

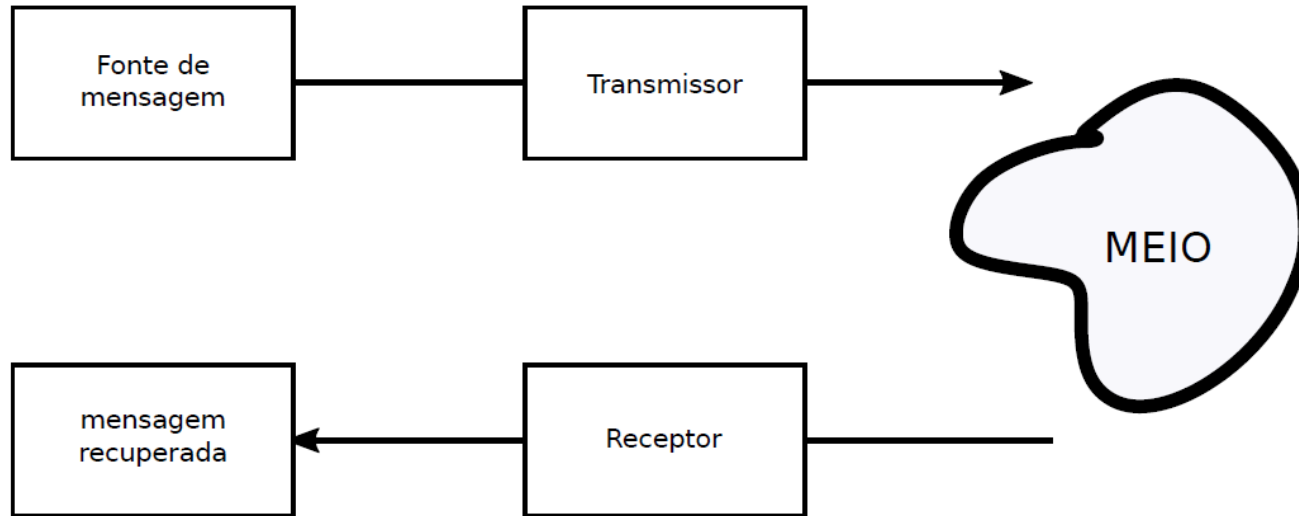
Camada Física da Computação

Aula 14 – Modulação AM

2018 – Engenharia da computação

Rodrigo Carareto

Várias fontes, vários receptores, bandas passantes...



O problema a ser enfrentado: vários emissores, vários receptores

Bandas americanas

UNITED STATES FREQUENCY ALLOCATIONS THE RADIO SPECTRUM

RADIO SERVICES COLOR LEGEND

AERIAL BROADCAST	AIR TO AIR	AIR TO AIR (NON-RESEARCH)
AERIAL BROADCAST (SATELLITE)	AIRBORNE	AIRBORNE (SATELLITE)
AERIAL BROADCAST (NON-RESEARCH)	AIRBORNE (SATELLITE)	AIRBORNE (SATELLITE)
AIRBORNE	AIRBORNE (SATELLITE)	AIRBORNE (SATELLITE)
AIRBORNE (SATELLITE)	AIRBORNE (SATELLITE)	AIRBORNE (SATELLITE)
BROADCASTING	BROADCASTING (SATELLITE)	BROADCASTING (SATELLITE)
BROADCASTING (SATELLITE)	BROADCASTING (SATELLITE)	BROADCASTING (SATELLITE)
DATA COLLECTION (SATELLITE)	DATA COLLECTION (SATELLITE)	DATA COLLECTION (SATELLITE)
FIXED	MOBILE	STANDARD FREQUENCY AND TIME SIGNAL
FIXED (SATELLITE)	MOBILE (SATELLITE)	STANDARD FREQUENCY AND TIME SIGNAL (SATELLITE)

