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OFDM Based Multi Tone Test Signal Generation using FPGA

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Abstract - In this paper, a new multi - tone test signal generation method is presented with different frequency tones uniformly distributed across a wideband spectrum. It employs OFDM (Orthogonal frequency-division multiplexing) spread spectrum technique to allow users to define signal parameters with a great flexibility as per test requirements.OFDM is a well known technique used in modern communication system to achieve high speed data rates and to alleviate multi path effects. It is a method of encoding digital data on multiple carrier frequencies. Response of such test signals from the device under test (DUT) can be captured and analyzed so as to characterize frequency response associated with each frequency tone. The simulation part consists of Matlab Simulink tool and its hardware part is implemented on a Xillinx FPGA board.

Keywords- Multi-tone testing,OFDM,Filter testing, FFT/IFFT, QAM, Low cost testing.

I.INTRODUCTION

Orthogonal frequency division multiplexing (OFDM) is one of the multi-carrier modulation (MCM) techniques that transmit signals through multiple carriers. These carriers(subcarriers) have different frequencies and they are orthogonal to each other.Orthogonal frequency division multiplexing techniques have been applied in both wired and wireless communications, such as the asymmetric digital subscriber line (ADSL) and the IEEE 802.11 standard. Recent innovations in integrated circuit technology and design have enabled the expanding growth of wireless communication systems and have further led to various wireless communication standards, which employ different spectrum and protocols for providing wireless communication services.

Unfortunately,characterizing the response across the full frequency band of a circuit component can be costly in terms of total testing time required and/or additional hardware required. There are different approaches of generating multi-tone test signals. A difficult challenge facing test engineers in the development of mixed analog/digital built-in-self-test (MADBIST) schemes lies in designing a high-quality analog signal source which can be fabricated on the same chip as the circuit-under-test.

There are different approaches of generating multi-tone test signals. A typical method is to use a phase-locked loop (PLL) circuit. By changing the feedback divider value in succession, different frequency signals can be produced sequentially. Such method is simple however slow, since PLL will consume considerable time to switch and lock among different frequencies.

Another method is to adopt multiple phase-locked-loop (PLLs)to generate multiple different frequencies simultaneously. This method speeds up the signal generation. Nonetheless, having multiple sets of PLLs increases signal generator design cost and design complexity. Then another method is to use AWG. It is capable of generating different complex waveforms of desired shape and frequency and has been widely used for production test and characterization. However a traditional AWG requires considerable amount of memory for data pattern storage.

To address these limitation, we develop a novel, yet efficient solution technique using programmable OFDM technology that can be generate multiple frequency tones uniformly distributed across the specified spectrum. This method is easy to implement and can be extended to test both baseband and RF band circuit with great flexibility and low design overhead. The normal OFDM spectrum wave is given below.

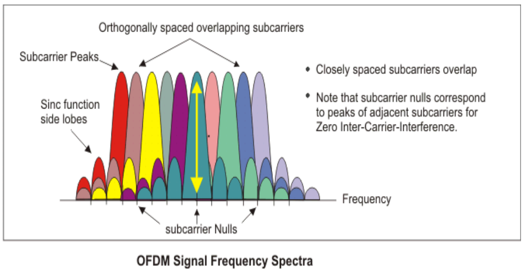


Fig 1. OFDM Spectrum

II.PROPOSED SYSTEM

It's important to have a fundamental understanding of Orthogonal Frequency Division Multiplexing (OFDM) because this technology is a basic building block for many of the current modulation schemes including; 802.11 WLAN, 802.16 WiMAX, and 3GP LTE.OFDM is a digital multi-carrier modulation scheme that extends the concept of single subcarrier modulation by using multiple subcarriers within the same single channel.OFDM makes use of a large number of closely spaced orthogonal subcarriers that are transmitted in parallel. Each subcarrier is modulated with a conventional digital modulation scheme (such as QPSK, 16QAM, etc.) at low symbol rate.

