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Chapter 5.1
Basic Modes and Bandwidth

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Signal Review

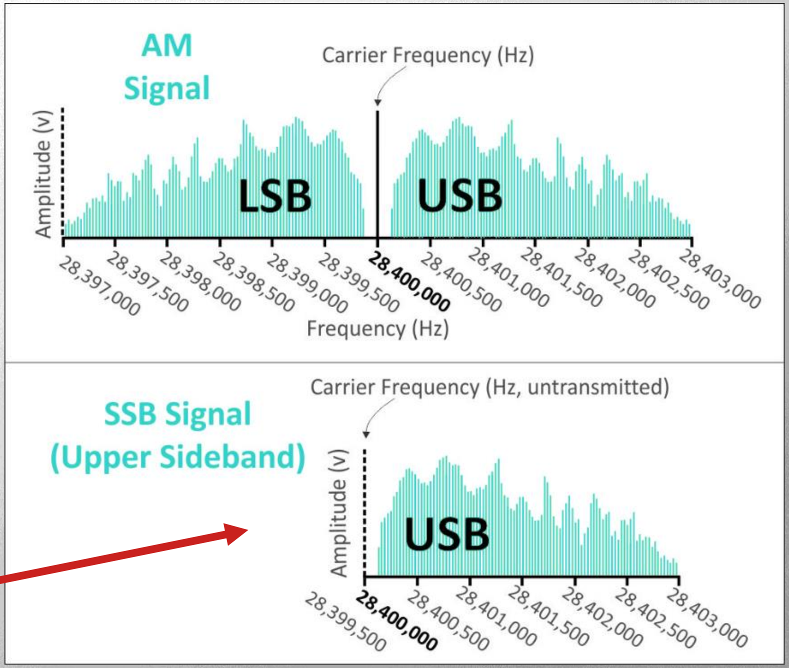
- *Continuous wave* (CW) – A radio signal at one frequency - a pure sine wave (unmodulated carrier - demo later)
- *Modulation* – superimposing information (digital, analog) on a signal by changing its frequency, phase angle, or amplitude
- *Demodulation* – recovering the information from a modulated signal

Amplitude Modulated Modes

- An AM signal is composed of a *carrier* and two *sidebands* – one higher than the carrier frequency (upper sideband – USB) and one lower (lower sideband – LSB)

Each sideband contains a copy of the modulating information.

A *single sideband* (SSB) signal is an AM signal with the carrier and one sideband removed/suppressed.



Note spectrum occupied vs. carrier frequency

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Moduation Modes

- *Amplitude Modulation* (AM) is a mode that varies the instantaneous *power level* of the RF signal to add speech or data information
- *Frequency Modulation* (FM) is a mode that varies the *frequency* of a signal to add speech or data information
- *Deviation* is the amount that an FM signal's frequency varies when modulated (5 kHz standard on VHF/UHF FM)
- *Phase modulation* (PM) is created by varying a signal's *phase angle*

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Bandwidth

- The FCC limits signal bandwidth so that many stations and types of signals can share the limited amount of spectrum

- Single sideband is the phone emission which uses the narrowest bandwidth

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Link Budgets

Link Budgets account for all the power gains and losses a signal experiences within a system

In amateur radio, this is generally the transmit power and antenna gains from the sending station minus any system losses the receiving station experiences

Losses result from ionospheric refraction, attenuation, or a variety of other causes

Link margin is the difference between the minimum power level needed to receive a signal (sensitivity) and the actual power level of the received signal, measured in dB

Take Quiz 1

G8A02 - What is the name of the process that changes the phase angle of an RF signal to convey information?

A. Phase convolution

B. Phase modulation

C. Phase transformation

D. Phase inversion

G8A02 - What is the name of the process that changes the phase angle of an RF signal to convey information?

A. Phase convolution

B. Phase modulation

C. Phase transformation

D. Phase inversion

G8A03 - What is the name of the process that changes the instantaneous frequency of an RF wave to convey information?

A. Frequency convolution

B. Frequency transformation

C. Frequency conversion

D. Frequency modulation

G8A03 - What is the name of the process that changes the instantaneous frequency of an RF wave to convey information?

A. Frequency convolution

B. Frequency transformation

C. Frequency conversion

D. Frequency modulation

G8A05 - What type of modulation varies the instantaneous power level of the RF signal?

A. Power modulation

B. Phase modulation

C. Frequency modulation

D. Amplitude modulation

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A. Power modulation

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C. Frequency modulation

D. Amplitude modulation

G8A07 - Which of the following phone emissions uses the narrowest bandwidth?

A. Single sideband

B. Vestigial sideband

C. Phase modulation

D. Frequency modulation

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A. Single sideband

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G8A13 - What is a link budget?

A. The financial costs associated with operating a radio link

B. The sum of antenna gains minus system losses

C. The sum of transmit power and antenna gains minus system losses as seen at the receiver

D. The difference between transmit power and receiver sensitivity

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B. The sum of antenna gains minus system losses

C. The sum of transmit power and antenna gains minus system losses as seen at the receiver

D. The difference between transmit power and receiver sensitivity

G8A14 - What is link margin?

A. The opposite of fade margin

B. The difference between received power level and minimum required signal level at the input to the receiver

C. Transmit power minus receiver sensitivity

D. Receiver sensitivity plus 3 dB

G8A14 - What is link margin?

A. The opposite of fade margin

B. The difference between received power level and minimum required signal level at the input to the receiver

C. Transmit power minus receiver sensitivity

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Chapter 5.2
Radios Building Blocks

In the following chapters we'll learn about the fundamental circuits from which radios are built.

In modern radios, many of these functions can be performed on digitized signal data by software developed for digital signal processing (DSP)

A Software-Defined Radio (SDR) is one in which most signal processing functions (such as filtering, detection, modulation) are performed by software

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Filters

- Filters are used to attenuate or pass signals within a defined range of frequencies.
- Classified by **response,** how they act on signals
  - Passband – the range of signals passed on
  - Stopband – the range of signals attenuated or rejected

