Performance Analysis Of Fractionally Spaced Adaptive Equalizer using 16QAM Receiver

Kanwar Veer Partap Singh[1], Jyotisna Rishi[2]

[1]*Department of Electronics And Communication Engineering, Punjab Technical University*
Bhai Gurdas Institute Of Engineering and Technology, Sangrur (Pb) India

[2] *Bhai Gurdas Institute Of Engineering and Technology, Sangrur (Pb) India*

Abstract

In recent years, many equalization techniques have been studied such as Fractionally Spaced Adaptive Equalizer, Blind Equalization, Decision-Feedback Equalization, Linear Phase Equalizer and Symbol spaced Equalizer, but Fractionally Spaced Adaptive Equalizer is the best technique to compensate the distortions and mainly the inter-symbol interference and it show fast convergence. The Bit Error Rate is also applaudable. The Fractionally Spaced Adaptive Equalizer provides better results over Conventional Equaliser. So it is used for channel estimation.

Any digital signal gets distorted when passed through a medium during the process of communication. An equalizer is used to null the effect of this distortion. A proposed Fractionally Spaced Adaptive Equalizer is implemented using MATLAB and Sys Generator. By the results obtained from the thesis, it has been concluded that proposed Fractionally Spaced Adaptive Equalizer takes less space as well as consume less power. By comparing the constellation diagrams of both the equalizers, it has been observed that the constellation diagram of the proposed Fractionally Spaced Adaptive Equalizer is more concentrated and clear but Conventional Equalizer gives most widely distributed output. The eye pattern of FSE is also clear and shows more efficiency. Also, for a given value of Signal-to-Ratio, the Bit Error Rate of proposed Fractionally Spaced Adaptive Equalizer is less. It uses LMS algorithm instead of RLS algorithm. LMS algorithm is slower than RLS but it has more efficiency as well as it gives an output that is easily achievable. Proposed Fractionally Spaced Adaptive Equalizer shows better performance in case of convergence too. FSE can also be used with all other type of modulations techniques like BPSK , QPSK, etc.

***Keywords*— FSE, Distortion, MATLAB, Constellation, QAM**

I. INTRODUCTION

Communication is a process by which and information is sent by a transmitter, it goes through a channel of propagation of information and is received by the receiver at the other end. An input transducer is applied before the transmission of data over the medium(also known as channel) to convert the signal into the required form and output transducer is applied to convert the signal to its original form .When the signals are transmitted over a communication channel then they are distorted because of various channel imperfections like linear distortion, channel nonlinearities, distortion caused by multipath effect, channel fading.

Multi-path effect means that signals transmitted from a transmitter take different paths to reach the receiver as they have multiple copies.Thus, at the receiver, the received signals should be the sum of all these multi-path signals. Because the paths traversed by these signals are different, some are longer and some are short.If signals are in phase, they will intensify the resultant signal else the resultant signal is weakened. This is called channel fading. ISI or intersymbol Interference also has the same cause. Since all of these paths are of different lengths and some of these effects will also slow the signal down,Hence the time taken by all the copies of the signal will not be the same.This means that part or all of a given symbol will be spread into the subsequent symbols, thereby interfering with the correct detection of those symbols. Additionally, the various paths mostly distort the amplitude or phase of the signal thereby causing further interference with the received signal.

To mitigate this problem of distortion, equalizers are used. The design of the communication system depends on the assumption of the channel transfer function .But, in most of the digital communications applications, the channel transfer function is not known at enough level to incorporate filters to remove the channel effect at the transmitters and receivers. Also, these channels' transfer functions vary with time. So it is not possible to use an optimum filter for these types of channels.

But an equalizer gives the inverse of channel to the Received signal and combination of channel and equalizer gives a flat frequency response and linear phase.

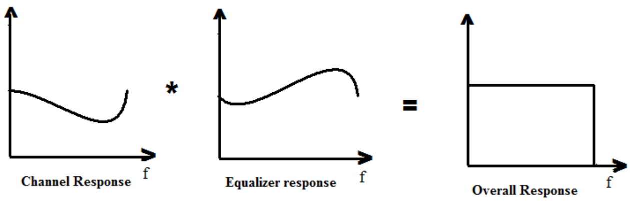


Fig. 1 Overall Response of an Equalizer

II. Objectives

From the above mentioned issues, the following objectives had been proposed:

- To study the effect of channel impairments on the performance of a communication system.
- To study various channels equalization techniques and compare FSE with conventional equaliser.
- To implement a Fractionally Spaced Adaptive Equalizer using system generator.
- To calculate the resources utilised by the Fractionally Spaced Adaptive Equalizer for an FPGA.
- To calculate the power consumption by the proposed design.

