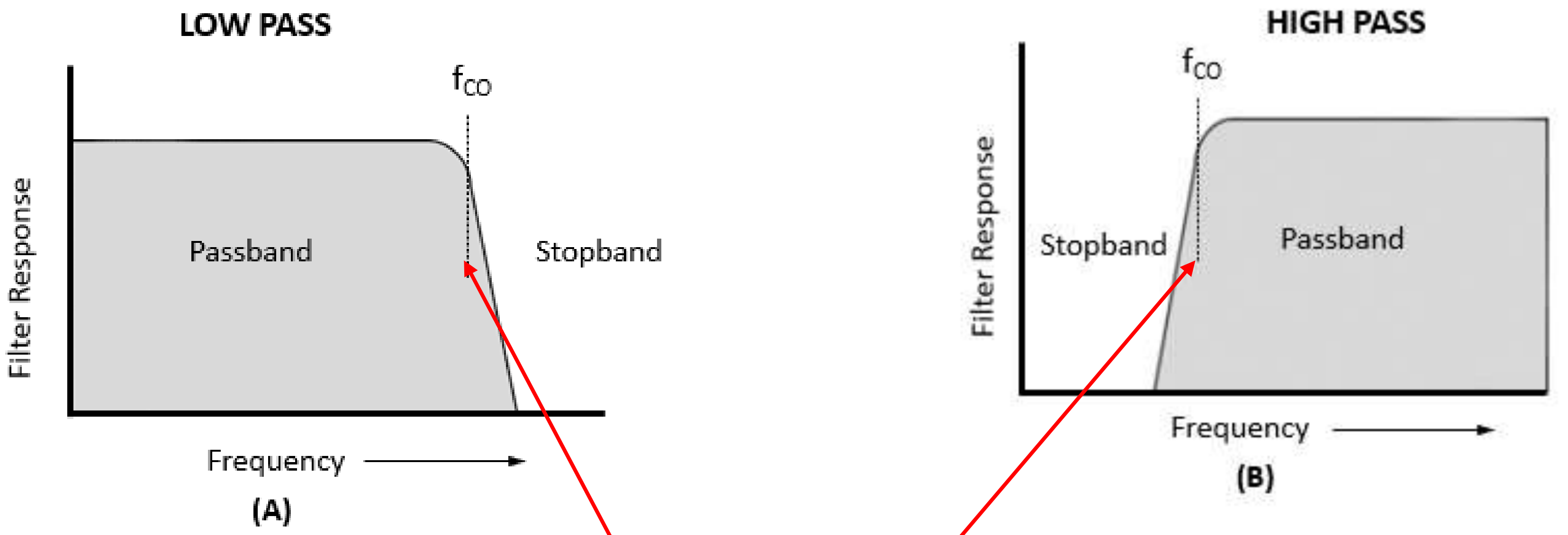
5. RADIO SIGNALS AND EQUIPMENT – NR6H

Chapter 5 Part 2 of 2

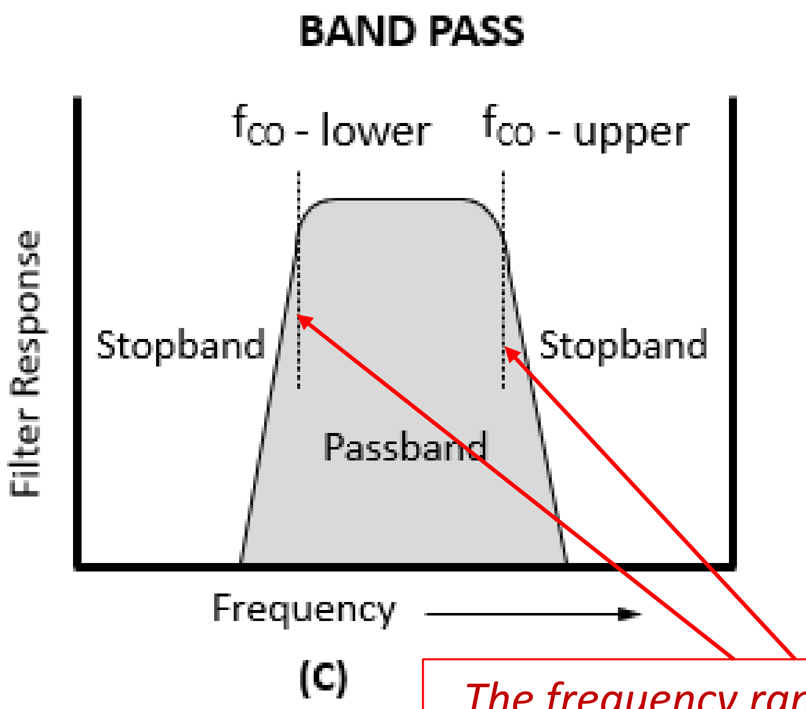
ARRL General Class
Sections 5.2, 5.3, 5.4, 5.5

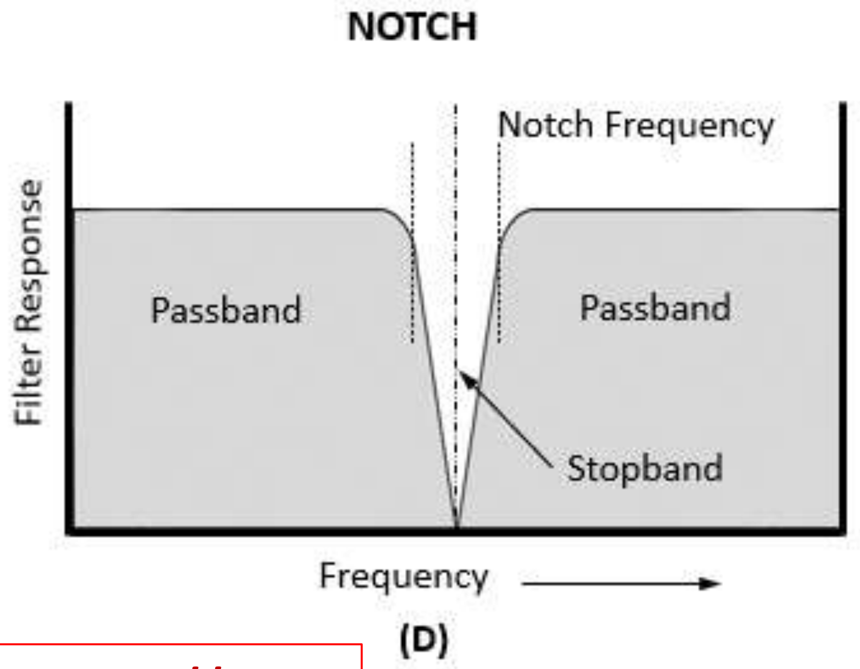
Filter response



*The **cutoff** frequency is the frequency at which the output signal power is reduced to **one-half** that of the input signal.*

Generic filter response

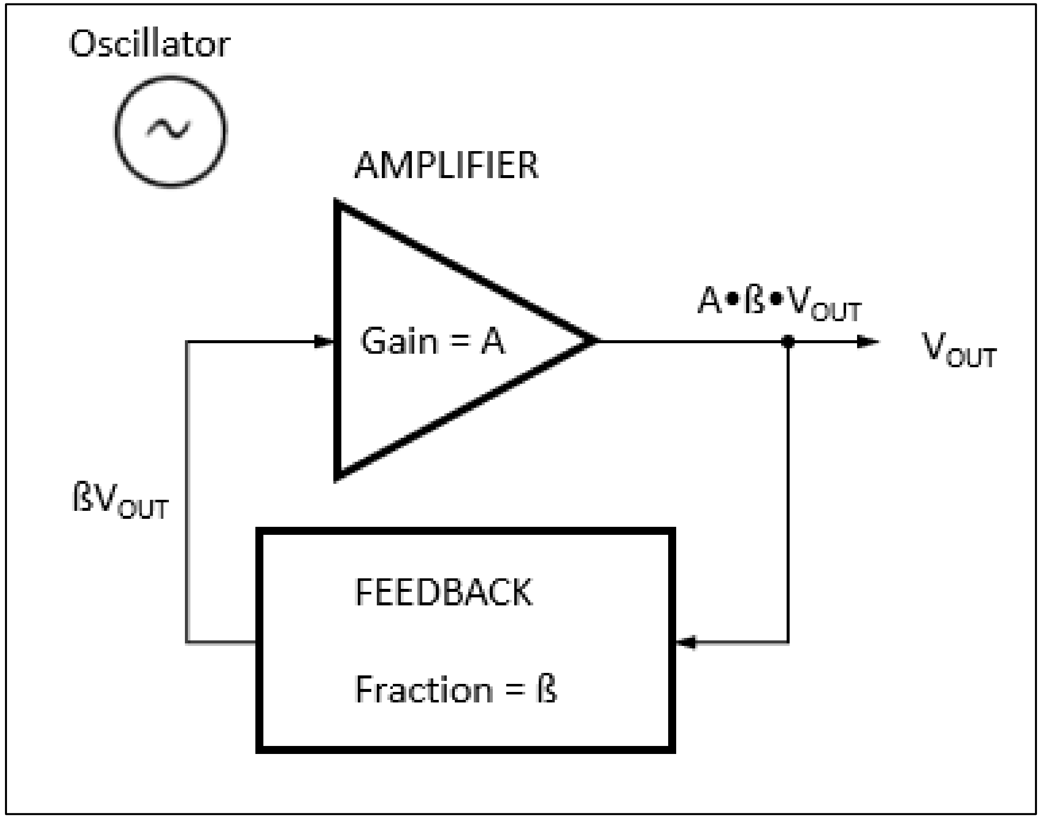




*The frequency range between the **upper and lower cutoff** frequencies is the filter's **bandwidth**.*

Oscillators

An oscillator consists of an **amplifier** with a **filter feedback** from the output to input.

