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

Submission Title: [Proposal of SHR for 802.15.4ad SUN OFDM LR mode based on SC-OFDM]

Date Submitted: 27 July 2025

Source: Hiroshi Harada and Goro Kawabuchi (Kyoto University)
Address Yoshidahonmachi. Sakyo, Kyoto, 606-8501, Japan
Voice: +81-75-753-5317 , E-Mail: hiroshi.harada@i.kyoto-u.ac.jp

Re: [Wireless Next Generation, Long Range extension enhancements to 802.15.4-2020]

Abstract: Proposal of synchronization header (SHR) for 802.15.4ad SUN OFDM Low Rate (LR) mode based on SC-OFDM. 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 technical specification based on SC-OFDM for 802.15.4ad Low Rate LR mode.

Proposal of SHR for 802.15.4ad SUN OFDM LR mode based on SC-OFDM

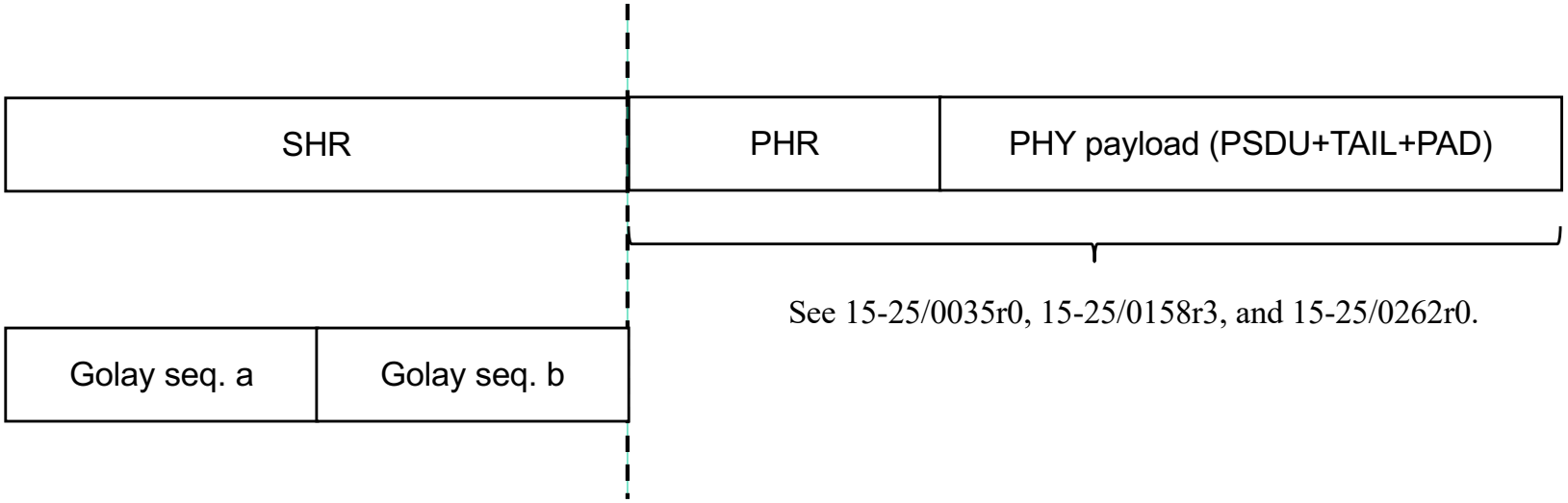
July 27, 2025

Hiroshi Harada, Ph.D., IEEE fellow, and Goro Kawabuchi
Kyoto University

Background

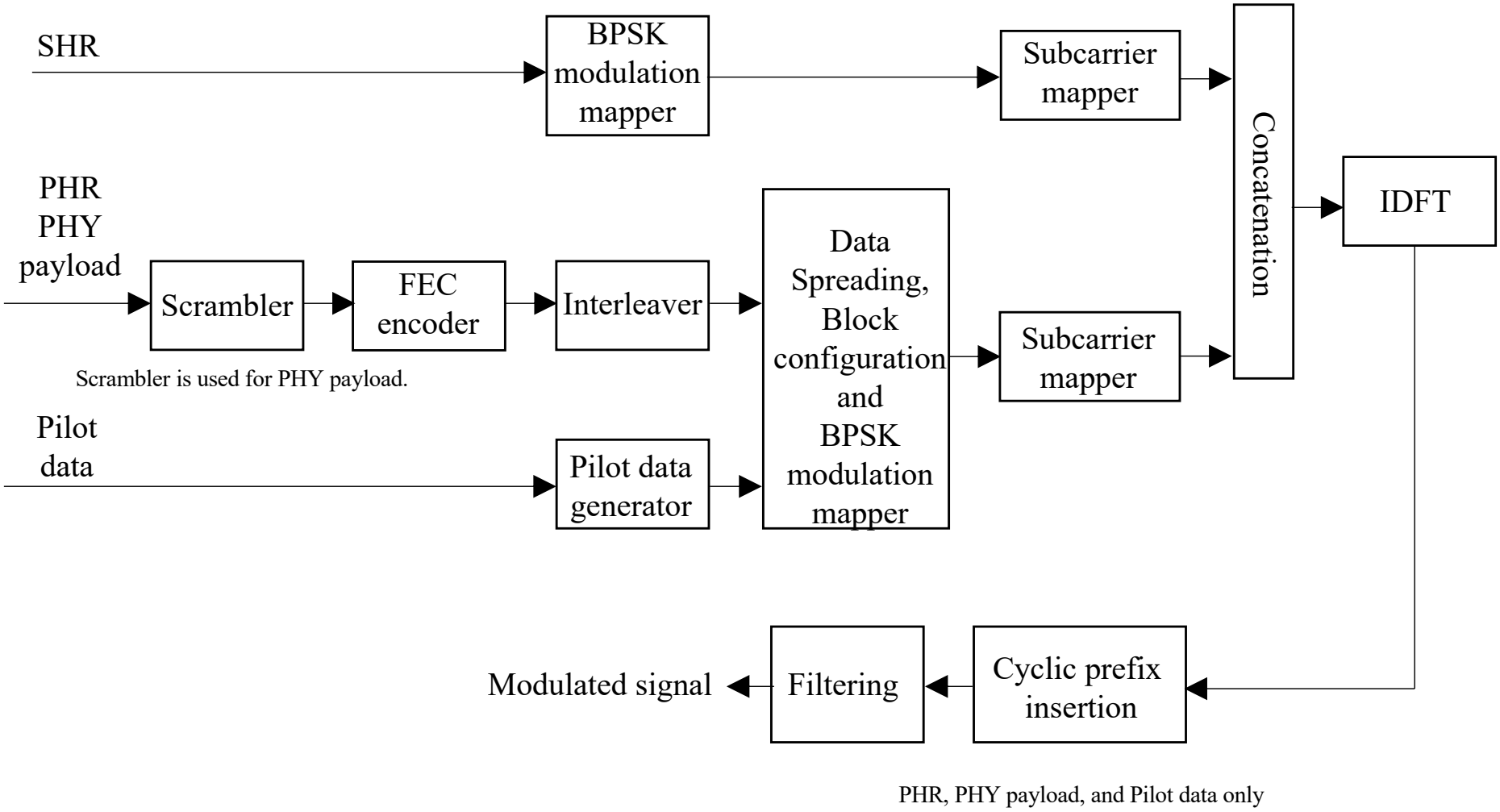
- We have already proposed IEEE 802.15.4 SUN OFDM LR in 15-25/0035r0, 15-25/0158r3, and 15-25/0262r0.
- This proposal was an SC-OFDM (Single Carrier OFDM) system that selects a frequency for communication using the OFDM method and transmits blocks consisting of pilot signals and information symbols at the selected frequency.
- We have demonstrated the transmission characteristics of the proposed SC-OFDM system in AWGN and multipath fading environments in 15-25/0158r3 and 15-25/0262r6.
- However, these documents only covered the payload.
- This contribution document proposes the synchronization header (SHR) for our proposed SC-OFDM and shows its synchronization performance.

