ECE 447 Fall 2025

Lesson 28

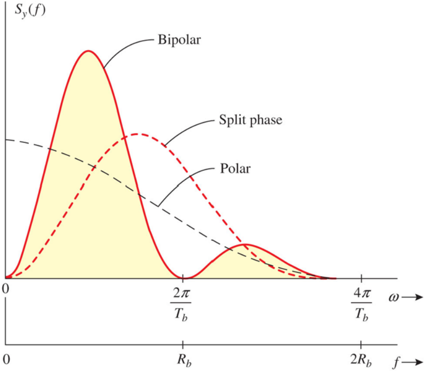
Digital Carrier Modulation and Demodulation (Bandpass Signals)

UNITED STATES AIR FORCE ACADEMY

Schedule and Admin

- Schedule.
- Admin
  - **HW4**. Graded. Submit any regrade requests via Gradescope.
  - **Lab 4**. Graded. Submit any regrade requests via Gradescope.
  - **HW5**. Grading...
  - **Lab 5**. PDF due 6 Nov to Gradescope.

Review



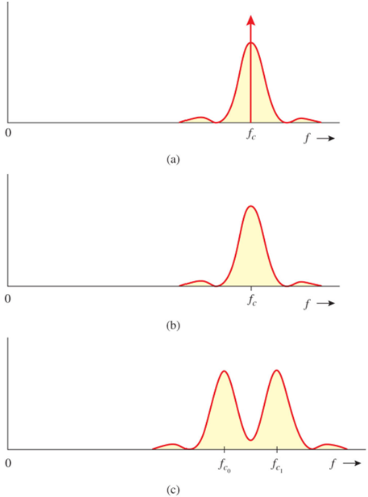
- The baseband polar signaling BW in this figure is for RZ. If changed to NRZ (full-width pulse), the bandwidth reduces to R_b. (Important for HW 6 6.8-1)

Binary Carrier Modulations

- ASK - self-explanatory
- Angle modulations: PSK and FSK
- PSK
  - If $m(t)$ uses polar signaling $\{\pm 1\}$, phase shifts for BPSK signal, $\varphi_{PSK}(t)$, is π radians apart
  - $\varphi_{PSK}(t) = m(t)\cos(\omega_c t)$
  - Constellation plot?
- FSK:
  - Sum of two alternating ASK signals with different carrier frequencies, ω_{c0} and ω_{c1}
  - $a_k = \{0, 1\}$
  - $\varphi_{FSK}(t) = \Sigma a_k p(t - kT_b)\cos(\omega_{c1} t) + \Sigma(1 - a_k)p(t - kT_b)\cos(\omega_{c0} t)$
- FT modulation property derives PSDs of digital bandpass signals:

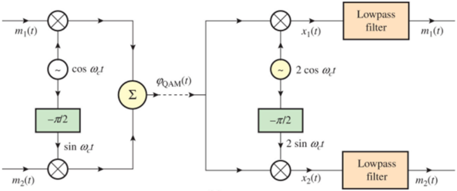
$$S_\varphi(f) = \frac{1}{4}S_M(f + f_c) + \frac{1}{4}S_M(f - f_c)$$

Binary Carrier Modulations

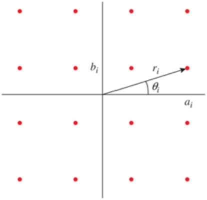


M-ARY CARRIER MODULATIONS

- Focus on QAM - most widely used in modern systems



(a)



(b)