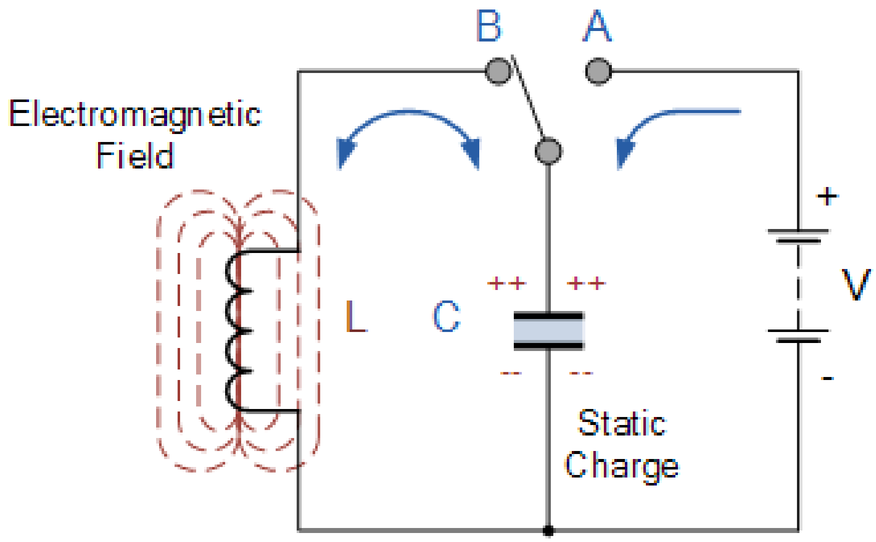


Oscillators

LC oscillator’s feedback circuits consist of an inductor (L) and capacitor (C) connected (in parallel or series) to form a resonant circuit

- Often called a tank circuit because of their ability to store energy
- The resonant frequency of the LC circuit (determined by the L and C values) is the frequency of the oscillator

Changing the L or the C changes the frequency



Other Oscillators

Phase-locked loop (**PLL**)

- Synchronizes a VCO to a reference signal

Direct digital synthesizer (**DDS**)

- Controllable by software
- Comparable stability to crystal oscillators
- Used as the high-stability VFO in most current transceivers

Mixers

A mixer circuit combines signals with two frequencies, f1 and f2, and produces signals with the **sum and difference** frequencies at its output **(heterodyning)**

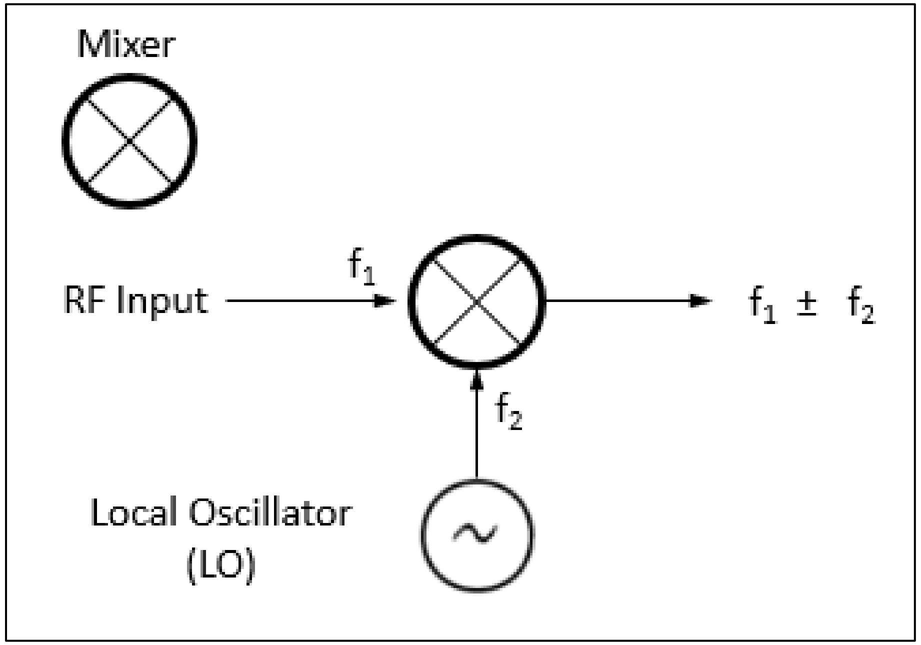
Example …

- f1 = 14.050 MHz
- f2 = 3.35 MHz
- There will be output signals at:

  (f1 + f2) = 14.050 + 3.35 = 17.40 MHz

  and

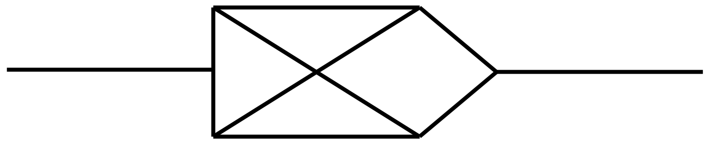
  (f1 - f2) = 14.050 - 3.35 = 10.70 MHz



Multipliers & Modulators

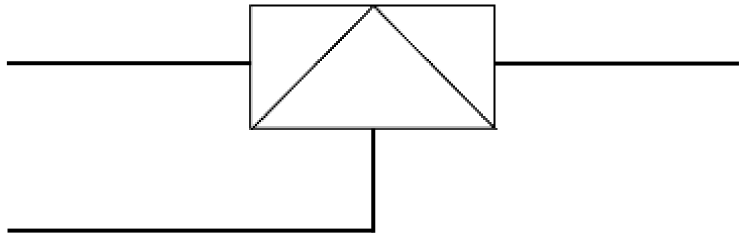
Multiplier

- Creates a **harmonic** (multiple) of an input frequency



Modulator

- **Add info** to a carrier signal by varying the carrier's amplitude, frequency, or phase
- Can be designed for any modulation type ; AM, FM or SSB



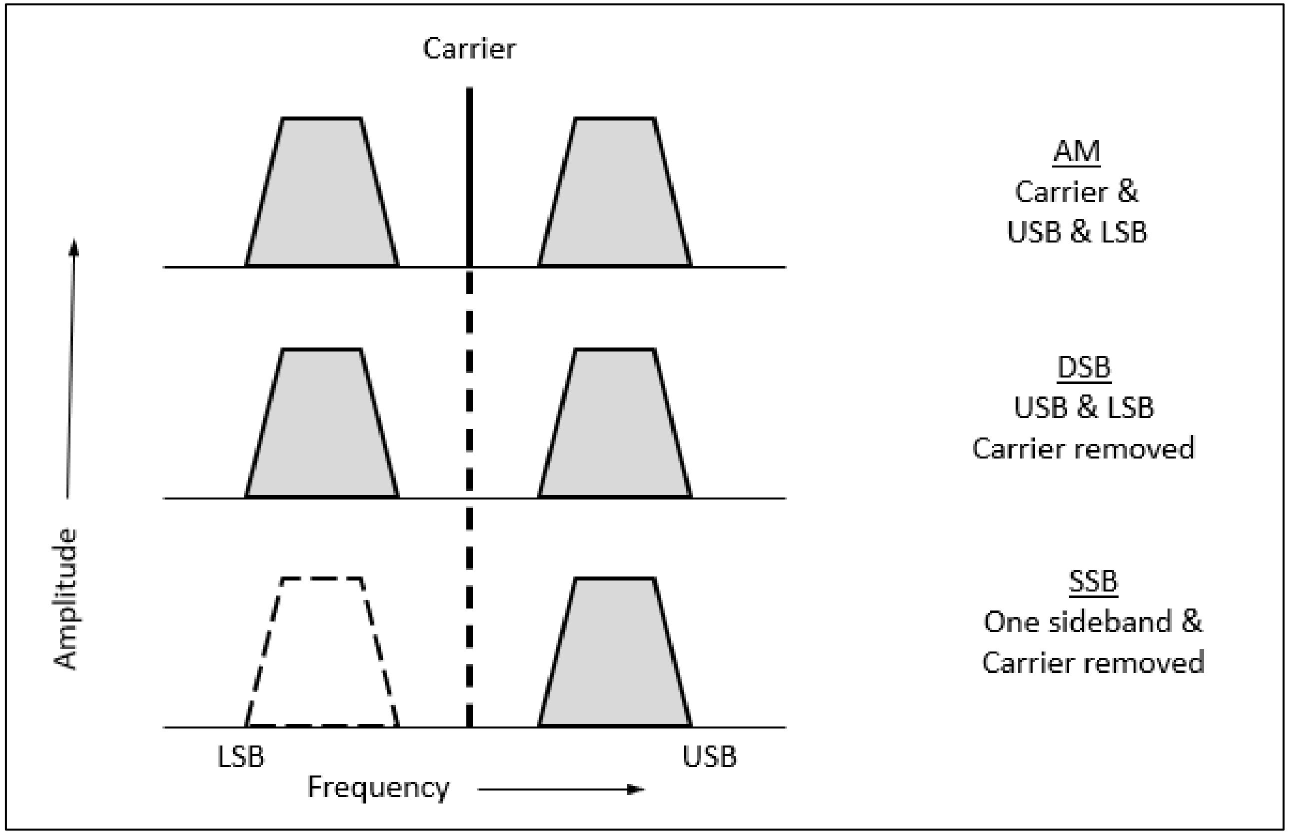
Amplitude Modulation

3 types:

Full **AM** has both sidebands and the carrier.