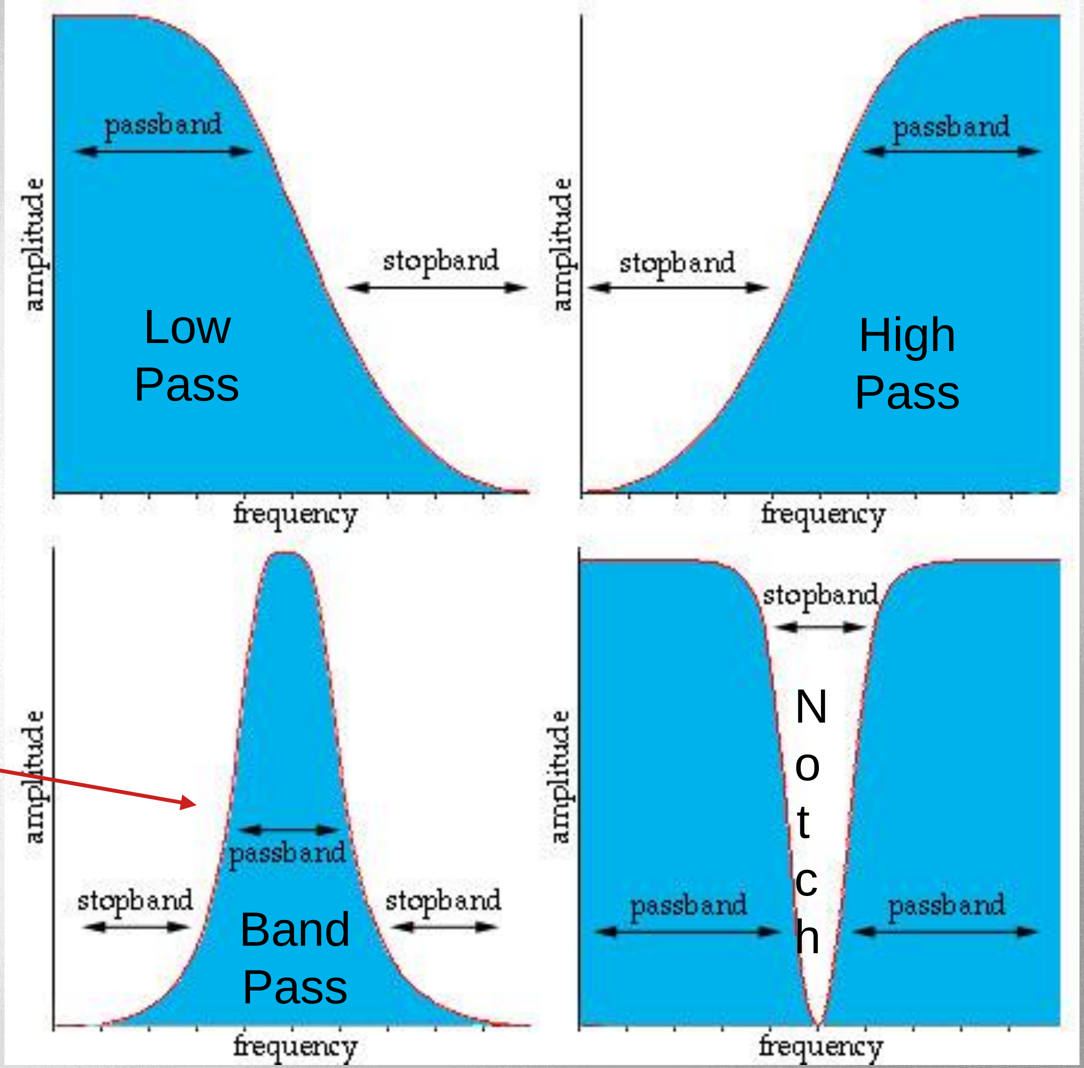
Filters

Low Pass – passes frequencies below the cutoff frequency

High Pass - passes frequencies above the cutoff frequency

Band Pass - passes frequencies between high and low cutoff frequencies (half-power points – next slide)

Band Stop (or Notch, if very narrow) – attenuates frequencies between high and low cutoff frequencies



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Filters

- Cutoff frequency – the frequency at which the output signal power is reduced to one-half the input signal power (-3 dB)
- Bandwidth – the frequency range between a filters upper and lower cutoff (half-power) frequencies (bandpass, notch)
- Insertion Loss – signal loss or attenuation within the passband
- Ultimate rejection – maximum attenuation outside of the passband

More on filters (including demos) later...

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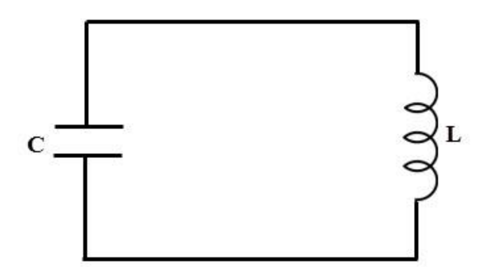
Oscillators

- An oscillator consists of an amplifier that increases signal amplitude (*gain*) and a *feedback* circuit to route some of the amplifier's output signal back to its input
- Oscillator circuits must include a filter so that feedback is present at only the intended frequency
- Oscillator = amplifier + filter + feedback loop
- The oscillator output frequency can be fixed or variable

Oscillators

- The filter of an LC oscillator is a resonant circuit made from inductors and capacitors. It sets the oscillator’s frequency
  - Parallel LC circuits are sometimes called *tank circuits* because they “store” energy
- The output frequency of a *variable-frequency oscillator* (VFO) can be adjusted by changing the value of L or C



LC Tank Circuit

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Oscillators

- Two other widely used VFO circuits:
- *Phase-locked loop* (PLL)
- *Direct digital synthesizer* (DDS)
  - The *Direct digital synthesizer* has the advantage of being controllable by software and having stability comparable to a crystal oscillator – commonly used as the VFO in modern transceivers

Mixers

- A mixer circuit combines signals (local oscillator, RF input) with two frequencies, f_1 and f_2, and produces signals with the sum and difference frequencies at its output. This mixing of two signals is also called heterodyning)
- Example: If f_1 = 14.250 MHz and f_2 = 13.795 MHz, the output of the mixer will contain signals at both 455 KHz ($f_1 - f_2$) and at 28.045 MHz ($f_1 + f_2$: this will be filtered out)

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Multipliers

- *Multipliers* create harmonics of an input signal to reach a desired operating frequency
- Multipliers are often used when a stable VHF or UHF signal is required that cannot easily be generated directly at VHF/UHF (more later...)

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Modulators

- Modulator circuits add information to a carrier signal by varying its amplitude, frequency, or phase

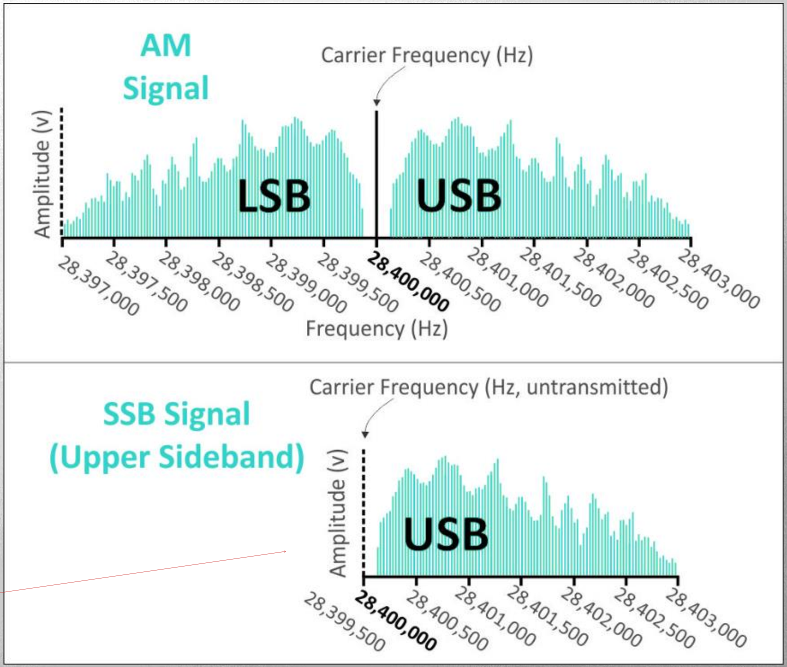
- The modulating information can be speech, data, or images

Amplitude Modulated Modes

- An AM signal is composed of a *carrier* and two *sidebands* – one higher than the carrier frequency (upper sideband – USB) and one lower (lower sideband – LSB)

Each sideband contains a copy of the modulating information.

A *single sideband* (SSB) signal is an AM signal with the carrier and one sideband removed/suppressed.



Notice the bandwidth occupied vs. the carrier frequency!!

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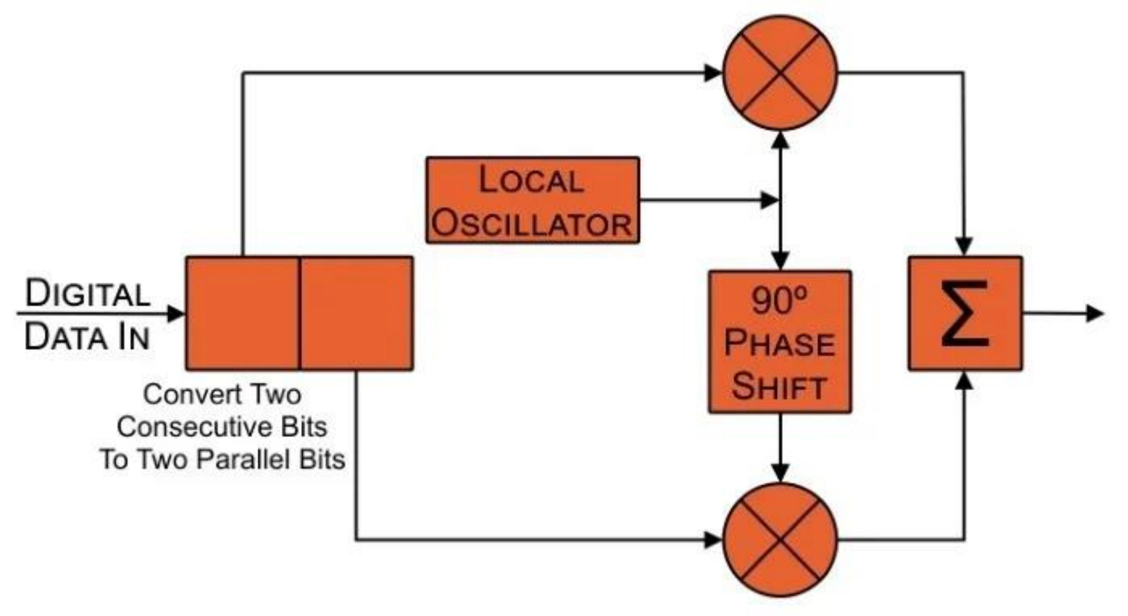
Frequency & Phase Modulation

- Frequency modulation (FM) – the signal frequency varies (deviates) in proportion to the modulating signal's amplitude
- Phase modulation (PM) – deviation varies with both amplitude and frequency of the modulating signal
- Phase modulation is produced by a *reactance modulator* connected to a tuned RF amplifier following the oscillator

Quadrature or I/Q Modulation

- Uses In-phase and Quadrature (shifted by 90°) signals – can produce signals with any form of modulation by varying the state (inverted or not) and modulation of the input signals
- Well-suited to DSP
- Widely used in SDRs



Take Quiz 2

G7B07 - Which of the following are basic components of a sine wave oscillator?

