Chapter 5
Radio Equipment

Transmitters, Receivers

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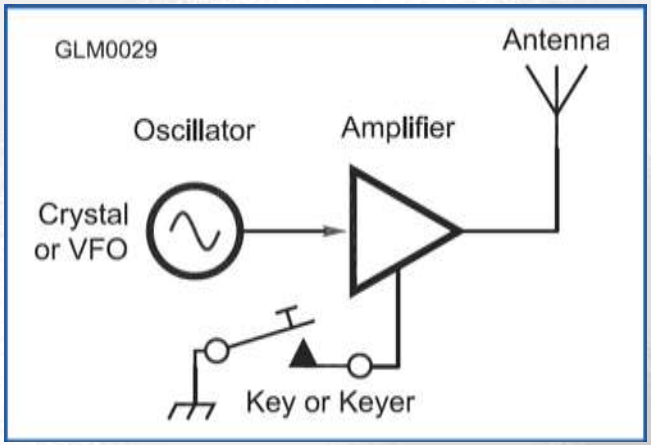
CW Transmitters

The simplest transmitter is an oscillator driving an amplifier with a Key for modulation.

- Suited for operation on one band
- Amplifier isolates the oscillator for stability.



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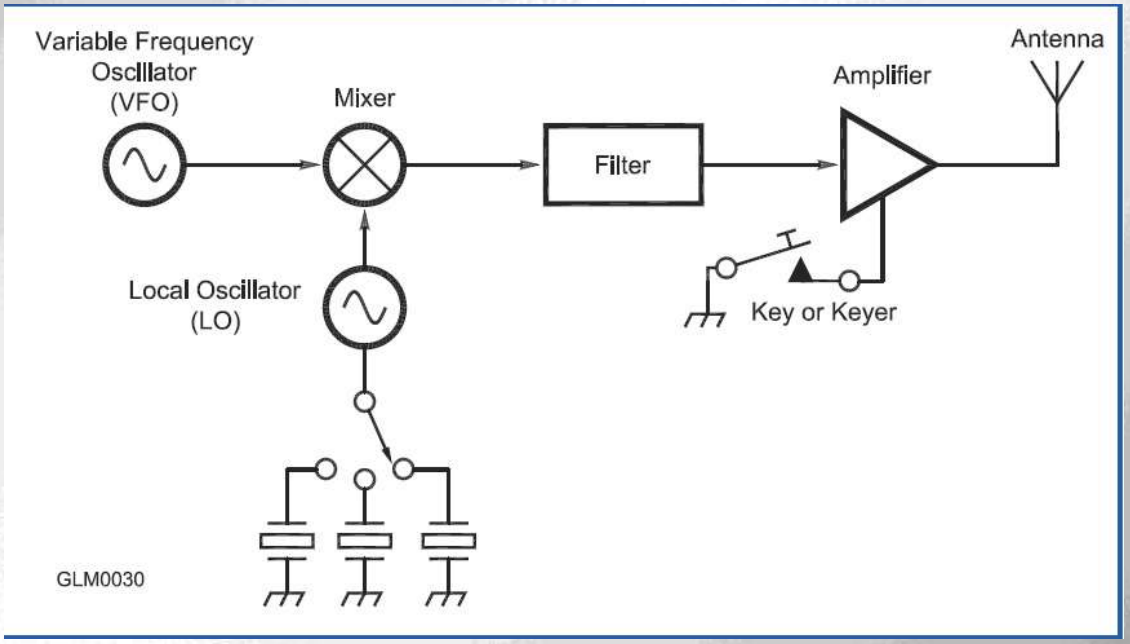
Multiband CW Transmitter

Other bands can be added to the simple transmitter by mixing the oscillator with fixed frequencies.



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SSB Phone Transmitter

For AM or SSB, speech is mixed with the VFO in a balanced mixer.

