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PAPR Reduction and Channel Estimation in Universal Filtered Multicarrier System Using MIMO

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Abstract: Due to its effectiveness, UFMC is also one of the modulation methods now employed in 5G technology. Additionally, it offers low frequency and tenacity PAPR makes analog-to-digital and digital-to-analog converters more difficult and decreases the effectiveness of radio-frequency (RF) power amplifiers. For receivers to correctly recover the broadcast signals, channel state information (CSI), which is obtained through channel estimate, is crucial. For OFDM, there are several well-defined traditional pilot-aided channel estimate algorithms, It is sometimes referred to as UF-OFDM due to the similarities between UFMC and OFDM. The channel estimate methods used for OFDM are therefore adaptable to this 5G method with a few adjustments. Two distinct channel estimate methods that may be assessed for UFMC are least square (LS) and minimum mean square error (MMSE). Techniques for interpolation like linear and spline are also assessed for UFMC. Since LS is more susceptible to noise at higher SNRs, simulation findings demonstrate that MMSE offers superior MSE performance than LS. Both the AWGN and Rayleigh fading channels exhibit the MSE floor.

Keywords— UFMC(Universal filtered multicarrier frequency), MATLAB, MIMO(Multi- Input Multi - Output) channel estimation, channel sate information (CSI).

1. INTRODUCTION (*Heading 1*)

The most well-known method of multi-carrier modulation used today is orthogonal frequency division multiplexing (OFDM). Because of its straightforward and effective modulation and demodulation stages employing Fast Fourier Transformation (FFT) and inverse FFT, it is used in standards like Long-Term Evolution (LTE) and Wi-Fi (IFFT). Additionally, it enables receiver scalar equalisation per-subcarrier. However, it is generally known that because to the comparably large spectral side-lobe level, the rectangular symbol form of OFDM is neither properly localised in time nor in frequency. To increase system speed, LTE strictly enforces synchronisation. Such an approach is not practical for new forms of wireless services like the Internet of Things (IoT) and the tactile Internet, even if it is sensible for today's networks that generally send high-rate data to high-end devices like smart phones and tablets. Future 5G wireless communication systems must thus be able to handle a wide range of traffic types, including routine high-rate traffic, occasional tiny packet transmission, and urgent low latency transmission. Low-end devices (such simple sensor components) should be permitted to transmit with relaxed synchronisation criteria for time-frequency misalignments in 5G in order to decrease the signalling overhead and battery usage. When doing so, it is important to look at the inter-carrier interference that is brought to other, nearby users. Filter-bank based multi-carrier is a potential 5G replacement technology for OFDM (FBMC). The unique filtering of each subcarrier significantly improves resilience against inter-carrier interference (ICI) effects. Filters used in common FBMC systems, however, have lengths that are several times that of samples per multi-carrier symbol. As a result, its downside is that it has a high filter length, which makes it difficult to communicate in brief uplink bursts, which is necessary in some of the possible application scenarios for 5G systems, such as low latency communication or energy-efficient Machine-Type Communication (MTC).

