ROBUST 10-Mbps: MODULATION

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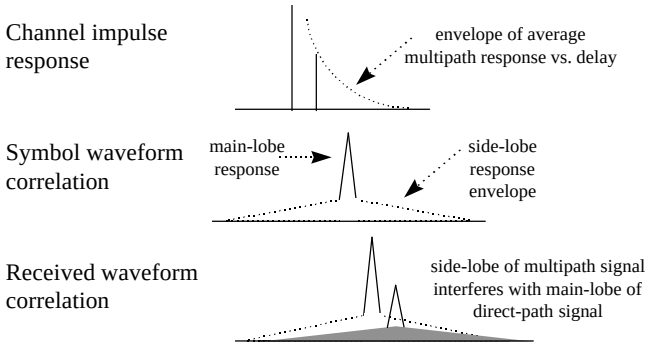
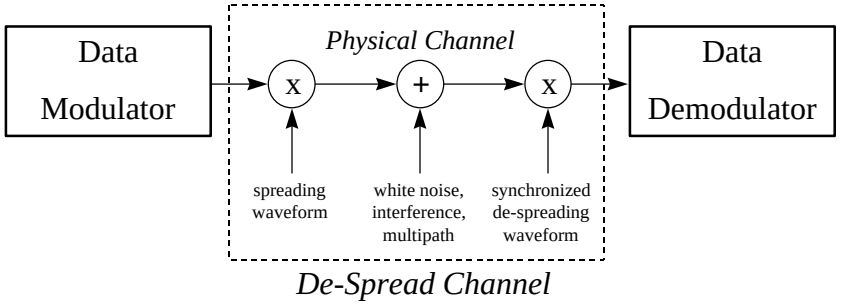
DSSS vs. Multipath Interference

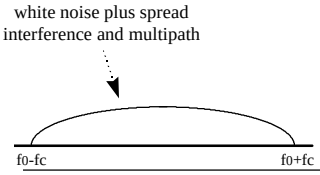


Intrasymbol Interference Mitigation Demands:
- –Increased Processing Gain to Avoid High “Irreducible Error Rate”
- –Use of More Bits/Symbol for Required Data Rate

Another Viewpoint



De-Spread Channel

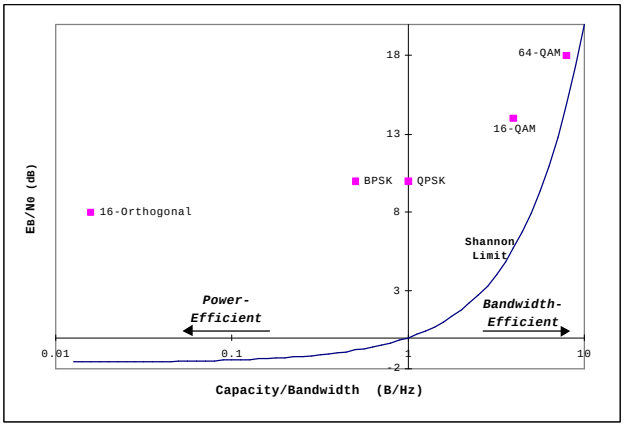


- Approximates white noise channel
- Data bandwidth can be large (if synchronous to spreading)

Data Modulation Selection

Spread-spectrum signaling allows the use of **Power-Efficient** Data Modulation

Processing Gain is chip rate divided by symbol rate; no penalty for wider data-modulation bandwidth



Jammer/Signal Ratio Comparison

DPSK	DQPSK	16-ary Orthogonal
4 chips/bit	8 chips/symbol	16 chips/symbol
PG = 6 dB	PG = 9 dB	PG = 12 dB
10 dB E_B/N_0	15 dB E_S/N_0	13 dB E_S/N_0
J/S= -4 dB	J/S= -6 dB	J/S = -1 dB

- J/S=PG-E_S/N_0 with Implementation Loss ignored
- Same chipping rate and data rate
- Numbers rounded to nearest dB

Bi-Orthogonal Modulation Adds Another Bit

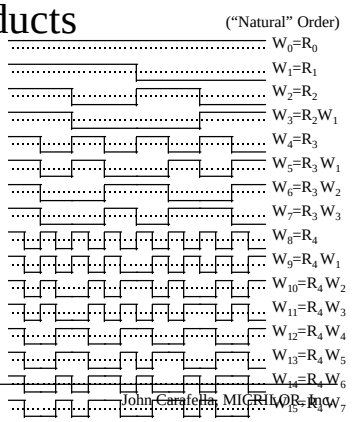
- For Coherent Signaling
  - Send One of M Waveforms: Log_2M Bits
  - Sign Conveys Additional Bit
- For Non-coherent Signaling
  - Send One of M Waveforms: Log_2M Bits
  - DPSK Between Symbols Conveys Extra Bit
- 16-ary Bi-Orthogonal Yields 5 Bit/Symbol

Orthogonal Modulations with DSSS

- Pulse-Position Modulation
  - requires time gaps to accommodate multiple time positions
  - can be confused in multipath
- Frequency-Shift Keying
  - requires extra bandwidth (convolves DSSS & M-FSK spectra)
- Cyclic Code-Shift Keying (as in JTIDS)
  - inter-symbol partial correlations unless time gaps inserted
  - can be confused in multipath
- Walsh-Function Orthogonal Signaling
  - most natural for DSSS (Walsh-function sub-elements = DSSS chips)