- USB and LSB are created
- VFO is cancelled out by balance action of mixer
- One sideband is selected by a filter
- AM (with carrier) may be selected by injecting the VFO signal after the filter
- Sideband is mixed with Local Oscillator to heterodyne to operating frequency.
- Signal is amplified by a Linear Amplifier

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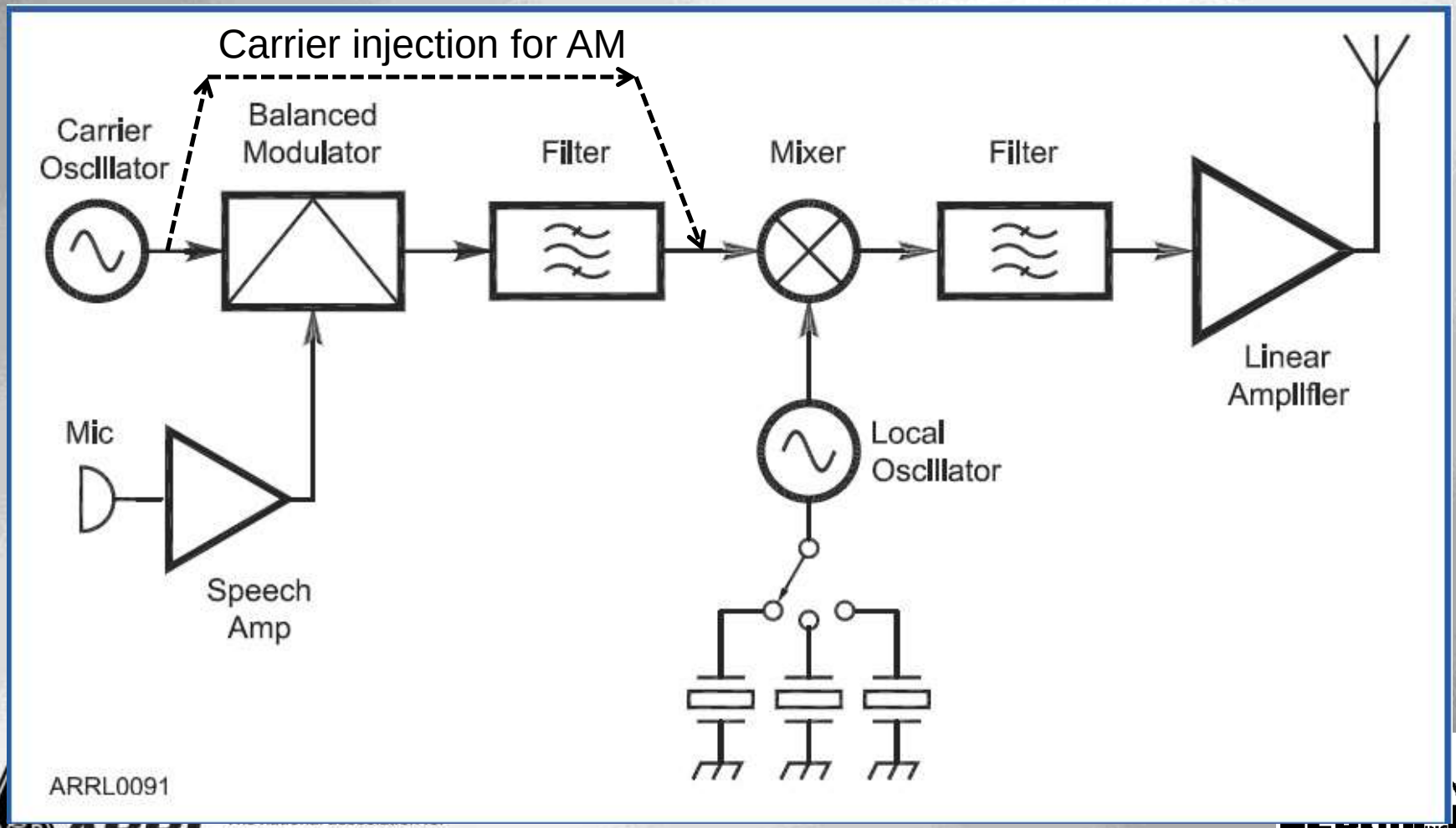
SSB Phone Transmitter



FM Phone Transmitters

Simple FM transmitters apply modulation at a much lower frequency than the output frequency.

- Frequency Multipliers raise the modulated signal frequency.
- Frequency deviation is also multiplied.
- Bandwidth by Carson's Rule:
  - Add highest modulating frequency and peak deviation
  - Multiply by 2
  - BW = 2*(Fmod + Fdev) => 2 * (3KHz + 5KHz) = 16KHz
- Because of wide bandwidth FM is not allowed below 29.5MHz.