2. Related Work

In order to solve the ICI issue and boost system performance, UFMC is a multi-carrier transmission scheme. In order to reduce out-of-band sidelobe levels, filtering operation is applied to a set of subsequent subcarriers (e.g., a given allocation of a single user), which leads to better ICI robustness and better suitability for fragmented spectrum operation than OFDM. For both perfect and imperfect frequency synchronisation between the transmission and reception sides, UFMC performs better than CP-OFDM. compare the SER performance of the UFMC system with that of the OFDM system, and examine the impact of poor CFO compensation. The MIMO-OFDM (MULTI-INPUT MULTI-OUTPUT ORTHODONAL FREQUENCY DIVISION MULTIPLEXING)[9] systems, which provide stable performance of diversity and spatial multiplexing as well as superior spectrum efficiency than UMFC systems, have attracted substantial attention. MIMO-OFDM systems, however, have high peak-to-average power ratios (PAPR). Many techniques have recently been put out in the literature to lower the PAPR for OFDM systems, including clipping, selective mapping (SLM), partial transmit sequence (PTS), constellation shaping, and adaptive all-pass filters. In the meanwhile, a number of strategies were put out to lower the PAPR of MIMO-OFDM signals on the transmitter side. The SLM scheme is a desirable and effective approach among them since it may effectively reduce PAPR without causing signal distortion. However, additional bits must be set aside for the transmission of the phase rotation sequences as side information (SI) for the conventional SLM (C-SLM) system, which lowers the data rate. Additionally, a frequency selective fading channel will interfere with the SI, thereby degrading bit error rate (BER) performance. For Alamouti MIMO-OFDM systems, a blind SLM (B-SLM) approach based on maximum likelihood (ML) is presented in [8], which does not need the SI transmission. This letter proposes the P-SLM, an unique phase offset SLM approach, to lower the PAPR without SI in Alamouti MIMO-OFDM systems. The phase offset for the P-SLM method relates to the phase rotation sequence and exists between the signals at various transmit antennas. The phase offset with the smallest Euclidian distance is then chosen as the sign of the phase rotation sequence utilised at the transmitter, and a MED decoder is also suggested for the receiver. Since they have a one-to-one correlation, the SI may be determined in this manner by calculating the phase offset. As a consequence, the P-SLM system does not need to set aside bits for the transmission of the SI, increasing the data rate.

Selective mapping, first

Selective Mapping (SLM) is a distortion-free method that effectively reduces PAPR without requiring more power or resulting in data rate loss. The simulation results demonstrate the superior PAPR reduction of the suggested SLM approach.

All active subbands are subjected to the universal filter multicarrier. Different numbers of successive subcarriers may make up each filtered sub-band. Sub-band filtering may stop out-of-band emission and keep the relationship between subcarriers in each sub-band orthogonal. By choosing other sequences from the same data source, the SLM is used to lower the PAPR before choosing the transmit signal with the lowest PAPR.

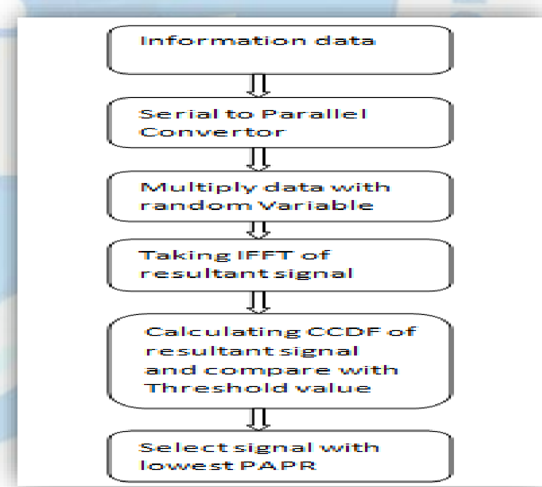

Fig.1 *Flow Chart for selective mapping techniques Selecting a Template*

B. PEAK TO AVERAGE POWER RATIO

A big PAPR decreases the radio frequency (RF) power amplifier's efficiency and adds to the complexity of analog-to-digital and digital-to-analog converters. It is possible to impose regulatory and application limits to

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lower the peak transmitted power, which in turn lowers the multi carrier transmission's range. The transmitter power amplifier is no longer restricted to the linear area in which it should operate, which prevents spectrum expansion. The battery life suffers as a result of this. Thus, it can be shown in communication systems that a high PAPR value might outweigh all of the potential advantages of multi carrier transmission.

PAPR of a Multicarrier Signal

Let the data block of length N be represented by a vector is

X= [x0, x1, x2, ..., xN-1]T Duration of any symbol in the set X is T and representsone of the sub-carrier set. The complex data block for the OFDM signal to be transmitted is given by

The PAPR of the transmitted signal is defined as

Reducing the max|x(t)| is the principle goal of PARP reduction techniques. Since, discrete- time signals are dealt with in most systems, many PAPR techniques are implemented to deal with amplitudes of various samples of x(t). Due to symbol space output in the first equation, we find some of the peaks missing which can be compensate by oversampling the equation by some of the factor to give the true PAPR value.

