Time Domain Synchronous OFDM System Using Compressed Sensing Space Time Block Code for Optical Fiber Communication

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Abstract— *More than one signal is transmitted in an optical communication channel using the concept of orthogonal frequency division multiplexing (OFDM), which efficiently handles inter-symbol interference and efficiently utilises the frequency and available bandwidth. Because the transmitting antenna transmits signal in a noisy channel, the noise in the channel must be estimated. In a noisy channel, the channel estimation technique aids in analysing the effect of noise on the transmitted data. As a result of its high transmission rate, orthogonal frequency division multiplexing (OFDM) plays a significant role in wireless communication. Information is transmitted by both spatial and temporal dimensions in space-time shift keying (STSK), which can be used to achieve the right balance between diversity and multiplexing gains. STBC is a powerful technique used at the transmitter to achieve high data rates, greater capacity, and a low Bit Error Rate (BER). Compressed sensing (CS) is explored in this research in order to increase throughput and reduce bit-error performance by transmitting extra information bits in each subcarrier block, as well as to reduce the complexity of the equaliser. In this study, the space time block coding algorithm is combined with channel estimation via the ANN technique. The analysis of the results shows that the proposed methodology performs better in terms of BER.*

Keywords— ***OFDM, DSP, IFFT,MC,RF***

I. INTRODUCTION

Orthogonal frequency division multiplexing (OFDM) has drawn a lot of interest in optical fibre communications as an efficient multiplexing innovation immune to inter symbol interference (ISI) and inter carrier interference (ICI) caused by a scattering channel, and it could be a candidate for more elastic optical fibre networks [1-3]. The OFDM system's versatility and scalability are due to its unique frame structure. A guard interval (GI) is introduced between neighbouring OFDM symbols to reduce ISI and ICI. There are now three primary types of OFDM systems based on the guard interval design method.

Cyclic Prefix OFDM is the very first type (CPOFDM). CP is a partially identical copy of the OFDM symbol with the symbol duration filled in. Because of its cyclic structure, ISI has no impact on the system, and subcarrier orthogonality is guaranteed. When the length of the cyclic prefix is larger than the channel's maximum transmission latency, all ISI can be eliminated and the subcarriers are kept orthogonal to each other [4-6]. The Zero Padding OFDM is the second type (ZP-OFDM). To eliminate ICI, ZP is used as the guard interval instead of the traditional CP, while zero padding can efficient manner save transmission power. ZP-OFDM is more adaptable than CP-OFDM because it can use the extended cyclic channel matrix to effectively reduce complexity channel equalisation [7, 8].

Time Domain Synchronous OFDM is the third type (TDS-OFDM). The guard interval in this type of OFDM is filled with pseudo noise (PN) sequences. The PN sequence can be used for system synchronisation and channel estimation because it is recognised at the receiver end. TDS-OFDM is also referred to as PN Padding OFDM (PN-OFDM). TDS-OFDM is being used in the multi-carrier portion of the Chinese Digital Terrestrial/Television Multimedia Broadcasting (DTMB) telecommunications network standard, which describes physical layer transmission protocols such as frame structure, channel coding, and modulation schemes [9, 10].

Recent times, optical CP-OFDM has piqued the interest of the optical communications society, and it has undoubtedly demonstrated its possibilities in a wide range of applications across all levels of optical networking, from long haul to metro, access, and network services [9-10]. However, because the useless fraction of data symbols is also included in the transmission process, using CP will result in a loss of data rates (bandwidth). CP also causes power loss in comparison to the empty guard interval. The valuation of power loss is proportional to the CP to OFDM symbol timeframe ratio [2-6]. We properly examine the TDS-OFDM principle and revise an appropriate TDS-OFDM frame structure using the enhanced algorithms. We can reach the conclusion from the simulation results that the proposed TDS-OFDM scheme achieves stable overall performance of synchronous accuracy and carrier frequency offset (CFO) prediction performance in a coherent optical communication system.

II. LITRATURE REVIEW

C. Jing, X. Tang, X. Zhang, L. Xi and W. Zhang [1], This research combines the features of QPSK OFDM and 16QAM OFDM systems in optical fiber communication. The proposed methodology has been demonstrated to have high CFO evaluation and sequential accuracy.

