Project: IEEE P802.15 Working Group for Wireless Personal Area Networks(WPANs)

Submission Title: Supporting document for FSK-based ranging in TG4m

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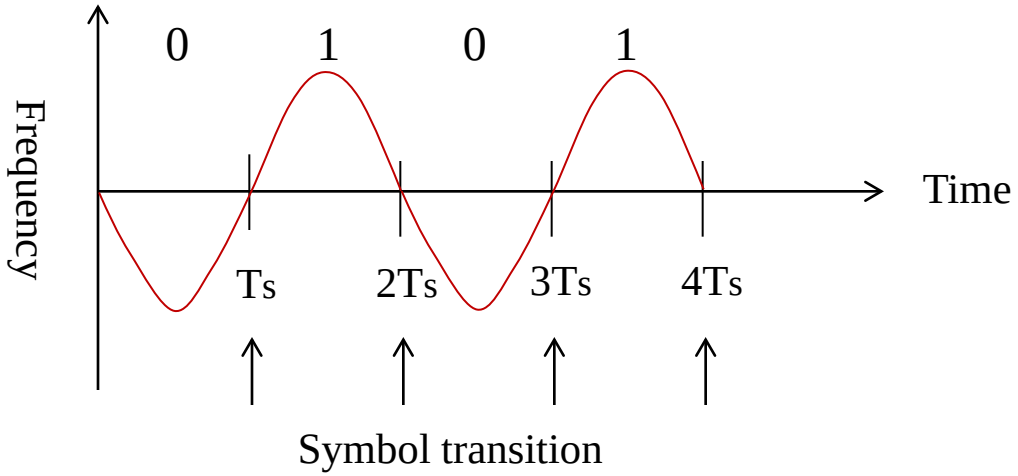
Abstract: This contribution presents a supporting information for FSK-based ranging

Outline

- The goal of this document is to give answers to the questions about FSK-based ranging presented in Doc. 12-334-02
- This document includes
  - Ranging performance in AWGN & Multipath channel environments

Ranging in FSK PHY (1)

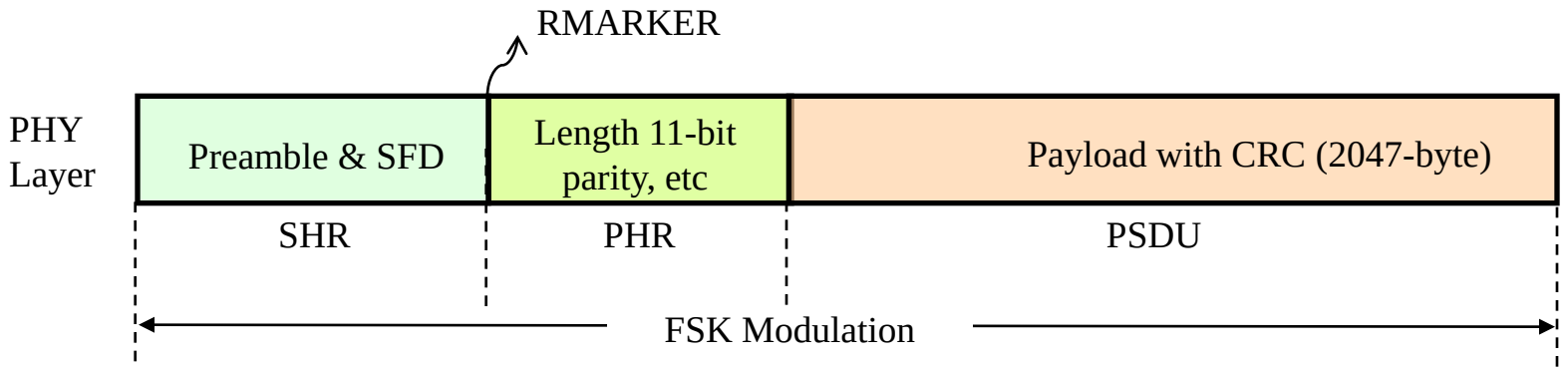
- Ranging sequence
  - Select best sequence for retrieving symbol transition timing
  - Repetition of “01” pattern (preamble-like sequence) would be good



