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Comparison of OFDM and FDMCM Uplink with Hybrid Receiving

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ABSTRACT

The main aim of this project is to develop a system which can help us to know more about millimeter-wave orthogonal frequency division multiplexing (OFDM)and frequency division multi-carrier mixing (FDMCM) uplink transmission with hybrid receiving and with a wide bandwidth. The purpose of the project is to analyse and observe simulation results caused by wideband effects. To analyse the spectral efficiency, power spectral density and signal to noise ratio of both OFDM and FDMCM and compare these parameters and conclude in which frequency ranges or conditions one will work better than the other.
Keywords - millimeter-wave, OFDM, FDMCM, Spectral Efficiency.

I. INTRODUCTION

Wideband millimeter wave (mm Wave) communication is a technology that allows for fast wireless data transfer using frequencies in the millimeter wave range. It can transmit large amounts of data at very high speeds. One technique used in mm Wave communication is called Orthogonal Frequency Division Multiplexing (OFDM).

OFDM is a way to send data by dividing the frequency spectrum into many small parts. Each part carries a bit of the data, and they don't interfere with each other. This makes data transmission efficient and reliable, even in environments with signal problems.
In mm Wave communication, wideband OFDM is used to make the best use of the available frequency spectrum, allowing for high data rates. It is especially useful for mm Wave frequencies because they can lose their signal easily. By dividing the spectrum into small parts and spreading the data across them, wideband OFDM can overcome these problems and achieve reliable communication.

In the uplink direction of mm Wave communication, where data is sent from user devices to the base station, a combination of digital and analog processing is often used to improve signal reception. This combination is called hybrid receiving. It uses digital signal processing (DSP) and analog beamforming.

DSP uses complex algorithms to detect, equalize, and cancel interference in the digital domain. Analog beamforming uses a group of antennas to steer and focus the received signals in the analog domain. By combining digital and analog processing, hybrid receiving can improve the performance of mmWave uplink communication.

Overall, wideband mmWave OFDM and FDMCM uplink with hybrid receiving are advanced techniques that use the unique properties of mmWave frequencies to achieve fast and reliable wireless communication. They are important for next-generation wireless networks with high data capacity and better user experiences.

II. LITERATURE SURVEY

This section we will give a brief introduction of the latest methods for comparison of OFDM and FDMCM uplink hybrid receiving. And some strategies are used for reference in our model

1. OFDM millimeter-wave communication for future wireless systems by Singh, M., Jindal, M., & Gupta, A. (2017): This paper is centered around the utilization of OFDM (Orthogonal Frequency Division Multiplexing) for millimeter wave communication in upcoming wireless systems. It examines the benefits of employing OFDM in dealing with frequency-selective channels, reducing the impact of multipath fading, and achieving remarkable spectral efficiency in millimeter wave OFDM systems. The references provided encompass a wide array of subjects related to millimeter wave OFDM, encompassing channel modeling, analysis of system performance, beamforming techniques, and evaluating the feasibility of millimeter wave communication for future wireless systems. These references can serve as an initial reference point for further exploration.

2. An introduction to millimeter-wave mobile broadband systems by Pi, Z., Khan, F., & Krishnamurthy, P. (2011): This article introduces millimeter wave mobile broadband systems and talks about how we can use high-frequency waves for fast wireless communication. It explains the benefits and difficulties of using these frequencies and how OFDM plays a key role in achieving high data rates in millimeter wave systems.

3. Smart antennas for communications systems by Daniel J. Bem et al: Here is a simplified outline of the key challenges in developing advanced base station antennas, known as smart antennas, which are essential for the next generations of mobile communication systems.Smart antennas include not only radio frequency (RF) components but also a wide range of digital signal processing (DSP) and beamforming technologies.

4. Milli-meterwave mobile communication for 5G cellular by Rappaport, T. S., Sun, S., Rangan, S., & Mayzus, R. (2013): This paper explores the possibility of using millimeter wave frequencies for 5G cellular communication. It examines the benefits and difficulties of utilizing these high-frequency waves and highlights the practicality of millimeter wave OFDM (Orthogonal Frequency Division Multiplexing) for fast wireless communication.