3. Universal Filtered Multicarrier Frequency

Universal filtered multi-carrier has been proposed to overcome FBMC. FBMC is the requirement for relatively long filter length, which may induce extra delay in addition to hardware complexity and is thus infeasible for the short burst traffic[18]. By filtering a series of successive subcarriers, UFMC can achieve lower OOB emission as compared to OFDM and it is capable of supporting segmented spectrum, low latency and asynchronous framework.

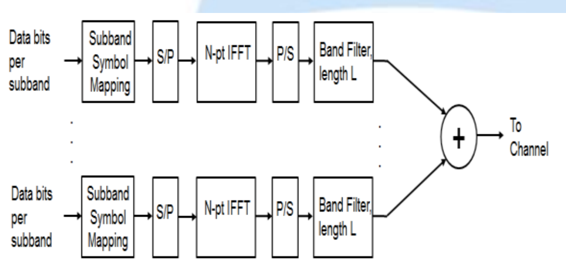

Fig.2 *Block diagram of UFMC transmitter*

A. SIDELOBE SUPPERSION BY SUBCARRIER WEIGHTING

A single non-weighted subcarrier sn(x), n = 1, 2, . . ., N, is represented in frequency domain as

$$S_n(x) = d_n \sin(\pi(x-x_n)) / \pi(x-x_n)$$

$$n = 1, 2, 3, ..., N. \qquad (1)$$

Where, x is a normalized frequency given by

$$x = (f - f_0) T_0 , \qquad (2)$$

where f denotes the frequency and f0 is the center frequency. In addition, xn is the normalized center frequency of the nth subcarrier. In (1), rectangular time domain windowing at the transmitter with window length T0 is implicitly assumed. When a different type of windowing, e.g., raised-cosine windowing, is applied, or a non-negligible guard interval length $T\Delta > 0$ is assumed, (1) has to be adapted according to the Fourier transform of the chosen window.

The goal is to suppress the sidelobes in a certain frequency range, we consider sn(x) only in that range.

We observe M samples at the normalized frequencies ym, m = 1, 2, . . ., M, lying in the frequency range where the optimization of the sidelobes is performed. With that, (2) reduces to

$$S_{n,m} = s_n(y_m) = d_n \sin(\pi(y_m-x_n)) / \pi(y_m-x_n), \quad n = 1, 2..., N,$$

$$m = 1, 2..., M. \qquad (3)$$

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Finally, stacking the vectors sn into a matrix we get S = (s1, s2, . . ., sN). To minimize the sidelobes of the weighted transmission signal d, we have to solve the following optimization problem

$$G = \arg\min \|s\_\tilde{g}\|2$$

where is a trial value of g.

In addition, we include two constraints on the weighting vector g. The first constraint ensures that the data symbols $\bar{d}$ after SW require just the same transmission power as the data symbols d before SW, i.e.,

The second constraint ensures that the elements of g are real valued and lie between pre-defined limits, i.e., Such a constraint guarantees that each subcarrier receives a certain amount of the transmission power which is inherently controlled through the ratio ρ = gmax/gmin. Furthermore, gmin and gmax can be selected such that a weighted symbol dn remains in the same decision region as the original symbol dn. In such case no signaling from transmitter to receiver is required, e.g., for PSK this is valid for gmin > 0.

The optimization problem given in (5), together with the constraints in (6) and (7), can be generalized to a nonlinear programming problem with a quadratic equality (6) and a linear inequality constraint (7). To solve such an optimization problem many effective and reliable numerical algorithms exist, e.g., the projected Lagrangian method.

B. FILTERBANK MULTI-CARRIER

Filter Bank Multi Carrier is a form of multicarrier modulation scheme that uses a specialised pulse shaping filter known as an isotropic orthogonal transform algorithm, IOTA within the digital signal processing for the system. This scheme provides good time and frequency localisation properties and this ensures that inter-symbol interference and inter-carrier interference are avoided without the use of cyclic prefix required for OFDM based systems[8]. With high enough out-of-band attenuation of the sub-band filters, the filter bank itself can provide sufficient frequency isolation to implement the needed reception and selectivity. This enables you to move all signal processing functions after the filter bank to the low sampling rate.