A QPSK OFDM system has a BER of the less than 3.8e-3 at a 13-dB electro - optic signal-to-noise ratio (OSNR), while the 16-QAM OFDM system has a BER of less than 3.8e-3 at a 20-dB OSNR.

HaoWu, Member, YuanLiu, and KaiWang [2], The impact of an extended Kalman filter transmission estimation method on a massive-MIMO system was illustrated.

Whenever the SNR is low, this one has been revealed that non-allocating sub carriers to Zero padding lead to better results. The methodology utilizes the high speed Fourier transform/inverse high speed Fourier transform to torque for short complexity. This paper also investigates DFT-based modulation scheme for transceiver massive MIMO systems. The simulation results show the constraints of the proposed technique in low SNR AWGN channels. The best results are displayed using an improved Kalman filter with FFT system, that also immensely reduces computational complexities.

Aqiel Almamori, Seshadri Mohan [3], Channel state information (CSI) evaluation for sensing of input signal data was created using the Kalman Filter and basic experience of the channel or established pilot bits.

The examinations conducted the OFDM-based QPSK modulation technique. A reconfigured Kalman filter is applied to the received data that can provide channel state information (CSI) and estimate channel noise.

The result analysis of the enhanced Kalman filter is less dependent on the channel statistics and yields the minimum MSE.

J.W.Choi, B.Shim, Y.Ding, B.Rao, and D.I.Kim [4], Presented an overview of CS advanced technologies at a high level, such as basic configuration, the piecemeal recovery process, and performance assurance As a consequence, in various wireless communication systems, we describe three distinct CS sub-problems: vulnerability estimation, medium identification, and vulnerability detection. We also go over some of the most significant factors when building CS-based wireless communications systems. Which include the potential and constraints of CS strategies, beneficial recommendations to keep in mind, slight points to keep in mind, and several preliminary knowledge for performance improvement.

Z.Gao, L.Dai, C.Qi, C.Yuen, and Z.Wang [5], A low complexity signal technique based on structured compression sensors (SCS) was recommended to significantly enhance detection accuracy.

To create the necessary constructed economy, we first propose an integrated reporting categorised at the transmitter level in which discrete SM signals are categorised in distinctive constant frequency ranges to carry the symbol of the prevalent space cluster. As a consequence, a constructed subspace tracking technique (SSP algorithm) is recommended to the receiver in order to cohesively gather many SM signals using systematic scarcity.

III. METHEDOLOGY

To substantially improve detection accuracy, a low complexity signal method based on established compression sensors (SCS) was recommended.To create the required constructed economy, we first propose a comprehensive reporting categorised at the transmitter level in which discrete SM signals are classified in distinct continual frequencies ranging to carry the symbol of the prevalent space cluster.

As a result, the receiver is advised to use a constructed subspace tracking methodology (SSP algorithm) to cohesively gather many SM signals using systematic scarcity.

The O-OFDM principle is identical to that of OFDM. The sole difference is that the signal is converted from a wireless signal in the energy domain to an opportunistic signal in the opportunistic domain. The architecture block diagram of the O-OFDM system is shown in Figure 1. OFDM baseband transmission, RF up-conversion, and optical modulation are all included in the transmitter. Optical detection, RF down-conversion, and OFDM baseband reception are all included in the receivers. The binary serial digital signal is input at the transmitter and then S/ transformed into N-channel parallel data. Each piece of data is modulated using the M-ary SK or AM technique. By using a constellation diagram, the signal is mapped to the appropriate complex domain. Then, using IFFT, N parallel carriers are converted to serial ones, and an OFDM symbol is placed before each symbol.

The cyclic prefix (C) is inserted, and the digital-to-analog conversion is used to turn the signal into an OFDM baseband analogue signal. The baseband signal is modulated to RF carrier frequency and then to opportunistic carrier before being delivered into single mode fibre (SMF). The receiver's DS is essentially the inverse of the transmitter's. A detector (D) converts the optical signal into electrical domain, and then an analogue to digital converter converts the signal into digital domain (ADC). After that, C is eliminated and a /S conversion is carried out. The signal is then translated to the frequency domain using FFT. The signal is finally de-mapped and transformed to serial data. The five functional blocks of conventional OFDM systems are as follows:

- Baseband OFDM transmitter
- Electrical-to-optical (E/ O) up-converter
- Optical fiber link
- Optical-to-electrical (O/E) down-converter
- Baseband OFDM receiver

Frame header (FH) and frame body (FB) make up each OFDM signal frame (FB). An OFDM symbol is a signal frame. Both FH and FB have the very same baseband symbol rate. The implanted guard interval (FH) is used to keep the subcarriers in a proper orthogonal state.