A. An amplifier and a divider

B. A frequency multiplier and a mixer

C. A circulator and a filter operating in a feed-forward loop

D. A filter and an amplifier operating in a feedback loop

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G7B09 - What determines the frequency of an LC oscillator?

A. The number of stages in the counter

B. The number of stages in the divider

C. The inductance and capacitance in the tank circuit

D. The time delay of the lag circuit

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G7C05 - Which of the following is characteristic of a direct digital synthesizer (DDS)?

A. Extremely narrow tuning range

B. Relatively high-power output

C. Pure sine wave output

D. Variable output frequency with the stability of a crystal oscillator

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G7C07 - What term specifies a filter's attenuation inside its passband?

A. Insertion loss

B. Return loss

C. Q

D. Ultimate rejection

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G7C09 - What is the phase difference between the I and Q RF signals that software-defined radio (SDR) equipment uses for modulation and demodulation?

A. Zero

B. 90 degrees

C. 180 degrees

D. 45 degrees

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G7C10 - What is an advantage of using I-Q modulation with software-defined radios (SDRs)?

A. The need for high resolution analog-to-digital converters is eliminated

B. All types of modulation can be created with appropriate processing

C. Minimum detectible signal level is reduced

D. Automatic conversion of the signal from digital to analog

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G7C11 - Which of these functions is performed by software in a software-defined radio (SDR)?

A. Filtering

B. Detection

C. Modulation

D. All these choices are correct

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G7C12 - What is the frequency above which a low-pass filter's output power is less than half the input power?

A. Notch frequency

B. Neper frequency

C. Cutoff frequency

D. Rolloff frequency

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G7C13 - What term specifies a filter's maximum ability to reject signals outside its passband?

A. Notch depth

B. Rolloff

C. Insertion loss

D. Ultimate rejection

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A. Notch depth

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G7C14 - The bandwidth of a band-pass filter is measured between what two frequencies?

A. Upper and lower half-power

B. Cutoff and rolloff

C. Pole and zero

D. Image and harmonic

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G8A04 - What emission is produced by a reactance modulator connected to a transmitter RF amplifier stage?

A. Multiplex modulation

B. Phase modulation

C. Amplitude modulation

D. Pulse modulation

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G8B03 - What is another term for the mixing of two RF signals?

A. Heterodyning

B. Synthesizing

C. Frequency inversion

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G8B04 - What is the stage in a VHF FM transmitter that generates a harmonic of a lower frequency signal to reach the desired operating frequency?

A. Mixer

B. Reactance modulator

C. Balanced converter

D. Multiplier

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G8B11 - What combination of a mixer's Local Oscillator (LO) and RF input frequencies is found in the output?

A. The ratio

B. The average

C. The sum and difference

D. The arithmetic product

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Chapter 5.3
Transmitters

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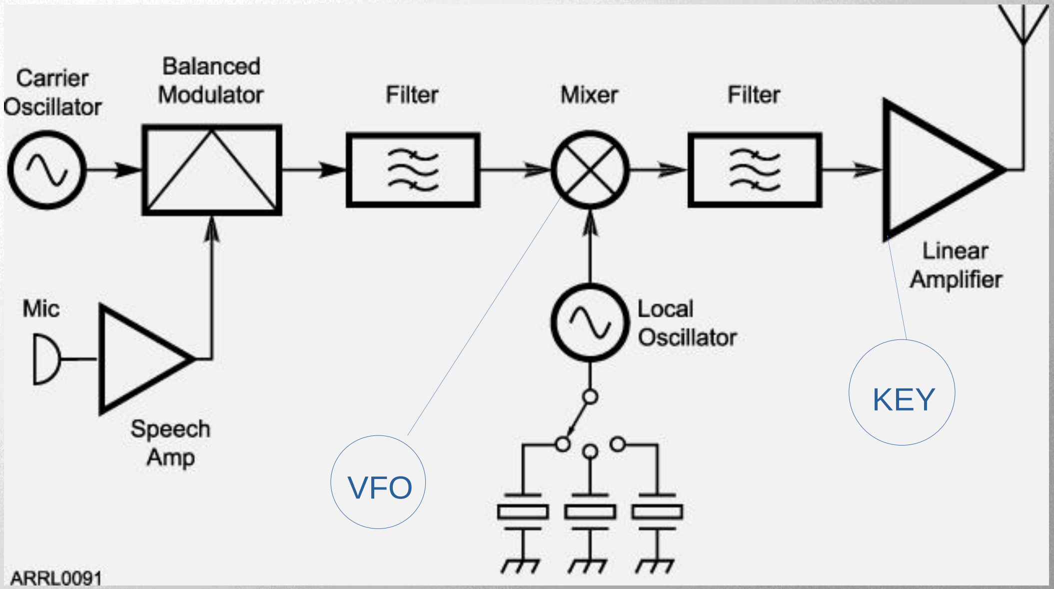
CW/SSB Phone Transmitter

In a CW transmitter (components in blue) the VFO feeds the mixer directly. The amplifier is keyed to generate CW. The local oscillator and crystals enable three band coverage.

In a SSB transmitter a ***balanced*** *modulator* stage combines signals from the carrier oscillator and speech amplifier to produce **double sideband (DSB)**

The first filter removes the unwanted sideband, producing SSB

The output of the first filter goes to the mixer



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FM Transmitters

- In a 2 meter FM transmitter, the modulated oscillator frequency is approximately 12 MHz
- A <u>Multiplier</u> then provides the 12th harmonic for transmission (12 x 12 = 144 MHz)
- For example, for an output on 146.52 MHz, the oscillator must produce a 146.52 ÷ 12 = 12.21 MHz signal

FM Transmitters

- The <u>*Deviation*</u> of the 12 MHz modulated oscillator output is **also** multiplied
- Example: If the 146.52 FM signal (produced from the 12 MHz oscillator) is to have the standard deviation of 5 kHz, the maximum deviation of the oscillator is:
- 5 kHz ÷ 12 = 416.7 Hz

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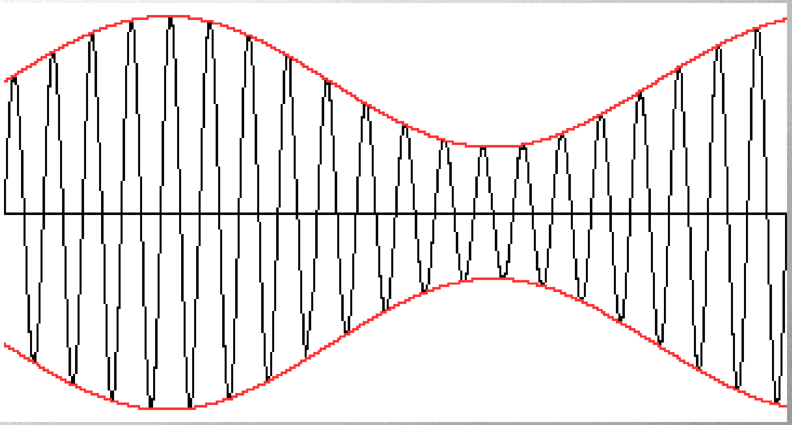
FM Transmitters

- *Carson's Rule* is a formula that gives an approximation of an FM signal's bandwidth (BW):
- BW = 2 × (peak deviation + highest modulating frequency)
- Example: If an FM phone signal's peak deviation is limited to 5 kHz and the highest modulating frequency is 3 kHz, then:
- BW = 2 × (5 + 3) = 16 kHz

Amplitude Modulated Modes

- *Amplitude modulation* (AM) is the instantaneous varying of the power or amplitude of a signal by adding speech or data information
- The AM signal's unmodulated *carrier* is a continuous wave whose amplitude does not change and contains no information
- The AM signal's *modulation envelope* follows the modulating signal. It is the waveform created by connecting the peak values of the modulated signal

Note: to prevent distortion Amplitude Modulation modes such as SSB require *linear* amplifiers whose outputs **preserve the input signal waveform** (more later...)