Ranging in FSK PHY (2)

- Ranging sequence
  - Preamble can be used

- FSK PHY Frame



Simulation Environments (1)

- Simulation environments
  - Data rate: FSK 200Kbps
  - Ranging sequence: Preamble
  - Operation clock used in FSK demodulator: 3.2MHz
  - FSK demodulator type
    - Quadricorrelator (QC) based frequency discriminator
    - Frequency discrimination is achieved by applying the FSK signal and a delayed FSK signal to the inputs of a multiplier
    - QC output for the received FSK signal “0” and “1” is represented as phase difference
  - Symbol transition estimation
    - Finding zero phase at QC output
  - No clock drift environment

Simulation Environments (2)

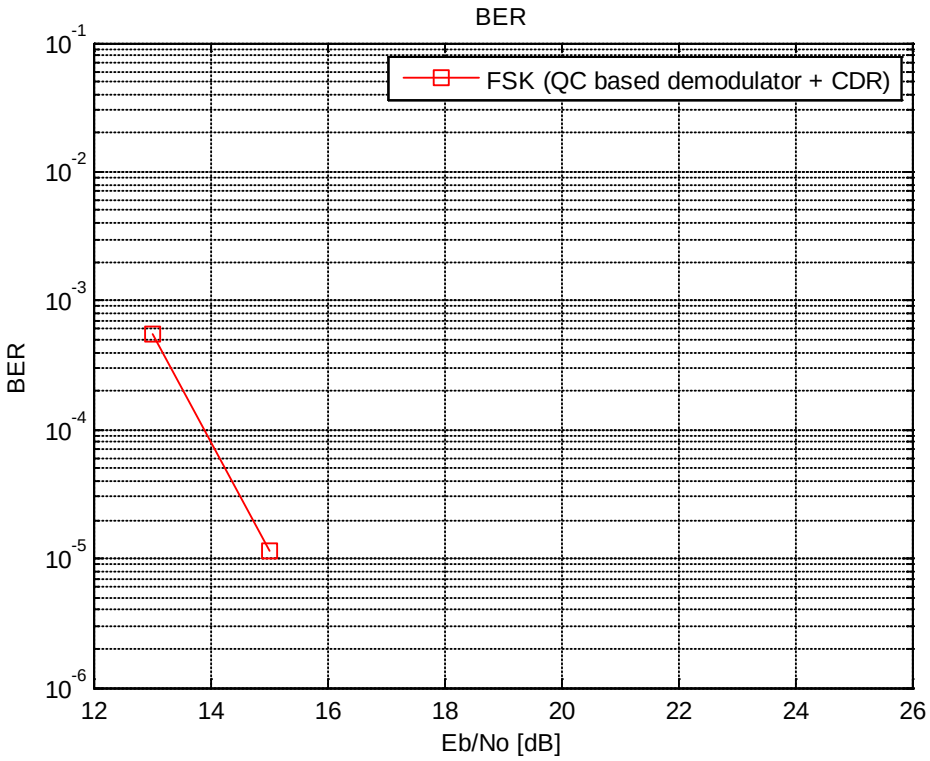
- Channel models
  - 1. AWGN channel
  - 2. Two-ray pseudo-static channel (considered in TG4g SUN)
    - There is only one reflection that occurs about 1us later
    - Average amplitude of the 2nd path is 10dB down on the first
  - 3. Rician fading channel: 3-path model
    - Max. Doppler shift: 100Hz
    - Rician K factor: 5dB
    - Path delay: [0, 1, 2] usec
    - Average path gain: [0, -10, -13] dB