OFDM is based on the well-known technique of Frequency Division Multiplexing (FDM). In FDM different streams of information are mapped onto separate parallel frequency channels. In the frequency domain, each transmitted subcarrier results in a sinc function spectrum with side lobes that produce overlapping spectra between subcarriers. The use of orthogonal subcarriers allows more subcarriers per bandwidth resulting in an increase in spectral efficiency. In perfect OFDM signal, Orthogonality prevents interference between overlapping carriers. Fig 2 below shows the general block diagram of OFDM.

IFFT is a key building block for generating time domain signal generated through IFFT is applied to the DUT whose frequency response can be analyzed for test characterization. The test signal is generated on a modulation scheme. There are three types of digital modulation schemes: ASK (Amplitude Shift Keying), PSK (Phase Shift Keying) and FSK (Frequency Shift Keying).

In this QAM modulation is selected for coding IFFT input frequency domain data. This is an important advantage that can simplify DUT frequency response analysis. QAM OFDM signal is more suitable for test applications.

III. SOFTWARE AND HARDWARE IMPLEMENTATION

OFDM signal generator is designed to test a set of selected filters,where n number of tones with 20MHz bandwidth OFDM signal as specified above is adopted. It should be stressed that this test signal generation method is very generic, the signal bandwidth, the number of tones, tone spacing, magnitude and phase parameters, etc., can all be configured with great flexibilities.

The QAM based OFDM multi-tone signal system for filter testing will be simulated using MATLAB and the hardware will be implemented on a Xilinx FPGA. For test comparisons, we first apply OFDM multi-tone signal to three fault free filters(HPF, BPF, and LPF). To perform the test, we change the filter tap coefficients for fault injection. In this way the frequency response curves will be plotted. Then it will be implemented on a FPGA board.

Comparing with the other multi-carrier test signal generation methods, the developed OFDM technique in this paper can greatly leverage test efficiency in regard to signal generation time and memory space requirement. Since a PLL circuit is generally employed for frequency sweeping. To switch from one frequency to another, it typically takes over tens of cycles for PLL to relock. Using AWG, unlike frequency sweeping, the signal patterns can be pre-calculated and saved, thus the total signal generation time can be reduced.

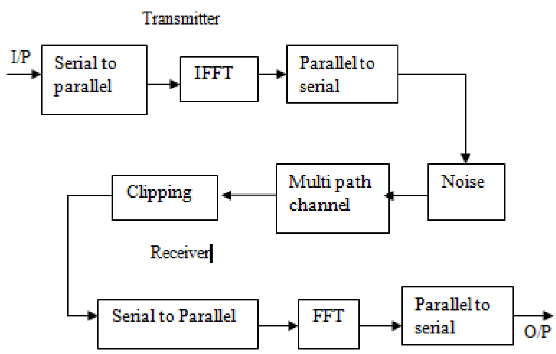


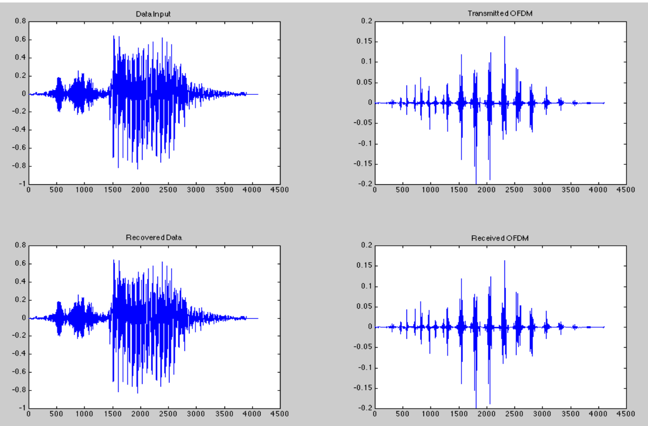
Fig 2: Block diagram of OFDM multi-tone testing

V.CONCLUSION AND FUTURE WORK

A new multi-tone signal generation scheme using OFDM method has been presented in this paper. Its advantages include low design overhead, short signal generation time, and good programmability. It alsoreduces computational cost and test time. It is also a suitable technique for BIST (Build-In-Self-Test) applications.

The program coding has been written and simulated in both Matlab and FPGA. Future work will be the implementation of hardware part in VLSI.