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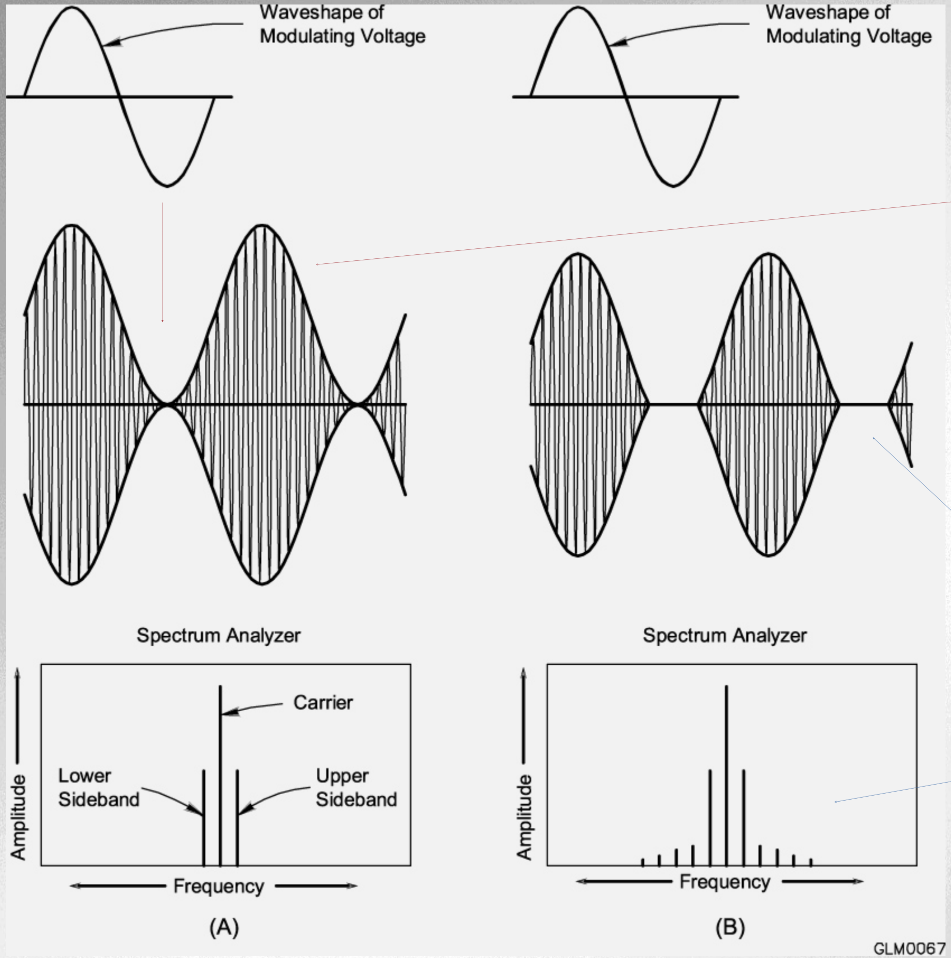
Signal Quality

- Overmodulation – AM Modes:
- Distorts the transmitted audio
- Results in excessive bandwidth by creating unwanted spurious signals called splatter or buckshot
- Often caused by misadjustment
  - Microphone gain set too high (reduce mic gain or speak more quietly)
  - Speech processor set too high (turn it down or off)



Modulation Envelope

The waveform created by connecting the peak values of the modulated signal

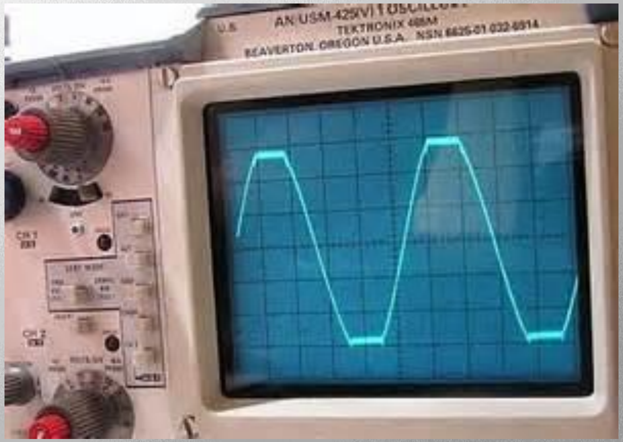
Overmodulation

Demo Video: AM Carrier, AM w/ Tone Modulation, AM w/ Voice Modulation, SSB Modulation

[C:\Users\ai2n\Videos\General Course - Videos\AM_and_SSB_Waveforms.wmv]

Overmodulation

- If the <u>drive</u> or <u>speech</u> levels to transmitter output stages or external amplifiers is increased beyond the point of maximum output power level, the result is *flat-topping* or *clipping*
- Use normal speech or audio levels during both testing and operation
- Under difficult conditions it's natural to raise your voice (only reduces intelligibility and causes excessive bandwidth)



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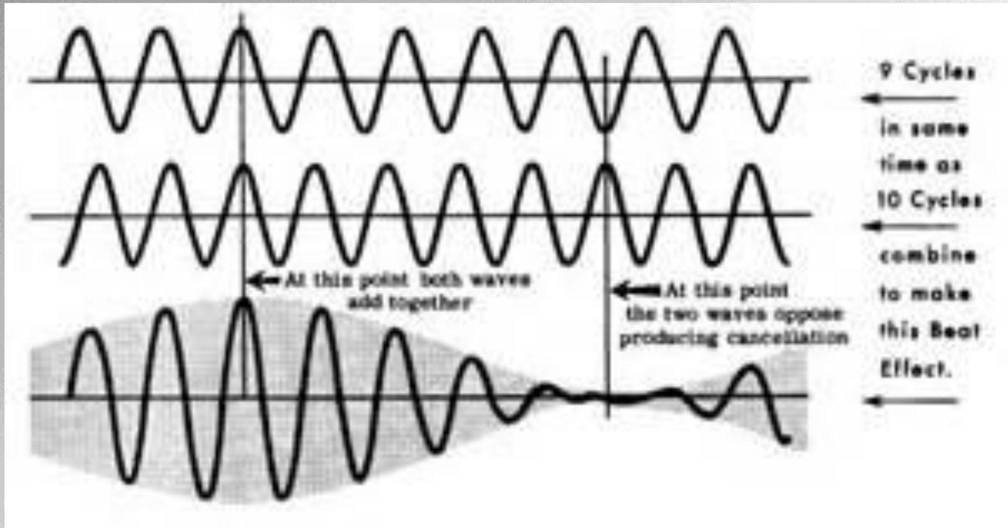
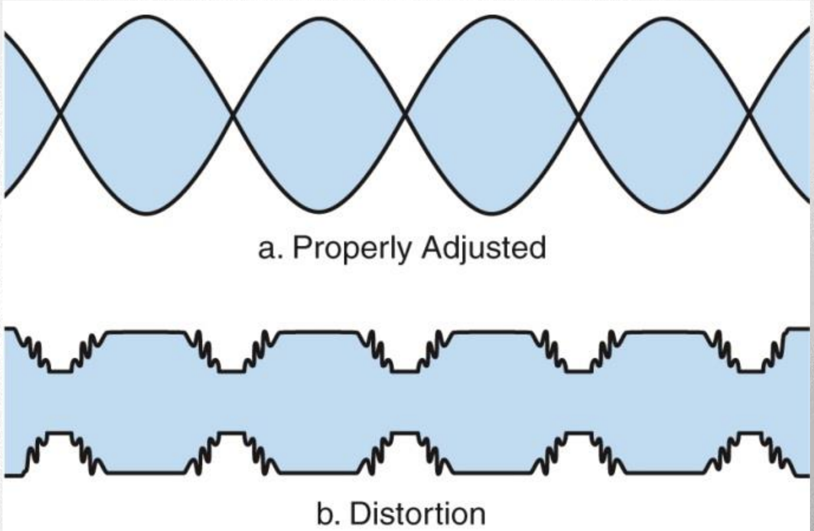
Overmodulation

