



# OFDM Modem

## Applications

- Digital Video Broadcast (DVB)
- Digital Audio Broadcast (DAB)
- Broadband Wireless Access (802.16x)
- Wireless LAN (802.11x & HiperLAN)

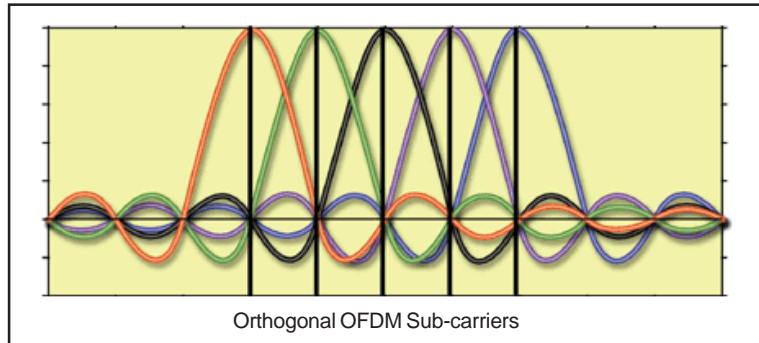
**Orthogonal Frequency Division Multiplexing (OFDM) is a multi-carrier modulation technique that employs overlapping, orthogonal narrow band signals. One of the main advantages of OFDM is that it is resistant to the multipath propagation that is inevitable in wireless radio communications. It has become the modulation method of choice for many new systems.**

**Plextek has developed an OFDM baseband modem that can be configured for a variety of applications.**

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Multipath propagation results from radio signals refracting around and reflecting off physical objects, resulting in multiple paths between the transmitter and receiver, each exhibiting its own loss and delay. The 'delay spread' (the difference in delay between that longest and shortest paths) is an important parameter. Indoor values are tens of nanoseconds, resulting in severe carrier fluctuation (including cancellation). Outdoor values can reach several microseconds, causing data symbols to run into one another (Inter-Symbol Interference or ISI). OFDM is robust against both of these effects by using a large number of simultaneous carriers, and very long symbol periods (it can do this because the data rate per carrier is quite low). The typical number of sub-carriers varies from 52 for 802.11a wireless LAN to 6817 for Digital Video Broadcasting (DVB-T) terrestrial TV. These carriers are spaced apart by the reciprocal of the symbol period as shown in the diagram above, resulting in their being orthogonal (i.e. one carrier does not interfere with another). The likely loss of a few carriers at any one time can be tolerated with suitable coding, using Coded OFDM (COFDM).

A combination of the long symbol period and a guard interval between symbols reduces any ISI to insignificant proportions.

Most OFDM transmitters employ Fast Fourier Transform (FFT) techniques to generate the sub-carriers.

The receiver uses a similar FFT to recover the sub-carriers once it has attained frequency and symbol synchronisation. To achieve optimum performance, known pilot symbols and reference carriers are provided to enable the receiver to equalise the sub-carriers to overcome some of the fading.

OFDM is ideally suited to high bandwidth broadcast applications, such as DVB, where immunity to large delay spread multipath is essential. A secondary benefit of OFDM for broadcast is its suitability for Single Frequency Networks (SFN) where synchronised transmitters can use the same frequency. OFDM is also well suited to wireless LANs where the dynamic nature of both the traffic and the propagation path require rapid adaptation to varying multipath.

## Propagation modelling

The design of any wireless system will be governed by the radio propagation environment. Plextek has undertaken many propagation studies, both indoor and outdoor at a range of frequencies up to 40GHz. See Paper "Multipath Measurements for High Data Rate Communications" at [www.plextek.com](http://www.plextek.com)

## 802.11 Wireless LAN

802.11b Wireless LAN (WLAN) technology is one of the most widely deployed and most rapidly expanding areas of radio communications. As demand for mobile data grows, networks will have to offer more bandwidth to support both larger numbers of users and higher data rates for individual users. Satisfying these demands involves the deployment of newer air interface technologies such as 3G cellular and 802.11a and 802.11g WLAN.

Plextek has developed a combined 802.11b/GPRS reference design for PCMCIA data applications. As part of an ongoing development program, Plextek has also developed an OFDM baseband implementation to provide our clients with a rapid route to new WLAN technologies. Plextek is also actively involved in the development of 3G mobile cellular and is committed to remaining at the forefront of technological development and innovation in mobile data.

### OFDM Modem Implementation

Plextek has developed an implementation of an OFDM modem compliant with the 802.11a wireless LAN standard. A block diagram of the modem is shown above. Although the design has been targeted at 802.11a, the main building blocks are applicable to many other standards. The modem supports all symbol modulations up to QAM64 and can achieve the maximum half duplex rate of 54Mbits/sec.

The target customers for this product are silicon vendors requiring a fast track route to the latest WLAN technologies.

Also targeted are developers of Broadband Access systems where OFDM offers significant benefits.

The Plextek OFDM modem is also well suited to many low volume, bespoke system developments and can easily be accommodated in a standard FPGA.

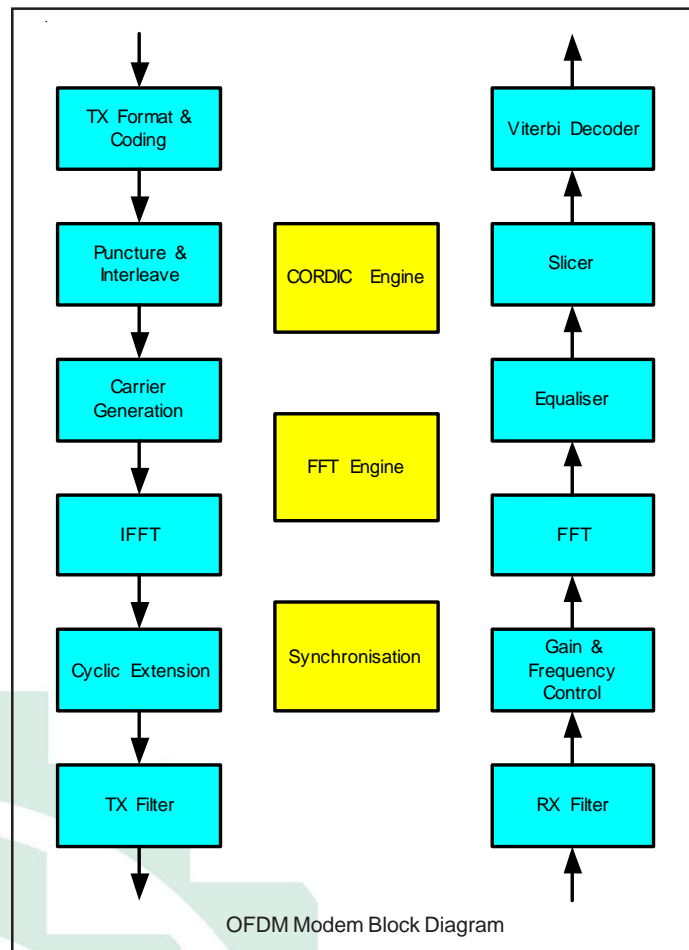
The design has been developed in C and ported to VHDL.

### OFDM RF Design

One of the challenges, and potential drawbacks, of OFDM is the Peak to Average Power Ratio (PAPR) requirements of the transmitter.

To achieve this PAPR and maintain linearity, most designs 'back off' the TX power amplifier by several dB. This technique requires large, expensive components and reduces the power efficiency of the transmitter which is not desirable for small battery powered devices. Plextek is also developing linearisation techniques that can be used to mitigate this problem.

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