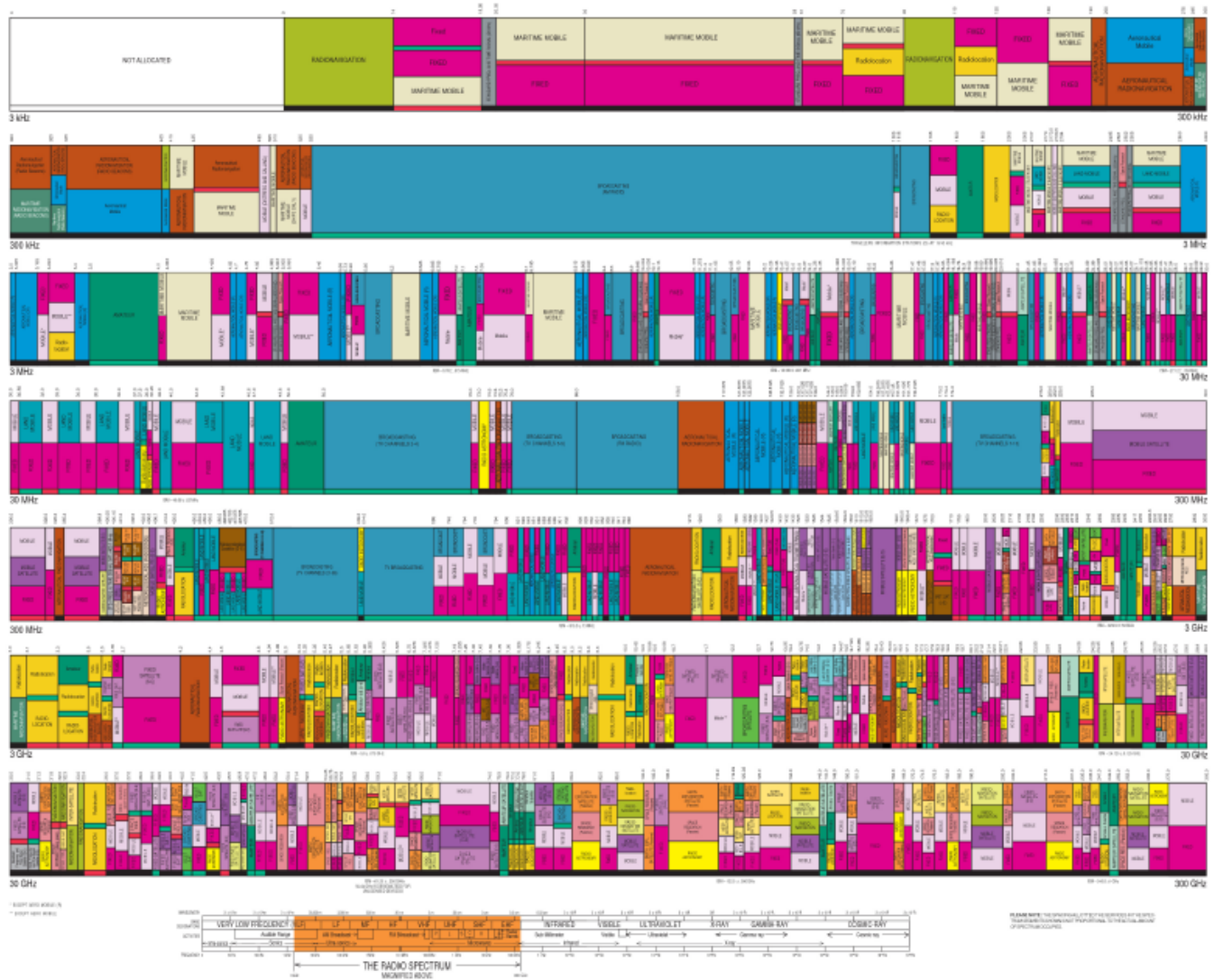
ACTIVITY CODE

GOVERNMENT EXCLUSIVE	GOVERNMENT GOVERNMENT SHARED
NON-GOVERNMENT EXCLUSIVE	

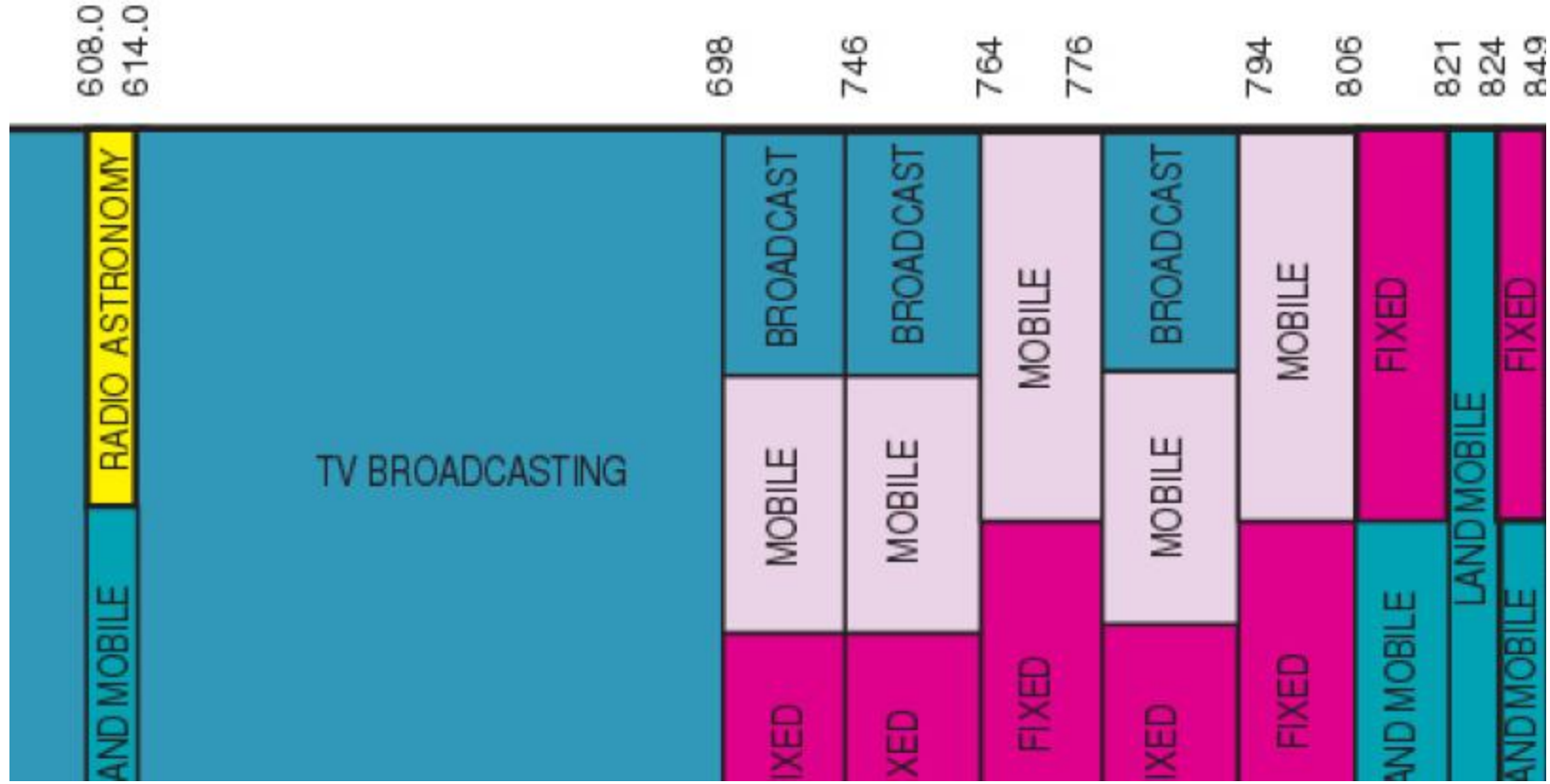
ALLOCATION USAGE DESIGNATION

SERVICE	EXAMPLE	DESCRIPTION
Primary	F1D2	Fixed Land Mobile
Secondary	M2B	Maritime Mobile (VHF)

