

A novel method to mitigate the peak-to-average power ratio in OFDM

by Kahesh Dhuness and Prof Sunil Maharaj

Orthogonal frequency division multiplexing (OFDM) has become a very popular method for high data rate broadband communication, primarily because it allows for more data to be transmitted in less bandwidth, hence increasing spectral efficiency. It also allows channel effects to be easily mitigated. This has led to it being deployed in various standards, such as digital subscriber lines (DSL), digital video broadcasting (DVB), worldwide interoperability for microwave access (WiMAX) and recently in 4G technology, such as long-term evolution (LTE).

Very soon a large number of devices will be encountered that employ OFDM. For instance, the South African government has announced that it will begin digital television broadcasting (which employs OFDM) and eventually shut off the traditional analogue television transmission by December 2013. This implies that a large percentage of South African households will eventually have

to buy a set-top-box (STB) to receive a digital (OFDM) television transmission. Not only is OFDM confined to television transmission, but it has also been established as a basis for fourth- and fifth-generation cellular technology. So, in addition to STBs, it will also be used in cellular phones, 4G and 5G cards, digital radio and local area networks (LAN), which constitute a large percentage of the wireless market.

However, it is known that OFDM is plagued by a large peak-to-average power ratio (PAPR). It is this high PAPR that results in energy-inefficient devices. Inefficient devices are especially unattractive in

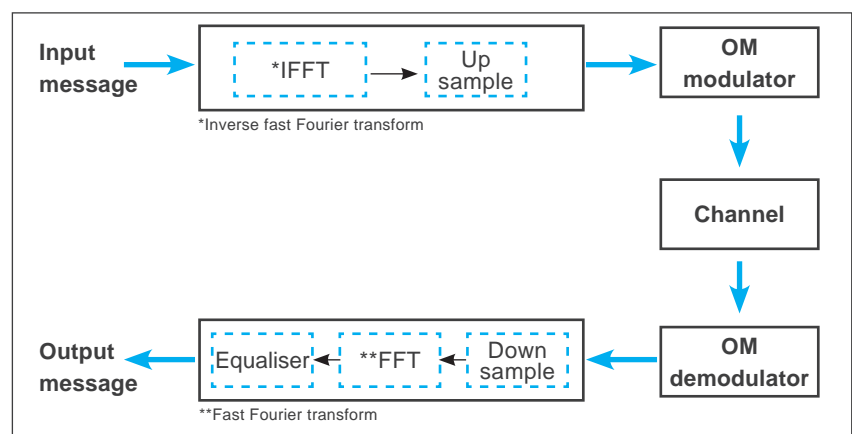
mobile devices like cellular phones, since this would result in regular recharging of the mobile device, which is not desirable. The current demand for energy-efficient devices has resulted in various methods being proposed to reduce the PAPR of an OFDM transmission. However, all these methods have a number of drawbacks.

The current demand for energy-efficient devices has resulted in various methods being proposed to reduce the peak-to-average power ratio of an OFDM transmission.

In research conducted in the Sentech Chair in Broadband Wireless Multimedia Communications (BWMC) at the University of Pretoria, a method called offset modulation (OM-OFDM) has been developed

that does not suffer from the drawbacks experienced by current methods in the field. A simple block diagram, depicted in Figure 1, shows the processes involved during an OM-OFDM transmission.

The OM-OFDM method involves phase modulation of an OFDM transmission. Thereafter, by controlling the dominant component of this OM-OFDM transmission, it allows for the PAPR of a transmission to be controlled.

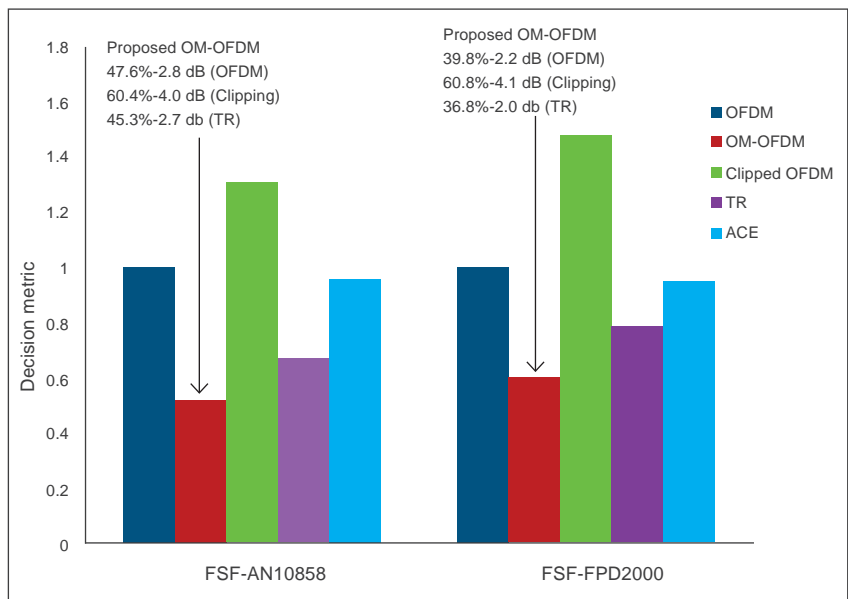


→ Figure 1. An OM-OFDM transmitter receiver.

A power performance decision metric (D) has also been introduced, which allows for various methods in the PAPR field to be compared. The decision metric is given by $D = (E_i / N_o) \cdot (W / R_b)$ where N_o is the noise power, W refers to the bandwidth occupancy and R_b is the data rate. Furthermore, E_i is the total energy per bit and can be written as $E_i = E_b + E_w$ where E_b is the received energy per bit and E_w is the wasted energy per bit due to inefficient power amplifier utilisation.

The proposed OM-OFDM method has been compared to two well-established PAPR reduction methods, which are tone reservation (TR) and active constellation extension (ACE) (both methods are used during digital television broadcasting), as well as the clipping PAPR reduction method. By using a decision metric (D), Figure 2 demonstrates the benefits of OM-OFDM in terms of energy efficiency when compared to the aforementioned methods. The simulations are done using a 64-QAM DVB-T2 transmission (a typical television transmission) through a real-world (5-tap typical urban frequency selective fading conditions) channel, in conjunction with two different off-the-shelf amplifiers, an AN10858 and FPD2000AS amplifier. The OM-OFDM method in Figure 2 is shown to offer between 23.6% and 60.8% at a bit error rate of net power performance improvement when compared to a traditional OFDM, clipped OFDM, TR and ACE methods.

In conclusion, the proposed offset method is shown to offer a performance improvement when compared to both simple (clipping), as well as more complex, well-established (ACE and TR) PAPR reduction methods. The 23.6% to 60.8% net power performance



→ Figure 2. Normalised decision metric (D) results for a 5-tap typical urban channel.

improvement obtained when using OM-OFDM would significantly improve the energy efficiency of devices that employ OFDM technology, hence showing promise of a potential innovation. 📌



→ Kahesh Dhuness



→ Prof Sunil Maharaj

Kahesh Dhuness and Prof Sunil Maharaj are associated with the Department of Electrical, Electronic and Computer Engineering at the University of Pretoria. Prof Maharaj holds the Sentech Chair in Broadband Wireless Multimedia Communications (BWMC) and is a DTI 2010 Technology Award Winner.