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

Submission Title: [SFD discussions for LECIM FSK-PHY]
Date Submitted: [Jan. 2012]
Source: Mi-Kyung Oh, Sangsung Choi, Kwang-Roh Park (ETRI)

   Voice: +82 42 860 5680, FAX: +82 42 860 5218, E-Mail: ohmik@etri.re.kr

Re: [802.15.TG4k]

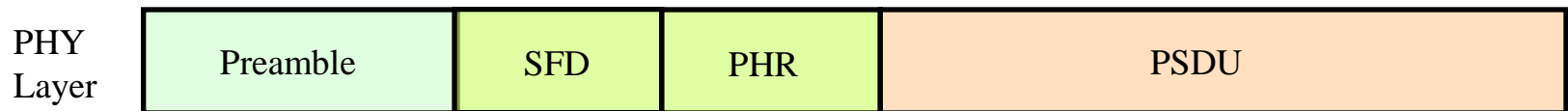**Abstract:**   This contribution is prepared to discuss about SFD sequence for FSK PHY.

Purpose:

FSK Packet Format

- ## PHY packet format

PHY Layer	Preamble	SFD	PHR	PSDU

- ## SFD sequence
  - It is used to break the preamble pattern and signal the start of the PHR
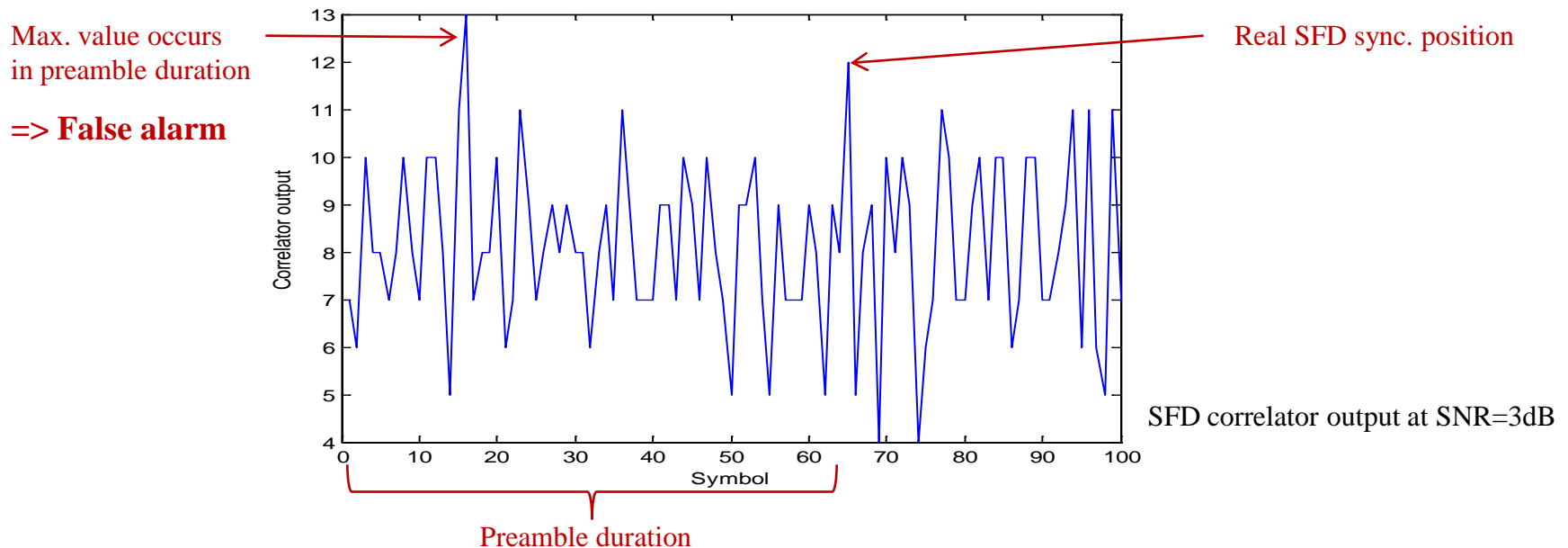
SFD False Alarm Scenario 1

- Scenario 1: No packet transmission in the air
  - The incoming bits at the receiver might be random
  - False alarm rate
    - Probability that the incoming random noise pattern are exactly matched with pre-defined SFD sequence
    - If false alarm occurs, the receiver starts to recover the PHR and PSDU. => It entails unnecessary energy consumption
    - $R_{false} = 0.5^n$ where n is the SFD length: doc.030/r0
    - When n=13, $R_{false} = 10^{-4}$: it means that SFD false alarm occurs at every 0.27sec (4 false alarms during 1sec)
    - There is issue how often the false alarm can be allowed per second.

