GNU Radio ile Uygulamalı Haberleşme Sistemleri-III

Linux Kış Kampı
Afyonkarahisar, 4-8 Şubat 2026

Outline

Quick Recap

Modulation

AM, SSB, NBFM, WBFM, CW
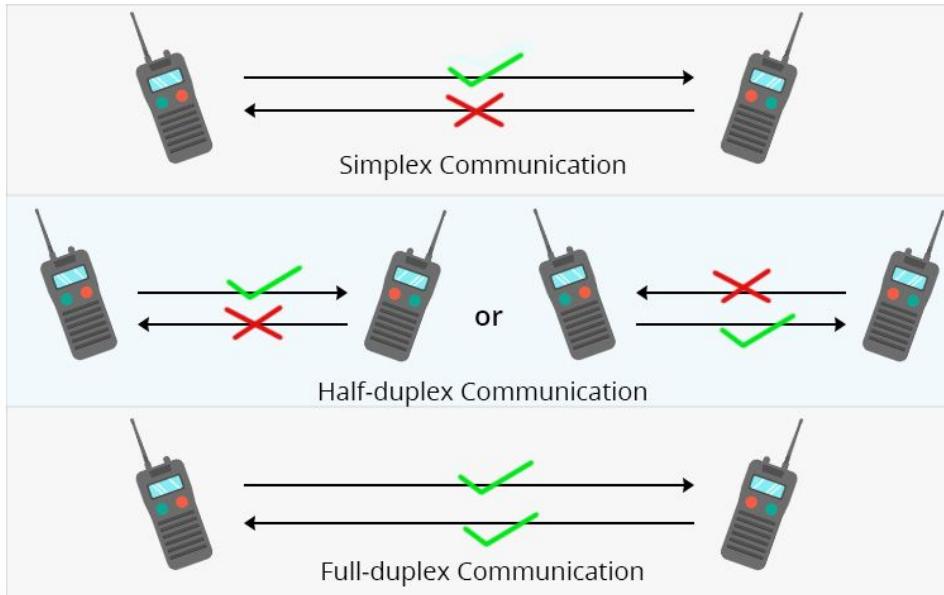
Recap - SDR

- What are two key parameters of an SDR?
- What is RTSA short for?
- What is the frequency range of airband?

Schedule

- First Day: GNU Radio Introduction, DSP, GR Simulation Mode
- Second Day: SDR Introduction, RTL-SDR, GR Real-Time Mode
- **Third Day: Analog Communications**
- Fourth Day: Digital Communications

Simplex/Duplex Communication
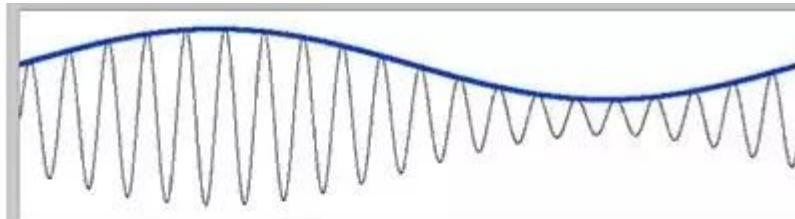
Modulation
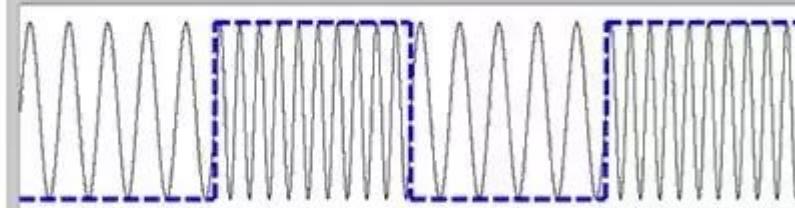
- **Modulation** is a process by which some characteristics of a carrier signal are varied in accordance with the message signal.
- Here the carrier signal is referred to as the "**modulated** signal," and the message signal is referred to as the "**modulating** signal."
- Typically, the frequency of the carrier signal is very **high** when compared to the message signal.
- Each modulation scheme has its own **advantages and disadvantages**, and all modulation schemes cannot be used with all applications.
- Discussing all analog and digital modulation techniques is beyond the scope of this course!

