CONSIDERATIONS IN THE DESIGN OF UWB SYSTEMS

1) FREQUENCY DIVERSITY

If sufficient frequency/path diversity is available, other forms of diversity, such as time diversity and space diversity, might not be needed.

2) PARAMETER ESTIMATION

Because a large number of paths will be resolvable, and because the total received energy is constant, independent of the number of paths, the energy-per-path is necessarily small. This implies that the SNR per path is small, and thus all channel estimates will be quite noisy.

3) NARROWBAND OVERLAY

Interference both to and from overlaid narrowband users has the potential to dominate system design.

System Performance Evaluation

- Channel Estimation:
  - Minimum-mean square error
  - Sample mean
- Data detection:
  - Maximum Likelihood
  - Maximal Ratio Combining

- NBI model: WSS Gaussian process with a given power spectral density.

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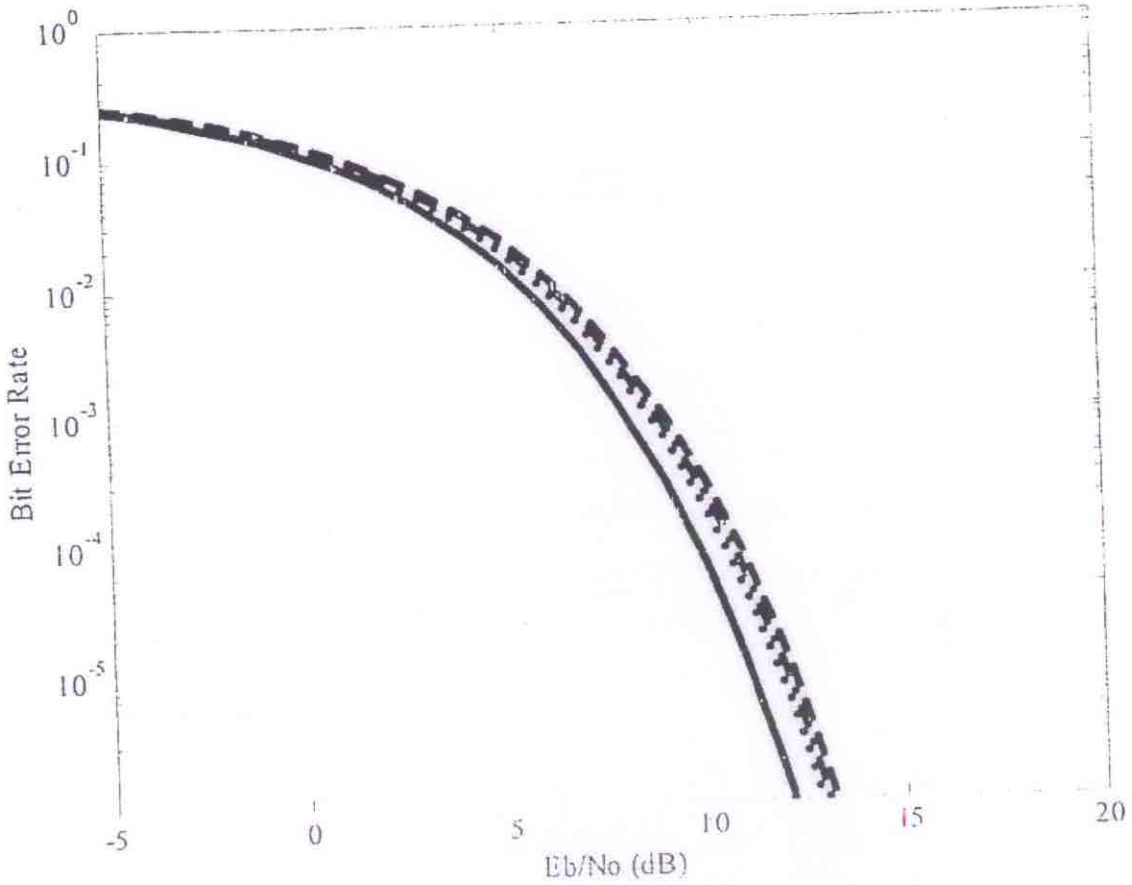
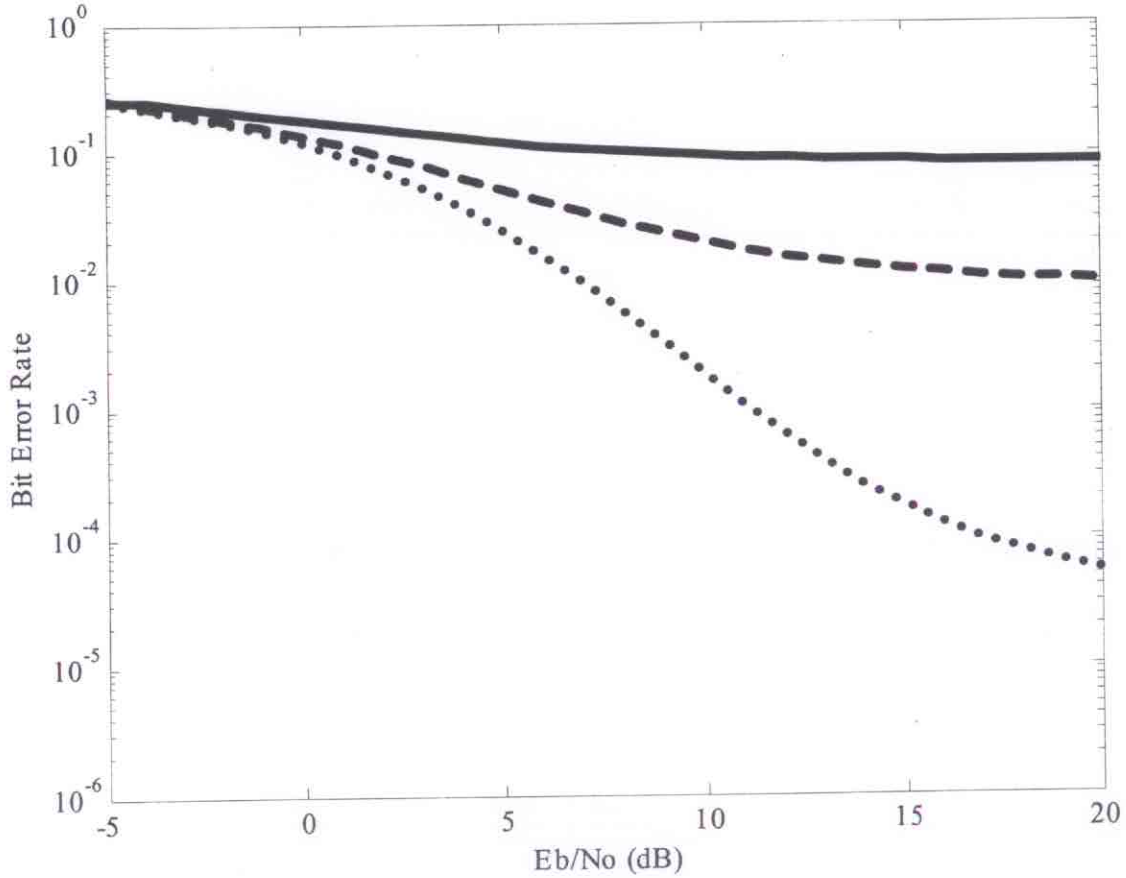
DS System: Perfect Channel Estimation. ML Detection.



