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Performance analysis of 5G waveforms with LTE

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***Abstract*——** **In recent times, new waveforms for 5G have been explored in multiple ways. It is difficult for the current mobile communication to assist the future mobile traffic requirement. To overcome this issue, studies have been carried out in 5th generation mobile communication has been. New waveforms such as UFMC (universal filtered Multi-carrier), FBMC (filtered bank Multi-carrier), F- OFDM (filtered orthogonal frequency division multiplexing) and W-OFDM (windowed-OFDM) are considered as very substantial candidates in respect of 5G system. An attempt has been made to evaluate the spectral properties of waveforms in this paper. The experimental results proved that the effective utilization of spectrum for each waveform.**

Keywords—: ***5G, UFMC, FBMC, W-OFDM, Spectrum***

I. Introduction

The IOT (internet of things) and MTC (machine type communication) will play an important role in the future [2]. But 5G is not only for MTC. An important design has to be formulated in 5G is to efficiently support the small packet transmission. Further, it will help in much future application. Conventional OFDM(orthogonal frequency division multiplexing) has high out-of-band (OOB). As a result, adjacent channel interference (ACI) occurs. In order to avoid ACI, a wide guard band can be used in OFDM. But it affects the spectral efficiency when a number of mobile devices simultaneously access a base station. For OFDM systems coordinated multi-point(CoMP)communication techniques have been recommended. One of the major hurdles in CoMP-OFDM systems is that as they are sensitive to multiple carrier frequency offsets (CFOs) between terminals and base stations. The frequency offset may occur due to Doppler shift resulting from terminals mobility or by oscillator frequency mismatch between a transmitter and a receiver. Multiple CFOs in CoMP-OFDM systems ruin the orthogonality between OFDM subcarriers and bring inter-carrier interference (ICI) at the receiver which leads to degradation in system performance immensely. To overcome this problem filter bank multi-carrier technique was suggested. The major difficulty in multi-carrier technique is high peak to average power ration so the DFT-pre-coding method is used in conjunction with CP-OFDM to enhance single carrier FDMA.

II. Design Consideration For various Waveforms

A. OFDM

Is a technique of multicarrier modulation, has broadly accepted for 4G communication systems (Long Term Evolution and Wi-Fi).It has many benefits such as

1. Endurance to channel delays
2. Single-tap equalization in a frequency domain
3. Effective implementation.

OFDM has some of the disadvantages:

1. Due to higher side-lobes, there is a loss in spectral efficiency
2. The stringent synchronization requirements.

New modulation techniques are being studied for 5G communication systems to cope up the above issues.

B. FBMC

FBMC provide a solution to manage the known limitation of spectral efficiency reduction and stringent synchronization in OFDM [2].

Transmit end processing operation:

Step 1: FBMC use prototype filter. It is a filter which is used for the zero frequency carriers and it is the base for the other subcarrier filters.

Step 2: The filters are described by the overlapping factor which is denoted by *K*. Here K, represents the number of multicarrier symbols that overlap in the time domain.

Step 3: The order of the prototype filter can be chosen as $(2*K-1)$ where $K = 2, 3$, or 4.

Step 4: The implementation of current FBMC uses frequency spreading. It uses an N*K length IFFT with symbols overlapped having a delay of (N/2), here N denotes subcarriers quantity. This design choice makes it feasibly easy to analyze FBMC

Step 5: To attain full capacity, FBMC use offset quadrature amplitude modulation. The imaginary part is delayed by half the symbol duration so that the real and imaginary parts of a complex data symbol are not transmitted simultaneously.

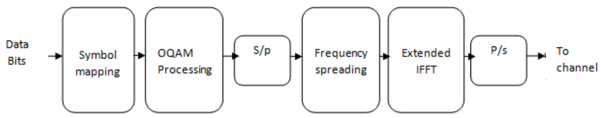


Fig. 1.Block diagram of FBMC-Transmitter

Receive end processing operation:

Step 1: The processing steps include matched filtering operation then it followed by Offset-Quadrature Amplitude Modulation separation to form the received data symbols.

