Joint Encryption Error Correction and Modulation (JEEM) Scheme

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Outline

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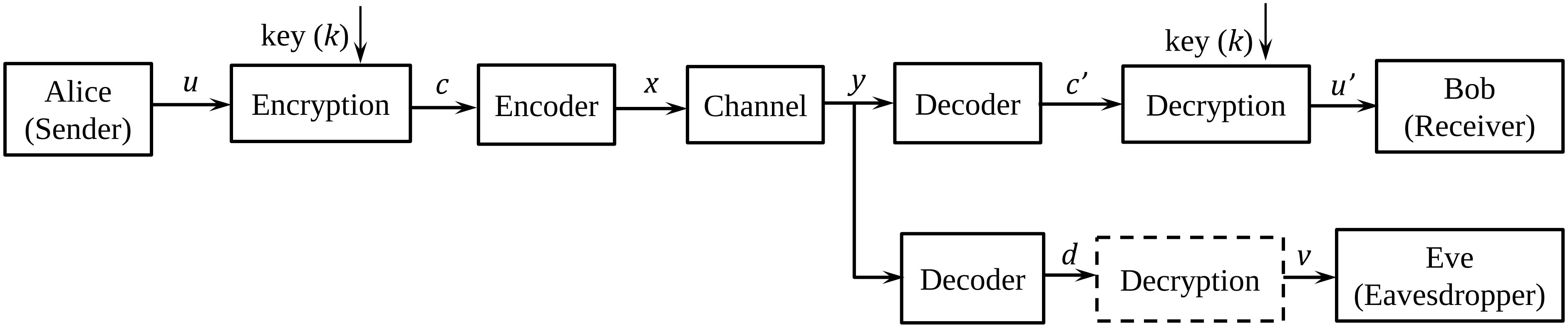
Motivation/Introduction

- Need for security, reliability and speed in wireless communication systems
- The best and often the only way to secure data in WN is to encrypt.
- Conventional modulation schemes are modified to provide random mapping of encoded information.
- JEEM - Physical layer encryption scheme to provide data reliability, secrecy and integrity

Related Work

- McEliece introduced the use of error correcting code as a public key cryptosystem.
  - Based on algebraic coding theory using t-error correcting Goppa code
  - Although very efficient, it has received little attention in practice because of the very large public keys.
- Rao proposed a private key cryptosystem based on algebraic-code using McEliece scheme.
  - Less computational intensive compared to McEliece scheme
  - Broken by a chosen-plaintext attack.
- Hwang et. Al proposed Secret Error Correcting Code (SECC) using preparata code
  - Did not use error vector originally introduced in the original McEliece scheme.

Secure Communication System Model



McEliece Cryptosystem

- Encryption of a plaintext $\boldsymbol{M}$ into a ciphertext $\boldsymbol{C}$

$$C = MG' + Z = MSGP + Z$$

C: cyphertext of length n,

M: plaintext of length k,

Z: random error vector of length n whose hamming weight $t' = t$,

$G' = SGP$: public key,

G: generator matrix of a t-error correction code (Goppa code for the McEliece's case),

S (scrambler) , G (generator matrix), P (permutation matrix) are private keys.

