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

Submission Title: [Correlation characteristics of SHR for 802.15.4ad Low Rate (LR) at the receiver and propose a modified SHR]
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Re: [Wireless Next Generation, Long Range extension enhancements to 802.15.4-2020]

Abstract: Discuss the correlation characteristics of SHR for 802.15.4ad Low Rate (LR) at the receiver and propose a modified SHR. A part of this contribution supported from the commissioned research (No. JPJ012368C05101) by National Institute of Information and Communications Technology (NICT) , Japan is included.

Purpose: Discuss the correlation characteristics of SHR for 802.15.4ad Low Rate (LR) at receiver and propose a modified SHR..

Correlation characteristics of SHR for 802.15.4ad Low Rate (LR) at the receiver and propose a modified SHR

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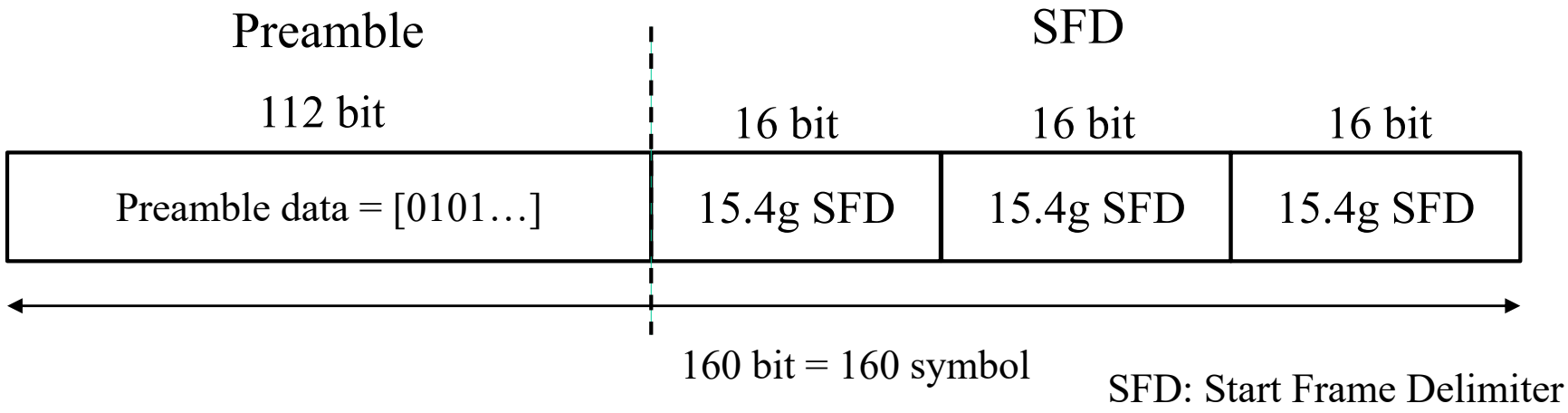
Background

- We have already proposed IEEE 802.15.4 SUN FSK Low Rate (LR) and SUN OFDM LR in 15-25-0035r0
- In these proposals, SHR or STF+LTF uses the SFD used in the existing 802.15.4 SUN FSK
- However, the synchronization characteristics of the receiving side of this SHR have not yet been evaluated.
- In addition, the synchronization characteristics of this SHR at the receiver need to have a good correlation with the SHR used in the existing 802.15.4 SUN FSK
- In this contribution, we show the synchronization characteristics of the IEEE 802.15.4 SUN FSK LR and SHR that we have proposed, as well as the cross-correlation characteristics with the SFD used in the existing 802.15.4 SUN FSK
- In addition, as reference data, we show the cross-correlation characteristics of the other SHRs proposed for the SUN OFDM LR and the SFD used in the existing 802.15.4 SUN FSK

Proposal for SHR in 15-25-0035r0

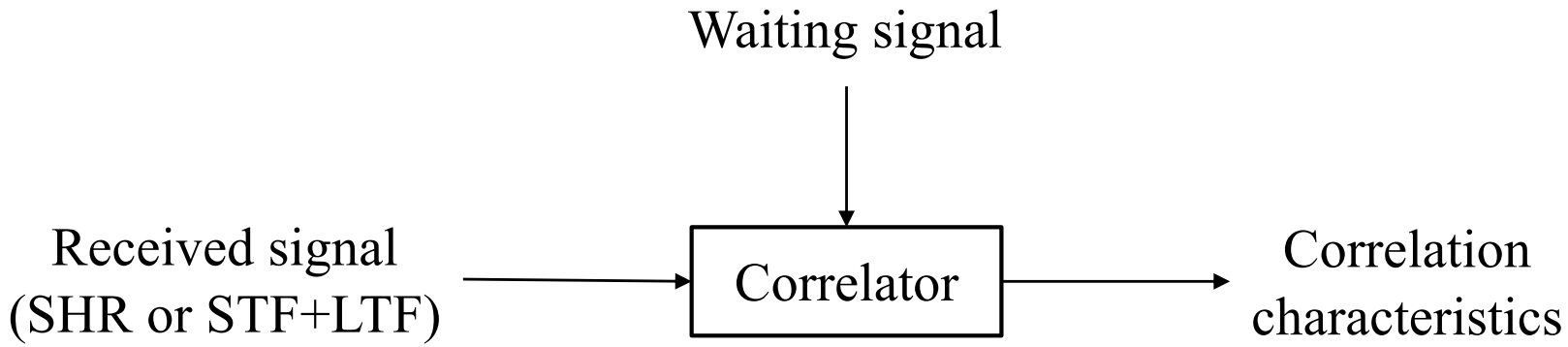


- From Doc.:15-25-0035r0
- It has been shown in discussions at 15.4k that long-distance transmission is possible with 3 octet or more SFDs. (Doc:15-12-0030r0)
- The characteristics of each SFD have already been evaluated in discussions at 15.4g, and their characteristics are well known
- Basically, different ones should be used, but some of the same ones may be used

