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Literature Survey for Frame Synchronization in Communication System

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***Abstract* – One of the key operations in communication system is frame synchronization. In order to enhance frame synchronization we use many types of techniques. But the optimum solution cannot be found in the exiting methods. Recently a new algorithm based on probability of false acquisition provides better frame synchronization in the received data with background noise and interferences. This literature survey discusses all the existing frame synchronization algorithms and their performance.**

***Keywords* – Frame Synchronization, Non Coherent Correlation Permutation Codes, Trellis Codes.**

I. Introduction

Frame synchronization is the process in the telecommunications transmission system to arrange the digital data at the receiving end. Frame synchronization is commonly achieved by two different techniques. These are periodically inserting a synchronization sequence (sync word) in the original data at the transmitter (continuous data) and another one is sync word appended at the beginning of each packet (packet transmission).

Various methods for locating sync word in data for both binary and M-ary communication system over Additive White Gaussian channels was explained in [12] and [10]. The design of binary sync words in the presence of background noise is discussed in the scholtz [14].Massey introduces optimum rule method [10] for finding location of sync word for binary data give a 3 db advantage over the other correlation methods. This rule is complicated than other correlation methods

Turbo codes based frame synchronization technique doesn't require additional preamble (or) sync words. Here Maximum a posteriori (MAP) types of frame synchronization technique minimize the probability of frame synchronization failure rate [9].The frame alignments are improved by using [3] bit erasure information by increasing P_{SYNC} value and reduction of Pt, sim in the overlap region. Here modified CCITT algorithm is used to improve the performances

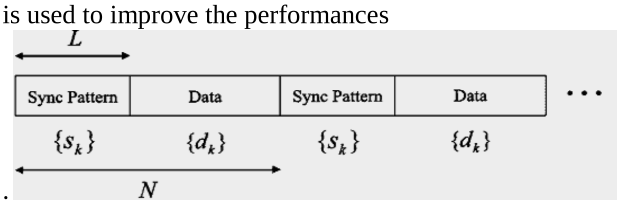

Fig.1.Frame structure of continuous data

The figure 1 shows that general frame structure for digital data communication system. Here sync data is periodically inserted into data. Correlation rule based method is more popular because of its simplicity of implementation and acceptable performance.At the receiver, after re-covering phase value, the given input values are correlated with a sync pattern and the frame synchronization is obtained by examining the correlation values.

Frame synchronization can also be obtained by maximum-likelihood (ML) rules and their various simplification methods. Frame synchronization is usually performed before carrier recovery is completed. Frame synchronization for UWB signals requires two algorithms, one for finding starting frames and other is finding position of first frame in the each symbol [1].

To find better frame boundary using soft decoder with help of soft information explained in [17]. For estimating carrier frequency offset and phase offset require perfect frame synchronizer. Synchronization is an essential requirement for the OFDM systems [4] because OFDM signals are transmitted block by block and the OFDM system is much more sensitive to synchronization error than the single carrier based system.

A good synchronization sequence has proper length in proposition to the frame length that means, it has minimum data redundancy. And it does not affect the normal operation of system performances. Permutation block codes and permutation arrays are used as a sync word has been studied at [15] and [2].and the channel characters and various noises has been reported in [8] and [13].

II. Literature Review

A. *Block coding technique*

A. J. Han Vinck, [6]Presented a technique to enhance the signal transmission against permanent frequency disturbance and impulse noise by using coded modulation. The combination of M–ary FSK modulation signal and block codes generate a constant envelop modulation signal in the PLC channel. These coding schemes are more suitable forPLC channels because computer terminals generate narrow bandnoise. This type of noise is permanent over a longperiod of time. Impulse noise also occurs but the duration of impulse noise is less than 100µ sec.

To handle these types of noises, the block codes are used. The given message is encoded as a code word of length m and the symbols of a code word are modulated with proper modulating scheme and transmitted into the channels. Normally narrow band noise may cause large envelops, so the error occurs at the demodulator output. Impulse noise has a broad band character and it lead to a multiple large envelopes. The demodulation is coherent as well as a non-coherent way is leading to low complexity transmission.

The block codes are used in the decoding processto handle these types of noises. Decoder compares the demodulatoroutput with allpossible transmitted code words. The size of the codebook depends on the minimum distance between the code words. Using code book we can predict original messages from the decoder. This method is more suitable for power line communication channels

B. Trellis coding technique

H. C. Ferreira, A. J. H. Vinck, and T. G. Swart [5] introduce a permutation trellis codes to overcome the disadvantage of Permutation block codes. It is the construction of long block codes .because construction of block codes is a difficult mathematical problem andgeneral decoding algorithm is not known. The combination of M-ary FSK modulation and new trellis codes makes transmission robust against narrowband, broadband, and background noise disturbances.