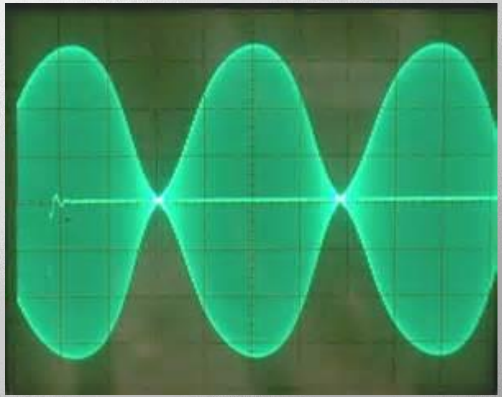
- Automatic level control (ALC) system helps prevent overmodulation and excessive drive
- ALC reduces output power on voice peaks
- Mic gain (or transmit audio) should be adjusted to cause the ALC to activate only on voice peaks
- A *Two-tone test* for transmitter ***linearity*** is very helpful in keeping your signal clean
- Test consists of modulating your transmitter with a pair of audio tones that are not harmonically related (usually 700 and 1900 Hz)

Two-Tone Test





LINEARITY
(vs Distortion)



Overdeviation

- Overmodulated FM signals:
- *Overdeviation* is caused by speaking too loudly or setting mic gain too high
- The received signal is distorted
- Creates interference to adjacent channels

Speech Processing

- *Speech processing* **increases the <u>average power</u> (apparent loudness) of the signal** without excessively distorting the signal
- The result is improved intelligibility of the received signal in poor conditions
- Speech processors can also amplify low-level background noise, reducing intelligibility (balance average power improvement against reduction in intelligibility)

Speech Processing

- Review: An incorrectly adjusted speech processor can cause:
  - Distorted speech
  - Excessive intermodulation products (Splatter)
  - Excessive background pickup
    - ***All of these choices are correct.***

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SSB Bandwidth

- With the displayed carrier frequency set to 14.347 MHz, a 3 kHz USB signal occupies 14.347 to 14.350 MHz. *When operating USB, your signal occupies a space starting at the displayed carrier frequency and extending up 3 kHz.*
- When the displayed carrier frequency is set to 7.178 MHz, a 3 kHz LSB signal occupies 7.175 to 7.178 MHz.
- When operating in a General Class phone segment when using 3 kHz wide LSB, your displayed carrier frequency should be at least 3 kHz above the edge of the segment.
- When operating in a General Class band, your displayed carrier frequency should be at least 3 kHz below the edge of the band when using 3 kHz wide USB.

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Take Quiz 3

G2A12 - What control is typically adjusted for proper ALC setting on a single sideband transceiver?

A. RF clipping level

B. Transmit audio or microphone gain

C. Antenna inductance or capacitance

D. Attenuator level

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G4B07 - What signals are used to conduct a two-tone test?

A. Two audio signals of the same frequency shifted 90 degrees

B. Two non-harmonically related audio signals

C. Two swept frequency tones

D. Two audio frequency range square wave signals of equal amplitude

G4B07 - What signals are used to conduct a two-tone test?

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C. Two swept frequency tones

D. Two audio frequency range square wave signals of equal amplitude

G4B08 - What transmitter performance parameter does a two-tone test analyze?

A. Linearity

B. Percentage of suppression of the carrier and undesired sideband for SSB

C. Percentage of frequency modulation

D. Percentage of carrier phase shift

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B. Percentage of suppression of the carrier and undesired sideband for SSB

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G4D01 - What is the purpose of a speech processor in a transceiver?

A. Increase the apparent loudness of transmitted voice signals

B. Increase transmitter bass response for more natural-sounding SSB signals

C. Prevent distortion of voice signals

D. Decrease high-frequency voice output to prevent out-of-band operation

G4D01 - What is the purpose of a speech processor in a transceiver?

A. Increase the apparent loudness of transmitted voice signals

B. Increase transmitter bass response for more natural-sounding SSB signals

C. Prevent distortion of voice signals

D. Decrease high-frequency voice output to prevent out-of-band operation

G4D02 - How does a speech processor affect a single sideband phone signal?

A. It increases peak power

B. It increases average power

C. It reduces harmonic distortion

D. It reduces intermodulation distortion

G4D02 - How does a speech processor affect a single sideband phone signal?

A. It increases peak power

B. It increases average power

C. It reduces harmonic distortion

D. It reduces intermodulation distortion

G4D03 - What is the effect of an incorrectly adjusted speech processor?

A. Distorted speech

B. Excess intermodulation products

C. Excessive background noise

D. All these choices are correct

G4D03 - What is the effect of an incorrectly adjusted speech processor?

A. Distorted speech

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C. Excessive background noise

D. All these choices are correct

G4D08 - What frequency range is occupied by a 3 kHz LSB signal when the displayed carrier frequency is set to 7.178 MHz?

A. 7.178 MHz to 7.181 MHz

B. 7.178 MHz to 7.184 MHz

C. 7.175 MHz to 7.178 MHz

D. 7.1765 MHz to 7.1795 MHz

G4D08 - What frequency range is occupied by a 3 kHz LSB signal when the displayed carrier frequency is set to 7.178 MHz?

A. 7.178 MHz to 7.181 MHz

B. 7.178 MHz to 7.184 MHz

C. 7.175 MHz to 7.178 MHz

D. 7.1765 MHz to 7.1795 MHz

G4D09 - What frequency range is occupied by a 3 kHz USB signal with the displayed carrier frequency set to 14.347 MHz?

A. 14.347 MHz to 14.647 MHz

B. 14.347 MHz to 14.350 MHz

C. 14.344 MHz to 14.347 MHz

D. 14.3455 MHz to 14.3485 MHz

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A. 14.347 MHz to 14.647 MHz

B. 14.347 MHz to 14.350 MHz

C. 14.344 MHz to 14.347 MHz

D. 14.3455 MHz to 14.3485 MHz

G4D10 - How close to the lower edge of a band's phone segment should your displayed carrier frequency be when using 3 kHz wide LSB?

A. At least 3 kHz above the edge of the segment

B. At least 3 kHz below the edge of the segment

C. At least 1 kHz below the edge of the segment

D. At least 1 kHz above the edge of the segment

G4D10 - How close to the lower edge of a band's phone segment should your displayed carrier frequency be when using 3 kHz wide LSB?

A. At least 3 kHz above the edge of the segment

B. At least 3 kHz below the edge of the segment

C. At least 1 kHz below the edge of the segment

D. At least 1 kHz above the edge of the segment

G4D11 - How close to the upper edge of a band's phone segment should your displayed carrier frequency be when using 3 kHz wide USB?

A. At least 3 kHz above the edge of the band

B. At least 3 kHz below the edge of the band

C. At least 1 kHz above the edge of the segment

D. At least 1 kHz below the edge of the segment

G4D11 - How close to the upper edge of a band's phone segment should your displayed carrier frequency be when using 3 kHz wide USB?

A. At least 3 kHz above the edge of the band

B. At least 3 kHz below the edge of the band

C. At least 1 kHz above the edge of the segment

D. At least 1 kHz below the edge of the segment

G7B10 - Which of the following describes a linear amplifier?

A. Any RF power amplifier used in conjunction with an amateur transceiver

B. An amplifier in which the output preserves the input waveform

C. A Class C high efficiency amplifier

D. An amplifier used as a frequency multiplier

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B. An amplifier in which the output preserves the input waveform

C. A Class C high efficiency amplifier

D. An amplifier used as a frequency multiplier

G7C01 - What circuit is used to select one of the sidebands from a balanced modulator?

A. Carrier oscillator

B. Filter

C. IF amplifier

D. RF amplifier

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G7C02 - What output is produced by a balanced modulator?

A. Frequency modulated RF

B. Audio with equalized frequency response

C. Audio extracted from the modulation signal

D. Double-sideband modulated RF

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G7C02 - What output is produced by a balanced modulator?

A. Frequency modulated RF

B. Audio with equalized frequency response

C. Audio extracted from the modulation signal

D. Double-sideband modulated RF

G8A08 - Which of the following is an effect of overmodulation?

A. Insufficient audio

B. Insufficient bandwidth

C. Frequency drift

D. Excessive bandwidth

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G8A10 - What is meant by the term "flat-topping," when referring to an amplitude-modulated phone signal?