Requirements for Good SHR

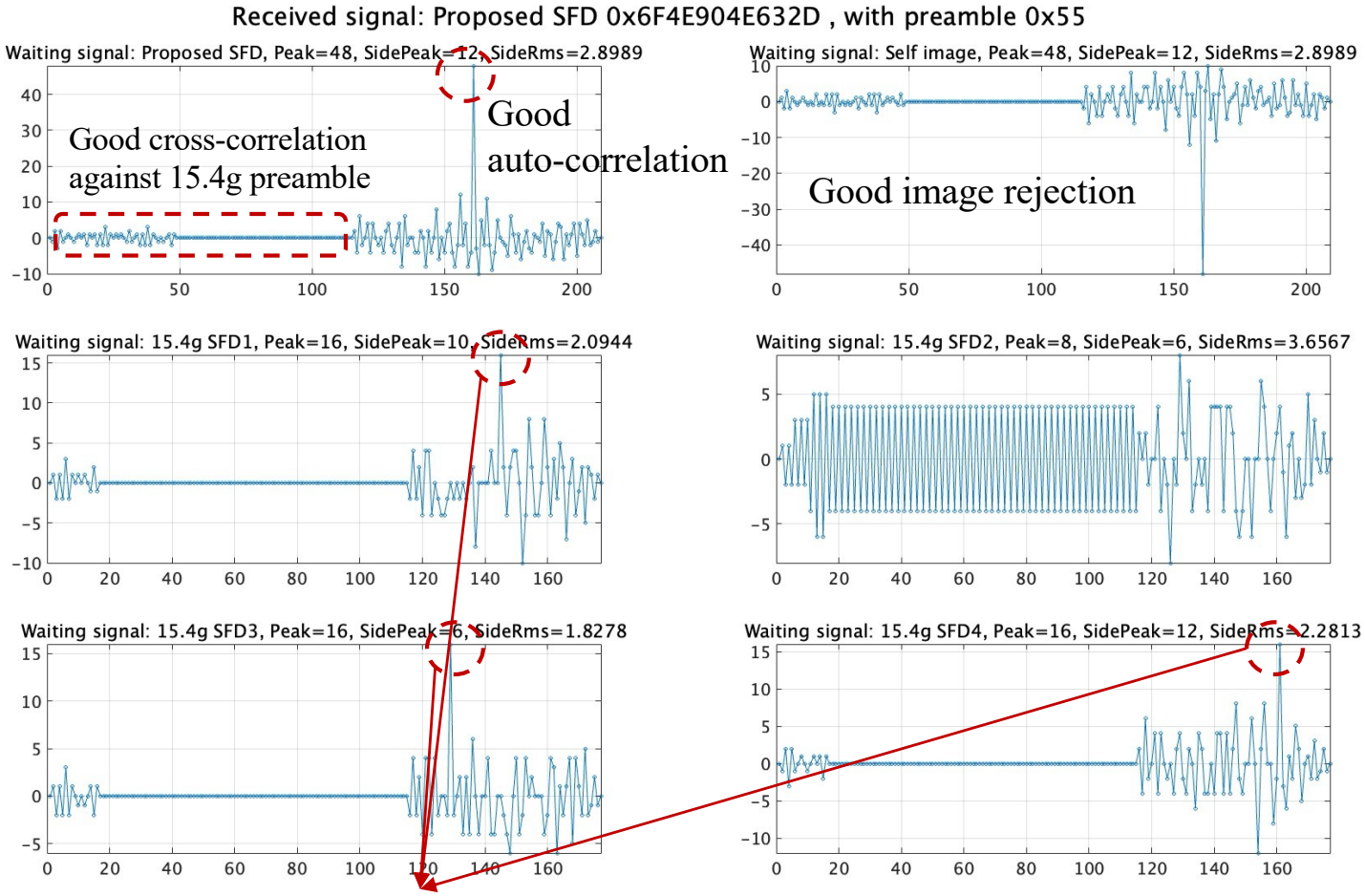
- Requirement for 802.15.4g SFD[1]
  - Good auto-correlation of individual sequence
  - Good cross-correlation between the selected sequences
  - Good image rejection of all auto- and cross-correlations
  - Good cross-correlation against preamble
- Requirement for 802.15.4ad SUN LR SHR (or STF-LTF)
  - Same as the above requirement for 802.15.4g SFD
  - Need for it to have good correlation with the SFD used in the existing 802.15.4 SUN.
  - Have sufficient margin for the PER characteristics of the payload section of 802.15.4ad SUN LR
- As in the case of 15.4g, it is necessary to investigate the correlation characteristics between the proposed SHR and the existing SFD.(Doc.:15-10-0112r1)

Overview of correlation performance evaluation



- At the correlator values above the threshold is detected
- Use six types of waiting signals.
  - Proposed SHR
  - Self image of proposed SHR
  - SFD1 (mandatory, uncoded): 0x904E
  - SFD2 (mandatory, coded): 0x7A0E
  - SFD3 (optional, uncoded): 0x6F4E
  - SFD4 (optional, coded): 0x632D

Correlation characteristics for SHR in 15-25-0035r0



If the 15.4g SFD is a waiting signal, the correlation peak is 16.

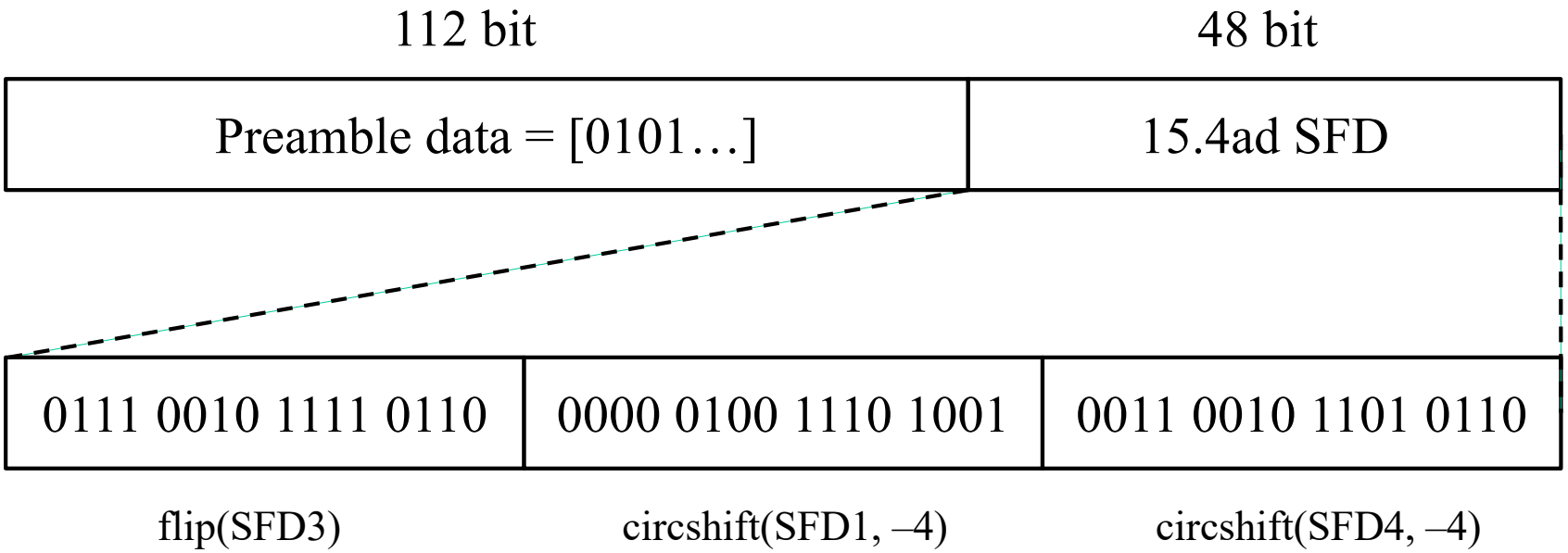
Correlation characteristics for SHR in 15-25-0035r0

