

EE359 – Lecture 12 Outline

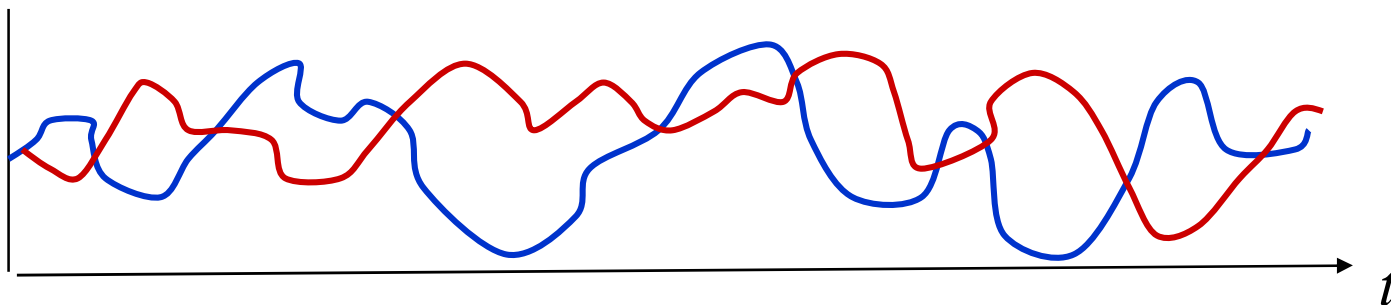
- **Announcements**
 - Midterm announcements
 - HW due **Friday at 5pm** (no late HWs)
 - No HW next week (practice MTs)
 - 2hr bonus lecture wk of 11/30 (no reg. lec. W 12/2)
- Selection Combining and its Performance
- Maximal Ratio Combining
- MGF Approach for Performance of MRC
- EGC
- Transmit Diversity

Midterm Announcements

- Midterm Wed Nov. 4, 8:45-10:45a in this rm.
 - Open book/notes (bring textbook/calculators)
 - Covers Chapters 1-7 (through today's lecture)
- Review Session Sunday 4-5:30pm, rm TBD
- Extra OHs
 - Me: Friday, Monday, Tuesday 2-3pm,
 - Yao: TBD
- Midterms from past 3 MTs posted
 - 10 bonus points for "taking" a practice exam
 - Solns for all exams given when you turn in practice exam

Review of Last Lecture

- Combined average and outage P_s
- P_s due to Doppler and ISI
- Introduction to Diversity
 - Send same bits over independent fading paths
 - Independent fading paths obtained by time, space, frequency, or polarization diversity
 - Combine paths to mitigate fading effects



Combining Techniques

- Selection Combining
 - Fading path with highest gain used
- Maximal Ratio Combining
 - All paths cophased and summed with optimal weighting to maximize combiner output SNR
- Equal Gain Combining
 - All paths cophased and summed with equal weighting
- Array/Diversity gain
 - Array gain is from noise averaging (AWGN and fading)
 - Diversity gain is change in BER slope (fading)

Selection Combining

- Selects the path with the highest gain
- Combiner SNR is the maximum of the branch SNRs.
- CDF easy to obtain, pdf found by differentiating.
- Diminishing returns with number of antennas.
- Can get up to about 20 dB of gain.

MRC and its Performance

- With MRC, $\gamma_{\Sigma} = \sum \gamma_i$ for branch SNRs γ_i
 - Optimal technique to maximize output SNR
 - Yields 20-40 dB performance gains
 - Distribution of γ_{Σ} hard to obtain

- Standard average BER calculation

$$\bar{P}_b = \int P_b(\gamma_{\Sigma}) p(\gamma_{\Sigma}) d\gamma_{\Sigma} = \int \int \dots \int P_b(\gamma_{\Sigma}) p(\gamma_1) * p(\gamma_2) * \dots * p(\gamma_M) d\gamma_1 d\gamma_2 \dots d\gamma_M$$

- Hard to obtain in closed form
- Integral often diverges

- MGF Approach

$$\bar{P}_b = \frac{1}{\pi} \int_0^{.5\pi} \prod_{i=1}^M M_i \left[\frac{-g}{\sin^2 \varphi}; \gamma_i \right] d\varphi$$

EGC and Transmit Diversity

- EGC simpler than MRC
 - Harder to analyze
 - Performance about 1 dB worse than MRC
- Transmit diversity
 - With channel knowledge, similar to receiver diversity, same array/diversity gain
 - Without channel knowledge, can obtain diversity gain through Alamouti scheme: works over 2 consecutive symbols

Main Points

- Diversity typically entails some penalty in terms of rate, bandwidth, complexity, or size.
- Techniques trade complexity for performance.
 - MRC yields 20-40 dB gain, SC around 20 dB.
- Analysis of MRC simplified using MGF approach
- EGC easier to implement than MRC: hard to analyze.
 - Performance about 1 dB worse than MRC
- Transmit diversity can obtain diversity gain even without channel information at transmitter.