III. Methodology

Various parameters of Fractionally Spaced Adaptive Equalizer are optimized by implementing the optimization algorithm in MATLAB and System Generator from Xilinx. Simulation platforms have been developed using MATLAB and SIMULINK.The performance of both the techniques have been evaluated and compared based on their Frame Error Rate Performance. Proper constellation diagrams and eye patterns are developed to compare the two equalizing techniques and then resource utilisation and power consumption of the FSE is calculated.

Following steps are taken to achieve the objectives:

- Design the full simulation model of the process of FSE and conventional equalizer using simulink in MATLAB.
- Add model parameters as needed.
- Add scopes or sinks for desired constellation diagrams.
- Run the simulation and check output graphs as well as the BER to compare the two.
- Generate the VHDL code using MATLAB.
- Synthesize the code in Xilinx to calculate resource utilization and power consumption.

IV. Results Obtained

It is clear from the BER and the constellation diagrams that FSE is far better than the conventional equalizer.

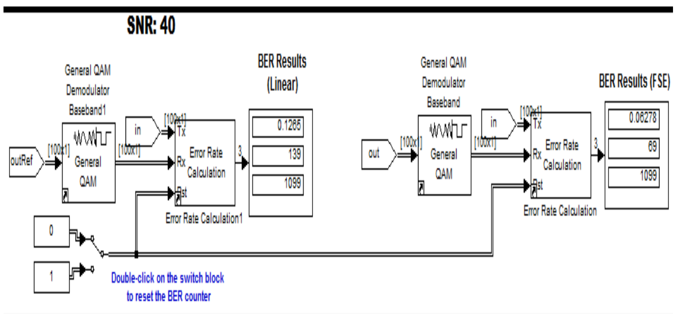


Fig. 2 Constellation diagram of the Input Signal

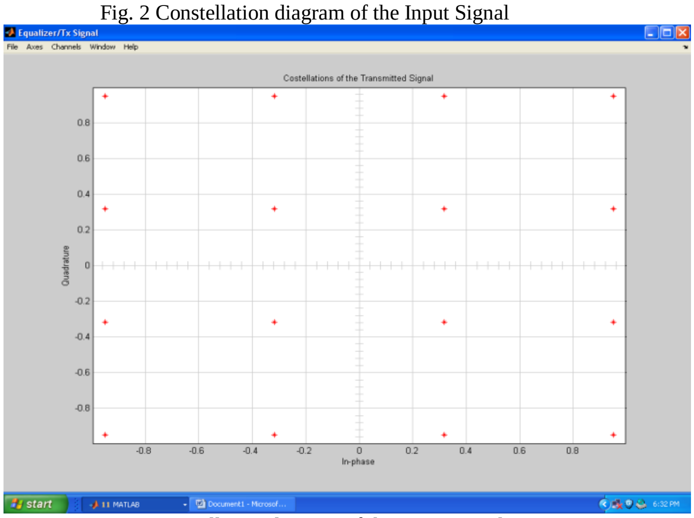


Fig.3 Constellation diagram of the Input Signal

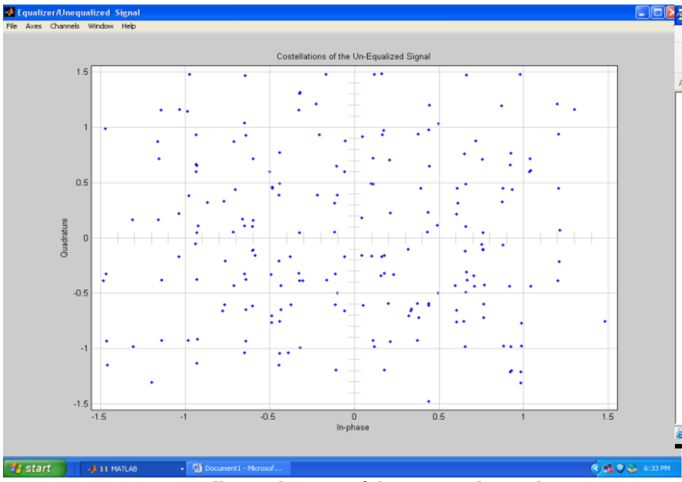


Fig. 4 Constellation diagram of the Distorted Signal

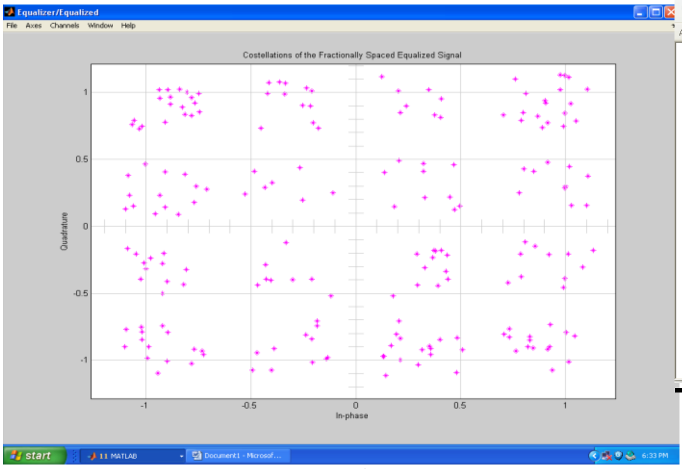


Fig. 5 Constellation diagram of the FSE Signal

Fig 2 Shows that the BER for FSE is 0.06278 and for the Conventional equalizer is 0.1265 (SNR=40 for both). Hence nearly half of the conventional equalizer.

Fig 7 and Fig 8 shows that FSE just uses 3% of the space of FPGA slice flip-flops and consumes only 178 mW of power.

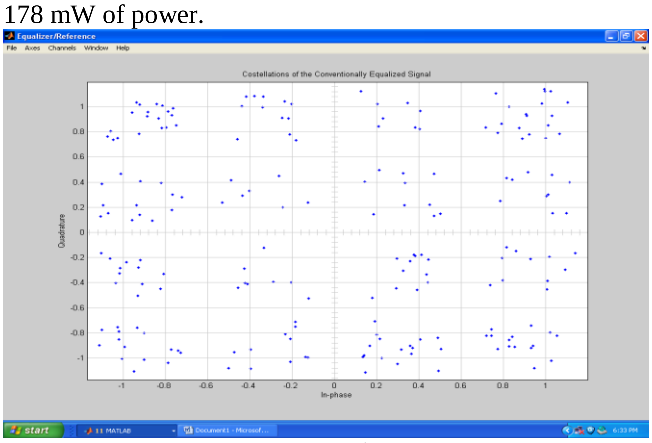
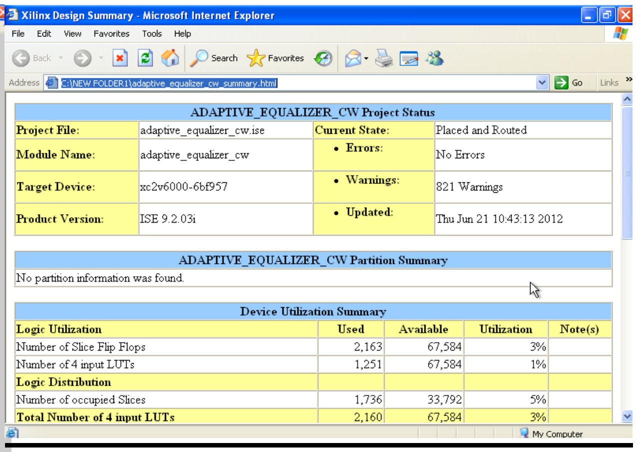


Fig .6 Constellation diagram of the FSE Signal



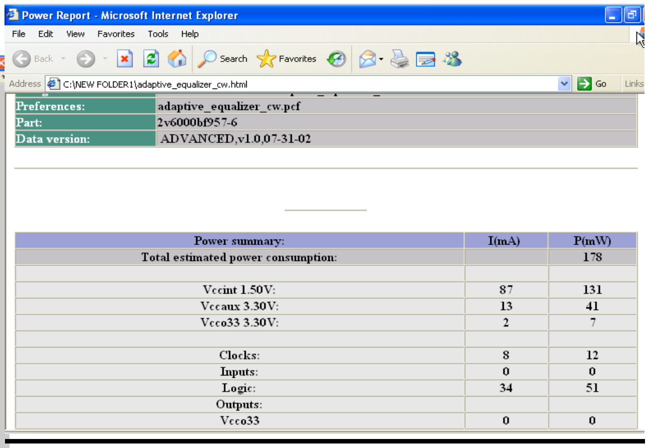
Xilinx Design Summary - Microsoft Internet Explorer

