Brief Overview on OFDM

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Abstract - In this present era the demand of wireless-communication is too high. This paper present the overview of Orthogonal Frequency Division Multiplexing (OFDM). Also present the problems of OFDM. How can high data rate services bandwidth utilization must be efficient. It should be characterized by significantly enhancing the spectral efficiency in order to increases the speed of operation and network capacity. In conventional FDM, the frequency sub channels are non-overlapping. This leads to inefficient way of utilizing the available bandwidth. In 1960's an idea of overlap and orthogonal frequency sub channels was proposed, hence the OFDM came into existence. In this paper we also describe the applications of OFDM.

Keywords: Orthogonal Frequency Division Multiplexing (OFDM), Digital Audio Broadcasting (DAB), Digital Video Broadcasting (DVB), Second Generation (2G), Third Generation (3g).

I. INTRODUCTION OF WIRELESS

In this era for better ways of living has been instrumental in advancing for peoples. They demand for communication services available at any time and place free people from the limitation of being attached and fixed devices. In present era thanks to the remarkable progress in wireless technology, affordable wireless communication technology has become a new generation. Mobile people up anywhere they want. Digital-Audio and Video broadcasting offers consumers high compatibility, that give nice quality. The components are now thin, light, small and inexpensive. Furthermore, cellular mobile phones capable of multimedia and broadband internet access are showing up on the service. Many projects studying about wireless networks with different extents of coverage in every area. It will deliver wireless possibility to internet in every area, even indoors or outdoors and in rural or metropolitan areas. In the following, their evolution and future developments will be introduced. The important role that the Orthogonal Frequency-Division Multiplexing (OFDM) technology plays in wireless media will also become very clearly.

In this present era, most people fill the need for information and entertainment through AVB. It deliver huge and better programs, digital broadcasting techniques, such as Digital Audio Broadcasting (DAB) and Digital Video Broadcasting (DVB), began to replace the analog broadcasting technologies in the past several years. The inauguration of AM radio can be traced back to the early in the old century, where analog TV programs were first broadcast before the World-War-Second. In the middle of twentieth-century, In Frequency Modulation easily availability of all radio programs. Their all technology depends on analog communication, music, drama, brought news, movies and much more into our daily life.

Cellular phones are now a necessity to several billions of people in the world. The migration from the Second-Generation (2G) to the Third-Generation (3g), and then onward to the fourth-generation (4G) mobile cellular communication systems. Their functionalities range from voice service to picture, video and broadband data services. But General Packet Radio Service (GPRS) and Enhanced Data Rate for Global Evolution (EDGE) systems provide transmission rates of up to several hundreds of Kbps as an enhancement of the GSM standard. Similarly, CDMA2000 1X upgraded the data transmission to 300 Kbps in United States.

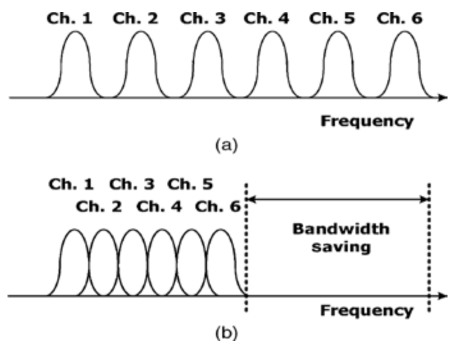
In 2G, the GSM system is used as the European standard and CDMA One IS-95 is adopted in United States. These give digital voice services at around 10 Kbps.

Two main-stream 3G standards are 3Xand Wideband-CDMA CDMA2000 (W-CDMA). High Speed Downlink Packet Access (HSDPA) is the enhanced version of W-CDMA has been standardized, which is regarded as 3.5G andcan achieve about a 10-Mbps rate of transmission. At present 3G standards provide data services with a data rate of up to 2 Mbps to accommodate multimedia users. In the Third-Generation Project Partnership (3GPP) long-term evolution (LTE) has started to plan possible solutions to future mobile communication technology. The main features include [1,3].

