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Analysis Of Transmit Power Spectrum Of WLAN Based OFDM System

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Abstract
In this paper, different Power Spectral Density (PSD) curves of OFDM signal based on WLAN with various pulse shapes are presented. OFDM waveform is analyzed in frequency domain response for different modulation techniques such as BPSK, QPSK, 16-QAM, 64-QAM for block size 50. Power Spectral Density increases with increase in levels of modulation. For high power spectral density of transmitter higher levels of QAM modulation techniques are preferred.

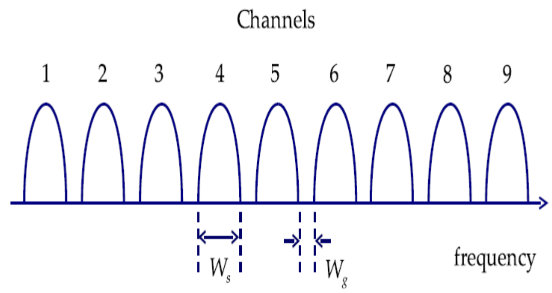
Keywords-WLAN, OFDM, Power Spectral Density, Power Spectrum, Frequency.

1 Introduction

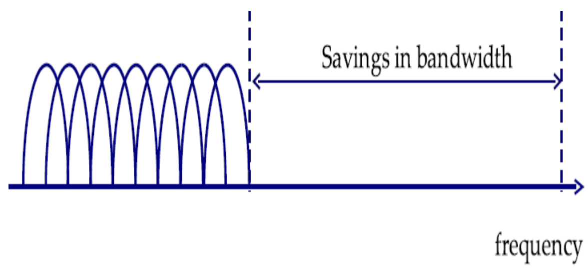
The main key role in wireless radio technologies is focused on effective bandwidth availability given that the spectrum is limited and this stimulates researchers and engineers to use the spectrum more efficiently [1]. The multicarrier modulation techniques are increasingly used in wireless local area network (WLAN) environments to provide high data rate transmission. The choice of multicarrier technique Orthogonal Frequency Division Multiplexing (OFDM) is due to its good performance in multipath environments. In an OFDM scheme, a large number of orthogonal, overlapping, narrow band sub-channels or subcarriers, transmitted in parallel, divide the available transmission bandwidth into several orthogonal sub-carriers and each subcarrier is modulated with modulation technique in same bandwidth.The separation of the subcarriers is theoretically minimal such that there is a very compact spectral utilization[2].

2 OFDM Transmission

Orthogonal Frequency Division Multiplexing (OFDM) is an attractive multiplexing technique used for transmitting large amounts of data over radio waves. OFDM has several properties like high spectral efficiency, robustness to channel fading, immune to impulse interference, uniform spectral density, and capacity to handle very strong echoes and less non-linear distortion [4]. OFDM is a multiplexing technique that divides anOFDM signal which is a sum of several sinusoids channel with a higher relative data rate into several orthogonal sub-channels with a lower data rate.A large number of closely spaced orthogonal subcarriers are used to carry data. The data is divided into several parallel streams of channels, one for each subcarrier. Each sub-carrier is modulated with a conventional modulation scheme at a low symbol rate, maintaining total data rate similar to the conventional single carrier modulation schemes in the same bandwidth. The carriers are independent of each other even though their spectra overlap. High data rate systems are achieved by using a large number of carriers. OFDM allows for a high spectral efficiency as the carrier power, and modulation scheme can be individually controlled for each carrier.



(a) Conventional multicarrier technique



(b) Orthogonal multicarrier modulation technique

Figure 1: Concept of the OFDM signal: (a) conventional multicarrier technique, and (b) orthogonal multicarrier modulation technique[7].

In conventional multicarrier technique each user is typically allocated a single channel that is used to transmit all data. In conventional system up to 50% of total spectrum is wasted due to extra spacing between channels. This problem overcomes by using wider bandwidth channels [4].