In the multiuser context, the subchannels or groups of subchannels allocated to the users are spectrally separated as soon as an empty subchannel is present in-between. Therefore, users do not need to be synchronized before they gain access to the transmission system. This is a very important factor for uplink in traditional base station-centric networks or in future dynamic spectrum access systems. In cognitive radio, FBMC offers the possibility to simultaneously carry out spectrum sensing and transmission functions with the same device.

C. GENERALIZED FREQUENCY DIVISION MULTIPLEXING

Generalized Frequency Division Multiplexing is a multicarrier modulation scheme that uses closed spaced non-orthogonal carriers and provides flexible pulse shaping. It is therefore attractive for various applications such as machine to machine communications.

GFDM is based on the modulation of independent blocks, where each block consists of a number of subcarriers and sub symbols. The subcarriers are filtered with a prototype filter that is circularly shifted in time and frequency domain. This process reduces the OOB emissions, making fragmented spectrum and dynamic spectrum allocation feasible without severe interference

D.CHANNEL ESTIMATION

A vital multi-carrier transmission method used to address the high data rate requirements of wireless communications is called Universal Filtered Multi-Carrier (UFMC). Orthogonal frequency division multiplexing (OFDM) has various restrictions that make it unsuitable for 5G. Being a 5G newcomer, UFMC combines the resilience of a filter bank multi-carrier with the simplicity of OFDM (FBMC). One of the popular study areas for the UFMC modulation technology is channel estimation. For receivers to correctly recover the broadcast signals, channel state information (CSI), which is obtained through channel estimate, is crucial. Due to the similarities between UFMC and OFDM, a variety of well-defined classical pilot-aided channel estimate algorithms are available for OFDM. This technology is also known as UF-OFDM. The channel estimate methods used for OFDM are therefore adaptable to this 5G method with a few adjustments. Two distinct channel estimate methods that may be assessed for UFMC are least square (LS) and minimum mean square error (MMSE). Techniques for interpolation like linear and spline are also assessed for UFMC. Since LS is more susceptible to noise at higher SNRs, simulation findings demonstrate that MMSE offers superior MSE performance than LS. Both the AWGN and Rayleigh fading channels exhibit the MSE floor.

4. SIGNAL TO NOISE RATIO

Science and engineering employ the signal-to-noise ratio (SNR or S/N) to compare the strength of a desired signal to the strength of background noise. SNR is referred to as the signal-to-noise ratio and is often stated in dB.

To obtain effective output, it is essential to be able to discriminate between different output signals. Decibels are commonly used to indicate Signal-to-Noise Ratio. The output is better the greater the SNR value. The explanation is that a high SNR output contains more signal—useful information—than noise—unwanted data.

You need to know the levels of the signal and noise in order to determine the signal-to-noise ratio. Subtract noise from the signal if the signals are given in decibels (dB). The power signal-to-noise ratio formula should

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be used if your calculations are in watts. SNR is equal to 20 log(signal/noise)

BITS PER ERROR RATE

The bit error rate (BER) in telecommunication transmission is the proportion of incorrect bits to all bits received in a transmission, and is often stated as ten to a negative power[21]. By comparing the sent bit sequence to the received bit sequence and calculating the mistakes, the BER is determined. The BER is the ratio of the number of bits received in mistake to the total number of bits received. An electrical test tool called a bit error rate tester (BERT), also known as a "bit error ratio tester or bit error rate test solution (BERTs), is used to evaluate the signal transmission quality of individual parts or whole systems.

The fundamental components of a BERT are:

• Digital communication analyzer, which is optional and displays the transmitted or received signal; • Electrical-optical converter and optical-electrical converter for testing optical communication signals; • Pattern generator, which transmits a defined test pattern to the DUT or test system; • Error detector connected to the DUT or test system, to count the errors generated by the DUT or test system;

5. SIMULATIONS AND RESULTS

Simulation and result deals with the PAPR reduction and channel estimation in UFMC that works under SLM techniques
All the requirement of the design is illustrated individually and the output is given in this chapter.

