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

Modulation Types
- AM/FM
- φ(t)
- I/O
- Ask/FSK/COF

Power Detectors
- AM demodulation
- Implement

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

Communication systems

- 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 implications

Modulation Math:

\[ V(t) = A(t) \cos(\omega_c t + \phi(t)) = I(t) \cos \omega_c t + Q(t) \sin \omega_c t \]

- Phase modulation
- \( \phi(t) = \frac{1}{2} \dot{\phi}(t) \) set FM
- Often write \( \Phi(t) = \omega_c t + \phi(t) \) total phase

- Spectrum given by tricky sidebands
- spectrum not by null
- \( A(t) = \cos(\omega_c t) \) for Ask
- \( M \uparrow M \)

- Synonymous representation
- Allows easy representation of any a phase mod.
- Suggests implementation
- Most phones built this way
- Specify \( IQ \) constellation

- \( \frac{\pi}{2} \) phase - pure phase - pure gap

- GPSK
- \( \frac{\sqrt{2}}{2} \) phase - pure phase - pure gap

- Bessel Fn.
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
  - An envelope only varies @ \( \omega_{m} \) ... slowly
  - Small \( V_{envelope} \) if possible
  - Sets detection floor \( \text{eg: } A(\phi) \)
  - Set \( \omega_{m} \ll \frac{1}{T} \ll \omega_{c} \)

- Discards all phase information necessarily

- **Undersample**
  - Deliberately alias your signal

**Baseband**

- Sample @ 5s
- Sample @ 2s
- Sample @ 2.5s

Get a copy every 5s

- Set a baseband copy as if you only measured modulated signal
- Some result!
- Signal must be band-limited so filtered carefully
Common receivers

Sampling
- Direct downconversion
  - Need really good ADC
  - Channel select in software → SDR

Undersampling
- Need very good stop band rejection on filter

Direct downconversion
- Need very linear amplifiers
- Remove 2nd harmonic product

Can mix & match techniques freely

Example: mix 06 channel selection
Superhet + undersampling