III. PROPOSED SYSTEM

A. OFDM

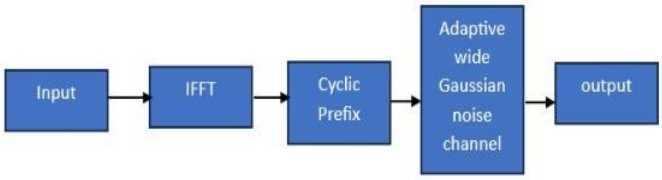

Fig 1. OFDM mm wave architecture

In an OFDM system, the input signal is a digital stream of data that needs to be sent over a wireless channel. This data is usually in the form of binary bits or symbols. Before transmission, the input signal is prepared and transformed into a suitable format for OFDM. This involves using the IFFT operation to convert the signal from the time domain to the frequency domain. The IFFT operation changes the signal from a set of parallel subcarriers in the frequency domain to a waveform in the time domain. In OFDM, the size of the IFFT is usually a power of two, like 64, 128, or 256, to make it more efficient. A cyclic prefix, which is a guard interval, is added at the start of each OFDM symbol. It consists of a copy of the last few samples of the symbol and is placed in front of it. The cyclic prefix helps reduce the impact of multipath fading and interference between symbols in the wireless channel. By including a guard interval, the cyclic prefix allows the receiver to separate the symbols even if there is a delay in the channel. The wireless channel has different issues, such as multipath fading, noise, and interference. A Gaussian white channel is a common model used to represent this channel. It assumes that the channel's response follows a Gaussian distribution and that the noise in the channel is additive white Gaussian noise (AWGN). This model simplifies the analysis and allows statistical tools to be used to evaluate the performance of the OFDM system. In an OFDM system, the input signal is transformed to the time domain using the IFFT operation. A cyclic prefix is then added to each symbol to reduce interference. These symbols are transmitted over the wireless channel, which is typically modeled as a Gaussian white channel. At the receiver, the OFDM symbols are received, demodulated, and processed to recover the original input signal.

B. FDMCM

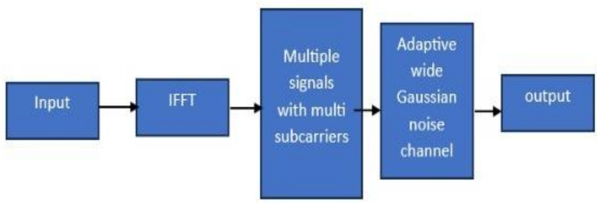

Fig 2. FDMCM mm wave architecture

Frequency division multicarrier mixing (FDMCM) is a type of modulation technique that divides the signal into many subcarriers using a filter bank. These subcarriers are close together and have overlapping spectra, which helps to make efficient use of the available bandwidth. Each subcarrier is modulated separately using different methods like changing its amplitude, phase, or frequency. FDMCM has the advantage of providing good spectral efficiency while keeping interference with neighbouring channels low. This is achieved by using high-quality filters that have a narrow transition bandwidth and sharp cut off. FDMCM can also be used for multiuser communication by assigning different subcarriers to different users. However, FDMCM is complex and requires precise synchronization between the transmitter and receiver to maintain the separation between the subcarriers. It is also more prone to frequency selective fading, which can cause interference between symbols and reduce the overall performance of the system.

IV. SOFTWARE DETAILS

We are using MATLAB software 2021 for the comparison of OFDM and FDMCM uplink with hybrid receiving. MATLAB is a computer program that is great for doing math and science calculations. It helps you analyze data, make graphs, and create math models. MATLAB is really good at working with matrices and arrays, which are like organized sets of numbers. It has lots of tools and functions built in that can help you do math stuff like solving equations, finding areas under curves, and working with data. It also supports different kinds of math and science, like working with numbers, statistics, signals, images, and videos.

V. RESULTS

The result of the project includes:

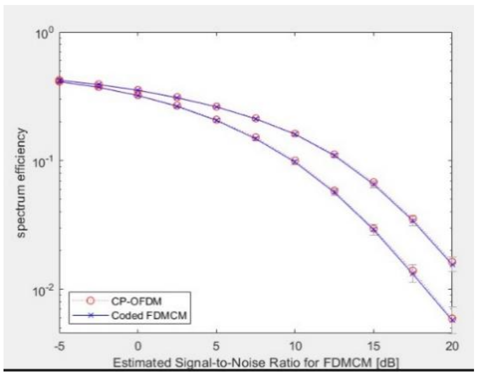

Fig.3. Spectral efficiency vs SNR

In summary, spectral efficiency is measured in bps/Hz and represents the data rate achieved per unit of bandwidth, while SNR is measured in decibels and represents the signal quality relative to the noise level. They serve different purposes in evaluating and comparing communication systems.