JEEM Encryption Scheme

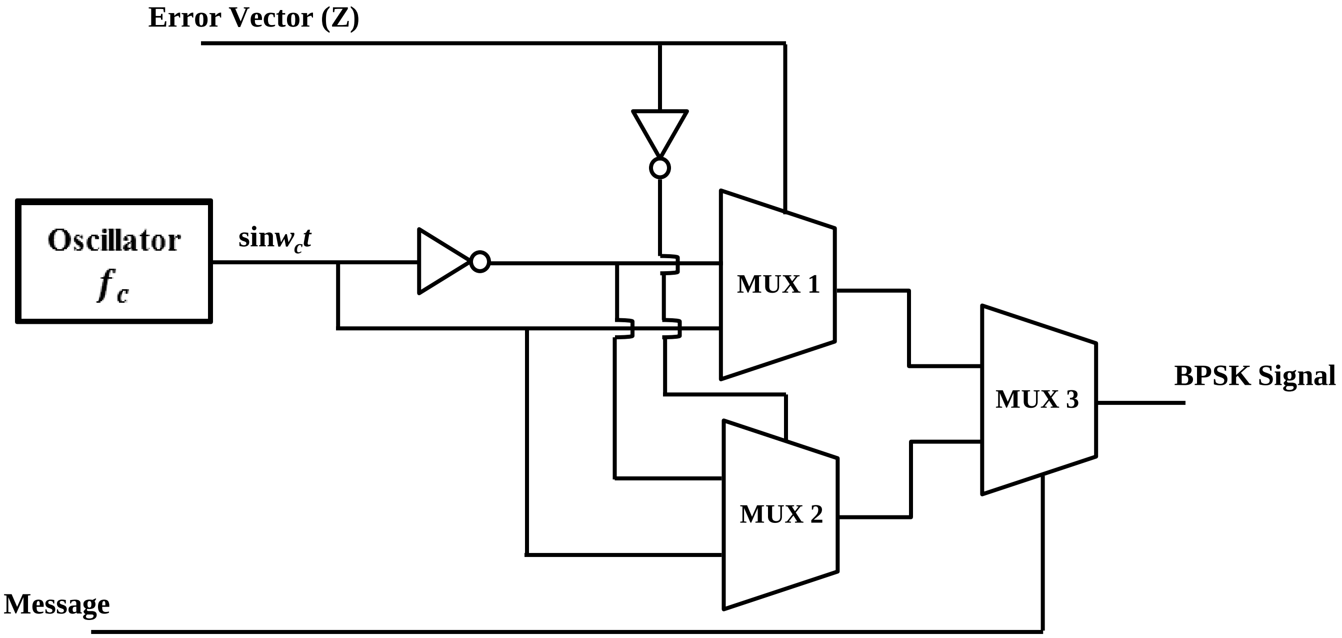
$$C' = MG' = MFGP$$

$$C = (MG')M_r = (MFGP)M_r$$

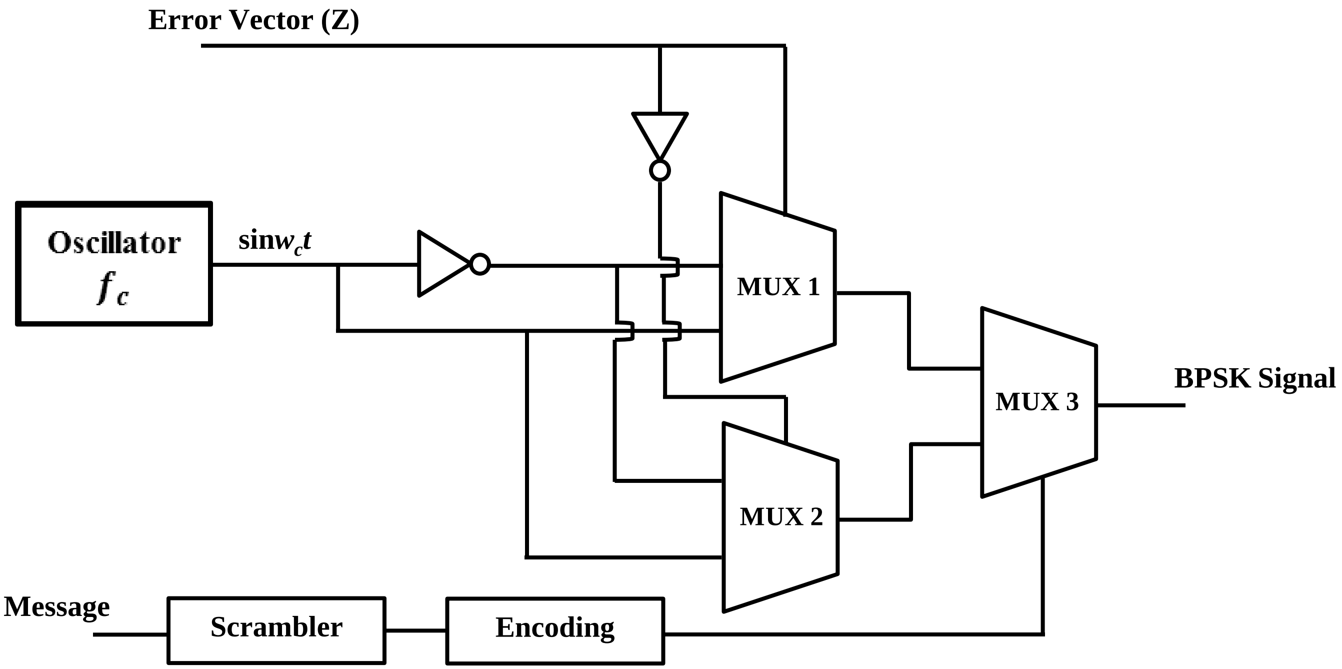
$$C = (MG')M_r = (MFGP)M_r \equiv MSGP + Z$$

