

Real Time Implementation of OFDM System on TMS320C6713

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ABSTRACT

Orthogonal Frequency Division Multiplexing (OFDM) is mainly designed to overcome the effects of multipath reception, by dividing the wideband channel into many narrowband sub-channels. To avoid ISI due to multipath, successive OFDM symbols are separated by guard band. This makes the OFDM system resistant to multi-path effects. This paper describes a real-time implementation of a half-duplex OFDM system using Matlab software Simulink, DSP processor TMS320C6713 and Code Composer Studio. In this approach, Matlab and Simulink are effectively used to develop an OFDM system including transmitter, receiver and an AWGN channel. The graphical environment of Simulink enables the creation of sophisticated algorithms and the Real Time Workshop converts the Simulink model into C code which is ready to be downloaded onto the DSP processor.

Keywords

FFT, FDM, IFFT, OFDM, QAM, SIMULINK

1. INTRODUCTION

The rapid growth in telecommunication market in the last decades are in need of new techniques that can provide high data rates. Wireless communications has seen enormous growth in the past few years. Wideband wireless OFDM communication systems are much popular because of their high spectral efficiency and the capability of OFDM to transmit high data rates over

Broadband radio channels with frequency selective fading. Such systems are also popular due to the inherent error robustness in a multipath environment and hence has been chosen for several next generation broadband wireless local area network (WLAN) standards like IEEE802.11a, IEEE802.11g, and European HIPERLAN/2, and terrestrial

digital audio broadcasting (DAB) and digital video broadcasting (DVB-T). OFDM is a special case of multicarrier data transmission technique in which a single data stream is transmitted over multiple subcarriers of narrow bands. The subcarriers are closely spaced and are modulated with low data rates. These subcarriers are orthogonal to each other.

Due to rapid increase in the transistor density, it is better to keep the functionality completely in a programmable Digital Signal Processor (DSP) which allows for much faster changes and upgrades. OFDM needs to compute several hundred or thousand points of Fast Fourier Transforms (FFT) within a few tens of microseconds in order to achieve high speed data transmission in narrow bands. Initially TMS320C5402 DSP Starter Kit (DSK5402) was used as the combination of C and Assembly programming languages. After that the main programming language was assembly. Since the assembly programming is very difficult, ready to use assembly code segments are required. So instead of working on C or Assembly languages, it is better to work with Matlab and Simulink. In this project, a technique based on Simulink and Texas Instrument's DSK C6713 is presented. First, the use of Simulink enables the creation of models from the Simulink's large collection of pre-written block-sets and then the C code is generated with the help of Real Time Workshop and Embedded Target for TI C6000 DSP. Here, both Matlab and Simulink are effectively used to develop an OFDM system including transmitter, receiver and an AWGN channel. The complete OFDM system is simulated in the Simulink environment, which can then be downloaded on to a DSP processor.

2. IMPLEMENTATION

The design approach that the real time implementation of system will follow is illustrated in Fig 1.

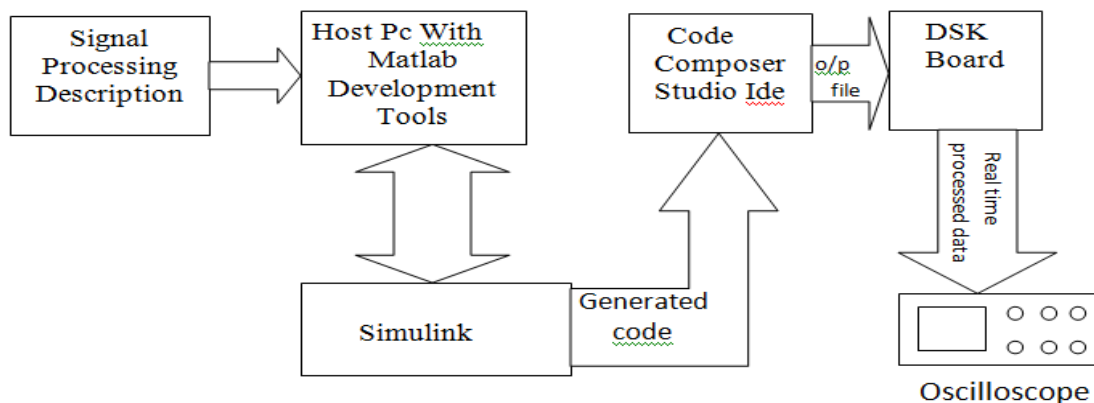


Fig 1: Interface between DSP hardware and SIMULINK

Here, the first block shows the signal processing description that is we will begin with a concept of what should be programmed. The next step is to model the concept with blocks from Simulink's large collection of prewritten block sets. Basically, a block diagram that models the concept is built using Simulink. If a specific block required is not included in Simulink's block sets, we may choose to write the own blocks from scratch using Matlab. The Simulink uses a block based approach to algorithm design and implementation.