- Advanced points
  - Auto-correlation of individual sequence
  - Image rejection of all auto- and cross-correlations
  - Cross-correlation against 15.4g Preamble
- However, the peak in the case that a waiting signal is 15.4g SFD is 16
  - Because the 15.4g SFD is reused
- Because the peak of the cross-correlation characteristics between 15.4g SFDs is a maximum of 8, it is necessary to achieve lower the cross-correlation peak between the 15.4ad SHR and the 15.4g SFD to around 8

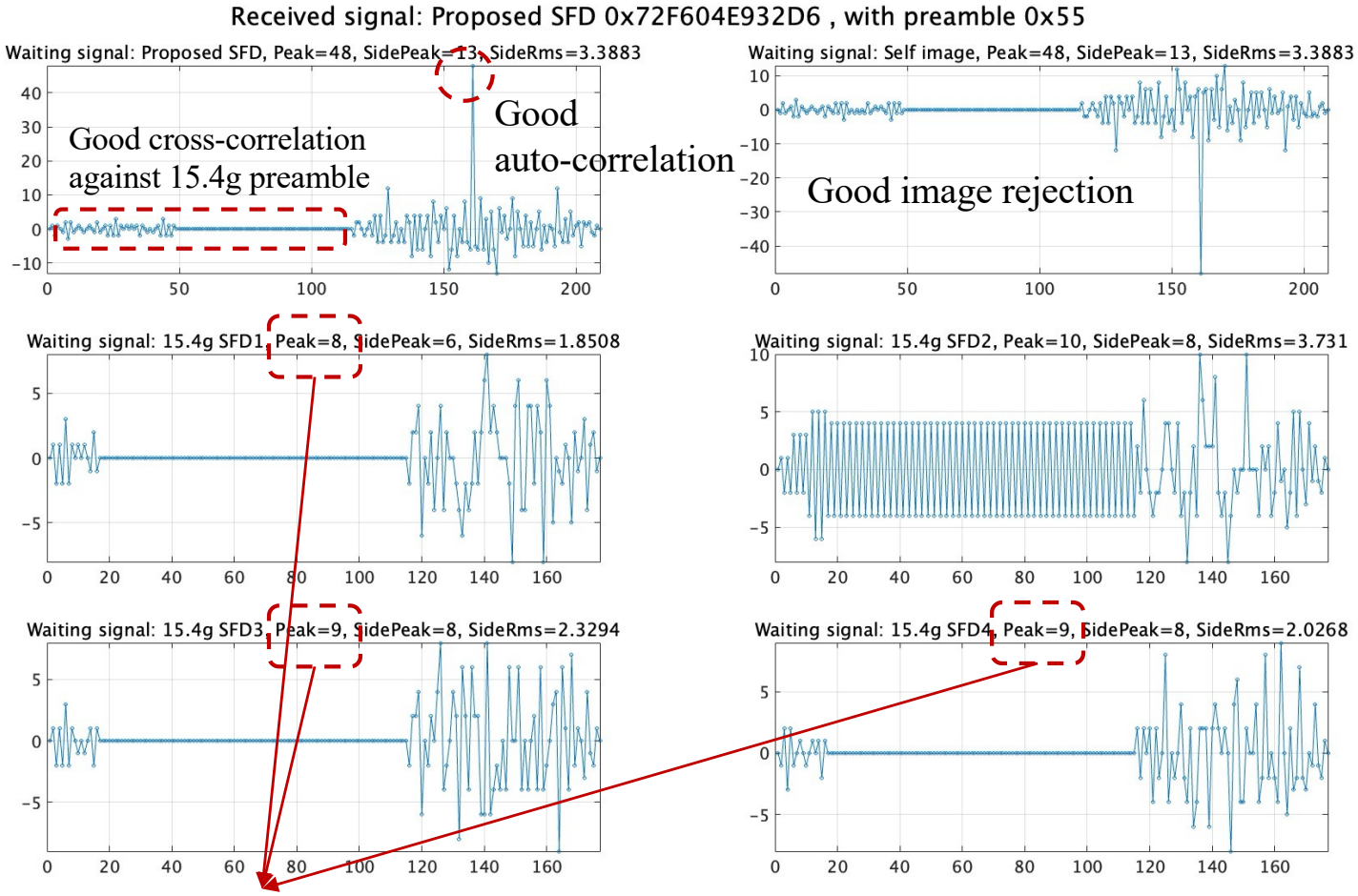
Proposal for modified SHR

- This proposal is a modification of our SHR proposal, and it designs a 15.4ad SFD that does not interfere with the existing SFDs
- Apply the following simple transformations to the 15.4g SFD
  - flip(A): reverses the order of the elements in A
  - circshift(A, K): Circularly shifts the elements in array A by K positions
- The modifications are simple, but are designed so as not to lose the excellent properties of the 15.4g SFD (in terms of the requirements of page 5).

