Chapter 5
Radio Equipment

Transmitters, Receivers

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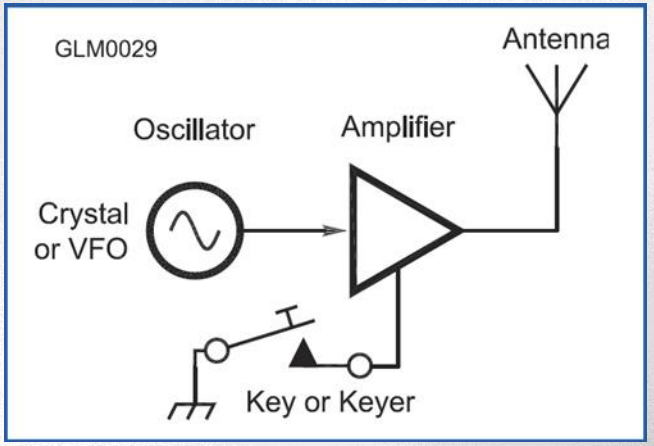
CW Transmitters

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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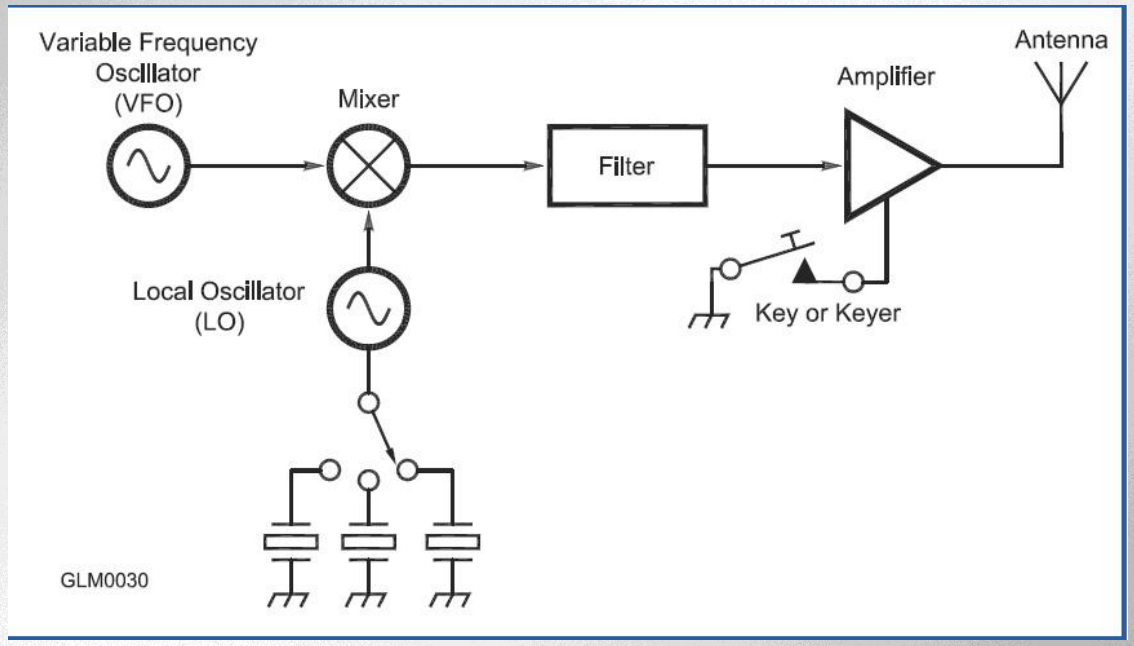
Multiband CW Transmitter

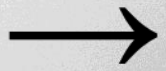
Other bands can be added to the simple transmitter by mixing the oscillator with fixed frequencies.