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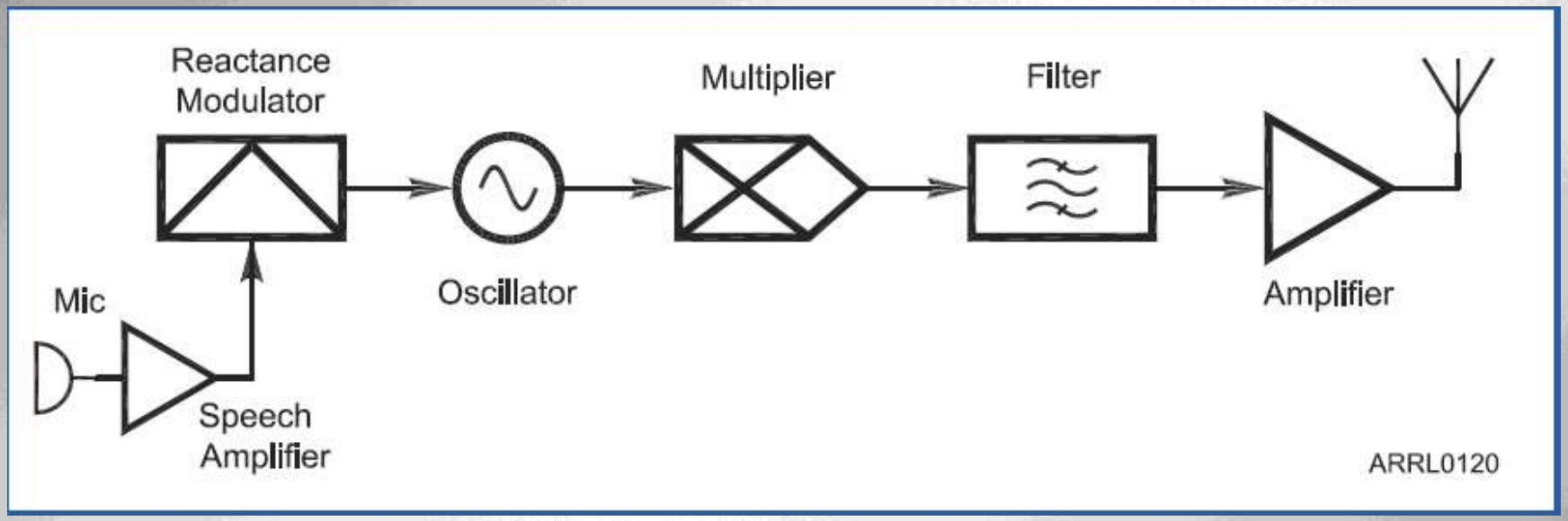
FM Transmitter Diagram



Fosc = 12.21MHz
Fout = 146.52MHz
Multiplier = 12

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Overmodulation of AM Transmitters

When you turn the microphone gain too high, the RF amplifier is driven into a *non-linear* region.

- Peaks of the RF envelope will flatten or be clipped and the signal may cut off between peaks
- New frequencies will be produced by the mixing of the signal frequencies in the non-linear amplifier.
- Mixing products may interfere in adjacent channels as “splatter”

- Monitor your signal by listening or with a scope.
- Use a two-tone test to check linearity.