A. Signal distortion caused by insufficient collector current

B. The transmitter's automatic level control (ALC) is properly adjusted

C. Signal distortion caused by excessive drive or speech levels

D. The transmitter's carrier is properly suppressed

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G8A11 - What is the modulation envelope of an AM signal?

A. The waveform created by connecting the peak values of the modulated signal

B. The carrier frequency that contains the signal

C. Spurious signals that envelop nearby frequencies

D. The bandwidth of the modulated signal

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D. The bandwidth of the modulated signal

G8B06 - What is the total bandwidth of an FM phone transmission having 5 kHz deviation and 3 kHz modulating frequency?

A. 3 kHz

B. 5 kHz

C. 8 kHz

D. 16 kHz

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D. 16 kHz

G8B07 - What is the frequency deviation for a 12.21 MHz reactance modulated oscillator in a 5 kHz deviation, 146.52 MHz FM phone transmitter?

A. 101.75 Hz

B. 416.7 Hz

C. 5 kHz

D. 60 kHz

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Chapter 5.3 (con’t) - Amplifiers

- High-power HF amplifiers often use vacuum tube circuits that require operator adjustment (more to come)
- Solid-state RF power amps are becoming more common - USE CAUTION: excessive drive power can damage them: use automatic level control (ALC) to prevent this
- Review: Amplitude Modulation modes such as SSB require *linear* amplifiers **whose outputs preserve the input signal waveform**

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Amplifier Classes

- *Class A* – The most linear - it amplifies the entire waveform (never turns off)
- Lowest signal distortion, Least efficient
- *Class AB* - amplifying devices on >50% but <100% of the waveform
- *Class B* – a pair of amplifying devices each on 50% of the time - cross-over distortion is a possibility
- *Class C* – amplifying devices are active for less than one-half of the signal’s cycle
- Class C has the highest efficiency but poor linearity
- Class C is only suitable for CW and FM because those modes don't require good linearity

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Amateur Amplifiers

- Most linear amplifiers can be operated in either Class AB for SSB operation or in Class C for CW

- The efficiency of an amplifier is defined as the *RF output power divided by the DC input power* (both in watts)

Manual Amplifier Tuning

- Set the band switch to proper frequency
- Apply a small amount of drive power while adjusting the TUNE (Plate) control to minimum ("*dip*") plate current
- Adjust the LOAD (Coupling) control to maximize (or "peak") output power WITHOUT exceeding maximum rated plate current
- *DIP the Plate (<u>Tune</u>), PEAK the Load (<u>Coupling</u>)*

Amplifier Tuning

[C:\Users\ai2n\Videos\General Course - Videos\Heathkit_SB-220_Linear_Amplifier Tuning.wmv]()

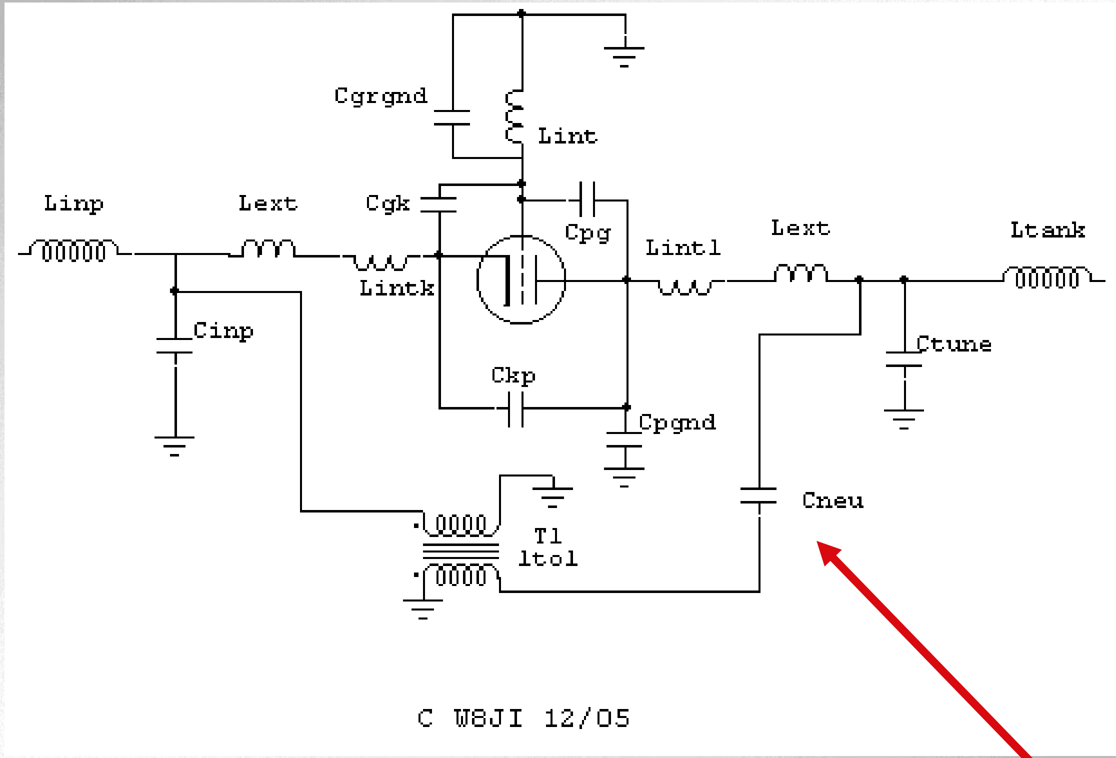
Amplifier Tuning

- Continue to adjust drive, tune, load for desired output power
- Watch meters to prevent exceeding the maximum grid and plate current
- Input power may also be adjusted during the process
- Continue adjustments until desired output power is reached

Neutralization

- HF amplifiers are susceptible to oscillation (called *self-oscillation*) due to positive feedback from stray capacitance
- Self-oscillation creates spurious output signals and may damage the tube or amplifier components
- The technique of preventing self-oscillation by providing carefully-phased negative feedback is called *neutralization*

Neutralization



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Amplifiers

- Transceivers often include a delay in the keying circuit that is used to key the amplifier (and other devices)
- The delay assures that the Transmit/Receive (T/R) relay is completely switched before the transceiver is allowed to supply any RF output
- The delay prevents *hot-switching,* which can damage the T/R relay or other external devices

Take Quiz 4

G4A04 - What is the effect on plate current of the correct setting of a vacuum-tube RF power amplifier's TUNE control?

A. A pronounced peak

B. A pronounced dip

C. No change will be observed

D. A slow, rhythmic oscillation

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G4A05 - Why is automatic level control (ALC) used with an RF power amplifier?

A. To balance the transmitter audio frequency response

B. To reduce harmonic radiation

C. To prevent excessive drive

D. To increase overall efficiency

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G4A08 - What is the correct adjustment for the LOAD or COUPLING control of a vacuum tube RF power amplifier?

A. Minimum SWR on the antenna

B. Minimum plate current without exceeding maximum allowable grid current

C. Highest plate voltage while minimizing grid current

D. Desired power output without exceeding maximum allowable plate current

G4A08 - What is the correct adjustment for the LOAD or COUPLING control of a vacuum tube RF power amplifier?

A. Minimum SWR on the antenna

B. Minimum plate current without exceeding maximum allowable grid current

C. Highest plate voltage while minimizing grid current

D. Desired power output without exceeding maximum allowable plate current

TERRIBLE wording! PEAK the load/coupling control without exceeding...

G4A09 - What is the purpose of delaying RF output after activating a transmitter's keying line to an external amplifier?

A. To prevent key clicks on CW

B. To prevent transient overmodulation

C. To allow time for the amplifier to switch the antenna between the transceiver and the amplifier output

D. To allow time for the amplifier power supply to reach operating level

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G7B01 - What is the purpose of neutralizing an amplifier?

A. To limit the modulation index

B. To eliminate self-oscillations

C. To cut off the final amplifier during standby periods

D. To keep the carrier on frequency

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G7B02 - Which of these classes of amplifiers has the highest efficiency?

A. Class A

B. Class B

C. Class AB

D. Class C

G7B02 - Which of these classes of amplifiers has the highest efficiency?

A. Class A

B. Class B

C. Class AB

D. Class C

G7B04 - In a Class A amplifier, what percentage of the time does the amplifying device conduct?

