Advanced Research and Engineering Solutions (ARES)

Asymmetric Modulation for Cognitive Radio and Intelligent Environments

2004 Software Defined Radio
Technical Conference and Product Exposition

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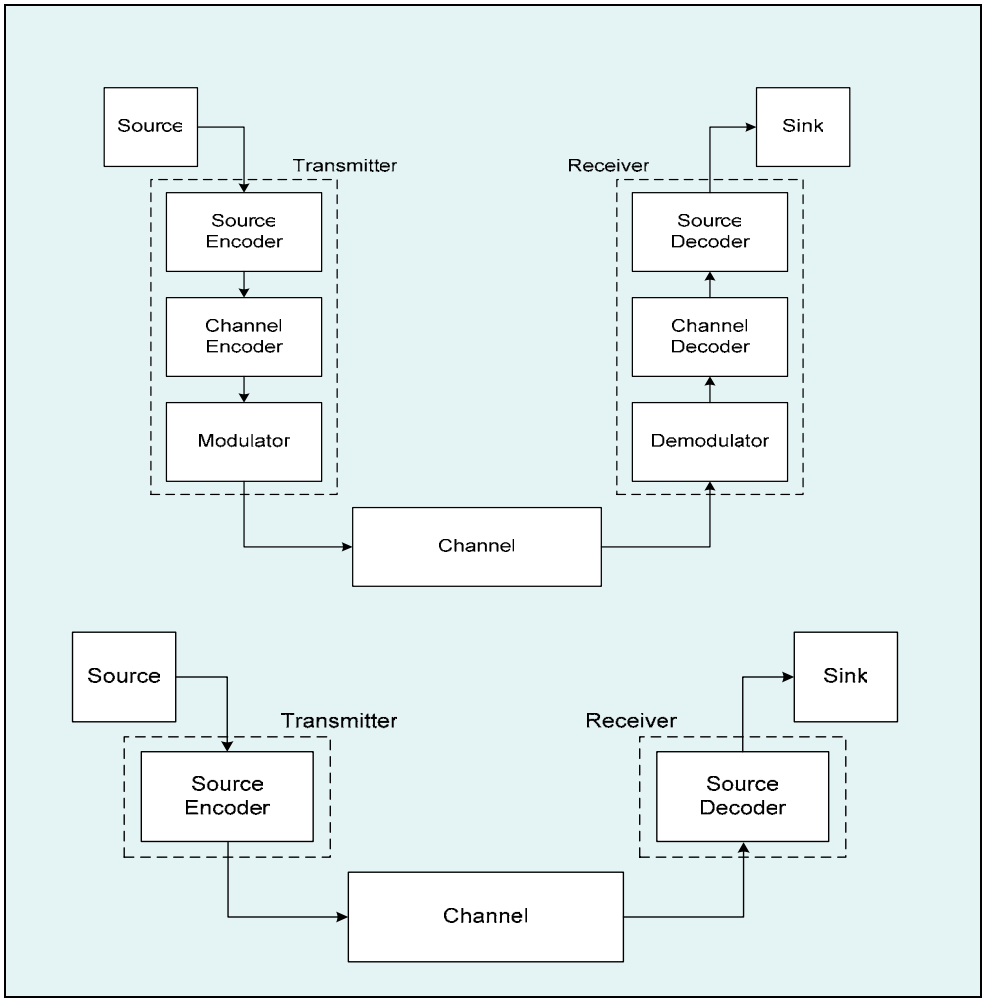
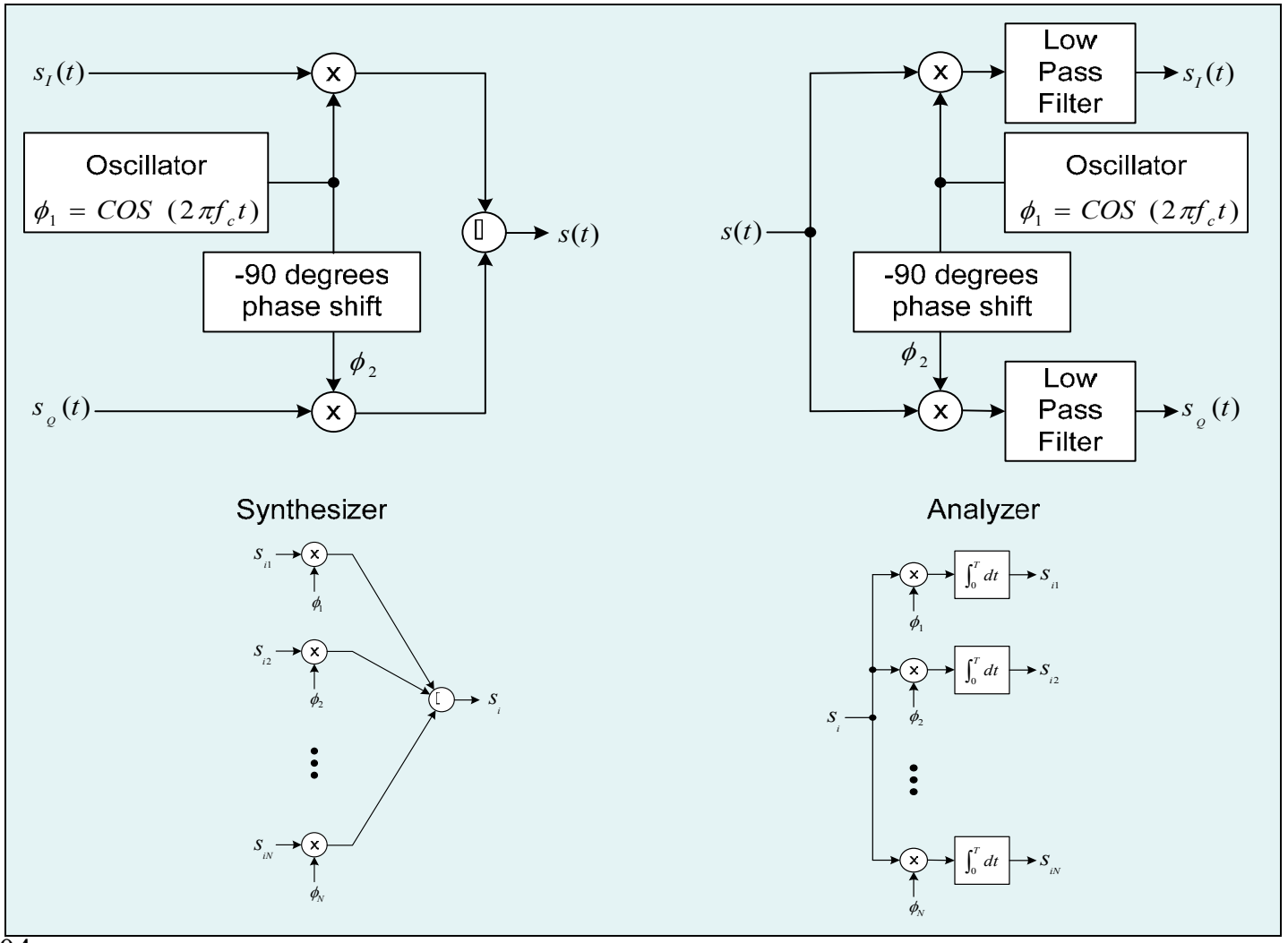
Outline