II. OFDM (ORTHOGONAL FREQUENCY DIVISION MULTIPLEXING)

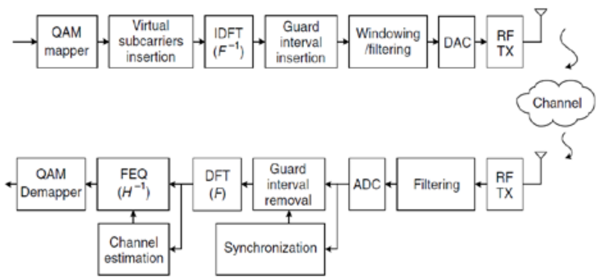
In this era studying about wireless networks with different extents of coverage are under way. The essential role that the orthogonal frequency-division multiplexing (OFDM) technique plays in wireless communication systems will also become very clear.

They will enable wireless access to internet backbone everywhere, either indoors or outdoors and in rural or metropolitan areas. In the following, their evolution and future developments will be introduced. Independent data are modulated on different sub-channels and then these sub-channels are frequency-multiplexed. The purpose of the non-overlap is to eliminate the possible interference among adjacent sub-channels, also known as ICI inter-carrier interference [2]. In systems of parallel transmission, a few non-overlapping sub-channels share the whole band of frequency, which is in Fig.



In the mid-1960s, spectral efficiency was improved by overlapping the sub-channels, as shown in Fig, which saves up to 50% of the spectrum used. Toward this end, Orthogonal Frequency-Division Multiplexing (OFDM) technology developed. Notice it the guard band between two adjacent sub-channels constitutes a waste of spectrum. OFDM is not only a frequency multiplexing technique that mandates orthogonality among sub-channel signals, but also a special case of multi-carrier modulation. Consequently, OFDM can be regarded as either a multiplexing technique or as a modulation scheme [2,4].

The transmitted data is generated from random signal at real time input. Their Tx is complete block by block. Furthermore, the size of the data generated is depends on the block size. The modulation schemes are used to map symbols of bits. This generation of data is passing on to the next stage, MIMO Encoder or Space Time Encoder is the Space Time Encoder stage converts one single input data stream into multiple output data streams. How the output streams are formatted depends on the type of MIMO. There make usefulness of the OFDM sub-carriers. This data is fed into the channels. Mostly in the cellular technology, mobile antenna height may be smaller than the surrounding infra. So existence to direct or line-of-sight path between the transmitter and the receiver is highly sensible. In those cases mainly propagation cause by reflection and scattering from the buildings and by diffraction over or around. So, in practice, the transmitted signal arrives at the receiver via several paths with different time delays creating a multi-path situation.



At the receiver, these multi-path waves with randomly distributed amplitudes and phases combine to give a resultant signal that fluctuates in space and time. That's why a receiver at one location that may have a signal that is much different from the signal at another location, only a short distances away, because of the change in the phase relationship among the radio waves receiver. That is effect of significant fluctuations in the amplitude of the signal. That process of randomly fluctuations in the received signal level is termed as fading [4-5]. Fading can be classified as frequency-flat and frequency-selective. If the signal bandwidth is lesser than the bandwidth which is Coherence, the fading is known as flat frequency channel. If they're the bandwidth of signal is greater than on the channel of Coherence bandwidth, the fading is frequency-selectivity of channel. MIMO technology reduced the effect of flat fading but not the frequency selective fading but by using the OFDM modulation in congestion with the MIMO, frequency selective fading can be converted to flat fading by using N subcarriers in the OFDM technology which makes the signal bandwidth lesser than the coherence bandwidth. OFDM signals are generated digitally and the signal consists of a sum of subcarriers that are modulated using BPSK or QPSK or QAM. The relationship between all the carriers must be controlled to maintain the orthogonality of the carriers [6]. After modulating digitally input data, then the resulted spectrum is converted back to its time domain using Inverse Fourier Transform (IFFT). The IFFT converts a number of complex data points, of length power of 2, into the time domain signal of the same number of points [3].