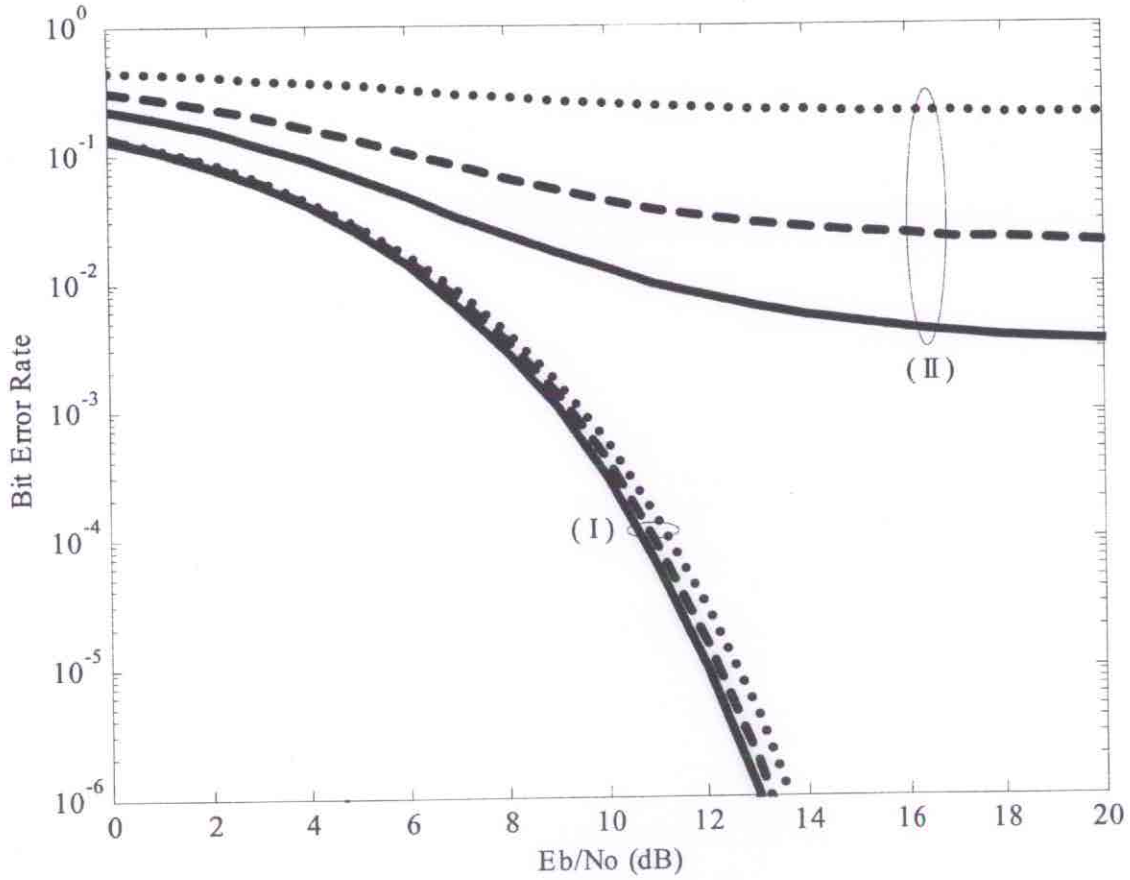
Performance of a single user DS system in the presence of NBI with perfect channel estimation. SIR: -10 dB (dotted lines), -15 dB (dash-dot), and --20 dB (dashed). Solid line: presence of thermal noise only. Signal and NBI bandwidths are equal to 500 and 40 MHz, respectively. Processing gain: 127 (PN sequence).

DS System: Perfect Channel Estimation. MRC Detection.