Step 2: Then the received data symbols are de-mapped to bits and obtained the bit error rate.

Step 3: If channel is present, the effects of frequency-selective fading may be diminished by using linear multi-tap equalizers.

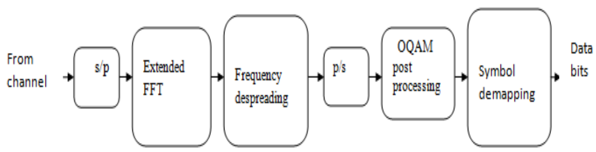


Fig. 2.Block diagram of FBMC-Receiver

Table. 1. Simulation parameters

numFFT	1024
numGuards	212
K	4
numSymbols	100
bitsPerSubCarrier	2
snrdB	12

C.UFMC

The advantages of UF-OFDM over FBMC are:

• With short burst lengths, it give a better waveform efficiency of spectrum in time - and band limited

• Cyclic Prefix-OFDM can be reused in UF-OFDM, but FBMC required a lot of changes.

• Due to complex plane orthogonality, UF-OFDM having QAM modulation supports CoMP and delivers full MIMO, but FBMC suffers lack of this complex orthogonality.

$$X=\sum_{i=1}^{n} T*V*s$$

Where ,

T –Toeplitz matrix

n- Number of sub band

V- IFFT matrix

s-per subcarrier of transmitting in sub band

In LTE system at channel bandwidth of 20 MHZ. It uses 100 blocks that are resourced. Each block is having 12 subcarriers which is spacing of about 15 KHz. It leads to a 10 percent loss because only 18 MHz of allocated spectrum is utilized. Another 7 percent loss in efficiency, due to the usage of cyclic prefix of 144/160 samples is used per OFDM symbol. Finally, the total possible spectral efficiency loss is about 17 percent. Universal filtered multicarrier modulation technique which is known as a new modulation technique provides efficient spectrum usage. UFMC is described as a generalization of F-OFDM (filtered OFDM) and FBMC modulations [1]. In F-OFDM, the entire band is filtered and each subcarrier is filtered in FBMC, while in FBMC subcarriers are filtered by group. This process of subcarriers grouping allowed to decreasing the filter length as compared with FBMC.

Transmit end processing operation:

Step 1: The subcarriers of entire band denoted by (*N*) are divided into sub-bands (a group of subcarriers).

Step 2: A fixed number of subcarriers is present in each sub-bands for transmission.

Step 3: An *N*-pt IFFT is operated to each sub-band and embedding zeros for the unallocated carriers.

Step 4: A filter filters each sub-band having a length (*L*), and each sub-bands responses are added together.

Step 5: The filtering process is done to reduce the out-of-band spectral emissions. Different filters per sub-band can be adapted. Here the same filter is used for each sub-band.

Step 6: For each sub-band to filter the IFFT output a Chebyshev window with parameterized side lobe attenuation is applied.

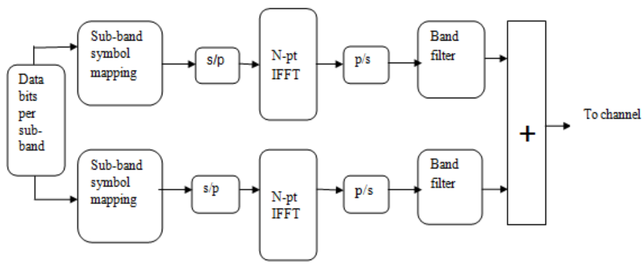


Fig. 3.Block diagram of UFMC-Transmitter

Receive end processing operation:

The receive processing of UFMC which is like OFDM is FFT –based.

Step 1: For the FFT operation, the sub-band filtering broadens the time window of the receiver to the next length as power-of-two.

