Lecture 14: FDM, AM Radio, and the Superheterodyne Receiver

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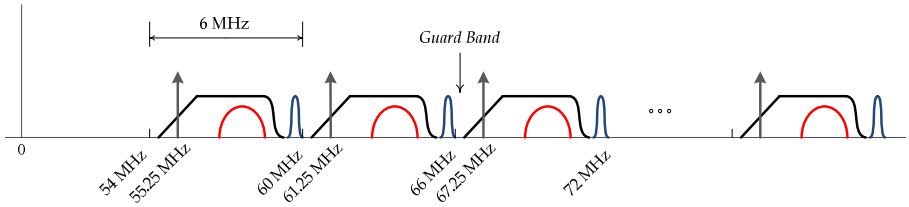
EE421: Communications I: Lecture 14. For more information read Chapter 4 in your textbook or visit http://wikipedia.org/.

Multiplexing: FDM

- Frequency Division Multiplexing (**FDM**) is a process that allows the transmission of several signals over the same channel at the same time.
- This is achieved by modulating the different signals on different carriers with different **carrier frequencies**.
- The receiver isolates one signal from the rest using a **tuneable BPF**.

TV Broadcasting (FDM)



- For an FDM system, you need to know:
  - *Broadcast frequencies* for the stations (i.e., allocated spectrum).
  - *Bandwidth* of each station.
  - *Guardband* between adjacent stations.

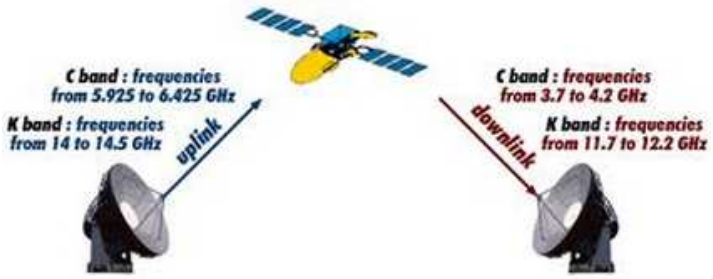
TV Broadcasting

- Terrestrial TV uses broadcast frequencies within the ranges:
- VHF (Very High Frequency): 30 MHz to 300 MHz
- UHF (Ultra High Frequency): 300 MHz and 3 GHz.

TV Broadcasting

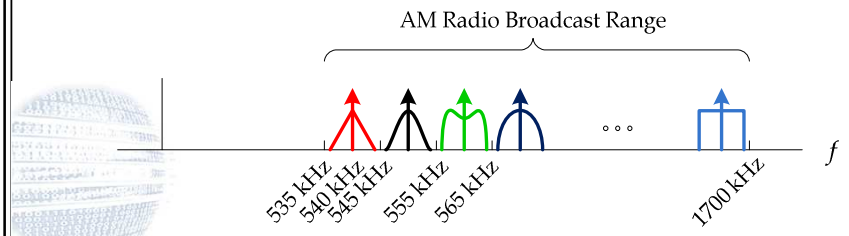
- Satellite TV uses broadcast frequencies within the ranges (Uplink/Downlink):
- C band: 6/4 GHz
- Ku band: 14/10-12 GHz
- Ka band: 27-31/18-20 GHz

Uplink/Downlink

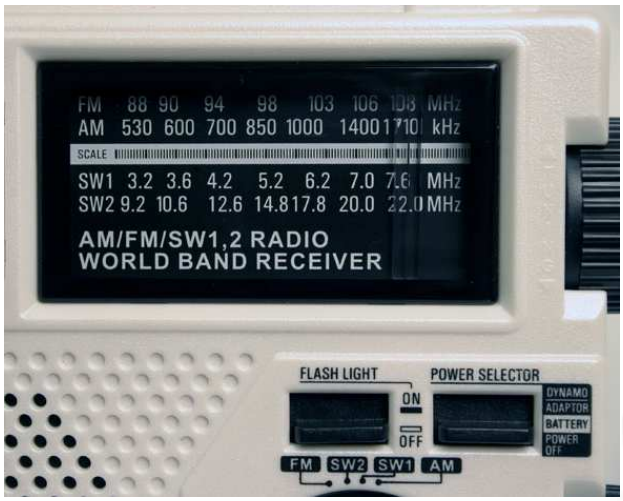


AM Radio Broadcasting

- Each station is an AM modulation of human voice.
- FDM is used to multiplex signals on the air waves.
- **US:** Each station occupies a bandwidth of ___ kHz.
- **Europe:** Each station occupies a bandwidth of ___ kHz.



