Code Shift Keying for High Data Rate Navigation Signal

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Motivation

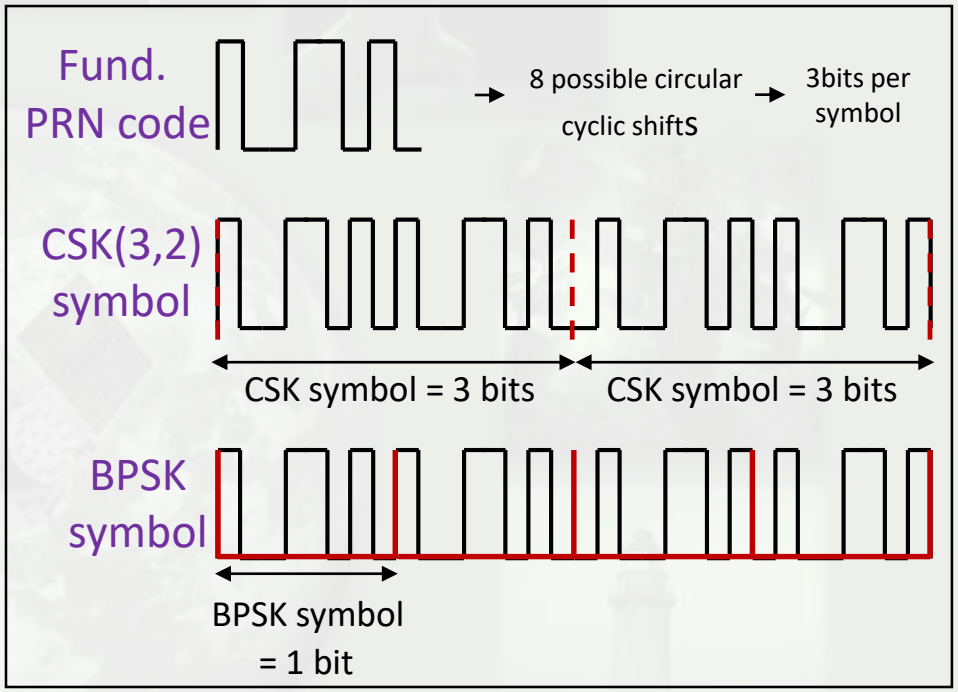
- NavIC provides the basic PNT service with its SPS signals.
- New services demand additional data capacity, which is not available with SPS. Example of such services are:
  - High accuracy service with PPP corrections,
  - Integrity for Safety of life applications,
  - Emergency warning service,
  - Data authentication etc…
- Collectively, these services may require data rates of >1000 bps, which is very high compared to basic PNT services.
- In the context of such requirements; a navigation signal supporting high data rate is being studied and presented.

High Data Rate Navigation Signal

- To provide ***flexible shared data capacity***
  - Sharing of data capacity across variety of services
  - Flexibility in allocating throughput to variety of services
- To provide common physical and data-layer signalling for data based services
- To provide independent means of ranging to support basic PNT functionality.
- Two options for increasing data rate:
  - Increasing chip rate: requires large bandwidth
  - Decrease code length: affects orthogonal properties
- Code Shift Keying (CSK) can support high data rate without affecting signal bandwidth or orthogonal properties of codes.

Code Shift Keying (CSK)

- Each symbol
  - circular code phase shift of fundamental PRN sequence.
- CSK(U,N)
  - U : number of bits per symbol
  - N : number of PRN codes per symbol
  - Increment in bit rate by factor U/N



- FFT based correlator for demodulation

$$Y^i = \text{IFFT}(\text{FFT}(v[k]) \times \text{FFT}(c_d[k])),\ i = 0,\ldots,M-1$$