Modulation
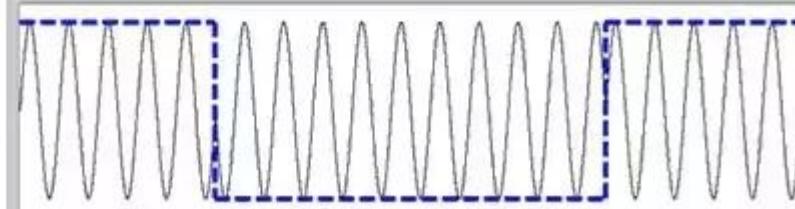
Amplitude Modulation
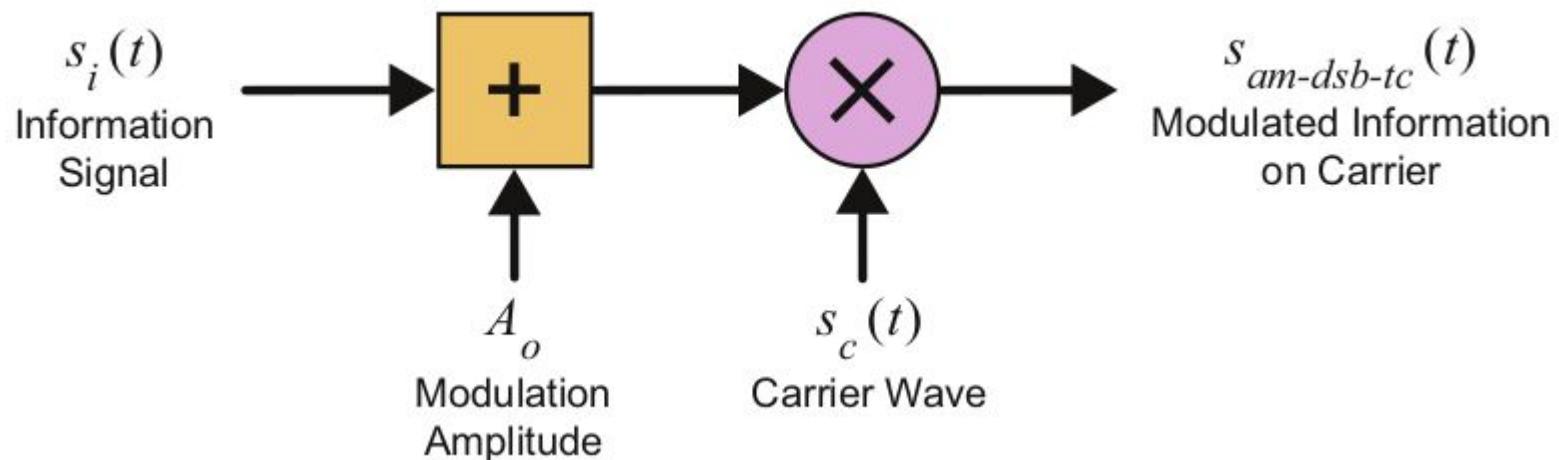
Frequency Modulation
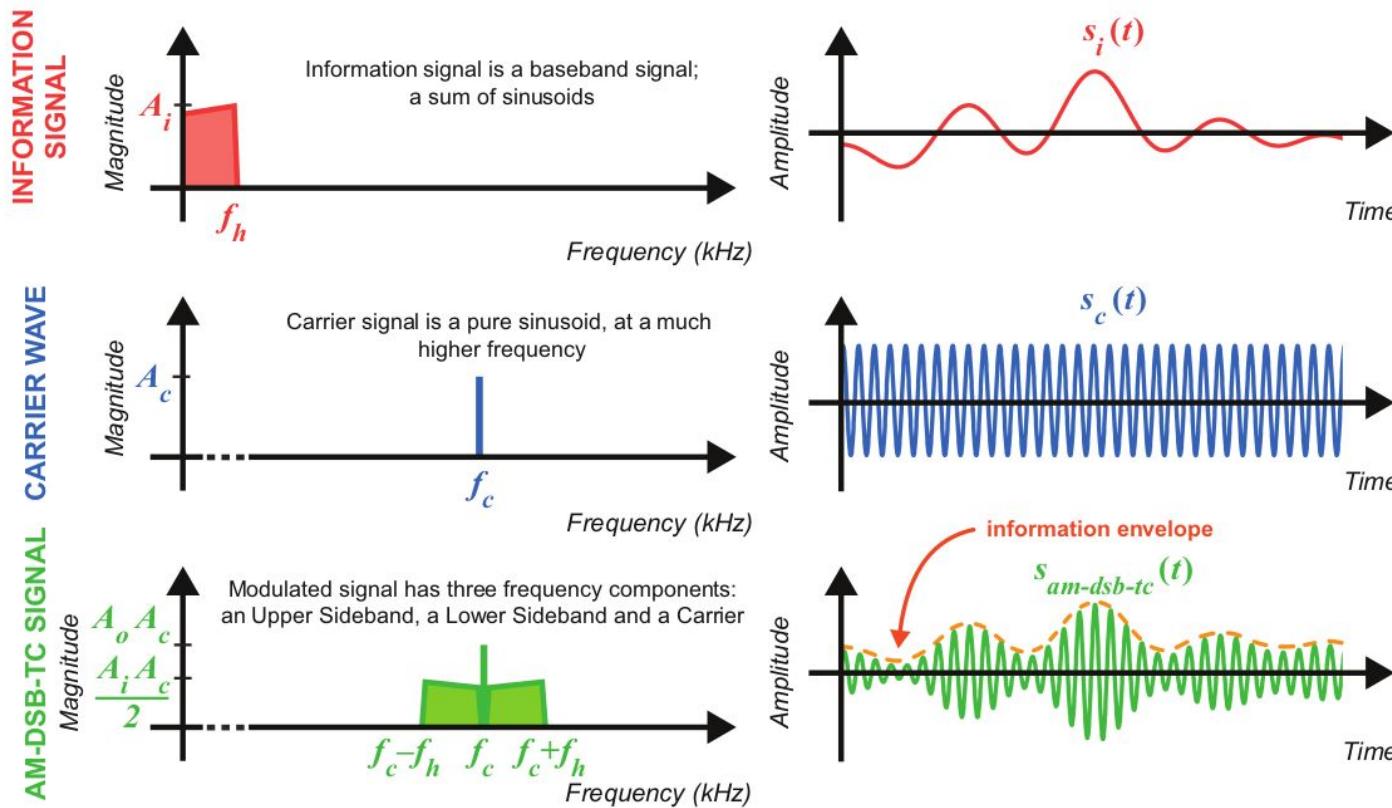
Phase Modulation
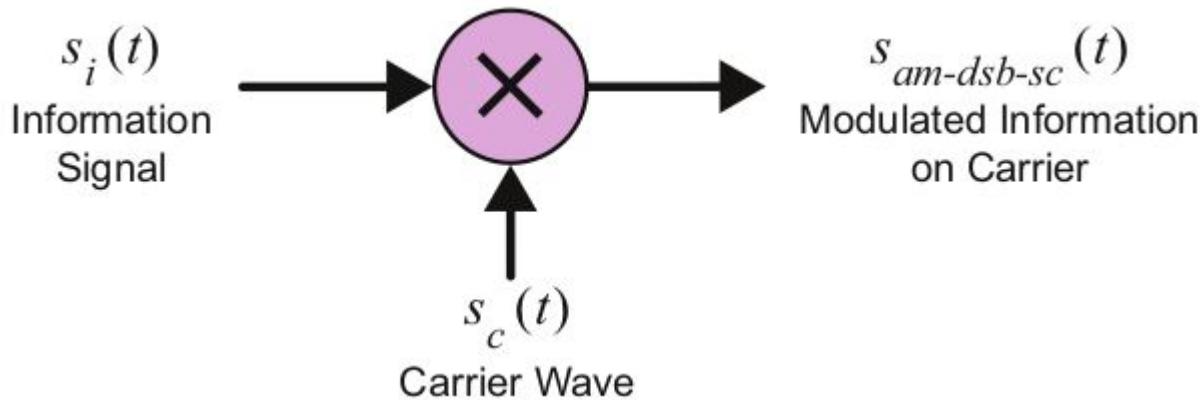
# AM-DSB-TC: Double Sideband Transmitted Carrier AM