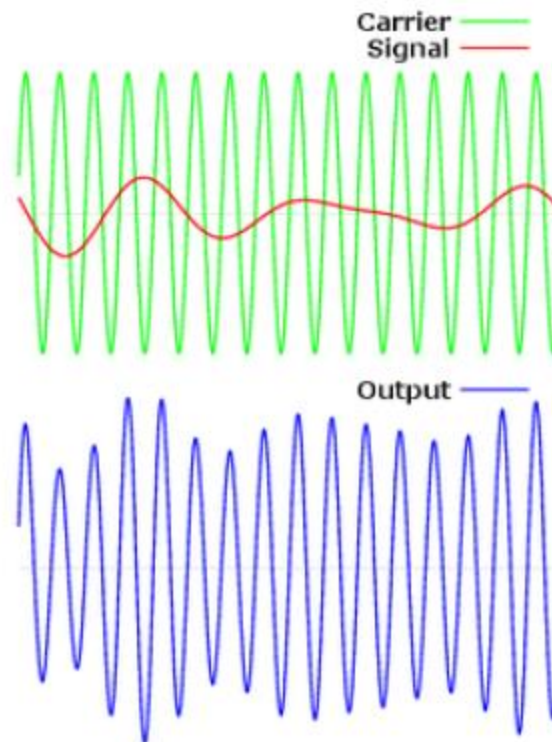
THIS TABLE IS A SUMMARY of the frequency allocations in the United States. It is not intended to be a substitute for the actual regulations. For more information, see the Federal Communications Commission's website at <http://www.fcc.gov>.