Frame configuration of proposed SC-OFDM



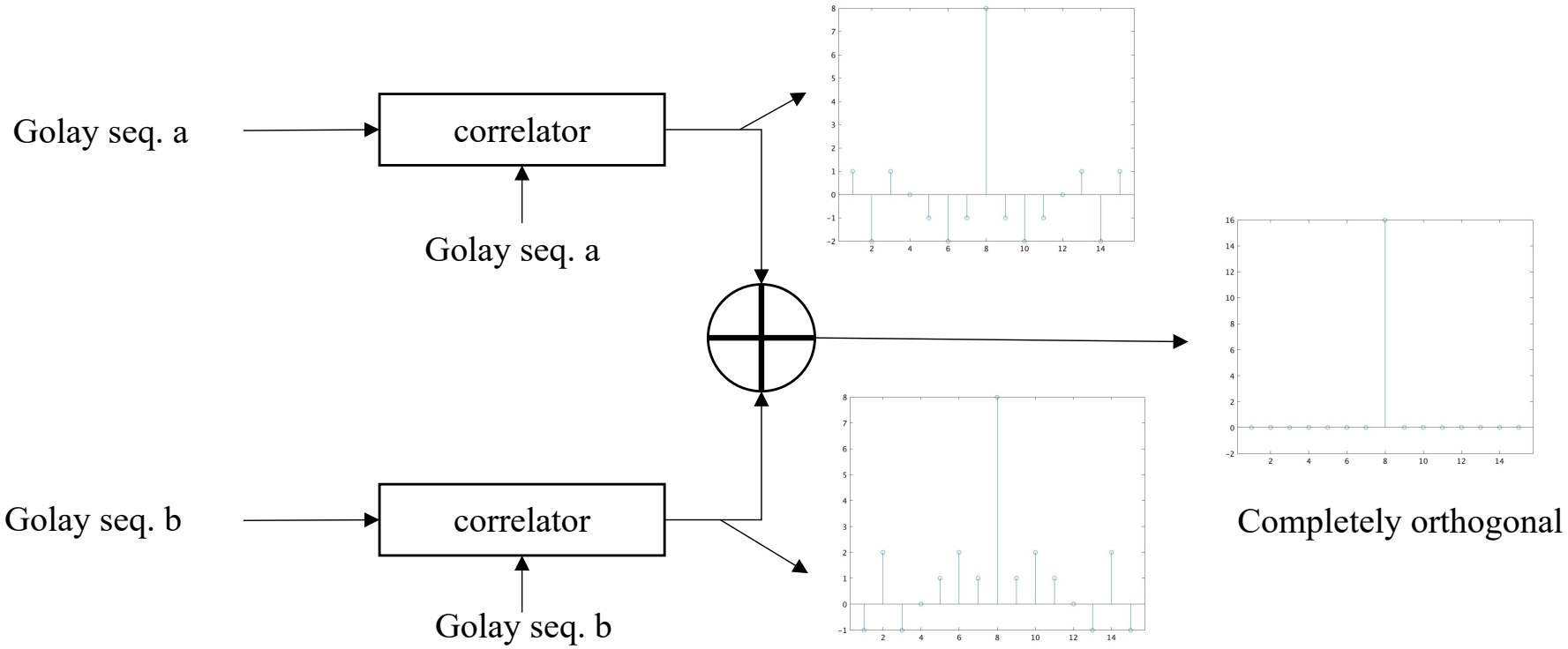
- In this SC-OFDM, SHR consists of two Golay sequences a and b of equal length.
- This is because the PHR and PHY payload parts are transmitted in blocks, and pilot data is stored in each block.

Reference modulator diagram

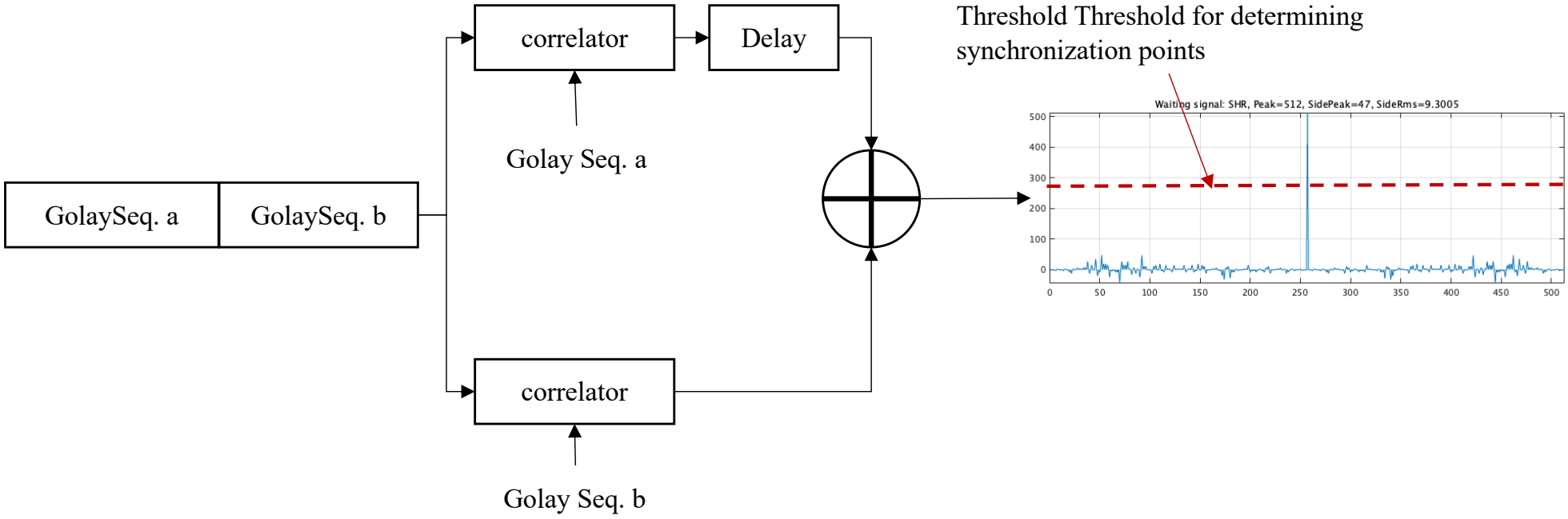


Golay sequence

- Constructed using a pair of complementary symbols a and b [1]
- The sum of the autocorrelations of symbols a and b is completely orthogonal