Modified SHR



Correlation characteristics for modified SHR



moderate cross-correlation peak with 15.4g SFD

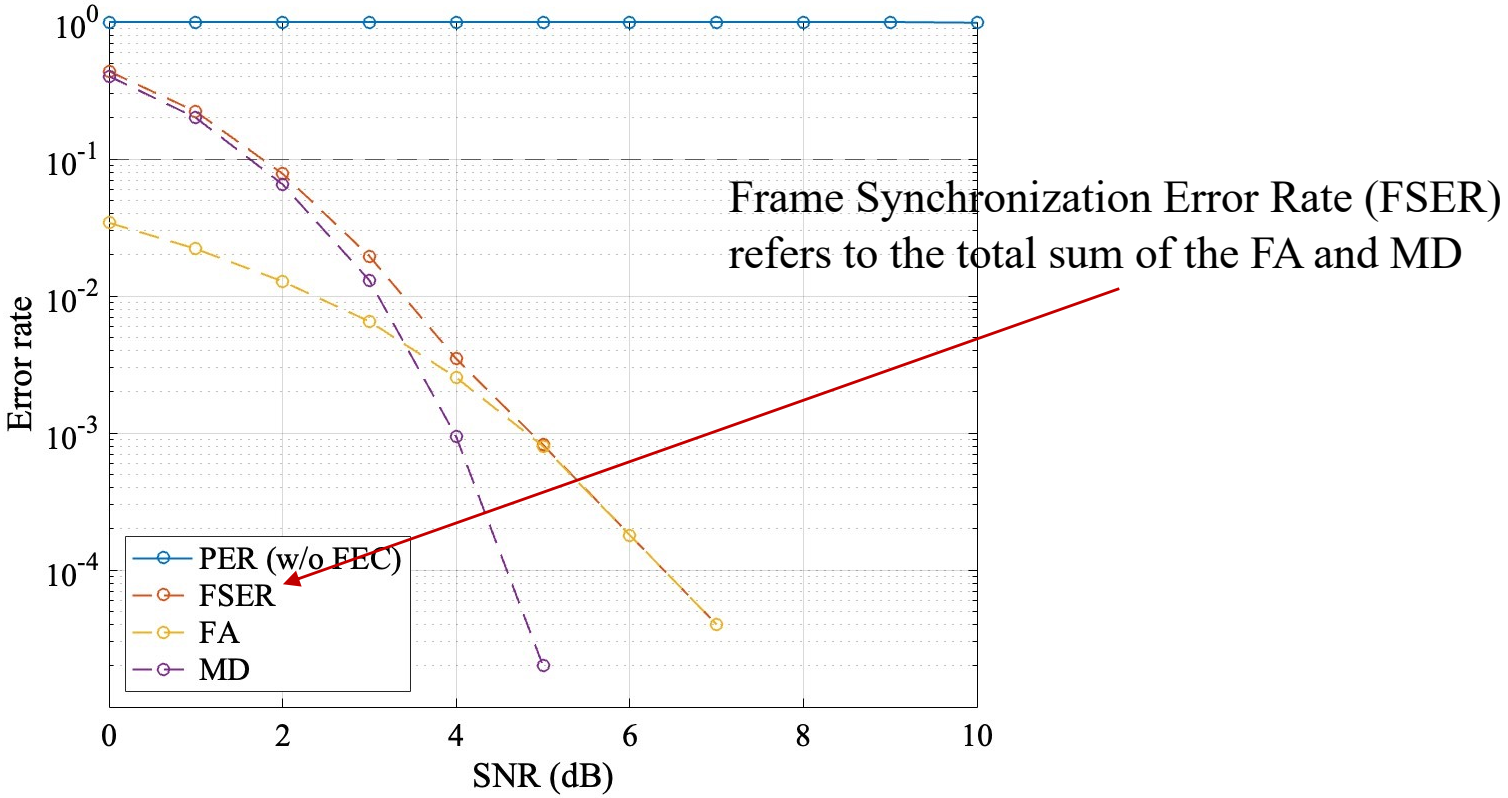
SNR and received signal power conversion

- In the case of Noise Figure (NF) =0dB and bandwidth =31.25/3 kHz, noise power should be -133.8 dB
- The conversion between SNR and received signal power is shown as follows

SNR(dB)	Received power (dBm)
-10	-143.8 dBm
-5	-138.8 dBm
0	-133.8 dBm
5	-128.8 dBm
10	-123.3 dBm

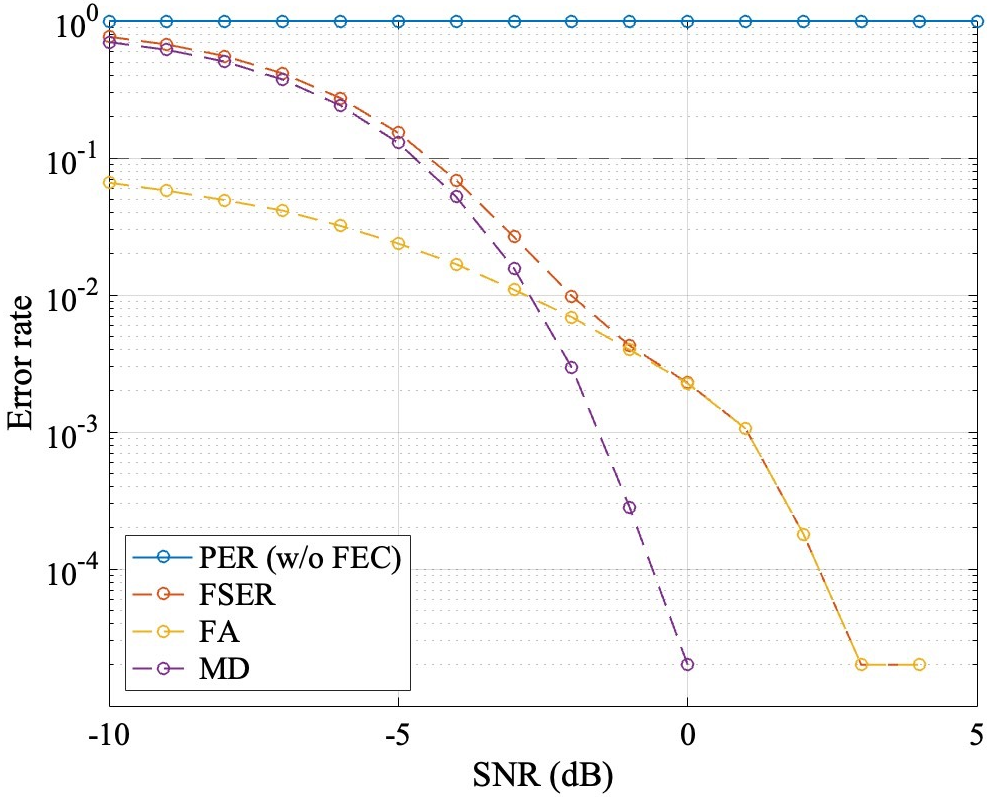
FA and MD characteristics of modified SHR (2-GFSK)

- False Alarm (FA) and Miss Detection (MD) characteristics against the SNR with threshold = 22



FA and MD characteristics of modified SHR (BPSK)