- Introduction
- Asymmetric Modulation
  - Design
  - Mathematical Analysis
  - Graphical Analysis
- Asymmetric Coherence
- Opportunities for Intelligent Environments
- Conclusion

Complex Baseband System Model

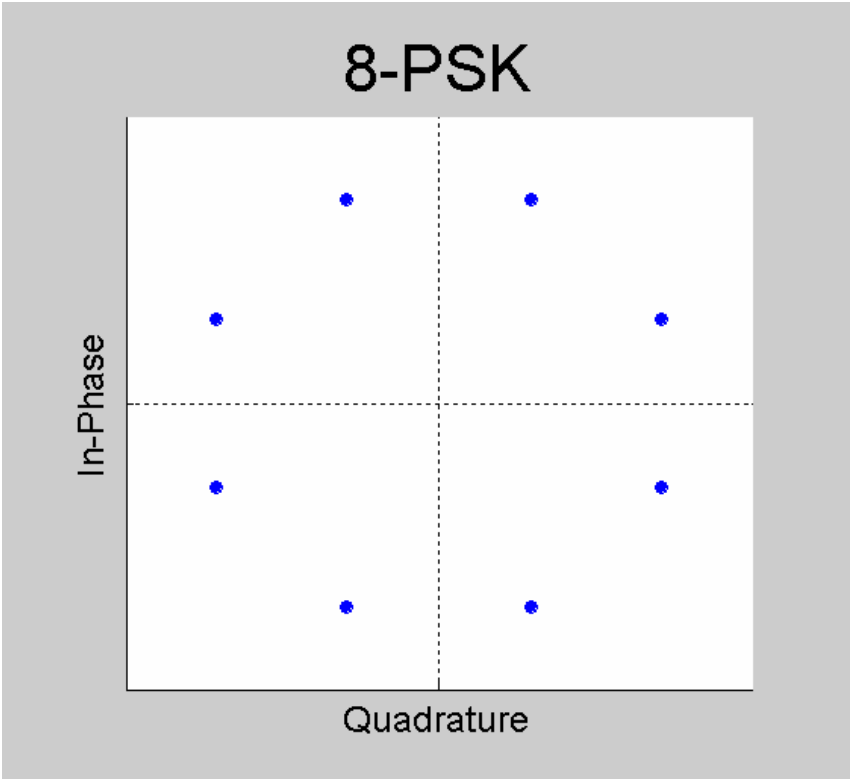


Orthogonal Basis Functions

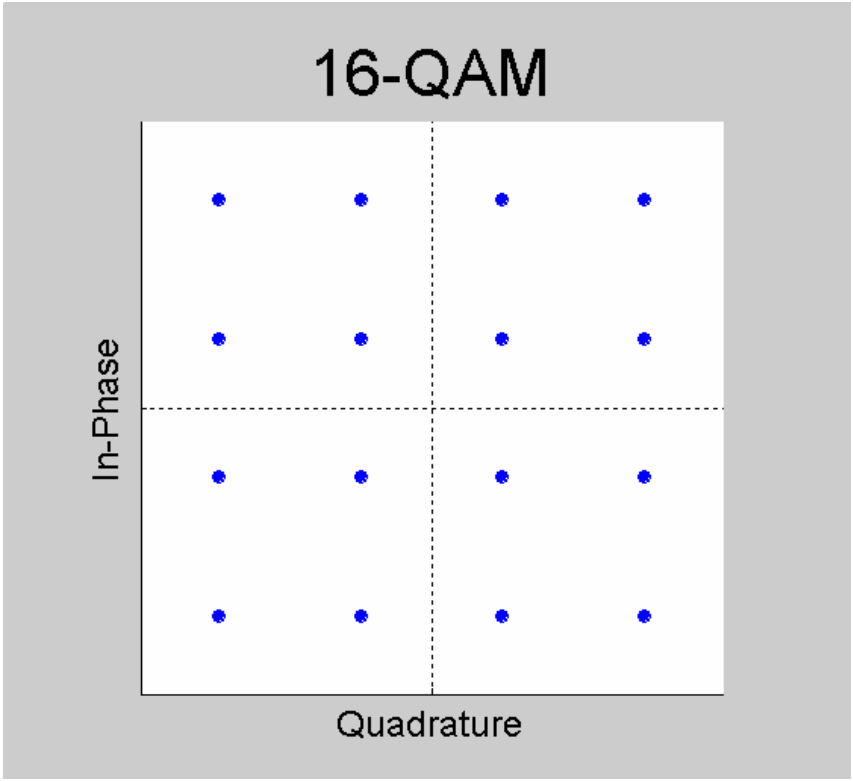


