Modulation Types
- AM/FM
- $\phi(t)$
- I/Q
- Ask, Fsk, cok

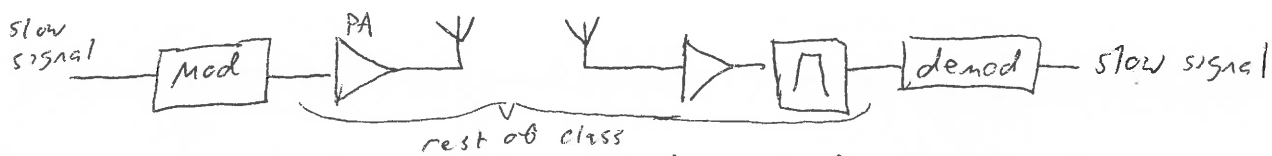
Power Detectors
- AM demodulation
- Implement

Architectures
- Direct sample
- Direct down
- Undersample
- Superhet
- IQ - SSB

Frequency Pictures

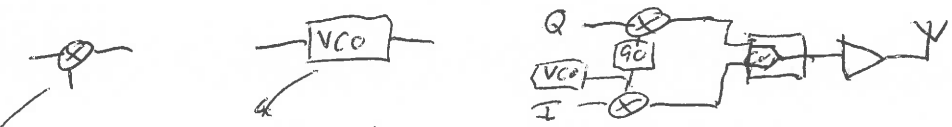
Communication systems

- Talked a lot about sinusoids moving through systems
- Not interesting in its own right ~ want to send information
- Still want to use high f sinusoids ~ radiation, fractional BW
- Need to put information onto them: a process called modulation



- high f sinusoid being modulated called carrier
- Lots of types of modulation ... alphabet soup
  - ↳ give you an idea what's out there
  - ↳ Look for some circuit implementations

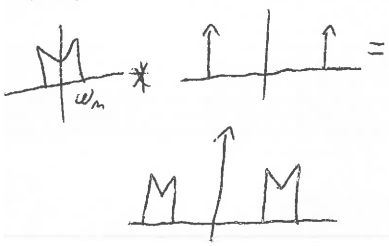
Modulation Math:



$$V(t) = \underbrace{A(t)}\cos(\omega_c t + \underbrace{\phi(t)}) = I(t)\cos\omega_c t + Q(t)\sin\omega_c t$$

- amplitude modulation
  - if digital ASK or OOK
- spectrum just by mult

A(t) · cos($\omega_c t$)

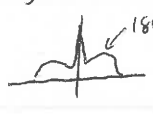


- phase modulation
  - if digital PSK/FSK
- if $\phi(t) = f(t)t$ get FM
- often write

$\Phi(t) = \omega_c t + \phi(t)$ ← total phase

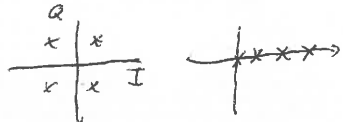
$\omega_i(t) = \frac{d\Phi(t)}{dt}$

- spectrum given by tricky sidebands (Bessel fn.)



$BW = 2\left(\frac{\Delta\omega}{\omega_m}+1\right)\omega_m$ (deviation, modulation freq.)

- synonymous representation
- Allows easy representation of amp & phase mod.
- suggests implementation ... most phones built this way
- specify w/ IQ constellation



- QPSK
- pure phase

- ASK
- pure amp

How do we get these signals back down to baseband?

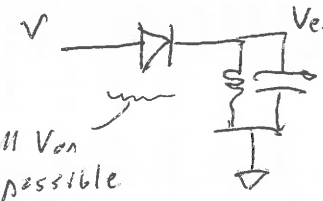
- if it's going slow we can pick off the frequency

↳ shift frequency w/ a mixer ← most common

↳ use 2nd order harmonic distortion ← requires high power, shifts only to DC... awk for FM

↳ power detect / envelope detect

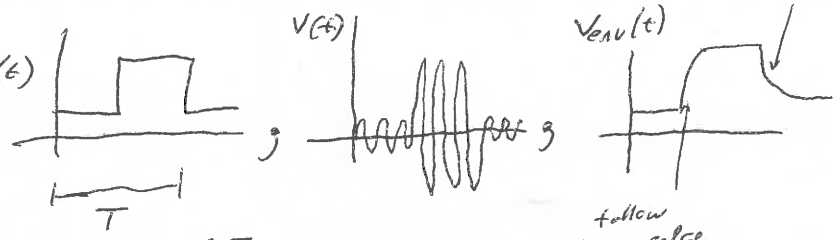
~ AM envelope only varies @ ω_m ... slowly