RESULT FOR MATLAB CODING:



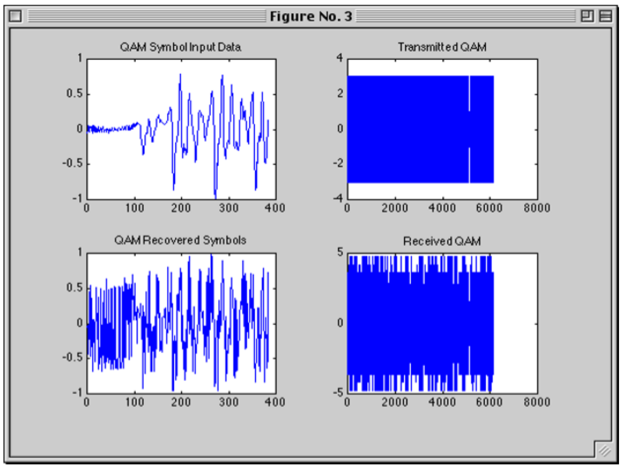


Figure 6: 16-QAM Input and Output

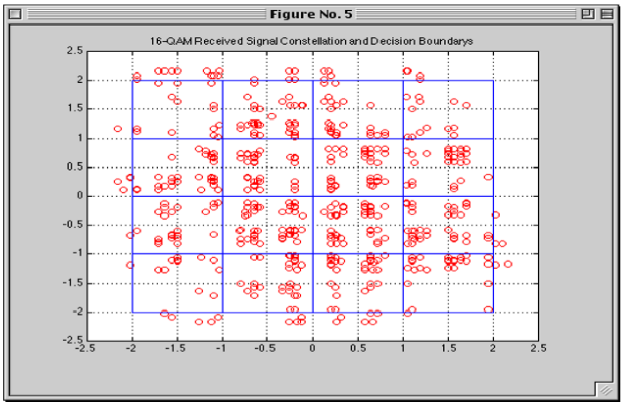
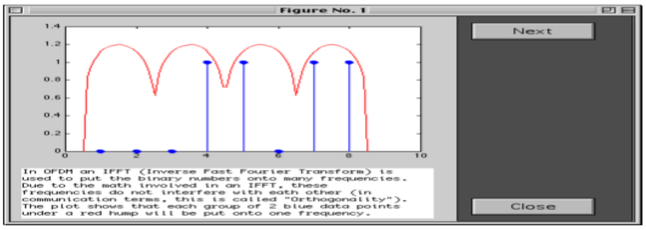
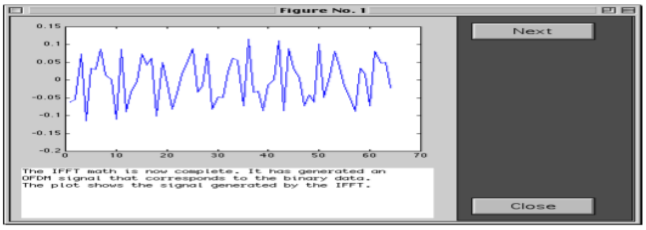
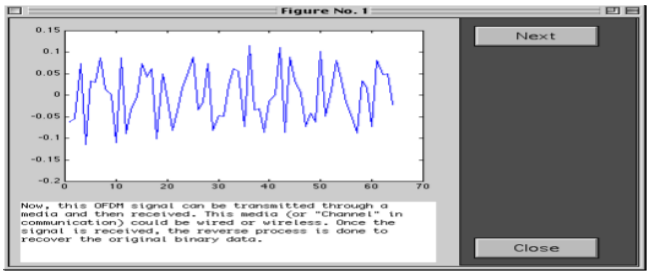
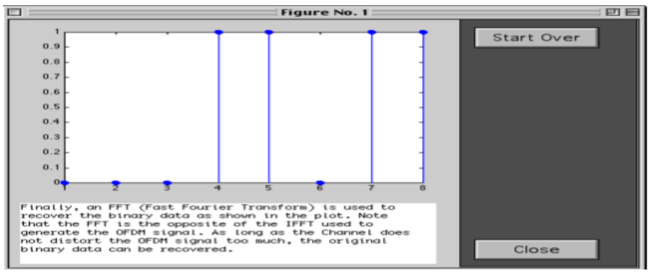


