21
Types of Analogue Signal Demodulators 21
AM – Demodulation 22
Envelope Detector (Diode detector) 22
Product Detector (Non-Coherent Detector) 22
Synchronous Detector (Coherent Detector) 23
Coherence vs. Incoherence 23
FM Demodulation 25
Slope Detector 25
Foster-Seely Discriminator 25
Ratio Detector 25
Quadrature Detector 26
PM Demodulation 27
Coherent Phase Detector 27
CW Demodulation 28
Types of Digital Signal Demodulators 28
Amplitude Shift Keying (ASK) 28
Frequency Shift Keying (FSK) 28
Phase Shift Keying (PSK) 28
Quadrature Amplitude Modulation (QAM) 28
Emission Designators 29
Receiver Block Diagrams 30
AM (A3E) Receiver 30

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SSB (J3E) 30
FM [F3E] Receiver 31
CW (A1A) 31
DIY Simple Receiver 32
Build your own AM FM Receiver 32

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Receivers

A radio receiver is a device that receives radio waves that were captured in an antenna. The receiver selects a specific frequency using a tuner, amplifies the weak rf signals and demodulates the signal to convert it into usable information like audio (sound), video, or data.

Receiver Configurations

Radio receivers are categorised by their design architecture and application. The primary types are

- Direct conversion
- Tuned Radio Frequency (TRF).
- Superheterodyne (high performance).
- Crystal radios.
- Direct Conversion/Software-Defined Radios (SDR).

Receiver Rating

No matter what type of receiver, they are rated on three criteria, their sensitivity, selectivity and stability,

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.

Amateur radio receiver sensitivity typically ranges from 0.1µv to 1µv for a usable signal. Higher sensitivity means better weak-signal reception. A radio with too much sensitivity may suffer from overload.

Some examples and ranges of receiver sensitivity:

- VHF/UHF FM Transceivers (Typical): 0.15µv to 0.2µv for 12dB SINAD (Signal-to-Noise and Distortion ratio).
- Budget/Handheld Radio (e.g., Baofeng): Often around 0.18µv or better.
- HF Receiver (e.g., 14.2 MHz, 2.1 kHz BW): Typical noise floor is around 0.05µv (-133dBm.)

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. This is covered later in "noise".

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Dynamic Range

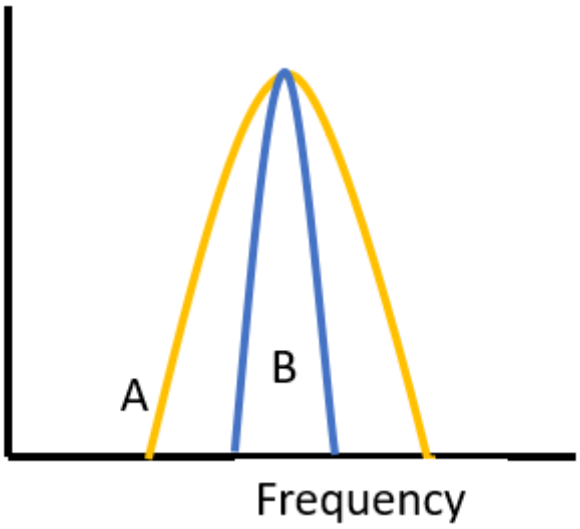
A receiver's dynamic range is the ratio between the strongest and weakest signals a receiver can process without distortion or noise interference. This range dictates the system's ability to pull out faint signals in the presence of powerful ones.

Dynamic range is measured in decibels (dB).

Example: Wi-Fi devices have a minimum detectable signal floor at -100dBm and the maximum tolerated signal is often around -20dBm. This yields a standard operating dynamic range of 80dB.

Selectivity

Selectivity is an important parameter in any radio receiver. A tight selectivity range is necessary for the receiver to be able to select the wanted signal from the unwanted adjacent signal. In the case below, receiver B is more selective than receiver A.



In some amateur radio receiver selectivity examples include Intermediate Frequency (IF) filters (e.g., 500 Hz for CW, 2.4 kHz for SSB), DSP notch filters, and roofing filters to reject nearby signals. These techniques allow operators to separate desired signals from adjacent interference, crucial in congested HF situations.

Stability

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

The overall receiver gain must be carefully controlled so that spurious emissions are not produced within the receiver.

Some amateur radio receivers use Temperature Controlled Crystal Oscillators (TCXOs) to remain stable even during temperature variations.

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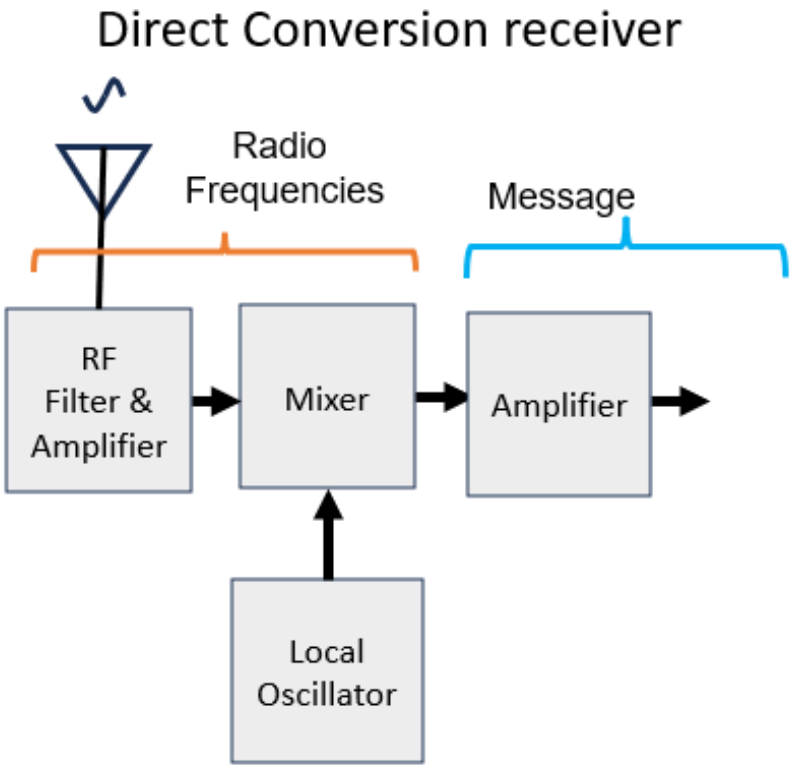
Receiver Configurations Groups

There are a variety of receiver configurations that can be used, and the choice of configuration can have a significant impact on the three criteria previously discussed.

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 for the intended signal.

This is a simple circuit. 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.



Tuned Radio Frequency Receiver (TRF).

A tuned radio frequency receiver (or TRF receiver) is a receiver composed of one or more tuned radio frequency (RF) amplifier stages followed by a detector (demodulator). This receiver was popular in the 1920s, but it was tedious to operate.

Tuning in a station on the radio required each stage of the radio to be individually adjusted to the station's frequency. Later models had ganged tuning.

The 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.

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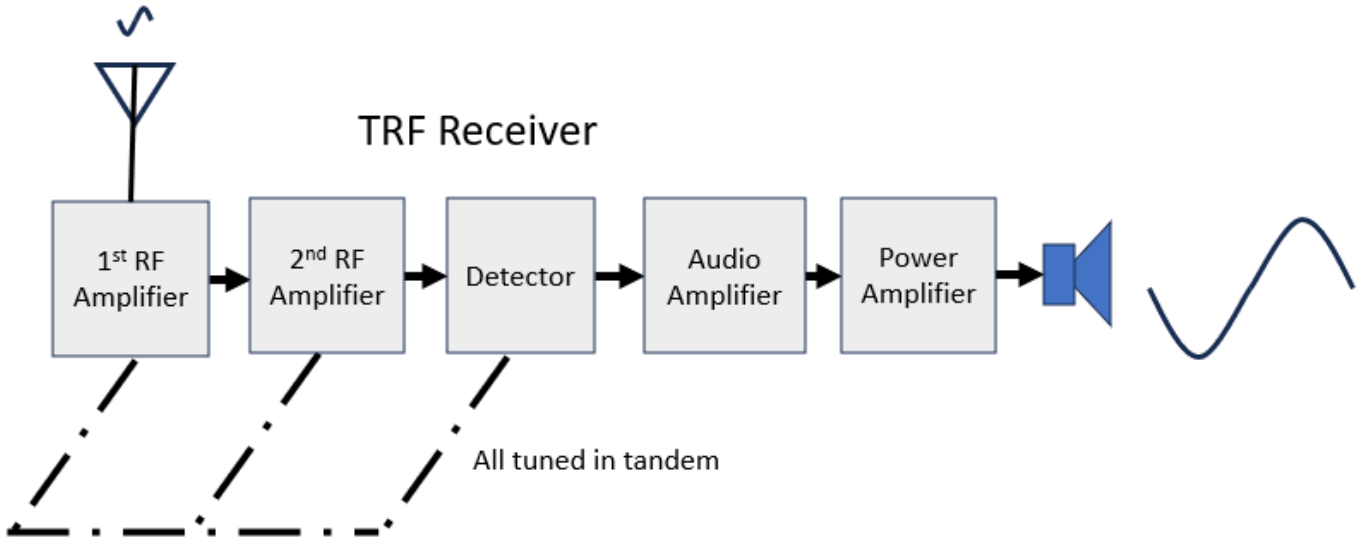


Superheterodyne Receiver.