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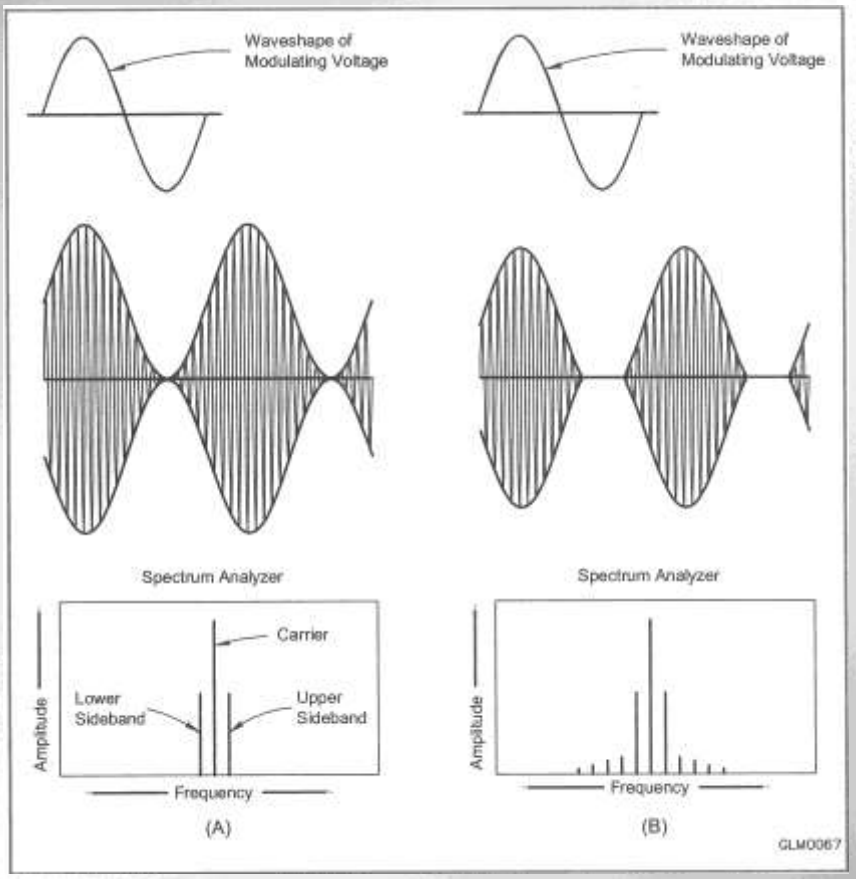
AM Full and Over Modulation



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Speech Processing

Phone communications can be improved by:

- Keeping the average power level high
- Boosting some of the audio frequencies
- Compressing or clipping the audio peaks

Compression is stated in decibels

- 10 db means the peaks are reduced by 10db
- Lower levels are not compressed as much
- Too much compression can make the signal sound noisy and distorted.

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Overdeviation of FM Transmitters

In FM transmitters, too much deviation causes more power in the minor sidebands

- Causes interference to adjacent channels.
- Causes distortion in the receiver because of the limits of the discriminator.
- Adjustment of deviation requires test equipment
- Reduce the microphone level or talk across the microphone while monitoring your signal.

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Key Clicks on CW

When a CW transmitter is turned on or off too rapidly, transient frequencies are produced which sound like clicks or thumps.

- Key clicks are usually only heard by nearby receivers.
- Key clicks can be reduced by using a shaping filter in the keying circuit to control the turn-on and turn-off times.

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Digital Modulation Concerns

If the digital mode uses an audio signal sent by a Phone transmitter:

- Distortion can be caused by over modulation or over deviation.
- Levels of digital signal are adjusted by monitoring the transmitter output just like other Phone methods.
- PSK31 reception is sensitive to levels of intermodulation distortion.
- Keep drive below level which causes ALC action
- PSK operators give signal RSQ reports for Readability, Strength, Quality. Q is 1 to 9.

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Classes of RF Power Amplifiers

RF Amplifiers for CW and FM can be more efficient because they are constant output with no modulation.

- RF Amplifiers for SSB and AM have an output which varies with modulation.
  - Output must have a linear relationship to input
  - Linear operation usually means less efficiency.
- Efficiency is the RF output PEP divided by the DC plate or collector power.

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Classes of RF Power Amplifiers

Class C – Conducts the least. Up to 80% efficiency but lowest linearity. Used for CW, RTTY, and FM

Class A – Tube conducts for whole cycle. Poor efficiency – less than 50%. (Worst at no signal.) Good linearity

Class B – Tube conducts for half cycle. Higher efficiency than A – up to 65%. Linearity OK for some uses.

Class AB – More conduction than B. Has *idling current* at no signal. Efficiency not as good as B. Linearity better than B. Commonly used for SSB

- AB1 – No grid current
- AB2 – Some grid current

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Operating Power Amplifiers

Amplifiers must be *Tuned* and *Loaded*.

- *Bandswitch* set for the operating band.
- Apply driving signal level to produce increase in plate current.
- Adjust Tune for a dip in plate current
- Adjust Load for maximum RF output power
- Increase drive signal and repeat Tune and Load
- Limit plate and grid current to tube reccomendations for longest tube life.

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Neutralization of Amplifiers

Feedback from the amplifier output to the input through the plate to grid capacitance can cause the amp to oscillate.

- Oscillation is sometimes at VHF
- Evidenced by plate current without RF drive
- Neutralization cancels the feedback effects to prevent oscillation.
- Adjustment is usually only done when the tubes are replaced

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Superheterodyne Receivers

Heterodyning is when two frequencies are mixed to produce sum and difference frequencies.