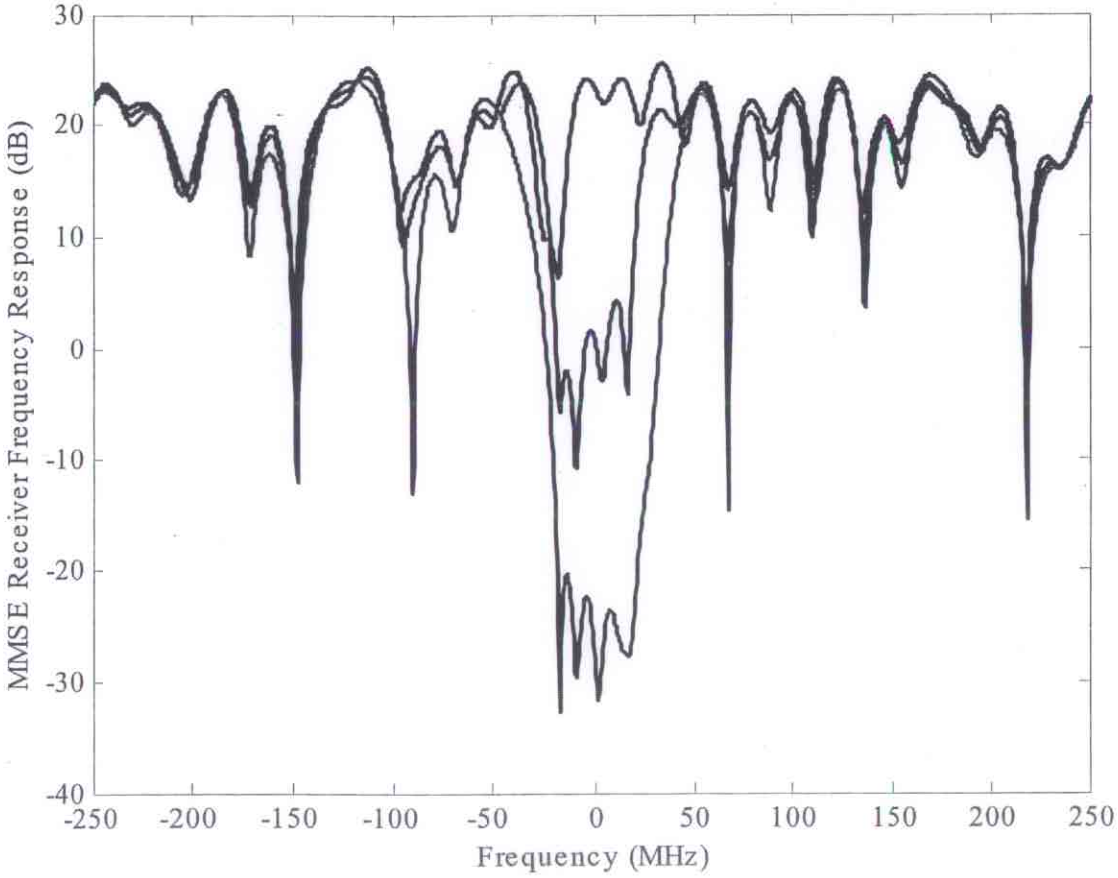
Performance of a single user DS system in the presence of NBI with perfect channel estimation. SIR: -10 dB (dotted lines), -15 dB (dashed), and –20 dB (solid). Signal and NBI bandwidths are equal to 500 and 40 MHz, respectively. Processing gain: 127 (PN sequence).

DS System: NBI



Performance of a single user DS system in the presence of thermal noise and NBI with imperfect channel estimation. (I) MMSE/ML, and (II) SM/MRC. Number of training bits used in the channel estimation: 1 (dotted lines), 10 (dashed), and 30 (solid). Signal and NBI bandwidths are equal to 500 and 40 MHz, respectively. SIR = -10 dB. Processing gain: 127 (PN sequence).

Frequency Response: MMSE/ML receiver



Eb/No = 10 dB.
NBI: SIR = -10 dB (blue) and –30 dB (red). Bandwidth: 40 MHz.

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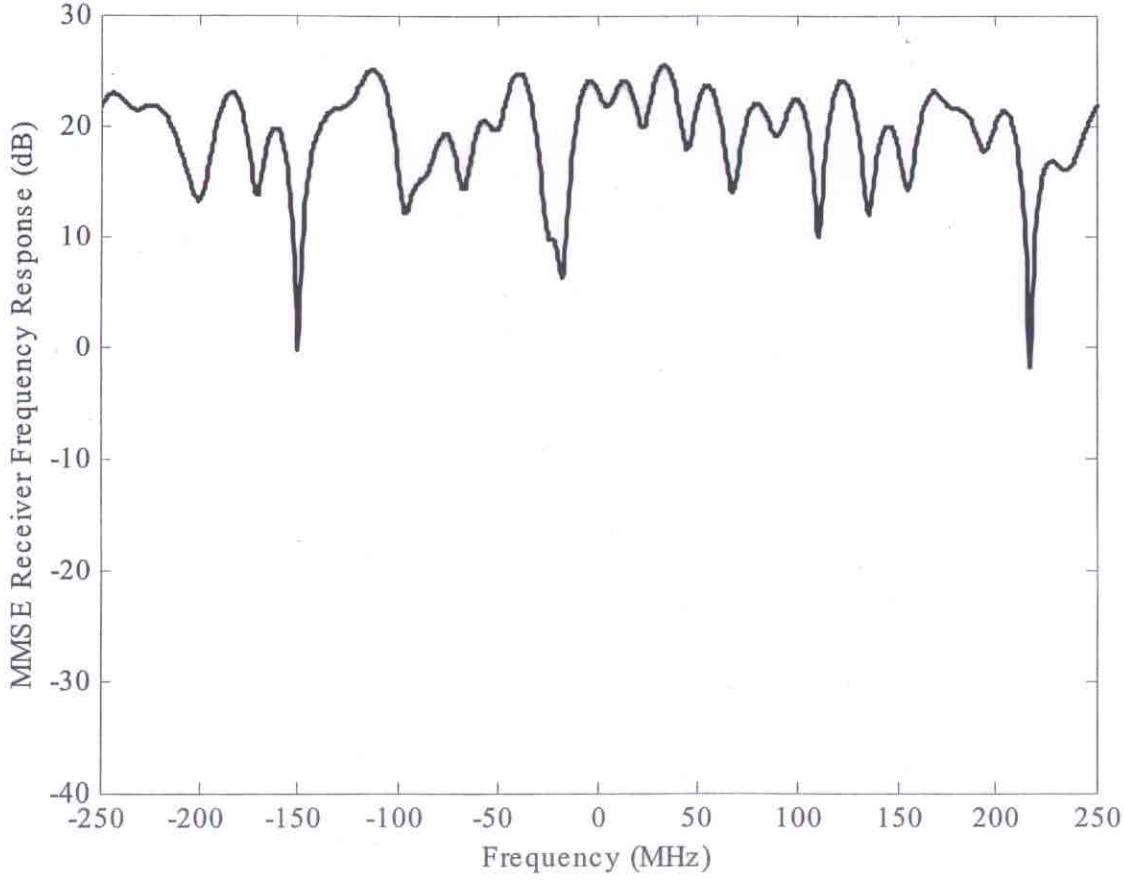
Frequency Response: MMSE/ML receiver



Eb/No = 10 dB.