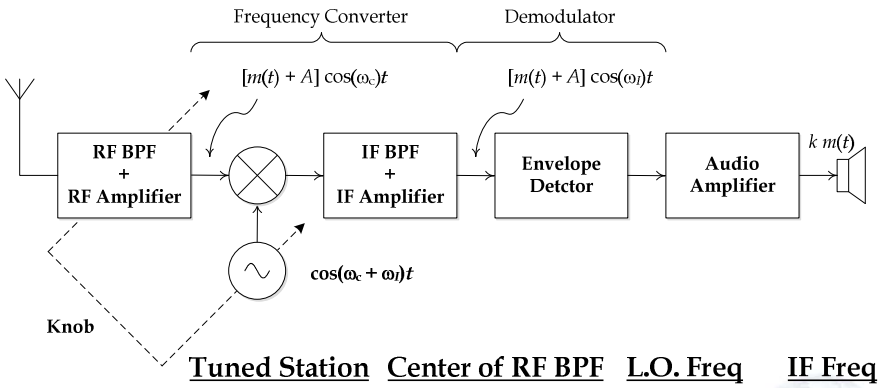
HW: Look at Your Radio Dial



The Superheterodyne Receiver

- Receivers in FDM system require a BPF.
- It is extremely difficult (*expensive*) to design highly selective (*narrowband*) filters at **high** center frequencies.
- This is specially true if the filter is **tuneable**.
- Solution: Use a two-stage filtering process, one of which at lower frequency.

AM Superheterodyne Receiver



Tuned Station	Center of RF BPF	L.O. Freq	IF Freq
1000 kHz	**1000 kHz**	**1455 kHz**	**455 kHz**
1020 kHz	1020 kHz	1475 kHz	455 kHz
1500 kHz	1500 kHz	1955 kHz	455 kHz