ADAPTIVE_EQUALIZER_CW Project Status			
Project File:	adaptive_equalizer_cw.ise	Current State:	Placed and Routed
Module Name:	adaptive_equalizer_cw	• Errors:	No Errors
Target Device:	xc2v6000-6bf957	• Warnings:	821 Warnings
Product Version:	ISE 9.2.03i	• Updated:	Thu Jun 21 10:43:13 2012

ADAPTIVE_EQUALIZER_CW Partition Summary
No partition information was found.

Device Utilization Summary				
Logic Utilization	Used	Available	Utilization	Note(s)
Number of Slice Flip Flops	2,163	67,584	3%	
Number of 4 input LUTs	1,251	67,584	1%	
Logic Distribution				
Number of occupied Slices	1,736	33,792	5%	
Total Number of 4 input LUTs	2,160	67,584	3%	

Fig .7 Resource Utilisation of the FSE Signal on FPGA



Power Report - Microsoft Internet Explorer

Preferences:	adaptive_equalizer_cw.pcf
Part:	2v6000bf957-6
Data version:	ADVANCED,v1.0,07-31-02

Power summary:	I(mA)	P(mW)
Total estimated power consumption:		178
Vccint 1.50V:	87	131
Vccaux 3.30V:	13	41
Vcco33 3.30V:	2	7
Clocks:	8	12
Inputs:	0	0
Logic:	34	51
Outputs:		
Vcco33	0	0

Fig 8.Power Consumption of the FSE Signal on FPGA

V. CONCLUSION

By doing the simulations and synthesize with the FSE technique using MATLAB and System Generator. By the results obtained from this thesis, it has been concluded that proposed Fractionally Spaced Adaptive Equalizer shows better performance than Conventional Equalizer. By comparing the constellation plot of both the equalizer it has been observed that the constellation of the proposed Fractionally Spaced Adaptive Equalizer is more concentrated and clear but Conventional Equalizer gives most widely distributed output.

REFERENCES

[1] S.Haykins (2002) Adaptive Filter Theory. Fourth edition. India: Dorling Kindersley.

[2] B.P.Lathi (1998) Modern Digital and Analog Communications system. Third edition. USA: Oxford University Press.

[3] J. Proakis and J. H. Miller (July1969) An adaptive receiver for digital signalling through channels with intersymbol interference. IEEE Trans. Inform. Theory, IT-15:484-497.

[4] Amit Agarwal (2009) Design and Real Time Implementation of Adaptive Equalizer using Xilinx FPGA. Thesis, IIT Kharagpur.

[5] C. Dick, F. Harris and M. Rice (2004) FPGA Implementation of Carrier Synchronization for QAM Receivers, Journal of VLSI Signal Processing. 36: 57-71.

[6] Majid S. Nag mash, Mohd Fadzil Ain and Chye Yin Hui (2009) FPGA Implementation of Software Defined Radio Model based 16-QAM. European Journal of Scientific Research, ISSN 1450-216X, 35(2):301-310.

[7] Xuan-Thang Vu, Nguyen Anh Duc and Trinh Anh Vu (2010) 16-QAM Transmitter and Receiver Design Based on FPGA.5th IEEE Symposium on Electronic design, test and application , 95-98 .

[8] S. U. H. Qureshi (1985) Adaptive equalization. Proceedings of the IEEE, 73(9):1349-1387.

[9] Kevin Banovic, Mohammed A.S., Khalid Esam and Abdel-Raheem (2007) FPGA Implementation of a Configurable Complex Blind Adaptive Equalizer. IEEE International Symposium on Signal Processing and Information Technology, 150-153.

[10] Yongxue Zhang and Lixin Yu (2005) Implementation of Adaptive Blind Equalizer with Carrier Recovery for QAM Receiver Chip, 6th International Conference on ASIC, 1:147-152.

[11] B. Petersen, D. Falconer (1994) Suppression of adjacent-channel, cochannel and intersymbol interference by equalizers and linear combiners. IEEE Trans on Communication, 42: 3109-3118.

[12] http://www.xilinx.com