A superheterodyne receiver (or "superhet") uses a mixer to convert incoming radio signals to a consistent, lower frequency, called an intermediate frequency (IF).

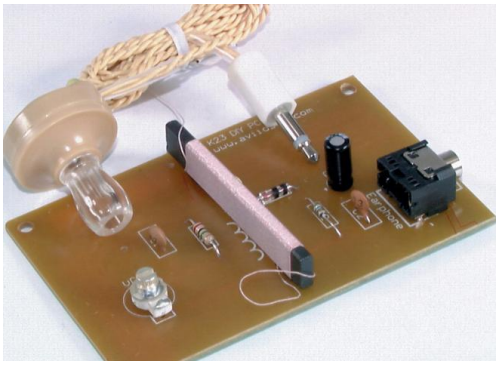
The superheterodyne radio receiver has been in widespread use for years, and it is still widely used for high performance applications. A variety of selectivity and filter requirements are applicable for superheterodyne receivers.

A Selective front end is required to ensure sufficient image rejection. The filters in the IF provide the main adjacent channel rejection.

The superheterodyne radio is discussed in more detail later.

Crystal radios.

A crystal radio is a simple radio receiver from the early 20th century that powers itself entirely from incoming radio waves. The crystal radio uses a long wire antenna, a coil-and-capacitor tuning circuit, and a diode as a detector. The detector converts the amplitude-modulated (AM) signals into sound, and the signal is heard through high-impedance headphones.



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Direct Conversion/Software-Defined Radios (SDR).

Software-defined radio (SDR) replaces traditional receiver hardware with software running on a computer.

SDR enables flexible, reconfigurable communication, allowing a single device to receive various protocols (FM radio, 5G, LTE, aircraft tracking)

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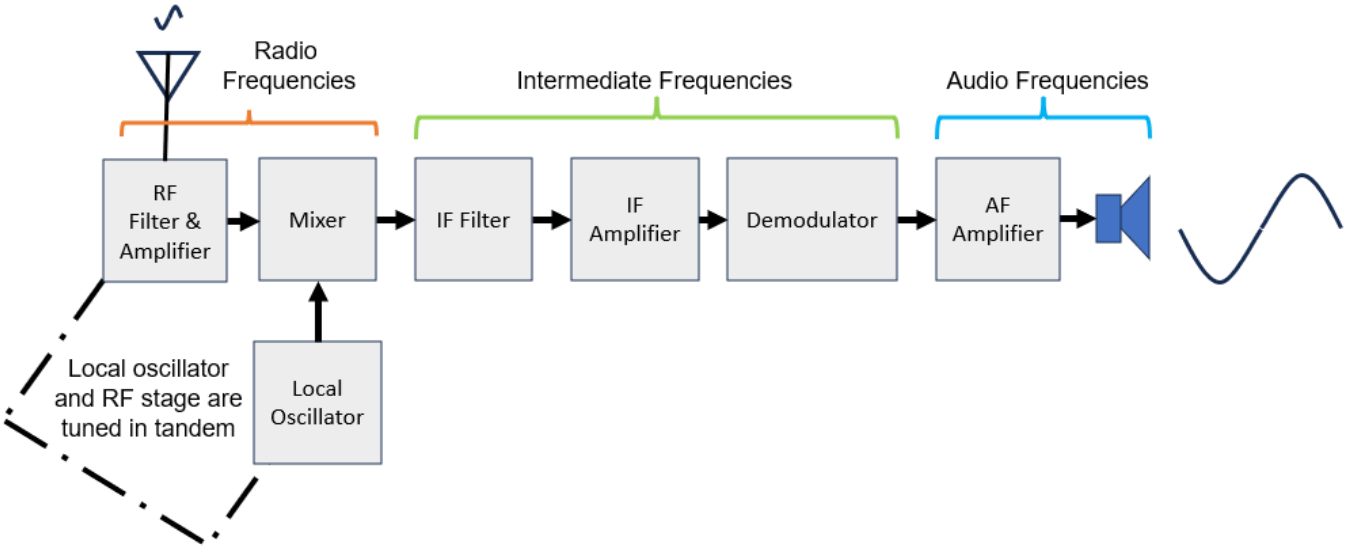
Superheterodyne Receiver in Detail.

A superheterodyne receiver, often shortened to the term “superhet”. The superhet is a receiver that uses frequency mixing to convert a received signal to a fixed intermediate frequency (IF). This IF can be more conveniently processed than the original carrier frequency. Virtually all modern radio receivers use the superheterodyne principle. Below is a block diagram of a superheterodyne receiver.



Antenna. Captures a very weak rf signal and passes to the RF Filter for further processing

RF Filter & Amplifier. This stage selects the desired signal from the antenna and provides initial amplification while reducing image frequencies

Local Oscillator (LO) The Local Oscillator (LO) produces a constant, stable signal at a frequency typically offset from the desired signal. If the intermediate frequency (IF) is to be 455 kHz, that means that local oscillator would be at a frequency which is 455 kHz above the incoming rf signal frequency.

Mixer A mixer combines the rf signal frequency with the local oscillator frequency to produce an Intermediate Frequency (IF).

IF Freq = RF Frequency – LO Frequency and IF Freq = RF Frequency + LO Frequency

IF amplifier. The IF amplifier is where most of the amplification and selectivity (narrowband filtering) occurs, ensuring only the desired signal passes through.

Detector / Demodulator. A demodulator is placed after the IF amplifier and extracts the audio or information signal from the modulated IF carrier.

Audio Amplifier: Boosts the demodulated signal to drive speakers or headphones.

Automatic Gain Control (AGC): Feeds back a voltage from the detector to the IF/RF amplifiers to keep the output levels constant, despite the level of the input signal.

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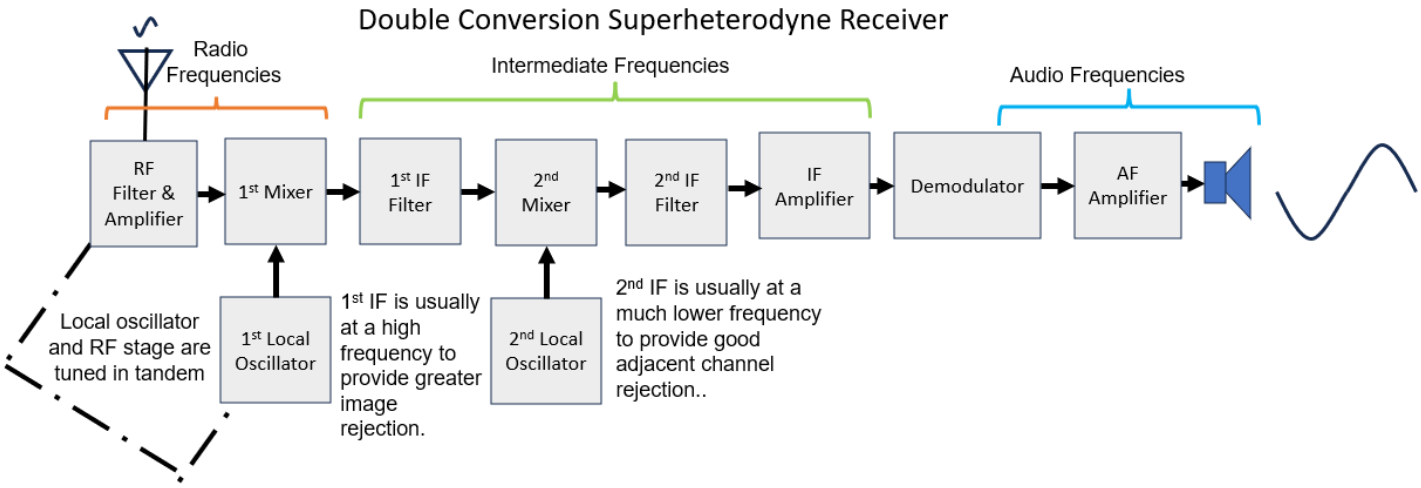
Double Conversion Superhet

A Double Conversion Superhet is a radio receiver that uses two distinct stages of frequency conversion (mixers) to convert an incoming radio frequency (RF) signal to two different Intermediate Frequencies (IF). This design enhances performance by using a high first IF for excellent image rejection and a low second IF for high selectivity.

These high-performance radios use two IF stages (e.g., 10.7 MHz, then 455 kHz).



A double superheterodyne (dual conversion) receiver solves the major trade-off in single superhet by converting incoming signals through two separate Intermediate Frequency (IF) stages. This method achieves exceptional image frequency rejection and razor-sharp adjacent channel selectivity, which are difficult to balance in a single conversion design.