TDS-OFDM is a technological breakthrough in the field of optical communication in various ways. To begin, TDSOFDM uses N as the guard interval to provide significantly faster synchronisation than C-OFDM. Second, inside each sub-frame, N specifies the unique signal frame address. Thirdly, by adopting the known PN sequence as FH to minimise ISI, TDS-OFDM delivers the benefits of quick network acquisition since this could be done exclusively in time domain.

Optical communication is employed rather than wireless communication in this study, with OFDM integration. As illustrated in Fig. 3, the proposed scheme is divided into N parallel groups with b number of data bits processed in each group, with b number of data bits processed in each group. b1 bits are mapped to the IM selector for each group of b bits, which selects K active indices from Na available indices. The remaining b2 bits are used to generate K STTC code-words, which are then resynchronize to provide additional diversity gain for better BER and MSE performance.

The activated indices are then mapped to the K coordinate interleaved code-words using the IM selector, while the inactive indexes are set to zero. The block creator then collects all code-words from G groups in parallel and creates a frame, which is then mapped to space-time trellis code-words, modulated with DWT-OFDM, and finally transmitted. We analyse OFDM modulating with Nc subcarriers, which are eually divided into N subcarrier groups, each group containing Mg = Nc/N subcarriers in the frequency domain, in the system shown in Fig. 3. Out of the Na possible subcarrier indices in the virtual domain, K number of indices are active in each subcarrier group.

In OFDM, Nc can take on very high dimensions, and if the index selector is applied directly to Nc, there could be an enormous lots of alternative active indices combinations, making active indices selection nearly impossible. As a result, to perform index selection, the subcarriers are partitioned into N smaller groups. The data packets are separated into G groups at the transmitter's input, as shown in Fig. 3.