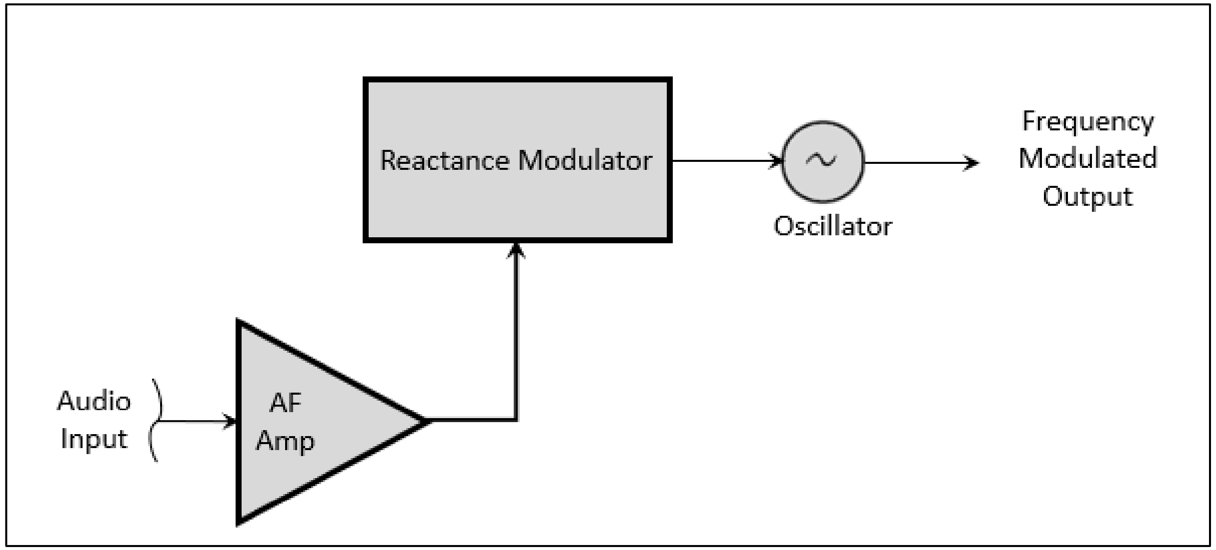
DSB removes the carrier, but has the same bandwidth as full AM.
(Can be created with a “balanced modulator”)

SSB removes one sideband and has the lowest bandwidth of the 3.
(Most efficient)