Common Modulation Schemes

Constant Envelope



Modulated Envelope



AsPSK

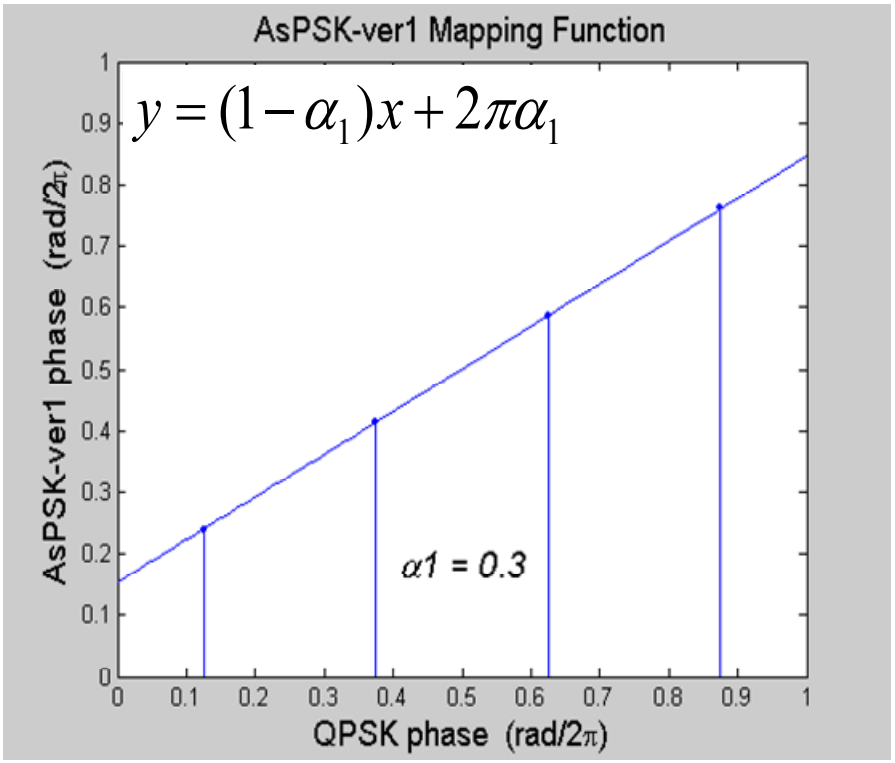
Asymmetric Phase-Shift Keying

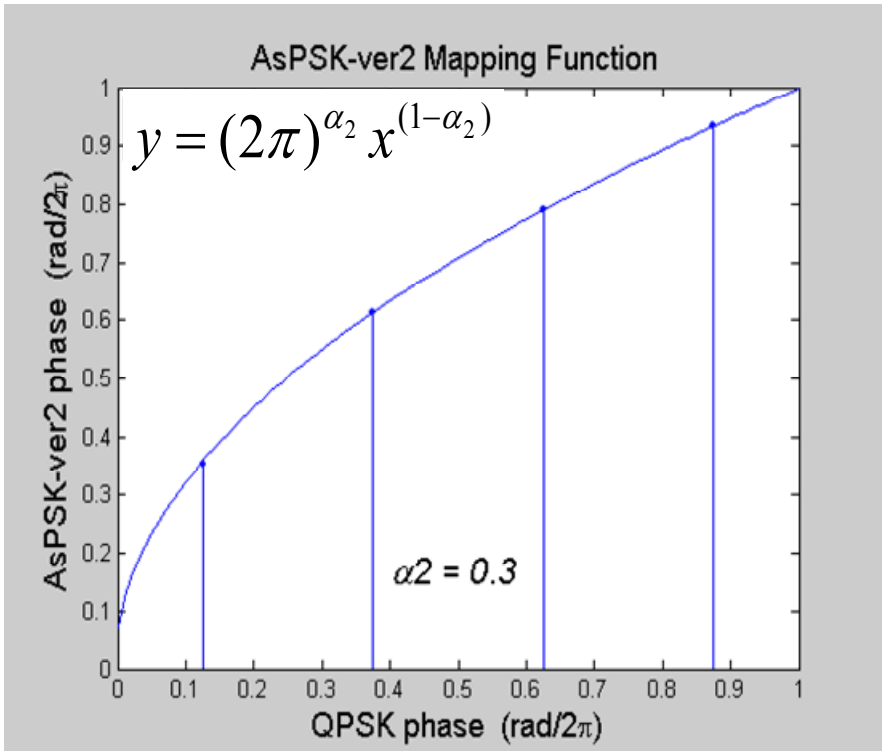
AsQAM

Asymmetric Quadrature Amplitude Modulation

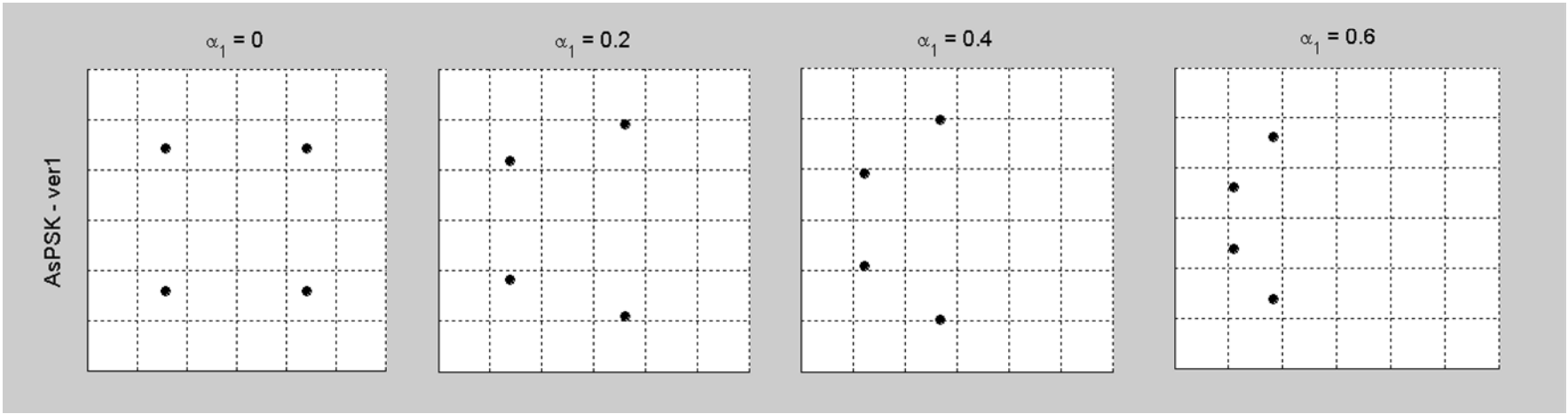
Asymmetric Phase-Shift Keying