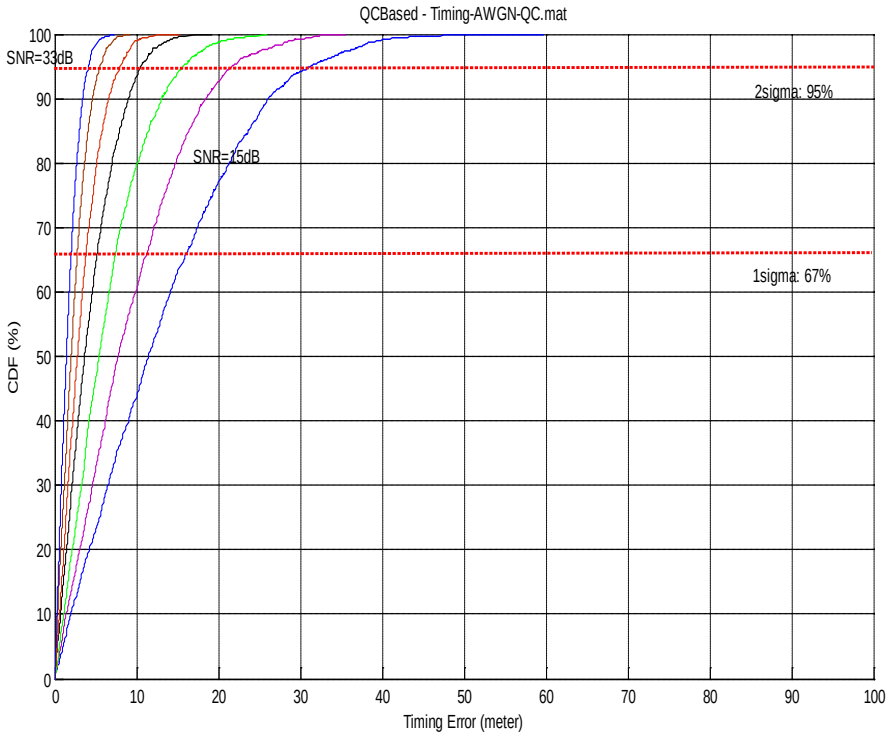
Simulation Environments (3)

- Symbol Transition Estimation
  - TG4m FSK PHY packet format is used
    - No FEC & interleaving, no spreading
  - Symbol transition estimation is performed only for successful packet reception

Simulation Results: AWGN

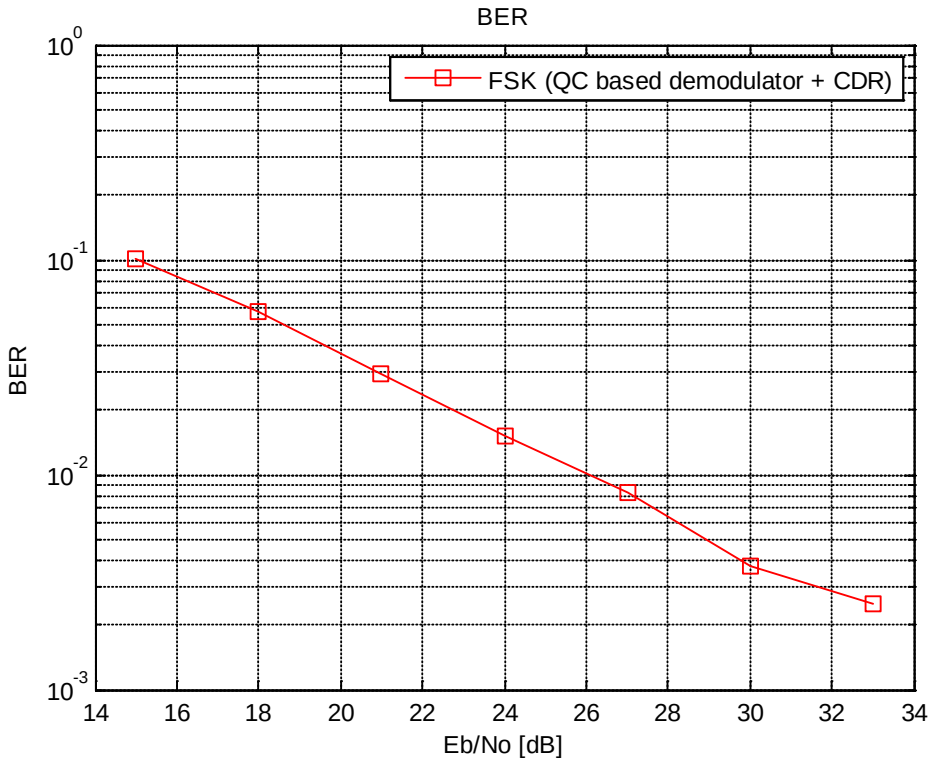
- BER & Timing error (CDF)
  - ±20m ranging accuracy: 2σ probability@SNR18dB