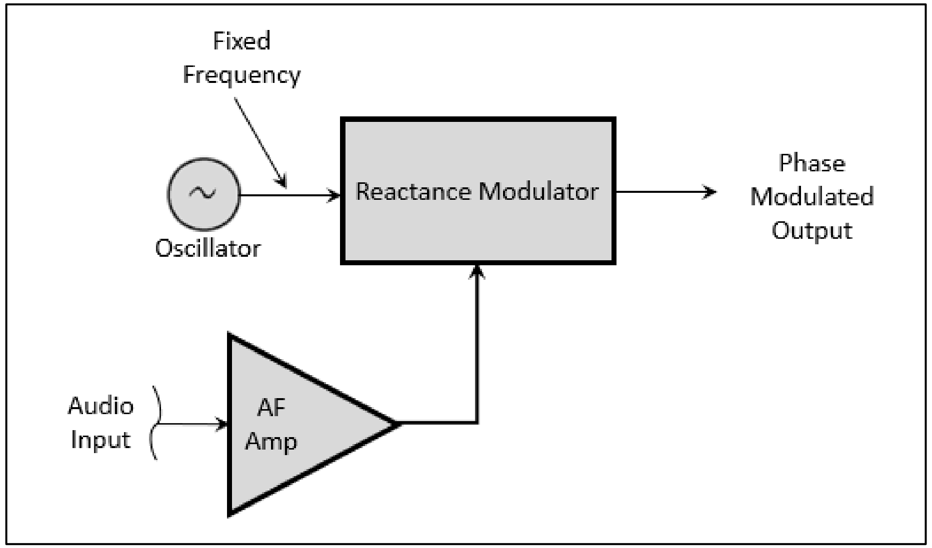


Frequency & Phase Modulation

Using a reactance modulator



(A) FREQUENCY MODULATION



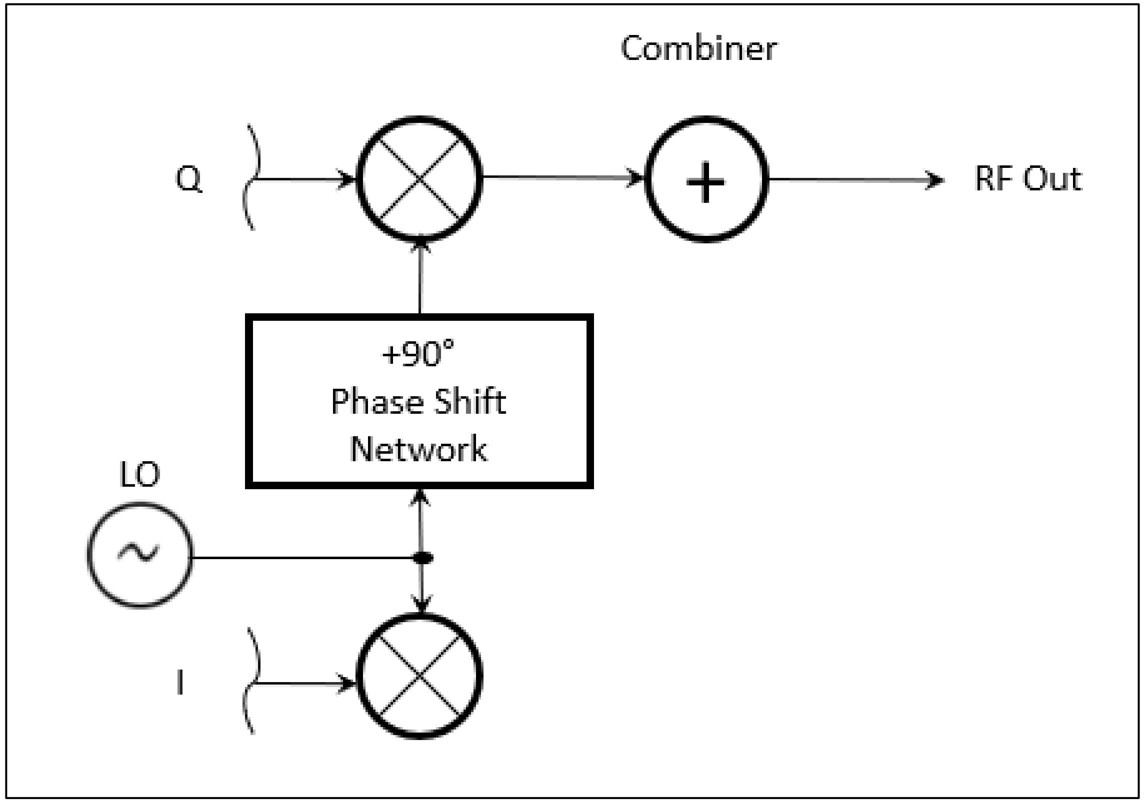
(B) PHASE MODULATION

Quadrature Modulation

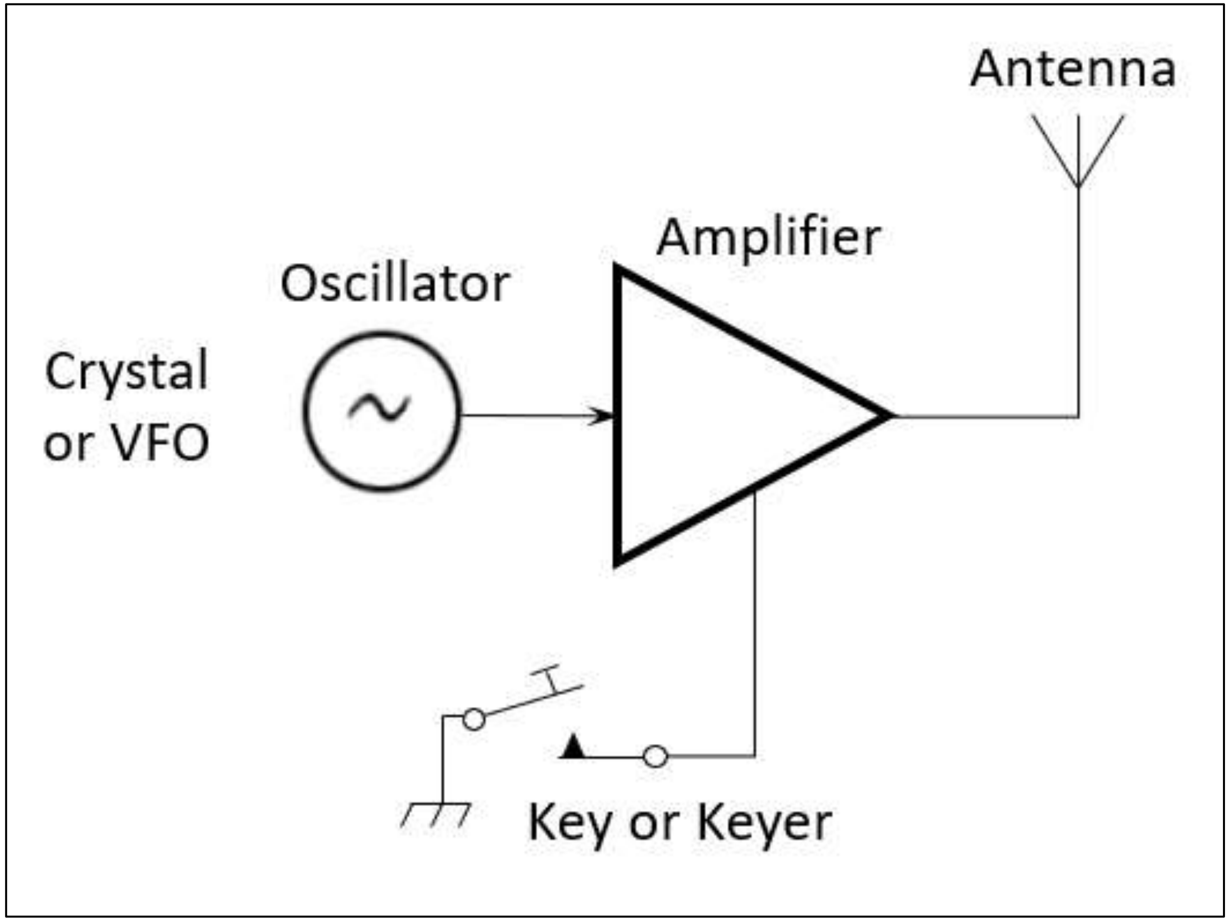
I/Q = In-phase / Quadrature

Can create **any type of modulation**

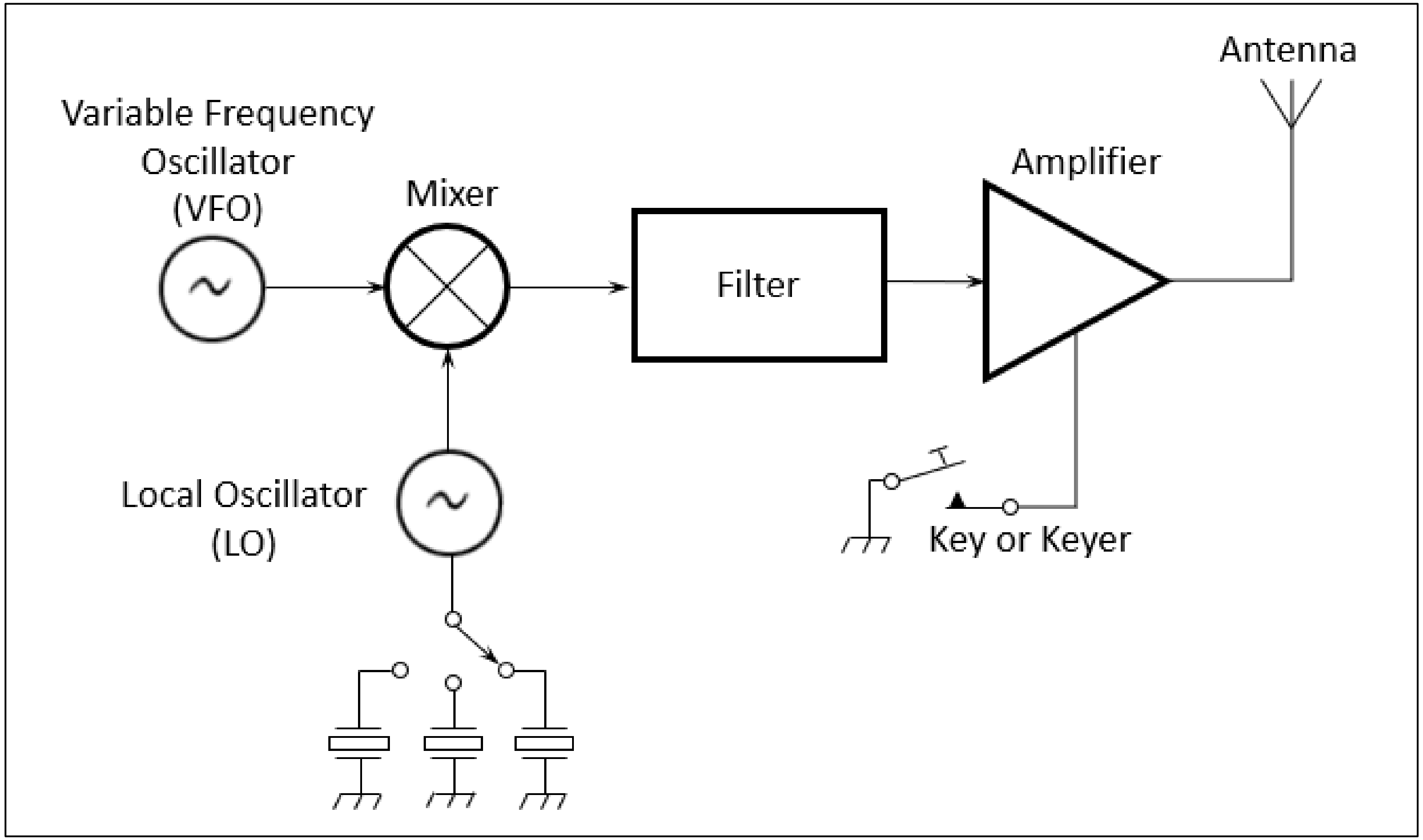
The RF output of the combiner consists of a pair of modulated signals that have carrier signals 90° different in phase