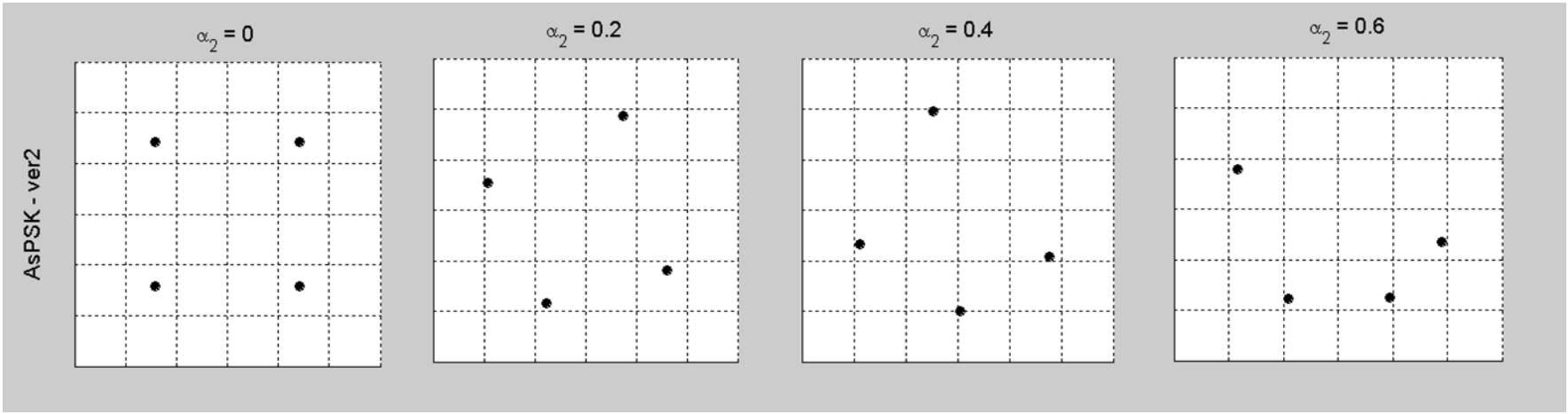
Mapping Functions





AsPSK: Constellations





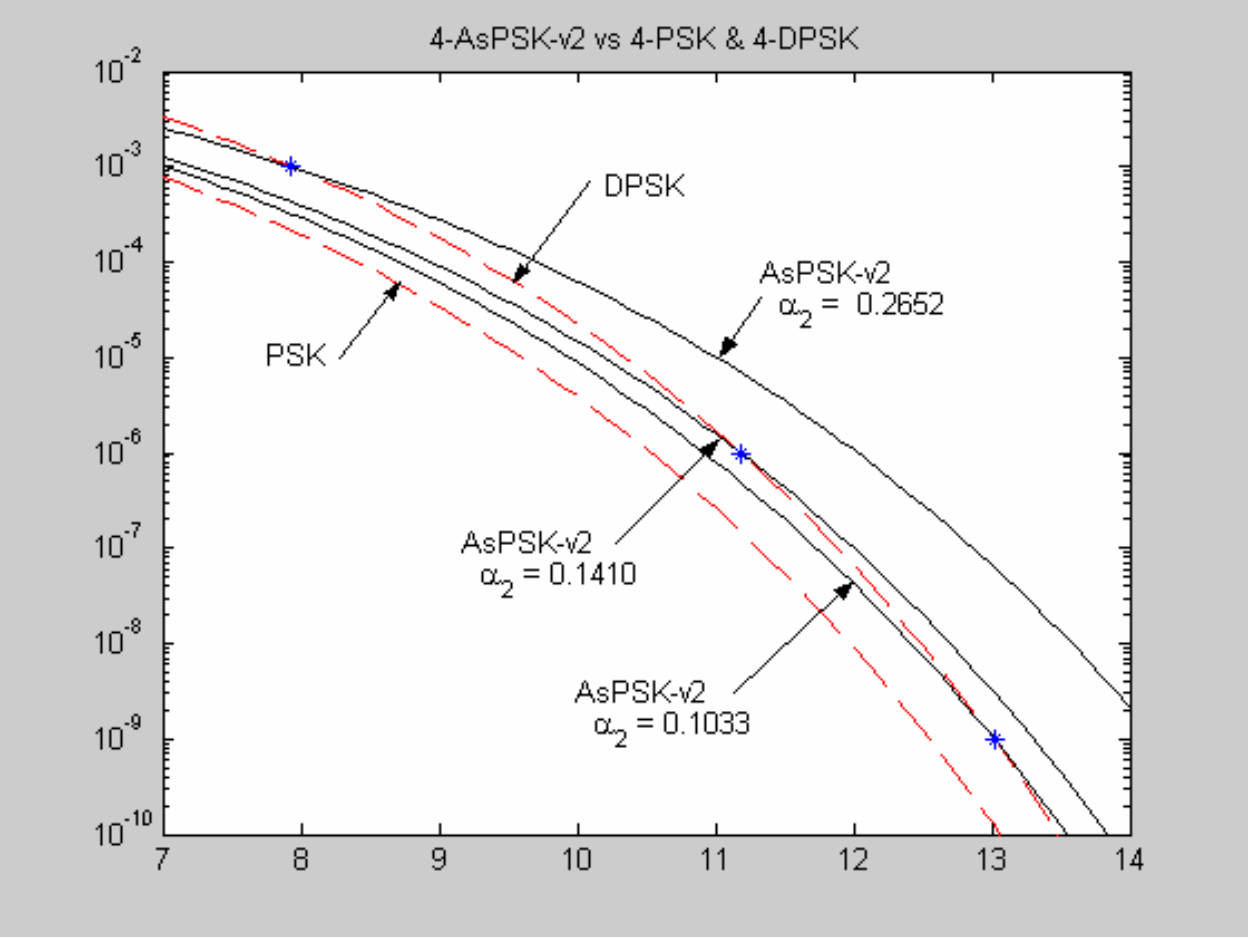
AsPSK: Expected BER in AWGN

AsPSK-☎$_1$ & AsPSK-☎$_2$

$$P_{b1} \approx Q\left(\sqrt{2 \cdot \lg(M)} \cdot \sqrt{\frac{E_B}{N_0}} \cdot \sin\left\{ \frac{\pi \cdot (M - 1 - \alpha)}{M} \right\} \right)$$