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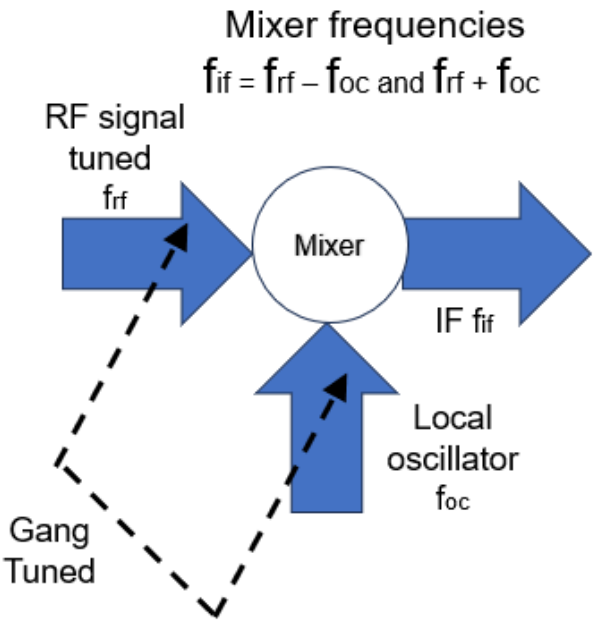
Mixer Frequencies and Image Frequencies

Mixer Frequencies

A frequency mixer is a device that translates signals from one frequency to another by mixing an input signal with a local oscillator. The mixer generates new frequencies, specifically the sum and difference of the inputs.



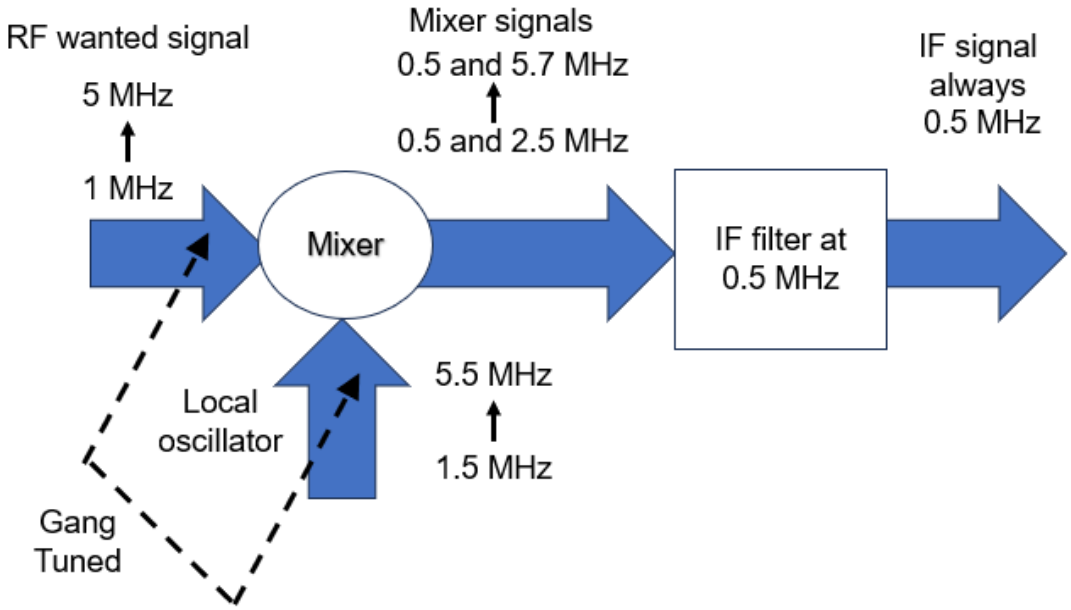
In the example shown above, there can be two possible IF frequencies generated.

RF + LO and RF – LO.

The local oscillator frequency is always higher than the RF signal by the frequency of the IF.

In the example below, sample frequencies are included to understand how a steady IF is generated.

The required IF frequency is 0.5 MHz and the RF range is 1 – 5 MHz. The oscillator is 0.5MHz higher than the RF frequency. The mixer produces two frequencies of plus or minus. The IF filter only passes the 0.5MHz signal and blocks the higher frequencies.



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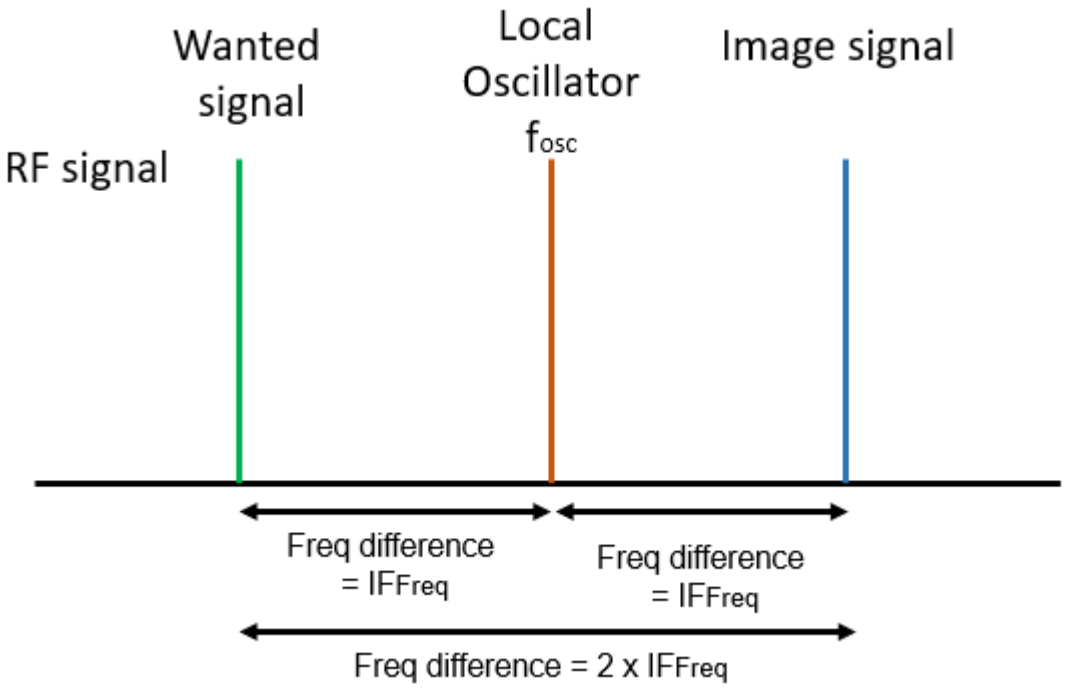
Example. The radio input tunes the RF signal to 3.7MHz, and the oscillator is tuned to 4.2MHz. The mixer output would be the difference (0.5MHz) and the sum (7.9MHz). The IF filter only passes the 0.5MHz signal and blocks the higher frequencies.

Image Frequency

There are two RF frequencies that can produce the same IF frequency. This is called the Image frequency. This frequency is the RF carrier frequency plus 2 x IF frequency.

$$Image = RF\ signal + (\ 2\ x\ IF)$$



This is where the selectivity of the front end becomes very important. In the example above, the 8.9MHz would not pass to the mixer.

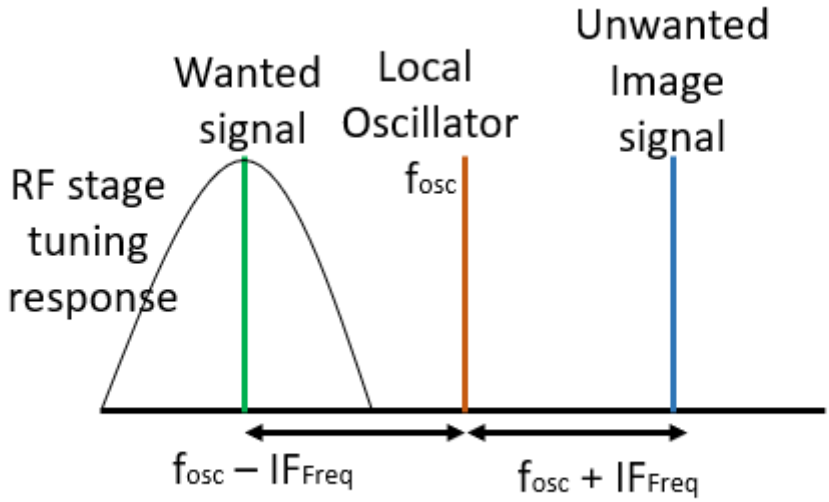


Image frequency = wanted signal frequency + (2 x IF_{Freq})

The first RF stage needs to be narrow enough to reject the image frequency. The tight tolerances of the IF filters keep the IF to the required frequency. Irrespective of the incoming signals, the RF amplifier and local oscillator must be tuned for that frequency together.

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Image rejection

Image rejection is the receiver's ability to suppress unwanted image frequency signals. This prevents two different radio frequencies from producing the same intermediate frequency (IF).