- $\boldsymbol{F}$ is a non-linear function instead of scrambler in the McEliece scheme.
- $\boldsymbol{G'}$ is generator matrix of low-density parity-check code (LDPC)
- Random modulation using $\boldsymbol{M_r}$ instead of modulo-2 addition of $\boldsymbol{C'}$ with $\boldsymbol{Z}$
- The modulation is controlled by the error vectors.
- Provides both randomization and modulation without compromising the structure of the McEliece-like scheme.

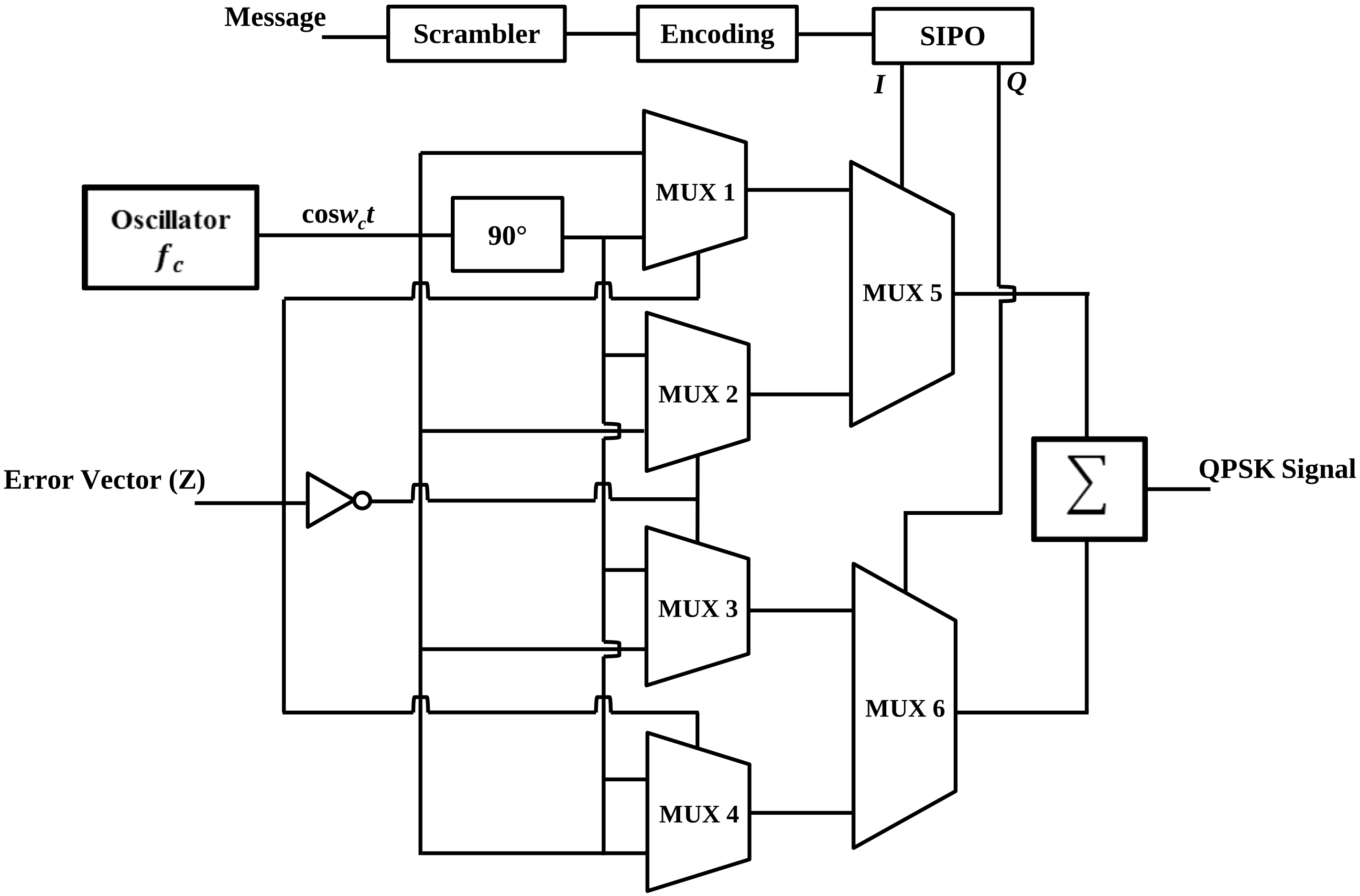
Random Modulation Scheme - BPSK



Encryption Randomized Modulation Scheme - BPSK



Encryption Randomized Modulation Scheme - QPSK

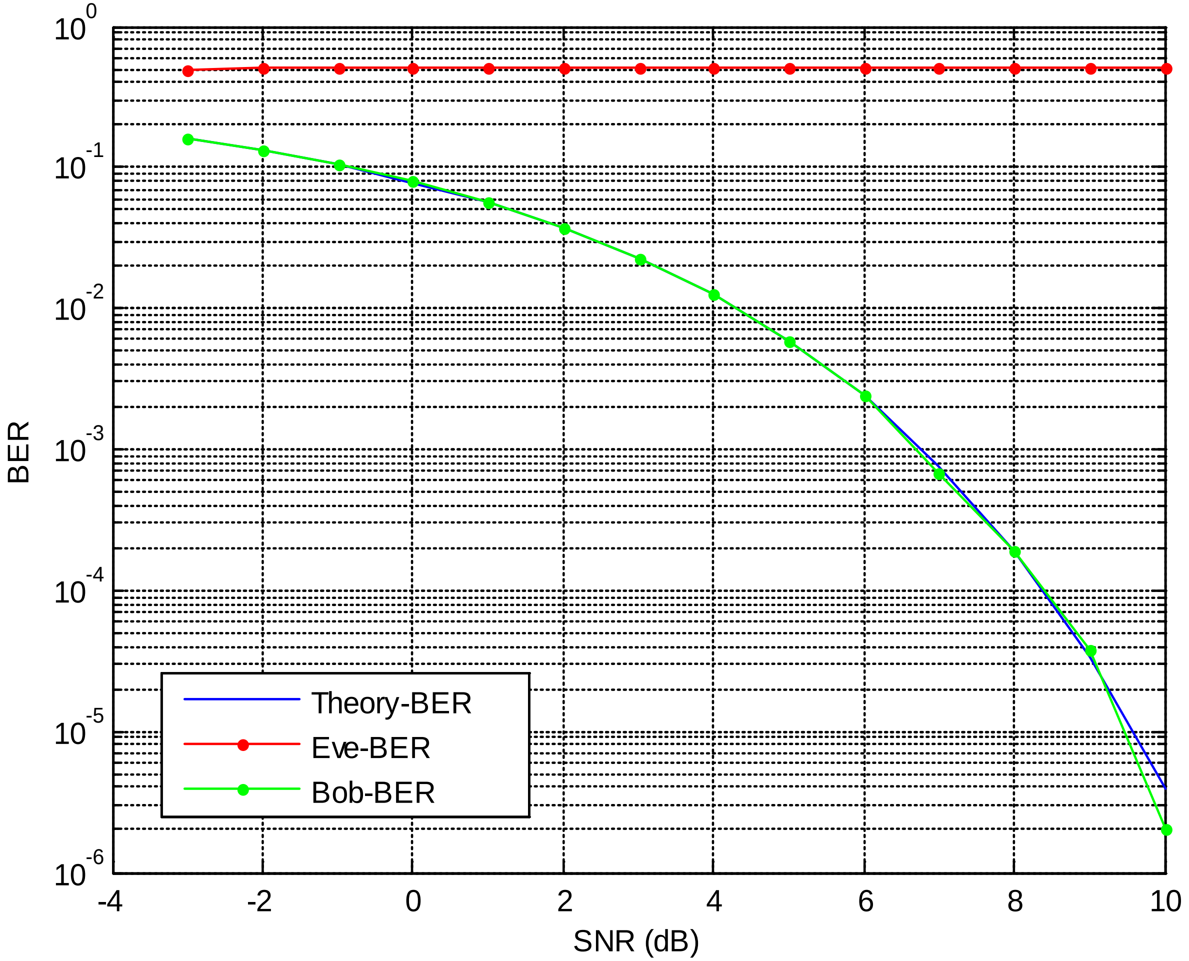


*Serial-in parallel-out (SIPO)