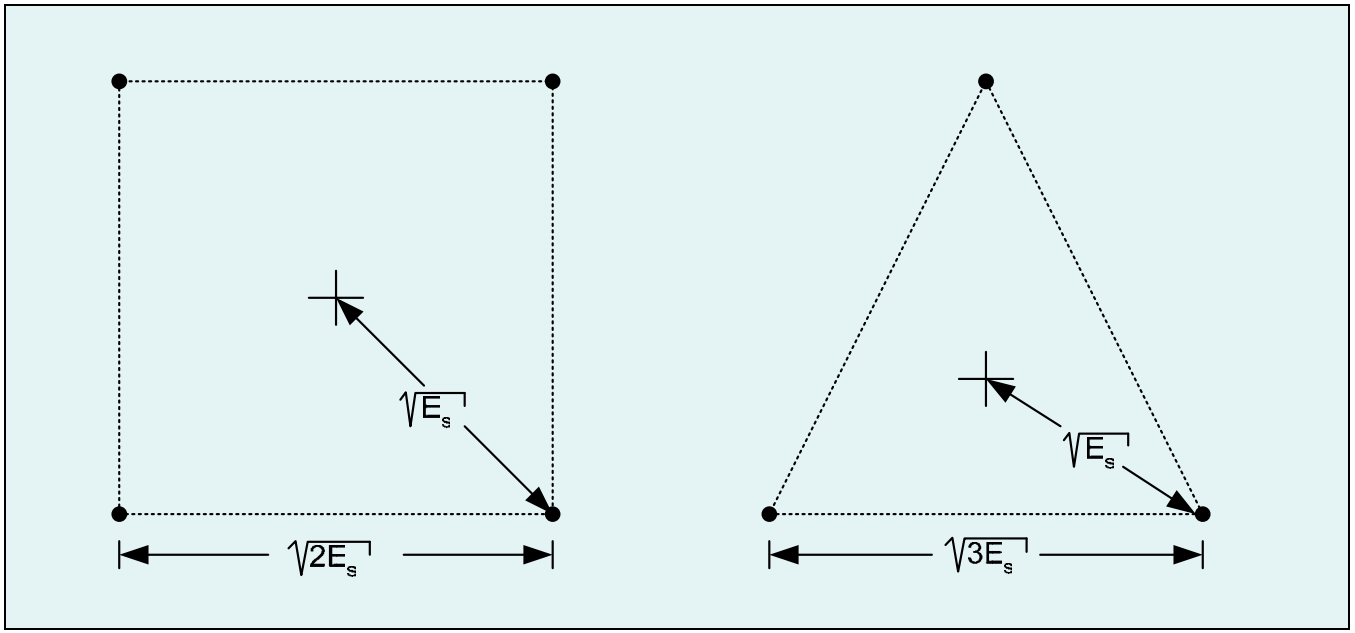
$$P_{b2} \approx Q\left(\sqrt{2 \cdot \lg(M)} \cdot \sqrt{\frac{E_B}{N_0}} \cdot \sin\left\{ \pi \left[\frac{M-1}{M} \right]^{(1-\alpha)} \right\} \right)$$