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Spectral-Encoded Concept: Summary

- A conventional signal is multiplied by a spreading sequence in the frequency domain:
  - signal spreads in time.
  - frequency counterpart of a DS/CDMA system.
- Multiple access capability is achieved by assigning distinct spreading sequences to different users.
- When interference suppression is desired, a spreading sequence is used which has a spectral null where the narrow-band interference is located.

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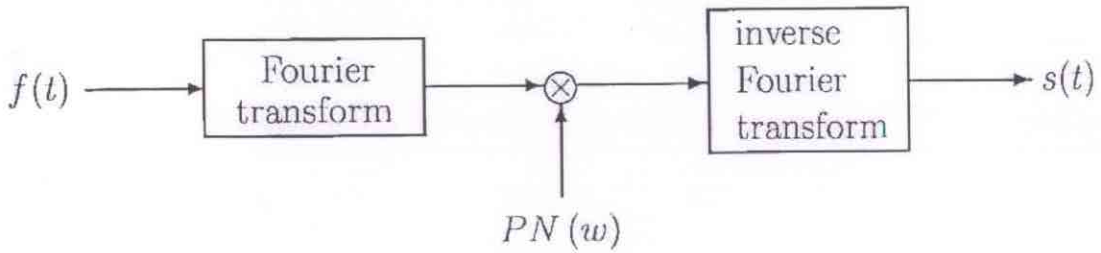
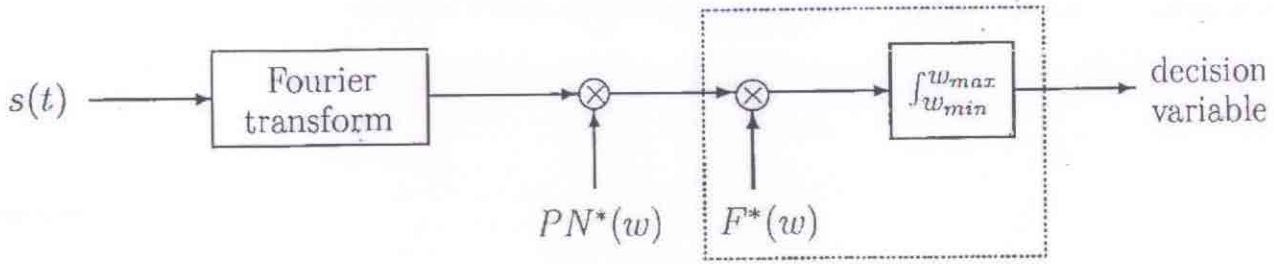
Spectral-Encoded UWB Communication System