Assume that the wanted and unwanted signals are at the same voltage level at the input. The receiver reduces the unwanted signal to a level below the wanted signal.

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Noise

Radio noise is unwanted, random interference, can be internal or external, that disrupts or obscures desired radio signals. This interference raises the noise floor, making it difficult to receive weak signals.

Key types and sources of noise

Atmospheric Noise: Caused by natural electrical disturbances like lightning.

Man-Made Noise: Generated by artificial sources including power transmission lines, electrical equipment, ignition systems, and switching power supplies.

Thermal Noise (Johnson-Nyquist): Caused by the random thermal agitation of electrons inside electrical conductors at temperatures above absolute zero.

Galactic/Cosmic Noise: Radiation originating from celestial sources outside the Earth's atmosphere.

Thermal Noise (Voltage)

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.

Any circuit element that is above absolute zero will produce thermal noise, also called Johnson noise. A simple fixed resistor can produce white noise in any amplifier circuit, and this can only be reduced by lowering the circuit's temperature. This noise is independent of the resistor's material composition.

Thermal Noise (Power)

Thermal noise is the unavoidable power generated by the random thermal agitation of charge carriers inside an electrical conductor.

SINAD

SINAD (Signal-to-Noise and Distortion ratio) is a measure of signal quality, calculated as the ratio of the total received power (signal + noise + distortion) to the unwanted noise-plus-distortion power, typically expressed in decibels (dB). Higher SINAD values indicate better signal quality and higher, cleaner audio

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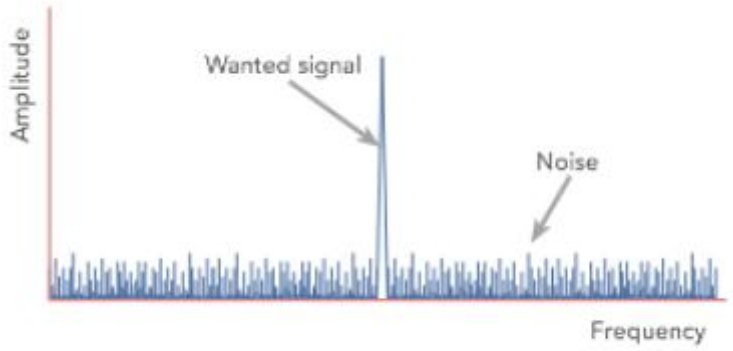
Signal to Noise Ratio

Radio noise or radio static is unwanted random radio frequency electrical signals.

The term noise encompasses natural, electromagnetic or atmospheric noise as well as manmade radio frequency interference (RFI) and internal thermal noise.

Signal-to-Noise Ratio (SNR) defines the ratio of signal power to background noise power within a system, expressed in decibels (dB).

A higher SNR indicates a clearer, stronger signal and a lower ratio implies higher noise and poorer data quality.



White noise spectrum

Band noise.

Band Noise or broadband noise is unwanted sound or radio interference that spreads across a wide range of frequencies.

Narrowband noise

Narrowband noise only affects a specific frequency,

Noise density.

Noise density is often called noise spectral density and is the amount of noise power present per unit of bandwidth, typically measured in Watts per Hertz

Noise density represents the distribution of noise across a frequency spectrum, enabling engineers to calculate total noise power.

White Noise

White noise is a consistent, "shushing" sound that combines all audible frequencies at equal intensity.

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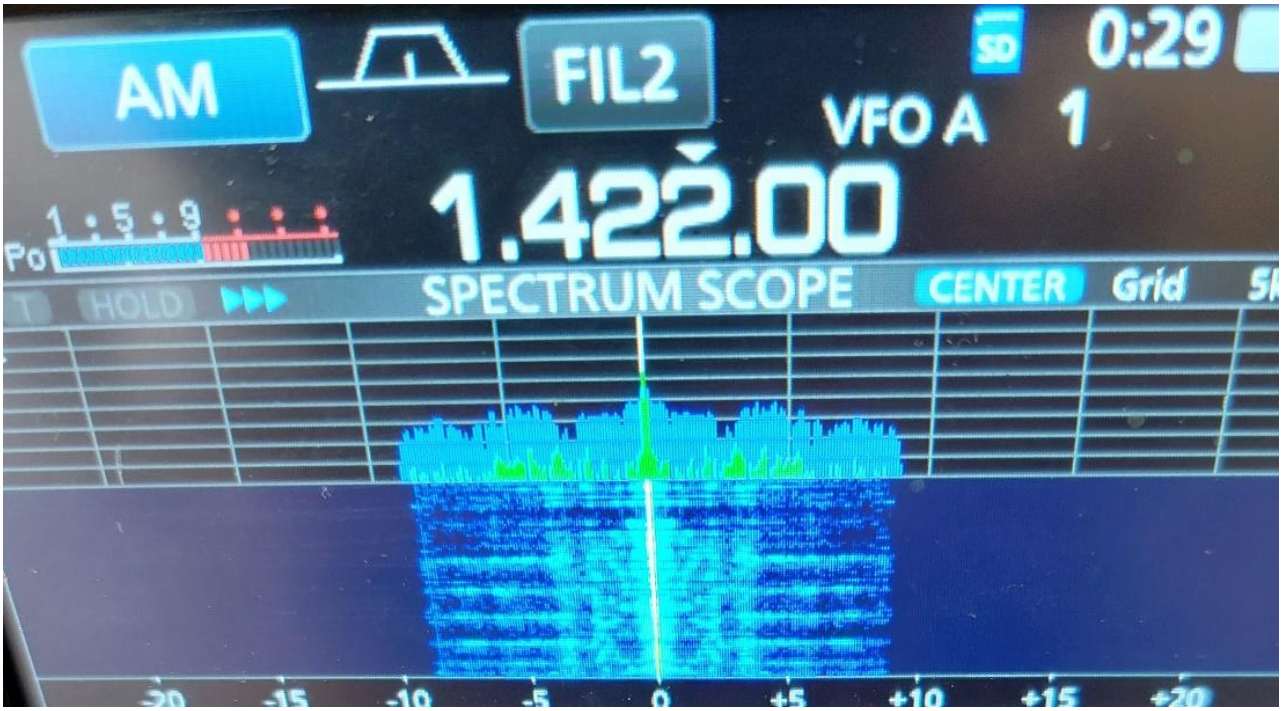
Bandwidth

Radio bandwidth is the range of frequencies occupied by a modulated radio signal. The bandwidth represents the difference between the highest and lowest frequencies of a signal.

Example: An AM broadcast radio channel on 750kHz has a bandwidth of 10kHz. The station occupies the frequencies from 760kHz to 770kHz.

The image below is a spectral figure of an AM signal at 1.422 MHz. The total bandwidth for this signal occupies 18 kHz.



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Signal Reports

A signal report informs the transmitting station, the readability and signal strength of their signal at your receiver.

There are three parts to a signal report.
R - Readability scaled 1 to 5 and judged by the receive operator.
S - Signal strength off the receiver's meter.
T - Tone on a scale of 1 to 9. Used for morse code only and judged by the operator.

Readability
1. Unreadable
2. Barely readable, occasional words distinguishable.
3. Readable with considerable difficulty
4. Readable with practically no difficulty
5. Perfectly readable

Signal strength.
This reading is a voltage measurement at the antenna input to the receiver. A midscale reading of S9 is triggered by 50µV at the antenna. Over S9, the meters indicate as follows:
• +20 means 20dB over S9 (10 times) or 500µV
• +40 means 40dB over S9 (100 times) or 5,000µV (5V)
• +60 means 60dB over S9 (1000 times) or 50,000µV (50V)

Wikipedia

Example: Signal report of 5 and 9 means the signal is perfectly readable and signal strength of 9.

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Common Receiver Terms

Audio amplifier

An audio amplifier is a device that takes an audio signal and amplifies it so that your speakers can play the audio. A receiver includes an audio amplifier, but the receiver also has extra functionalities such as a tuner, preamp, input selection, volume controls, and more.

Automatic Gain Control

Automatic gain control (AGC) is closed-loop feedback regulating circuits 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.

Blocking

Blocking is a condition in a receiver where an off-frequency signal (generally further off-frequency than the immediately adjacent channel) causes the signal of interest to be suppressed. Blocking rejection is the ability of a receiver to tolerate an off-frequency signal and avoid blocking. A good automatic gain control design is part of achieving good blocking rejection.

Capture Effect

This is a phenomenon associated with frequency modulation (FM) and Amplitude Modulation (AM) to a lesser extent.

The capture effect is a characteristic of a FM receiver circuit where two or more signals are transmitted on the same frequency, only the stronger signal will be demodulated. In the FM circuit, the incoming signal is limited in amplitude.

The capture effect is where the weaker signal is not amplified but attenuated. When both signals are nearly equal in strength or are fading independently, the receiver may rapidly switch from one to another and exhibit flutter.