Based ondistance-preserving mappings technique permutation trellis codes are constructed and also viterbi algorithm isused for Minimum-distance decoding process. Combination of M-ary FSK modulation and permutationtrellis coding can be provided for a constant envelope modulation signal, frequency spreading to avoid bad parts of the frequency spectrum. New trellis codes are capable of achieving various coding rates and constraint lengths

The "classical" non coherent demodulator detects envelopes, and outputs are estimated for the transmitted frequency, the one that corresponds to the largest envelope. This makes the demodulation process simple and independent from the channel attenuation. To reduce the decoding complexity, the Viterbi algorithm for the permutation codes is used. In the receiver section trellis decoder compares the output of the modified demodulator. Using this we can remove narrowband, broadband, and background noise disturbances. On comparing the two trellis paths that are different in d positions, the d-1 errors allow the correct decoding process. It is capable for long block codes using trellis codes and it is used for large distance data communication and also it is attractive for PLC application.

C. Markov chain technique

Heon Huh and James V. Krogmeier [7] presented a method to find optimum frame synchronization for Markov chain corrupted by AWGN. Here Trellis path search is used to implement frame synchronization for Markov chain decoding process and it is better than convolutional codes. Normally pilotsymbol assisted modulation (PSAM) is used for high data rate transmission and also it is powerful error control coding.

It gives high coding gain. This model suitable for many different frame synchronization situations e.g., convolutionally coded transmissions and continuous-phase modulation. Here two different frame synchronization situations are assumed. One is normal frame synchronization where there is ambiguity over the whole frame. The other one is where the ambiguity window is short relative to the frame length.

The first stage estimates the window containing the frame start using a simple synchronizer. The second stage finds the exact frame start in the window obtained by the first synchronizer. Once forward and backward recursions are finished the metric for each delay is obtained from the calculation over synchronization pattern period. For the proposed synchronizer, there is no limit in the number of resolvable delays. In the state-estimate synchronizer, the number of resolvable delays is equal to the number of states.

The proposed synchronizer performs a correlation only over a window of size L, once the correction terms $\alpha\mu(\Sigma start)$ and $\beta\mu{+}L(\Sigma end)$ are obtained by one-time forward and backward recursions .State-reduction methods can be applied to reduce the computational complexity. This frame synchronizer can also be used in non-coherent demodulation by incorporating per-survivor processing for unknown parameter estimation

D. Ternary sequences method

Eun Cheol Kim, Jaesoo Yang, and Jin Young Kim, [4] introduced a technique to improve performance of frame synchronization and frequency offset compensation. In this case add a ternary sequences to OFDM system in time domain .This technique is based on correlation character and r.m.s frequency error. Normally OFDM is used for high speed data transmission in the communication system. In this method, a steam of given data is divided into parallel data and these data are modulated with separate sub carriers. So, the given data are transmitted in the form of block by block. Hence it needs synchronization in receiver. Normally Cyclic prefix is added with block of data to remove interferences. Generally correlation method is a good method to detect sync word in the receiver. But Ternary sequences can achieve a zero out off phase correlation and large peak value. It is added to the head of the last cyclic prefix of the j^{th} OFDM block. Using this ternary sequences it needs low amount of power and it does not affect the normal operation of the system. In the receiver section the received signal is correlated with known ternary sequences. And then detect the ternary sequences and remove that sequences from the received data.

The ternary sequences are easily found out due to the large peak value. So easily detect the starting position of the frame. This method gives better frame synchronization performances and also it is better than MSB and GIB methods

E. Non coherent correlation method

Marco chiani, [11] presented a frame synchronization method for binary PSK signals in the presences of additive white Gaussian noise and phase offset due to imperfect carrier phase estimation .Here the optimum method is based on the non coherent correlation. When frame have same length means, coherent demodulation method is used in the receiver and for a multi level operation non coherent modulation is used. Non coherent correlation detector can be easily modified by adding a correlation term in the metric evaluation.

Hypotheses testing theory is used to find starting position of the frame, here we choose two possible hypotheses values namely H0, H1 and also LRT(likelihood ratio test) and GLRT(generalized likelihood ratio test) methods are used find the starting frame value. In the receiver section the probability of false alarm is defined as

$$P_{FA} = Pr\{\wedge(R) > \lambda\ |H_o\} \qquad (1)$$

Where, Λ (.) is the selected metric and is the selected threshold. Similarly, the probability of missed detection is

$$P_{MD} = Pr\{\wedge(R) < \lambda\ |H_1\} \qquad (2)$$

And the probability of correct detection is

$$P_D = 1 - P_{MD} \qquad (3)$$

Using the P_D value we can align the received frame sequences. And this method is effective for AWGN channel. And it is optimum and has low complexity.