A. 100%

B. More than 50% but less than 100%

C. 50%

D. Less than 50%

G7B04 - In a Class A amplifier, what percentage of the time does the amplifying device conduct?

A. 100%

B. More than 50% but less than 100%

C. 50%

D. Less than 50%

G7B08 - How is the efficiency of an RF power amplifier determined?

A. Divide the DC input power by the DC output power

B. Divide the RF output power by the DC input power

C. Multiply the RF input power by the reciprocal of the RF output power

D. Add the RF input power to the DC output power

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G7B11 - For which of the following modes is a Class C power stage appropriate for amplifying a modulated signal?

A. SSB

B. FM

C. AM

D. All these choices are correct

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Chapter 5.4
Receivers

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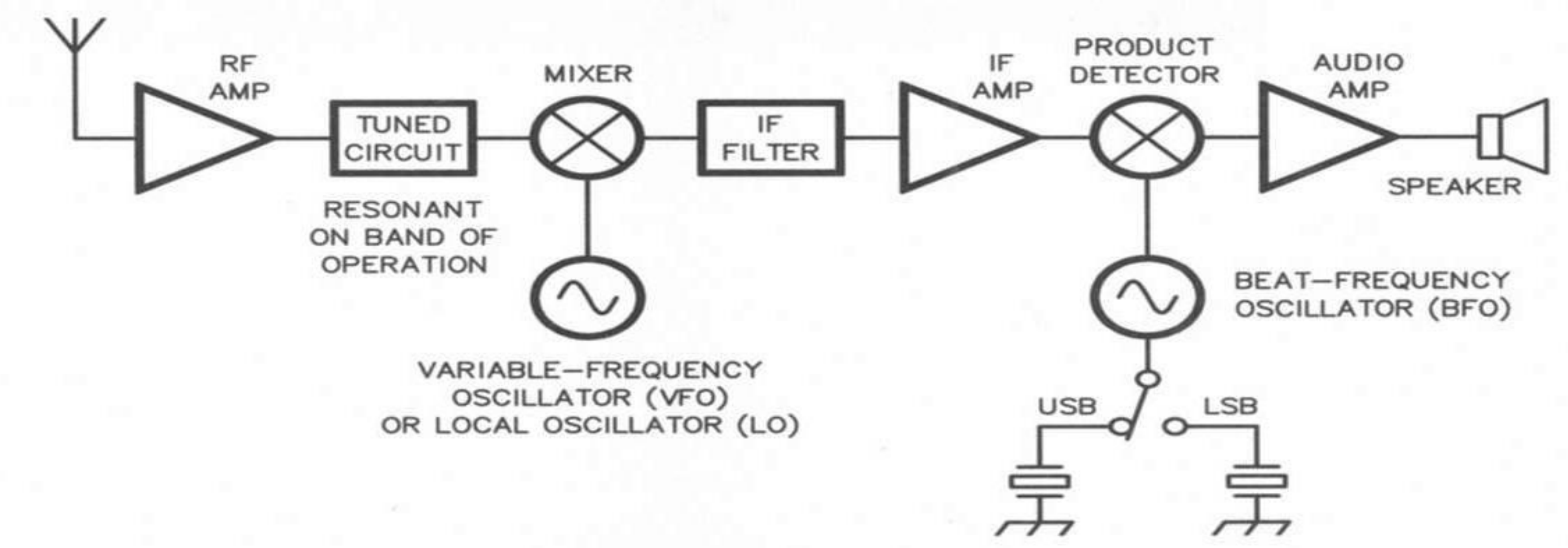
Superheterodyne Receiver – Walk-through

Received signals are incredibly weak – on the order of nano or picowatts



IF = Intermediate Frequency

Superhetrodyne Receiver

Received signals are first boosted by the RF amplifier, then applied to the RF input of a mixer

The **local oscillator** (LO) is adjusted so that the desired signal creates a mixing product at the *intermediate frequency* (IF)

A **product detector** (demodulator) stage follows the IF amplifier to extract (recover) the modulating information

Input amplifier gain, demodulator stage bandwidth, and input amplifier noise can all affect receiver sensitivity

Simplest Superhet

- The simplest possible superheterodyne receiver consists of a mixer connected to the antenna, an HF oscillator to act as a LO, and a detector that operates directly on the resulting IF signal

- Once amplified to a more usable level, SSB and CW signals are demodulated by a *product detector* - A type of mixer that combines the IF signal with the output of a *beat frequency oscillator* (BFO) to produce an audio frequency (AF) mixing product

Image Signals

- Example: If the IF is 455 kHz and the LO frequency is 13.800 MHz, signals at both 14.255 and 13.345 MHz will create a mixing product at 455 kHz
- Assuming the receiver is supposed to receive the 14.255 MHz signal, the undesired signal at 13.345 MHz is called an *image*
- Filters in the RF Front End (the RF amplifier and first mixer) remove image signals to eliminate this interference

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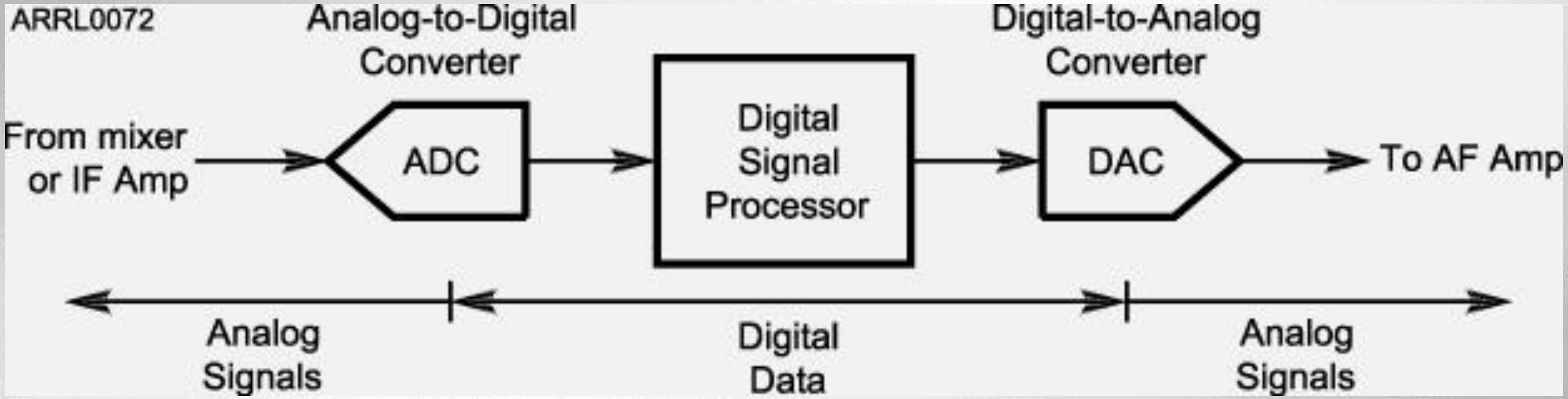
Digital Signal Processing

The general term for converting signals from analog to digital form, operating on them with a microprocessor, and converting them back to analog is digital signal processing (DSP)



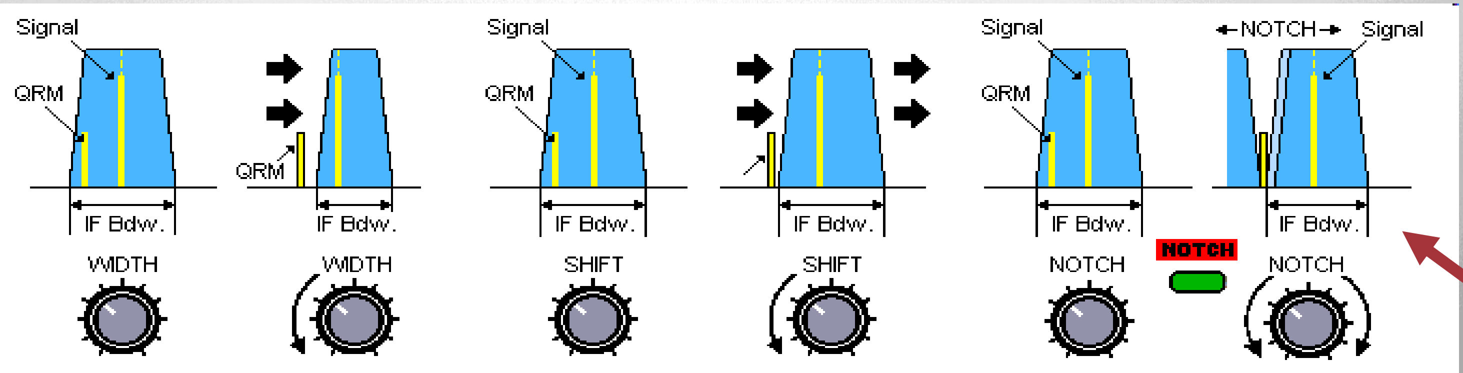
A DSP IF Filter consists of an analog to digital converter, a digital to analog converter, and a digital processor chip

