

# OFDMA Modulation Technique in 4G LTE Mobile Networks

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STUDENT REPORT

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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.

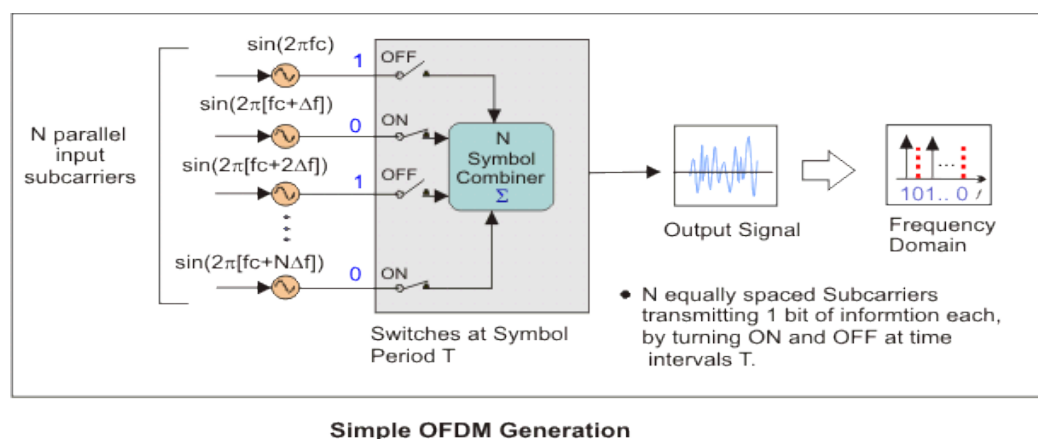
## 1.1 Introduction to Modern Mobile Communications

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

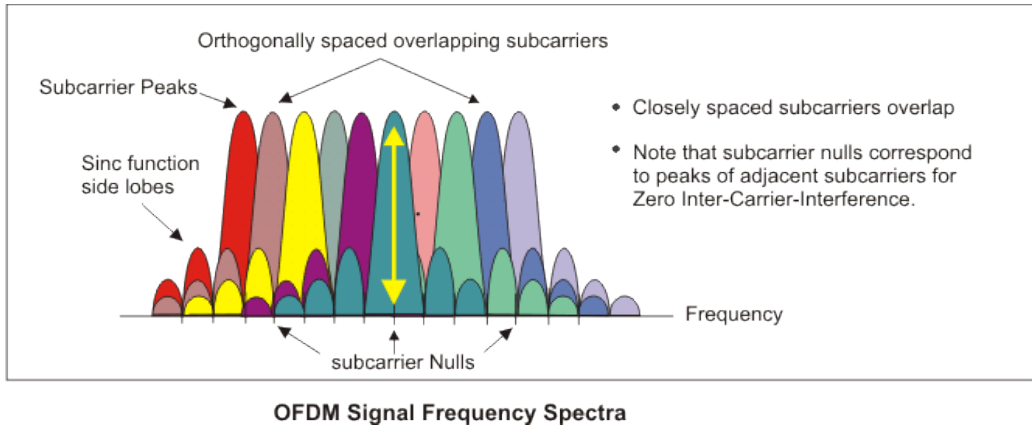
OFDM stands for *Orthogonal Frequency Division Multiplexing*. It relies on different principles used together to combine advantages.



**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  $\Delta f$ , 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,  $\Delta f$ , 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,  $\Delta f$ , 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 ISI (*Inter-Symbol Interferences*) 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.

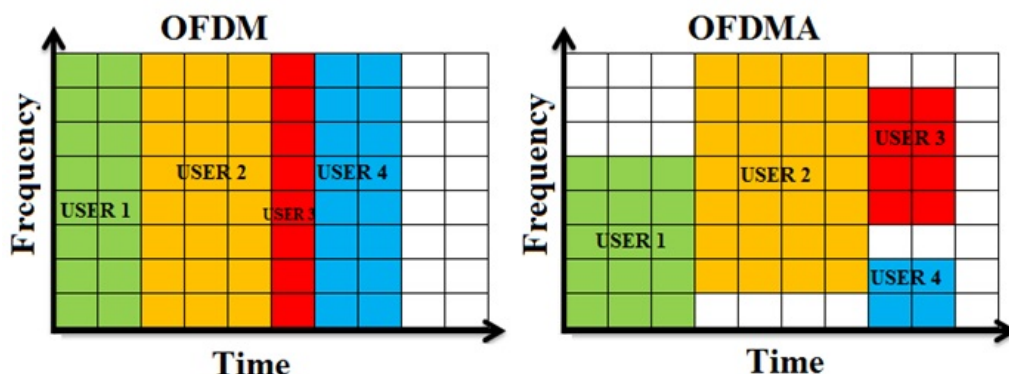
OFDM is very efficient in high data rate communications. However, it requires some modifications to be usable in multi-user environments and OFDMA tries to address this issue.

### 1.3 What does OFDMA bring ?

OFDMA stands for *Orthogonal Frequency Division Multiple Access*. It allows multiple users to communicate at the same time while keeping the high data rates offered by OFDM.

The base principle of OFDMA consists in sharing the time and frequency resources between users. It can somehow be compared to a combination of OFDM, FDMA (*Frequency Division Multiple Access*) and TDMA (*Time Division Multiple Access*)[2]. Users are assigned a subset of sub-carriers in the given frequency range and use it for a certain time before it is attributed to another user.

All communications can happen in parallel and the attribution of sub-channels is made independently one from another : they can take place at different times and involve different size of sub-channels, see *Figure 1.3*.



**Figure 1.3:** Comparison between OFDM and OFDMA [source: [differencebetween.com](http://differencebetween.com)]

OFDMA still keeps a strong disadvantage from OFDM which is the high peak-to-power ratio which makes the use of this technique inefficient in terms of energy for small and portable devices. Despite this fact, OFDMA communication technique has been chosen for 4G LTE networks, designed especially for mobile communications (voice calls, video calls and streaming, World Wide Web access, ...). The next chapter explains briefly how this is achieved.

**See also,** [3, Chap. 19].

## 2 | OFDM in 4G-LTE Mobile Networks

The 4G-LTE (*4th Generation-Long Term Evolution*) is the commercial name of a standard for a communication protocol (physical layer), developed by the 3GPP (*3rd Generation Partnership Project*) and released progressively in different countries around the world, since 2009.

### 2.1 4G-LTE Overview



# Bibliography

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