Now recently communication standards adopting the OFDM modulation scheme for better communication.

The OFDM principle and its mathematical expression have been introduced. The design of OFDM parameter, the guard interval ratio and FFT size, will be discussed. In the multi-carrier transmitter consists of a set of modulators, each with different carrier frequencies. The transmitter then combines the modulator outputs and generates the transmitted signal. Suppose that the N data to be transmitted are Xk, k = 0; 1; . . . ; N _ 1, where Xk is a complex number in a given constellation, such as QPSK or QAM. Also suppose that the kth carrier frequency for Xk is fk. Then, the complex-valued multi-carrier transmitter output is given by

$$x(t) = \sum_{k=0}^{N-1} X_k e^{j2\pi f_k t}$$

A digital transmitter will generate its output in a sampled-data fashion. By letting t = nTs, where Ts is the sample interval, for implement their transmitters and receivers digitally whenever

$$x(nT_s) = \sum_{k=0}^{N-1} X_k e^{j2\pi f_k nT_s}$$

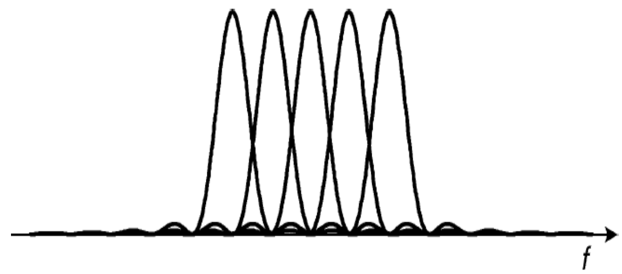
their carrier frequencies are uniformly spaced in the frequency domain by a frequency spacing of fS, i.e. fk = kfS; k = 0; 1; . . . ; N - 1, then

$$x(nT_s) = \sum_{k=0}^{N-1} X_k e^{j2\pi k f_S nT_s}$$

Let fS = 1/NTs the minimum separation to keep orthogonality among signals on different modulators then the OFDM signal is given by

$$x_n = x(nT_s) = \sum_{k=0}^{N-1} X_k e^{j2\pi nk/N}$$

If N is a power of two, then there exist many fast and efficient algorithms and architectures for implementing such an IDFT operation. For a multiplying constant (1/N), the above formula is the equation of an N-point inverse discrete Fourier transform (IDFT) [5]. It is such efficient digital realization of the OFDM transmitter that makes the OFDM technology a feasible solution to advanced communication systems. Without specific time-domain windowing on the OFDM symbol (xn) to shape its waveform, the OFDM subcarriers have sinc shaped spectra, as shown in Fig.



III. PROBLEMS IN OFDM

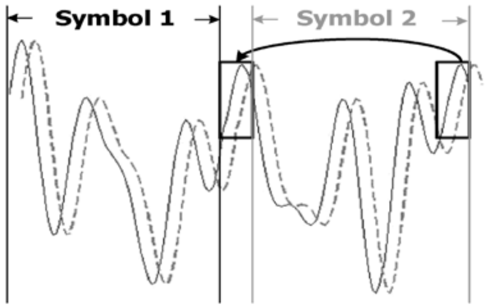
Guard Interval

To eliminate ISI, a guard interval of Ng samples is usually inserted at the beginning of each OFDM symbol, as depicted the length of the guard interval is made longer than the delay spread of the wireless channel. As a result, the degree of delay spread in the operating environments must be obtained beforehand. Note that the guard interval actually wastes transmission resources; hence the ratio of the guard interval length to the effective OFDM symbol duration is usually kept below 1/4. In wireless channels, a receiver may receive several delayed replicas of the transmitted signal, which is known as the multipath effect shows a scenario in which there are two copies of the received waveform–one on time and the other delayed by some time. Inter-symbol interference (ISI) is induced because the tail part of symbol 1 will interfere with the processing of symbol 2. During the guard interval, the transmitter can send null waveform. This scheme is called Zero Padding (ZP) transmission A ZP–OFDM system has lower transmission power and a simpler transmitter structure. Unfortunately, the ZP–OFDM scheme introduces ICI, as the orthogonality among subcarriers is destroyed when multiple copies of the time-shifted ZP–OFDM waveform are received. The cyclic prefix is an exact copy of a segment of the OFDM symbol located toward the symbol end.