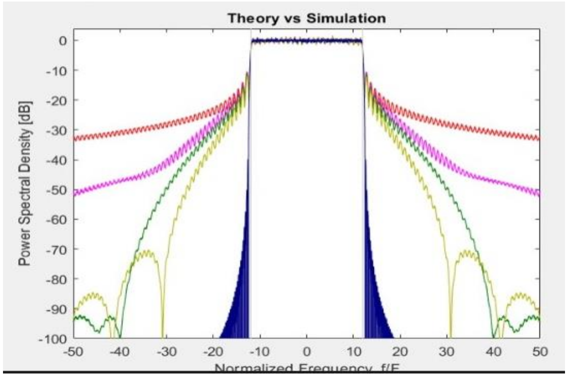

Fig 4. PSD vs normalized Frequency

Power Spectral Density (PSD) is a measure of the power distribution across different frequencies in a signal. It provides information about the power content or strength of a signal at different frequency components. The PSD is typically represented in units of power per unit frequency (e.g., watts per hertz, dBm/Hz). Normalization frequency, in the context of PSD, refers to a scaling factor applied to the PSD values to ensure that the total power is preserved. When calculating the PSD, it is important to normalize the values to accurately represent the power distribution relative to the total power in the signal.

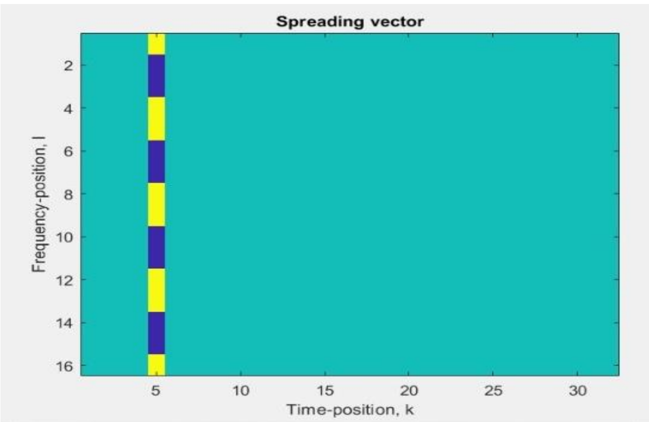

Fig 5. Spreading Vector

The spreading vector is typically multiplied with the data symbols to increase the bandwidth of the signal, spreading it over a wider frequency range. This spreading process helps in achieving multiple access capabilities, enabling multiple users to share the same frequency band while maintaining their individual signals separable at the receiver.

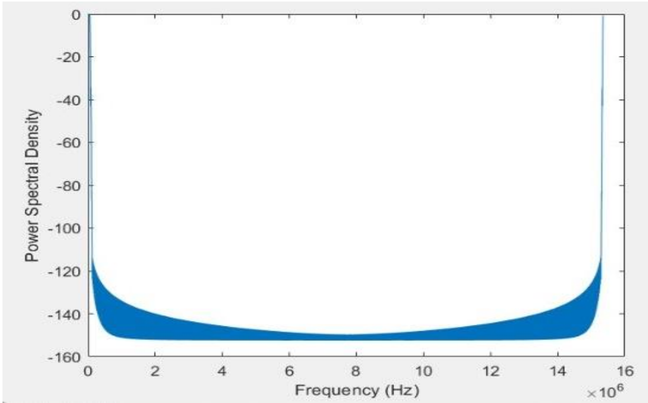

Fig 6. PSD vs Frequency

The power spectral density plot shows how the power is distributed across different frequencies in the signal. It provides insights into the signal's frequency components and their relative power levels. The shape of the PSD plot indicates the power contributions at different frequencies, such as dominant frequency components, bandwidth usage, or presence of noise.

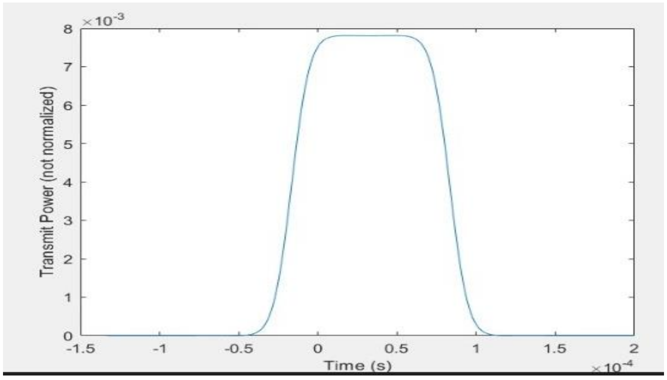

Fig 7 Transit power vs Time

"Transit time" refers to the time delay experienced by a signal as it propagates through a system or medium. It is the time it takes for a signal to travel from the input to the output of a system.