A synchronization method for new SHR at the receiver

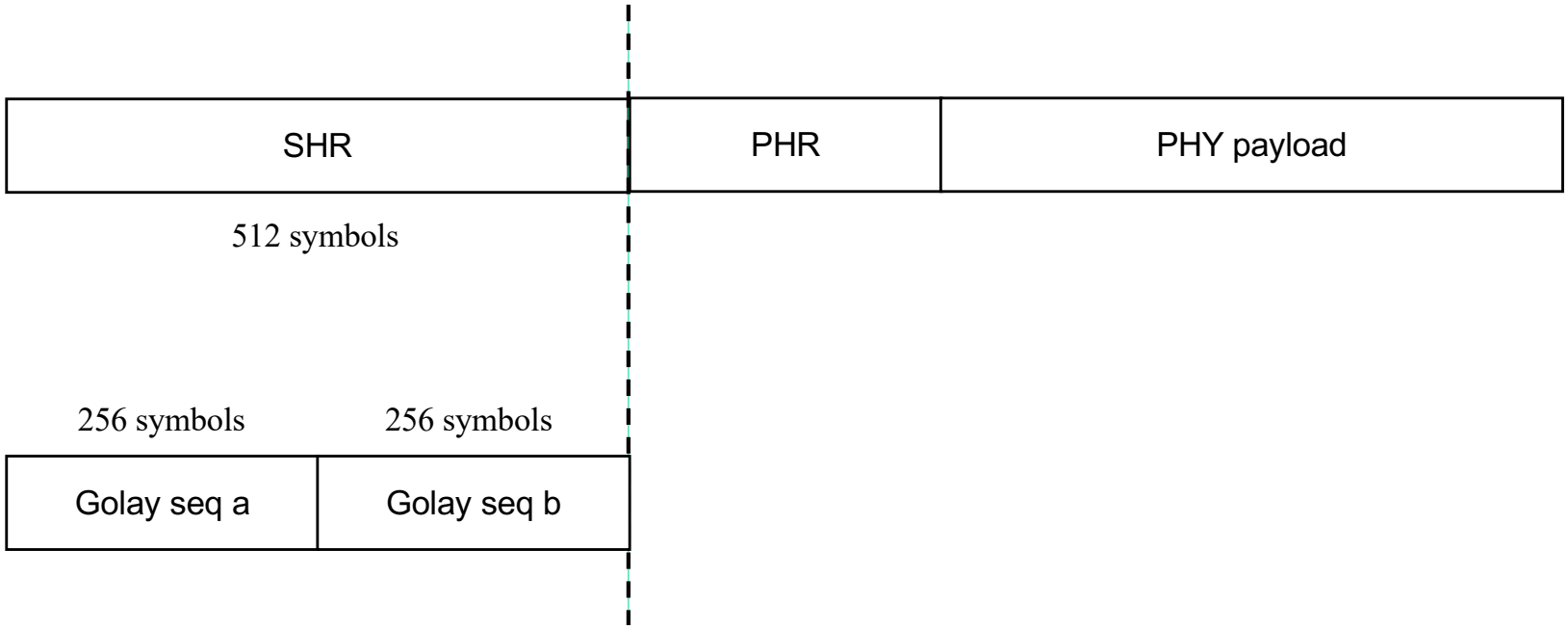


Evaluation of synchronization performance by proposed SHR

Simulation setup

	SC-OFDM
Channel spacing	200 kHz
Subcarrier spacing	31.25/3 kHz
DFT size	16
Number of subcarriers used	14
Num. of data-subcarriers	1
OFDM symbol duration	120 us
Guard interval	24 us
Primary modulation scheme	BPSK

