Welcome to EE 133!

Analog Communications Design Laboratory

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What's fishing got to do with EE133?

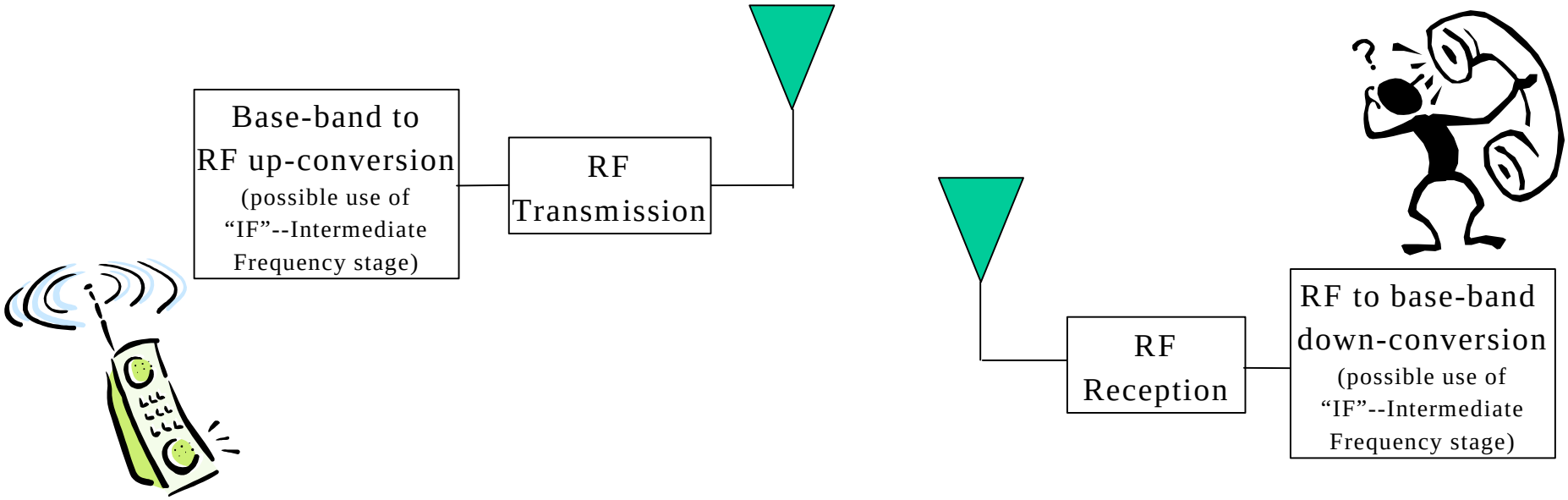
- (nothing really but…) Both are experimental and experience helps
- Lab class--lectures are driven by "need to know"
- Course Description (HO#1) tells the story about what you'll learn (but actually there's much more…:)
- So, let's get started:
  - System-Level View
  - Information and Spectrum
  - Filtering
  - Amplification

Bob's hike across back country of Yosemite--August, 2001

System-Level View

- Wireless transmission of information, including both the coding and decoding at Radio Frequencies (RF)
- Applications: a) well-known AM & FM radio ("broad casting", 500-1800KHz & 80-108MHz respectively), b) "walkie-talkie" radio (two-way, 10's MHz), c) cordless phones (700MHz), d) cell phones (1-2GHz), e) Wireless "LAN" (10GHz)…
- We'll talk in detail about a) & b); we'll also consider some of the issues at higher frequencies, including different coding/transmission technologies

Simple Block Diagram (and more…)

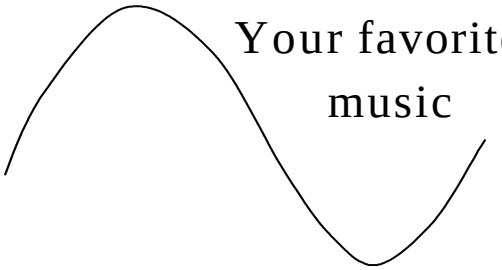


Information and Spectrum

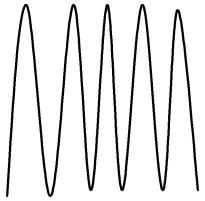
- Range of frequencies where electro-magnetic waves can propagate; limitations imposed by:
  - Nature and Enviroment (diffusion/scattering--related to wavelength: $f \bullet l = c(velocity)$)
  - Regulatory Agencies (I.e. FCC)
- Information needs to be coded onto carrier frequencies (and later decoded off them)--the information doesn't propagate very far without E&M waves
- Bandwidth (about carrier frequency) depends on coding method--can be as "narrow" as audio or could be much broader as in the cases of : "wide band" FM, data links or "spread spectrum" transmission techniques (discussed much later)

What does coded information look like?