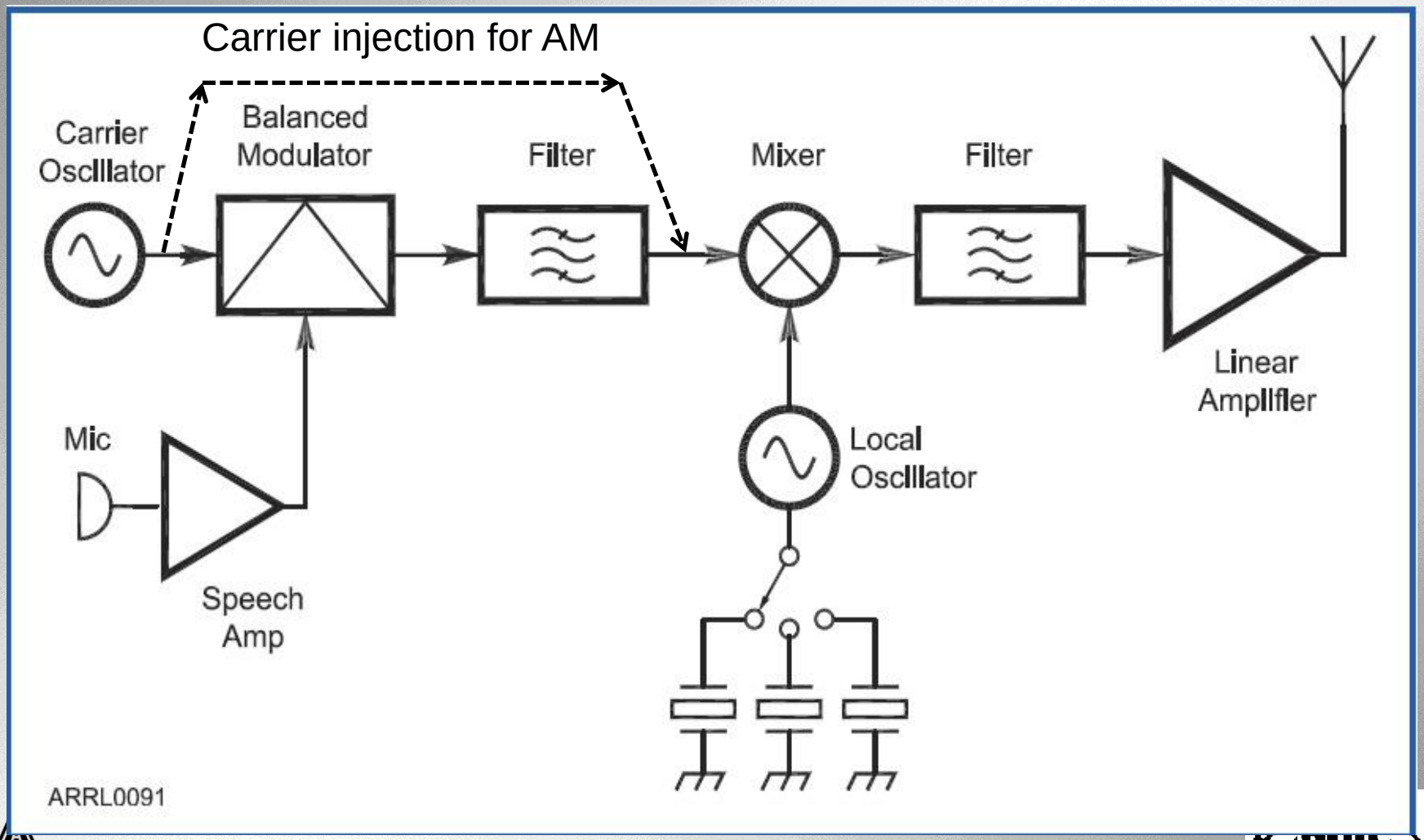
SSB Phone Transmitter

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



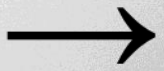
SSB Phone Transmitter



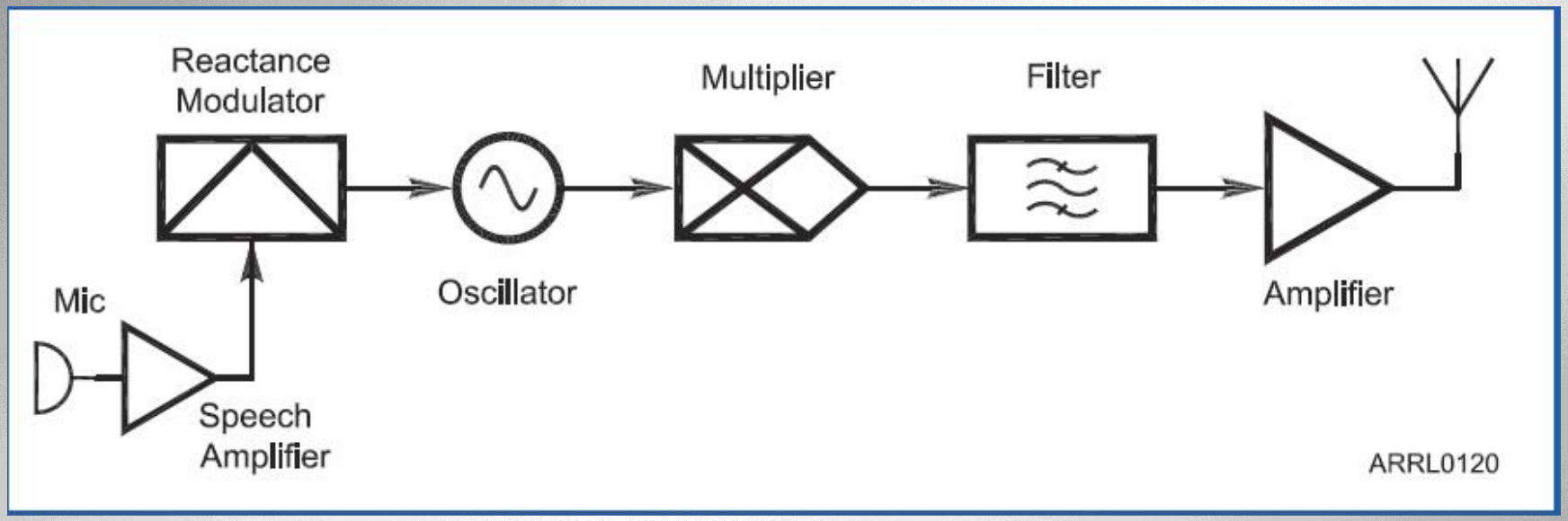
FM Phone Transmitters

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.



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 appear in adjacent channels as “splatter” interference

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

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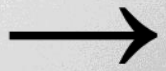

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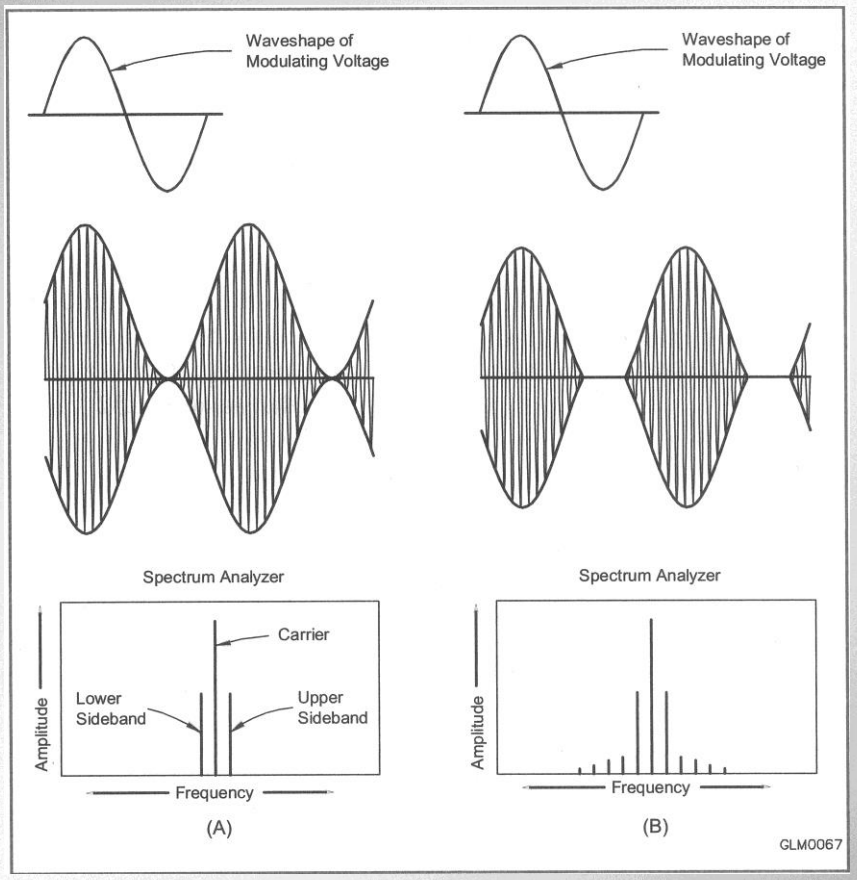
AM Full and Over Modulation



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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 compression 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.

Overdeviation of FM Transmitters

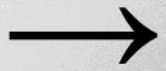
In FM transmitters, too much deviation causes more power in the minor sidebands

- 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
- Monitor your signal with a second receiver.

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.

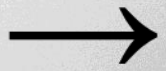
- Key clicks are usually only heard by nearby receivers.
- Key clicks can be reduced by using a shaping filter in the keying circuit to control the turn-on and turn-off times.



Digital Modulation Concerns

If the digital mode uses an audio signal sent over 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.



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, Vcc * Icc.

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

Operating Power Amplifiers

Amplifiers usually 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 less than tube recommendations for longest tube life.