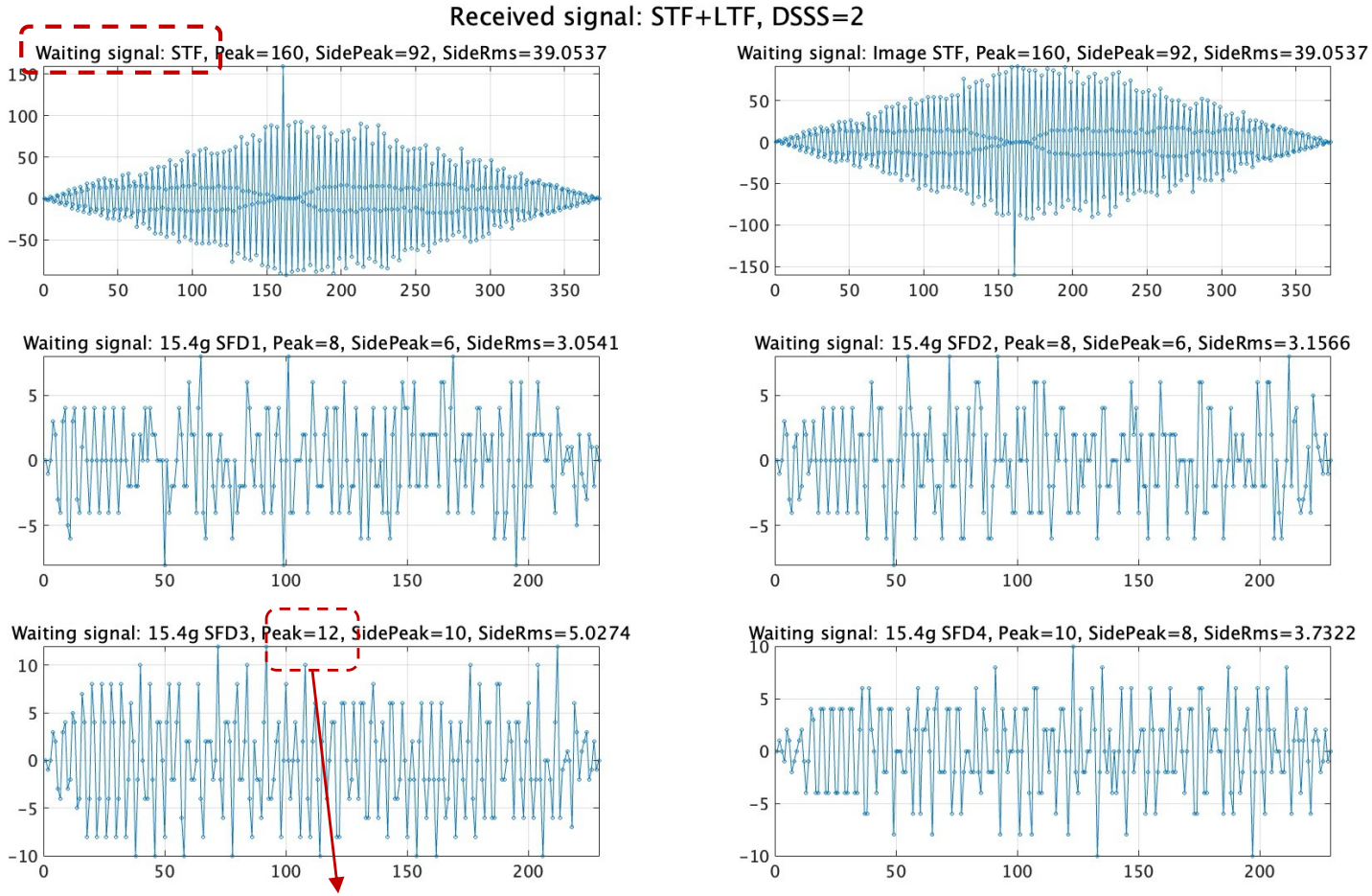
- FA and MD characteristics against the SNR with threshold = 22



Appendix

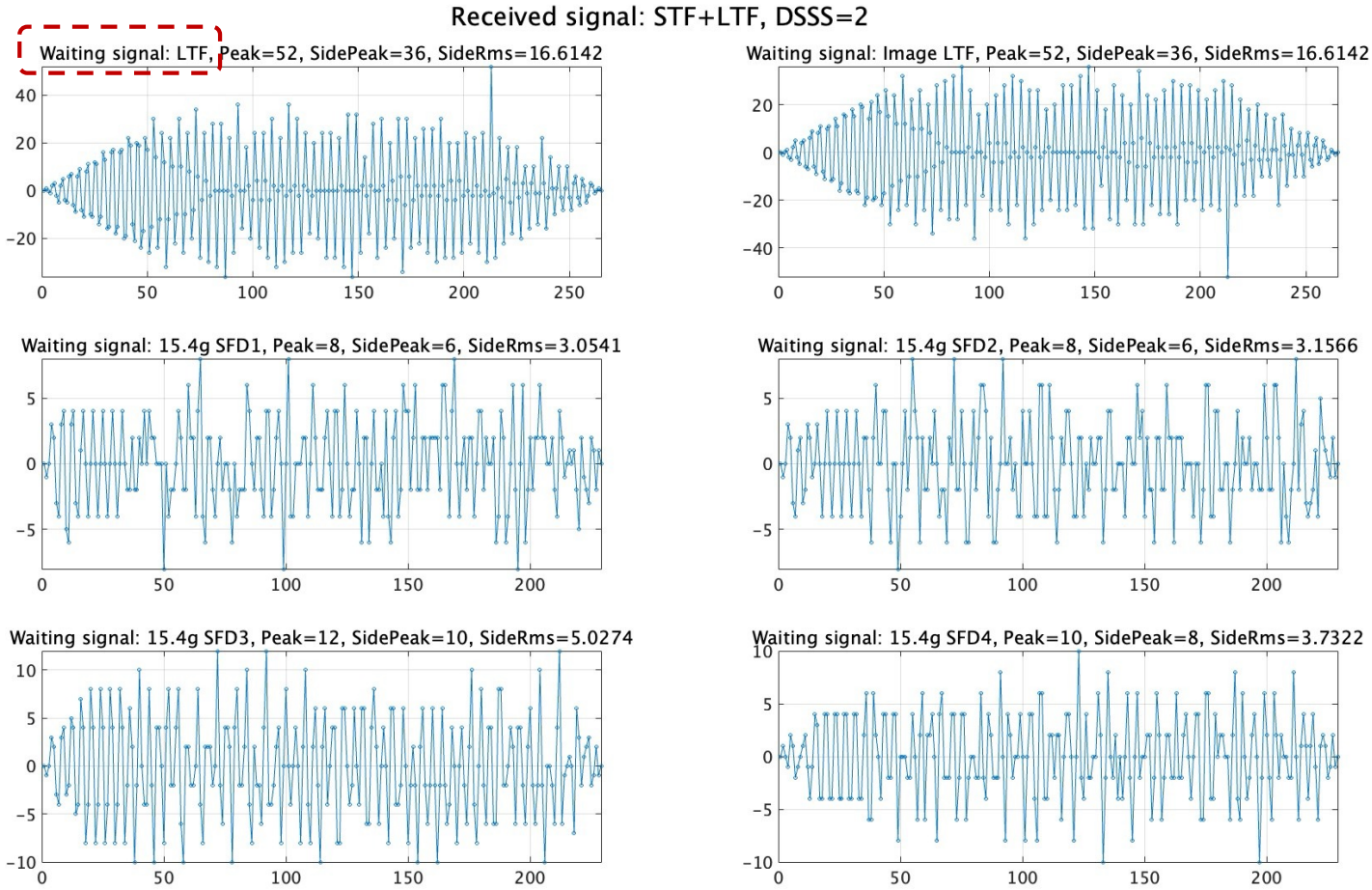
- Correlation characteristics when using 15-24-0651r0 (By TI)
- Correlation characteristics when using 15.4g SFD
- FA and MD of 15.4g SHR
- Threshold decision for modified SHR