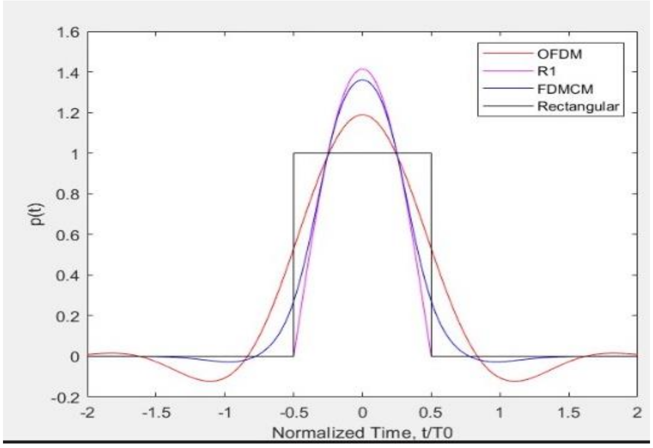

Fig 8 P(t) vs Normalized Time

This shows how the signal acting in time domain with amplitude, the strength of the signal is good for fdmcm that ofdm and below fig shows the same in terms of frequency.

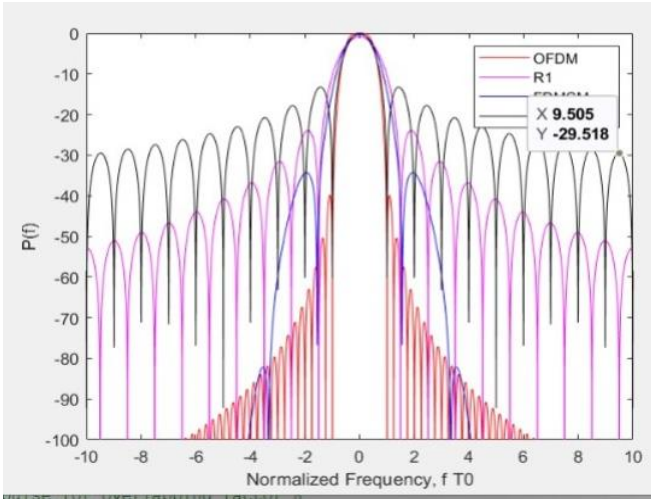

Fig 9 P(f) vs Normalized Frequency

VI. FUTURE SCOPE

Comparison of OFDM and FDMCM uplink with hybrid receiving which has millimeter wave as the input is very useful for fast transmission and receiving to the base station. Satellite communication has been important in the telecom industry for many years, especially for broadcasting and multimedia services. Satellites help distribute TV and radio signals and deliver multimedia content to a large audience overvast areas. In digital broadcasting and multimedia services, a technique called FDMCM is used to transmit high-quality audio and video over the airwaves. FDMCM divides the available spectrum into smaller parts, which helps ensure reliable transmission even in challenging conditions with signal loss and interference. This allows for dependable and high-speed multimedia services.

VII. CONCLUSION

In this paper, we analysed the spectral efficiency, signal to noise ratio and power spectral density of wideband mm-wave OFDM and FDMCM systems with a large antenna array at the BS. The analysis and the simulation show that the wide bandwidth makes the beam points to a direction away from the path, i.e., causes the beam squint effect. We show that by increasing the number of subcarriers the beam squint effect can be alleviated.

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B Jyothsna is a Associate Professor in Bhoj Reddy Engineering College For Women, Hyderabad affiliated to JNTUH, where she has been a faculty member since 2001. She completed 20 years of service in this college. She worked as incharge HoD for a period of eight months. She headed many committees established by the college and conducted various programs for students and faculty. B Jyothsna completed her M. E at Osmania University College Of Engineering, Hyderabad and her undergraduate studies at Osmania University College Of engineering, Hyderabad. Her research interests lie in the area of wireless communications, optical communications, Digital design. Under her guidance many students successfully completed their mini and major projects.

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