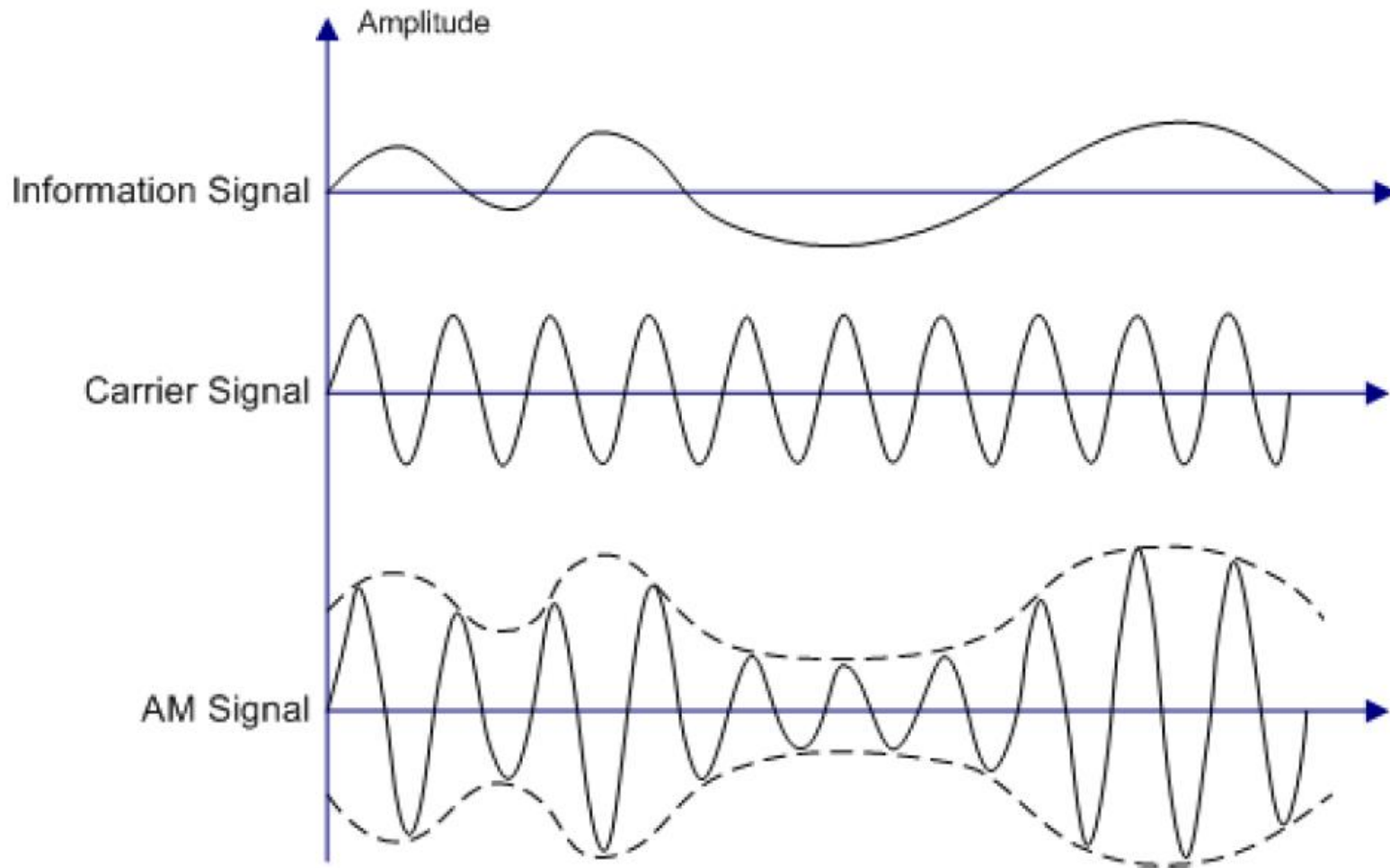
Bandas americanas



Como colocar informação em uma frequência única de recepção?