Correlation characteristics when using 15-24-0651r0



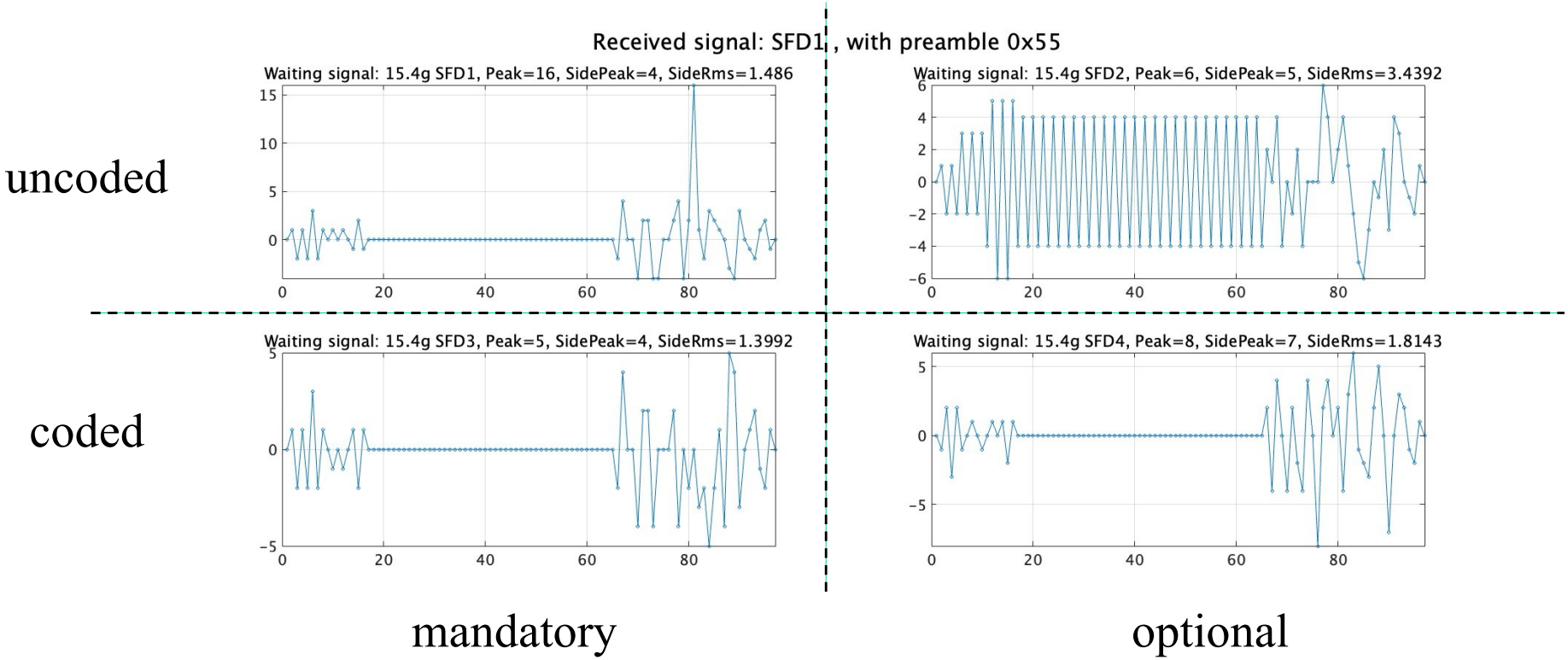
cross-correlation peak of 12 with mandatory 15.4g SFD

Correlation characteristics when using 15-24-0651r0



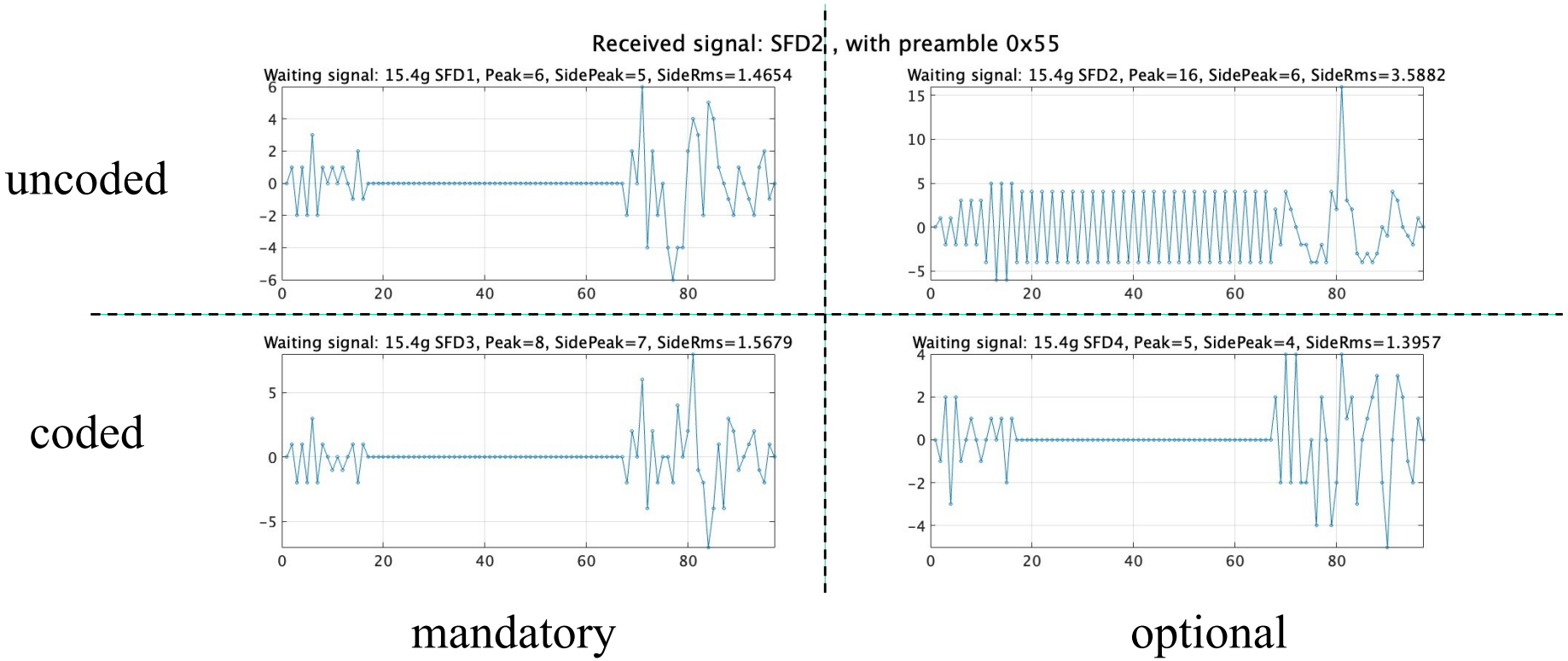
Correlation characteristics when using 15.4g SFD