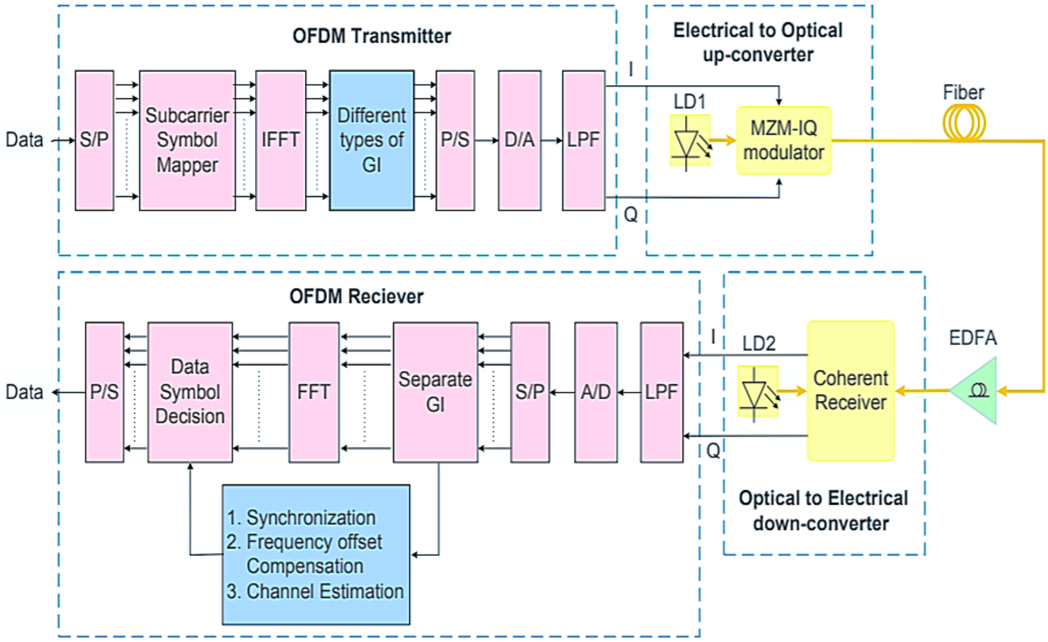

Figure 1: Optical OFDM

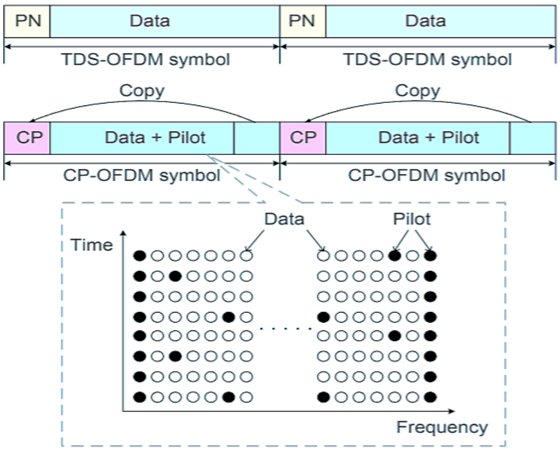

Figure 2: Optical OFDM Frame Structure

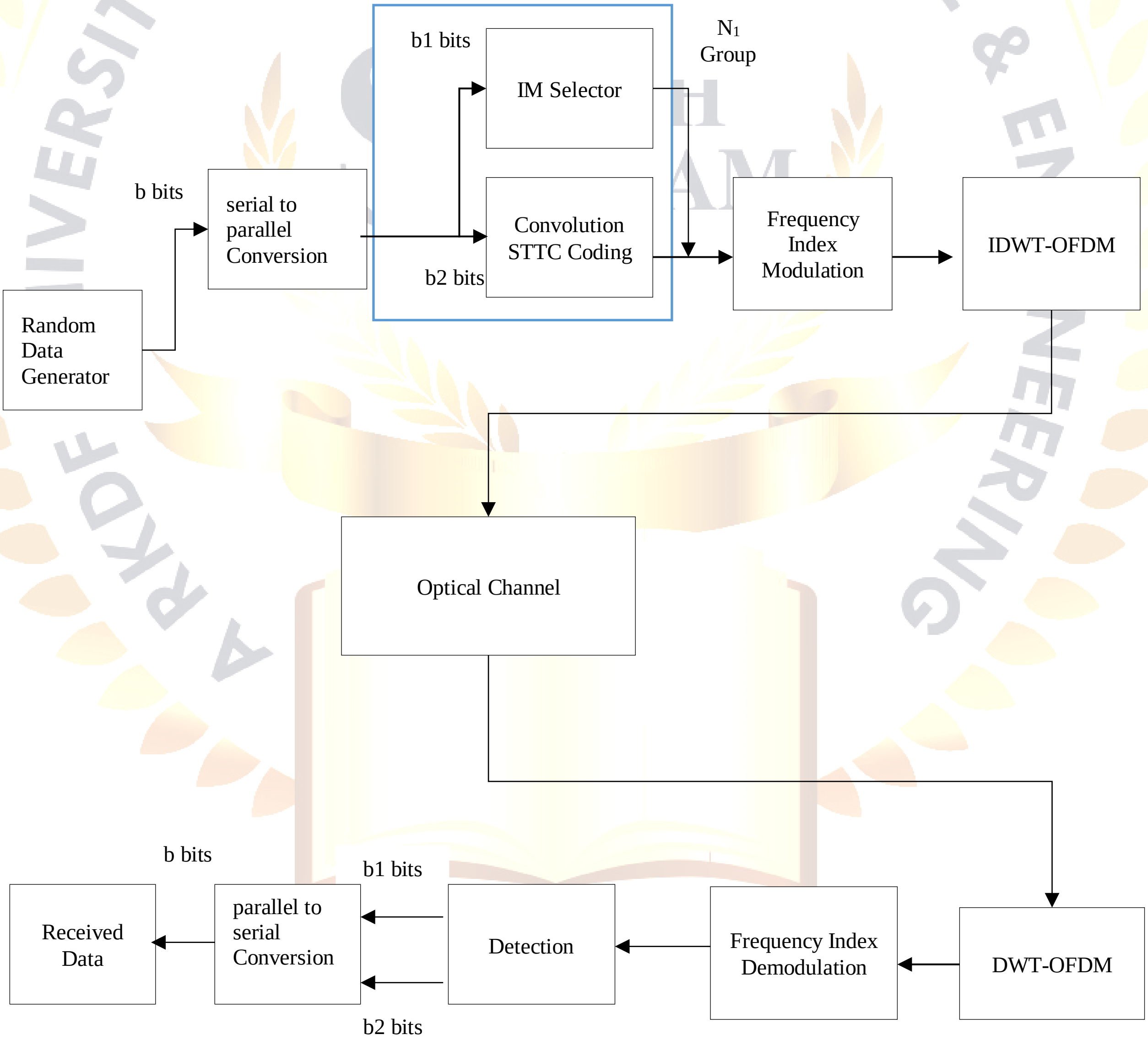

Figure 3: The Proposed Transceiver Architecture

IV. RESULT ANALYSIS

Mean Square Error performance is analyzed under WGN channel utilising Matlab software with frequency index modulation approach in simulation of proposed approach. The research framework is simulated and compared to each other using a variety of signal to noise ratios (Eb/No), as shown below. The optical-OFDM and the CS-aided STBC optical-OFDM are compared at the same transmission data rates. Monte Carlo simulations are used to evaluate the BER performance of these methods.

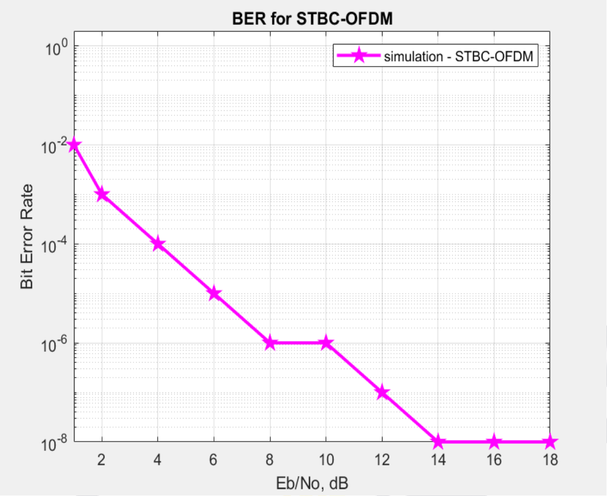

Figure 4: BER Performance of CS-STBC Vs SNR

According to Fig. 4, the suggested technique has a performance range of 0-18 dB. More specifically, the proposed algorithm has a 10-7 BER when compared with existing system. Despite having a reduced decoding complexity, it