Transmitter



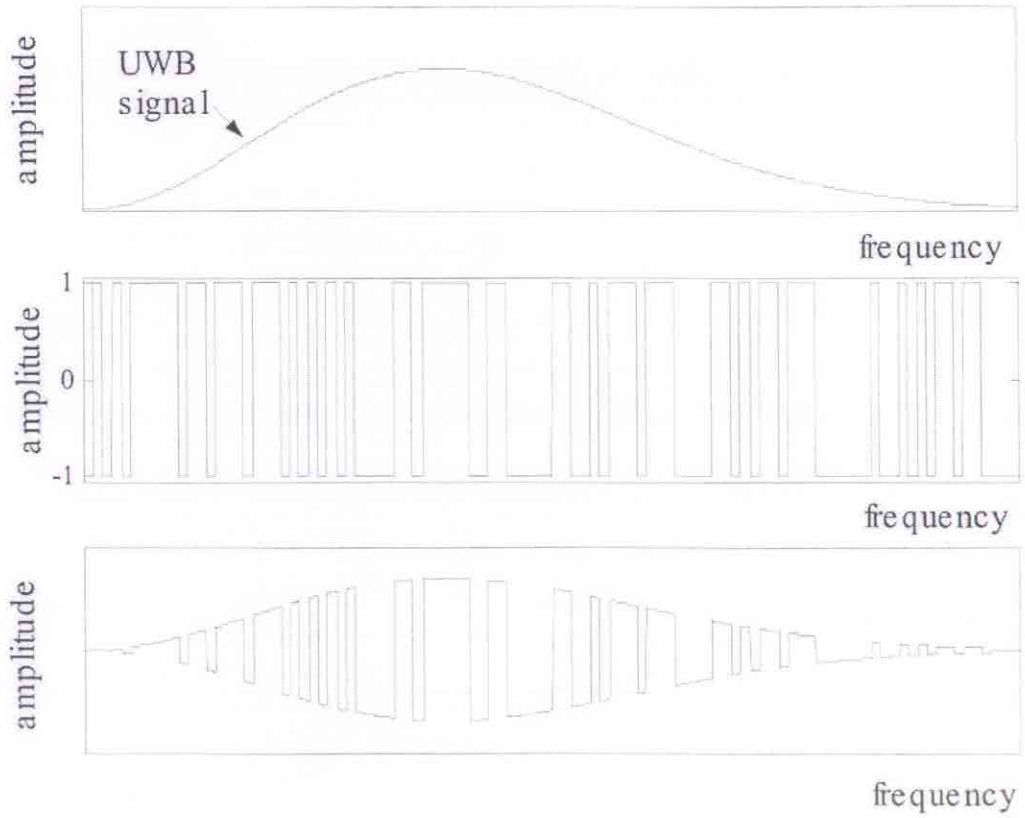
Receiver

Spectral-Encoded UWB Communication System

UWB signal spectrum →

Spreading sequence →

Product (transmitted signal spectrum) →

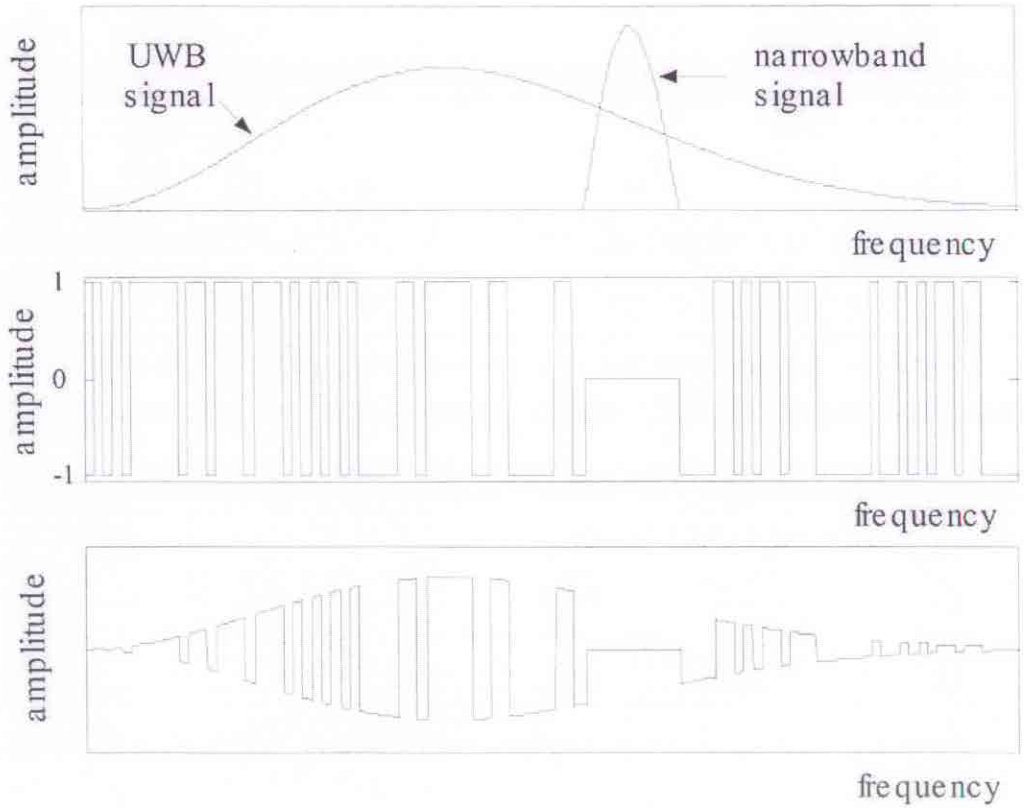


Spectral-Encoded UWB Communication System

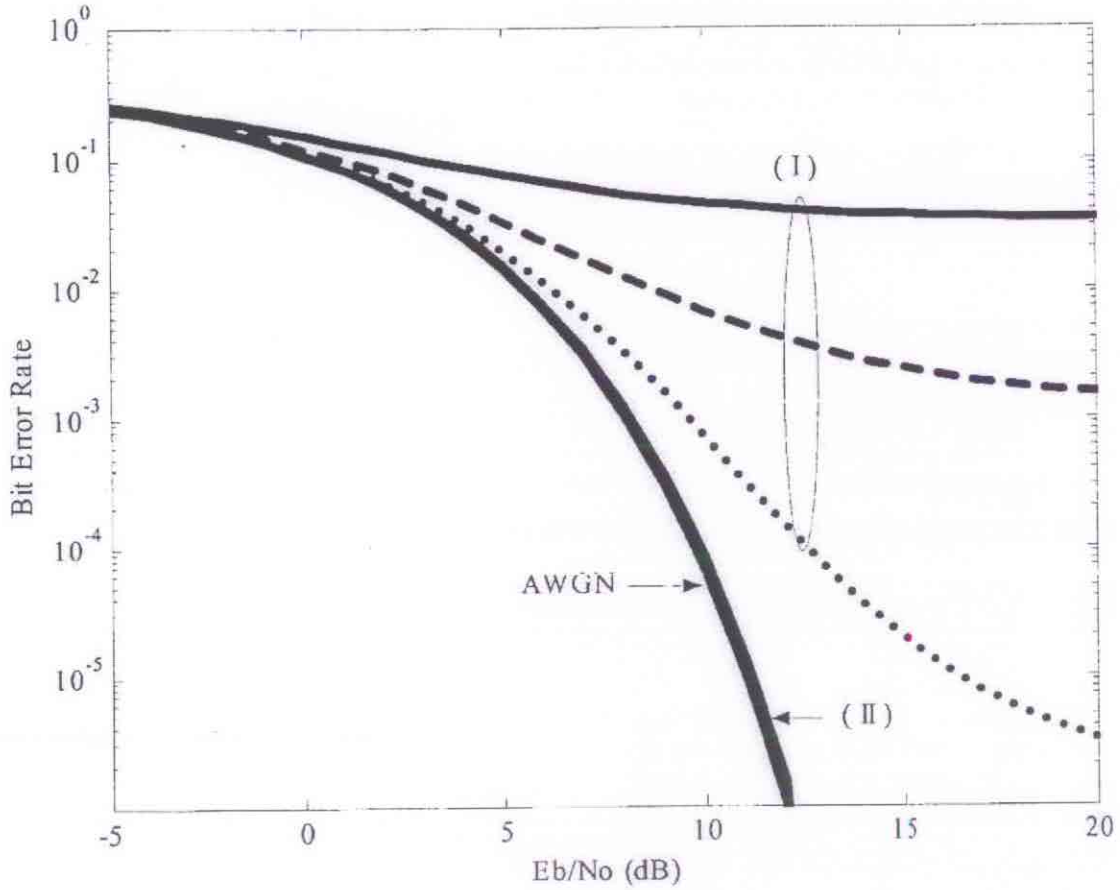
UWB and narrowband signals spectrum →

Spreading sequence →

Product (transmitted signal spectrum) →