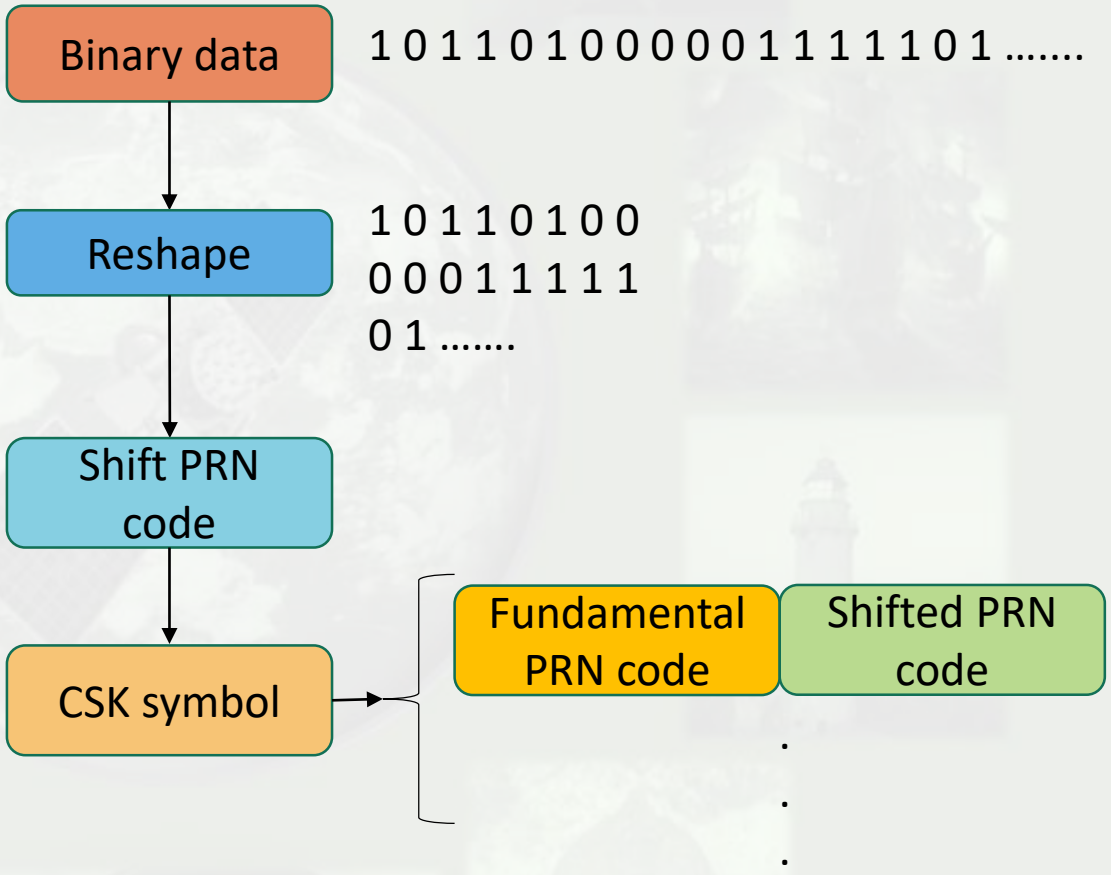
Challenges in CSK

- Classification of code phase shift due to data encoding and signal dynamics.
- The channel delay & Doppler can be estimated from other signals
  - *Needs a dedicated pilot signal.*
- ***Tracking and demodulating a CSK signal without pilot is challenging.***

