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Embedded Universal Audio Scrambler using OFDM Technique

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***Abstract*—**A telecommunication system requires anti-tapping procedure for the security puposes. One of the procedure is an embedded universal audio scrambler by using OFDM technique. The technique uses multicarrier and orthogonal frequencies in modulating data signal through IFFT/FFT process and digital mapping, PSK and QAM. OFDM simulation had been done by simulink (MATLAB) using parameters based on experiment in DSP board, TMS320C6713. The result showed that the best performance (smallest data error) was obtained by using 16QAM with 64 IFFT/FFT length.

***Key words*—**OFDM, PSK, QAM, IFFT/FFT

I. INTRODUCTION

Telecommunication is an information and data exchange process. One of the popular media is telephone or radio communication. Sometimes, the information or the data communicated is related to confidential problems such as in military services, goverment issues or business stuffs. Therefore, a mechanism is required to protect users from tapping by outsiders. One of the procedure is by using an universal audio scrambler with OFDM technique.

In this paper, we present simulation of OFDM technique using parameters based on experiment on TMS320C6713 board by varying SNR, PSK and QAM types, and FFT/IFFT length as variables.

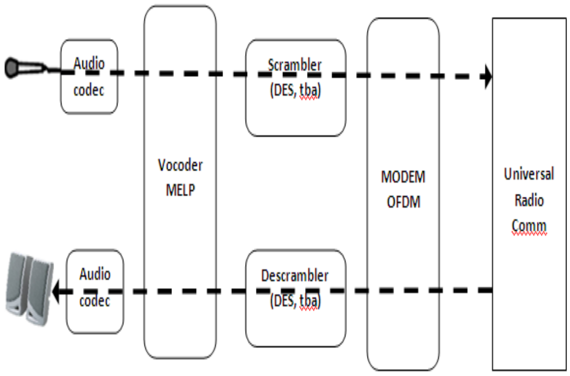

Figure 1. Universal audio scrambler diagram block

II. DESIGN AND IMPLEMENTATION

2.1 Orthogonal Frequency Division Multiplexing (OFDM)

Orthogonal Frequency Division Multiplexing (OFDM) is a transmition technique using multicarrier and orthogonal frequencies. Orthogonal means a mathematical relation (Eq. 2.1) between carriers to set each value of the carrier frequencies in order to optimize the bandwith usage without overlapping effect.

$\int \psi_a . \psi_b \, dt = 0 \quad , a \neq b$ (2.1) The orthogonality guarantee that two subcarrier signal, ψ_a and ψ_b , will not interact each other as shown by Fig. 2.1

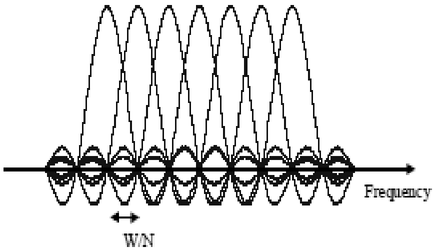

Fig. 2.1 Orthogonal subcarriers in OFDM spectrum

Block diagram of OFDM is shown in figure 2.2.

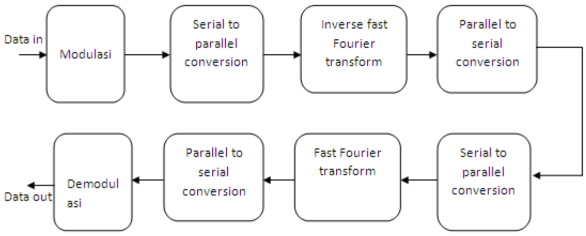

Figure 2.2 OFDM diagram block

In transmitter block, data is mapped digitally using PSK or QAM methode. Then this serial data will be converted to parallel form before feeded to IFFT (Inverse Fast Fourier Transform) for generating OFDM symbol. These parallel symbols will be re-converted to serial before transmitted to its receiver. Then after accepted by the receiver block, the same process of transmitter is conducted in opposite direction.

2.2 Phase Shift Keying (PSK) and Quadrature Amplitude Modulation (QAM)

QAM is a modulation scheme where the modulated waves are summed and generate waveform which is combination of both Phase-Shift Keying (PSK) and Amplitude-Shift Keying (ASK). Therefore, PSK is a special form of QAM where it change/modulate the phase of two carrier waves with constant amplitude.

