Waveform Contenders of 5G Technology

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Abstract - *There are different multiplexing techniques which are used in different mobile networks and wireless technologies. The most emergent and used wireless technologies now-a- days are 3G and 4G, also termed as LTE (Long Term Evolution). The most efficient multiple access technique for wireless technologies is OFDM, which has been adopted for 3G and also 4G-LTE. Now as the technology is being advanced to 5G, there are some drawbacks of OFDM so the new different filtering techniques are the emerging waveform contenders for 5G wireless technology which are FBMC, UFMC & GFDM. All the three techniques have been discussed here in this paper.*

Key Words: OFDM, FBMC, UFMC, GFDM

1.INTRODUCTION

The different multiplexing techniques which are very efficient are OFDM and CP-OFDM (Cyclic Prefix OFDM). Cyclic Prefix is the copy of tail of the given data symbol which works as the guard band. This Cyclic Prefix is applied to the OFDM symbol and creates redundancy in the symbol, due to which the bandwidth requirement increases which is a drawback. So, to use less bandwidth new different techniques for filtering and processing have been adopted for 5G wireless technology. These different filtering techniques are FBMC, UFMC, GFDM. In this paper all the three techniques have been discussed and the reasons why OFDM is not used as the access technique for 5G has also been discussed.

1.1 OFDM(ORTHOGONAL FREQUENCY DIVISION MULTIPLEXING)

OFDM is an access technique which is considered the most efficient access technique for the wireless technologies. It is a multicarrier transmission scheme which divides the bandwidth into different sub-channels known as sub-carriers so as to multiplex in both time and frequency domain. In OFDM the sub-carriers are spaced at $\Delta f = 1/TSymbol$ which is known as orthogonality. The fig 1 shows the orthogonality in OFDM.

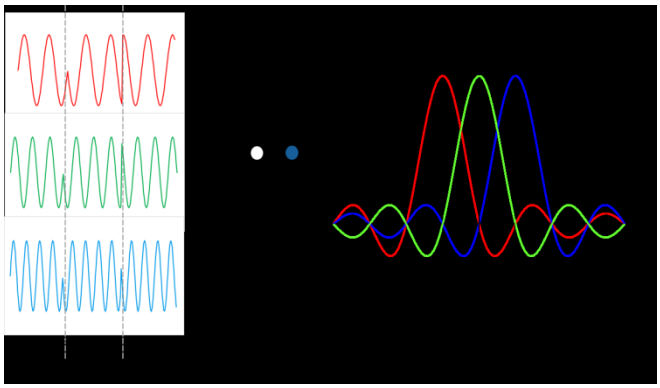

Fig.1: Orthogonality in OFDM

The advantages of OFDM are as follows:

1. The spectrum efficiency of OFDM based system is considerably good.
2. It is robust against multipath propagation.
3. It has a less complex receiver.
4. Multiple user scheduling advantage

1.2 LIMITATIONS OF OFDM

The limitations of OFDM are as follows:

1. Cyclic Prefix Overhead: The added Cyclic Prefix adds redundancy to the transmission scheme which needs more bandwidth.
2. Sensitivity to Frequency and Timing Offsets: In OFDM it is considered that the transmitting and receiving frequencies are the same. So the orthogonality looses with the change in frequencies which leads to ICI.
3. High Peak To-Average Power Ratio (PAPR): When multiple subcarriers are summed up, the PAPR increases which leads to crest factor which is a big challenge.

2.WAAVEFORM CONTENDERS OF 5G TECHNOLOGY

Generally OFDM is used as the access technique in all the network technologies like 3G and 4G. But due to the basic disadvantages or limitations of OFDM, it is not used in 5G technology as it cannot fulfill the demands of 5G. So different pulse shaping schemes have been used for 5G signals other than the conventional OFDM.

The different filtering methods that are used for 5G will reduce the OOB emissions and will increase the spectrum efficiency. These filters will also help in reducing the Inter Carrier Interference (ICI). These techniques are FBMC, UFMC and GFDM.