Modulação AM

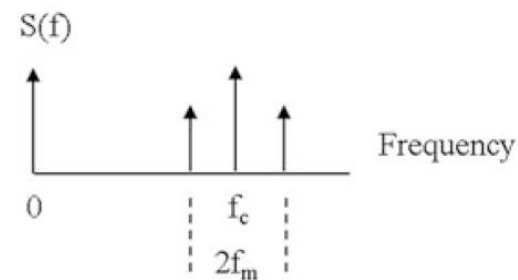
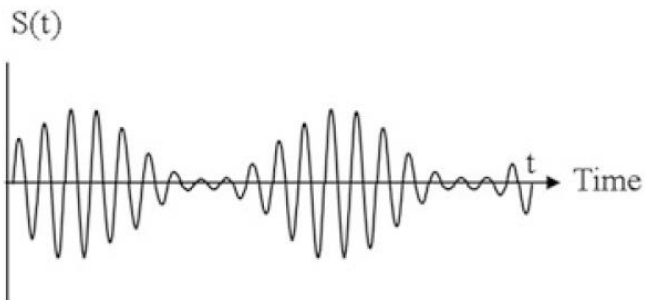
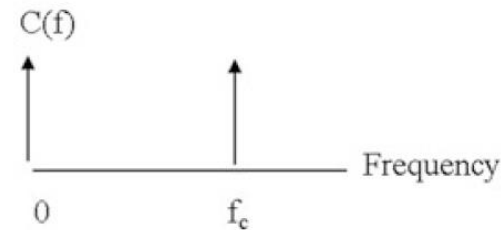
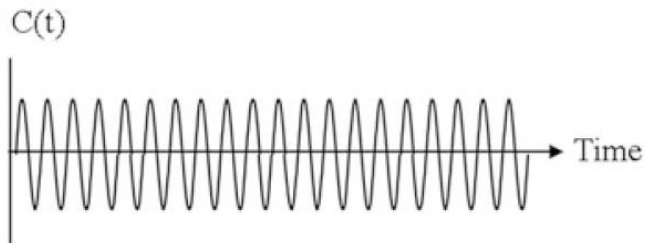
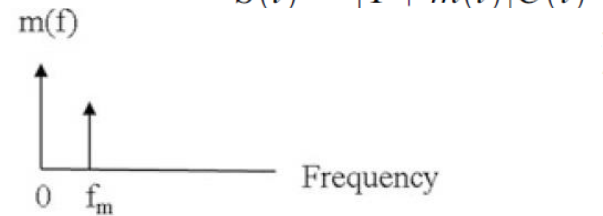
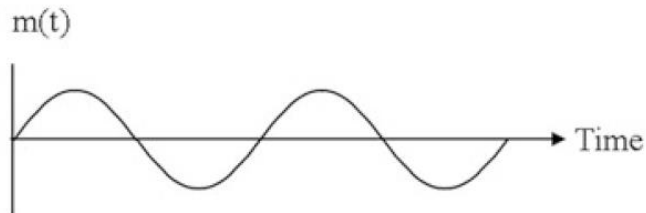