In the case of an FM signal, the capture affect dominates when the stronger signal was about twice as strong as the weaker signal. In AM signals the stronger signal has to be about twenty times that of the weaker signal.

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.

Cross modulation

Cross-modulation is an effect in which amplitude modulation (AM) from a strong undesired signal is transferred to a weaker desired signal. A cross-modulation specification ≥ 100 dB would be considered decent performance. This figure is often not given for modern HF receivers, but if the receiver has a good third-order intercept point, it is likely to also have good cross-modulation performance.

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Emphasis

Pre-emphasis is undertaken in the FM transmitter, and the de-emphasis is undertaken at the FM receiver.

Emphasis is the technique of boosting higher audio frequencies (pre-emphasis) before transmission and reducing them (de-emphasis) 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.

Desensitisation

Desensitisation or receiver blocking is a form of interference in a radio receiver that is unable to receive a weak radio signal that it might otherwise be able to receive. This is caused by a nearby transmitter with a strong signal on a close frequency, which overloads the receiver and makes it unable to fully receive the desired signal.

In a typical receiver, the Minimum Detectable Signal (MDS) level is determined by the thermal noise of its electronic components. When a signal is received, additional spurious signals are produced within the receiver because it is not truly a linear device. When these spurious signals have a power level that is less than the thermal noise power level, then the receiver is operating normally. When these spurious signals have a power level that is higher than the thermal noise floor, then the receiver is desensitised.

Intermodulation

Intermodulation (IM) or intermodulation distortion (IMD) is the amplitude modulation of signals containing two or more different frequencies. Intermodulation is caused by non-linear behaviour of the signal processing (physical equipment or even algorithms) being used.

Limiter

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.

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.

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Reciprocal mixing [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.

S Meter

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 50μV signal at the antenna input to the receiver.

Squelch

The receiver squelch is a circuit that acts to suppress the audio output of a receiver in the absence of a strong input signal. Squelch is used in two-way radios and VHF/UHF radio scanners to eliminate the sound of noise when the radio is not receiving a desired transmission.

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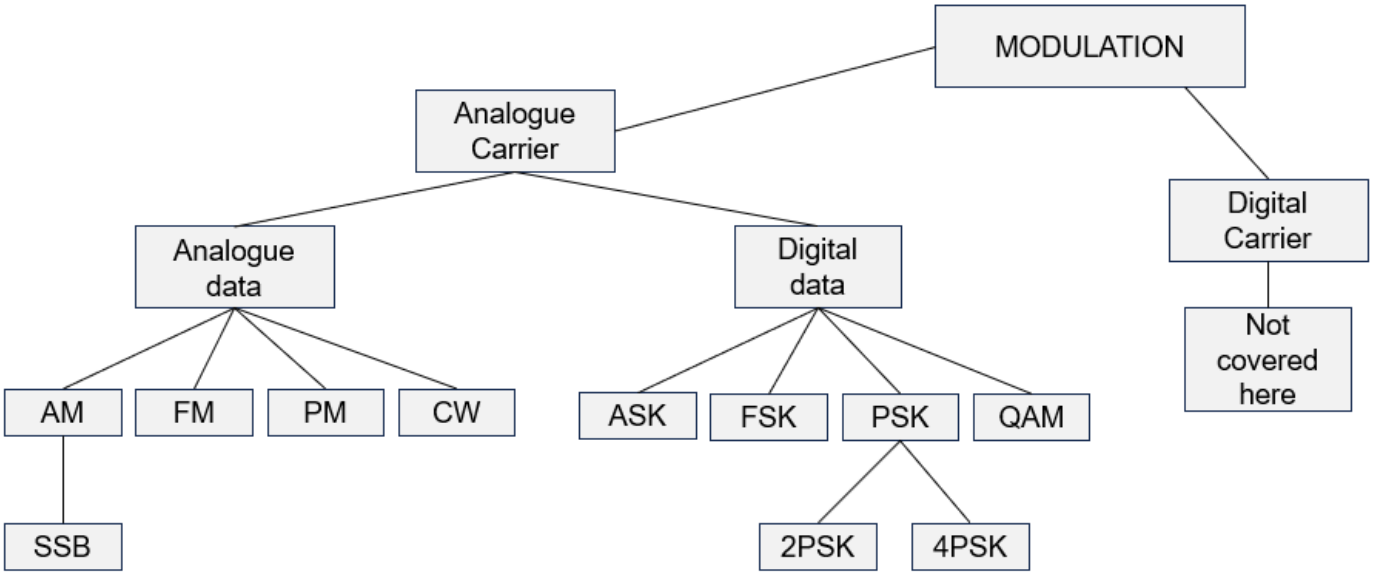
Demodulators

Modulation Types



For every modulation technique used in amateur radio, there must be a corresponding modulator and demodulator.

A modulator is a process of including information onto a radio carrier signal.

A demodulator is the process of extracting information from a radio carrier signal.

Types of Analogue Signal Demodulators

Amplitude modulation (AM)	Envelope detector (Diode detector), Synchronous Detector (Coherent Detector) or Product detector
Single Side Band (SSB)	Synchronous Detector (Coherent Detector) or Product detector.
Frequency modulation (FM)	Slope Detector, Foster-Seeley Discriminator, Ratio Detector or Quadrature Detector:
Phase modulation (PM)	Coherent Phase Detector
Morse code (CW)	Product detector

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AM – Demodulation

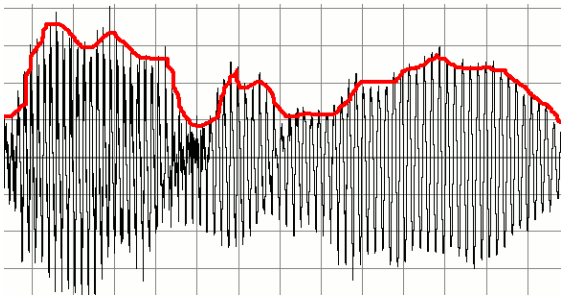
Envelope Detector (Diode detector)

Amplitude modulation, AM, can be demodulated easily with a single diode rectifier circuit and an RC network for smoothing the signal.

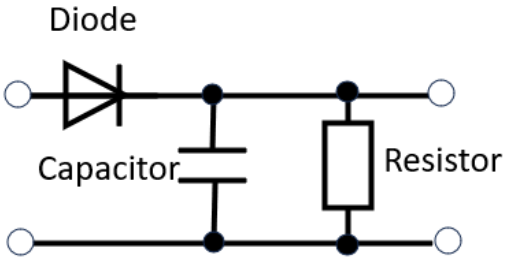
An envelope detector cannot be used for SSB demodulation.

An envelope detector or peak detector is a circuit that converts a high-frequency amplitude modulated signal and provides a demodulated output.

The incoming AM signal is in black and the demodulated signal is shown below in red.



A circuit for an envelope detector is shown below. The time constant of the capacitor and resistor are important to achieve good demodulation.



Envelope Detector

Envelope detectors use either half-wave or full-wave rectification of the signal to convert the AC into a pulsed DC signal. Filtering smooths the final output. Some "ripples" may remain.

Reducing the filter cutoff frequency gives a smoother output but decreases the high frequency response.

Product Detector (Non-Coherent Detector)

A product detector can be designed to accept either IF or RF frequency input for SSB signals. The product detector takes the product of the modulated signal and a local oscillator.

The simplest form of product detector mixes the RF or IF signal with a locally derived carrier (the Beat Frequency Oscillator, or BFO) to produce an audio frequency copy of the original audio signal and a mixer product at twice the original RF or IF frequency. This high-frequency component can then be filtered out, leaving the original audio frequency signal.

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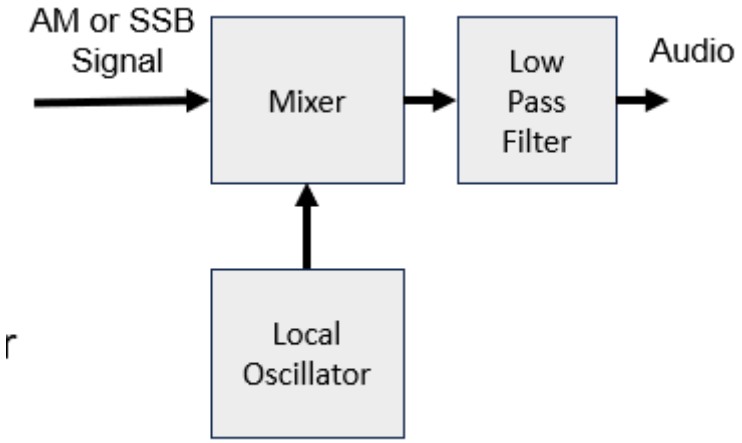


Product Detector

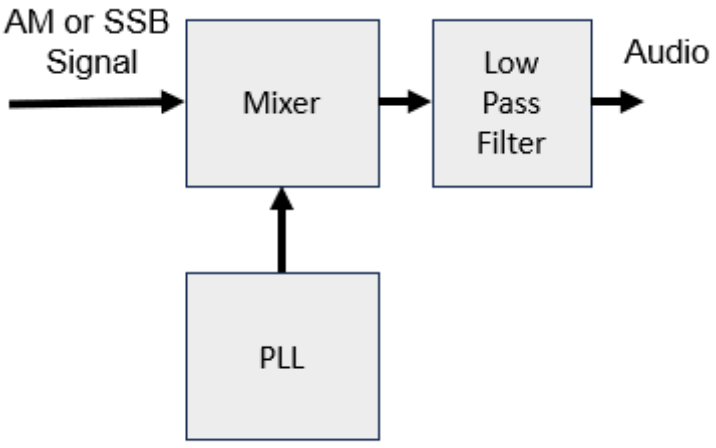
Synchronous Detector (Coherent Detector)

A synchronous detector is a specialized, superior form of product detection for AM. It uses a phase-locked loop (PLL) to match the carrier's frequency and phase, eliminating fading-related distortion

A synchronous detector can be used for AM and SSB signals.