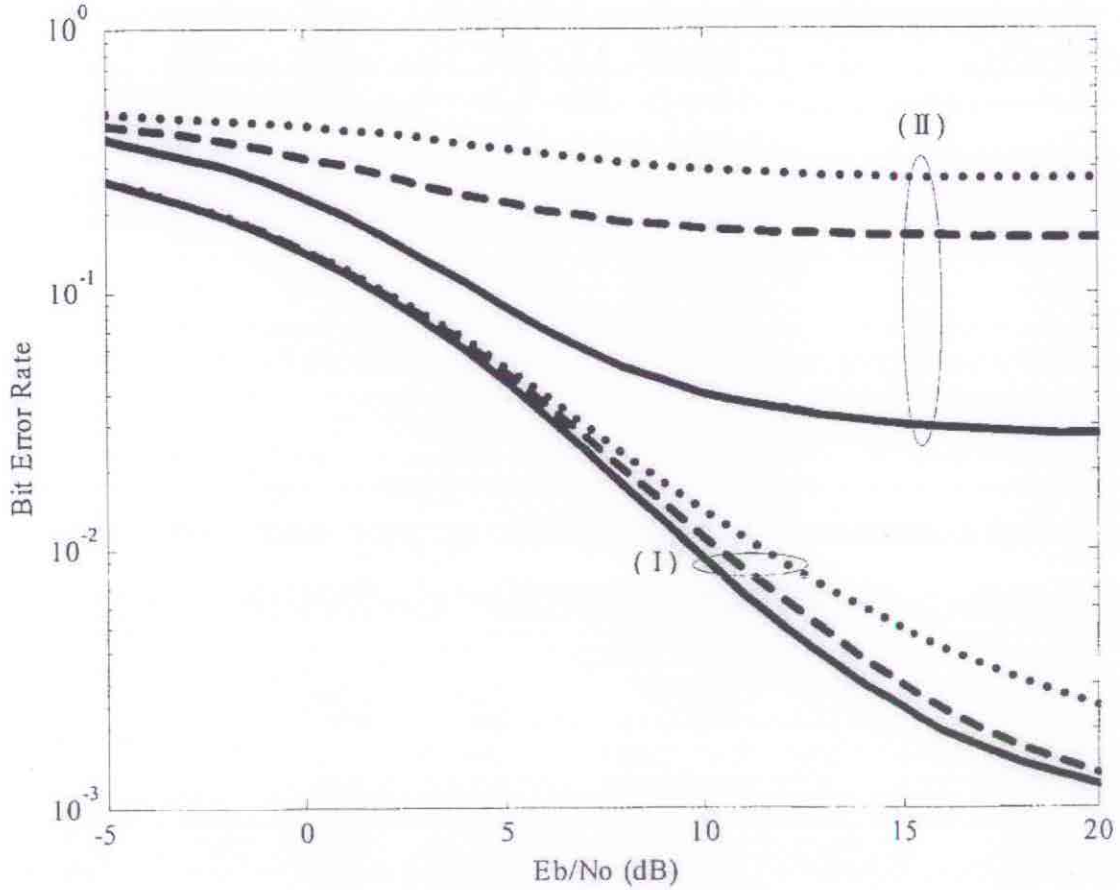


SE UWB Systems: Perfect Channel Estimation



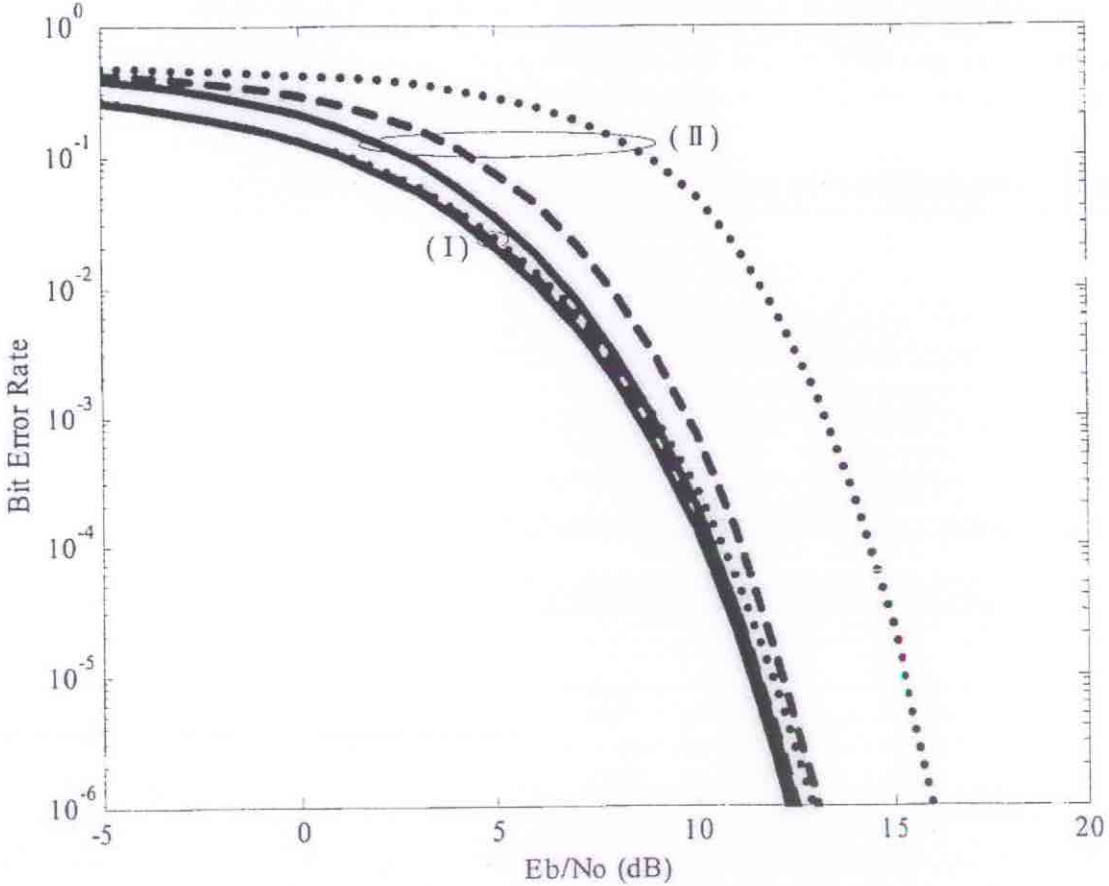
Performance of the spectral-encoded system in the presence of NBI. Perfect channel estimation. The SIR is equal to -5 (dotted lines), -10 (dashed), and -15 dB (solid). (I) no interference suppression, and (II) interference suppression. MRC. Signal and NBI bandwidths are equal to 500 and 10 MHz, respectively. Processing gain: 31.