(in frequency and time domains…)

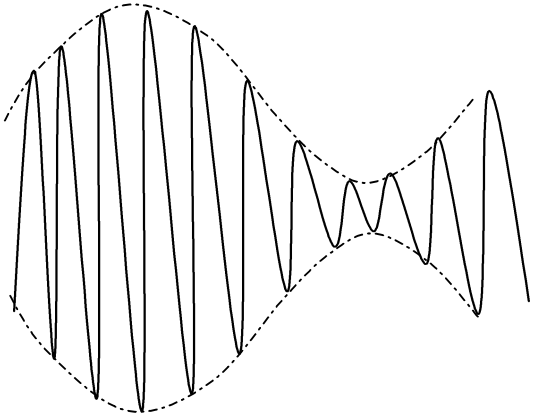


Your favorite music

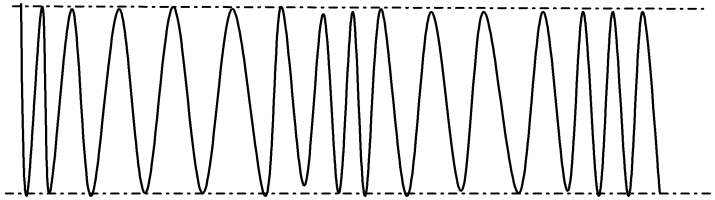


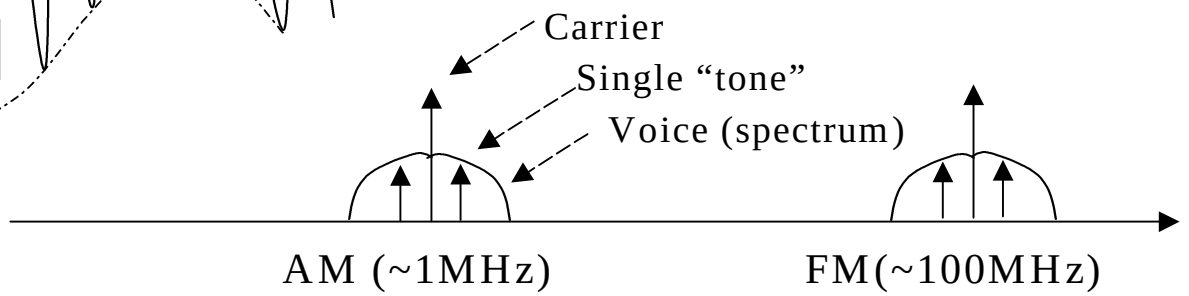
Your station's carrier frequency

The Amplitude Modulated (AM) version of your music



The Frequency Modulated (FM) version of your music



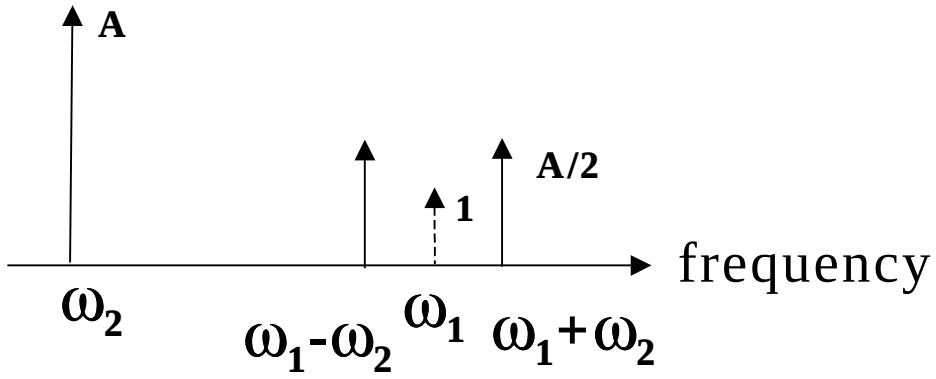


How do we code (and decode) information?