Neutralization of Amplifiers

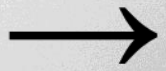
Feedback from the amplifier output to the input through the plate to grid capacitance can cause the amp to oscillate.

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

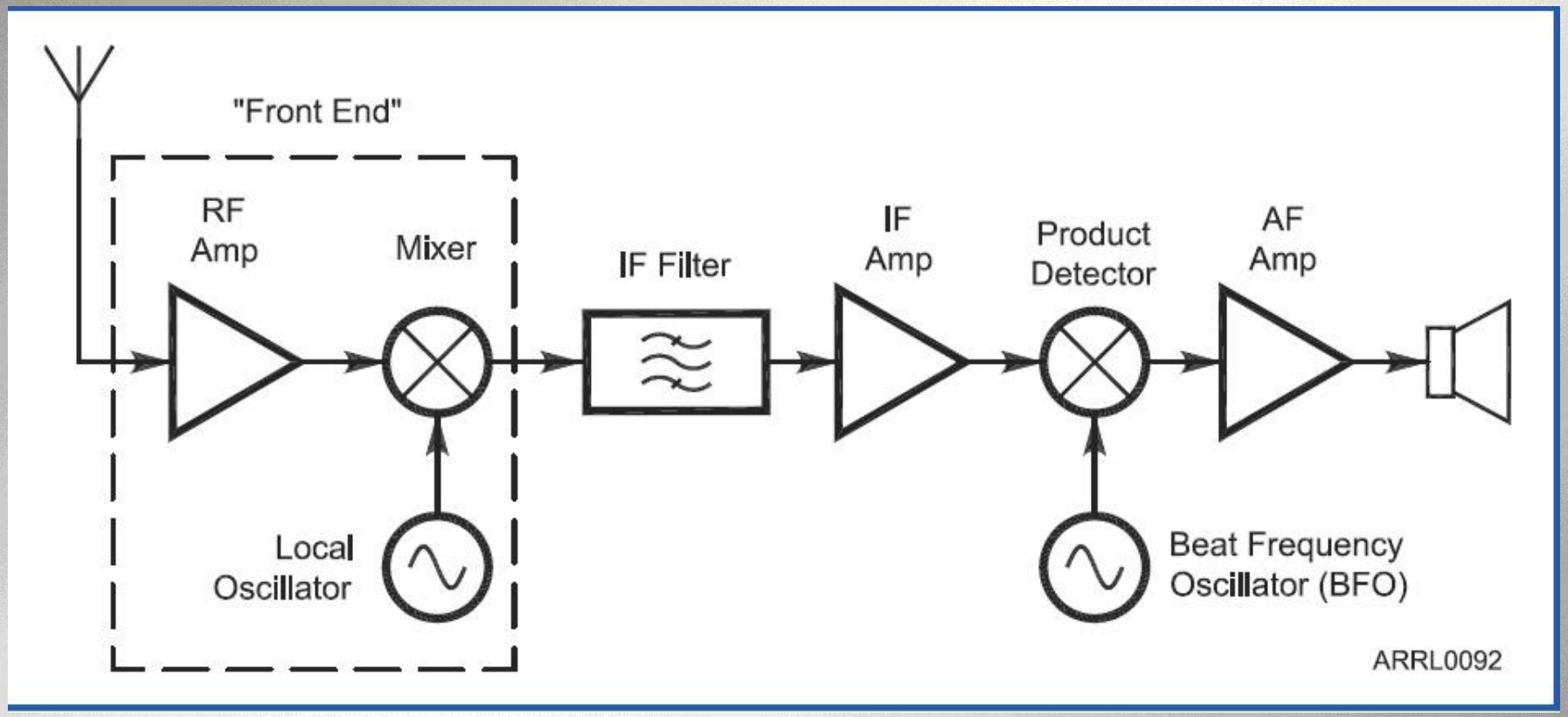
Superheterodyne Receivers

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.