- Math and computation
- Algorithm development
- Modelling, simulation, and prototyping
- Data analysis, exploration, and visualization
- Scientific and engineering graphics
- Application development, including Graphical User Interface building

A.GRAPHICAL RESULT

The PAPR reduced with UFMC and SLM techniques and also shows how UFMC equalize the symbols

- Conventional UFMC
- Comparision of PAPR with P-SLM ,C-SLM &B-SLM
- UFMC VS UFMC-SLM
- UFMC with sub-bands and sub-carriers
- OFDM with sub-bands
- UFMC pre-Equalization symbols
- UFMC Equalized symbols

This graph shows us how we get PAPA reduced UFMC by using Discrete Wavelate Transform(DWT) in 7 level with convention UFMC through this we can easily analysis which has low PAPR. In this graph black dot is conventional UFMC with less PAPR.

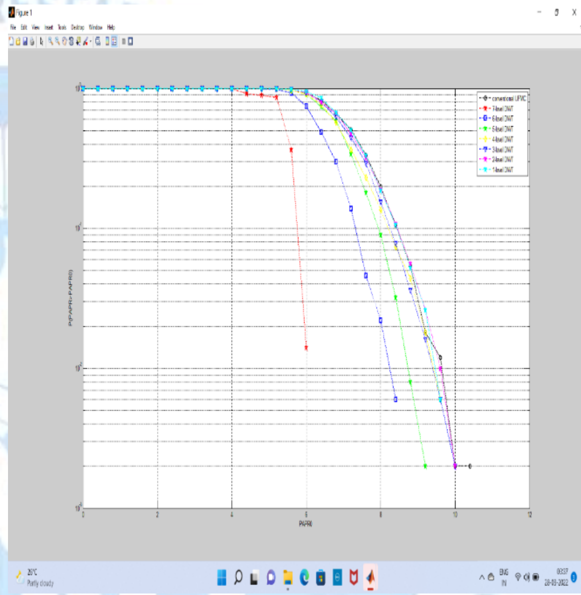

Fig.3 *Conventional UFMC*

The following graph we compared Phase-offset Selective Mapping (P-SLM), Conventional Selective Mapping (C-SLM) and Blind Selected Mapping withPeak-to-average Power Ratio (PAPR). It clearly shows which SLM has reduces PAPR efficiently.

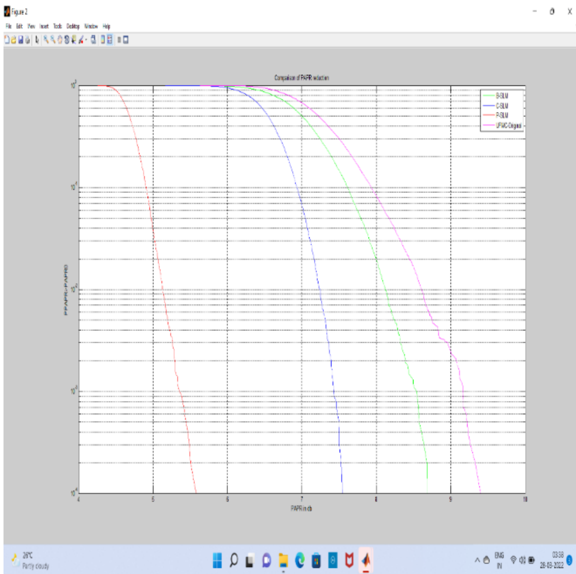

Fig.4 *Comparision of PAPR with P-SLM ,C-SLM &B-SLM*

The following graph we used Selective Mapping (SLM) technique with Universal Filtered Multicarrier (UFMC). It anlysis the performance of Bit error Rate (BER) of UFMC.