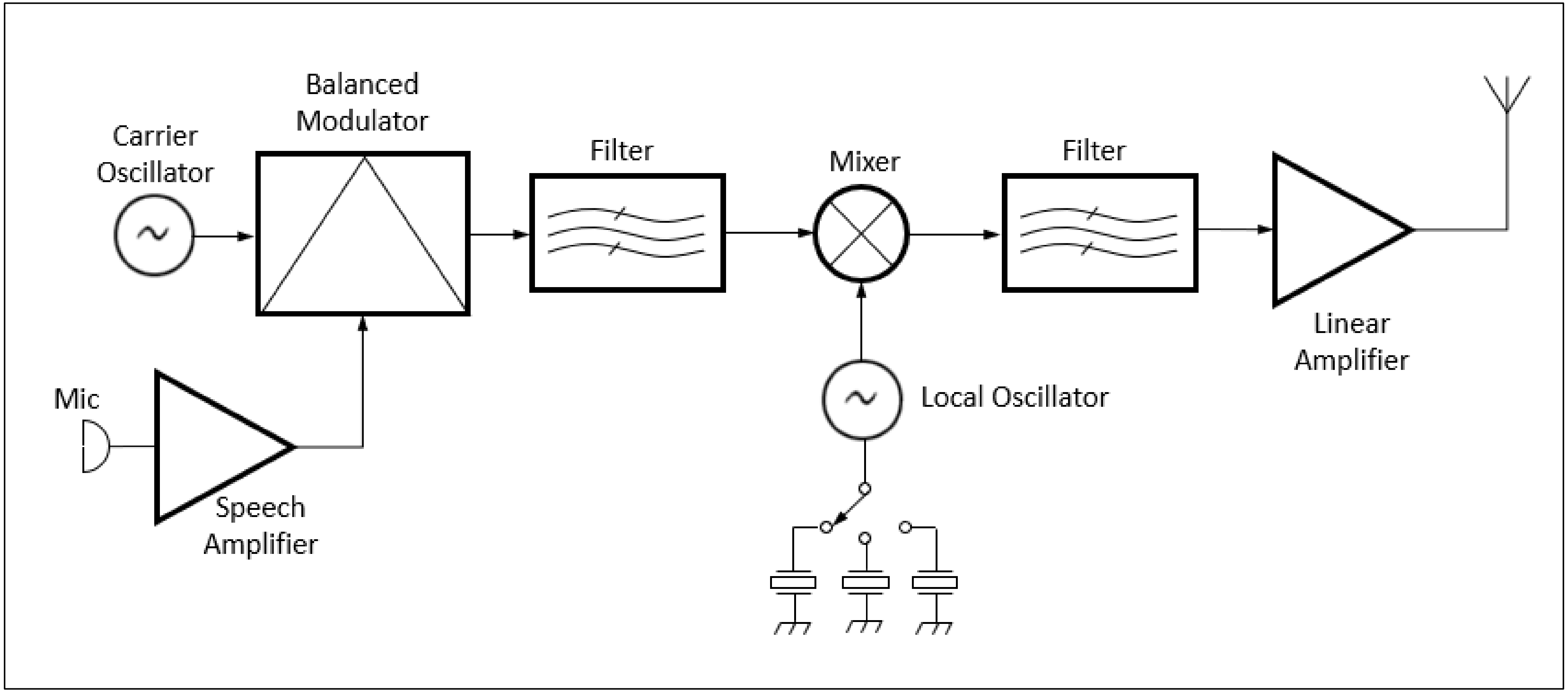
CW Transmitter



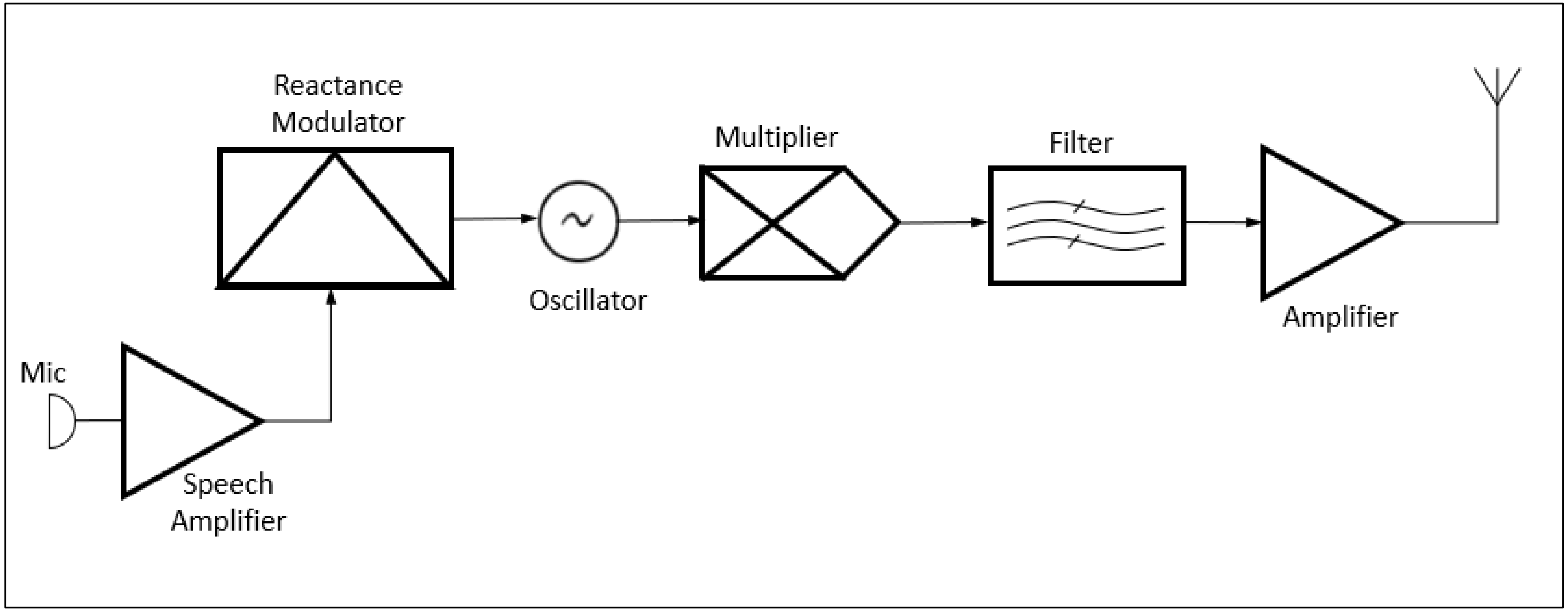
CW Transmitter – multiple bands



SSB Phone Transmitter



FM Transmitter



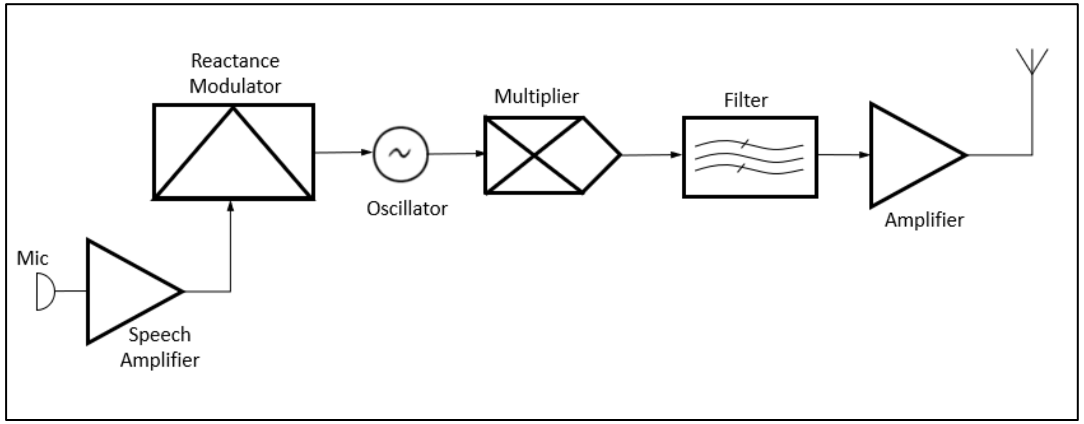
For 2m (146.52MHz) : Oscillator 12.21MHz -> Multiplier x12 -> 146.52MHz

Modulation (deviation) is also multiplied

FM Transmitter deviation

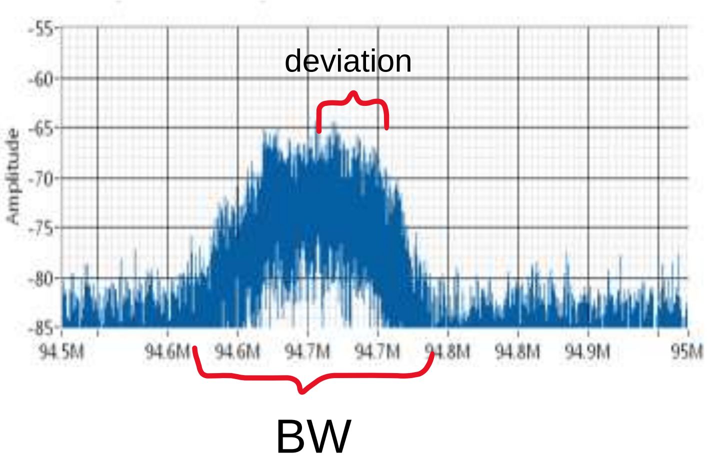
If deviation on the output is 5kHz

- Oscillator deviation = 5 / 12 = 416.7 Hz



Carsons Rule

- Approximation of signal bandwidth
- Bandwidth = 2 x (Peak deviation + Highest modulation frequency)