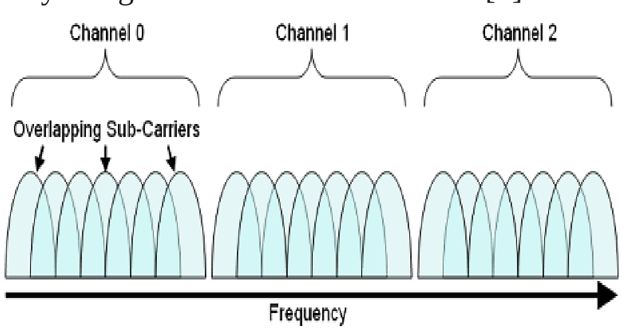


Figure 2: Spectral efficiency of OFDM [5]

The frequency band containing the message is divided up into parallel bit streams of lower-frequency carriers, or sub-carriers.These sub-carriers are designed to be orthogonal to one another, such that they can be separated out at the receiver without interference from neighboring carriers.

3 Wireless LAN / IEEE 802.11

The IEEE released the 802.11 specifications in June 1999. The 802.11 specifications were developedspecifically for Wireless Local Area Networks(WLANs) by the IEEE and include four subsetsof Ethernet-based protocol standards: 802.11,802.11a, 802.11b, and 802.11g.

OFDM has been considered by many IEEE standard working groups, such as IEEE 802.11a/g/n, IEEE 802.15.3a, and IEEE 802.16d/e. 802.11a operates in the 5 - 6 GHz range with data rates commonly in the 6 Mbps, 12 Mbps, or 24 Mbps range. As 802.11a uses the orthogonal frequency division multiplexing (OFDM) standard, data transfer rates can be as high as 54 Mbps [8]. OFDM breaks up fast serial information signals into several slower sub-signals that are transferred at the same time via different frequencies, providing more resistance to radio frequency interference. The modulation parameters of OFDM for IEEE 802.11a are listed in Table 1.

Parameter	**Value**
Channel spacing	20MHz
IFFT	64
Subcarrier Spacing(F_c)	312.5kHz(=20MHz/64)
Useful symbol period	3.2 usec
Modulation schemes	BPSK, QPSK, 16-QAM, 64-QAM
Total symbol period	4 usec

Table 1: Physical Layer simulation parameters for IEEE 802.11a [3]

4 Implementation Model Of WLAN

Before transmitting information data there are different modulation schemes are used.

The data is modulated in a baseband fashion by the IFFT. Then the data is transmitted to the channel. The receiver performs the inverse process of the transmitter [3]. Figure 3 shows the general architecture of a typical OFDM transceiver. In the data transmitter section OFDM signal is generated by firstly choosing the spectrum based on input data and modulation scheme used.Each carrier to be produced is assigned same data to transmit.