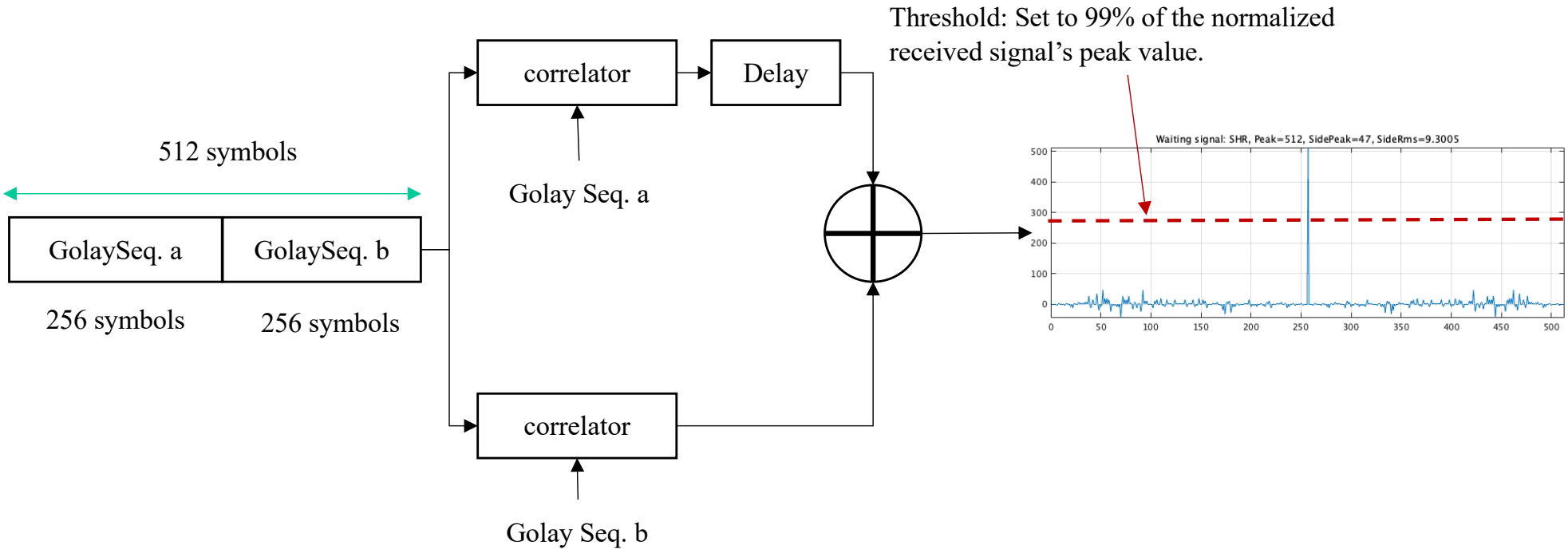
Example of proposed SHR



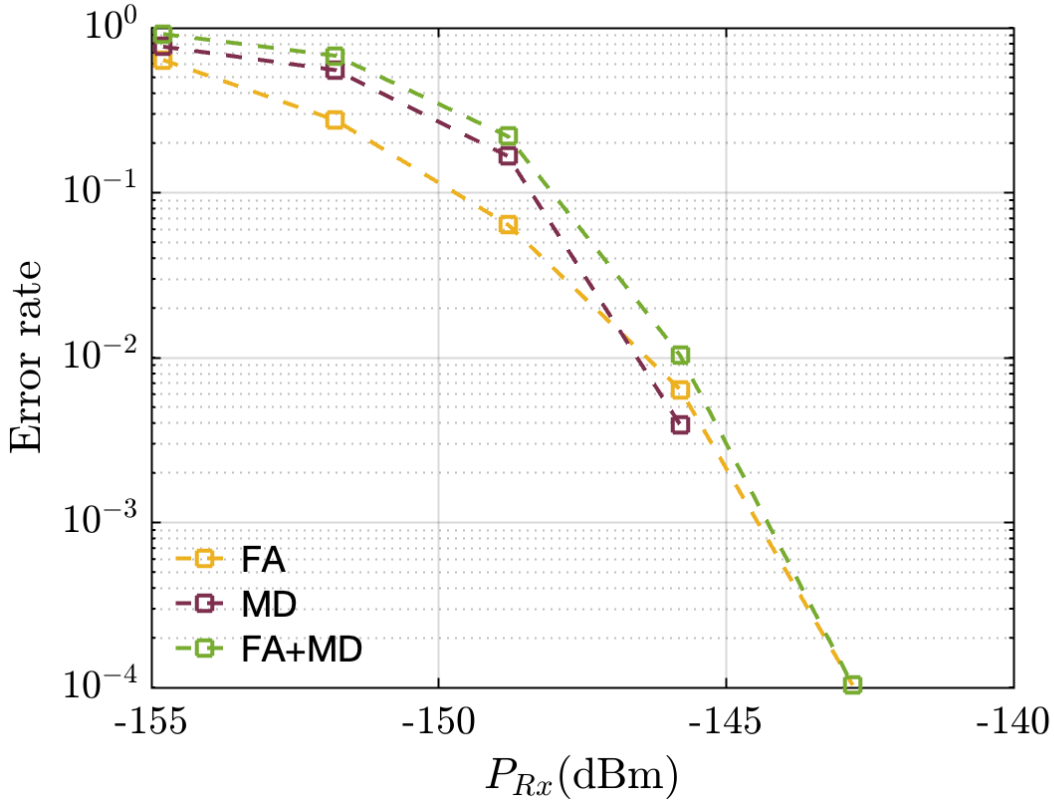
	Golay seq. a	Golay seq. b
Value	0xEDE2ED1DEDE212E2EDE2E D1D121DED1DEDE2ED1DEDE2 12E2121D12E2EDE212E2	0xEDE2ED1DEDE212E2EDE2E D1D121DED1D121D12E2121DE D1DEDE2ED1D121DED1D

The sequence is based on [1].