AM-DSB-TC: Double Sideband Transmitted Carrier AM

INFORMATION SIGNAL

Information signal is a baseband signal; a sum of sinusoids

$s_i(t)$

CARRIER WAVE

Carrier signal is a pure sinusoid, at a much higher frequency

$s_c(t)$

AM-DSB-TC SIGNAL

Modulated signal has three frequency components: an Upper Sideband, a Lower Sideband and a Carrier

information envelope

$s_{am-dsb-tc}(t)$

AM-DSB-SC: Double Sideband Suppressed Carrier AM

$s_i(t)$
Information Signal

$\times$

$s_{am\text{-}dsb\text{-}sc}(t)$
Modulated Information on Carrier

$s_c(t)$
Carrier Wave
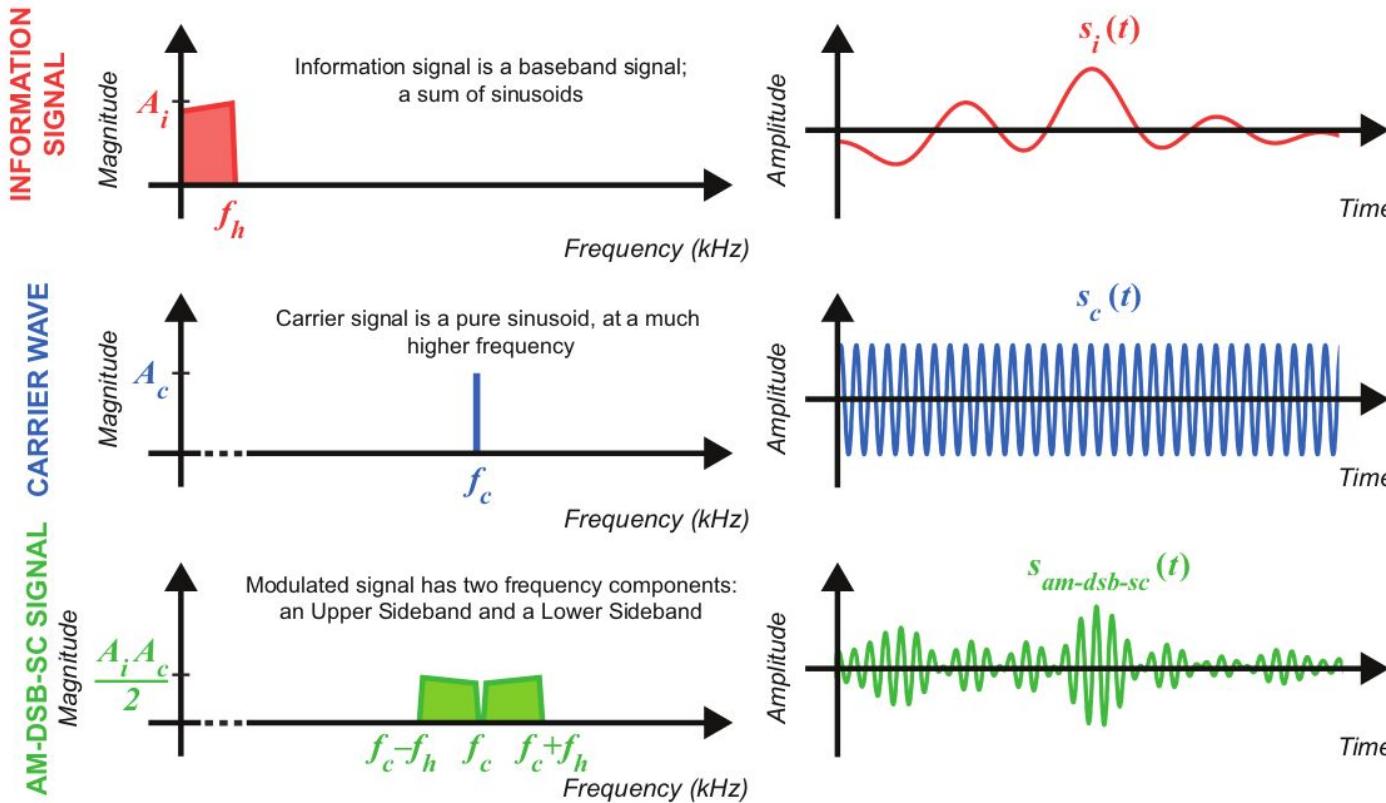
- Carrier wave is not transmitted
- Much of the power is distributed between the side bands
- DSB-SC is generated by a mixer
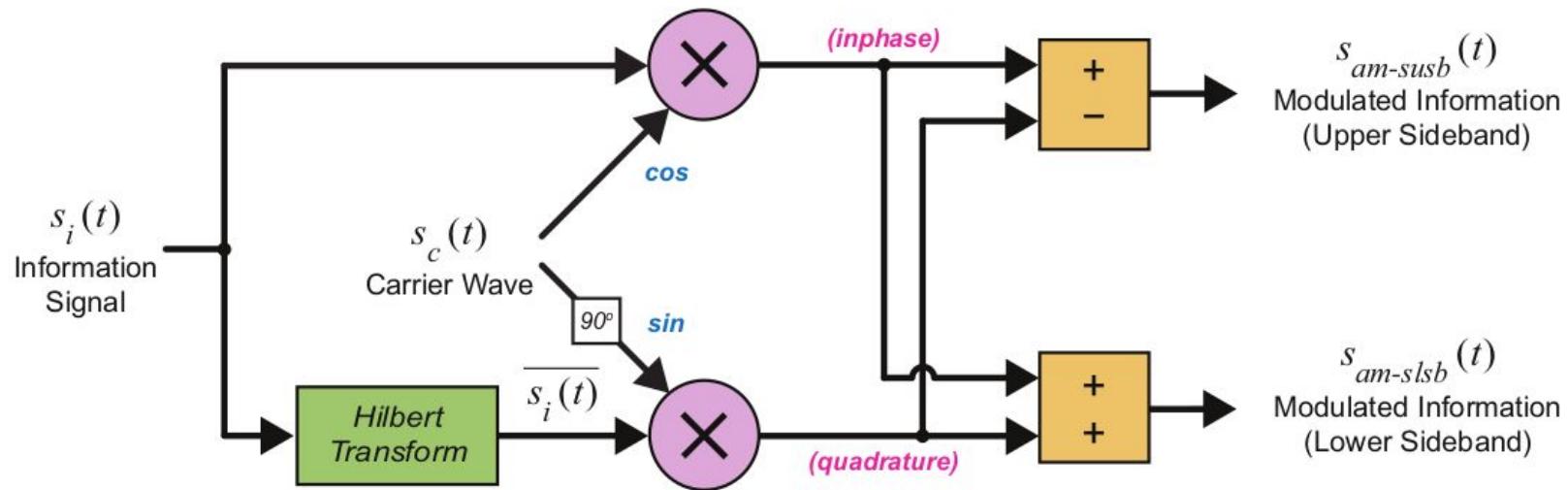
# AM-DSB-SC: Double Sideband Suppressed Carrier AM
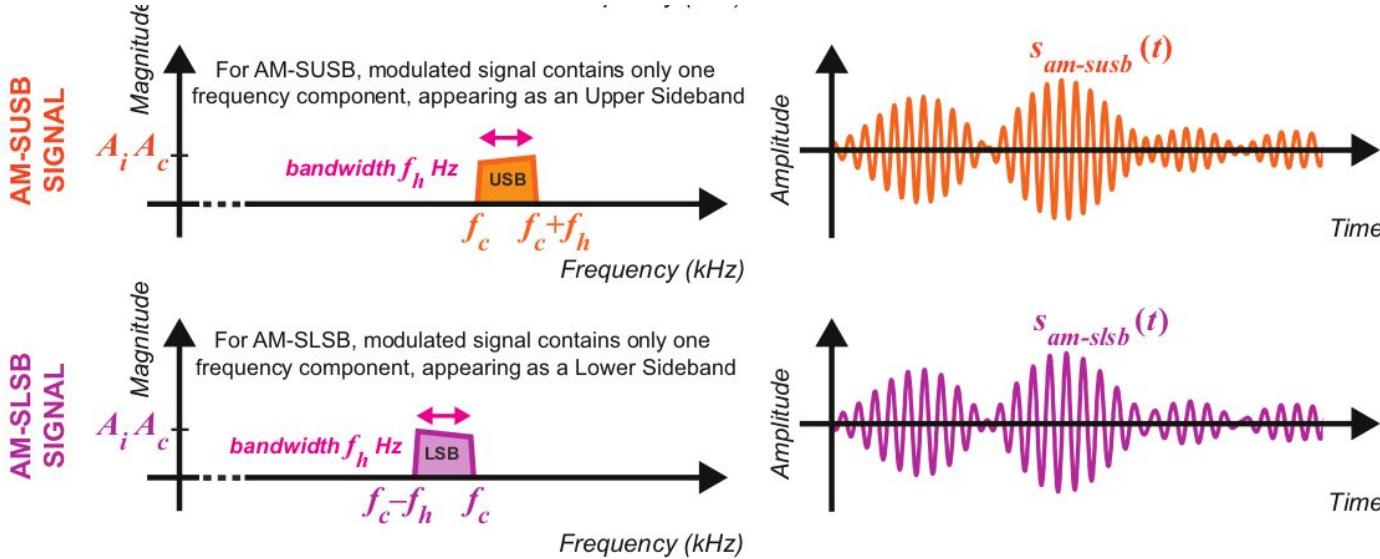
AM Demodulation

