**Lab 4：Frame synchronization and frequency offset correction**

|  |  |
| --- | --- |
| **Author** | Name：蔡浩宇/曹子惠 Student ID:12112201/12112441 |
| **Introduction**  Experimental goal: master frame synchronization and frequency offset correction algorithms  1.Fundamentals of Frame Synchronization and Frequency Bias Correction：  Frame synchronization is the process of ensuring that data frames are correctly parsed and processed at the receiving end. In digital communications, data is divided into a series of frames for transmission. The goal of frame synchronization is to accurately identify the start and end positions of each frame at the receiving end so that the data can be correctly decoded and processed. Header Detection: The receiving end determines the start position of a frame by detecting a specific header pattern. A common method is to use a predetermined sequence of bits or a predefined code word as the frame header identifier. End-of-frame detection: Similar to header detection, the receiver also needs to detect the end of the frame to determine the end position of the frame. Usually a specific sequence of bits or code word is used as the end-of-frame identifier. Clock Recovery: The receiver needs to recover the sending clock information from the received data in order to accurately divide the frame. This can be achieved by extracting the clock edges in the data or by utilizing the clock reference signal provided by the transmitter. ERROR DETECTION AND CORRECTION: The frame synchronization process also includes the step of error detection and correction of the received data to ensure data integrity and reliability.  Frequency bias correction is used to solve the problem of frequency shift in communication due to transmission medium or other factors. Frequency offset refers to the difference between the local clock frequencies of the transmitter and receiver. Frequency deviation detection: The receiving end calculates the size of the frequency deviation between the clock of the receiving end and the clock of the sending end by analyzing the received data. Frequency Bias Estimation: The receiver uses the frequency bias detection results to estimate the actual frequency bias value and converts it into a suitable representation. Frequency Bias Compensation: The receiver uses the frequency bias estimate to adjust the frequency of the local clock to eliminate the difference in frequency bias between the receiver and the transmitter. This can be accomplished by adjusting parameters in the clock control circuitry or by introducing appropriate compensation algorithms. Frequency Bias Tracking: Since the frequency bias may vary over time, the receiver needs to track and correct the frequency bias in real time. This can be achieved by constantly monitoring the received data and dynamically adjusting the frequency offset compensation value according to the frequency offset variation.  1700907987736  1700908018275   1. Design Principles of Training Sequences：   Periodicity: The training sequence needs to contain a certain frequency variation periodically so that the receiving end can estimate the degree of frequency deviation by comparing the received signals with the preset training sequence and carry out frame synchronization operation at a certain frequency.  Frequency information: The training sequence needs to contain certain frequency information to help the receiver determine the amount of frequency deviation.  Uniqueness: The training sequence needs to be unique, i.e., the pattern of the training sequence is not repeated with other data during the whole data transmission process, so that the receiver can accurately distinguish the training sequence from the actual data.  17009076376041700907709824  1700908424621  **Lab results & Analysis**：  1.  the programming process: First, acquire the received signal. Once the signal is acquired, we use LabVIEW to design a sliding correlator block that computes the correlation between the received signal and the known training sequence over a range of time offsets. And the maximum correlation value or peak indicates the most probable time offset, which can then be used for synchronization.      2.  the programming process: acquiring the signal, then construct a MOOSE block that processes the received signal to estimate the channel response or perform symbol equalization.  HE_34V4}~_BXTJX8HB]A6XE  72~KUW8L%H`JPX2CH65MU9I  AGXO7[R%~6%51)A0~T724%Q  3.  When using the Moose algorithm to estimate the frequency bias, the range of frequency bias values that can be accurately estimated are[−,−]，That is, the estimation range is limited by the symbol rate and the length of the training sequence.  =4MHz,=22,；  17010995274631701099652198  =1MHz,=22,；  17010995006351701099652198  =1MHz,=10,.  17010996782081701099652198  The estimation range increases with the symbol rate and decreases with the length of the training sequence  4.  No correction：    Correction：    No correction：    Correction：    No correction：    Correction：    The measurements revealed that in the case of the sliding correlator algorithm, as the frequency offset angle increased, the accuracy of the frequency offset estimation deteriorated. This indicates that the sliding correlator algorithm’s performance is sensitive to the frequency offset angle, and proper correction is crucial for improving accuracy.  When utilizing the Moose algorithm, even as the frequency offset angle varied, the Moose algorithm consistently exhibited higher accuracy in estimating the frequency offset, so it a more reliable choice for frequency offset correction in practical applications. | |
| **Experience**  **蔡浩宇**      AGXO7[R%~6%51)A0~T724%Q72~KUW8L%H`JPX2CH65MU9IHE_34V4}~_BXTJX8HB]A6XE  曹子惠      **Problems**  Algorithm Implementation Problem: Understanding and implementing frame synchronization and frequency bias correction algorithms can be difficult. Experimental Procedure Problem: Problems in understanding the sliding correlation algorithm and the Moose algorithm and analyzing the performance of the Moose algorithm during the build process.  **Experience**  In understanding the frame synchronization and frequency bias correction algorithms in digital communications and experimentally verifying them using LabVIEW, it is important to understand the importance of frame synchronization in digital communications: frame synchronization is a critical step in ensuring that the receiver correctly parses the data from the sender. With the frame synchronization algorithm, the start position of each frame can be correctly identified when the data stream is received, so that the data can be correctly decoded and processed. Understand the role of the Frequency Bias Correction algorithm: Frequency bias refers to the shift in signal frequency due to inconsistencies in the local clocks of the transmitter and receiver. The frequency offset correction algorithm compensates the received signal for the frequency to eliminate the error caused by the frequency offset, thus improving the reliability and performance of the system. | |
| **Score** | 100 |