Common DSP Functions

- *Signal filtering* – offers a wide range of filters with adjustable bandwidth and shape, such as *notch* filters
- *Noise reduction* – DSP can distinguish and remove some kinds of noise, leaving only the desired speech or CW for the operator to copy
- *Audio frequency equalization* – Adjustable receive or transmit audio frequency response to suit preferences
- ***DSP advantage: A wide range of filter bandwidths and shapes can be created***

Common Manual or DSP Functions

- *Notch filtering* – Interfering carrier signals in the receiver's passband can be sensed and removed by DSP
- An *automatic notch filter* can track interfering signals as they change frequency and eliminate more than one at a time



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Notch Filter

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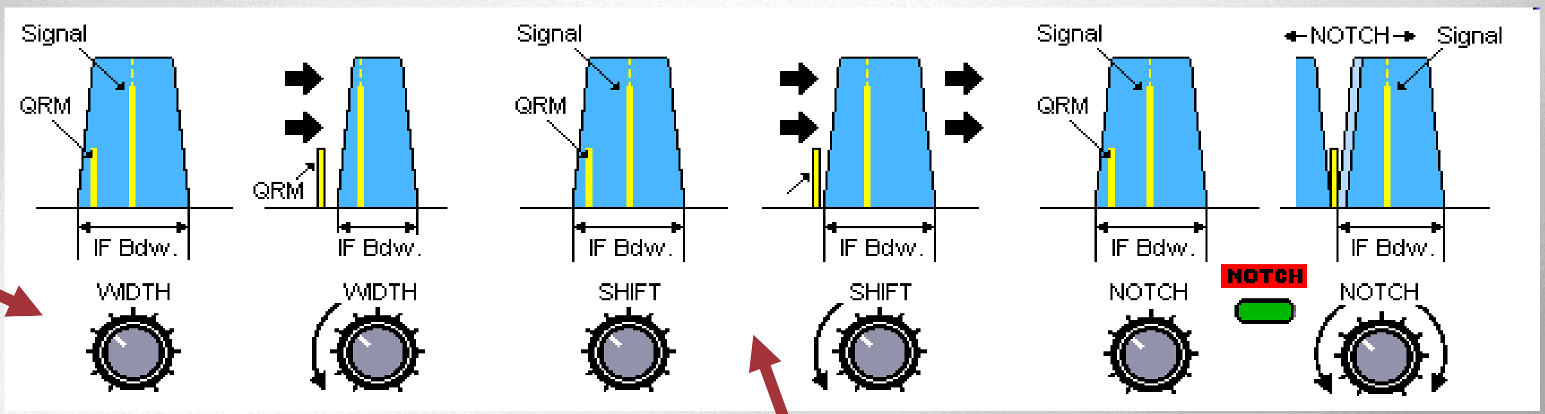
Common Manual or DSP Functions

- One use for the IF shift control on a receiver is to avoid interference from stations very close to the receive frequency

- Matching the receiver bandwidth to the bandwidth of the operating mode results in the best signal to noise ratio



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Next two videos….

IF Shift - Width

C:\Users\ai2n\Videos\General Course - Videos\IF_Shift_Demo.wmv

Bandwidth Demo - RL3A

C:\Users\ai2n\Videos\General Course - Videos\RL3A Filter Demo.wmv

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Common DSP Functions

- A DSP noise blanker temporarily reduces receiver gain during noise pulses
- As noise reduction level is increased received signals may become distorted – nothing is perfect; the noise blanker may interpret some signal components as noise

Use Opposite Sideband

- An advantage of selecting the opposite or "reverse" sideband when receiving CW signals on a typical HF transceiver is that it may be possible to reduce or eliminate interference from other signals

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SO2R (Poland) calling CQ

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Receiver Linearity

- If the received signal is distorted, spurious signals will appear just as if a transmitting station were emitting them
- A common form of receiver nonlinearity is caused by *front-end overload*
- The *attenuator* and RF gain controls can reduce received noise and distortion caused by strong incoming signals

S Meter

- S meters are found in receivers
- The AGC circuit adjusts receiver gain by changing a voltage that controls the RF and IF amplifier gain
  - This voltage is read by the *S meter* of the receiver, which is used to measure received signal strength

(Note: S9, +20, etc)

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S Meter

- S meters are calibrated in *S units*, equal to about 6 dB change per S unit
- S9 is at the midpoint of the S meter display – a very good signal
- Additional markings +20, +40, and +60 correspond to *dB above S9*
- A reading of S9 + 20 dB, therefore corresponds to a signal 20 dB (100 times) stronger than an S9 signal
- To go from S8 to S9 on a distant receiver, transmitter output must rise by a factor of 4

3 dB = 2x change
6 dB = 4x change
10 dB = 10x change

Take Quiz 5

G4A01 - What is the purpose of the notch filter found on many HF transceivers?

A. To restrict the transmitter voice bandwidth

B. To reduce interference from carriers in the receiver passband

C. To eliminate receiver interference from impulse noise sources

D. To remove interfering splatter generated by signals on adjacent frequencies

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G4A02 - What is the benefit of using the opposite or "reverse" sideband when receiving CW?

A. Interference from impulse noise will be eliminated

B. More stations can be accommodated within a given signal passband

C. It may be possible to reduce or eliminate interference from other signals

D. Accidental out-of-band operation can be prevented

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G4A03 - How does a noise blanker work?

A. By temporarily increasing received bandwidth

B. By redirecting noise pulses into a filter capacitor

C. By reducing receiver gain during a noise pulse

D. By clipping noise peaks

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G4A07 - What happens as a receiver's noise reduction control level is increased?

A. Received signals may become distorted

B. Received frequency may become unstable

C. CW signals may become severely attenuated

D. Received frequency may shift several kHz

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G4A13 - What is the purpose of using a receive attenuator?

A. To prevent receiver overload from strong incoming signals

B. To reduce the transmitter power when driving a linear amplifier

C. To reduce power consumption when operating from batteries

D. To reduce excessive audio level on strong signals

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G4D04 - What does an S meter measure?

A. Carrier suppression

B. Impedance

C. Received signal strength

D. Transmitter power output

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G4D05 - How does a signal that reads 20 dB over S9 compare to one that reads S9 on a receiver, assuming a properly calibrated S meter?

A. It is 10 times less powerful

B. It is 20 times less powerful

C. It is 20 times more powerful

D. It is 100 times more powerful

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G4D06 - How much change in signal strength is typically represented by one S unit?

A. 6 dB

B. 12 dB

C. 15 dB

D. 18 dB

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G4D07 - How much must the power output of a transmitter be raised to change the S meter reading on a distant receiver from S8 to S9?

A. Approximately 1.5 times

B. Approximately 2 times

C. Approximately 4 times

D. Approximately 8 times

G4D07 - How much must the power output of a transmitter be raised to change the S meter reading on a distant receiver from S8 to S9?

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B. Approximately 2 times

C. Approximately 4 times

D. Approximately 8 times

G7C04 - How is a product detector used?

A. Used in test gear to detect spurious mixing products

B. Used in transmitter to perform frequency multiplication

C. Used in an FM receiver to filter out unwanted sidebands

D. Used in a single sideband receiver to extract the modulated signal

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B. Fewer digital components are required

C. Mixing products are greatly reduced

D. The DSP filter is much more effective at VHF frequencies

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G7C08 - Which parameter affects receiver sensitivity?

A. Input amplifier gain

B. Demodulator stage bandwidth

C. Input amplifier noise figure

D. All these choices are correct

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B. Image response

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G8B09 - Why is it good to match receiver bandwidth to the bandwidth of the operating mode?

A. It is required by FCC rules

B. It minimizes power consumption in the receiver

C. It improves impedance matching of the antenna

D. It results in the best signal-to-noise ratio

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Next Week
Chapters 5.5, 6