- Tune to center frequency of 441MHz
- Locate the AM modulated signal
- Demodulate the signal using both
  - General-purpose SDR App and
  - GNU Radio

AM-SSB: Single Sideband AM

AM-SSB: Single Sideband AM

For AM-SUSB, modulated signal contains only one frequency component, appearing as an Upper Sideband

bandwidth f_h Hz

$A_i A_c$

f_c $f_c + f_h$

USB

AM-SUSB SIGNAL

Magnitude

Frequency (kHz)

$s_{am\text{-}susb}(t)$

Amplitude

Time

For AM-SLSB, modulated signal contains only one frequency component, appearing as a Lower Sideband

bandwidth f_h Hz

$A_i A_c$

$f_c - f_h$ f_c

LSB

AM-SLSB SIGNAL

Magnitude

Frequency (kHz)

$s_{am\text{-}slsb}(t)$

Amplitude

Time

- Most frequent use in amateur radio on shortwave

SSB Demodulation
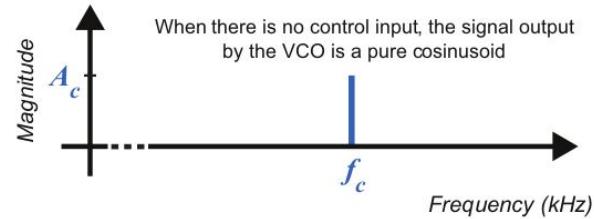
- Tune to center frequency of 441MHz
- Locate the SSB modulated signals
- Demodulate the signal using both
  - General-purpose SDR App and
 - GNU Radio