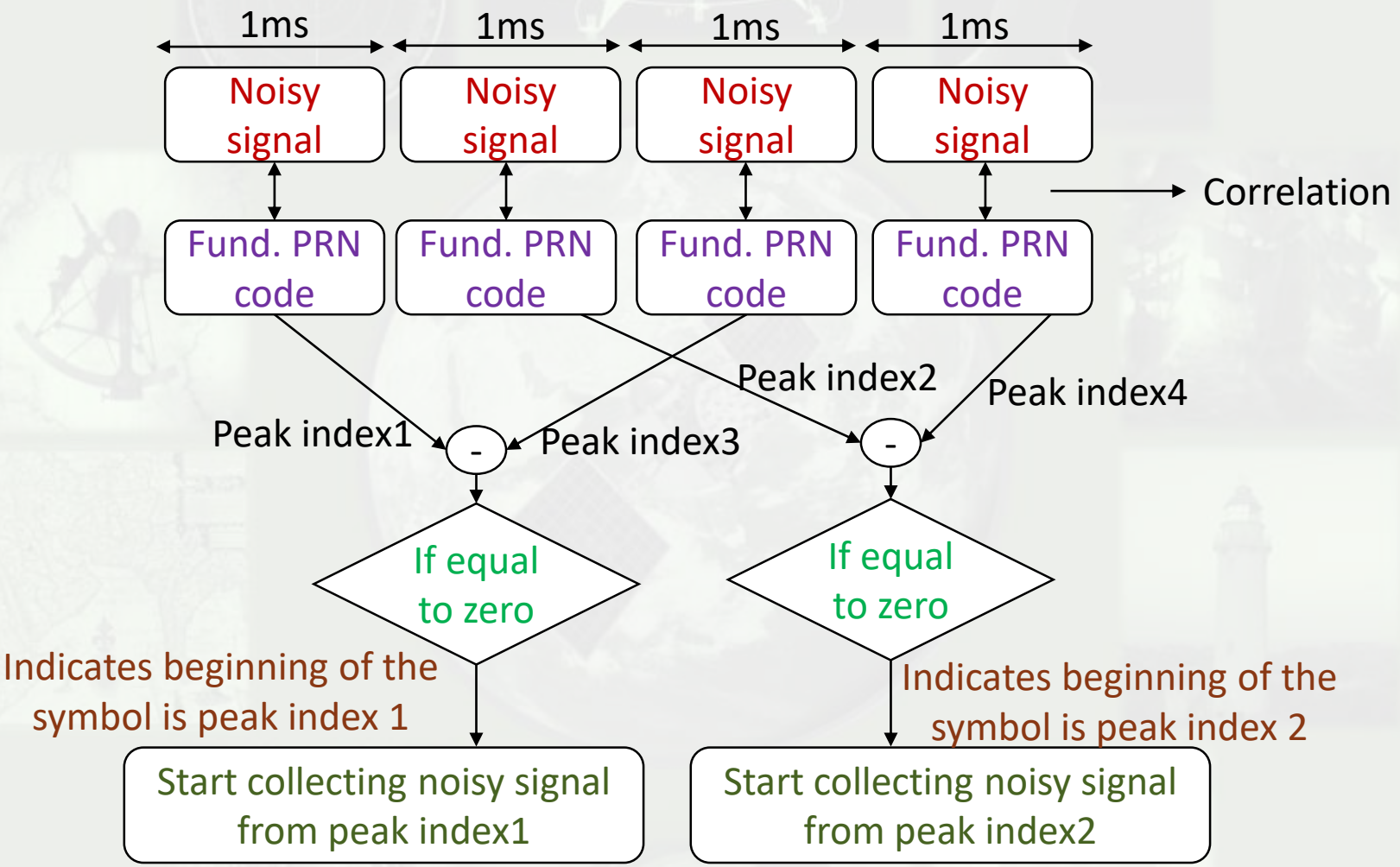
Considering these challenges an approach of multiplexing fundamental PRN code and shifted PRN code in one CSK symbol is proposed.