- Multiplication (a non-linear operation) of sinusoidal signals moves creates signals at different frequencies…remember Law of Sine and Cosine?
- Let's take a simple example--Amplitude Modulation: $V(t) = \left[A \cdot Cos(w_2 t)\right] \otimes Cos(w_1 t)$

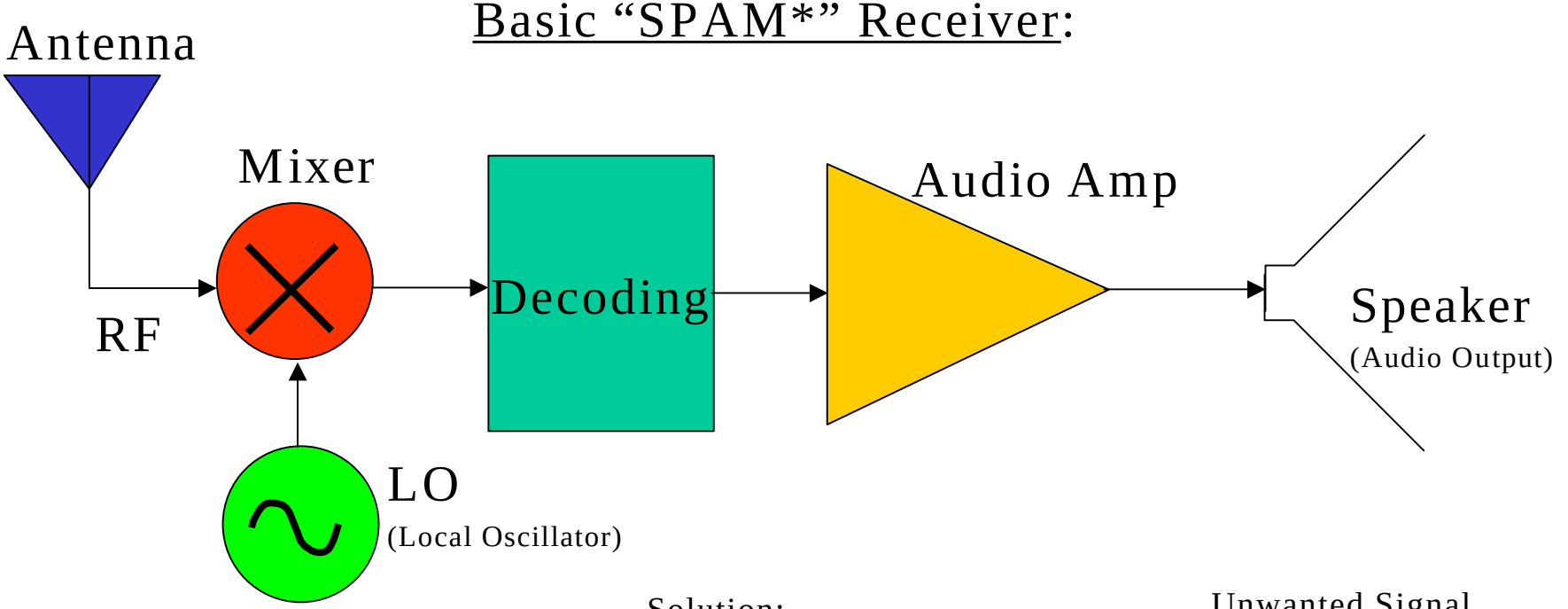
$$= \frac{A}{2}\left[Cos(\{w_1 + w_2\}t) + Cos(\{w_1 - w_2\}t)\right]$$

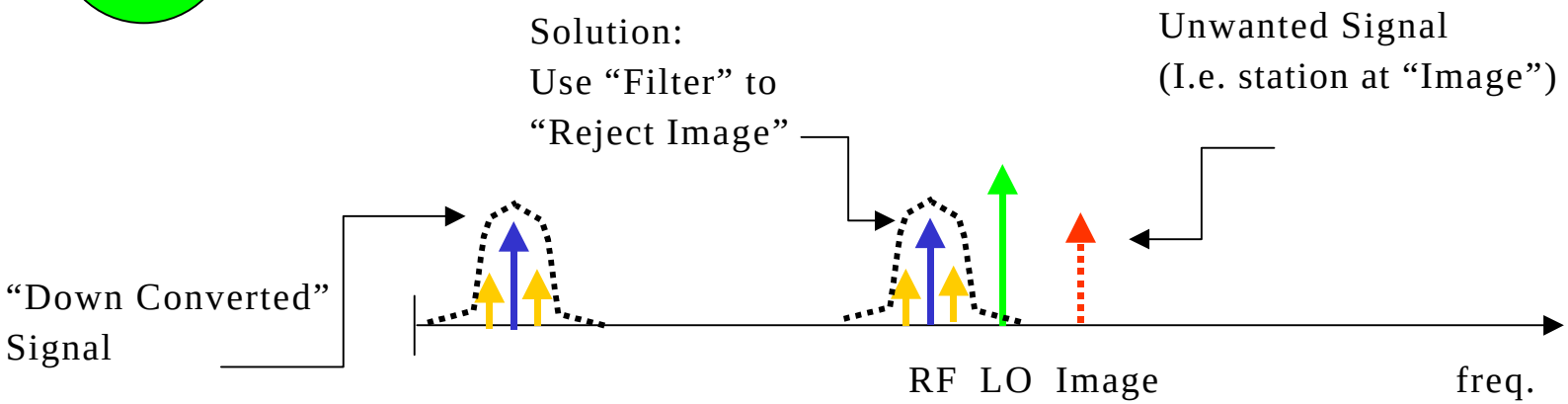
- Results in frequency domain look as follows:



Brief Preview of RF "Tran-ceivers"(**Tran**smit and Re**ceiver**)

Basic "SPAM*" Receiver:





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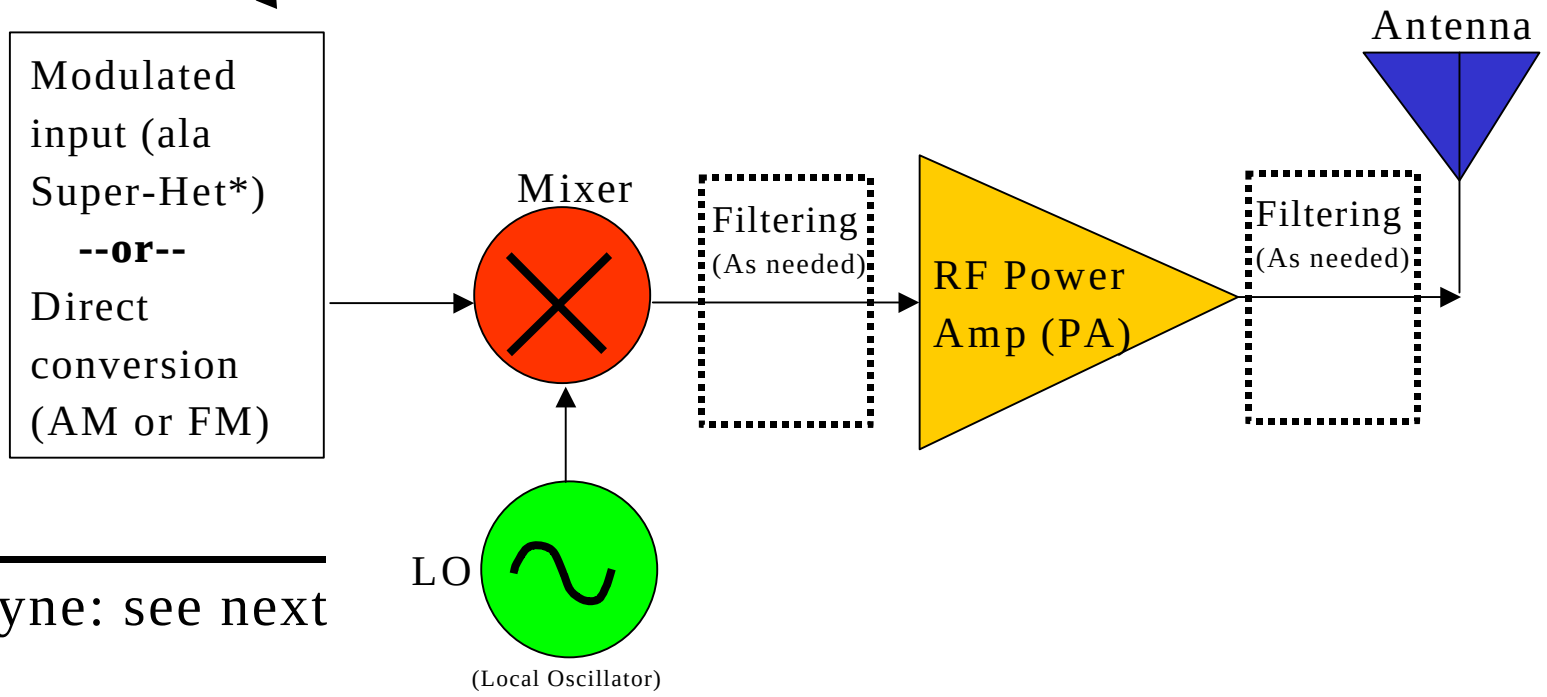
*__S__tanford __P__roject using __A__ngle __M__odulation

Transmitter Side Issues...