Step 2: Every value of alternate frequency belongs to a subcarrier main lobe. For balancing the joint effect of the channel and the filtering of sub-band purpose, per-subcarrier equalization is used in a system

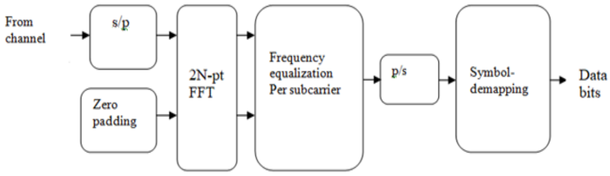


Fig. 4.Block diagram of UFMC-Receiver

The asset of Sub-band filtering is compressing the guards between sub-bands and also shortening the filter length, which constructs this scheme fascinating for short bursts. The feature of latter also makes it pleasing in comparison to FBMC, which endures from much longer filter length.

Table 2.Design parameters for simulation

numFFT	1024
Number of resource block	50
numSubbands	12
Cyclic prefix length	72
Filter length	513

D. F-OFDM

Some of the criteria need to be followed for appropriate filtering of OFDM [10]:

- It must a flat pass-band for overly the subcarriers in the sub-band
- For the minimization of guard-bands, it must a sharp transition band
- It would have adequate stop-band attenuation

Transmit end processing operation:

Step 1: The sub-band Cyclic Prefix-OFDM signal is applied through the designed filter.

Step 2: As the filter's pass-band belongs to the bandwidth of a signal, only a few subcarriers which are close to the edge are affected in this process.

Step 3: A major consideration in the F-OFDM is that length of the filter can be allowed to outstrip the cyclic prefix length.

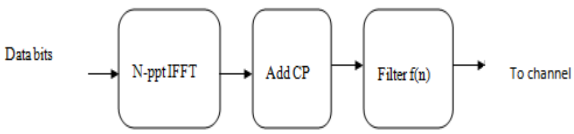


Fig. 5.Block diagram of F-OFDM-transmitter

Receive end processing operation:

The received signal is applied to a matched filter which is followed by the normal CP-OFDM receiver. It takes the measure for both the ramp-up filtering and latency prior to the Fast Fourier Transform operation.

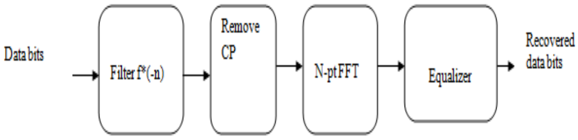


Fig. 6. Block diagram of F-OFDM-Receiver

Table 3. Design parameter for simulation

numFFT	512
Sub-band Size	20
numSubbands	10
Sub-band Offset	156

E.W-OFDM

It is an improved version of Orthogonal Frequency Division Multiplexing (OFDM) system [7]. In the W-OFDM system processing chain it does not use the filter but for each OFDM symbol it uses the extension and windowing method, as a result it reduces OOB power spectrum.