A synchronization method for new SHR at the receiver

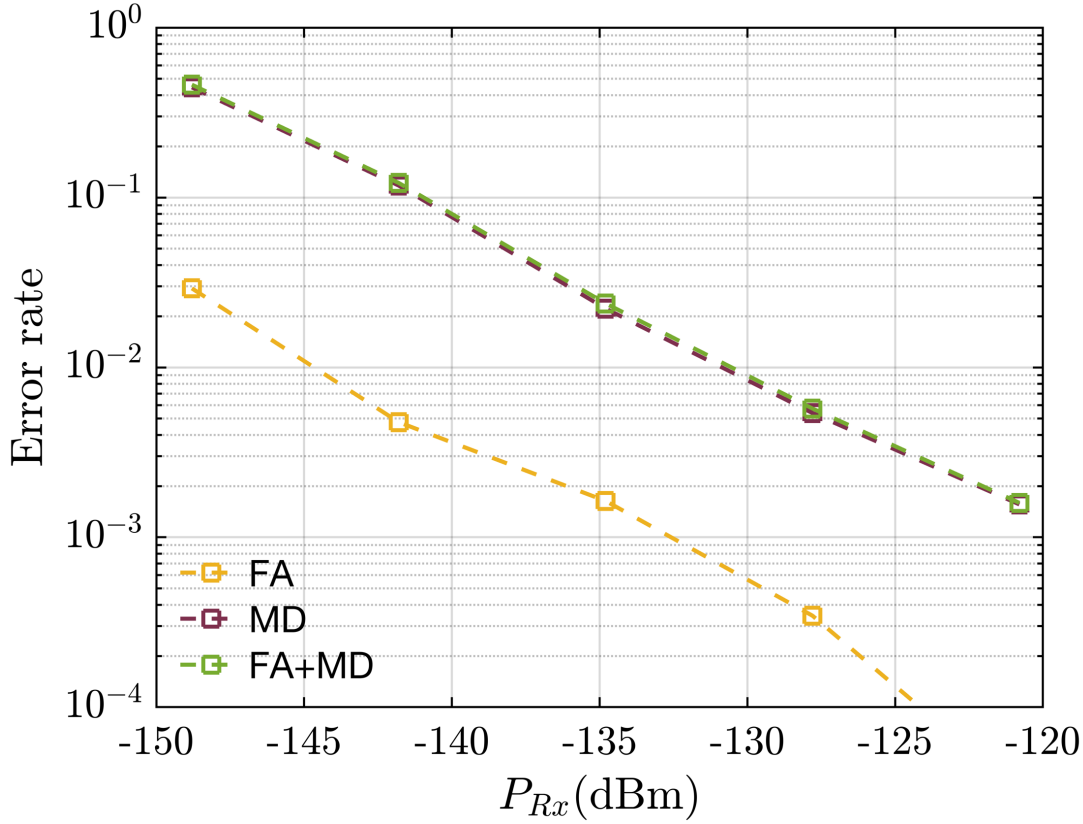


FA, MD Characteristics (Proposed SHR and SC-OFDM, AWGN)