At this point the design is still not designed to operate on any specifically hardware. To do that, we are using the C6x Target and Real Time Workshop to generate (or build) ANSI C code intended for the TI C6713 DSK. The C6x Target will then automatically take the generated ANSI C code from the SIMULINK block diagram. In the next step, the TI CCS tools such as the compiler, assembler and a linker are used to compile the specific machine code and load the targeted machine code to the TI C6713 DSK hardware. The experienced designer may choose to directly write the ANSI C code instead of building the SIMULINK model. The Code Composer Studio communicates with the DSP board through an USB host interface. The real time processed data can then be finally observed using an oscilloscope.

3. OFDM SYSTEM USING DSP PRINCIPLES

OFDM is a special case of multicarrier data transmission technique in which a single data stream is transmitted over multiple subcarriers of narrow bands. The subcarriers are closely spaced and are modulated with low data rates. They are made orthogonal to one another by appropriately choosing the frequency spacing between them. The orthogonality allows simultaneous transmission on a lot of sub-carriers in a tight frequency space without interference from each other.

The block diagram of an OFDM system is shown in fig 2. The random data generator generates a bit stream. This data stream is processed using the 16-QAM modulator to map the data into complex signals. These symbols are passed to an IFFT block to perform the IFFT operation and the time domain signals are obtained. The time domain modulated OFDM symbol from IFFT block is converted back to a serial stream and a guard interval in the form of cyclic prefix is added to each OFDM symbol. This data is now passed through an AWGN channel. The reverse operation is done at the receiver to obtain the original data back. That is, the cyclic prefix is removed and processed in the FFT block and finally passed through demodulator for data recovery.

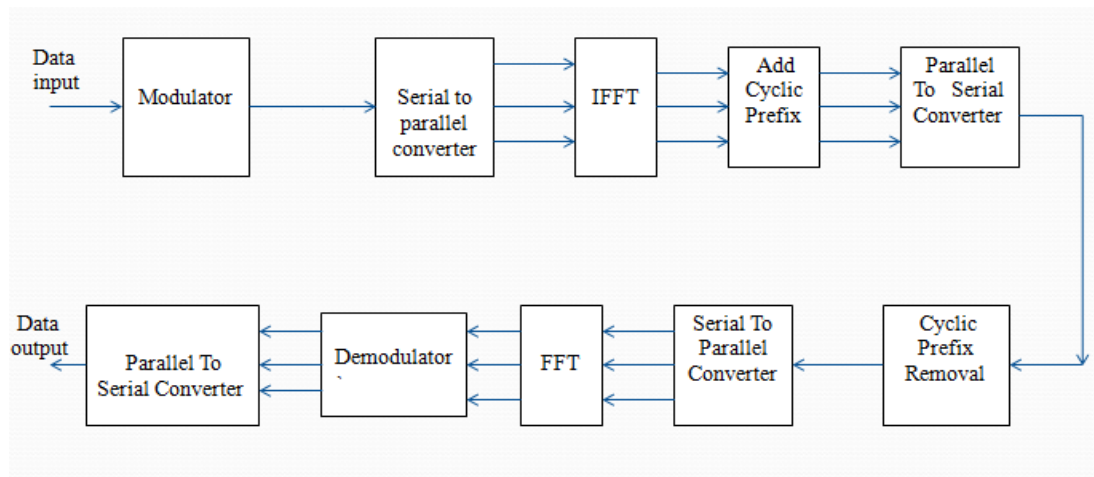


Fig 2 : Block diagram of OFDM system

3.1 Modulation

In the modulation technique, the signal wave is transformed in order to send it over the communication channel to minimize the effect of noise. This is done so that the received data can be demodulated to give back the original data. In an OFDM system, the high data rate information is divided into small packets of data which are placed orthogonal to each other. This is achieved by modulating the data by a desirable modulation technique such as Quadrature Amplitude Modulation.

3.2 Communication Channel

This is an AWGN channel through which the data is transferred. The noise present in this channel affects the signal and causes distortion in its data content.

3.3 Demodulation

Demodulation is the technique by which the original data is recovered from the modulated signal which is received at the receiver end. Here, the received data is first passed through a low pass filter and the Guard Interval is removed. After the data is converted back to parallel stream, the FFT operation is performed. A demodulator is used to get back the original signal. By considering the unmodulated signal data and the data at the receiving end, the bit error rate and the signal to noise ratio is calculated.