Modulação AM

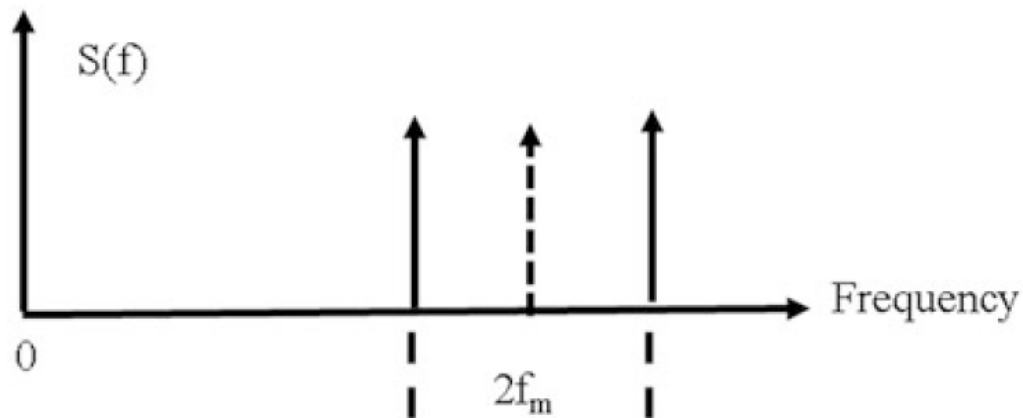
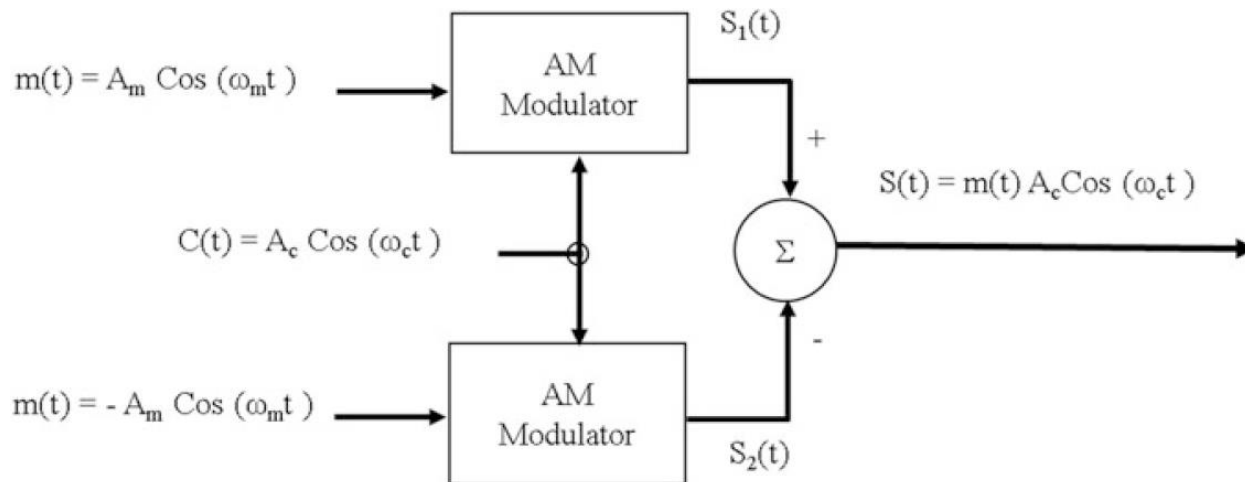
- $m(t) = A_m \cos(2\pi f_m t)$
- $C(t) = A_c \cos(2\pi f_c t) f_c \gg f_m$
- $S(t) = [1 + m(t)]C(t)$
 $= C(t) + m(t)C(t)$

Modulação AM DSB-FC (*double-sideband full carrier*)

- $m(t) = A_m \cos(2\pi f_m t)$
 - $C(t) = A_c \cos(2\pi f_c t) f_c \gg f_m$
- $$S(t) = [1 + m(t)]C(t)$$