Example if highest modulation frequency is 3kHz

- BW = 2 x (5 + 3) = 2 x 8 = 16kHz

Overmodulation

Causes

- Speaking too loudly
- MIC/audio gain too high

Symptoms

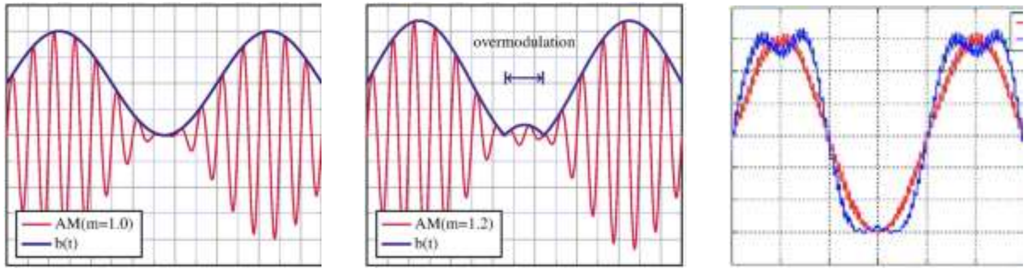
- Distorted audio
- Excessive bandwidth

ALC helps controlling transmit audio level

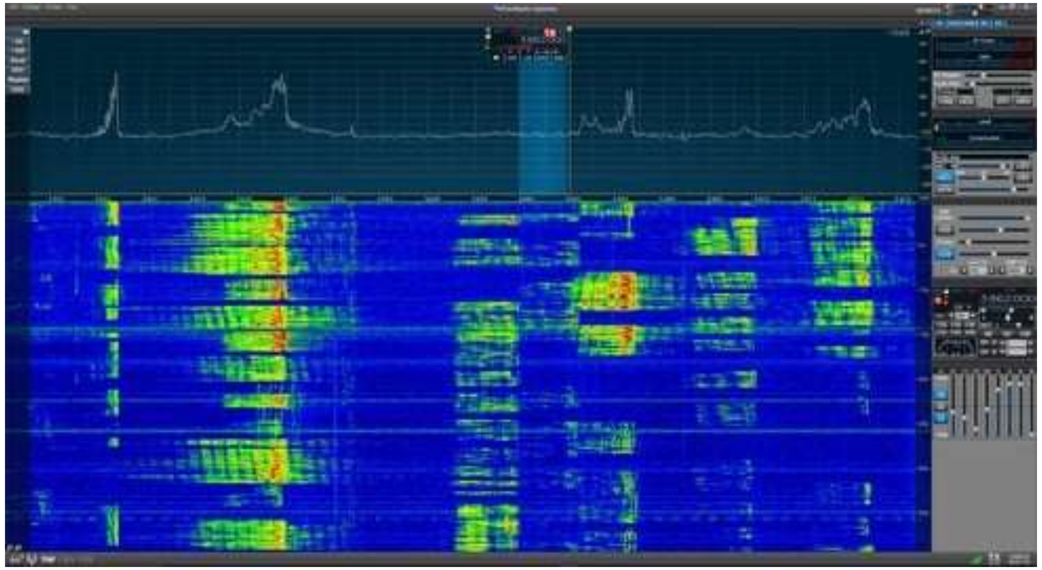
Speech processor increase average power

Two-tone test

Two **non-harmonically** related signals



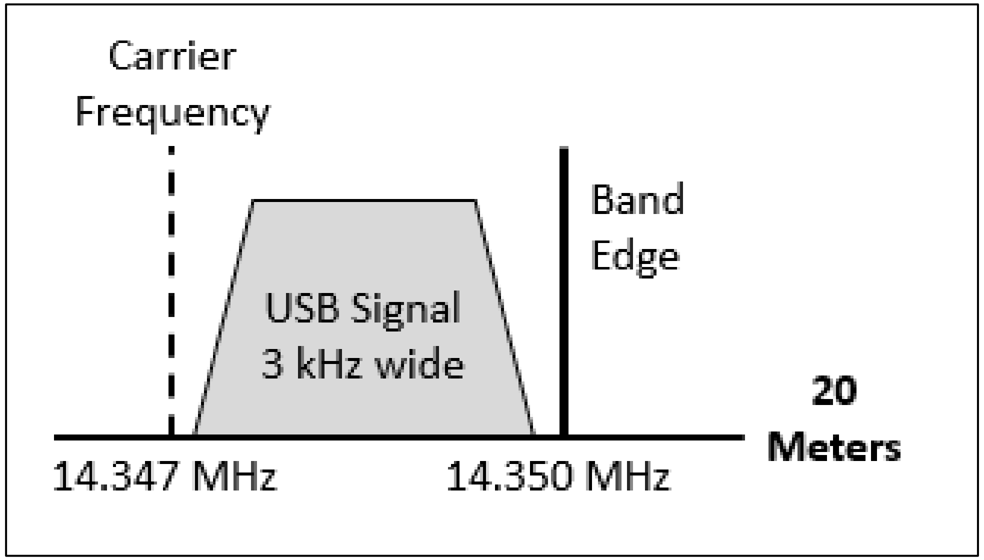
Normal Overmod Flat-top

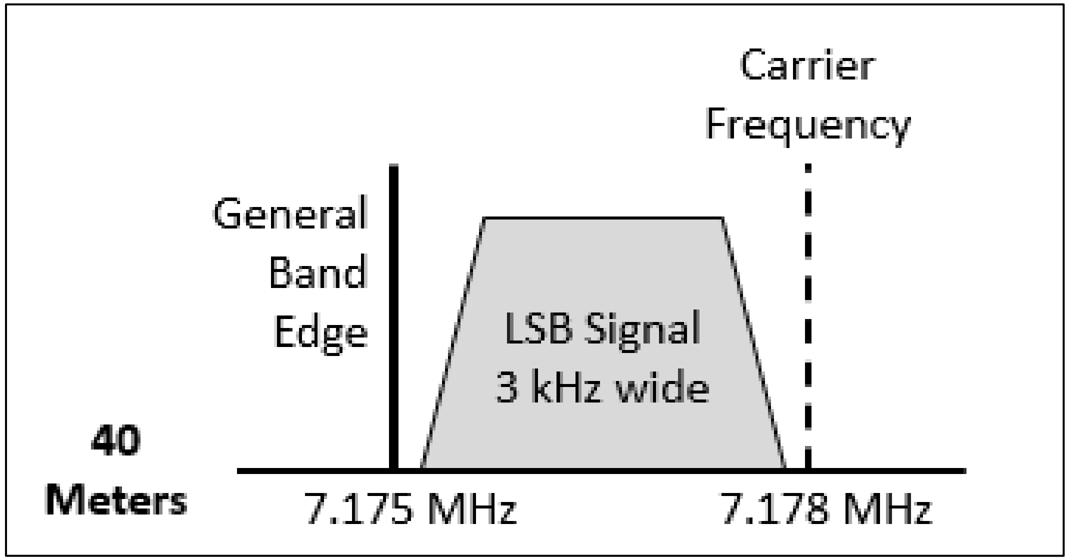


Stay in the band

SSB

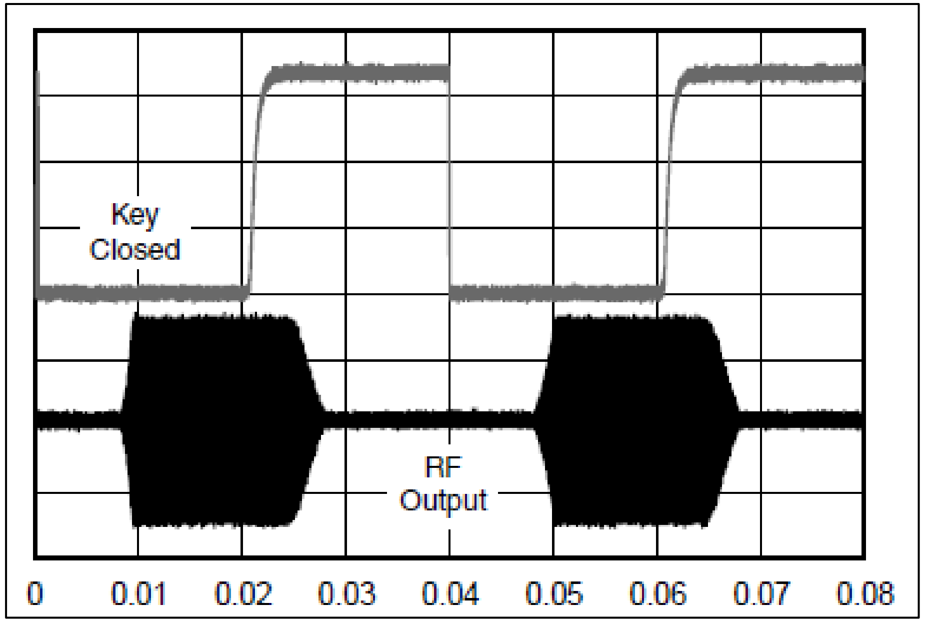
- 3 kHz bandwidth typical

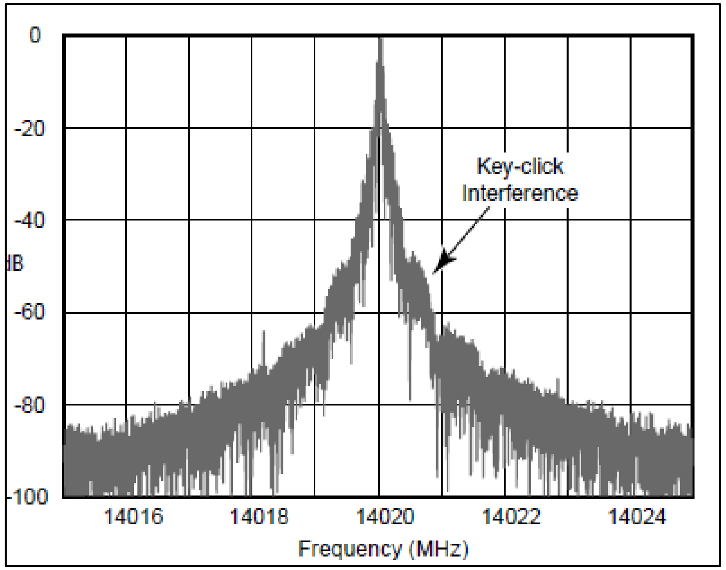




CW Key Clicks

Sharp transient clicking sounds heard on adjacent frequencies as a transmitter turns on and off too rapidly during CW transmissions or if transmitter turns on/off erratically.





CW waveforms can be inspected using a monitoring oscilloscope.

Amplifiers

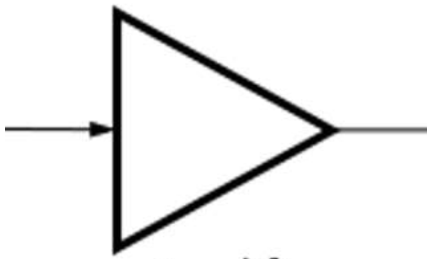
A.K.A. ’Linears’

Boost transmit power

Still common with vaccum tubes

Efficiency calculated as

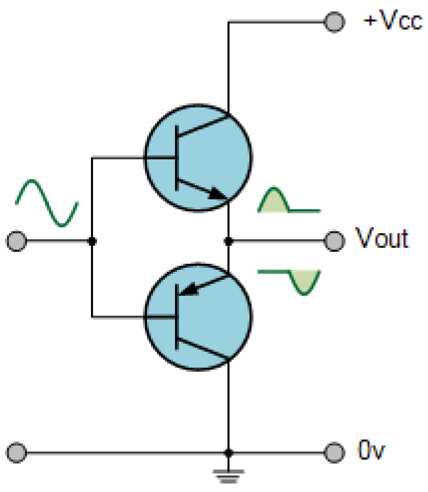
- output power divided by DC input power



Amplifier

Amplifier Classes

Refers to how the transistors/tubes are set to conduct



Class	Current flow	Linearity	Efficiency
Class-A	Always	Excellent	Bad
Class-B	Half-cycle	Not great	Good
Class-AB	Half-cycle+overlap	Good	Good
Class-C	Less than half-cycle	Poor	Excellent
Class-D	Digital/PWM	None	100%