III. Simulation Results

Table 4.Peak to average power ratio for new waveforms

waveforms	OFDM	UFMC	F-OFDM
PAPR	8.8843 dB	8.2379 dB	11.371 dB

COMPARISON BETWEEN VARIOUS WAVEFORMS

Fig. 7.Power Spectral Density of FBMC

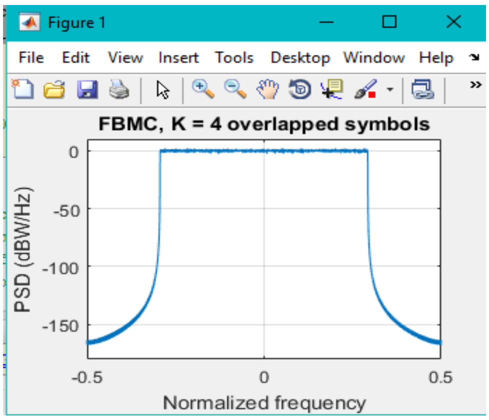


Fig. 8. Power Spectral Density of OFDM

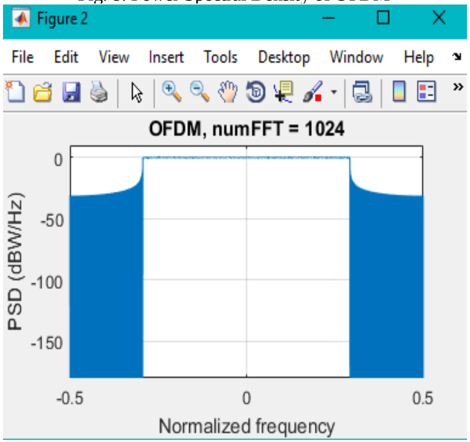


Fig. 9. Power spectral density of UFMC

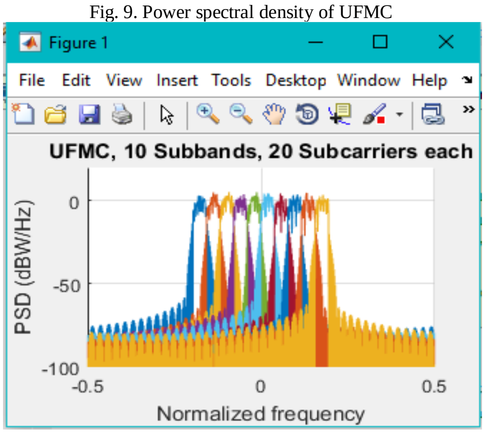


Fig. 9. Power spectral density of OFDM

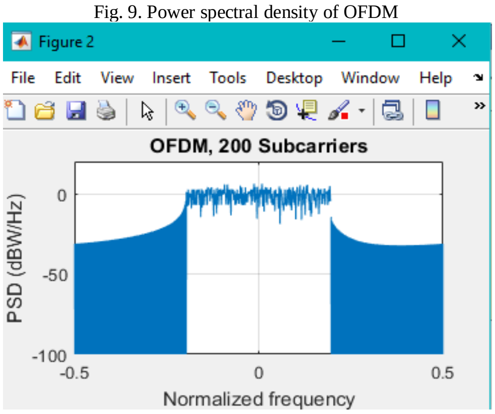


Fig. 10. Power spectral density of F-OFDM

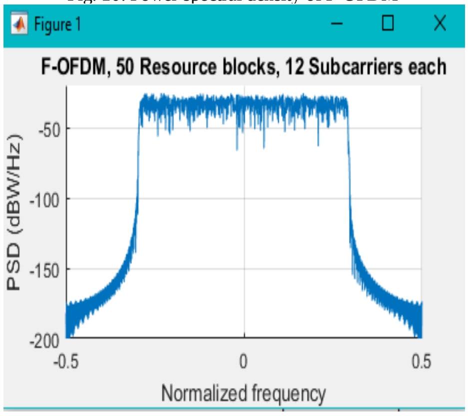
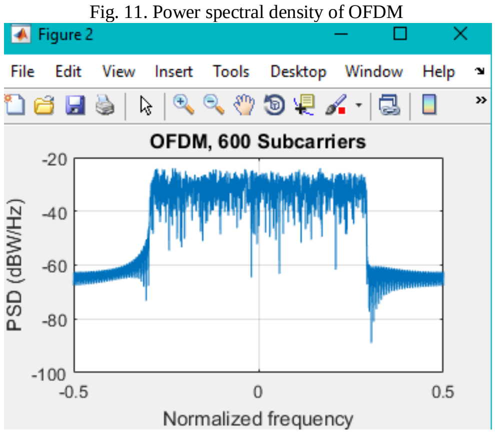


Fig. 11. Power spectral density of OFDM



IV.Conclusion

A new waveform approaches such as UFMC, FBMC, F-OFDM and, W-OFDM. These waveforms aid as a provider for the multiple access in order to manipulate the large collection of traffic types. From the simulation results, the new waveforms have lower sidelobes than the OFDM so it implies that the spectrum utilization is effective in these waveforms. FBMC is on a right path but it is still not ideal while applying practical applications it will arise many issues. Using UFMC we are capable to collect the advantages of FBMC and remove its major drawbacks. Like FBMC, UFMC is more potent to multi-user interference, provide higher spectral efficiency, greater performance in case of coordinated multipoint transmission and is better suited to fragmented spectrum than OFDM. UFMC is able to deliver complex orthogonality by avoiding many traps and compared to FBMC it improves at short burst/low latency transmission scenarios

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