A synchronous detector recovers information from a modulated signal by mixing the signal with both frequency and phase replica of the unmodulated carrier. This system retains the phase of the original signal.

Unlike non-coherent detection (like envelope detection), which only extracts amplitude, coherent detection recovers both the amplitude and phase of the signal.



Synchronous Detector

Coherence vs. Incoherence

The term “coherent” will come up several times in the discussion of demodulators, so it is worthwhile understanding the term.

Coherent: Two signals are coherent if they always maintain a constant relative phase relationship with one another.

Incoherent: Two signals are incoherent if they do not have a constant, stable phase relationship with one another.

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Unlike incoherent detectors that only detect intensity (power), coherent systems use the phase of the wave, allowing for complex modulation formats like Quadrature Amplitude Modulation (QAM).

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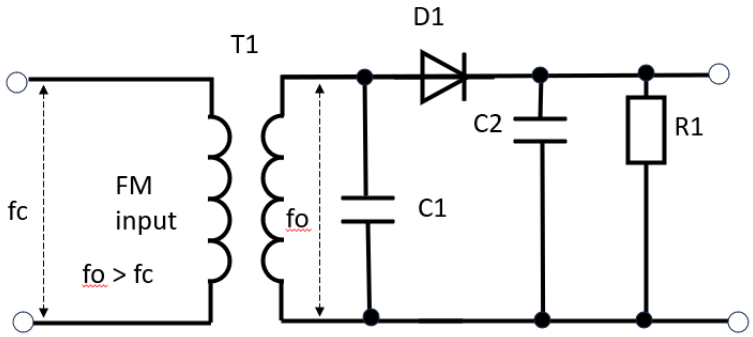
FM Demodulation

Slope Detector

A slope detector is a simple FM demodulator circuit that converts frequency variations (FM) into amplitude variations (AM). The AM signal is detected by a diode and filtered to recover the original audio.

A slope detector uses a resonant tank circuit that is tuned slightly off the carrier frequency. The rising or falling slope of the filter's response curve translates frequency changes into voltage changes (AM).

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



FM Slope Detector

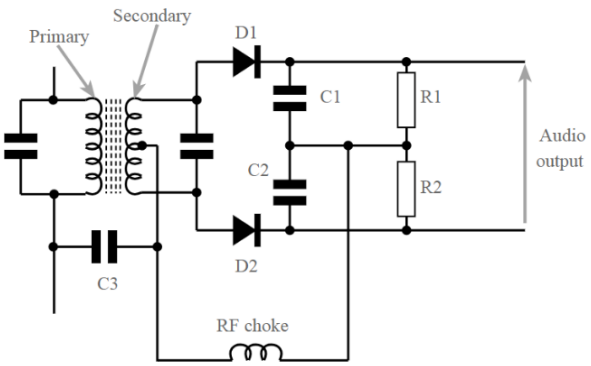
Foster-Seely Discriminator

The Foster-Seeley discriminator is a FM demodulator using a center-tapped resonant transformer to convert frequency variations into amplitude-modulated signals.

The Foster Seeley FM discriminator is characterised by the transformer, choke and diodes used in the circuit**.** The Foster Seeley discriminator also provides a voltage for automatic frequency control.

Like the slope detector, the Foster-Seely discriminator converts the FM signal to an AM signal and uses diodes for detection.

The Foster Seely discriminator offers excellent linearity for high-fidelity audio but requires a preceding limiter stage to remove amplitude modulation noise.



Ratio Detector

The ratio detector for FM signals is a variant of the Foster–Seeley discriminator. The ratio detector has the advantage over the Foster–Seeley discriminator that it does not respond to amplitude

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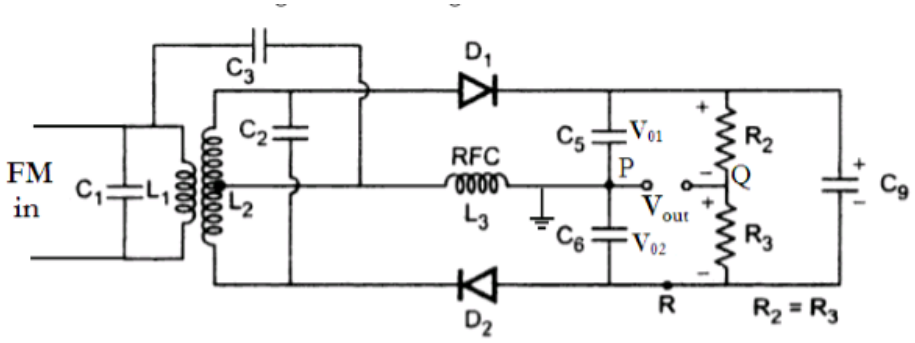
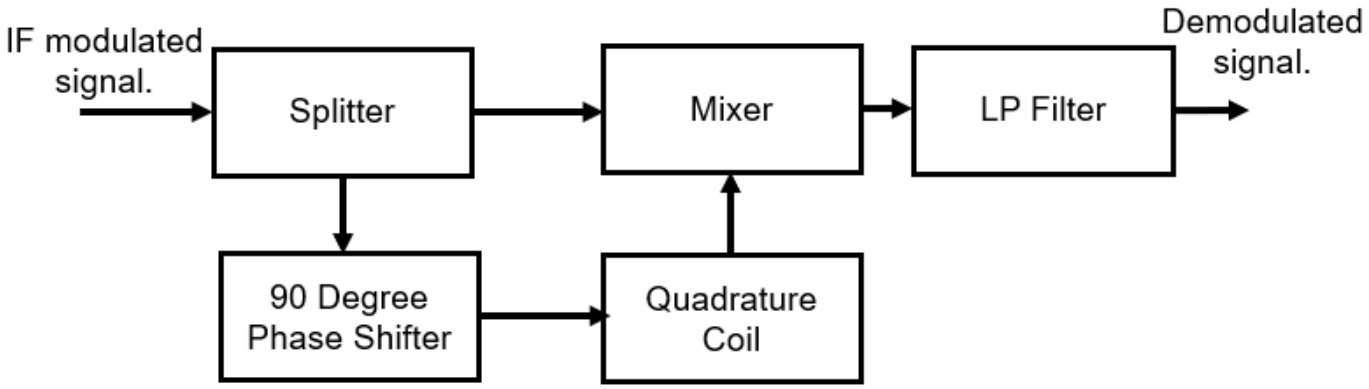
modulation (AM) signals. However, the output is only 50% of the output of a discriminator for the same input signal. The ratio detector has wider bandwidth, but more distortion than the Foster–Seeley discriminator.



Quadrature Detector

A quadrature detector is a commonly used Frequency Modulation (FM) demodulator. The quadrature detector converts signals into audio (or data) by detecting phase changes between two versions of the same signal.

The quadrature detector consists of a mixer, phase shifter with a low pass filter. The incoming signal splits with one entering the mixer directly and the second signal is 90° phase shifted. The mixer output is dependent upon the phase difference between the two signals.



Quadrature Detector

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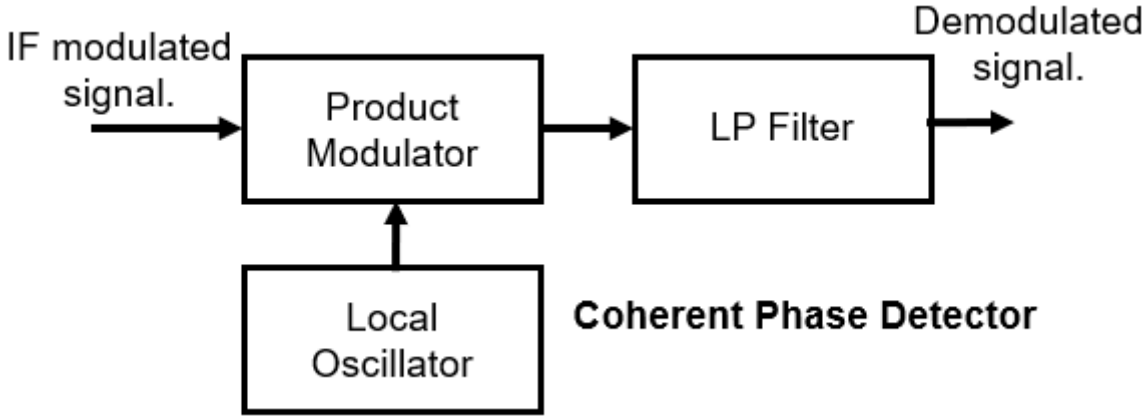
PM Demodulation

Coherent Phase Detector

A Coherent Phase Detector and a Coherent Detector are closely related but not strictly the same. Both methods rely on a local oscillator to maintain phase consistency with the incoming signal.