AsPSK: Dynamic Control



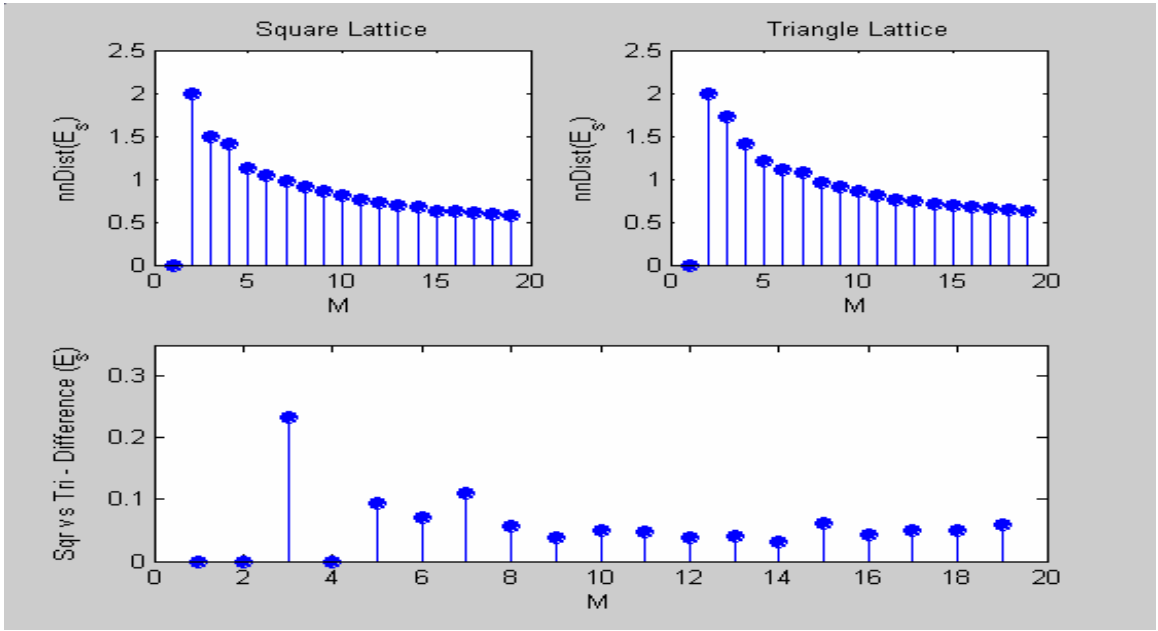
AsQAM: Lattice Structure

QAM vs AsQAM

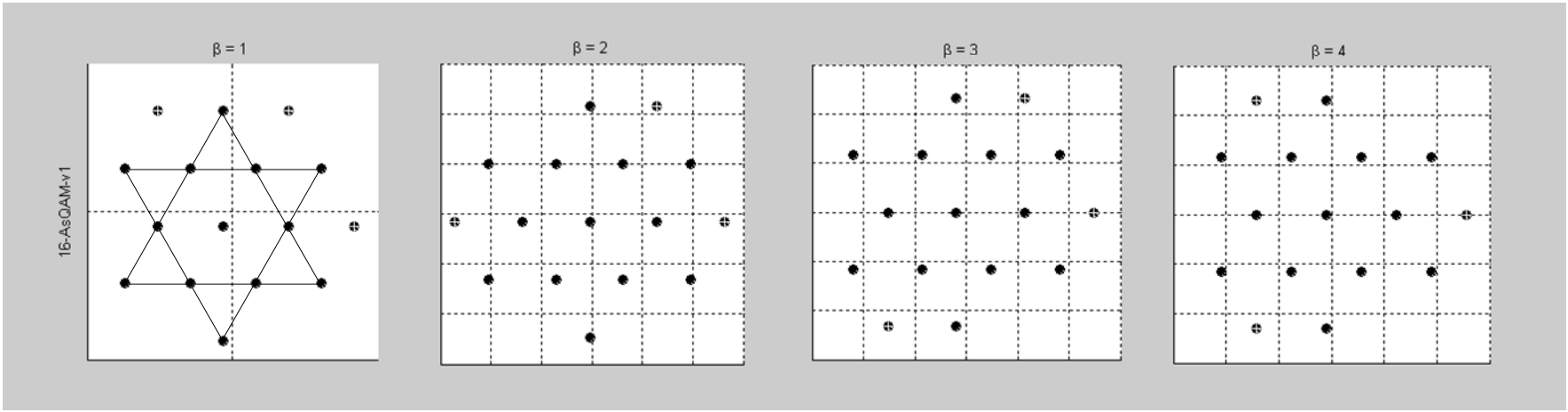


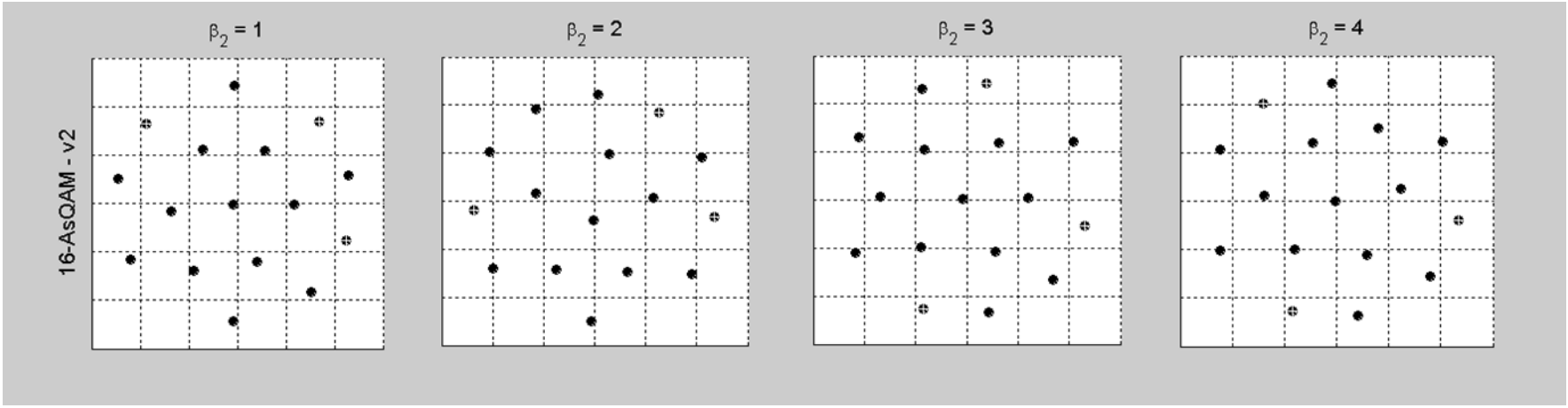
AsQAM: Lattice Structures

Direct Comparison of Square Lattice & Simplex Lattice



AsQAM: Constellations





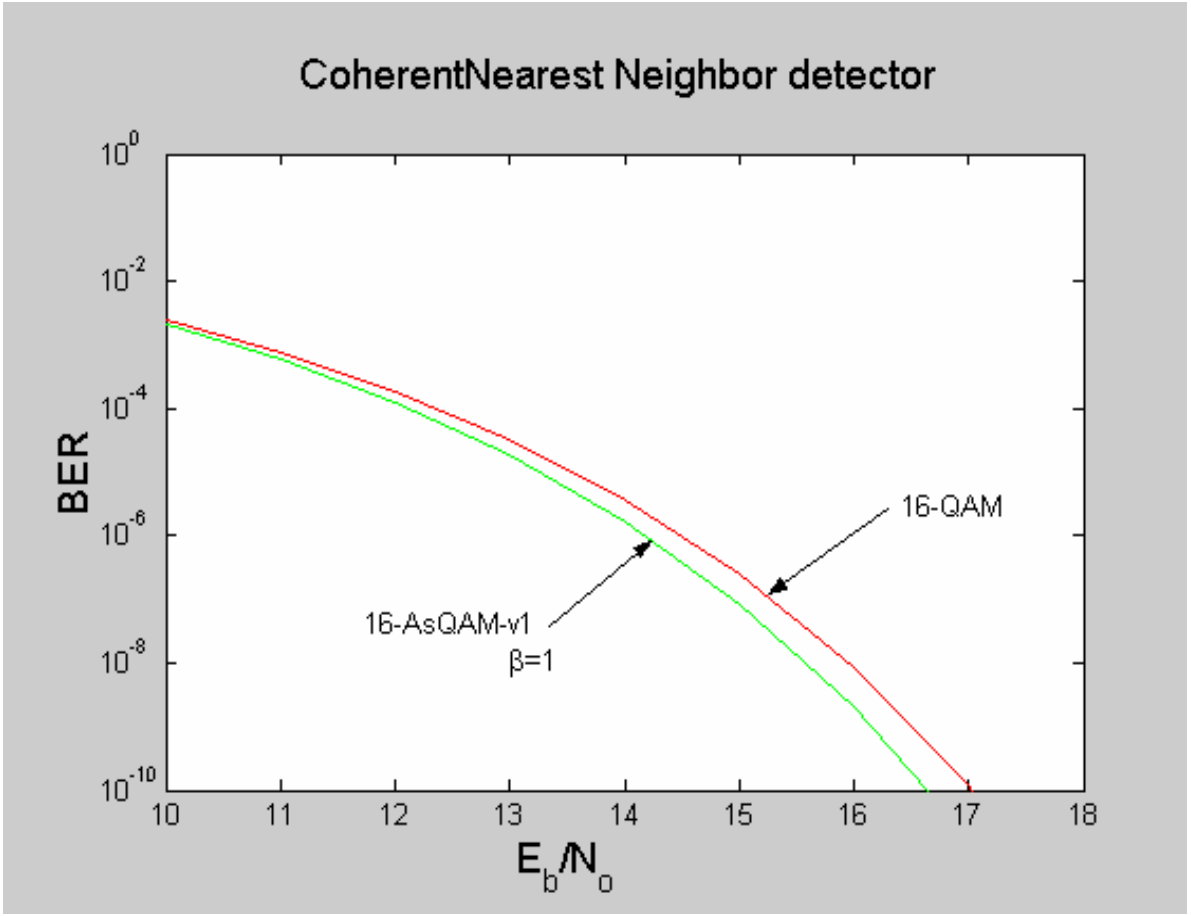
AsQAM: BER in AWGN

QAM & AsQAM

$$P_{b\_QAM} \approx \frac{3}{4} Q\left(\frac{2}{\sqrt{5}} \sqrt{\frac{E_B}{N_0}} \right)$$