2.3 Inverse Fast Fourier Transform (IFFT) and Fast Fourier Transform (FFT)

Modulation in OFDM technique use IFFT with particular length to change the domain of OFDM signal from frequency to time domain. Therefore, the signal will be transmitted with suitable pulse-shaping to the receiver. While FFT is used to re-order the modulated data signal before decoded to its original data.
Discrete Fourier Transform (DFT) and Inverse Discrete Fourier Transform (IDFT) are the simple form of FFT and IFFT to reduce the complexity of mathematical process (Eq.2.2). N is representation of DFT or IDFT length which effect on the shape of proceed signal. The bigger N value, the better pulse-shaping will be but the longer time needed for its computation.

$$X(k) = \sum_{n=0}^{N-1} x(n) e^{-j2\pi k/N} \qquad (2.2)$$

$$x(n) = \frac{1}{N} \sum_{n=0}^{N-1} X(k) e^{j2\pi k/N} \qquad (2.3)$$

III. EXPERIMENT METHOD

Simulink from MATLAB software had been used to design OFDM model. The design will be simulated before implemented on TMS320C6713 board with EVM OMAP L137. The model performance was tested by using an audio signal as the input of the board. The quality of its output signal was used as reference to set SNR (Signal to Noise Ratio) parameter that will be used as variable of OFDM simulation which use a data set as its input.

First, for 64 length of FFT/IFFT , we tried different types of PSK and QAM modulation in the experiment. As the result, we only obtained audio output at QPSK and 16QAM modulation. For others, no audio output observed. From this fact, we select QPSK and 16QAM as parameters for next experiment where we tried to vary different length of FFT/IFFT to observe the audio input at the output. As the output, audio input only proceed well at length 64 and 128 which became other reference for simulation in Simulink. After obtained four parameters, simulation was conducted in order to observe SNR effect on a data input in different type modulation (QPSK and 16QAM) and different length of IFFT/FFT (64 and 128).

IV. RESULT AND DISCUSSION

Implementation of OFDM model on TMS320C6713 board showed that audio input was clearly heard without noise at SNR = 29 as treshold value. The similar result was obtained in simulation where the data errors was zero (Table 4.1 and 4.2).

Table 4.1 Data error (%) for FFT length = 64

SNR	QPSK	16QAM
1	100	100
5	100	100
10	100	100
15	96.875	92.1875
20	76.5625	62.5
25	20.3125	7.8125
26	10.9375	4.6875
27	4.6875	4.6875
28	1.5625	3.125
29	0	0
30	0	0

Table 4.2 Data error (%) for FFT length = 128

SNR	QPSK	16QAM
1	100	100
5	100	100
10	100	100
15	98.4375	92.1875
20	93.75	62.5
25	68.75	6.25
26	50	4.6875
27	34.375	4.6875
28	23.4375	3.125
29	9.375	0
30	4.6875	0

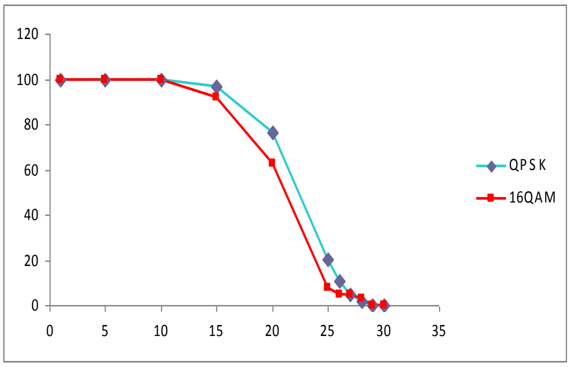

Figure 4.1 Error percentage for FFT length = 64 in different SNR

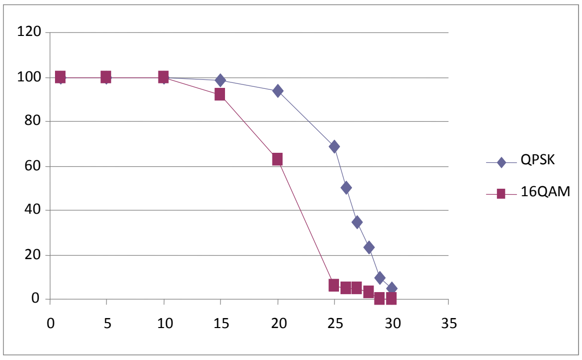

Figure 4.2 Error percentage for FFT length = 128 in different SNR

An exception was showed by SNR = 29 for QPSK modulation in table 4.2 where noise still exist in the output data. It is clearly caused by the FFT length which was set at 128. Besides, from these two tables we can see that 128 FFT length is not suitable for QPSK mapping since it increased the data error. Apparently, the FFT length is too over for computation QPSK data which only used 2 bit mapping.

Meanwhile, we also can see from the graph that for the same length of FFT, 16QAM is better than QPSK modulation. It is acceptable theoritically since QAM modulates include amplitude not only phase as well as in QPSK.

V. CONCLUSION

The system had been tested to see the performance of TMS320C6713 board. The smallest data error simulation was achieved by using 64 FFT length and 16QAM modulation type.

IV. ACKNOWLEDGMENTS

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