To remove ICI, cyclic prefixing (CP) transmission is preferred [2, 4].

Null Subcarriers

To prevent significant leakage to adjacent bands, OFDM systems usually do not transmit any data on the subcarriers near the two edges of the assigned band. These unused subcarriers are known as guard subcarriers or virtual subcarriers. The collection of all the unused subcarriers is called the guard band [6].

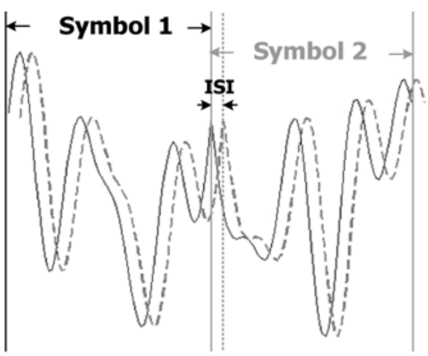


In addition to guard bands, some subcarriers around DC frequency (subcarrier index 0) may also be made null in order to evade the large yet unwanted DC and low-frequency components generated by the receiver front-end.

As the OFDM signal power spectrum has quite high side lobes, reservation of the guard band helps to reduce the out-of-band emission and thus eases the requirements on transmitter front-end filters. Nevertheless, adoption of guard band wastes some assigned bandwidth and decreases spectral efficiency of the OFDM system [3].

Spectrum Shaping

The Wireless signal regulated by spectrum masks which define the allowable maximum in-band and out-of-band signal power spectrum in Fig.



The spectrum of the signal the IEEE 802.11a wireless LAN system. For each channel, a 20-MHz bandwidth is allocated. The rectangular time window of the DFT operation and waveform discontinuity at the boundary of adjacent OFDM symbols make the signal spectrum side lobe fall off more slowly than that specified by the spectrum mask. As such, windowing the time-domain OFDM waveform is often applied to achieve a signal spectrum that complies with the mask.

Peak-to-Average Power Ratio

The peak-to-average power ratio (PAPR), defined as the ratio of the peak power to the average power, has been one weakness for OFDM communication systems. The PAPR formula is given by

$$\mathrm{PAPR} \triangleq \frac{max_t|x(t)|^2}{E_t\,[|x(t)|^2\,]}$$

And for the discrete time signal PAPR,

$$\mathrm{PAPR} \triangleq \frac{max_n\,|x(n)|^2}{E_n\,[|x(n)|^2]}$$

For example, the PAPR of a 256-subcarrier OFDM system can be as high as 256, or equivalently 24 dB. Such a high PAPR demands high dynamic range in the ensuing amplifier, especially the

Power Amplifier (PA) in the transmitter. In the extreme case, in which all the subcarriers are coherently and equally summed up, the time-domain OFDM signal can have a PAPR of about N.

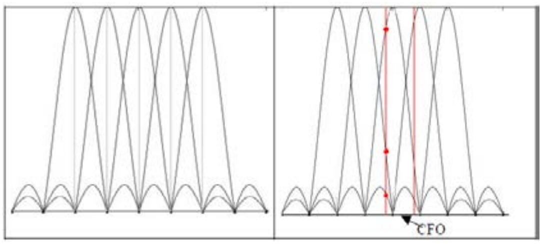
If not biased properly, the PA easily enters into saturation, causing nonlinear amplification of large-magnitude signals. To accommodate such large-dynamic-range signals linearly, the PA must work at an operating point, Po;avg, that is quite inefficient in terms of power consumption. Namely, a large Output Back-Off (OBO), shown in Fig. The output back-off is defined as the output saturation power to the average output power of a PA