← set $\omega_m \ll \frac{1}{\tau} \ll \omega_c$

- small Von if possible
- sets detection floor

eg: A(t)



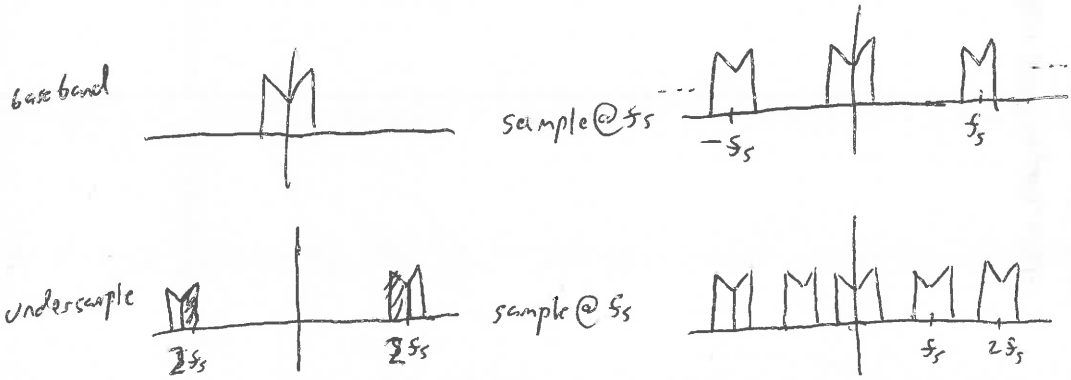
note $\omega_m = \frac{2\pi}{T}$

follow rising edge w/ low Ron of diode

~ discards all phase information necessarily

↳ undersample

- deliberately alias your signal



get a copy every f_s

- get a baseband copy as if you only measured modulated signal
- same result!
- signal must be band-limited so filter carefully

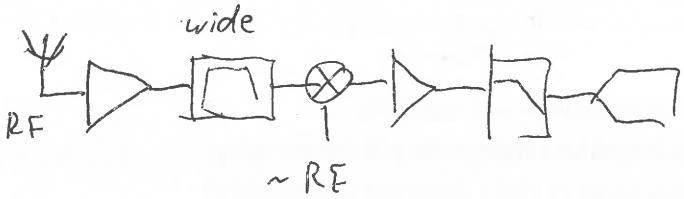
time domain

sample grabbed on next period + $\Delta\phi$

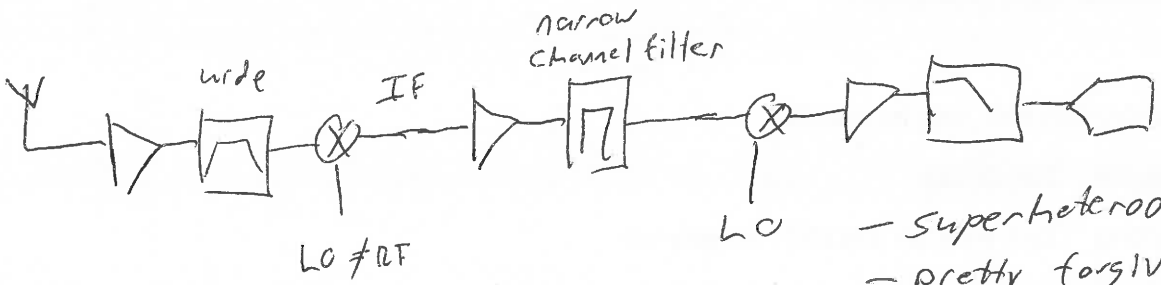
Common receivers

Direct ~~downconversion~~ sampling
- need really good ADC
- channel select in software → SDR

Undersampling
- Need very good stop band rejection on filter

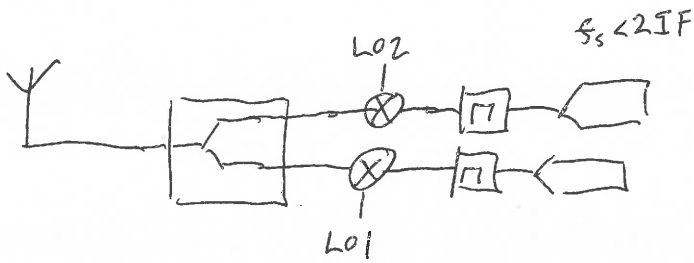


Direct downconversion
- Need very linear amplifiers
- Beware 2HD product



- superheterodyne
- pretty forgiving & very popular

- can mix & match techniques freely



- eg: mix of channel selection superhet & undersampling