Ganged Capacitor

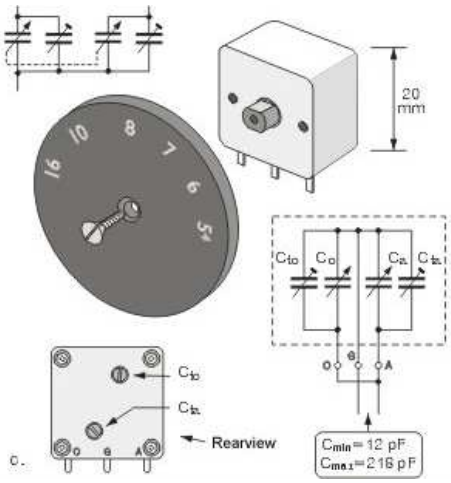


Image Station Problem

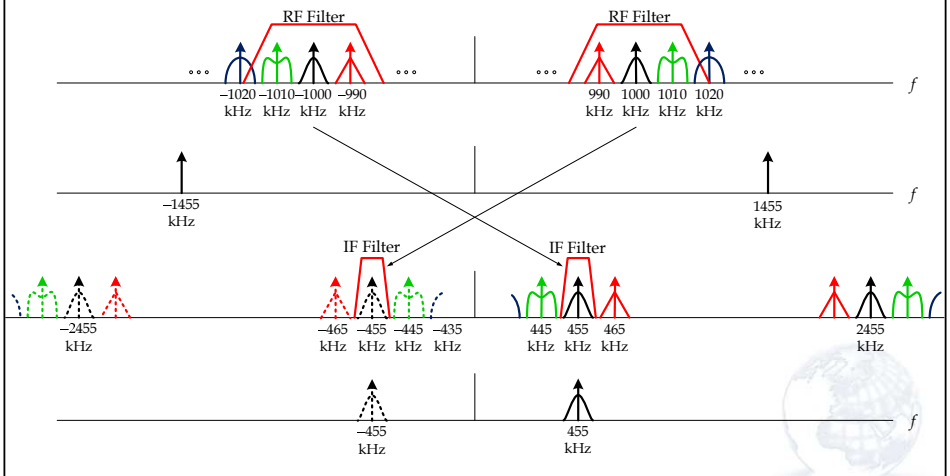
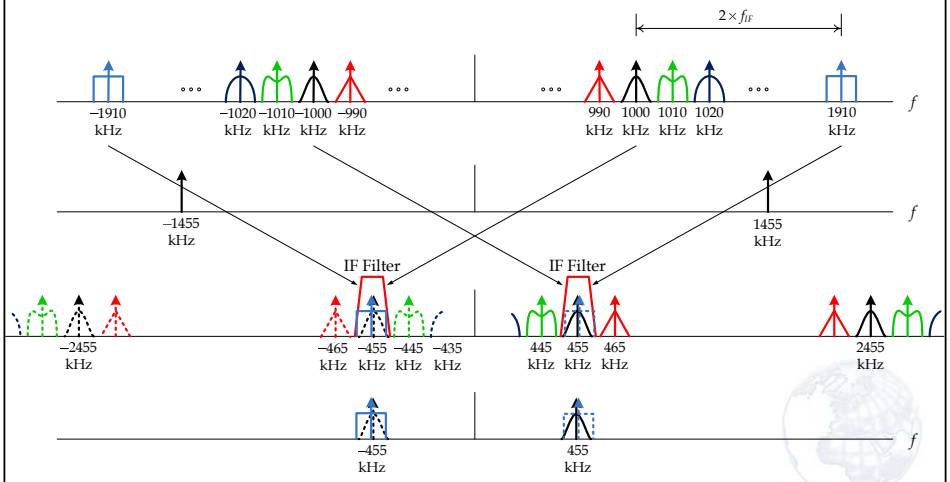


Image Station (*Part* 2)



Superheterodyne *Why*'s

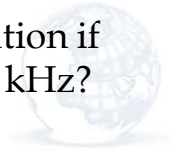
- *Why* the RF Filter?
  - Eliminates the *image station*.
  - Reduces the amount (power) of noise that enters the receiver.
- *Why* the IF Stage (heterodyning)?
  - With its high-selectivity and lower price, the IF filter isolates the desired radio station from all others sent using FDM.
  - Since the IF frequency does not change with the tuned station, it is easier to design the E.D.

Superheterodyne *Why's*

- *Why* the sum, not difference?
- The sum (as opposed to the difference) in the receiver results in a smaller tuning range ratio, which requires a smaller tuning capacitor for the local oscillator.
- Hence, this solution is cheaper.

Homework

- Now design a superheterodyne receiver, but this time using the difference for L.O.:
  - If you want to listen to the station at 1000 kHz what settings should you choose for the RF BPF, the oscillator, and the IF BPF?
  - Repeat the same problem if you want to listen to the 1020 kHz and 1500 kHz stations.
  - What is the frequency of the image station if you are listening to the station at 1000 kHz?



Superheterodyne *Everywhere!*

- The superheterodyne receiver is much more popular nowadays compared to the homodyne receiver.
- It is used in many communication systems including: FM Radio, Analog and Digital TV broadcasting, Cellular phones, WiMAX, Satellite and Microwave systems, GPS, etc.
- Some popular IF frequencies:
  - AM radio receivers: 455 kHz
  - FM radio receivers: 10.7 MHz
  - Analogue television receivers: 45.75 MHz

Homework

Solution: *Not in the Exam*

Supply		Block		Local oscillator frequency	Intermediate freq. range
Voltage	Tone	Polarization	Frequency band		
13 V	0 kHz	Vertical	10.70–11.70 GHz, low	9.75 GHz	950–1,950 MHz
18 V	0 kHz	Horizontal	10.70–11.70 GHz, low	9.75 GHz	950–1,950 MHz
13 V	22 kHz	Vertical	11.70–12.75 GHz, high	10.60 GHz	1,100–2,150 MHz
18 V	22 kHz	Horizontal	11.70–12.75 GHz, high	10.60 GHz	1,100–2,150 MHz