SFD False Alarm Scenario 1

- Scenario 1: No packet transmission in the air
  - Solution for reducing false alarm rate when random input bit is assumed: doc.014/r1
    - In conjunction with preamble pattern (0xAA or 0x55), lower R_{false} value can be obtained due to increased n
    - For example
      - SFD sequence: 0110111101001110
      - Preamble pattern: multiples of 01010101
      - New sequence at the SFD detector
        - 01010101+0110111101001110
        - $n = 24$, $R_{false} = 6 \times 10^{-8}$ (=1 false alarm for 450 sec)
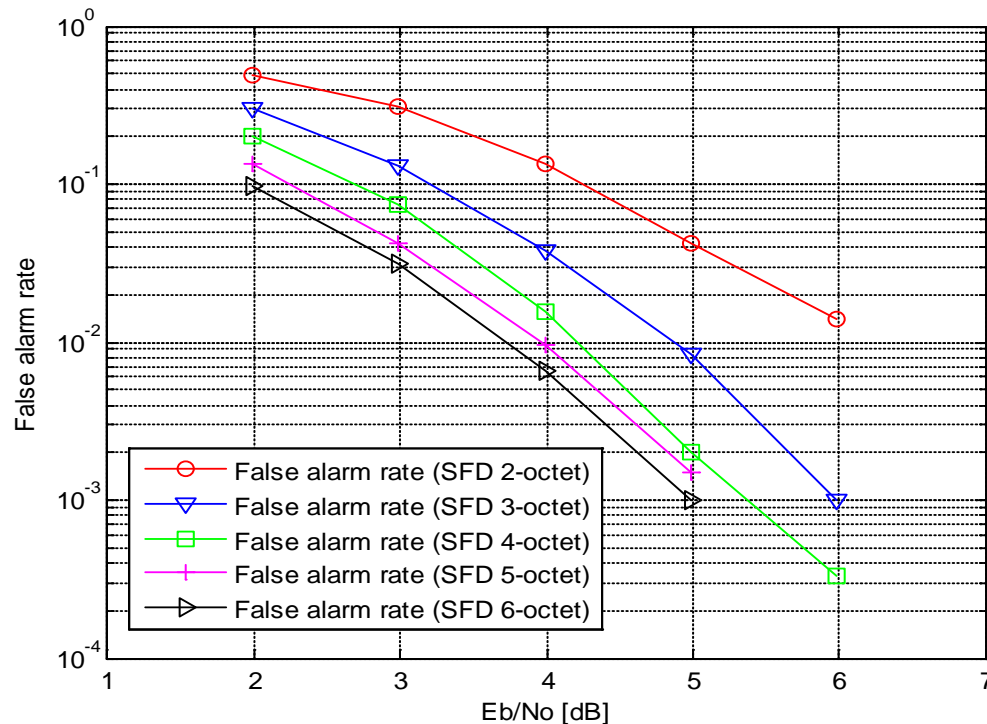
SFD False Alarm Scenario 2

- ## Scenario 2: Packet receiving at the receiver
  - The incoming bits at the receiver might be parts of packet (those are not random any more)
  - False alarm rate: probability that SFD detection occurs at the wrong position, e.g., preamble duration

Max. value occurs
in preamble duration

=> **False alarm**

Real SFD sync. position

SFD correlator output at SNR=3dB

Preamble duration

SFD False Alarm Scenario 2

- Scenario 2: Packet receiving at the receiver
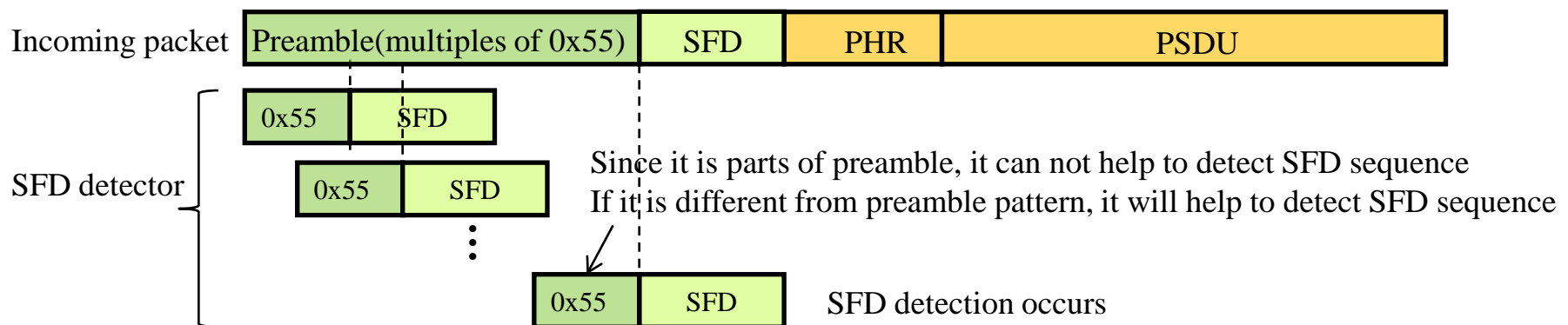 - In this scenario, false alarm rate of 10^{-2} means 1 false alarm per 100 packets