- Superhet receivers mix the incoming RF with a Local Oscillator to produce an Intermediate Frequency (IF).
- IF is filtered and amplified before demodulation
- For SSB, a Product Detector and BFO are the demodulator which produces AF.
- The AF is amplified for output to a speaker.

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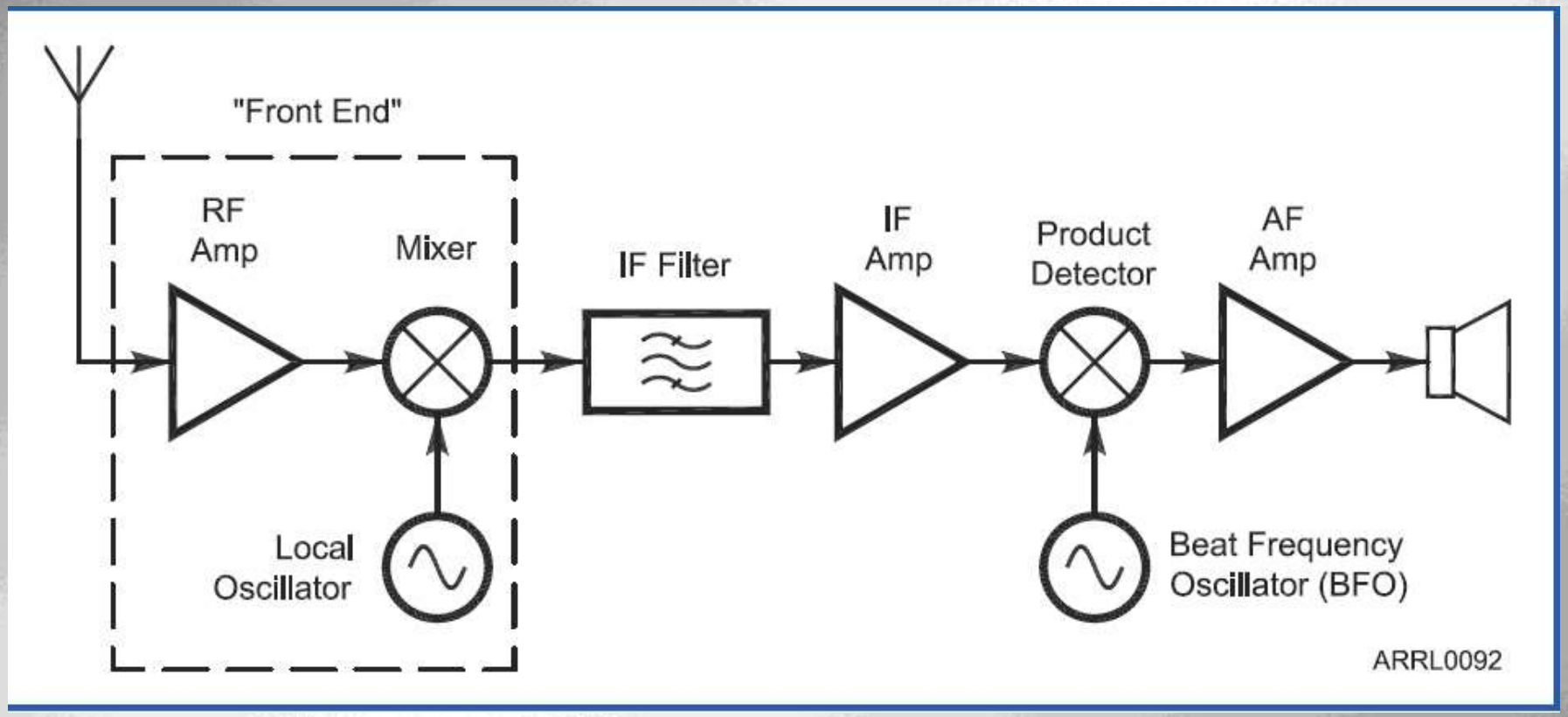
Receivers for AM, SSB, and CW



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Receivers for FM

Superhet design is also used for FM receivers

- IF amplifier can limit signal peaks to reduce AM noise.
- Frequency deviation is changed to audio by a frequency discriminator.