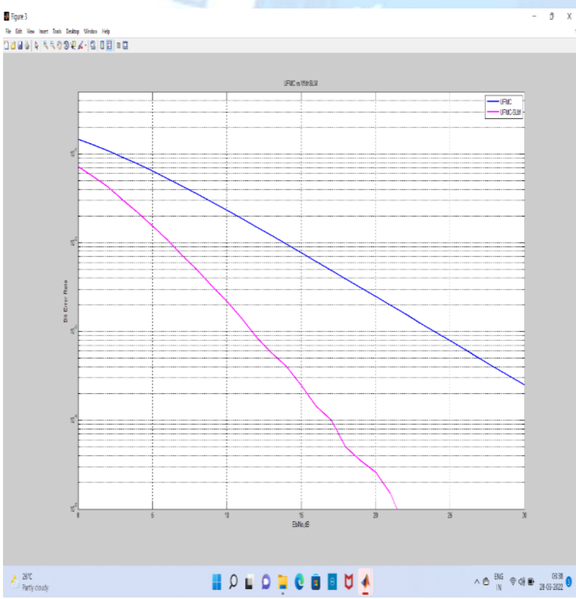

Fig.5 *UFMC VS UFMC-SLM*

The following graph shows us OFDM with sub-bands, and it clearly shows lare size of band gap in the OFDM so there are amny chances to get interference and it will creats PAPR problem

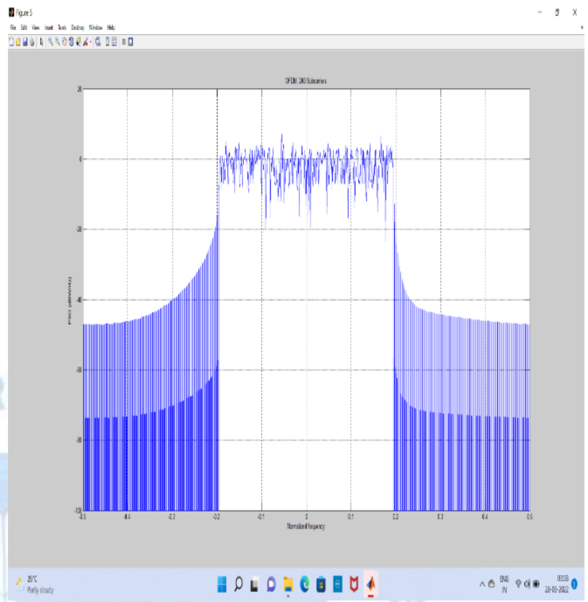

Fig .6 *OFDM with sub-bands*

This graph shows UFMC with 20 Sub-Bands and sub-Carriers, it shows there is minimum gaps with each other so it shows very less chance to get interference.

Because the sub-band and sub-carriers were filtered so it avoids noise and give us noise free modulation.

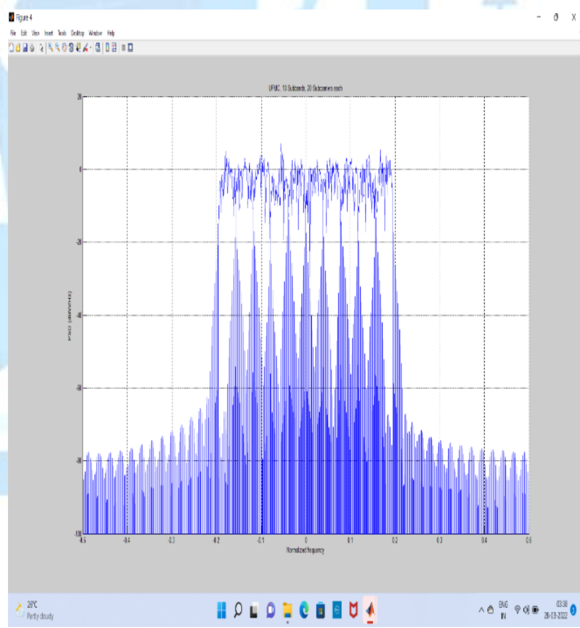

Fig.7 *UFMC with sub-bands and sub-carriers*

This graph show all symbols are assembled at the same place before equalization with Quadrature Phase Shifting Keying (QPSK).