Imperfect channel estimation. No notch out process.



System performance in the presence of NBI with imperfect channel estimation. No notch out process. (I) MMSE, and (II) SM. MRC. Number of training bits: 1 (dotted lines), 10 (dashed), and 30 (solid). SIR = -10 dB. Signal and NBI bandwidths are equal to 500 and 10 MHz, respectively. Processing gain: 31.

Imperfect Channel Estimation. Notch out process.



System performance in the presence of NBI with imperfect channel estimation. NBI suppression (notch out). (I) MMSE, and (II) SM. MRC. Number of training bits: 1 (dotted lines), 10 (dashed), and 30 (solid). SIR = -10 dB. Signal and NBI bandwidths are equal to 500 and 10 MHz, respectively. Processing gain: 31.

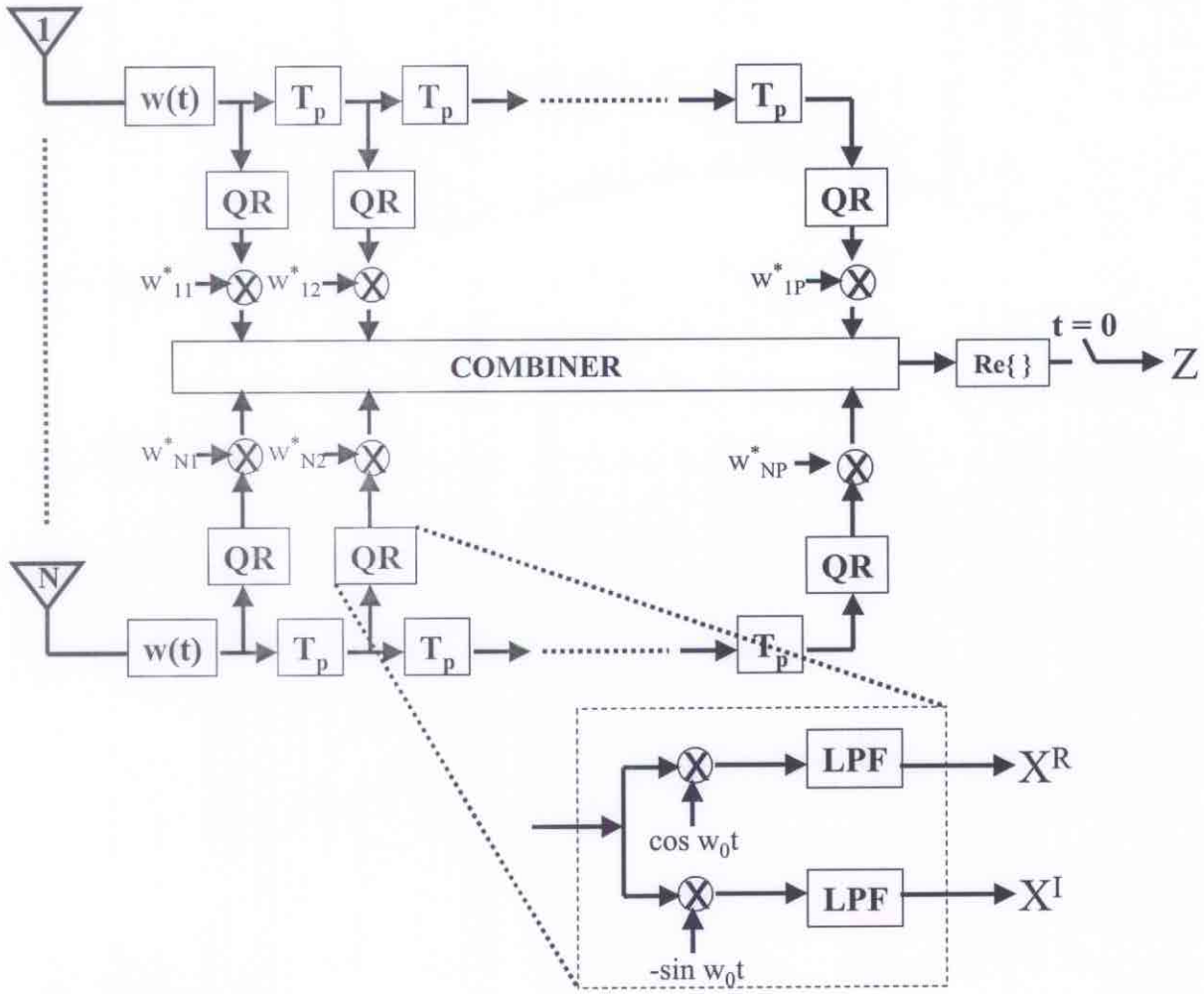


Fig. 2. Array Receiver Structure.