has been observed that the proposed methodology is adequate to attain a better performance. NN channel estimation and equalization are also performed to further reduce complexity, and it is shown that NN have less MSE than traditional channel estimation techniques. Figure 6 depicts the MSE's performance.

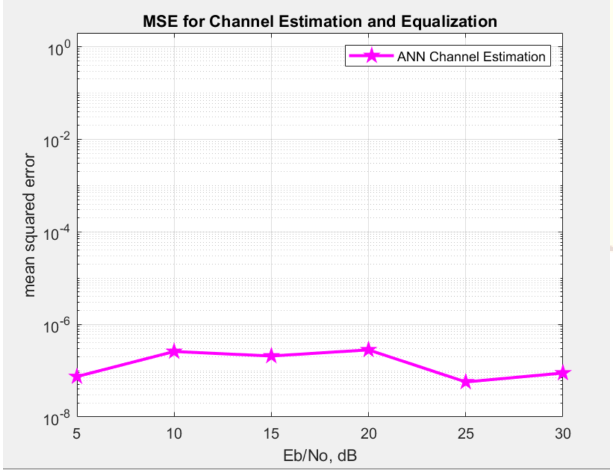

Figure 6: MSE Performance of ANN Equalizer with CS-STBC Vs SNR

V. CONCLUSION

a space time block code bandwidth index modulation scheme based on CS-aided low complexity detections for transmission over single frequency channels is investigated in this study. To improve spectral efficiency and BER performance, information bits are transmitted using space, time, and frequency dimensions. In the simulation, the proposed methodology used space time block coding, which has better BER performance than the traditional OFDM-STSK system. The NN channel estimation outperforms traditional MMSE channel estimation techniques in terms of MSE performance.

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