

MGF Analysis of MRC. Equal Gain Combining. Transmit Diversity. Adaptive Modulation.

Lecture Outline

- MGF Analysis of MRC
- Equal Gain Combining
- Transmit Diversity
- Introduction to Adaptive Modulation
- Variable-Rate Variable-Power MQAM
- Optimal Rate and Power Adaptation

1. MGF Approach to MRC Diversity Analysis.

- Distribution of γ_Σ hard to obtain when fading is not Rayleigh or not identically distributed.
- Can use alternate Q function representation to greatly simplify $\bar{P}_b$ calculation.
- Using alternate representation and switching order of integration yields

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

for BPSK, where $\mathcal{M}_i$ is the moment generating function for the distribution of the i th branch SNR γ_i . Similar formulas for more general modulations using P_s approximation.

2. Equal Gain Combining

- In EGC, each branch is co-phased and equally weighted.
- Easier to implement than MRC, but harder to analyze.
- Distribution of combiner SNR γ_Σ complicated for more than two branches. Hard to obtain P_{out} and $\bar{P}_s$.
- EGC is about 1 dB worse in performance than MRC.

3. Transmit Diversity

- When channel known at transmitter, similar to receiver diversity. Get same array and diversity gain.
- When channel unknown at transmitter, can use clever Alamouti scheme over two symbol times to obtain full diversity gain, but no array gain.

4. Introduction to Adaptive Modulation

- Basic idea is to adapt at transmitter relative to channel fade level (borrows from capacity ideas).

- Parameters to adapt (degrees of freedom) include constellation size, transmit power, instantaneous BER, symbol time, coding rate/scheme, and combinations.
- Optimization criterion for adaptation is typically maximizing average rate, minimizing average power, or minimizing average BER.
- Few degrees of freedom need be exploited for near-optimal performance.

5. Variable-Rate Variable-Power MQAM

- Constellation size and power adapted to maximize average throughput given an instantaneous BER constraint.
- BER bound inverted to get adaptive constellation size $M(\gamma)$ that meets the BER constraint for any adaptive power policy $P(\gamma)$.

6. Optimal Rate and Power Adaptation for Maximum Throughput

- Optimal power adaptation $P(\gamma)$ found by maximizing average throughput $E[\log_2(M(\gamma))]$ relative to $P(\gamma)$.
- The optimal rate adaptation is found by substituting the optimal power adaptation $P(\gamma)$ into $M(\gamma)$.
- The optimal power and rate adaptation are the same as the capacity-achieving strategies with an effective power reduction $K = -1.5/\ln(5\text{BER})$. Throughput is within 5-6 dB of channel capacity.
- Different modulations and BER bounds result in different adaptive policies.
- Trellis codes for an AWGN channel can be superimposed on top of the adaptive modulation to partially bridge the gap with capacity.

Main Points

- Performance analysis of MRC greatly simplified using MGF approach.
- Performance of EGC about 1 dB worse than MRC, with somewhat less complexity.
- Transmit diversity can obtain diversity even without channel information at the transmitter using clever Alamouti scheme.
- Adaptive modulation varies modulation parameters relative to fading.
- Optimizing adaptive MQAM leads to the same variable-rate and power policy that achieves channel capacity, with an effective power loss.
- Adaptive MQAM comes within 5-6 dB of capacity, and this gap can be bridged through coding.