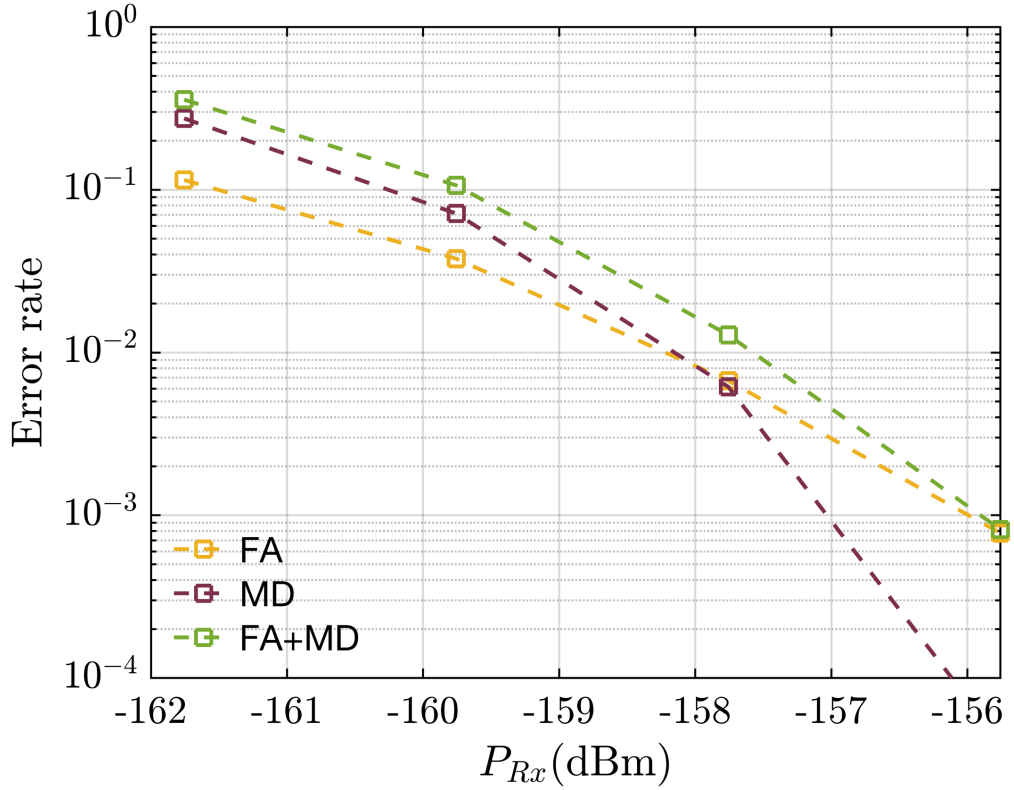
P_{Rx}: Received power

FA, MD Characteristics (Proposed SHR and SC-OFDM, IEEE 802.22 Profile A (fd=0.6Hz))



P_{Rx}: Received power

FA, MD Characteristics (Proposed SHR and SC-OFDM, Interference BW: 10 kHz, td: same as packet)