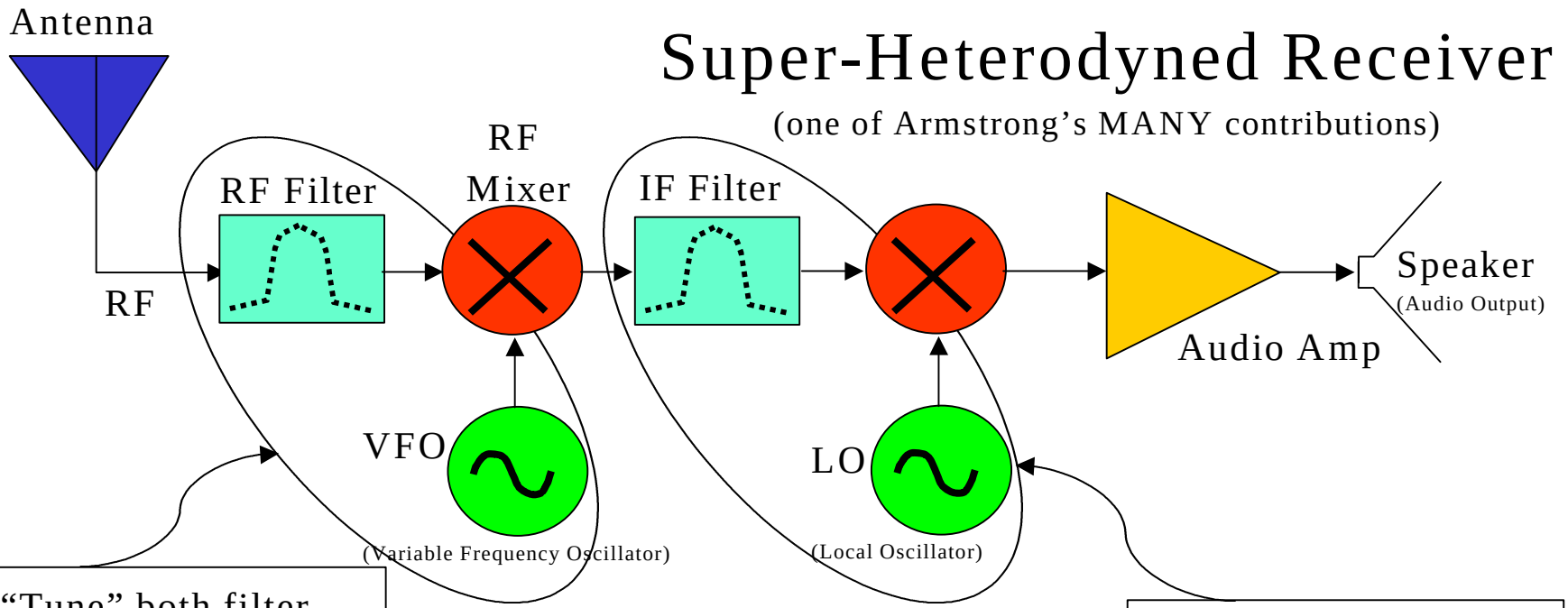
There are LOTS of choices and combinations here:
- Baseband-up-to-10's MHz can be done with DSP!
- AM is really easy (it's below 2MHz anyway)
- FM is also easy…BUT, frequency stability is not (so easy)
- Impedance matching and filtering at RF poses challenges as well...



*Heter-dyne: see next slide…

Super-Heterodyned Receiver

(one of Armstrong's MANY contributions)



"Tune" both filter and VFO at the same time…giving output of mixer ALWAYS at **I**ntermediate **F**reg.

IF at *FIXED* Freq. and therefore LO Freq. is also fixed in taking output of IF down to "basedband"

Advantages of Super-Het:

- Tuning/Image Rej. Decoupled from detection
- IF filtering can be optimized and also reused (I.e. many AM stations, converted to single IF)
- MUCH easier to work at IF vs. directly at RF (especially at high frequencies)

A Quick Look at BW…(including preview of FCC perspective)