Proposed CSK Design

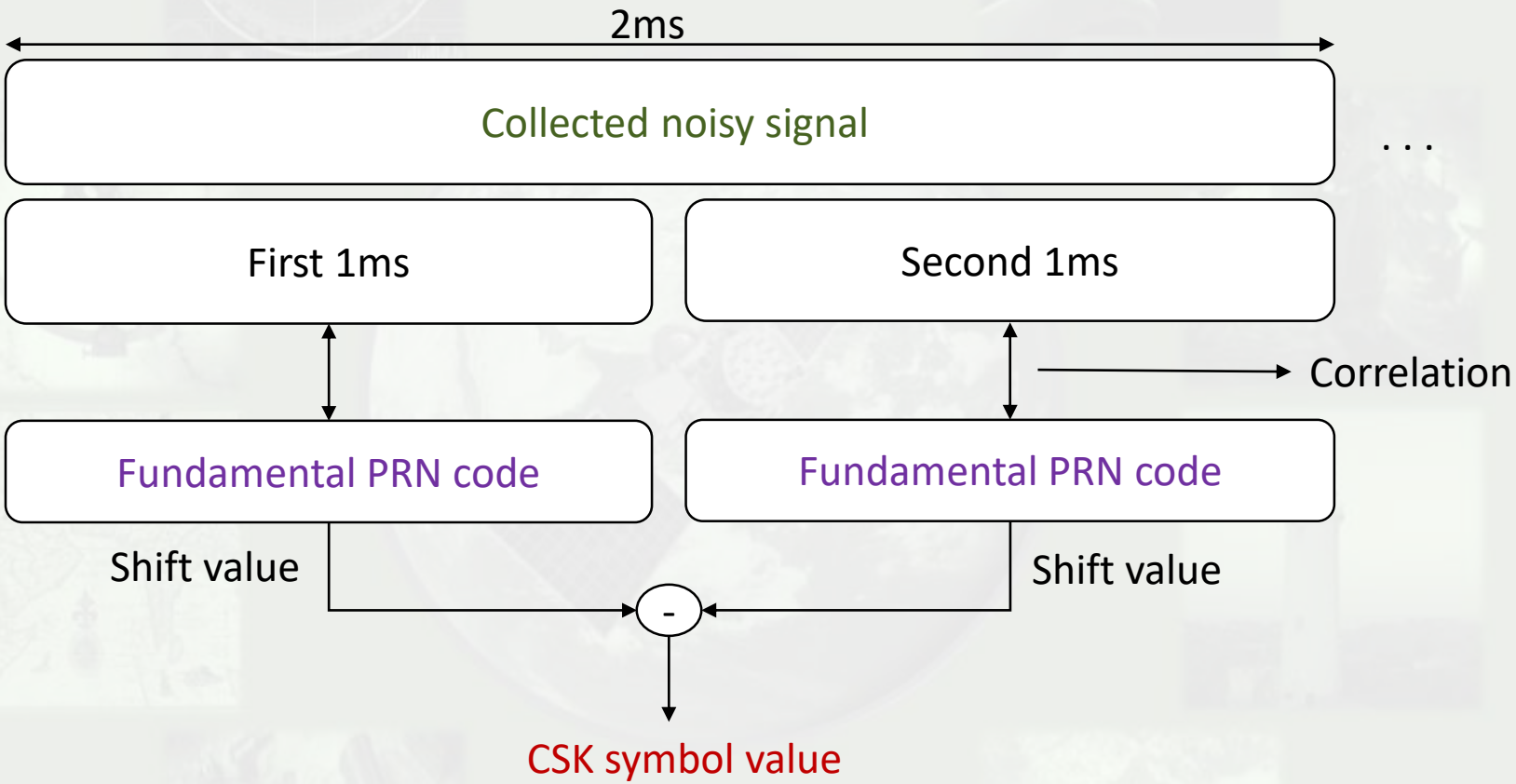
- Characteristics
  - One CSK symbol consists of fundamental PRN code followed by shifted PRN code
  - Shift in the shifted PRN code is the CSK symbol
  - Number of PRN codes in one symbol = 2