Modulação AM DSBSC *double-sideband suppressed carrier*



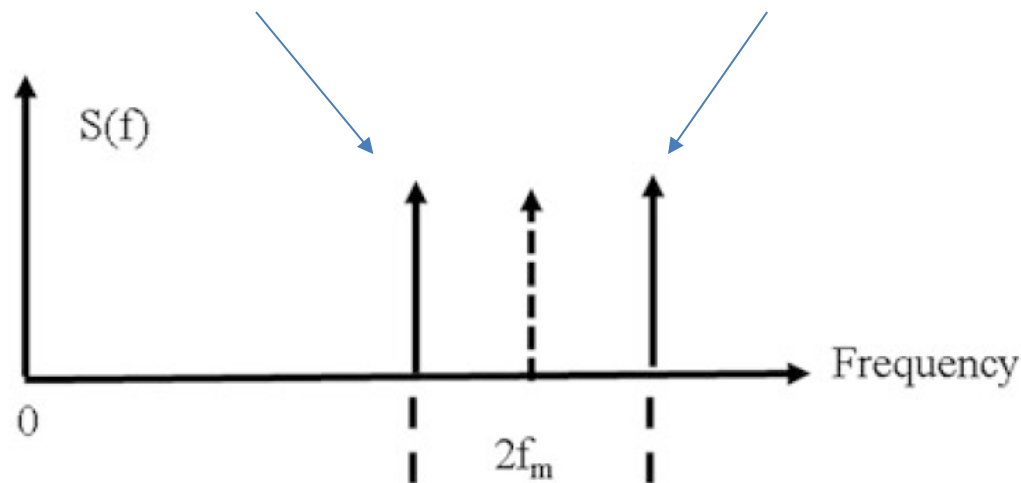
Modulação AM DSBSC

$$S(t) = M \cos(2\pi f_m) \cdot C \cos(2\pi f_c)$$

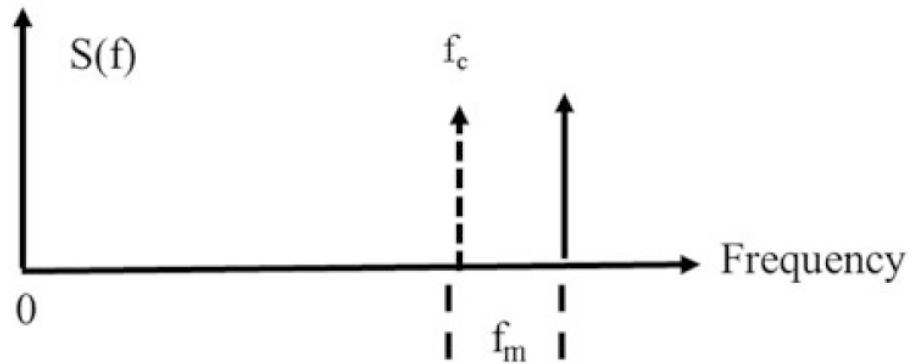
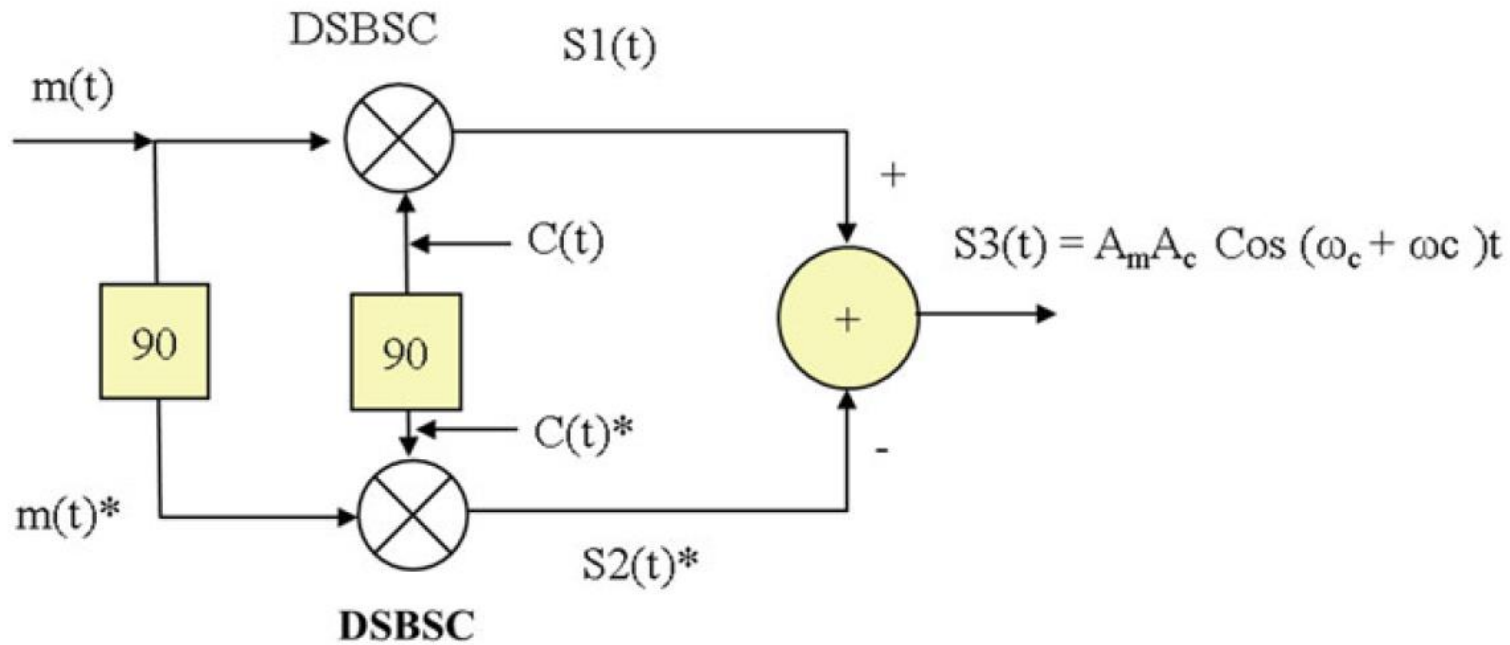
$$S(t) = M \sin(2\pi f_m + \phi) \cdot C \sin(2\pi f_c + \phi)$$

$$\sin(a)\cos(b) = \frac{1}{2} (\sin(a + b) + \sin(a - b))$$

$$S(t) = \frac{MC}{2} \sin(2\pi(f_c - f_m)t - \phi) + \frac{MC}{2} \sin(2\pi(f_c + f_m)t + \phi)$$