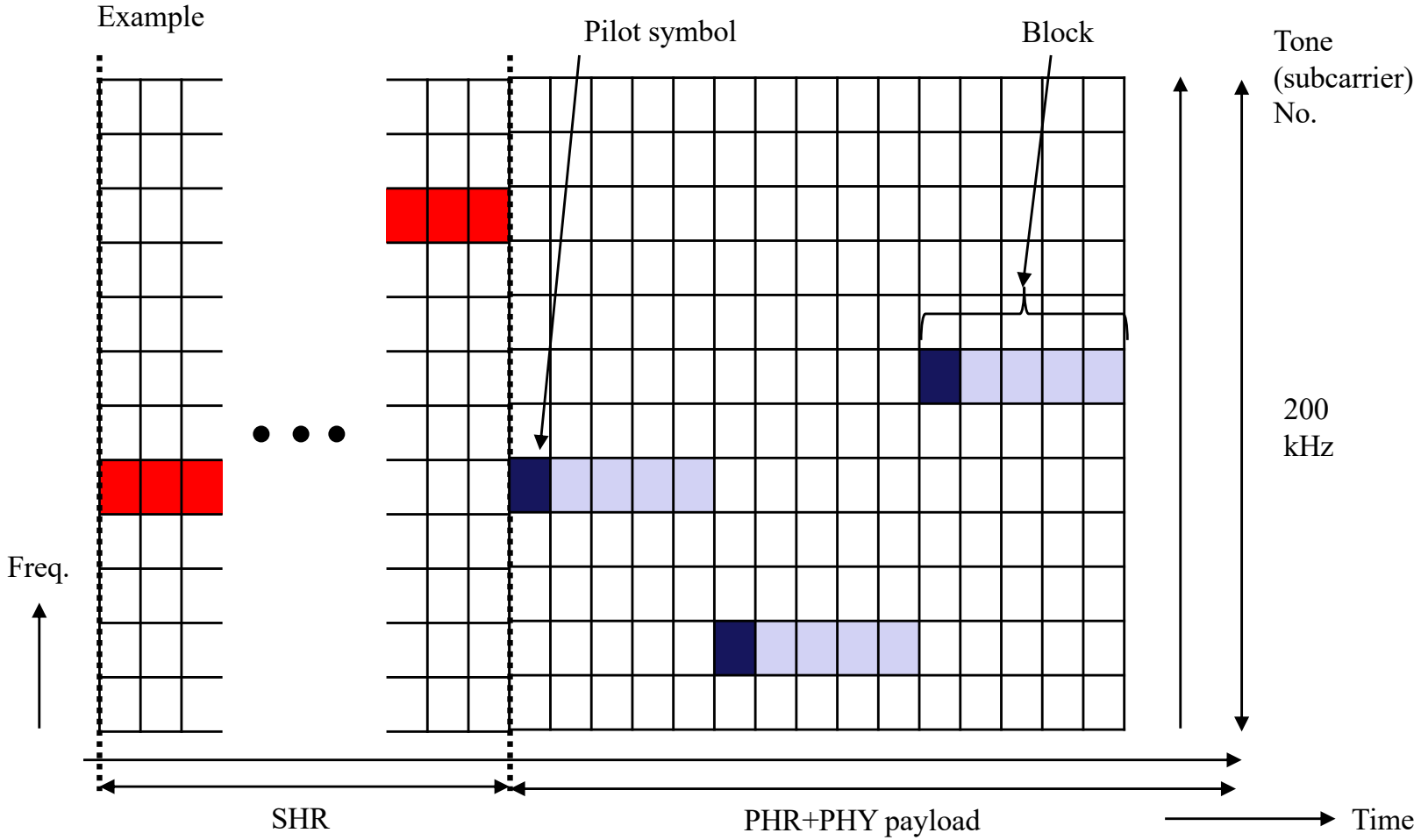


P_{Rx}: Received power

Required power to achieve required synchronization error

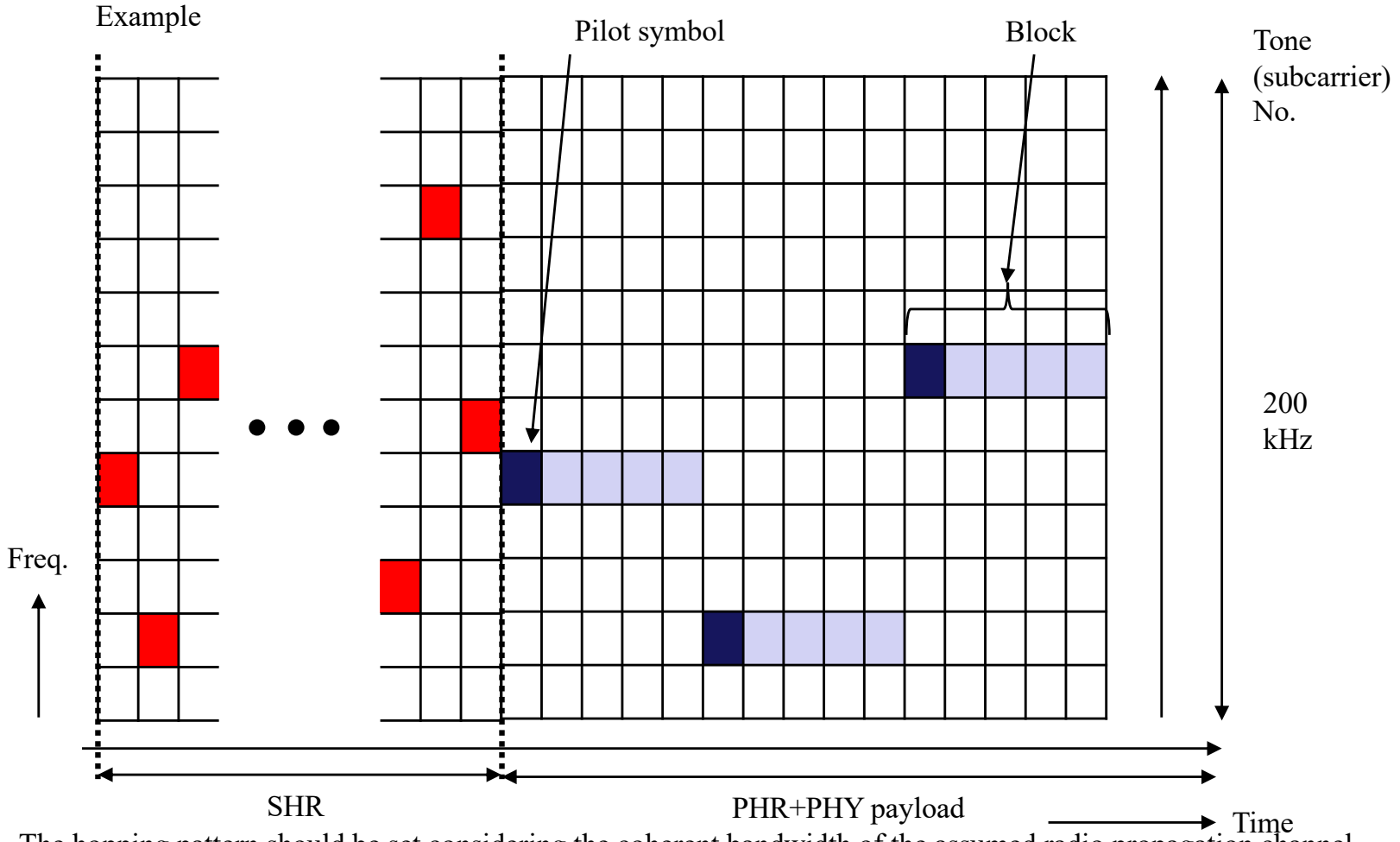
	Environment	Required error rate	Required power(dBm)
SC-OFDM	AWGN	10^{-2}	-145.8
	802.22 profile A	10^{-2}	-130.5
	Interference (BW : 10 kHz td : 5 ms)	10^{-2}	-157.6

Frame construction and frequency hopping examples for Proposed SC-OFDM (Hopping case 1)



- The hopping pattern must be set considering the coherent bandwidth of the assumed wireless transmission channel.
- In this case, frequency hopping for the SHR section is performed in Golay sequence units.
- SHR may be transmitted at a single frequency without hopping..

Frame construction and frequency hopping examples for Proposed SC-OFDM (Hopping case 2)



- The hopping pattern should be set considering the coherent bandwidth of the assumed radio propagation channel.
- In this proposal, hopping is performed for each symbol of the Golay sequence.
- SHR may be transmitted at a single frequency without hopping.

Reference

[1] M. J. E. Golay, "Complementary series," IRE Trans. Inf. Theory, vol. 7, no. 2, pp. 82–87, Apr. 1961, doi: 10.1109/TIT.1961.1057620.