Frequency Modulation (FM)
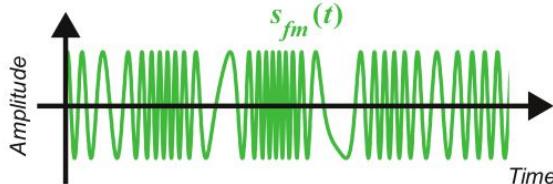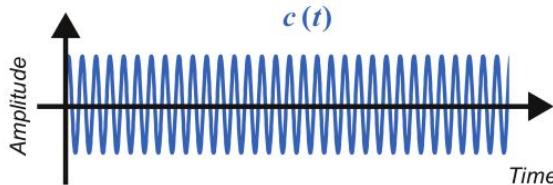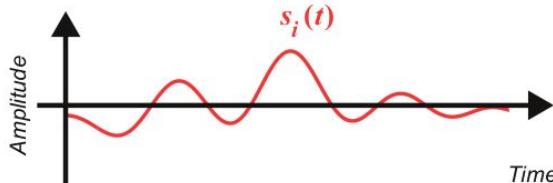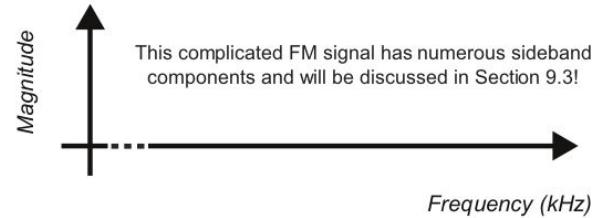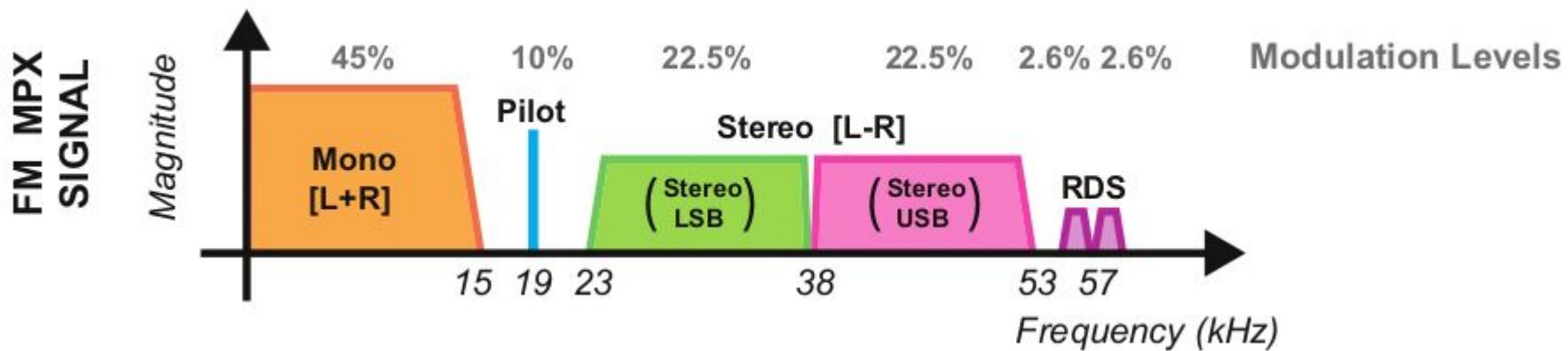
NBFM
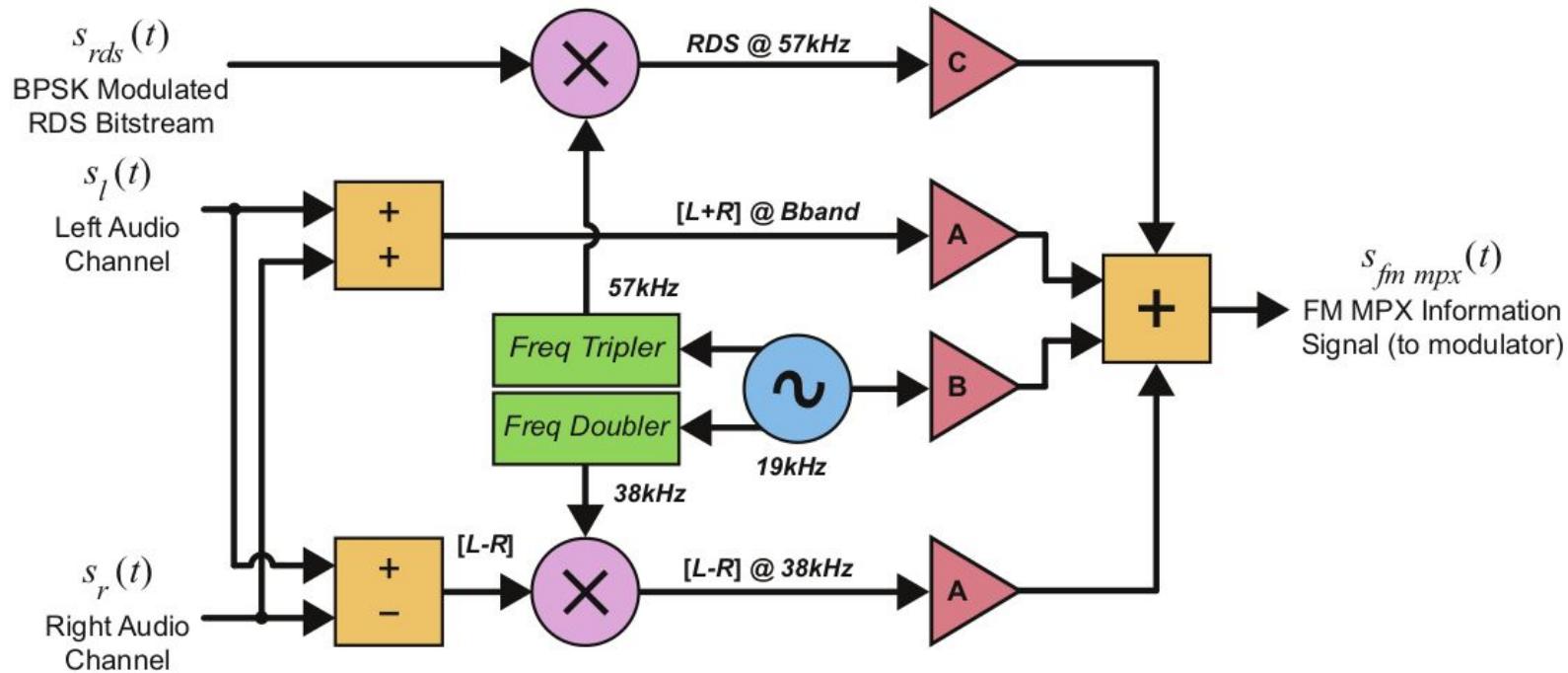
- Demodulate the signal emitted from walkie-talkie