F. Algorithm based non-binary synchronization sequences

The main aim of this paper is [16] to improve frame synchronization in transmitter and receiver using non binary sequences for permutation codes. And these codes are used for synchronize /resynchronize data in the channel in the back ground noise and interferences. In this method the probability of false acquisition formula is used for detect the misalignments. A good sync word has to be of the proper length in proportion to the frame length (that is, minimal insertion of redundancy in data), while allowing for a low probability of false acquisition in the data (P_{FAD}), and hence a high probability of acquisition (P_A).

In this method permutation set is chosen from permutation code book and permutation sequences are generated based on permutation set. Using permutation codes the incoming signals are converted into frame models and combined with permutation codes. This technique is called as frame mapping. After frame mapping process the incoming signals are modulated with M –ary FSK scheme and transmitted though channels. In the receiver the incoming modulated signal are demodulated with M –ary FSK scheme and frame remapping process needs permutation codes.

In this case the receiver already consist of permutation code book .The permutation set sequences is find out from the received signal and using this set sequences we can generate permutation codes. The frame synchronization algorithm sequentially searches for the synchronization sequence in the received frames corrupted by channel noise

$$P_{FAD} = \left(\frac{1}{M!}\right)\left[1 + \sum_{K=2}^{H} F_K \binom{M}{M-K}\right] \qquad (4)$$

Using this formula, F_k function gives the number of permutation sequences that differ from the synchronization sequence. At each symbol time instant, an L_S-tuple of received symbols is compared with the synchronization sequence (permutation codes), and any L_S-tuple of received symbols that differs to the synchronization sequence in at most H positions is declared the synchronization sequence. In this case difference of received frame is correctly alignment with help of permutation codes generated in the receiver. Finally we get original message signal without background noise and other interferences signal.

The following algorithm gives detail about how to create permutation codes. Using this algorithm we can generate different set of codes which are independently each other.

Set SE=∅.

1) Choose any permutation $P = P_1P_2....P_M$ where $Pi \in \{1,...,M\}$.
2) Set $S_C^I = P_{i+1}....P_{M-1}....P_M P_i$, , where i = 0,...., M−1.
3) For M odd, set M=2m+1, and for M even, set M=2m, where m is a positive integer.
a) For i =0,...,m form a set of Ti permutations from S^i_C as follows: Ti = $\{P_{i+1}...P_M P',...P'i\}$, Where$P'_1...P'_i \in S\{P^1...P_i\}$.
b) For j = m+1,...,M −1 form a set of Tj Permutations from s_c^j as follows: Tj=Pj+1...PMP'$_1$...P'$_i$, where $P'_{j+1}...P'_M \in S\{P_{j+1}...P_M\}$.
4) Set S_e =Ti∪...∪ .
5) Include Pin S

This algorithm produces a set of permutation codes and so it is also called as non-binary synchronization sequences and these are used to frame mapping and remapping operations in the system ,these permutation codes is effective for background noise and interferences. The Comparison between non binary Permutation sequences and sextic Barker sequences *at M* = 5 and *α* = 2 (*LS* = 10) is shown is Fig (2). This technique provides betterframesynchronizationinthe background noise and interferences.

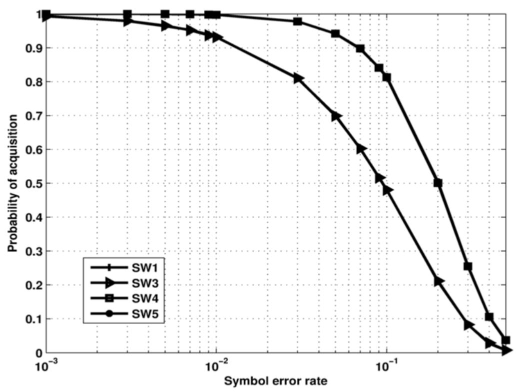

Fig.2. Performance of sync sequences

This Synchronization sequences are therefore more robust in the presence of interference compared to the sextic Barker sequence

III. Conclusion

In this paper, a brief literature survey for frame synchronization in the communication system is discussed elaborately and new algorithm based non binary permutation synchronization sequences used for improveframesynchronization in the system with background noise and interferences. Hereprobability of false acquisition information used to find out frame misalignment in the receiver. This algorithm provide betterframesynchronization performance than other conventional algorithms.

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