

FHSS

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Another Spread Spectrum Technique

- Can be used with FSK
- Slow hopping must be used with forward error correction (FEC) codes
- Simple implementation
- Processing gain is like DS-SS

Example Implementation

Spread Spectrum Techniques 463

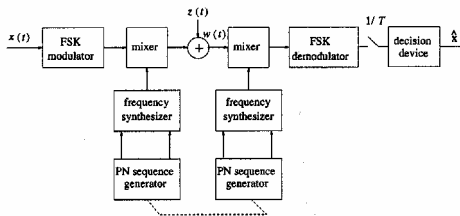


Figure 9.5. Simplified FH system operating on an AWGN channel. [Stuber, '01]

Hopping Types

- Fast – hops within a symbol
- Slow – same f_c for multiple symbols

Multi-user Interference

- When the hop frequencies of two users “collide”, that symbol is “wiped out”
 - BER is $\frac{1}{2}$ in a collision
- Error analysis just accounts for probability of collision

Slow FH-SS Noncoherent BFSK BER Analysis

- Let p_h = probability of collision or “hit”

$$P_e = \frac{1}{2} \exp\left(-\frac{E_b}{2N_o}\right) (1 - p_h) + \frac{1}{2} p_h$$

If M Hop Frequencies and K-1 Interfering Users

- Then hit probability is

$$p_h = 1 - \text{Prob that no user hits you}$$
$$= 1 - \left(1 - \frac{1}{M}\right)^{K-1}$$

Substitute

- Then BER for BFSK is

$$P_e = \frac{1}{2} \exp\left(-\frac{E_b}{2N_o}\right) \left(1 - \frac{1}{M}\right)^{K-1} + \frac{1}{2} \left(1 - \left(1 - \frac{1}{M}\right)^{K-1}\right)$$

Performance in Fading Channels

- Hopping gives frequency diversity
 - Fast hopping averages fades over a symbol period
 - Slow hopping requires FEC to recover from collisions