- Received signal: 15.4g preamble + 15.4g SFD1
- Waiting signal: SFD 1,2,3,and 4



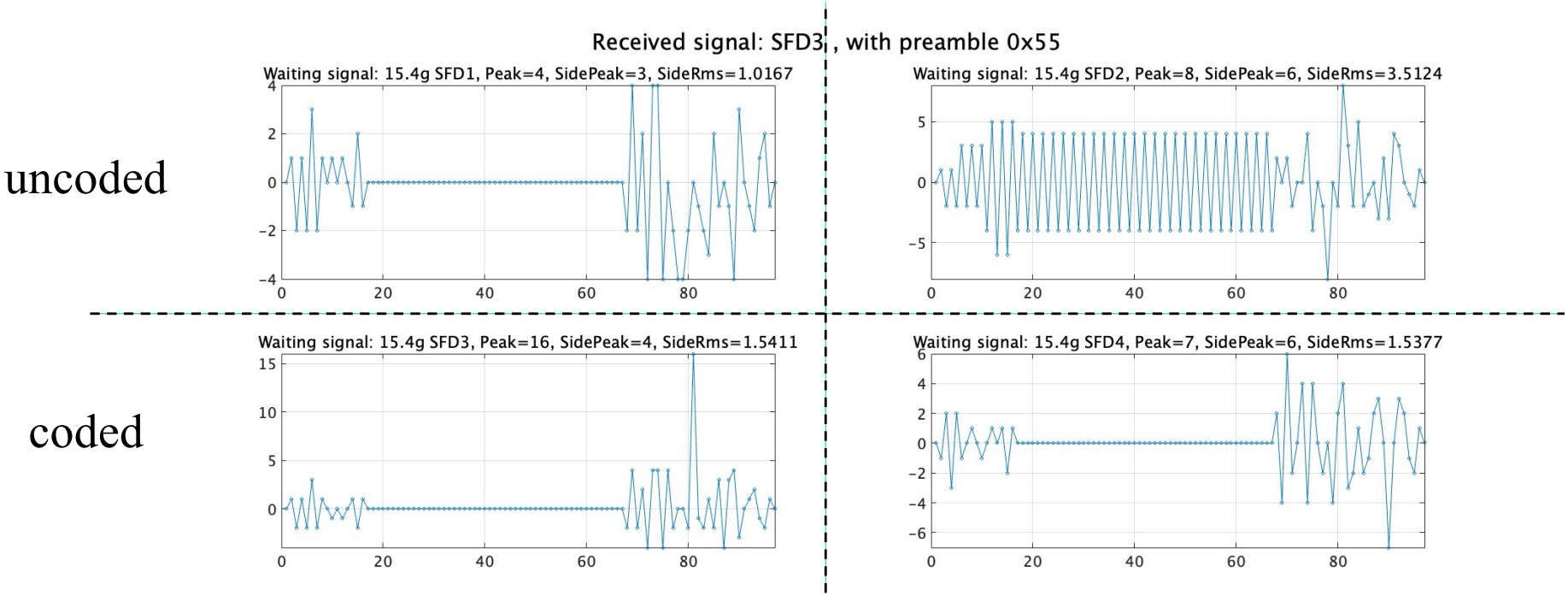
Correlation characteristics when using 15.4g SFD

- Received signal: 15.4g preamble + 15.4g SFD2
- Waiting signal: SFD 1,2,3,and 4



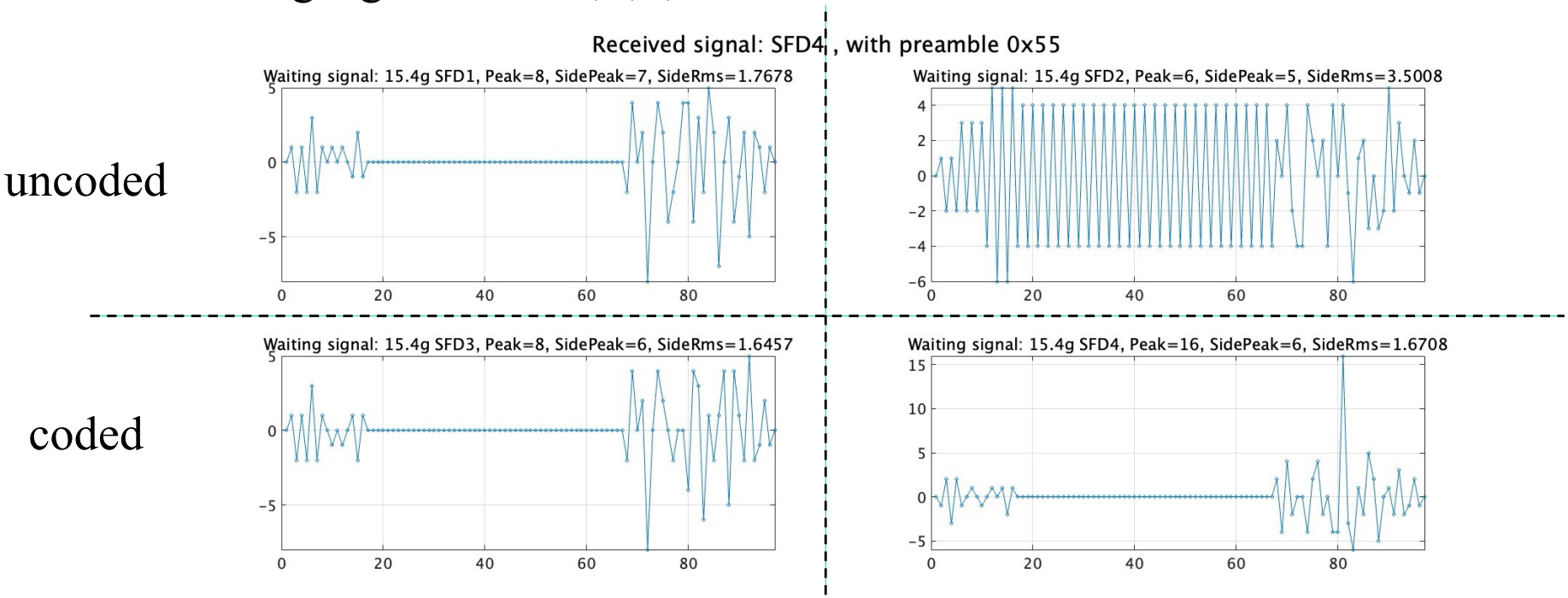
Correlation characteristics when using 15.4g SFD