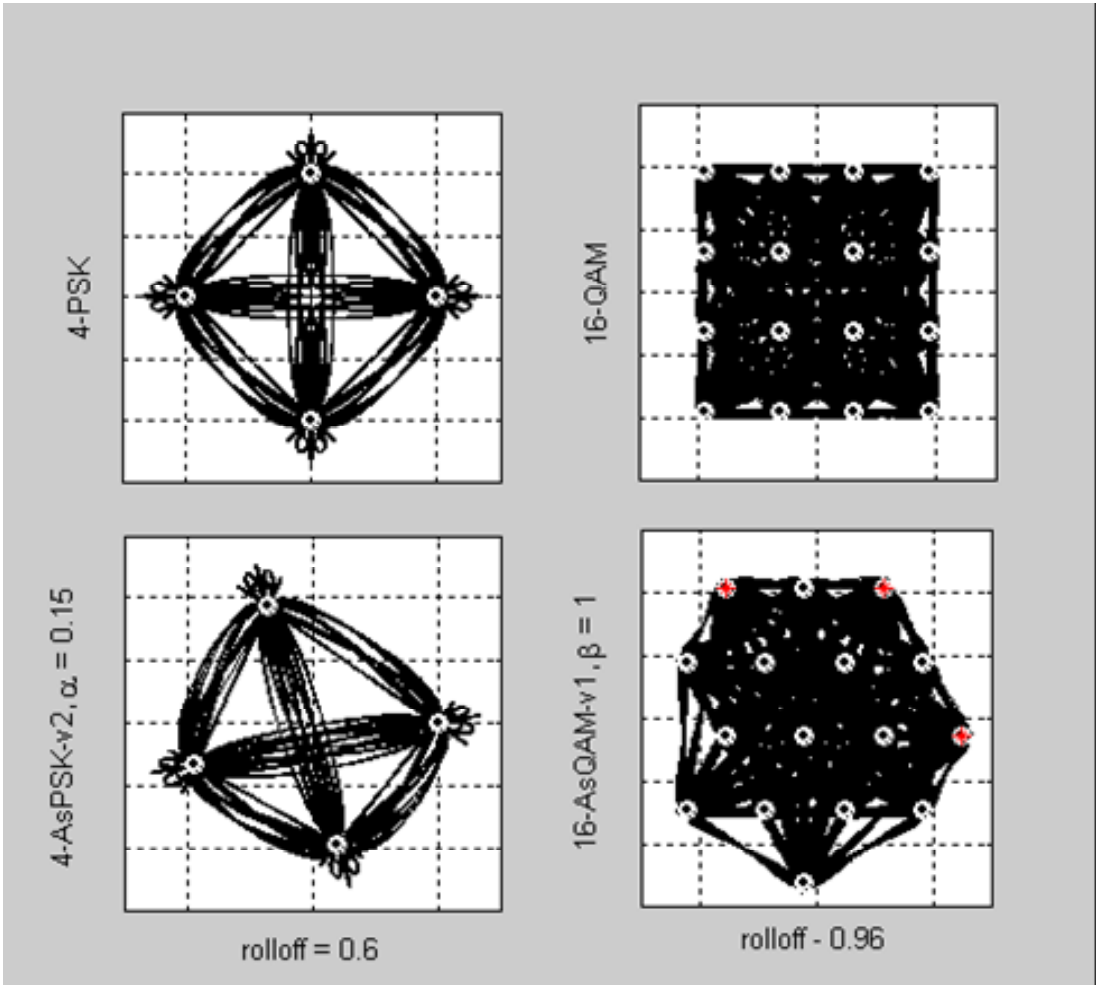
$$P_{b\_AsQAM} \approx Q\left(\frac{2\sqrt{2}}{3} \sqrt{\frac{E_B}{N_0}} \right)$$

AsQAM vs. Standard QAM



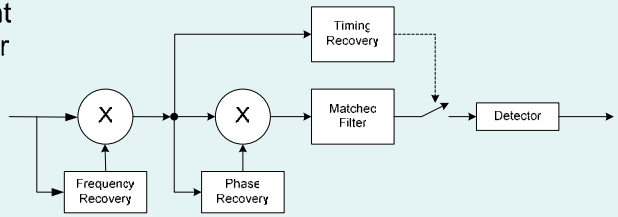
Nearest-Neighbor Distances	
∾	16-AsQAM- ☎$_1$
1	0.6761
2	0.6688
3	0.6690
4	0.6659
16-QAM	0.6325