4. OFDM SIMULATION

The OFDM model has been developed in Simulink using 16-level QAM as shown in fig 3. The blocks included in this model are random integer generator, Integer to Bit Converter, Bit to integer converter, general 16 level QAM modulator, selecting rows and obtaining complex conjugate, IFFT (Inverse Fast Fourier Transform), FFT (Fast Fourier

Transform), frame status conversion, general 16 level QAM de-modulator and a time scope to observe the simulation results.

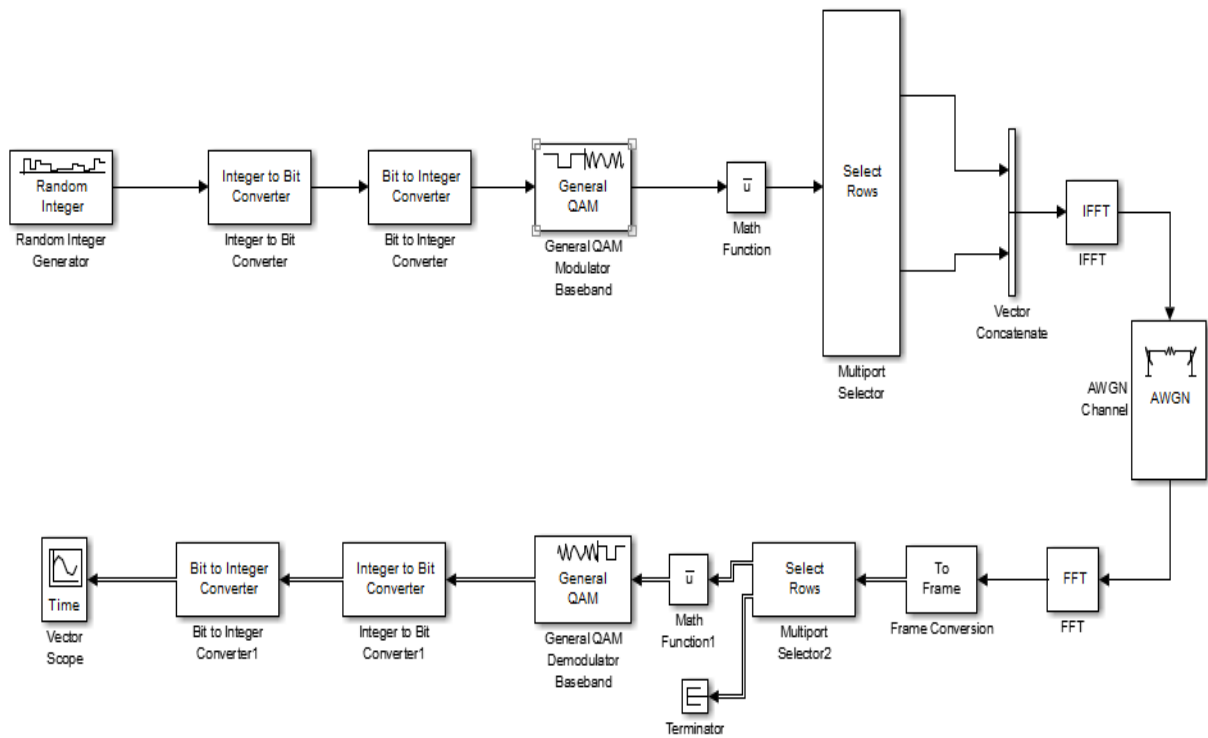


Fig 3 : Simulink model of a complete OFDM system

5. RESULTS

The simulation results for MATLAB code are shown in the below figures.