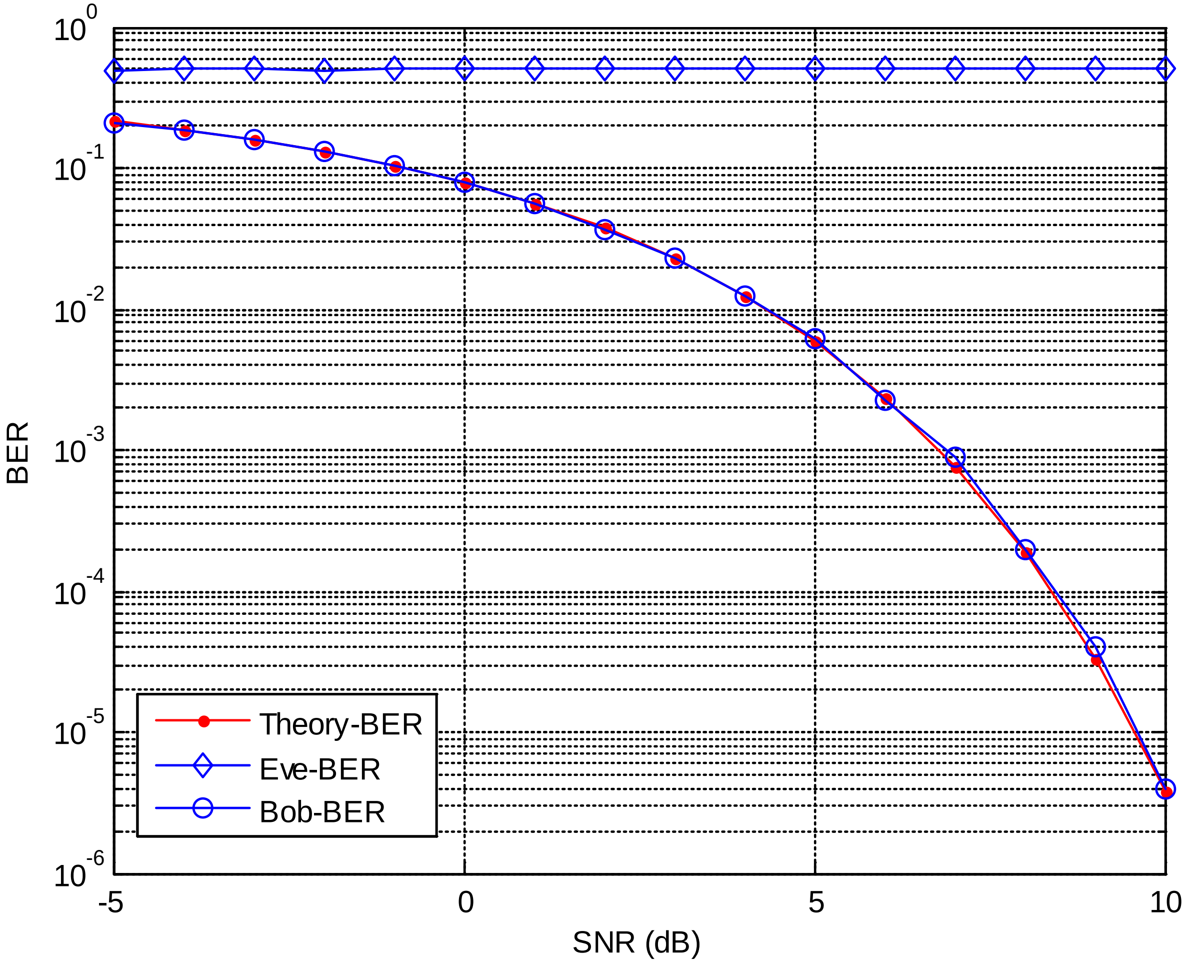
Evaluation of JEEM

- Bit error rate (BER), symbol error rate (SER) used as a measure of security
- High BER/SER at Eve can deliver improved resilience against eavesdropping
- Simulated performance of the communication channels for Bob and Eve for BPSK and QPSK modulation schemes
- Communication through an additive white Gaussian noise channel