Simulation environment details:
Doc. 877/r0

SFD False Alarm Scenario 2

- Scenario 2: Packet receiving at the receiver
  - For 1% PER, less than 10^{-2} false alarm rate is required
  - Since more than 120dB path loss should be considered in LECIM, the operating SNR will be low in harsh environments
  - Then, the solution for lowering false alarm rate at low SNR is to lengthen the SFD sequence
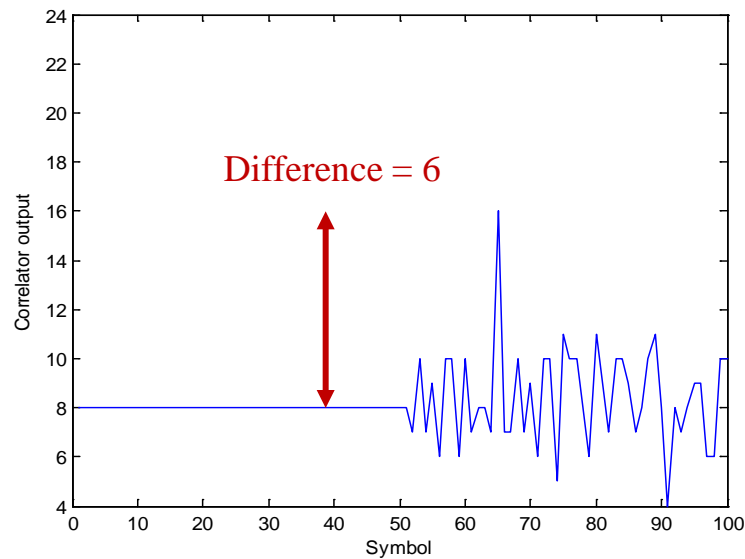
SFD False Alarm Scenario 2

- Scenario 2: Packet receiving at the receiver
  - Is it possible to use preamble pattern for lengthening the SFD sequence?
    - In preamble duration, the use of preamble pattern on SFD detection does not give any advantage to lower the SFD false alarm rate

Incoming packet | Preamble(multiples of 0x55) | SFD | PHR | PSDU

SFD detector

0x55 | SFD

0x55 | SFD

Since it is parts of preamble, it can not help to detect SFD sequence
If it is different from preamble pattern, it will help to detect SFD sequence
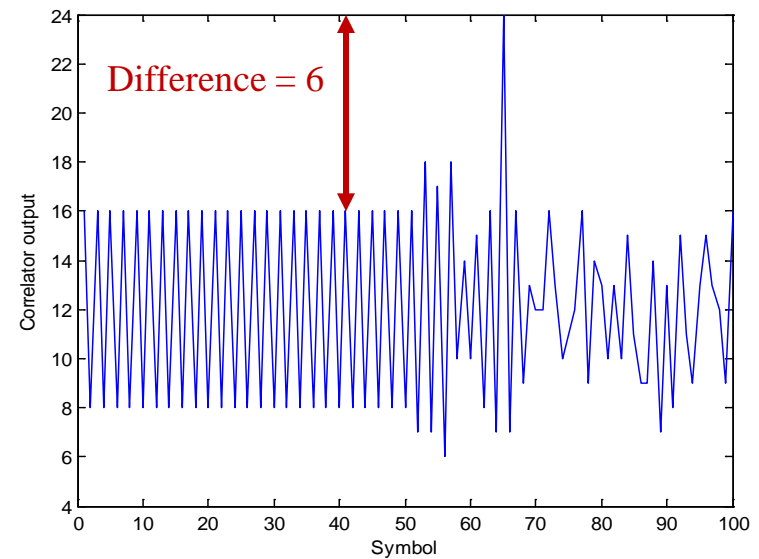
0x55 | SFD   SFD detection occurs

SFD False Alarm Scenario 2

- Scenario 2: Packet receiving at the receiver
  - Although 3-octet (0x55+2-octet SFD) is used, the difference in correlator output is same as 2-octet SFD case → no advantage

2-octet SFD sequence

0x55+2-octet SFD sequence

Conclusions

- Two different scenarios are considered for SFD false alarm rate
  - No packet transmission v.s. packet reception
  - Longer SFD sequence can help lowering the false alarm rate
  - During packet reception, the concatenation of preamble pattern on SFD detection is useless

- SFD sequence length
  - In order to satisfy 1% PER performance, 2-octet SFD is not enough at low SNR