Amplifier particulars

High currents, high voltages = potential danger

Newer amps have built-in protection for overdrive / overheat

More important to make use of **ALC to avoid overdrive**

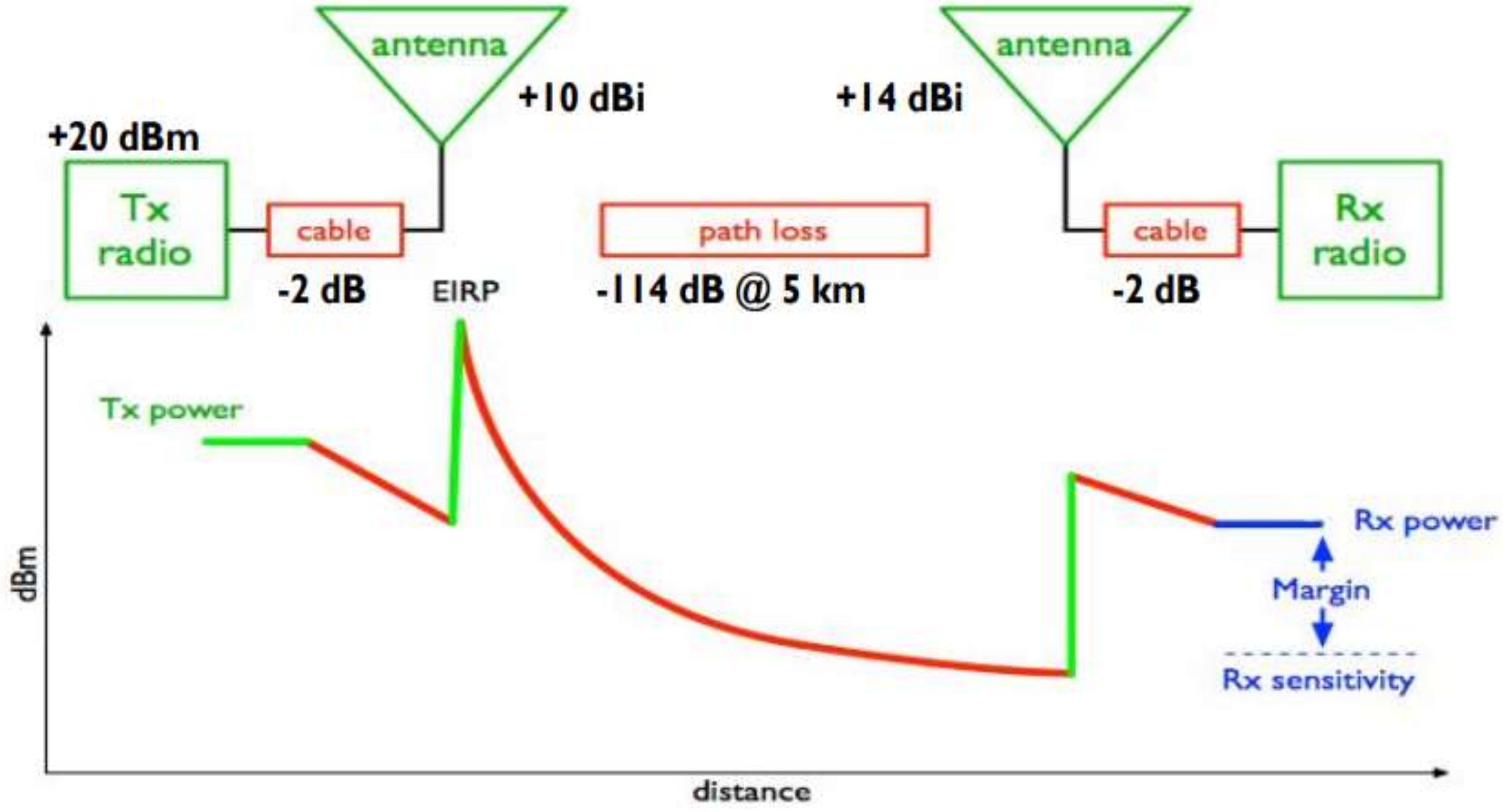
Switching from Rx to Tx may require a short delay to allow transmitter to activate

Neutralizing eliminate self-oscillation

Tube amps may have manual Tune adjustment

- Monitor plate current
- Adjust for ‘dip’
- Adjust Coupling/Load for max power output

Receivers



-74dBm

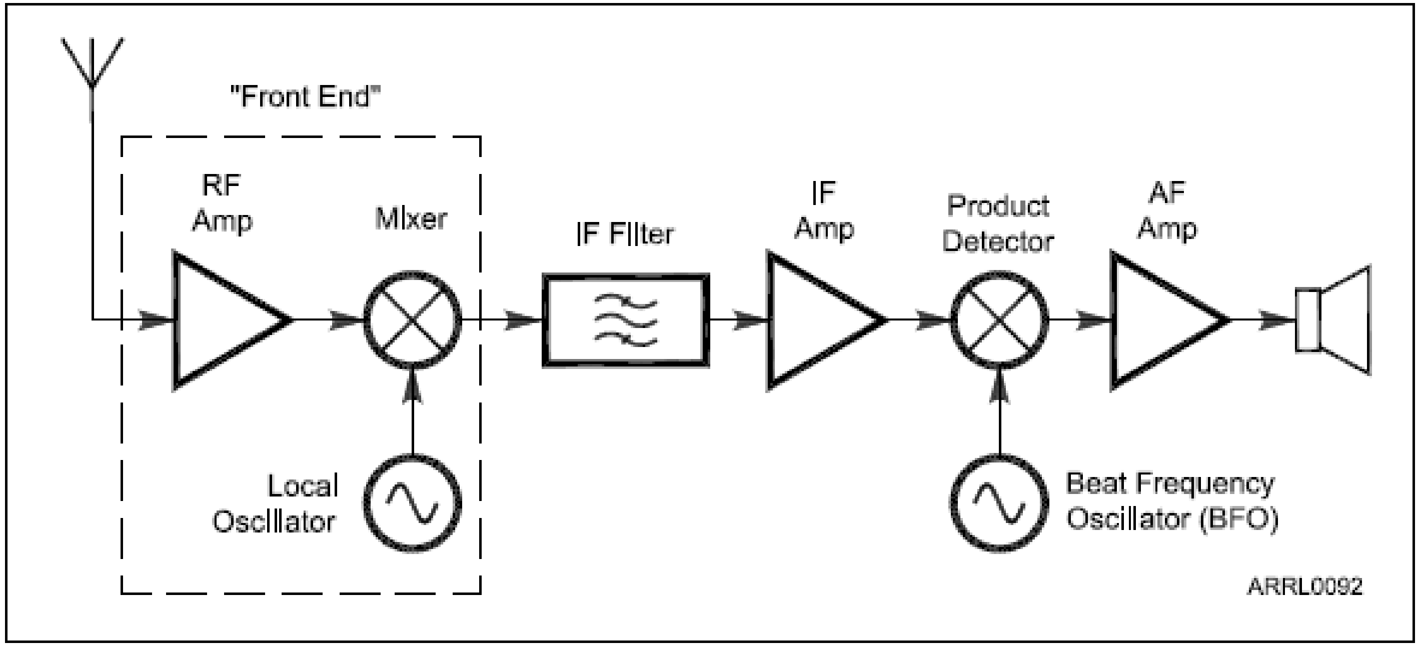
0.00000004 mW

Superheterodyne Receivers (AM)

A superheterodyne receiver converts signals to audio in two steps.

1) The front end converts the frequency of a signal to the intermediate frequency (IF) where most of the gain of the receiver is provided.

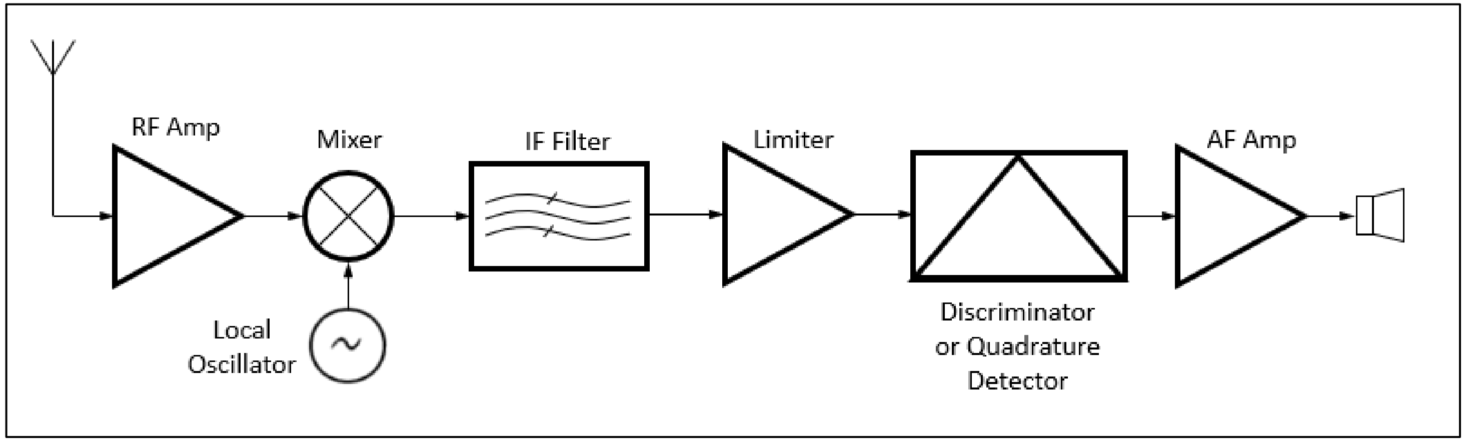
2) A second mixer – the product detector – converts the signal to audio frequencies.