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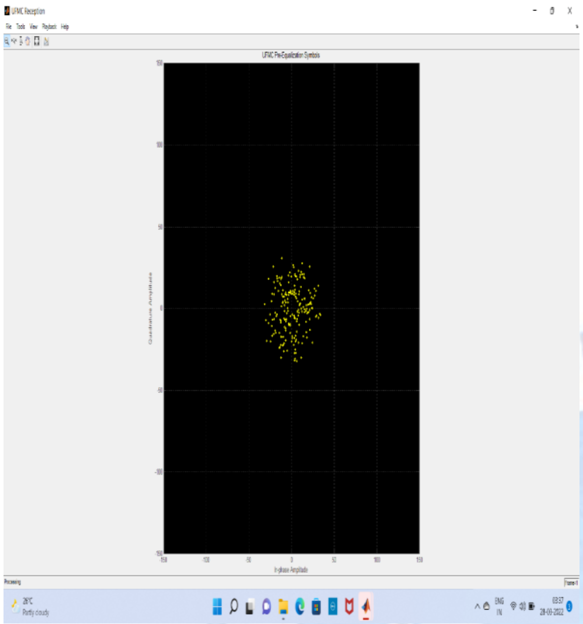

Fig.8 *UFMC pre-Equalization symbols*

This graph show how the symbols of Universal Filtered Multicarrier (UFMC) are assemled its allocated place after equalized symbols

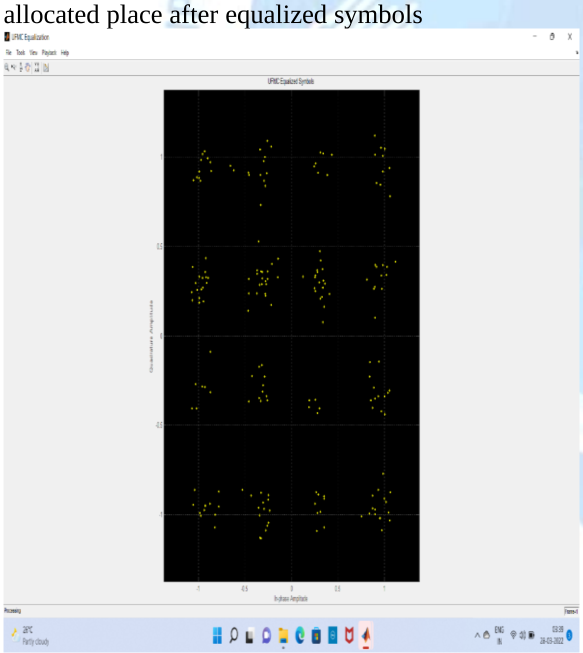

Fig. 9 *UFMC Equalized symbols*

6. CONCLUSION

Bit error rate and PAPR were among the criteria utilised to examine the UFMC-SLM. Better BER is provided by the suggested UFMC-SLM approach than by traditional UFMC and OFDM. Further analysis has been done on the impact of different design parameters on PAPR reduction in UFMC-SLM, and it has been found that the suggested approach offers more effective PAPR reduction than traditional schemes. Subcarrier weighting also helps to improve spectral efficiency. In universal-filtered multicarrier (UFMC) systems, out-of-subband (OOSB) emission is suppressed using a filter optimization technique. Because it combines the benefits of OFDM with filter bank multicarrier, UFMC is a desirable waveform choice for 5G mobile communication systems (FBMC). To suppress the OOSB emission, UFMC uses transmit filtering on a subband of a specific set of subcarriers. The performance of data reception at the receiver, however, might be negatively impacted by the change in frequency response in the subband brought on by filtering. In order to reduce the OOSB emission, a filter optimization approach is presented with restrictions on the subband frequency response. With these restrictions, it is possible to frame the filter design issue as an optimization problem with nonconvex constraints. This issue may be effectively transformed into a linear-constrained convex optimization problem using the proper transformation, which can then be solved using popular interior-point techniques.

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