ECE 447 Fall 2025

Lesson 36

Binary System Performance, Part 2

UNITED STATES AIR FORCE ACADEMY

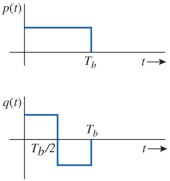
Schedule and Admin

- Schedule.
  - Lesson 36 - Binary digital system performance (Part 2)
  - Lesson 37 - Error correction
  - Lesson 38 - MATLAB Lab 7: Matched filters, multi-path, OFDM, BER (workday - no attendance for class)
  - Lesson 39 - Advanced topics: OFDM, MIMO, CDMA
  - Lesson 40 - Course review
- Admin
  - **HW8**. Assigned *today*. Due 02 Dec (Lsn 39) to Gradescope.

Review

Matched Filters and Binary Signaling Performance

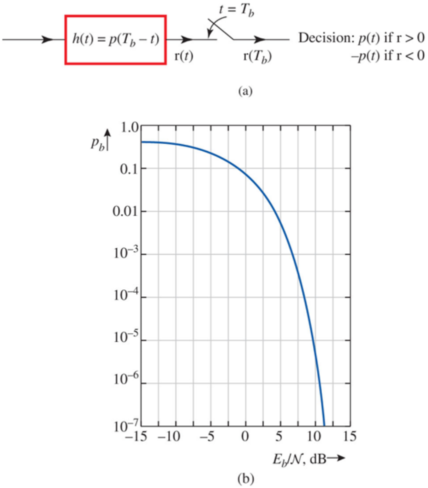
- Why?
- General binary case for real-valued pulses: $h(t) = p(T_b - t) - q(T_b - t)$
- $P_e = P_b = Q\left(\sqrt{\frac{E_p + E_q - 2E_{pq}}{2N_0}}\right)$, where $E_{pq} = \int_0^{T_b} p(t)q(t)dt$ is the inner product or correlation of the two pulses
- Example problem: Find the matched filter impulse response $h(t)$ and calculate the total bit error probability P_e assuming equiprobable transmission of 0 or 1



Binary Signaling Performance (AWGN)

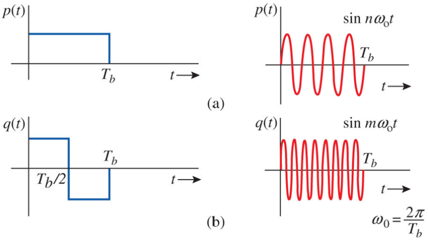
Polar signaling, $q(t) = -p(t)$

- Use general equations for P_e and a_0
- $E_p = E_q = \int_0^{T_b} |p(t)|^2 dt$
- $E_{pq} =$
- $P_e =$
- $a_0 =$
- $E_b = E_p \cdot P(m=1) + E_q \cdot P(m=0) =$
- BER depends on pulse energy not shape!



Binary Signaling Performance (AWGN)

Orthogonal signaling, $q(t)$ and $p(t)$ are orthogonal over $(0, T_b)$

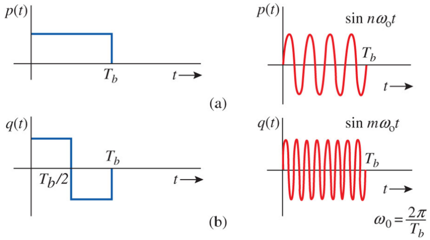


- Use general equations for P_e and a_0
- $E_q =$
- $E_{pq} =$
- $P_e =$
- $E_b = \frac{E_p + E_q}{2}$ assuming equiprobable
- $a_0 = \frac{1}{2}(E_p - E_q)$ (general form)
- Requires twice as much energy per bit (3db more power) to achieve same performance as polar signaling!

Binary Signaling Performance (AWGN)

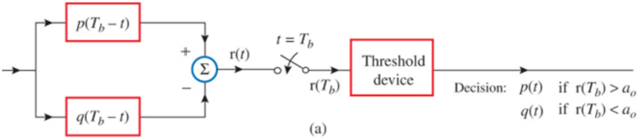
On-Off Signaling, special case of orthogonal signaling

- Use general equations for P_e and a_0
- $E_p = E_q$? Don't know, just leave E_p and E_q
- $E_{pq} =$
- $P_e =$
- $E_b = \frac{E_p + E_q}{2} =$
- $a_0 = \frac{1}{2}(E_p - E_q) =$



Receivers

Optimum binary threshold detector (baseband)



Coherent detector for bandpass signals