2.1 FBMC(FILTER BANK MULTI CARRIER)

FBMC is abbreviated for Filter Bank Multi Carrier. It is developed to give a flexible OFDM based architecture. In this technique, filtering is done at a sub-carrier level using filter banks at transmitter and receiver side. It is basic Nyquist Filter with a purpose to shape the signal to avoid OOB emissions. Fig.2 shows the modulation block of FBMC

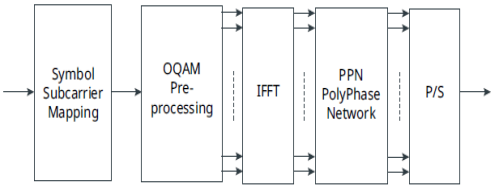

Fig.2: FBMC modulation block

FBMC supports asynchronous transmission, also suits for cognitive radio and the spectral efficiency of FBMC is also high.

2.2UFMC(UNIVERSAL FILTERED MULTI CARRIER)

UFMC is abbreviated for Universal Filtered Multi Carrier. Unlike FBMC, UFMC works on the basis of sub-bands which are created by grouping the subcarriers. This helps in avoiding aliasing effect. UFMC is a compromise technique between OFDM and FBMC. Fig3 shows the UFMC modulation block.

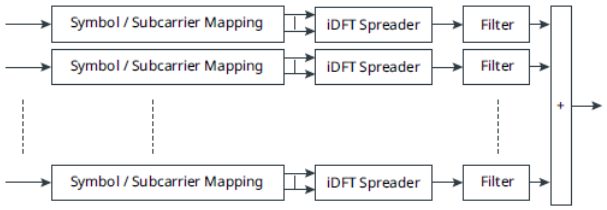

Fig.3: Modulation block of UFMC

2.3 GFDM(GENERALIZED FREQUENCY DIVISION MULTIPLEXING)

GFDM is abbreviated for Generalized Frequency Division Multiplexing. It spreads the spectrum available for users in different spectrums of high or low bandwidths. Along with the features provided by FBMC, it offers additional features such as:

1. Cyclic prefix has to be added.
2. Circular convolution is applied to the filters

Fig.4 shows the modulation block of GFDM.

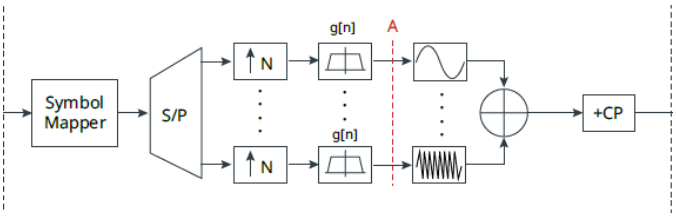

Fig.4: Modulation block of GFDM.

3. CONCLUSIONS

Hence by studying this paper, we understand the basics of all the waveform contenders of 5G. On the basis of this comparison, the modulation scheme can be decided according to the required parameters.

The advantages and disadvantages of all the waveforms have been shown below:

	Benefits	Disadvantages
OFDM	▪ Easy to implement (IFFT for transmitter and FFT for receiver).	▪ Loss of spectral efficiency due to guard bands and cyclic prefixes.
FBMC	▪ More tolerance towards frequency synchronization; ▪ FBMC filters each sub-carrier individually; ▪ FBMC does not have a cyclic prefix → provide a very high level of spectral efficiency.	▪ Computational complexity.
UFMC	▪ Modulable, shorter spectrum range; ▪ UFMC splits the signal into a number of sub-bands which it then filters; ▪ UFMC does not have to use a cyclic prefix → one can be used to improve the inter-symbol interference protection.	▪ Equal or higher complexity.
GFDM	▪ Only one cyclic prefix is needed between GFDM packet → better spectral efficiency; ▪ GFDM provides better control of the out-of-band emissions; ▪ GFDM reduces the PAPR.	▪ Higher complexity.

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