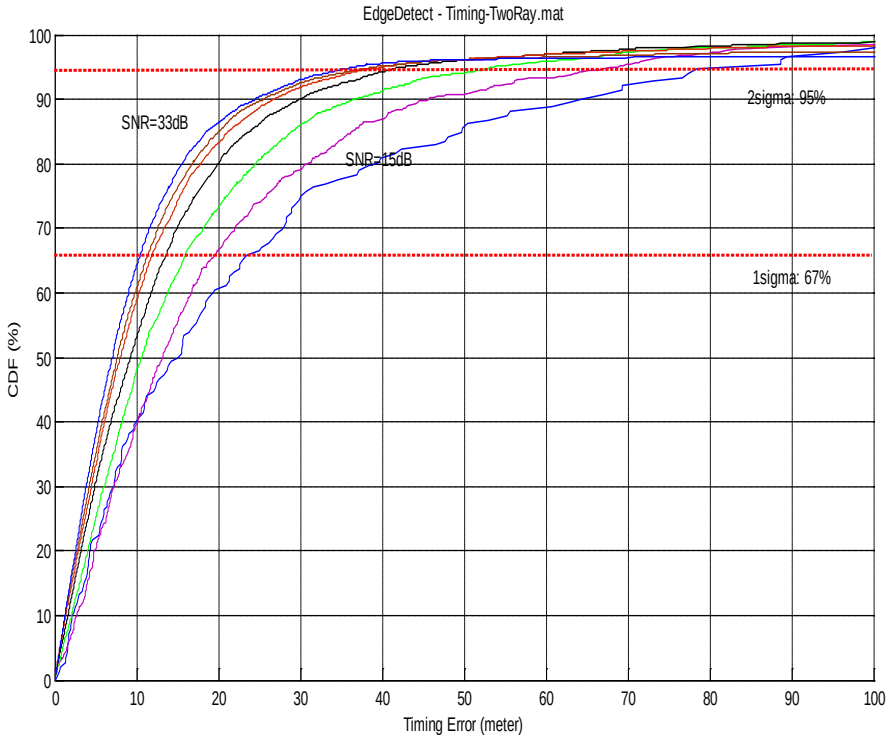




Simulation Results: Two-Ray Pseudo-Static

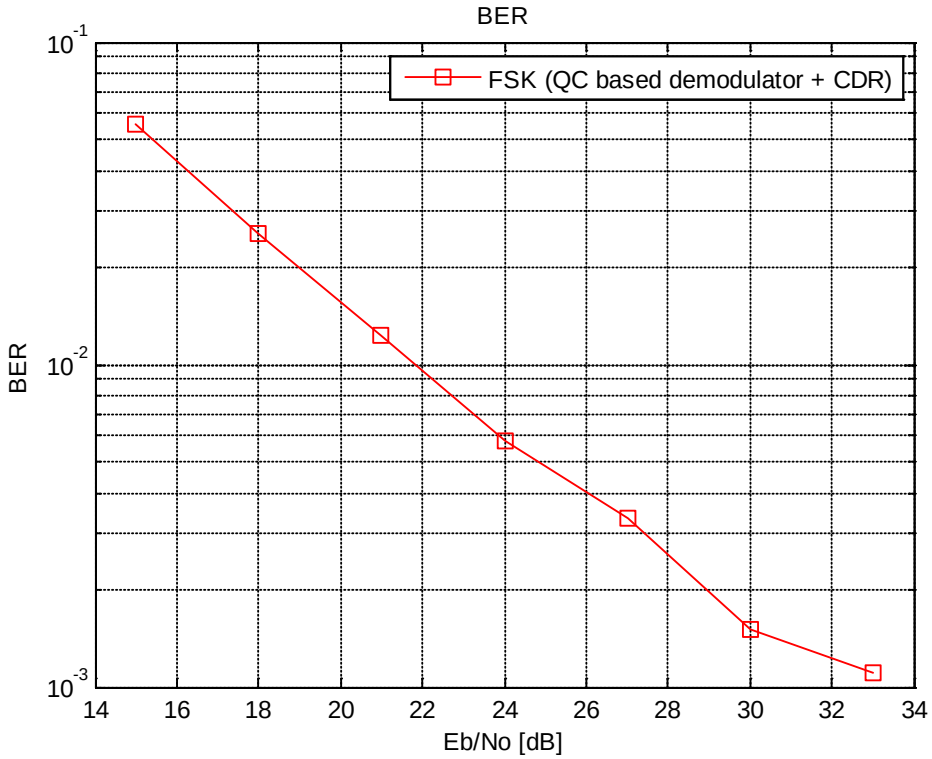
- BER & Timing error (CDF)
  - ±20m ranging accuracy: 1σ probability@SNR18dB

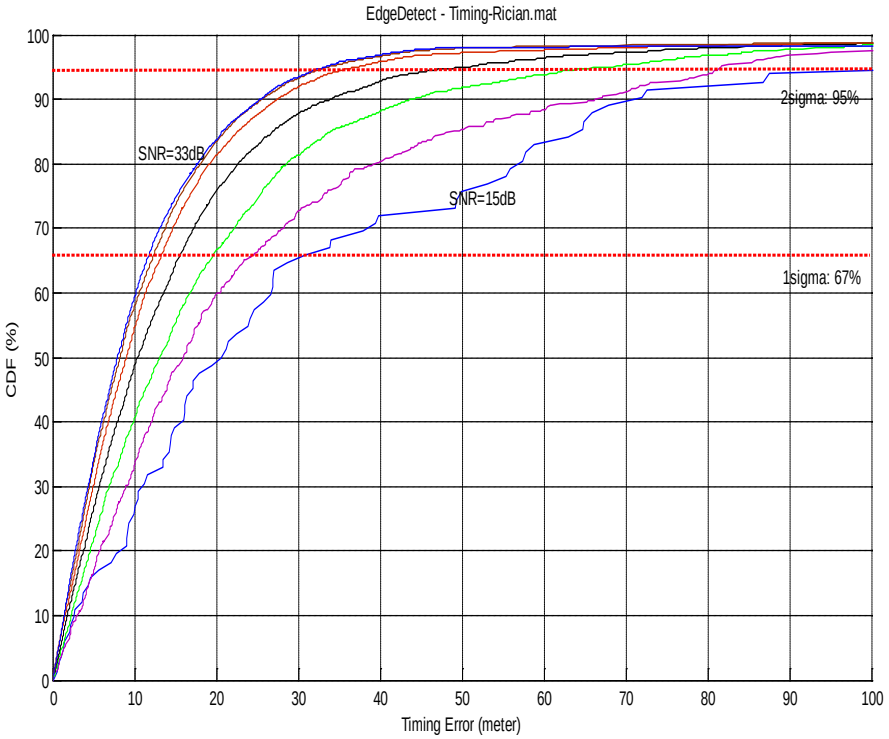




Simulation Results: Rician fading

- BER & Timing error (CDF)
  - ±20m ranging accuracy: 1σ probability@SNR21dB





Simulation Results

- In AWGN channel (LoS environment), the ranging performance is relatively good
- In multipath channels, some mechanisms for better performance would be required