- Received signal: 15.4g preamble + 15.4g SFD3
- Waiting signal: SFD 1,2,3,and 4



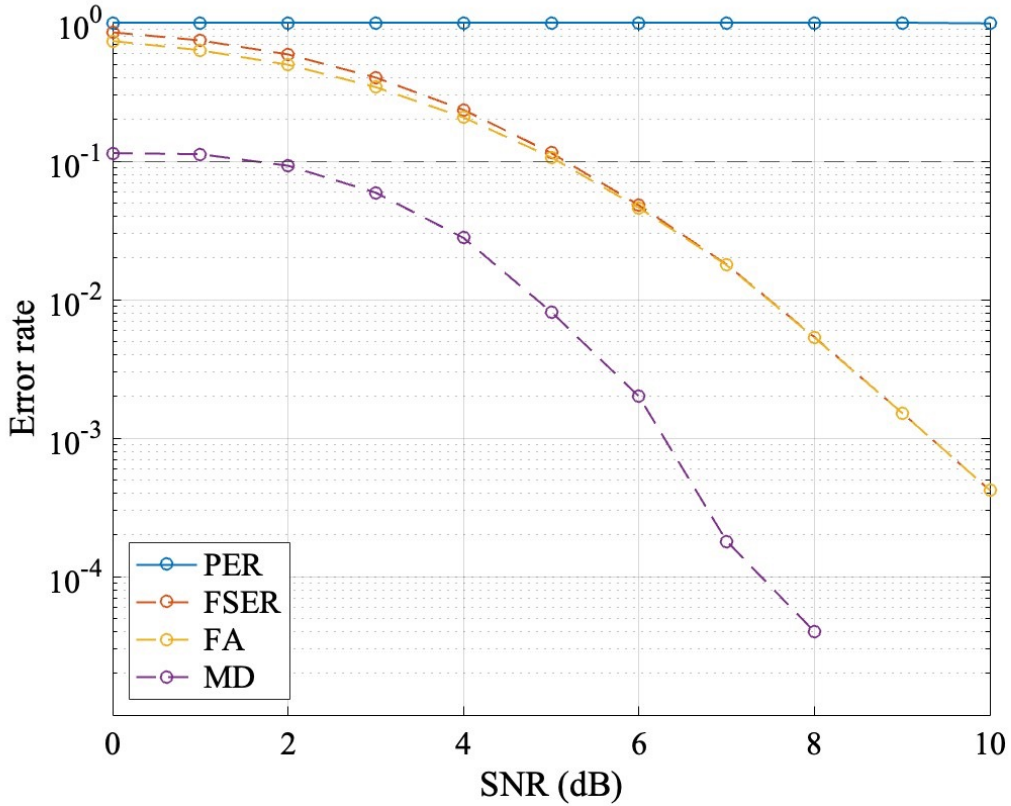
Correlation characteristics when using 15.4g SFD

- Received signal: 15.4g preamble + 15.4g SFD4
- Waiting signal: SFD 1,2,3,and 4



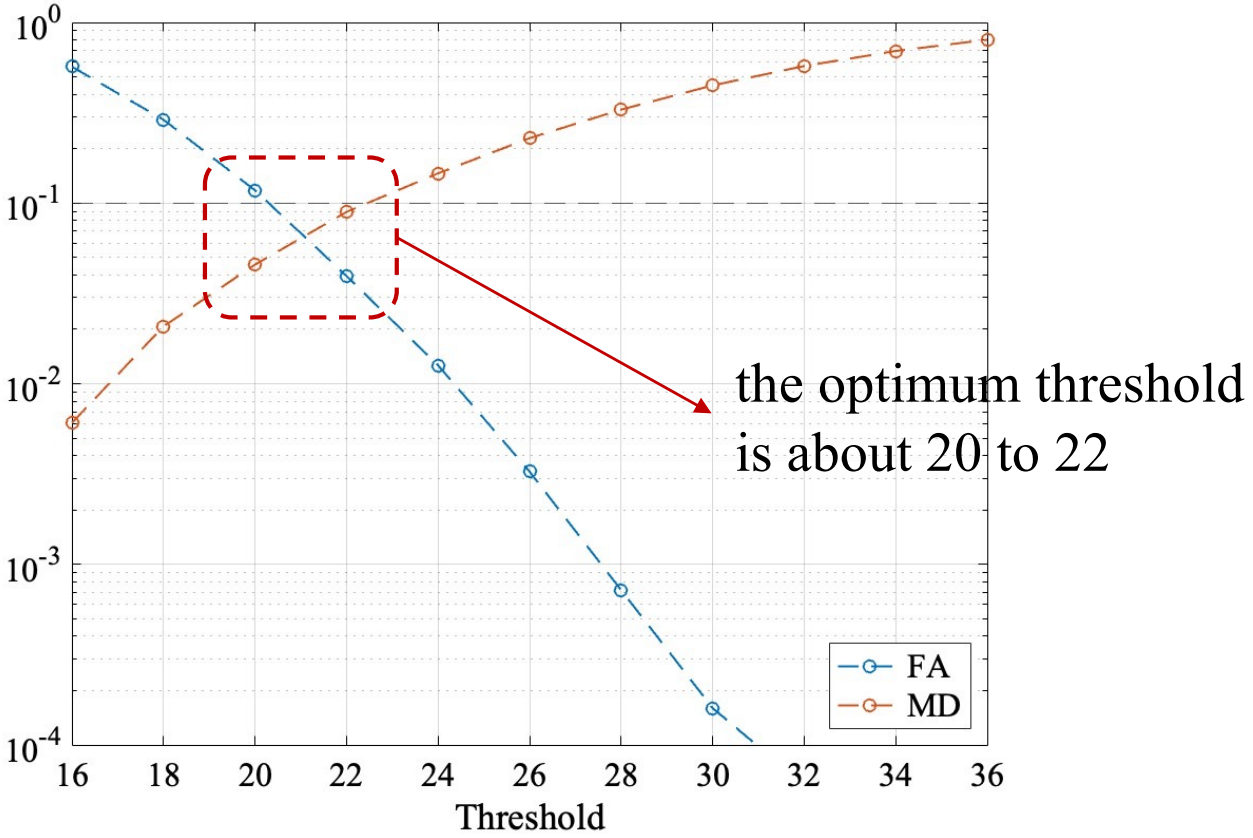
FA and MD characteristics of 15.4g SHR (2-GFSK)

- FA and MD characteristics against the SNR with threshold = 10



Threshold decision for modified SHR

- FA and MD characteristics of the proposed SHR against the threshold with SNR = 2 dB



Reference

[1] Liru LU, Hiroshi HARADA, Ryuhei FUNADA, Chin-Sean SUM, Design of the Start-Frame-Delimiter Pair for 802.15 Smart Utility Network System, IEICE Transactions on Communications, 2013, Volume E96.B, Issue 3, Pages 730-736, Released on J-STAGE March 01, 2013.