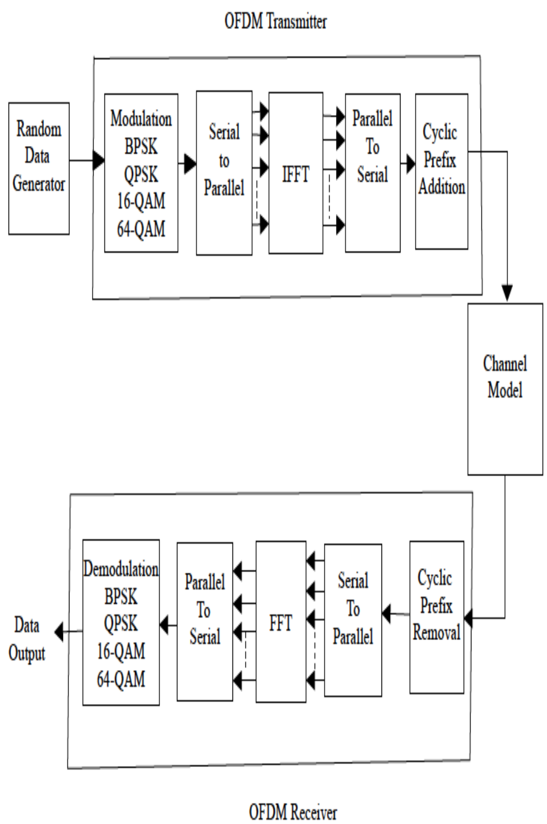


Figure 3: OFDM Transceiver

The spectral representation of the data is converted back into the time domain using an Inverse Fast Fourier Transform (IFFT). The Inverse Fast Fourier Transform (IFFT) is much more computationally efficient, and provides a simple way of ensuring the carrier signals produced are orthogonal. In order to transmit the OFDM signal the calculated time domain signal is then mixed up to the required frequency. The receiver performs the reverse operation of the transmitter, mixing the RF signal to base band for processing, then using a Fast Fourier Transform (FFT) to analyze the signal in the frequency domain [4].

5 Concept of Transmit Power Spectrum

In an OFDM signal, the complex values modulating the subcarriers in each symbol period are statistically independent of each other. Each carrier is modulated using binary phase shift keying (BPSK) or quaternary phase shift keying (QPSK) or quadrature amplitude modulation (QAM). Instead of separating each of the 52 carriers with a guard band, OFDM overlaps them. OFDM avoids Inter Carrier Interference problem because of its orthogonality property and by precisely controlling the relative frequencies and timing of the carriers. They are also independent of the values modulating any subcarrier in any previous or subsequent symbol period. As a result the power spectrum of the overall signal can be found by summing the power spectra of all individual subcarriers for any symbol period [7]. Power Spectral Density function (PSD) shows the strength of the variations (energy) as a function of frequency. It shows at which frequencies variations are strong and at which frequencies variations are weak.

The unit of Power SpectralDensity is energy per frequency (width) and energy can be obtained within a specific frequency range by integrating Power SpectralDensity within that frequency range. The power spectral density is averaged across 20 MHz bandwidth as specified by WLAN. Number of data symbols that constitute the envelope of power spectrum, spread over frequency bins. Power Spectral Density depends on levels of modulation.

6 Simulations and Results

The simulations are presented to analyze transmit power spectrum for various digital modulation techniques for WLAN standard of OFDM system. Plots between Power Spectral Density and frequency for digital modulation techniques are plotted and its comparisons are carried out. Simulations are performed on the different types of modulation schemes with same parameters. The aim of doing the simulation is to study transmit power spectrum based on WLAN under different modulation techniques

A Simulation Parameters

The system proposed has been simulated in Matlab. Table 2 lists the main simulation parameters. They are based on the OFDM standard IEEE 802.11a.

PARAMETERS	VALUES
Total data	2400
Number of OFDM symbols	40
Number of data subcarriers	52
Number of FFT points	64
Modulation Scheme	BPSK, QPSK , 16-QAM, 64-QAM
Cyclic Prefix	16
Frequency	20 MHz
Block Size	50

Table 2: Parameters used in simulation

The data is generated in the form of vector of 2400 bits fixed for all digital modulation simulations. The data is split in the OFDM carriers enhancing spectral efficiency. The extra pilot signal carrier giving information to receiver about communication system is added. The function of adding cyclic prefix is to add some last part of sequence according to guard length and add it with the whole part. The power spectral density is calculated in units of power per radians per sample. The length N of the FFT and the values of the input x determine the length of Power SpectralDensity and the range of the corresponding normalized frequencies.

B Simulated Plots between Power Spectral Density and Frequency for various digital modulation techniques in WLAN based OFDM systemand results

The simulation results are presented to analyze transmit power spectrum for various digital modulation techniques and fixing block size 50 for WLAN standard of OFDM system. Plots between Power Spectral Density and frequency for digital modulation techniques are plotted and its comparisons are carried out. Following simulations were performed on the different types of modulation schemes with same parameters.