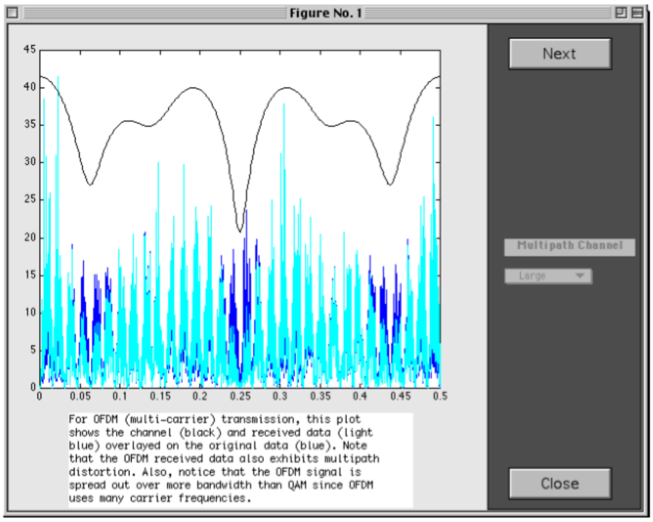
Figure 7: Received 16-QAM Signal Constellation

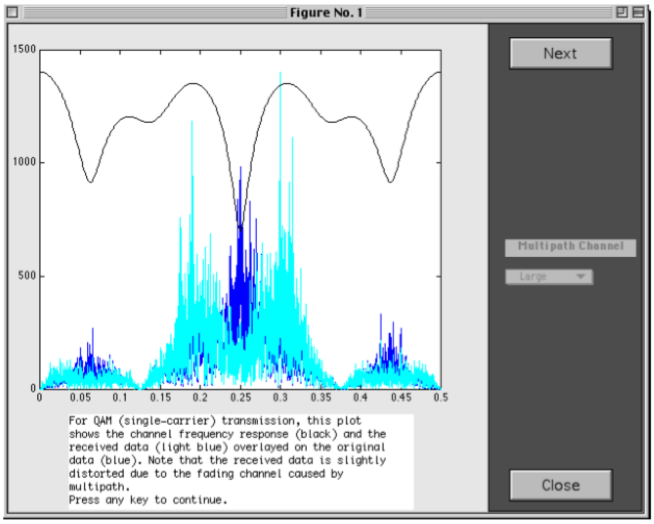




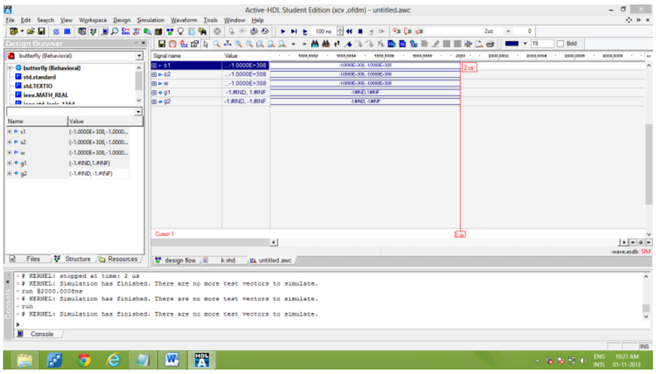


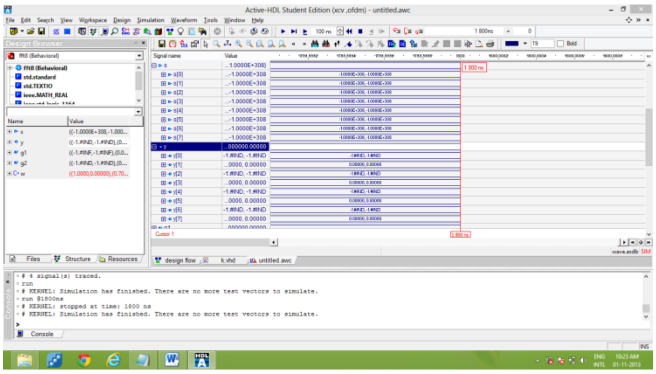






RESULT FOR FPGA SIMULATION:





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