$$\mathrm{OBO} = 10\,\log_{10}\frac{P_{o,max}}{P_{o,avg}} \quad (\mathrm{dB})$$

To reduce the PAPR, many approaches have been proposed. Clipping and windowing the peak signals exceeding some threshold are one of the possible solutions. Depending on the input data, the signals to be modulated on all the subcarriers are chosen from a set of code words that corresponds to waveforms with a lower PAPR. However, they may introduce in-band distortion and out-of-band radiation [5]. Some suggested using coding techniques [6, 7]. The drawback of the coding techniques is the overhead in transmission efficiency. Scrambling codes can also be adopted to destroy signal regularity, which can incur a high PAPR.

Inter Carrier Interference (ICI)

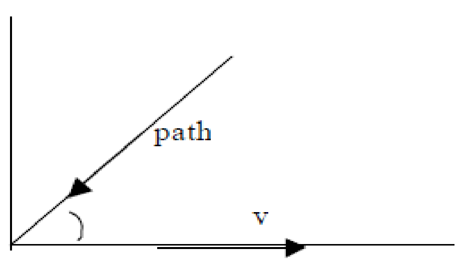
The co-channel interference is caused by reused channel, while ICI results from the other sub-channels in the same data block of the same user. ICI is different from the co-channel interference in MIMO systems. Even if only one user is communicate, ICI found, at Co-Channel Interference will not happen.



ICI problem would become more complicated when the multipath fading in channels. Above figure shown relationship between ICI & CFO. There are two factors of ICI that cause time variation and frequency offset. As discussed in [9], some kinds of time variations of channels can be modeled as a white Gaussian random noise when *N* is large enough, while other time variations frequency offsets can be modeled that is Doppler shift.

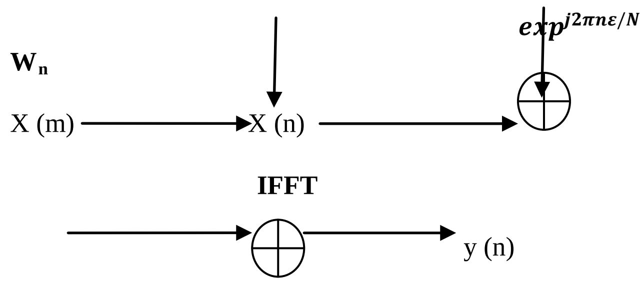
It generation of Doppler Effect. The Doppler Effect decreased the quality of a cell phone conversation in a moving area. The relative motion between receiver and transmitter, or mobile medium among them, would result in the Doppler Effect, a frequency shift in narrow-band communications.

In general, the Doppler frequency shift can be formulated in a function of the velocity, their angle between velocity direction and the communication link, and the carrier frequency, as shown in Fig.



This frequency offset can be caused by Doppler shift due to relative motion between the transmitter & receiver, And difference on the frequencies of the local oscillators at the transmitter and receiver. The main drawback of OFDM, however, it is sensible to small differences in frequency at the transmitting and receiving, it refers to as frequency offset. Their frequency offset is modelled as a multiplicative factor is introduced, in Fig. The received signal is given by, Where the normalized frequency offset ε, and is given by $\Delta \boldsymbol{f} \boldsymbol{NTS}$ $\Delta \boldsymbol{f}$ is the frequency difference between the transmitted and received carrier frequencies and $\mathbf{T_S}$ is the subcarrier symbol period. W(n) is the Adaptive White Gaussian Noise AWGN introduced in the channel.

$$\mathbf{Y\ (n) = x\ (n)}e^{j2\pi n\varepsilon/N} \mathbf{+ w\ (n)}$$



IV. CONCLUSION

In this study paper or its overview of the performance of OFDM systems in the presence of frequency offset between the transmitter and the receiver has been analyzing which problem persists in OFDM system which in terms of PAPR, ISI, and ICI etc. which depends on the frequency offset degrades the OFDM system performance. their analyzed or study of OFDM it found that OFDM is difficult in term of its problems.

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