Case 1 Transmit power spectrum for BPSK in WLAN

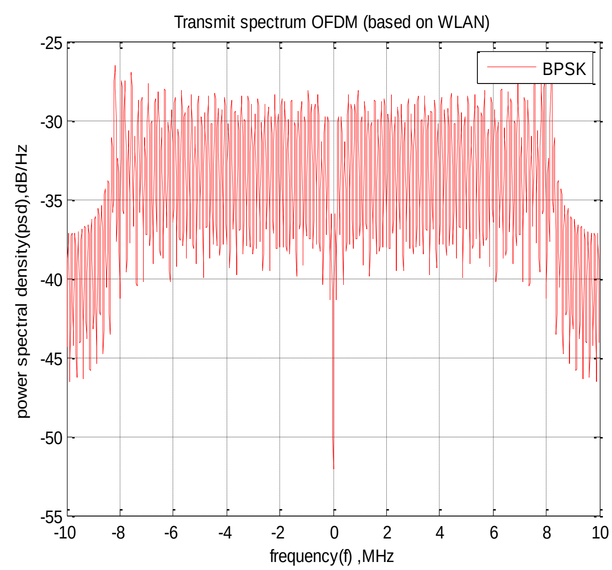


Figure 4: Plot of Power Spectral Densityagainst frequency for BPSK-WLAN

Case 2 Transmit power spectrum for QPSK in WLAN

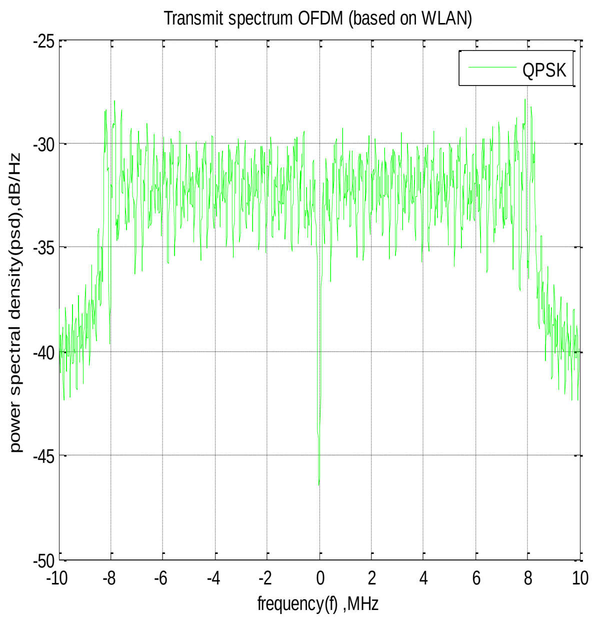


Figure 5: Plot of Power Spectral Densityagainst frequency for QPSK-WLAN

Case 3 Transmit power spectrum for 16-QAM in WLAN

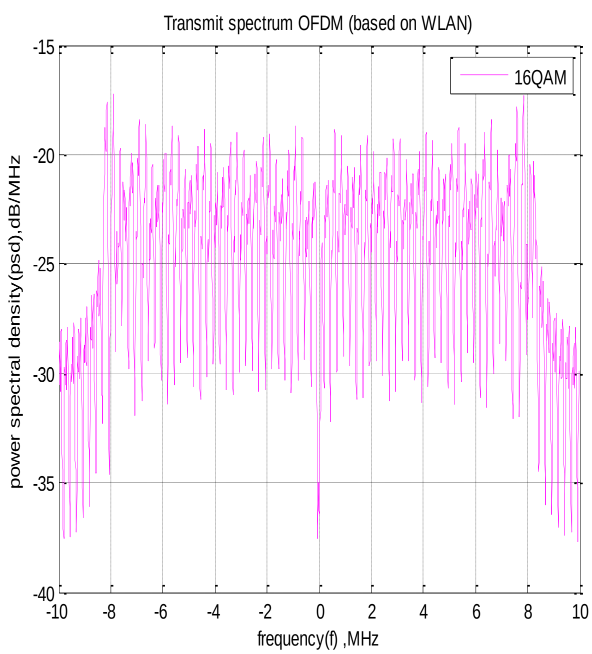


Figure 6: Plot of Power Spectral Density against frequency for 16-QAM in WLAN

Case 4 Transmit power spectrum for 64-QAM in WLAN

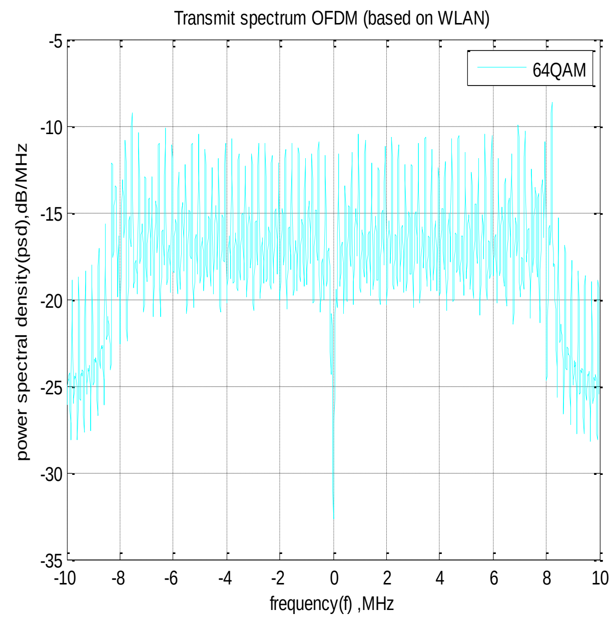


Figure 7: Plot of Power Spectral Density against frequency for 64-QAM in WLAN

Case 5 Transmit power spectrum for all digital modulation techniques in WLAN

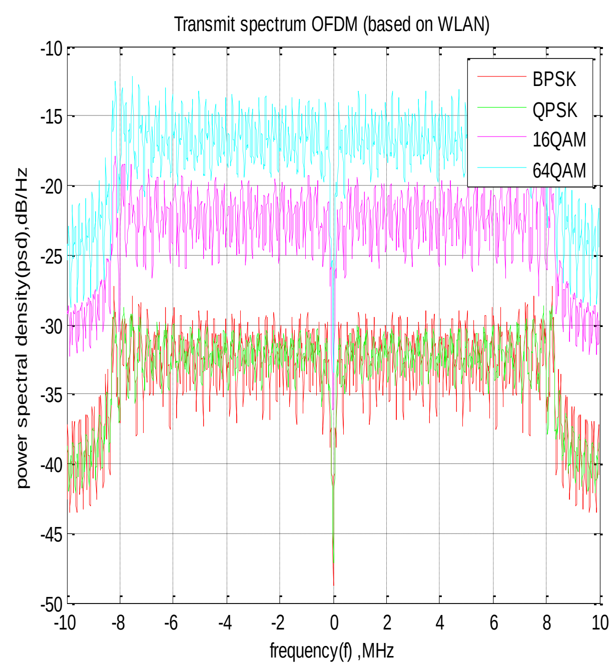


Figure 8: Transmit power spectrum for all digital modulation techniques in WLAN

Modulation	Power Spectral Density

Technique	(psd,dB/MHz)
BPSK	-32.5
QPSK	-32.5
16-QAM	-22.5
64-QAM	-17

Table 3: Simulated PSD(dB/MHz) with frequency(MHz) for all modulation techniques for block size 2048

Figure 8and **Table 3** shows that for all techniques - WLAN based OFDM, on fixing block size 2048 the Power SpectralDensity increases with increase in number of modulation levels. Power SpectralDensity has constant transmit spectrum within range -8 MHz to 8 MHz. From -10MHz to -8 MHz and for 8 MHz to 10 MHz shows side lobes of transmit spectrum.Power SpectralDensitystrengthens within range -8 MHz to 8 MHz.

Conclusion

It can be concluded that Power Spectral Density depends on the chosen modulation scheme.Power SpectralDensity strengthens with increase in number of modulation levels. In case of BPSK, QPSK modulation techniques the transmitted Power Spectral Density spectrum superimposed on each other. Power Spectral density is better in case of higher levels of QAM modulation techniques. Power Spectral Density is better in case of 64-QAM modulation technique than 16-QAM modulation technique. For all modulation techniques - WLAN based OFDM, it can also be concluded that signal strength is confined within the bandwidth range of -8 MHz to 8 MHz for different modulation techniques.

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