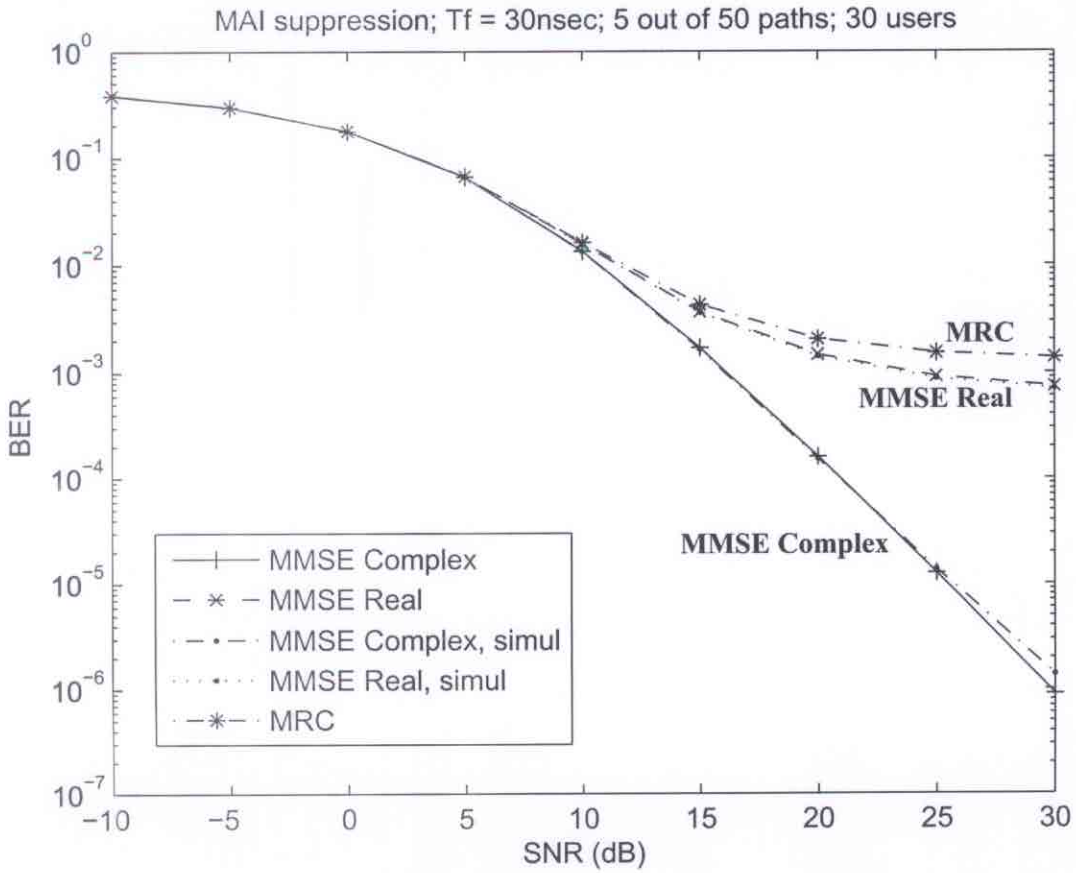


Fig. 4. MAI Mitigation: BER v_s SNR. Gaussian Channel.

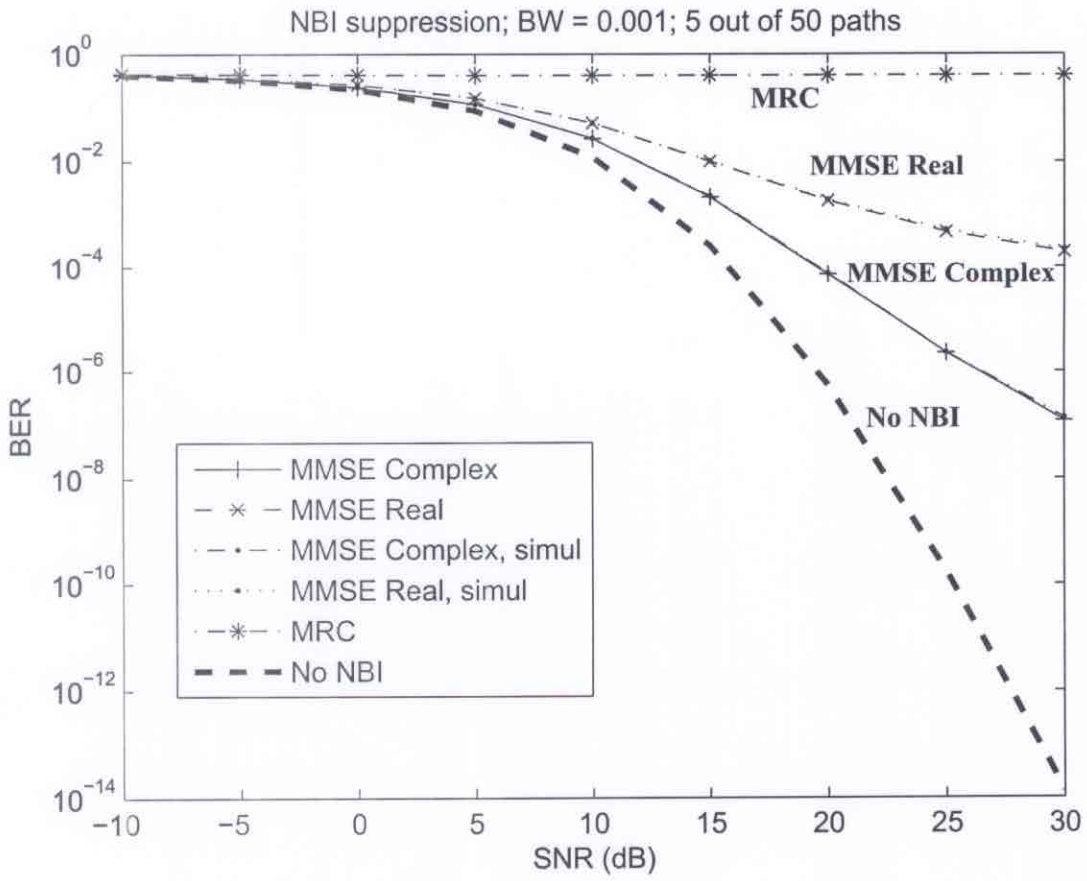


Fig. 8. NBI Suppression: BER v_s SNR. Gaussian Channel, 2 Collected Paths.