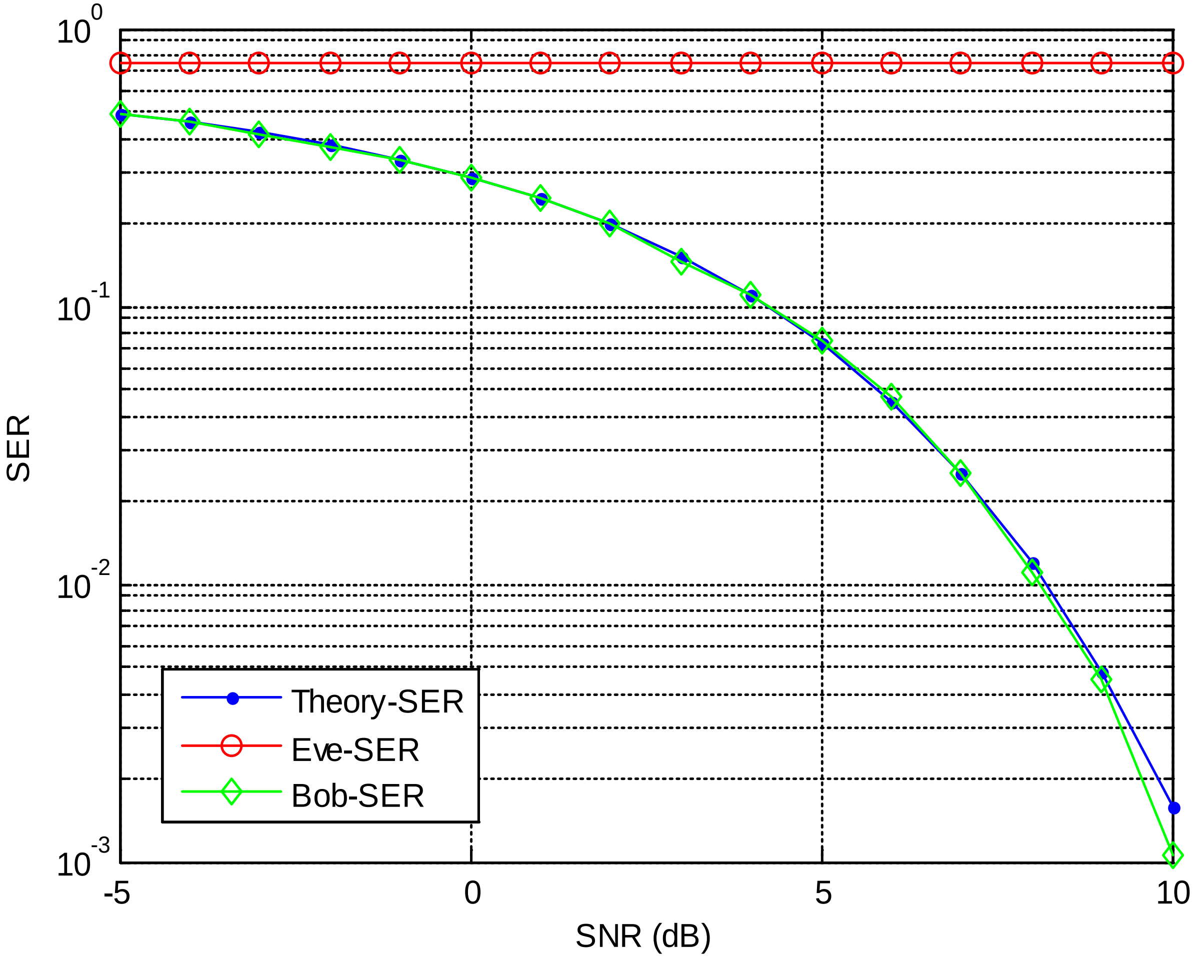
BER vs. SNR for BPSK



BER vs. SNR for QPSK

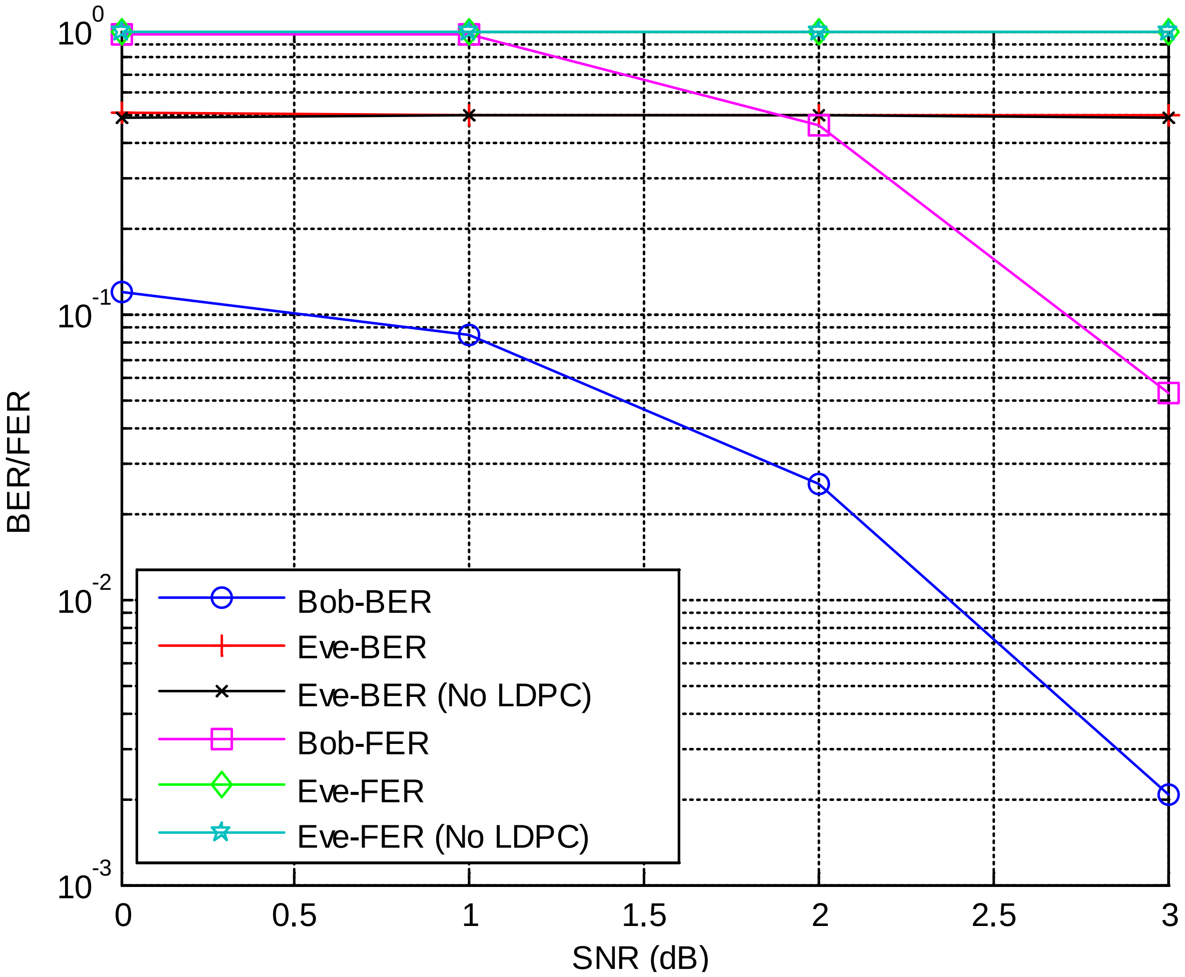


SER vs. SNR for QPSK



BER/FER vs. SNR

*Assumed Eve uses a LDPC decoder



Conclusions