Receivers for AM, SSB, and CW



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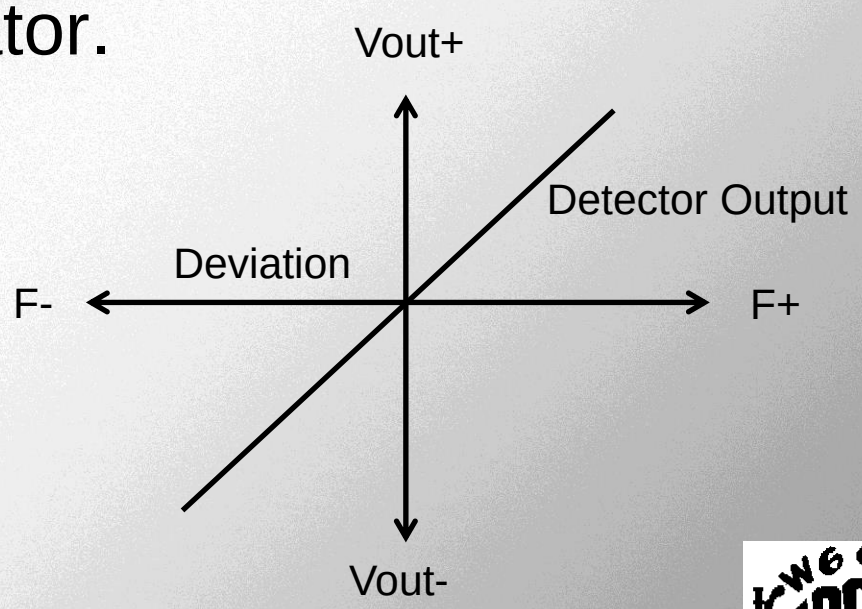
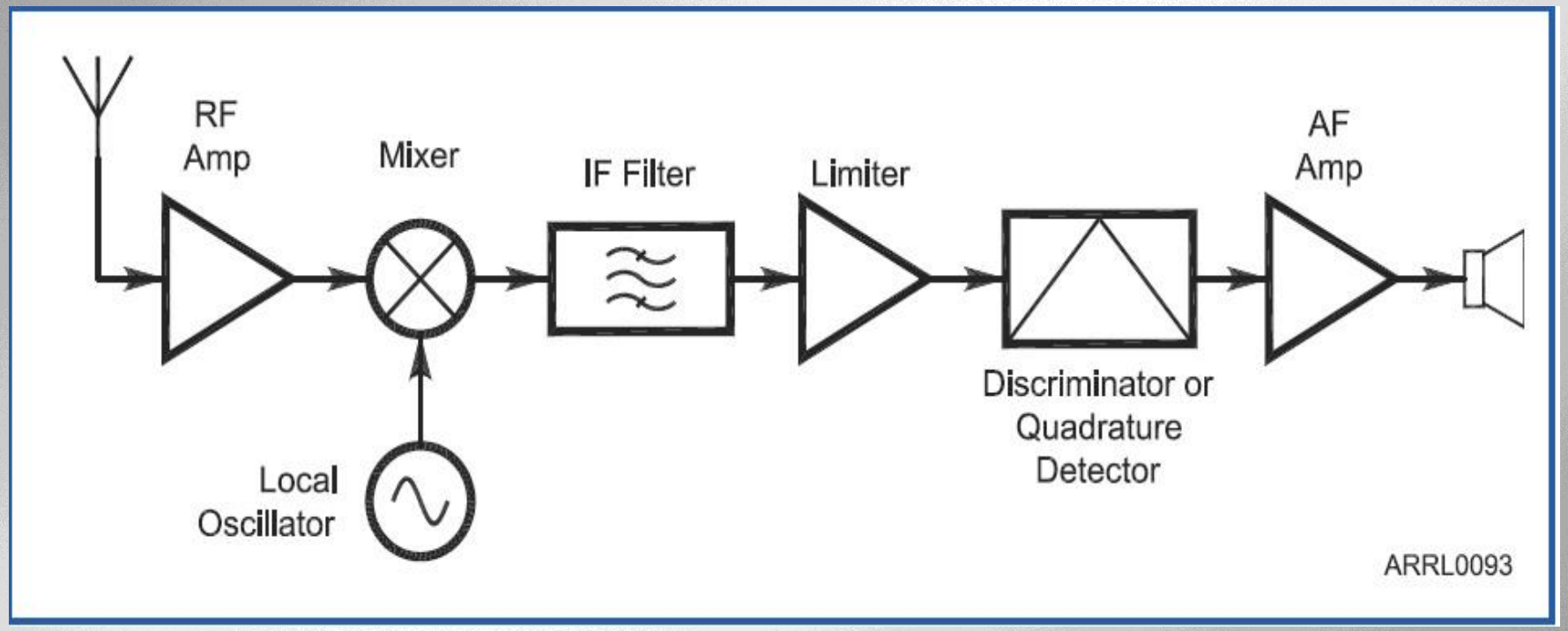
Receivers for FM

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.



FM Receiver



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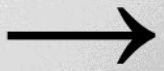

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Unwanted signals in Superhets

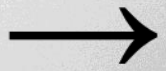
If LO is higher than F1, the LO mixes with F1 and produces an IF of LO – F1

- 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

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.



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.