

OFDMA Modulation Technique in 4G LTE Mobile Networks

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Abstract

The last two decades have seen the technologies and needs in mobile communications evolve together. This report tries to explain how the principles of OFDMA (*Orthogonal Frequency Division Multiple Access*) in 4G LTE networks allow for answering the current needs both in high data rate and high user capacity.

1 | From OFDM to OFDMA

To be able to transmit a lot of data to many users, the physical resources, i.e. space, time and electromagnetic (frequency) spectrum, need to be used and shared in an optimal way.

1.1 Introduction to Modern Mobile Communications

When talking about mobile communications, the space resource is usually managed by using fixed base stations (BS) placed in a certain pattern similar to bee-hive cells. These BS are placed so that they can deliver information wirelessly to mobile stations within the range of their cell or seamlessly moving from a cell to another.

To achieve high data rates and multiple user services within a cell, it is however necessary to design techniques making smart use of time and frequency resources. OFDM is one of these techniques and is being used in several applications both in cable and wireless network such as ADSL, VDSL or WLAN and 4G LTE.

1.2 Description of OFDM

OFDM stands for *Orthogonal Frequency Division Multiplexing*. It relies on different principles used together to combine advantages.

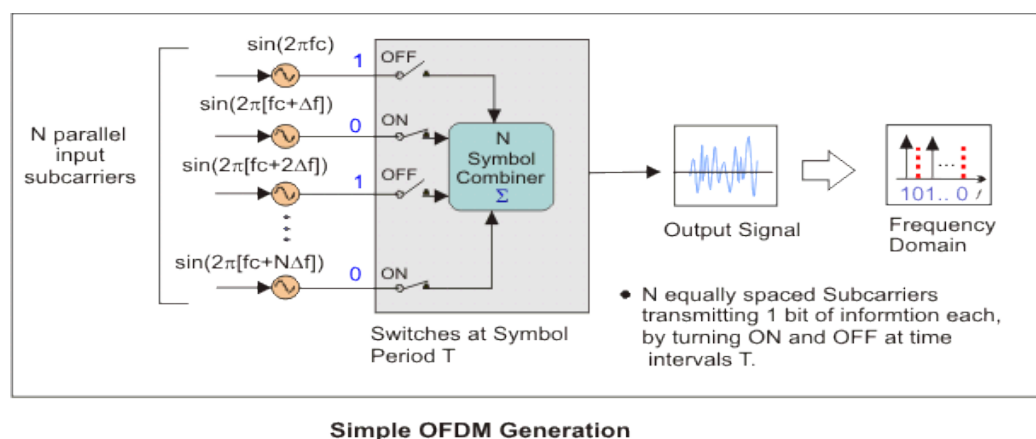


Figure 1.1: Modulation of signals using OFDM technique [source: Keysight]

The most basic of these principles is the FDM (*Frequency Division Multiplexing*). It consists in modulating several (N) signals using a QAM (*Quadrature Amplitude Modulation*) scheme, with sub-carriers that are regularly spaced by Δf , see *Figure 1.1*. All these modulated signals are then put into an IFFT (*Inverse Fast Fourier Transform*) and summed into a single signal, updated periodically according to the symbol period T and sent through the desired medium. At the receiver end, the inverse procedure is applied.

The second main concept is the orthogonality of the sub-carriers. When passing to the frequency domain, each sub-carrier will result in a sinc function. Therefore, the spacing, Δf , between each of them is chosen so that, in frequency domain, each sub-carrier overlap the others orthogonally, which means all the sinc functions have zero crossing and their side-loops cancel each other, while peaks remain distinguishable, see *Figure 1.2*.

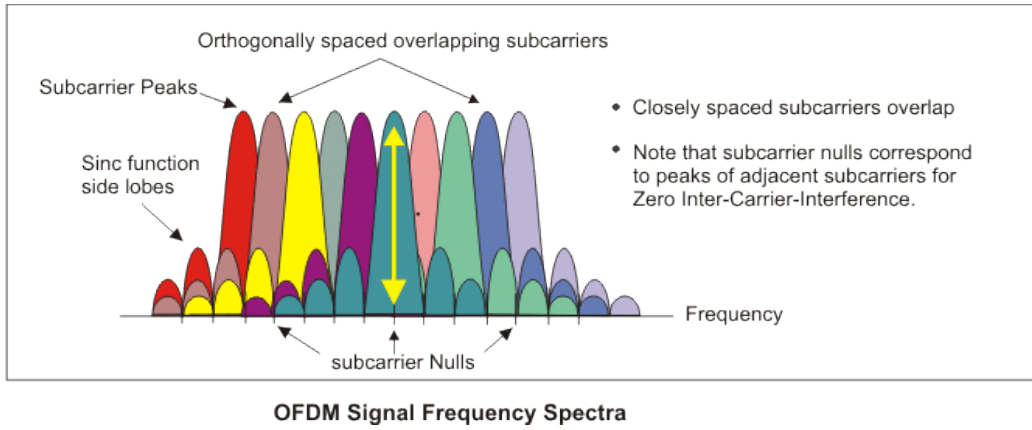


Figure 1.2: Frequency spectrum of OFDM signal [source: Keysight]

Since, there is no undesirable interference due to frequency overlapping, the spacing between each sub-carrier can be very short. To maintain the orthogonality, this spacing, Δf , actually has to be the inverse of a symbol period, T :

$$\Delta f = 1/T \quad (1.1)$$

Coming from this relation, and by sending information on parallel channels, it is possible to increase the overall data rate and therefore, the spectral efficiency, while decreasing the data rate on each subchannel. This helps to reduce potential inter-symbol interferences (ISI) at the receiver end, that could happen due to wave reflection, refraction or other multi-path phenomena [1] and is reinforced by a guard interval between each symbol.

Chapter 1. From OFDM to OFDMA

However, one of the worst disadvantages of OFDM is the high peak-to-power ratio which makes the use of this technique inefficient in terms of energy for small and portable devices.

1.3 What does OFDMA bring ?

2 | OFDM in 4G-LTE Mobile Networks

2.1 4G-LTE Overview

Bibliography

- [1] Ian Poole. *OFDM Orthogonal Frequency Division Multiplexing Tutorial*. Ed. by Radio Electronics. 2015. URL: <http://www.radio-electronics.com/info/rf-technology-design/ofdm/ofdm-basics-tutorial.php>.