Walsh Functions

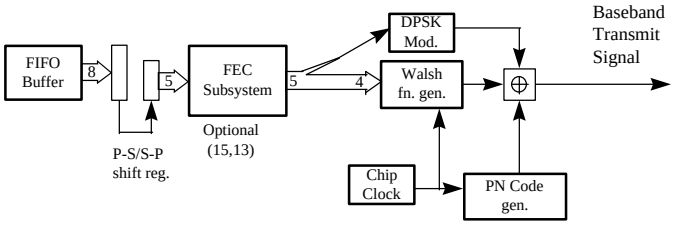
- 2^N Functions Orthogonal Over 2^N Chips
- Rademacher Function Products
  - Subgroup Structure
- Easily Generated
- Efficiently Processed
- PN-Code Cosets
  - Controlled Correlations



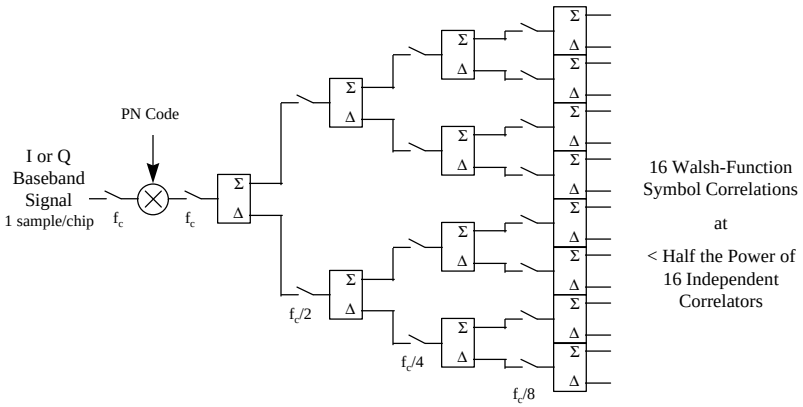
Optional Coding

- Used to Combat “Irreducible Error Rate”
- High-Rate R/S Code (Modified)
  - Minimal Reduction of Data Rate (8.67 Mbps)
  - Approximately 2-dB Coding Gain
- Short, Single-Error-Correcting Block Code
  - Non-Iterative Decoding
  - Very-Low Latency
- Simple Hardware Implementation

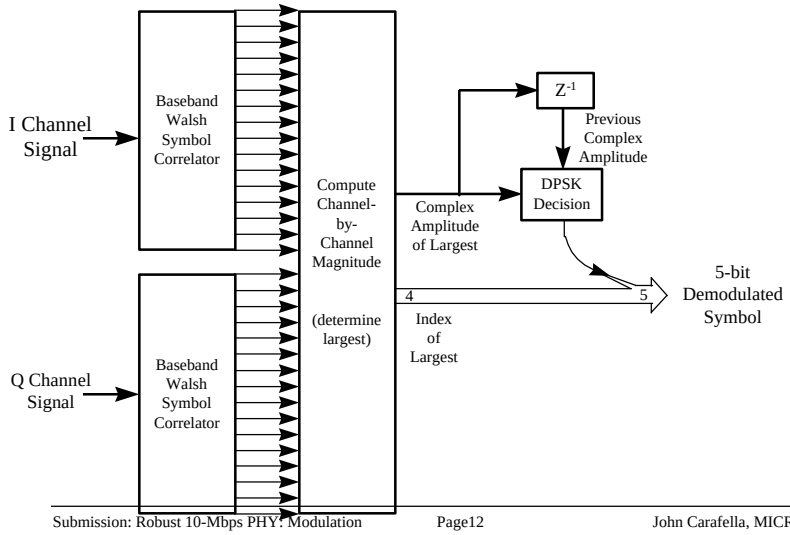
Data Transmission



Baseband Walsh Correlator

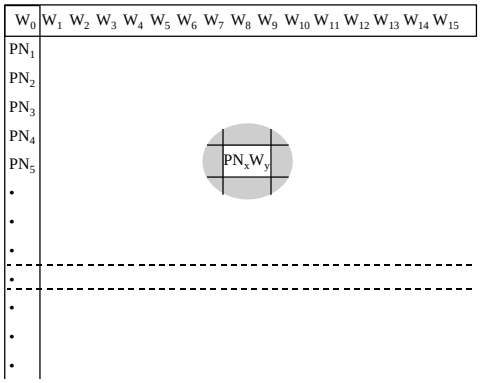


Data Demodulation



PN Code Selection

- 16 bits: 32K Codes
  (plus compliments)
- Functions W_0-W_{15}
  - Proper Subgroup
  - Coset Decomposition
  - PN Code Coset Leaders
  - 2048 Cosets
- Pick Cosets Having Low Near-In Crosscorrelation Side Lobes



Data Modulation Summary

- 10 Mbps Modulation
  - Robust in Multipath and Interference
  - 12-dB Processing Gain
  - 7 dB E_B/N_0
  - Natural Match to DSSS
- Optonal FEC + Good PN Codes (Multipath)
- Efficient Implementation