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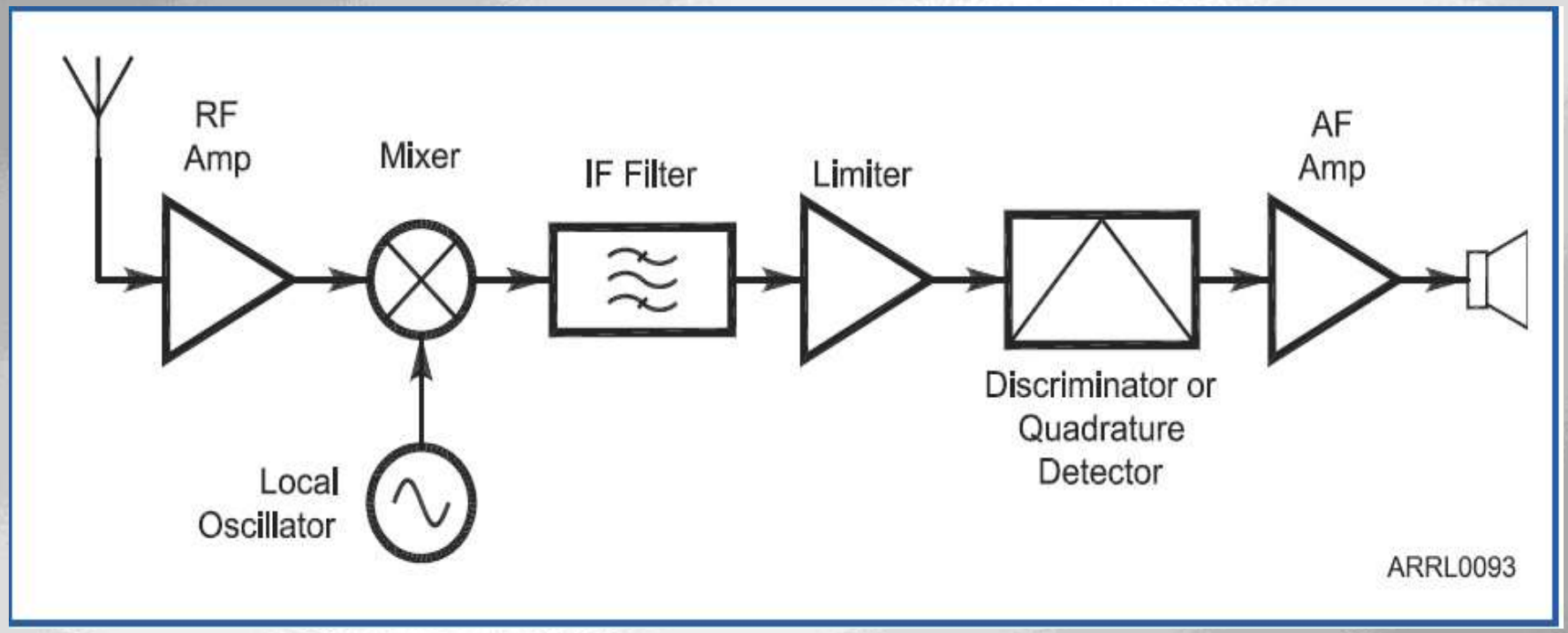

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Unwanted signals in Superhets

If LO is higher than F1, the LO mixes with F1 and produces an IF of LO – F1

- But another frequency, F2, at LO + IF will also produce the same IF
- F2 is called an *image* frequency and will be heard along with F1
- *Images* can be rejected by a tuned pre-selector
- *Birdies* are responses to frequencies generated within the receiver which leak into the input

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Digital Signal Processing and SDR

A DSP converts analog signals to digital data and processes the data using a program.

- The processed data may be directly converted to displayed data or converted back to analog.
- Processing can include filtering, noise reduction, rejecting heterodynes, and EQ (equalization)
- A Software Defined Radio (SDR) uses DSP to process a wide band of frequencies, eliminating many analog circuits like mixers and detectors.

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Receiver AGC and Linearity

HF receivers must deal with signals from 0.1uV to 1V – a range of 10 million to 1. This is a 140db range.

- A manual RF Gain control and an attenuator can be used to set the gain for desired output level and to prevent overload.
- AGC helps to keep the RX output more constant
- S Meters respond to the AGC voltage
  - S9 is supposed to be 50uV with each S unit = 6db
  - dB over S9 can be used as relative figures.

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