A coherent detector commonly refers to a receiver that extracts amplitude, phase, or frequency information.

A coherent phase detector is a specific type of coherent detector to specifically measure the phase difference between two signals.



A coherent phase detector mixes a received signal with a local oscillator to produce an output voltage that is directly proportional to the phase difference between them. Coherent phase detection uses both amplitude and phase to recover information and achieve better signal-to-noise ratios (SNR).

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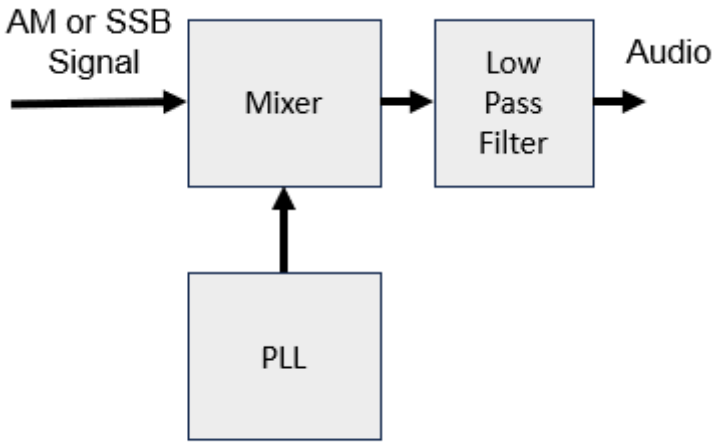
CW Demodulation

CW is demodulated using a Product Detector. A Beat Frequency Oscillator (BFO) is used to produce an audio frequency copy of the original audio.



Product Detector

Types of Digital Signal Demodulators

Amplitude Shift Keying (ASK)

ASK is an AM signal and is demodulated by the same processes and AM.

Frequency Shift Keying (FSK)

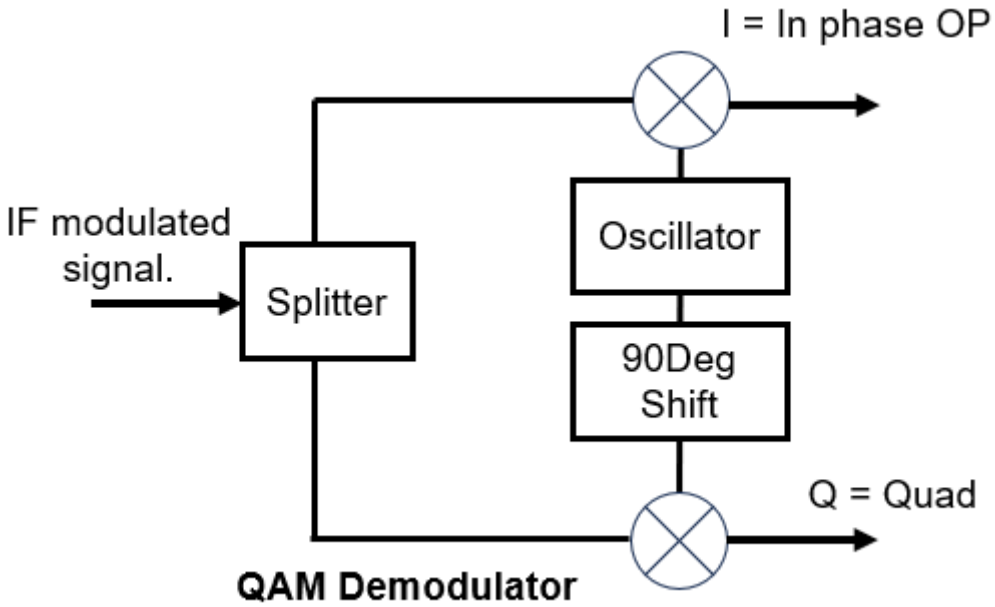
ASK is an FM signal and is demodulated by the same processes and FM.

Phase Shift Keying (PSK)

Phase Shift Keying (PSK) is demodulated by a Synchronous Detector (Coherent Detector) covered previously.

Quadrature Amplitude Modulation (QAM)

A Coherent I-Q Demodulator splits the incoming signal to extract the in-phase and quadrature components using mixers. A local oscillator (LO) with a phase shifter, and low-pass filters is used to recover the original baseband signal. This detects both phase and amplitude of the signal.



QAM Demodulator

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Emission Designators

Emission designators are alphanumeric codes (up to nine symbols) defined by the ITU to classify radio transmissions based on bandwidth, modulation type, signal nature, and information type. Common examples include F3E (FM voice) and A3E (AM telephony). The first four characters define necessary bandwidth, while the next three describe modulation, signal, and information.

Mode	First	Second	Third	Designator
CW	A = Double Sideband	1 = A single channel containing quantized or digital information without the use of a modulating sub-carrier	A = Telegraphy - for aural reception	A1A
AM	A = Double Sideband	3 = A single channel containing analogue information	E = Telephony (including sound broadcasting)	A3E
SSB	J = Single sideband, suppressed carrier	3 = A single channel containing analogue information	E = Telephony (including sound broadcasting)	J3E
FM	F = Frequency modulation	3 = A single channel containing analogue information	E = Telephony (including sound broadcasting)	F3E

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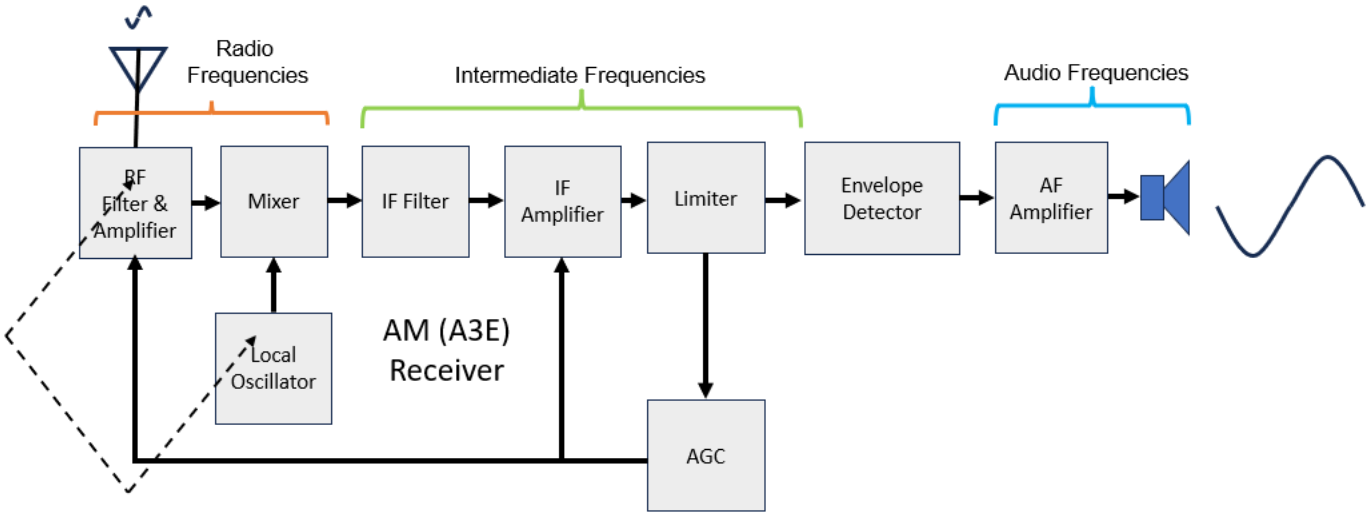
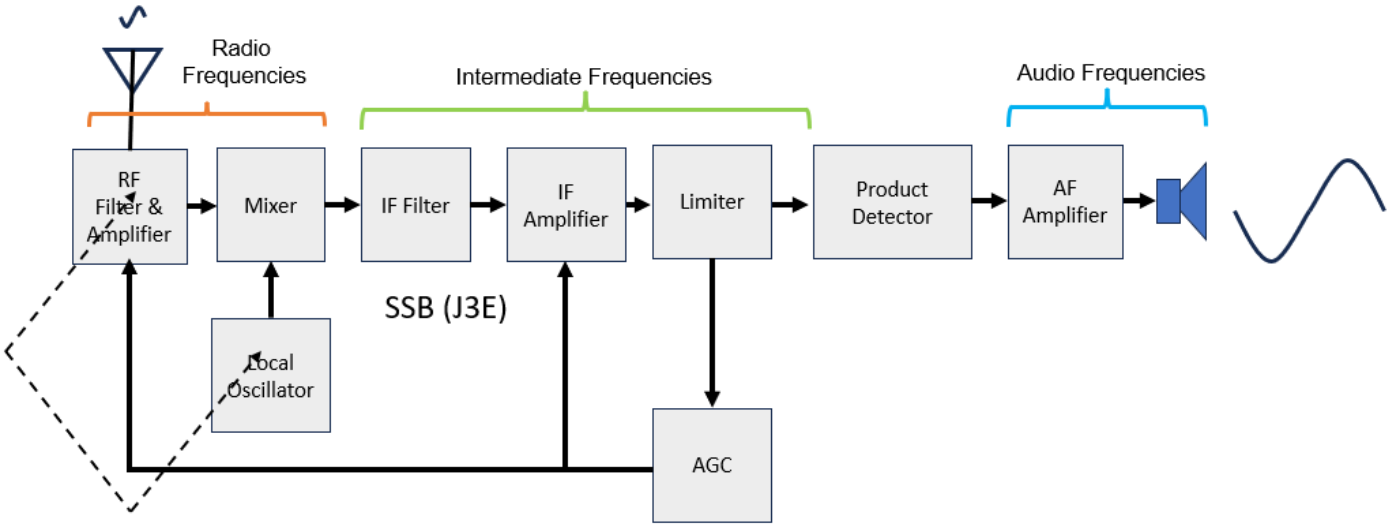
Receiver Block Diagrams