Clock Synchronization

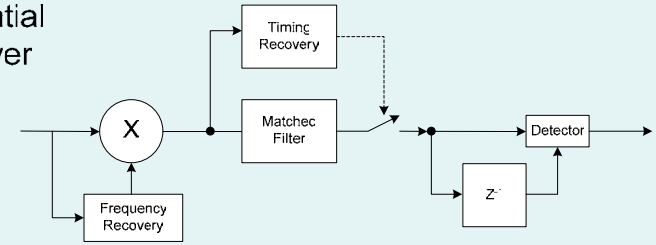


Coherent & Noncoherent Receivers

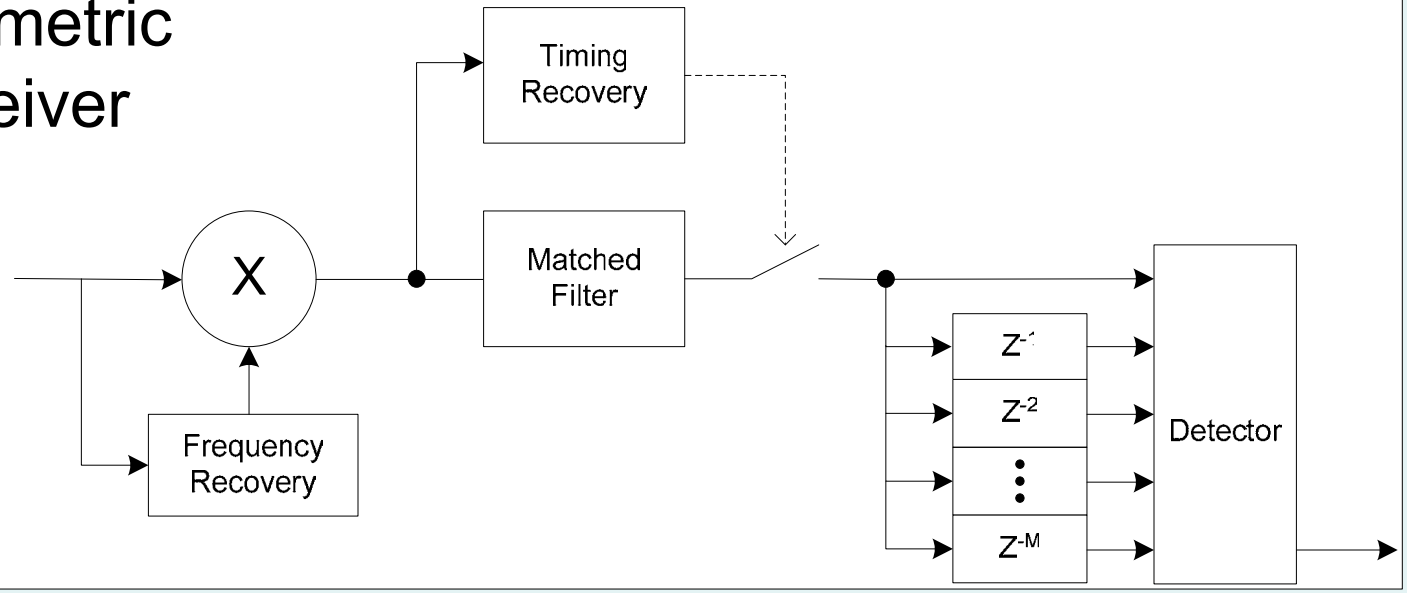
Coherent Receiver



Differential Receiver

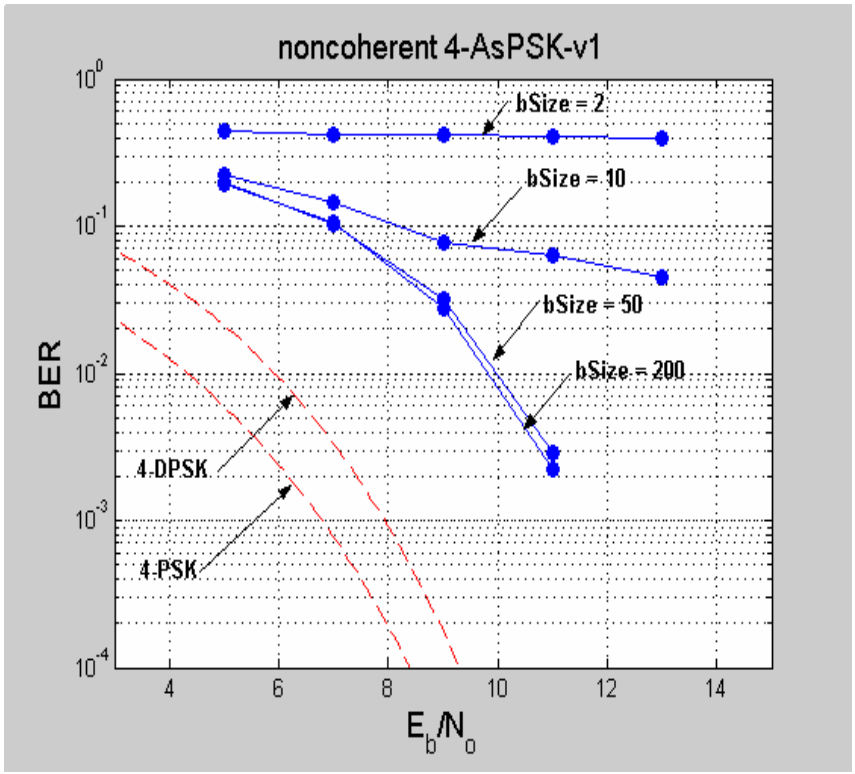


Asymmetric Receiver

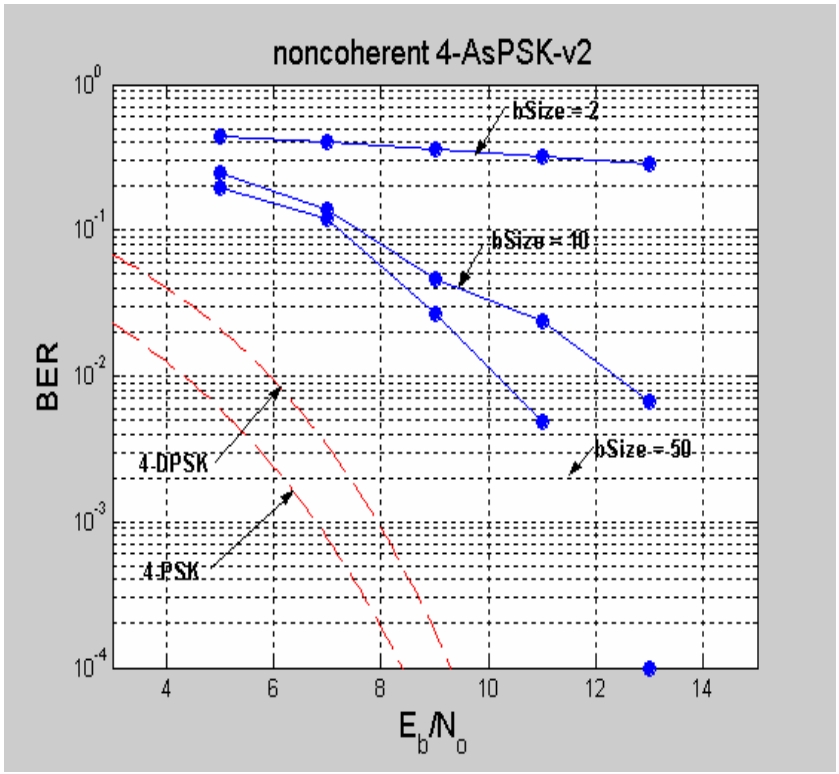


Detector Simulations

AsPSK- ☎$_1$



AsPSK- ☎$_2$



Opportunities for Intelligent Environments

- Dynamic Design
- Synchronization and Data Transfer Modes
- Low Priority Data Transfer at Low Cost
- Continuous and Discrete Constellation Monitoring

Conclusion

- Discrete and Continuous Dynamic Designs
- Optimal Lattice Structure
- Asymmetric Coherence
- Environmental Intelligence Capability

References

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[3] L. Venkata Subramaniam, S. Rajan, R. Bahl, "Performance of 4- and 8-State TCM Schemes with Asymmetric 8-PSK in Fading Channels," IEEE Transactions on Vehicular Technology, vol. 49, No. 1, pg 211-219, January 2000

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[5] G. Colavope, R. Raheli, "On Noncoherent Sequence Detection of Coded QAM," IEEE Communications Letters, Vol. 2, No. 8, August 1998