Superheterodyne Receivers (FM)

Limiter is a high-gain amplifier creating a square wave

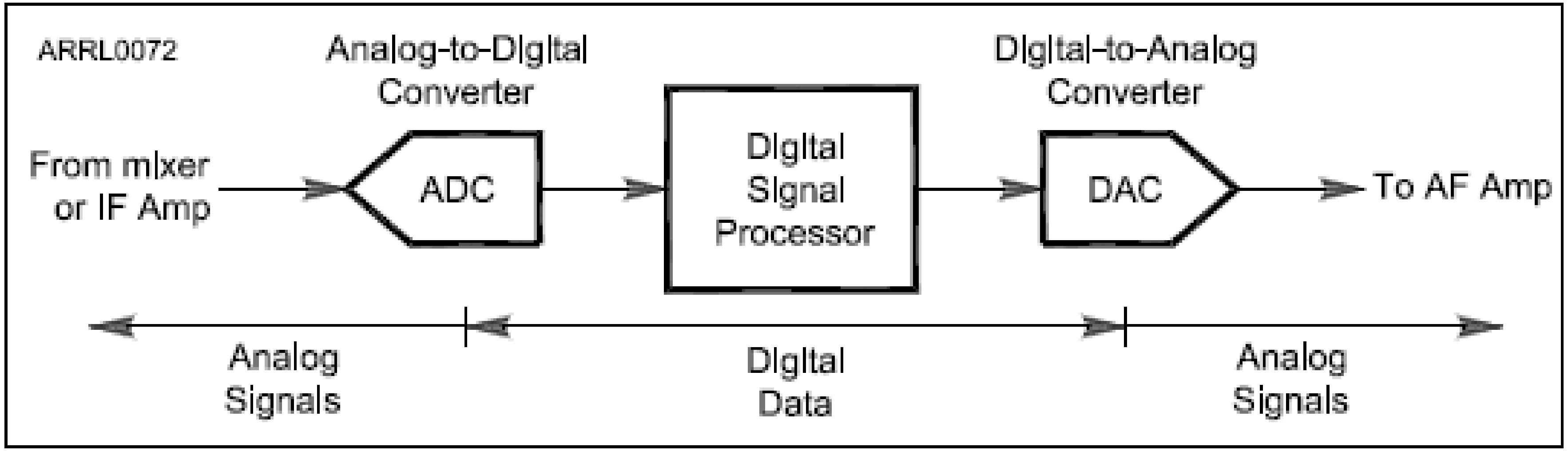
Discriminator converts frequency modulation to audio



Software Defined Radios (SDR)

Software Defined Radios (SDR)

Most / all decoding done in software



Improving reception

Adjusting RF gain / AF gain, AGC

Adjusting bandwidth (filters)

Shifting passband/IF frequency

- To avoid adjacent interfering signals

Noise Reduction filters

- Attempts to improve S/N ratio. Digital or Analog.

Noise Blanker

- Reduce sharp pulses (sparks)

Notch Filters

- Reduce narrow in-band signals

Introducing attenuation

S-meter

Measures received signal strength

One S-unit = 6dB (4x power)

S9 is 4 times more power than S8
..and 16 times more power than S7
..and 262144 times more power than S0

S0 through S9 and ”+20, +40, +60”

”S9 +20dB” is 100x more power than S9

Section 5.5

HF Station Installation

HF operation = Higher power, longer wavelength more components.

Two purposes of grounding

Safety: AC ground, RF burns

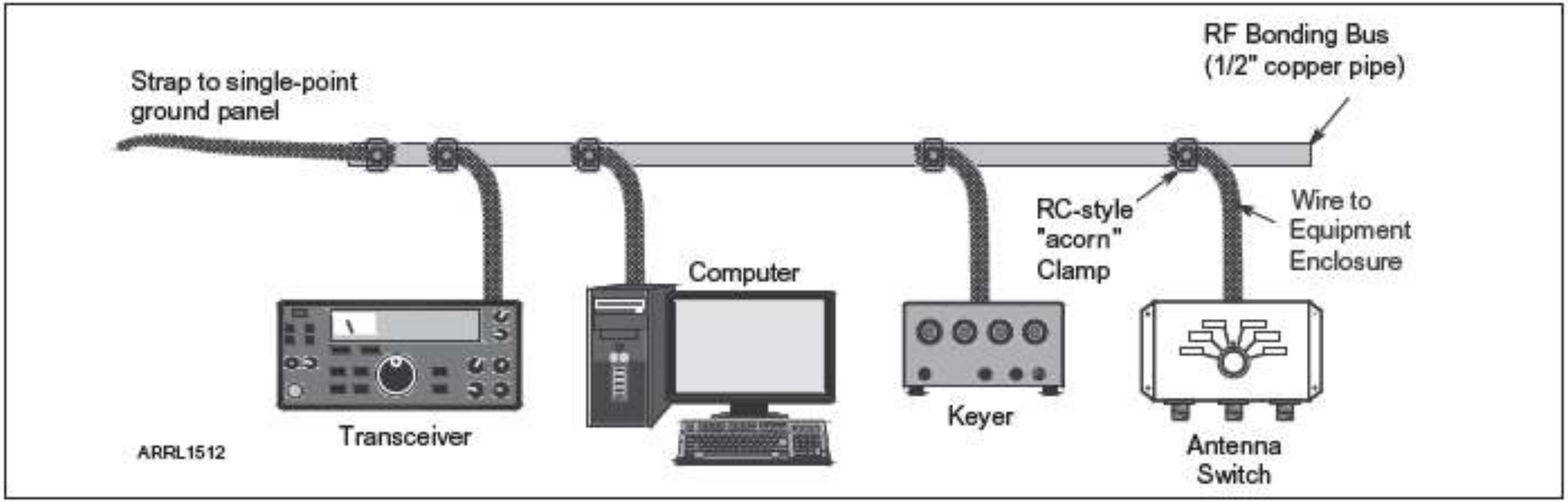
RF: hum and noise

Ground to a common point

- Avoid loops
- Keep as short as possible

Bonding

Avoid ¼ wavelength!



Mobile Installations

Full size antennas may be impractical

- Particularly true on lower frequency bands

Tips to improve antenna performance

- Use the most efficient antenna practical
- Make sure your ground connections to vehicle are solid
- Mount antenna where it is clear of metal surfaces

Mobile Installations

Check data sheet for max current

P = E x I → P = 12 x 10 = 120W

Radios generate a lot of heat!

- Use heavy gauge wire.
- Keep wires short
- Wire direct to battery
- Do NOT use cigarette lighter outlet
- Chassis may not be welded / metal

Common interference

- Whining from alternator / fuel pump
- Capacitor may help

Supply Voltage:		11 - 16 V DC (Negative Ground)
Current Consumption (Approx.):		
	RX:	500 mA (Analog)
		600 mA (Digital)
	TX:	9.4 A (144 MHz / Analog)
		9.5 A (144 MHz / Digital)
		10.2 A (430 MHz / Analog)
		10.3 A (430 MHz / Digital)
Case Size (W × H × D):		
	Panel:	140(W) × 72(H) × 20(D) mm (w/o knob & connectors)
	Rear Chassis:	140(W) × 40(H) × 125(D) mm (w/o connectors)
Weight (Approx.):		1150g (Panel + Rear Chassis + Connection Cable)
Transmitter		
Output Power:		50 W (144 / 430 MHz), 20 W (144 / 430MHz)
		5 W (144 / 430 MHz)
Modulation Type:		Variable Reactance
Maximum Deviation:		±5 KHz,

RF Interference (RFI): Causes & Solutions

RFI	CAUSE	SOLUTION
Fundamental Overload	Radio/TV receivers unable to reject strong signals … causes distortion or inability to receive desired signal	Prevent signal by using filters in signal path
Common-mode & Direct pickup	From electronic equipment with internal electronics … picked up on outside of cable shields and conductors of unshielded connections	Block current with RF chokes
Harmonics	Spurious emissions from an amateur station may be received by radio or TV equipment (there is no 1st harmonic … it's called the fundamental frequency)	Use a low-pass filter at the transmitter
Intermodulation	Poor contacts between conductors picking up RF signals can create a nonlinear connection that acts as a mixer and mixing products from the signals	Find/repair the poor contact or block the RF signals (look for odd-order harmonics … closest to the original frequencies)
Arcing	A spark or sustained arc creates radio crackling or buzz over wide frequency range, (from power-line hardware)	May require power company to make repairs; filter specific equip.

Common RFI Symptoms

CW, FM, or data

- Interference consists of ON/OFF buzzes, humming, clicks or thumps when the interfering signal is transmitted

AM phone

- Equipment experiencing overload or direct detection will often emit a replica of the speaker's voice

SSB voice

- Similar to AM phone, but voice will be distorted or garbled

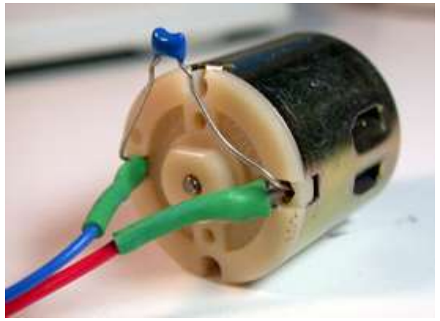
Suppressing RFI

Block RF by placing an impedance in its path

- Form conductor carrying RF current into an RF choke by winding it around or through a ferrite core

Ferrite beads placed on cables to prevent RF common-mode from flowing on outside of cables/shields

Interference to audio equipment and sensor connections can be eliminated by using a small (100 pF to 1 nF) bypass capacitor across balanced connections



QUESTIONS?

ONLINE EXAM REVIEW AND PRACTICE QUESTIONS:

http://www.arrl.org/examreview