Examine these block diagrams and know the contents of each block. A typical exam question is to show a block diagram and ask the name of the blocks.

AM (A3E) Receiver



SSB (J3E)



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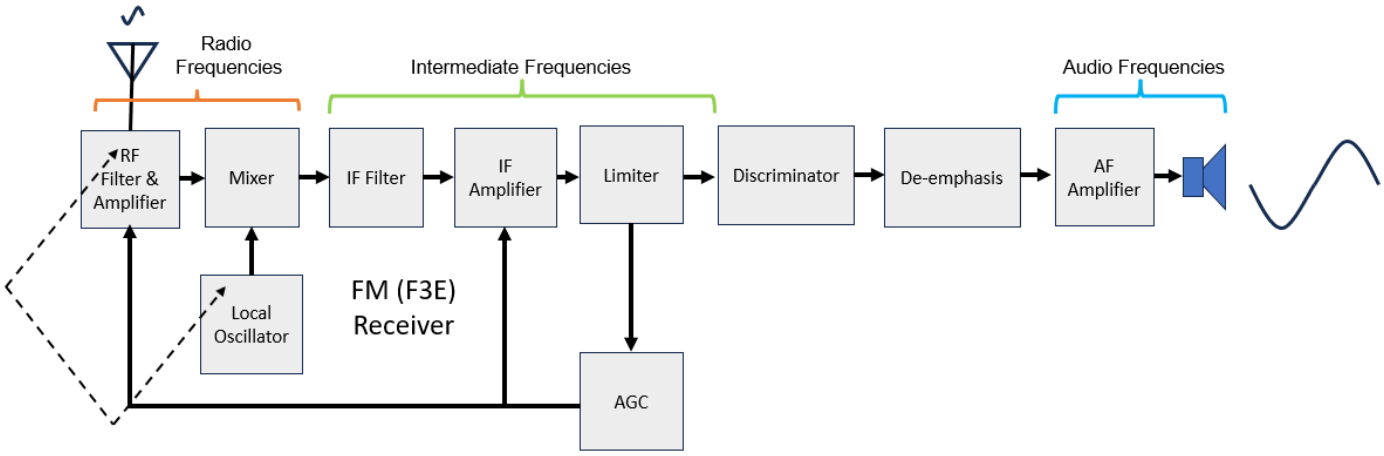
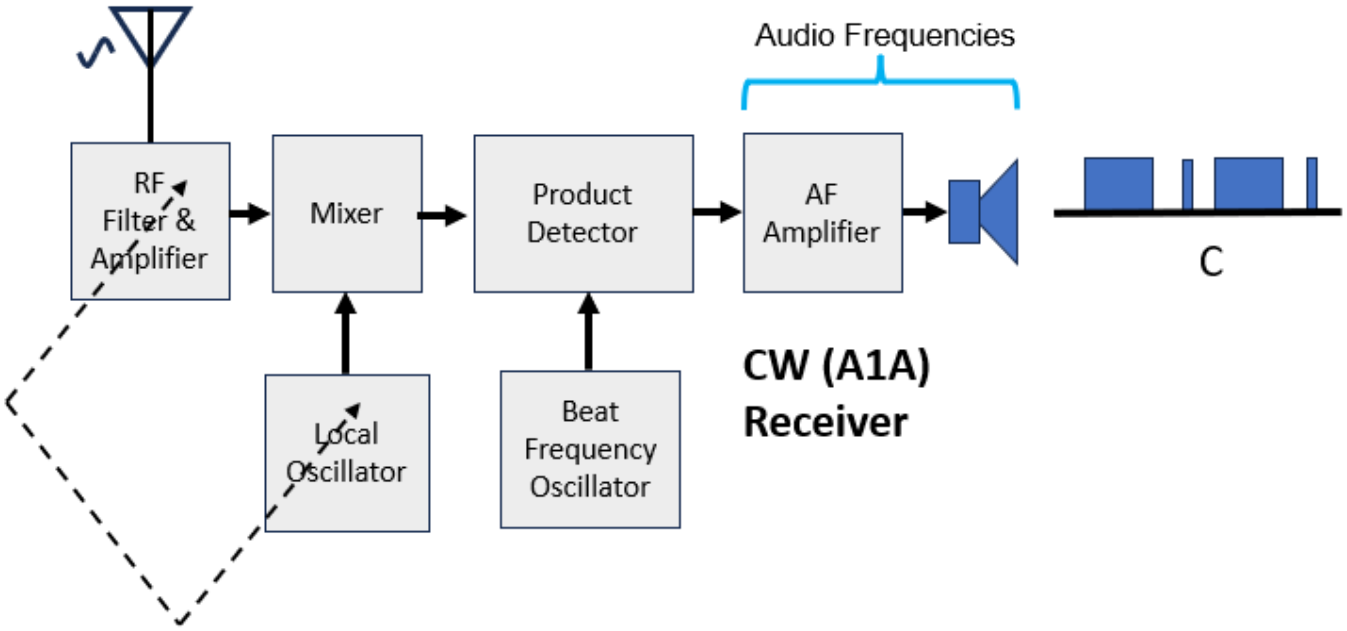
FM [F3E] Receiver



CW (A1A)



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DIY Simple Receiver

The simple kit receiver is the Hengxing Brand Hx2026 One-Pack Radio Kit Digital Production Kit Training Parts DIY.

Look for this online.

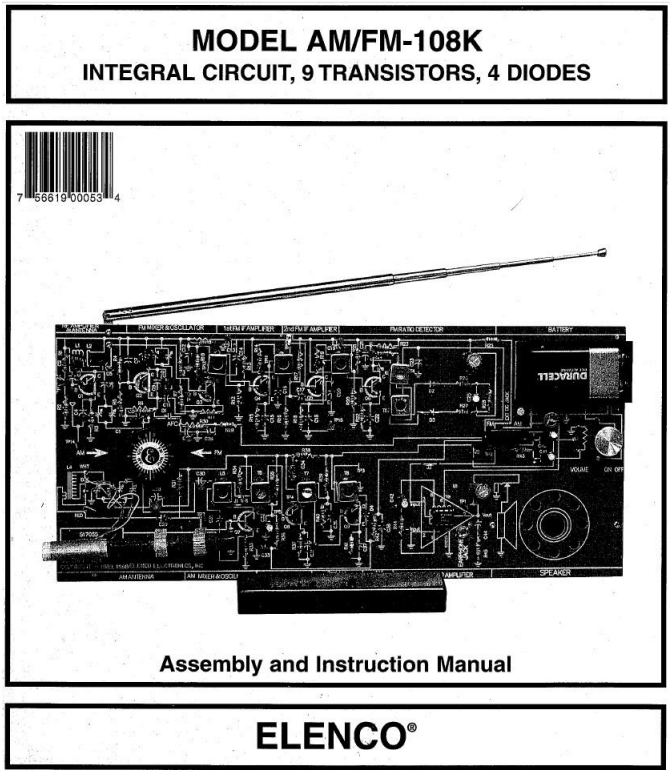
Build your own AM FM Receiver

I am not an agent for these radios, and I don't have any financial connection with the company, but I believe this would make a great learning tool.

The reasons I like this kit are as follows.

- The construction manual is very comprehensive and explains the operation of each stage.
- Needs a lot of high-quality soldering.
- Each step is well explained.
- Needs test equipment
- The parts are numbered and easy to identify.

Worth a look.



Go to Unit 13 Questions.

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