- We proposed a joint encryption, error correction and modulation scheme.
- It provides security and error correction at the physical layer.
- It utilizes a random mapping scheme in order to degrade Eve’s communication channel.
- It does not compromise the full error correcting capability.
- It has the potential of reducing the key size of McEliece-like schemes.

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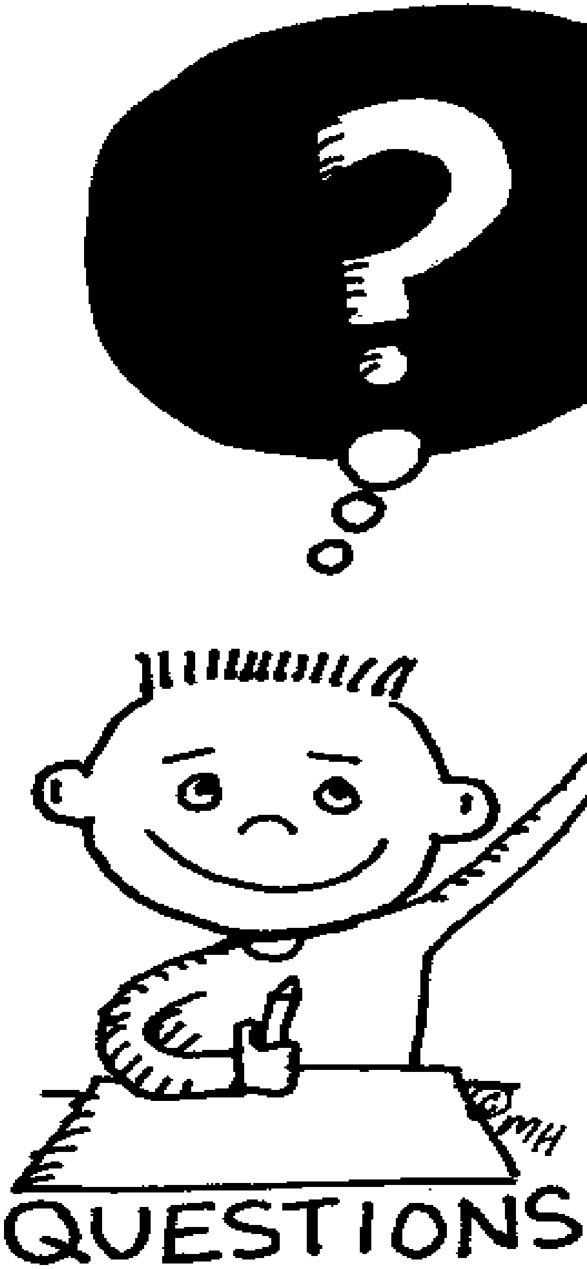

THANKS!