INTRODUCTION TO OFDM – ORTHOGONAL FREQUENCY DIVISION MULTIPLEXING

In modulations, information is mapped on to changes in frequency, phase or amplitude (or a combination of them) of a carrier signal. Multiplexing deals with allocation/accommodation of users in a given bandwidth (i.e. it deals with allocation of available resource). OFDM is a combination of modulation and multiplexing. In this technique, the given resource (bandwidth) is shared among individual modulated data sources. Normal modulation techniques (like AM, PM, FM, BPSK, QPSK, etc..,) are single carrier modulation techniques, in which the incoming information is modulated over a single carrier. OFDM is a multicarrier modulation technique, which employs several carriers, within the allocated bandwidth, to convey the information from source to destination. Each carrier may employ one of the several available digital modulation techniques (BPSK, QPSK, QAM etc..,).

Why OFDM

OFDM is very effective for communication over channels with frequency selective fading (different frequency components of the signal experience different fading). It is very difficult to handle frequency selective fading in the receiver , in which case, the design of the receiver is hugely complex. Instead of trying to mitigate frequency selective fading as a whole (which occurs when a huge bandwidth is allocated for the data transmission over a frequency selective fading channel), OFDM mitigates the problem by converting the entire frequency selective fading channel into small flat fading channels (as seen by the individual subcarriers). Flat fading is easier to combat (compared to frequency selective fading) by employing simple error correction and equalization schemes.

Difference between FDM and OFDM:

OFDM is a special case of FDM (Frequency Division Multiplexing). In FDM, the given bandwidth is subdivided among a set of carriers. There is no relationship between the carrier frequencies in FDM. For example, consider that the given bandwidth has to be divided among 5 carriers (say a,b,c,d,e). There is no relationship between the subcarriers ; a,b,c,d and e can anything within the given bandwidth.

If the carriers are harmonics, say (b=2a,c=3a,d=4a,d=5a , integral multiple of fundamental component a) then they become orthogonal. This is a special case of FDM, which is called OFDM (as implied by the word – ‘orthogonal’ in OFDM)

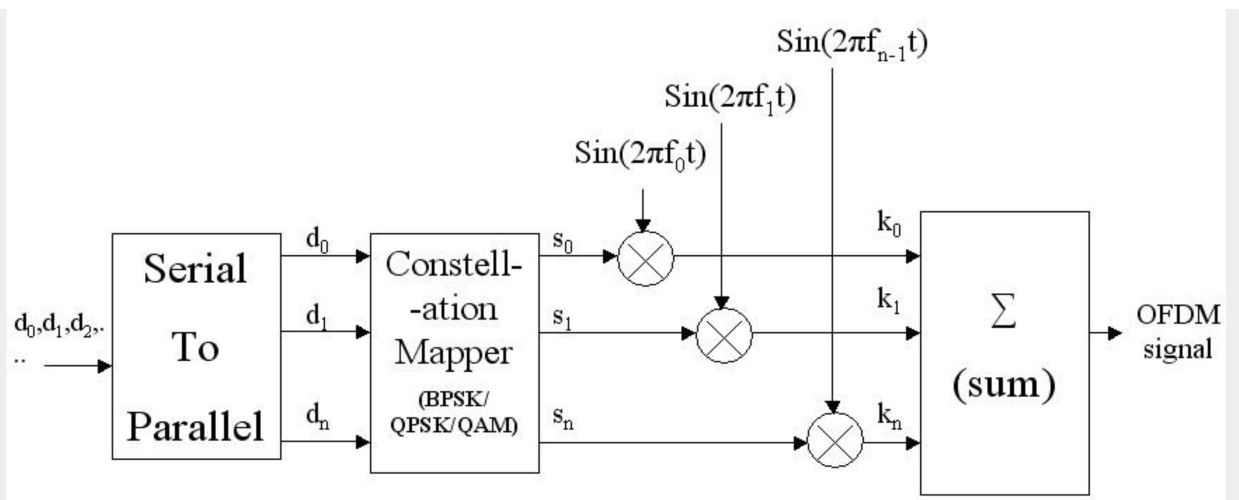
Designing OFDM Transmitter:

Consider that we want to send the following data bits using OFDM : D = {d0,d1,d2,…). The first thing that should be considered in designing the OFDM transmitter is the number of subcarriers required to send the given data. As a generic case, lets assume that we have N subcarriers. Each subcarriers are centered at frequencies that are orthogonal to each other (usually multiples of frequencies).

The second design parameter could be the modulation format that we wish to use. An OFDM signal can be constructed using anyone of the following digital modulation techniques namely BPSK,QPSK,QAMetc..,

The data (D) has to be first converted from serial stream into parallel stream depending on the number of sub-carriers (N). Since we assumed that there are N subcarriers allowed for the OFDM transmission, we name the subcarriers from 0 to N-1. Now, the Serial to Parallel converter takes the serial stream of input bits and outputs N parallel streams (indexed from 0 to N-1). These parallel streams are individually converted into the required digital modulation format (BPSK, QPSK, QAM etc..,). Lets call this output S_0,S_1,..S_N. The conversion of parallel data (D) into the digitally modulated data (S) is usually achieved by a constellation mapper, which is essentially a look up table (LUT). Once the data bits are converted to required modulation format, they need to be superimposed on the required orthogonal subcarriers for transmission. This is achieved by a series of N parallel sinusoidal oscillators tuned to N orthogonal frequencies (f_0,f_1,…f_{N-1}). Finally, the resultant output from the N parallel arms are summed up together to produce the OFDM signal.

The following figure illustrates the basic concept of OFDM transmission (note: In order to give a simple explanation to illustrate the underlying concept,the usual IFFT/FFT blocks that are used in actual OFDM system, are not used in the block diagram) .



OFDM Transmitter

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