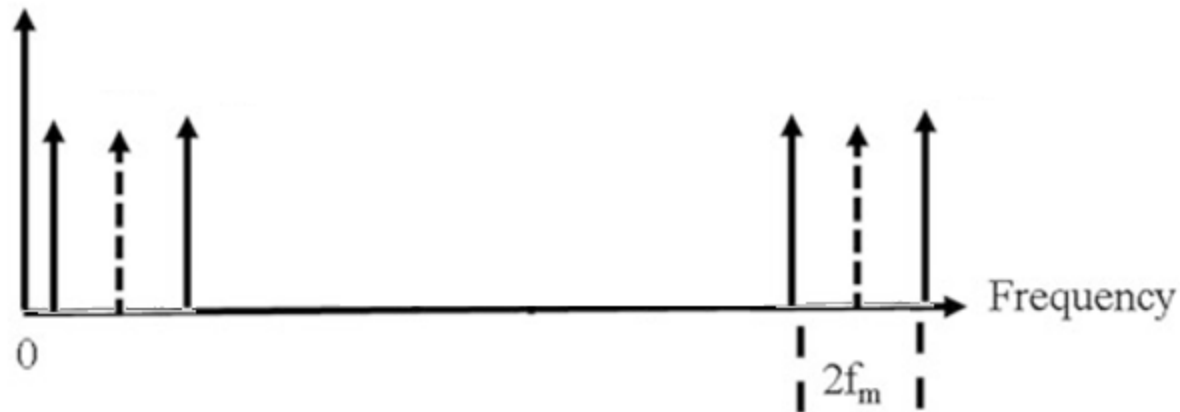


Modulação AM SSB (*single-sideband*)



Demodulação

$$S'(t) = \frac{1}{4} [\cos(2\pi f_m t) - \cos(2\pi(2f_c + f_m)t)] + \frac{1}{4} [\cos(-2\pi f_m t) - \cos(2\pi(-2f_c + f_m)t)]$$



Objetivos:

Construir um software que:

Faça a leitura de um arquivo de áudio previamente gravado com uma taxa de amostragem de 44100Hz.

Codifique esse sinal de áudio em AM.

Construa o gráfico do sinal modulado (nos domínios do tempo da frequência).

Execute o áudio do sinal modulado.

Demodule o sinal.

Execute o áudio do sinal demodulado.

Mostre o gráfico do sinal demodulado (no tempo e da frequência).

Importando o sinal

1. Importar um arquivo .wav: Você poderá usar a biblioteca `soundfile`, que contém uma função `.read(...)`
2. Após importar o arquivo, você deverá extrair o vetor com as amplitudes e então normaliza-lo (valores entre 0 e 1)
3. Para melhores resultados, você poderá tratar o sinal lido aplicando um filtro passa baixa (mostrado abaixo) utilizando-se a a classe `signal` (*from `scipy import signal`*)
4. A execução do áudio pode ser feito com a função `play` da biblioteca `sounddevice`
5. *Filtro passa baixa:*

```
# https://scipy.github.io/old-wiki/pages/Cookbook/FIRFilter.html
nyq_rate = samplerate/2
width = 5.0/nyq_rate
ripple_db = 60.0 #dB
N, beta = signal.kaiserord(ripple_db, width)
cutoff_hz = 4000.0
taps = signal.firwin(N, cutoff_hz/nyq_rate, window=('kaiser', beta))

yFiltrado = signal.lfilter(taps, 1.0, yAudioNormalizado)
```

Modulando e demodulando

1. A modulação do sinal poderá ser feita com a multiplicação entre a portadora de amplitude 1 e o sinal importado e normalizado.
2. A demodulação deverá ser feita com um filtro passa-baixa na frequência de corte do sinal importado. O módulo do sinal poderá ser obtido com a multiplicação do sinal de áudio e a portadora.

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