Reducing Frame Synchronization Loss through Optimized Start Frame Delimiter

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Abstract—**Frame sync loss occurs from noise on the Start Frame Delimiter (SFD), causing data errors and communication inefficiency. This problem impacts the reliability of the communication circuit, needing solutions to lower its frequency. While past studies have addressed it through frame and circuit design, the best SFD solution remains undiscovered. Barker codes offer potential, but the ideal SFD is still unknown. Our simulations assessed noise on the SFD and sync errors, aiming to find the optimal pattern. Results showed reducing SFD occupancy lowers noise risk, with the "1110" pattern being the shortest and most effective in improving sync.**

Keywords-Frame synchronization; SFD; BarkerCode; Telecommunications.

I. INTRODUCTION

Frame synchronization is important for packet transmission, especially in a network of cognitive radios [1].

Start Frame Delimiter (SFD) is most important part of the frame synchronization. Frame synchronization is achieved by the transmitter sending a frame in which SFD is injected at the beginning of each transmission data. The receiver detects the arrival of a packet by searching for the SFD, then removes the SFD from the data stream to restore the transmitted message. Therefore, SFD is most important part on the frame synchronization. However, there is an issue where noise superimposed on the SFD causes synchronization failure. This is referred to as frame synchronization loss, and it takes time to resynchronize especially when the SFD is incorrectly detected at the wrong position. It is already clear that frame synchronization loss directly affects the reliability of the entire communication channel circuit [2]. Therefore, solutions and methods to further reduce the frequency of occurrence are required.

The paper is structured as follows: Section II reviews related work on Start Frame Delimiter (SFD) design using Barker codes; Section III outlines the objectives and methodology of this study; Section IV presents the simulation setup, results, and discussion; and Section V concludes the paper with a summary of findings and suggestions for future research.

II. RELATED WORK

In the past, approaches to the issue of frame synchronization loss have included simulation-based performance evaluations of the time required for recovery [2] and methods involving changes to the frame length [3]. However, the crucial factor in frame synchronization loss lies in the SFD, making its design an important approach as well. One such approach is the use of Barker codes for SFD design. The Barker sequences serve as a known reference signal that we used for frame synchronization. These sequences have good autocorrelation properties [4]. Diago et al [5] are presents the implementation of frame detection algorithm based on the autocorrelation properties of Barker sequences in a digital communication system and simulated results are compared in a real wireless link.

III. METHODOLOGY

Previous research has made it clear that using Barker codes for SFD is beneficial, but the optimal SFD length has yet to be determined. In our study, we aim to quantitatively clarify the optimal SFD that utilizes the characteristics of Barker codes through simulations and propose an optimal SFD that can mitigate the issue of synchronization loss. If the cause of the frame synchronization loss issue is noise superimposed on the SFD, we hypothesize that reducing the occupancy rate of the SFD within the transmission channel would lower the probability of noise being superimposed on the SFD, thereby reducing the risk of noise superimposition to SFD. However, shortening the SFD length increases the risk of accidental matches with the SFD pattern at incorrect positions. Conversely, lengthening the SFD pattern to make it more complex could also increase the risk of noise superimposition. In this study, we conducted Monte Carlo simulations to evaluate the impact of each Barker code used as the SFD on frame synchronization loss.

IV. SIMULATION

This section presents the simulation setup and results.

A. Simulation setup

Table 1 shows all the pattern of Barker code. The outline of the simulation is as follow. The packet frame consists of a randomly generated data section and an SFD inserted at the beginning. The SFD uses a Barker code, and the data section is protected by Forward Error Correction (FEC). The transmission channel is modeled as an Additive White Gaussian Noise (AWGN) channel. The simulation involves sending 1000 packets, with each packet having a data section of 255 bytes plus the length of the SFD. The idling period signal is always set to high, meaning the digital value '1', and thus the '11' pattern in the Barker code will not be used.

TABLE I PATTERNS OF BARKER CODE

Length	Binary-Pattern
2	10/11
3	110
4	1101
4	1110
5	11101
7	1110010
11	11100010010
13	1111100110101

B. Result

Figure 1 shows the reception success rate, where the SFD patterns are indicated in the legend next to the label "Start=". It is observed that there is a difference in the success rate when $BER10^{-5}$. Furthermore, SFD patterns of 4 bits and 13 bits demonstrate similar success rates. To confirm the frame synchronization loss caused by noise superimposed on the SFD, we compare the number of times noise was superimposed on the SFD and the number of false SFD detections, as shown in Table 2. For the SFD pattern '110' , there were 0 occurrences of noise superimposition on the SFD, while the false detection count was 307. Upon further investigation of the data for this case, it was confirmed that the frame synchronization loss occurred due to noise in sections other than the SFD. The SFD patterns where the number of noise superimpositions on the SFD was greater than or equal to the false detection count were '1110', '11100010010', and '1111100110101'

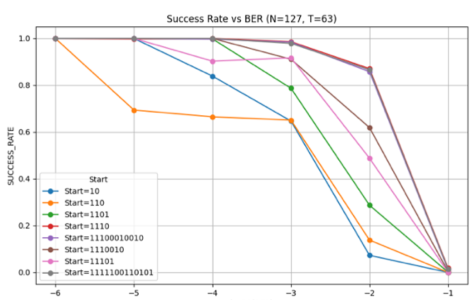

Figure 1. Reception Success Rate

TABLE II NOISE ON SFD AND MISDETECTION

BER	10^{-5}	10^{-4}	10^{-3}	10^{-2}
SFD	Noise superimposition number/ Misdetection number			
10	0/0	0/162	2/355	32/932
110	0/307	0/336	4/350	48/864
1101	0/0	1/2	8/212	46/708
1110	0/2	2/0	8/14	47/129
11101	0/0	3/95	10/81	65/502
1110010	0/0	0/0	10/82	79/343
11100010 010	0/0	2/1	11/5	102/54
11111001 10101	0/0	0/0	17/4	141/13

C. Consideration

In this simulation, it was not observed that noise was superimposed on the SFD in an environment with $BER10^{-5}$. On the other hand, the results for the SFD pattern "110" showed that frame synchronization errors occurred even in favorable communication environments. By comparing the number of noise superimpositions on the SFD with the number of false recognitions, it was considered possible to identify the optimal SFD that minimizes the risk of accidental matches. The simulation results revealed that the SFD patterns "1110", "11100010010", and "1111100110101" had a higher number of noise superimpositions than false detections. Additionally, in the environment with $BER10^{-3}$, the noise superimposition counts were observed in the order of "1111100110101>11100010010> 1110", suggesting that reducing the occupancy rate of the SFD in the transmission channel can lower the probability of noise superimposition on the SFD. Furthermore, it was confirmed that the false detection rate of the SFD pattern decreases as the SFD length increases. When comparing the number of successful receptions, in the environment with $BER10^{-3}$, the results showed "1110>11100010010 >1111100110101". Therefore, the most optimal SFD is "1110", which has the shortest bit length and mitigates synchronization errors while maintaining a high success rate.

V. CONCLUSION AND FUTURE WORK

In this study, simulations were conducted to evaluate the impact of noise superimposition on SFD and frame synchronization errors to identify the optimal SFD pattern. The simulation results revealed that reducing the occupancy rate of the SFD effectively suppresses the probability of noise superimposition. Particularly, the SFD pattern "1110" demonstrated excellent results, being the shortest in bit length while reducing false recognitions and improving frame synchronization success rates. While the optimal SFD was identified in this study, the problem of frame synchronization errors has not been fully resolved. Further research is necessary to explore different approaches to address this issue.

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