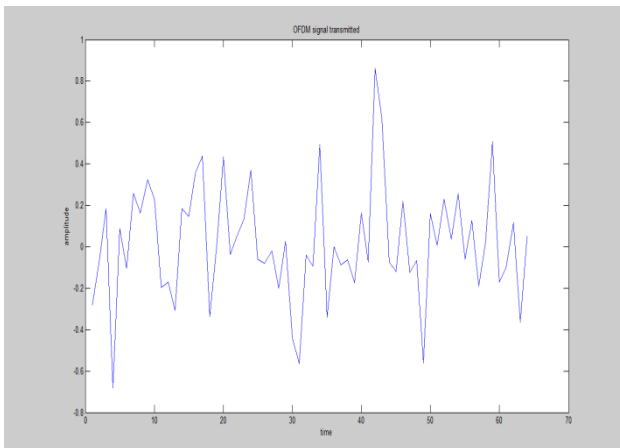


Fig 4 : OFDM signal transmitted

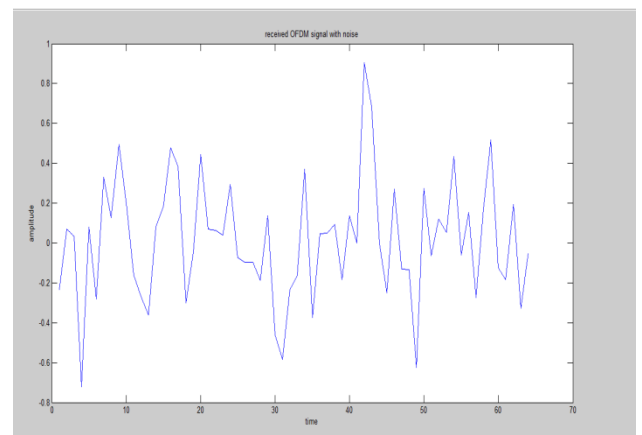


Fig 5 : Received OFDM signal with noise

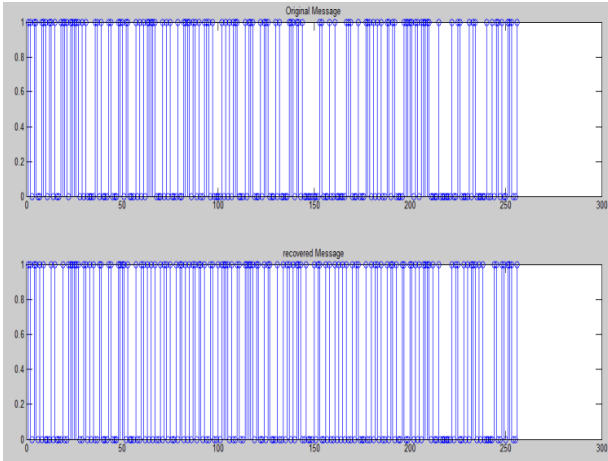


Fig 6 : Original message and recovered message

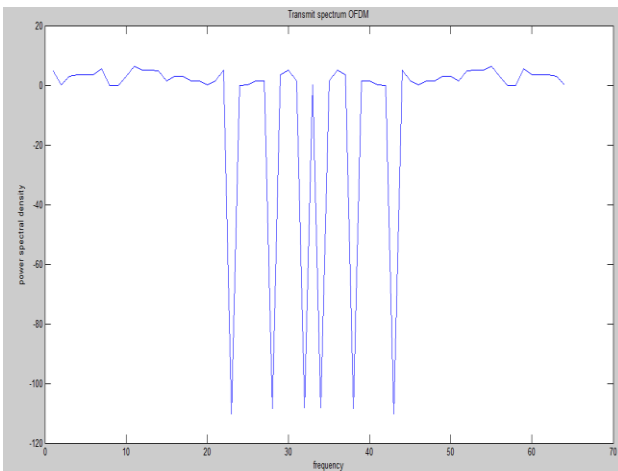


Fig 7 : Transmit spectrum of OFDM

The simulation results for Simulink model of OFDM system is shown in figure 8.

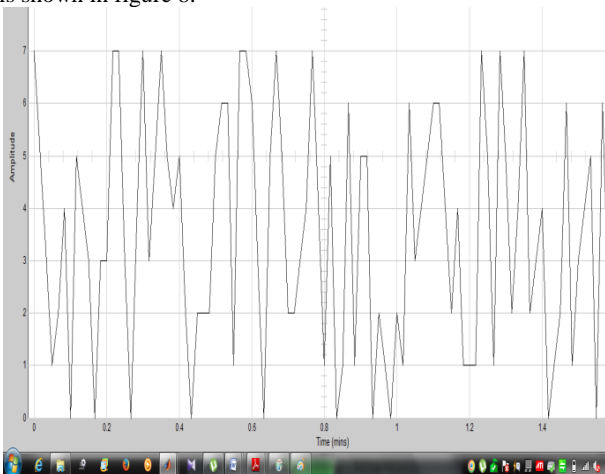


Fig 8 : OFDM signal generated from SIMULINK model

6. CONCLUSION

In this paper we introduced the simulation and implementation of a complete OFDM SYSTEM on a DSP through a graphical programming language, Simulink. Making use of graphical environment in both the simulation and implementation stages, the designer's mind is dedicated most of the time in developing and enhancing the algorithm and less time on coding. Moreover using a graphical programming language makes the algorithm very clear and can be easily modified and debugged.

7. REFERENCES

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