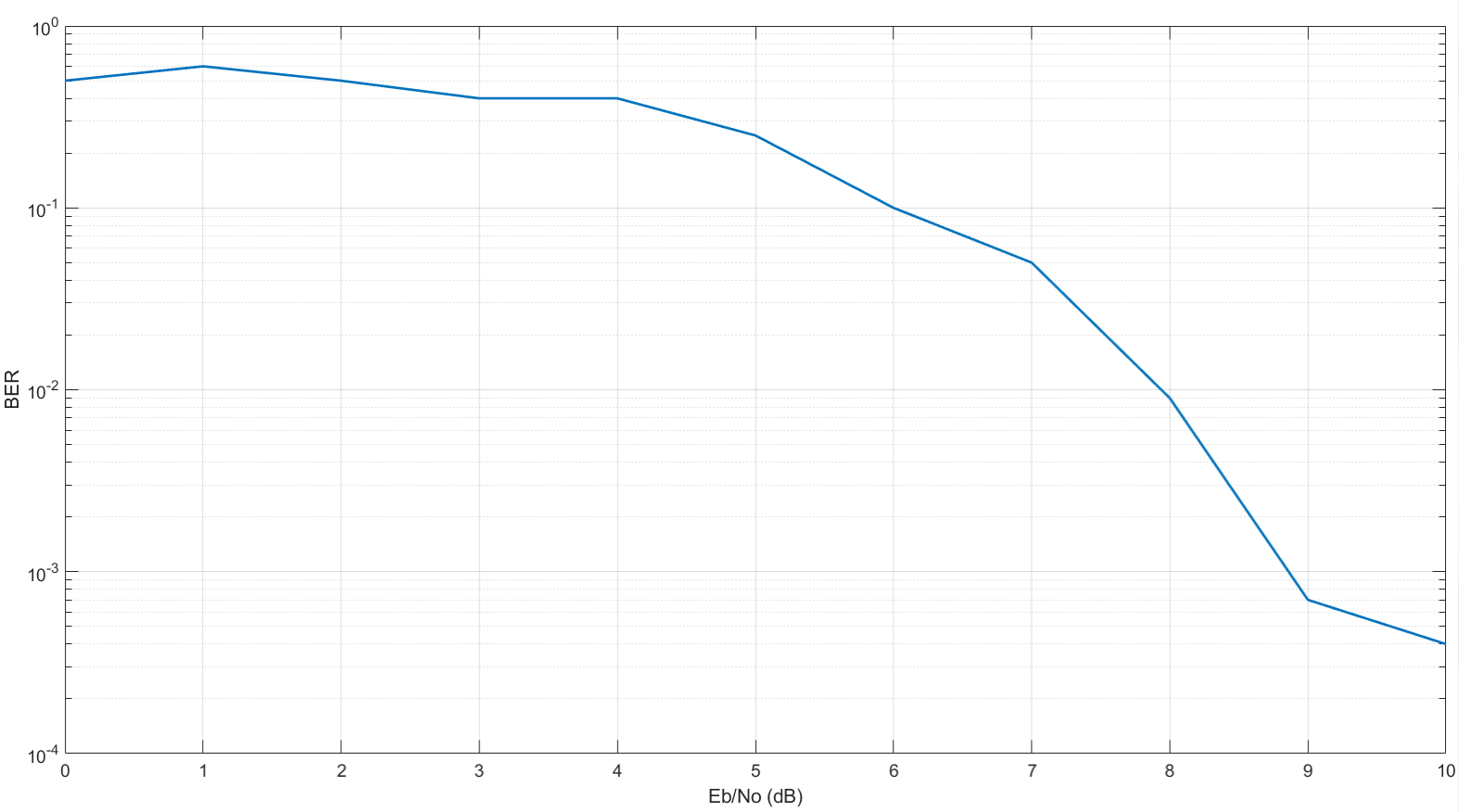
Proposed Design: Symbol boundary



Proposed Design: Demodulation

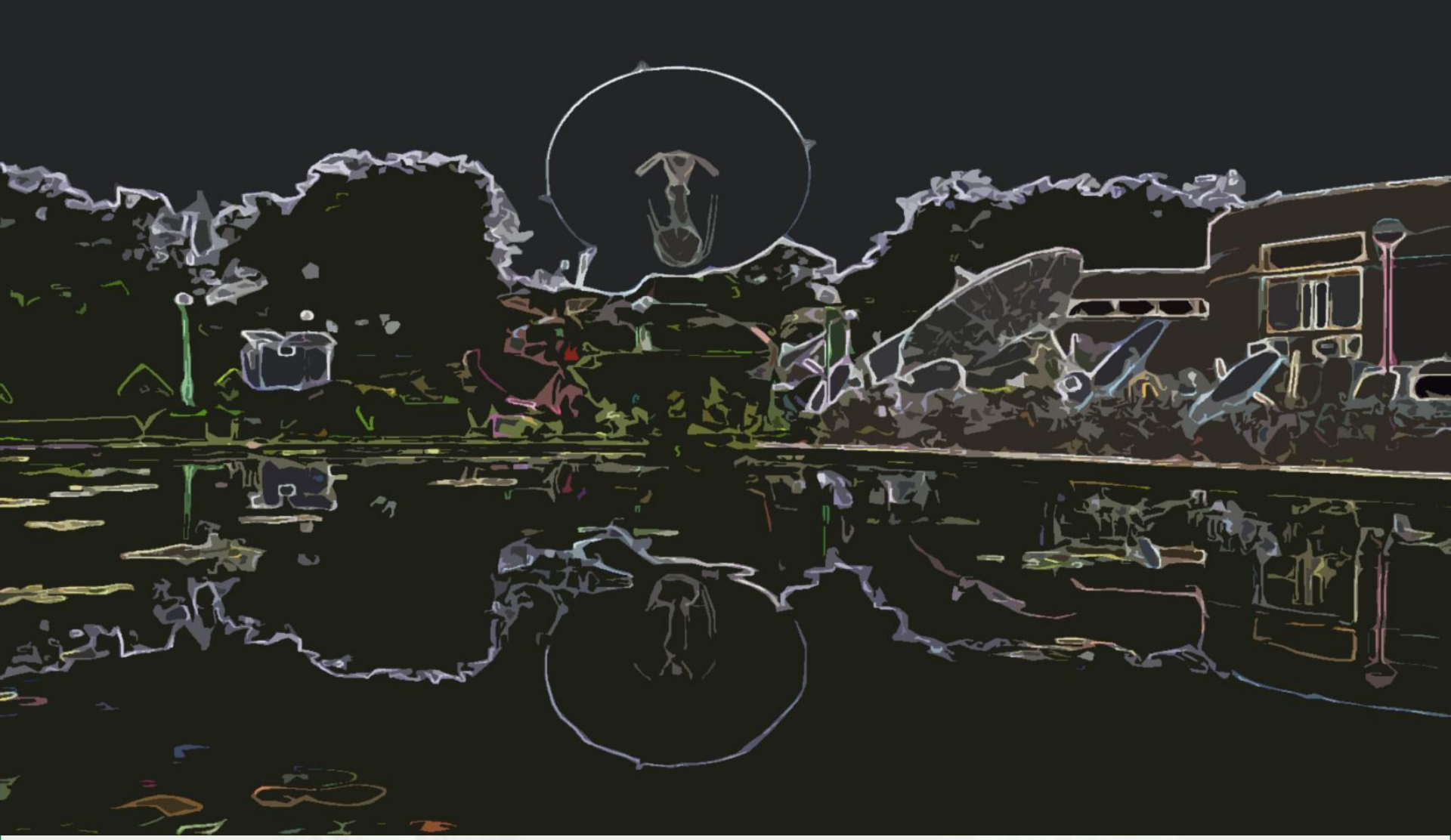


BER performance



Summary

- CSK modulation enables high data rate in navigation signals without affecting bandwidth or correlation properties.
  - However, it is challenging for standalone demodulation under signal dynamics.
- A multiplexed design is proposed to provide symbol boundary estimation and unambiguous demodulation.
  - Due to presence of fundamental PRN code in every symbol, symbol boundary can be established without any delay/Doppler ambiguity.



Thank You for Your Kind Attention

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