FM Radio Multiplex
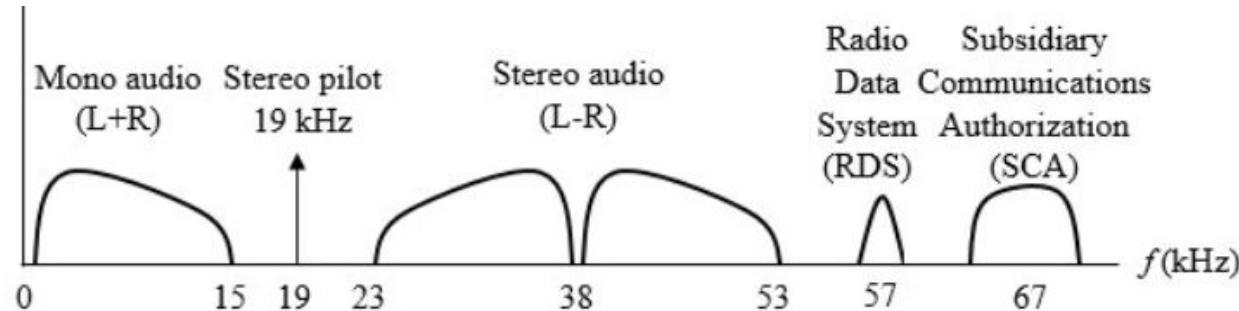
- It is common practice to multiplex multiple information signals together before performing modulation, as this allows for multi-channel transmission using one carrier.
- Stations in the FM band typically broadcast a composite baseband signal

Broadcast FM (WBFM)

Composite baseband

1. **L+R:** monophonic audio channel
2. **Pilot tone**: indicates the presence of stereo broadcasts, as well as to provide a coherent reference that can be frequency doubled to 38 kHz to demodulate them.
3. **L-R:** double sideband suppressed carrier modulation difference audio channel
4. **Radio Data System (RDS)**
5. **Subsidiary Communications Authority (SCA):** subcarriers may be located at 67 kHz and 92 kHz

WBFM Bandwidth
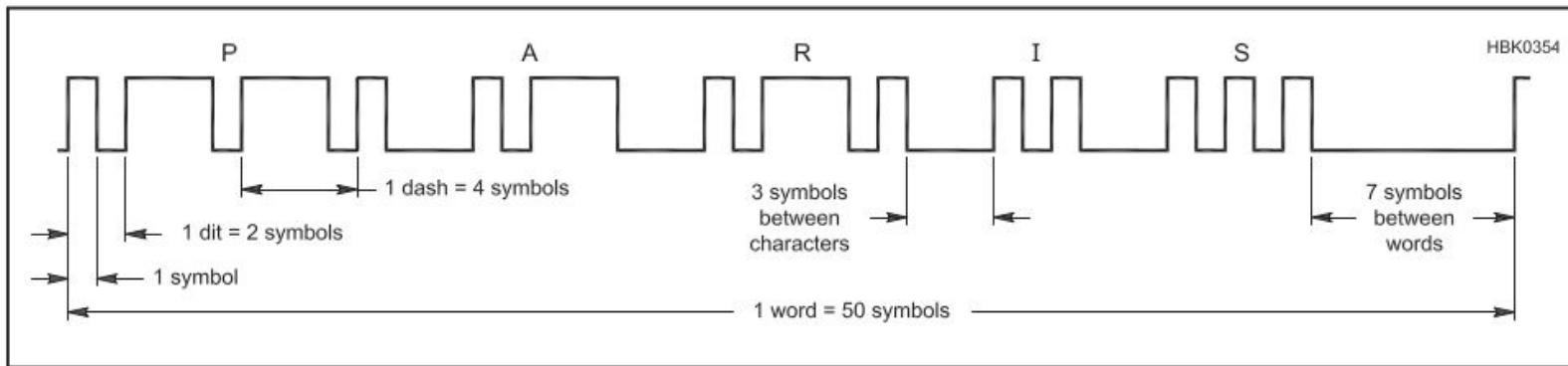
- Carson's rule
  - 2 (Δf + f i) Hz
    - Δf = the peak deviation, and
    - f i = the highest modulating frequency
- Let's calculate together a station's BW
  - The frequency deviation of the FM carrier is limited to a maximum of ±75 kHz in order to maintain a 25 kHz guard band between adjacent channels
  - The fixed frequency deviation of Δf = 75kHz
  - WFM station has a bandwidth of fi = 53kHz.
  - So the theoretical bandwidth of the station according to Carson's Rule is 256kHz
- The 56kHz band of modulated information past 200kHz is filtered and not transmitted
- But as it only contains a fraction of the total modulated energy, the information signal can still be recovered by receivers with little distortion.

Capture The Signal (CTS)

- Your instructor is transmitting in one of the ISM bands, your job is to find out the message hidden in the signal?

Continuous Wave (CW)

Characters in Morse code do not all have the same length. Longer codes are used for characters that are used less frequently while the shortest codes are reserved for the most common characters. For example, the most common letter in the English language, E, is sent as a single dit. In that way, the average character length is reduced, resulting in a faster sending speed for a given baud rate. Such a variable-length code is known as *varicode.*

CW Demodulation

- Tune to center frequency of 441MHz
- Find the CW modulated signal
  - *Hint: Use the table to decode the signal*

Capture The Signal (CTS)

- Your instructor is transmitting in one of the ISM bands, your job is to find out the message hidden in the signal?

Capture The Signal (CTS)

- Now, time to get altogether!