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Filter Centered Nonisotropic Fading Channel Archetypal For Wireless System Assessment

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ABSTRACT: In this paper filter based nonisotropic fading channel model for evaluating mobile radio communication is been proposed, fading occurs due to the multipath propagation of the signal. For assessing the performance and characteristics of a wireless communication system the channel has to be modelled in laboratory settings, the channel model can be hardware or software based. The development of the wireless systems becomes easier and faster when the channels are modelled in software platform as the channel models can be easily reorganized by altering the channel parameters. Channel is nonsiotropic if the scattering is non uniform. The channel model is designed based upon the filter approach rather the common sum of sinusoid method. The design is developed in VHDL and the different FPGA platforms for the channel model is studied.

KEYWORDS: Rayleigh fading, FDATool, Jake's power spectral density, VHDL, FPGA, mobile communication.

I. INTRODUCTION

The wireless communication system are developed and designed to operate in different scenarios. The transmitter and receiver establish secure and reliable communication through the wireless channel, the channel plays a vital role in deciding the overall performance of the wireless system, when information's are transmitted the signals has to overcome different atmospheric effects before reaching the receiver side. The various factors which effects the received signal are fading, scattering, reflection, diffraction etc. The fading occurs due to the multipath propagation of the signal through the channel, due to fading the received signal is time spread into a pulse train. Time spread occurs due the attenuation and propagation delays which occurs due the channels nature. Received signal can be modelled as equation (1).

$$r_l(t) = \sum_n \propto_n (t) e^{j2\pi f_c \tau_n(t)} \quad (1)$$

In which $\propto_n(t)$ is the attenuation factor and τ_n is the propagation delay, the channel can be statistically modelled as in equation (2) [1].

$$c(\tau;t) = \alpha(\tau;t) e^{-j2\pi f_c \tau} \quad (2)$$

$c(\tau;t)$ Is the time variant channel which can be represented by complex Gaussian random process in the t variable, if the channel is modelled using zero-mean complex valued Gaussian process it can replicate the behaviour of Rayleigh distribution and if the channel is modelled using unit variance Gaussian process in the presence of line of sight it can replicate the behaviour of Rican distribution. The nonisotropic scattering occurs when there non-line of sight propagation and delayed multipath non-uniform propagation. The channel can be modelled by obtaining its correlation functions and its

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power spectra, the channel can be modelled easily from equation (2) by deriving a low pass impulse response equivalent. A fading channel can be simulated by producing fading gains with respect to isotropic and nonisotropic natures. By using low pass filtering action to the generated complex Gaussian process the channel model can be effectively produced and can be applied to replicate a wide range of mobile radio channels in contrast to the sum of sinusoids approach. The channel in equation (2) is considered to be wide-sense-stationary, so the autocorrelation function can be defined as $J_0(2\pi f_m \Delta t)$ where $J_0(.)$ is the zero-order Bessel function. Power spectra for the channel can be defined by the Jake's model, which has being used to model the power spectral density (PSD) of mobile and ad hoc wireless systems respectively. The PSD for the channel can be represented as in equation (3) [1].

$$S_c(\lambda) = \begin{cases} \frac{1}{\pi f_m} \frac{1}{\sqrt{1-(f/f_m)^2}} & (|f| \le f_m) \\ 0 & (|f| > f_m) \end{cases} \quad (3)$$

In which f_m is the maximum Doppler frequency any by using low pass impulse response filtering equivalents the autocorrelation and PSD functions can be replicated by the filters transfer functions.

The paper is organized into four sections the first section deals with a brief introduction of to the filter based approach for creating a channel model, the second section deals with the necessity of channel model and the proposed model given more importance, third section deals with FPGA results for the Spartan 3E, Virtex-4 and Virtex-5 platforms respectively and the fourth section concludes the paper with a proposal to a future work.

II. PROCEDURAL DETAILS FOR THE PROPOSED DESIGN

A. Need for channel model for wireless system evaluation

Novel wireless systems are proposed and designed but they take more time to reach to the common man, the main hindering factor for the new wireless systems arrival is its evaluation. For fast evaluation and testing of wireless systems, the wireless scenarios has to be modelled properly otherwise the system may not perform as per its designed requirements [2], [3].

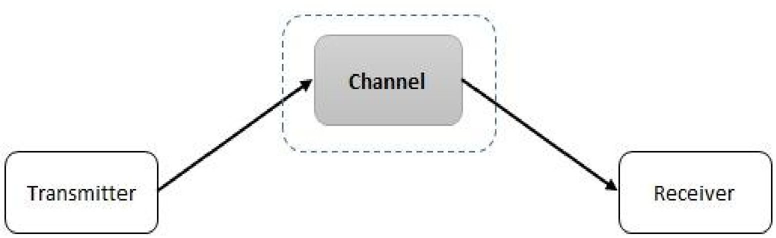

Fig 2.1. Basic elements in a wireless system

Fig 2.1 shows a basic elements of a wireless system the transmitter, the channel and the receiver. The transmitter transmits the information through the mysterious channel to the receiver where the information has to process the received information to extract the original data. The channel introduces fading effects which are hard to eliminate in the present conditions. The transmitter and receiver electronics can be easily modelled and debugging can be performed only if the modelled channel closely matches the original channel features. There are few literature which deals with the HDL based

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modelling of channel, if a channel model is created a complete fading channel simulator can be designed. If a resource efficient channel model is developed then the wireless system evaluation can be performed on a single hardware. In this paper a resource efficient Rayleigh fading channel is proposed which is explained in the next section.

B. Proposed channel model

A Rayleigh fading channel can be modelled by creating a zero-mean complex Gaussian noise generator [5] which produces the fading gains, then these gains will be passed through spectral shaping filter and through the low pass impulse filter and the fading effects can be seen after the signals are up sampled using interpolation filters. The channel efficiency depends upon the filter transfer function denoted as $H(f)$. The transfer function of the filter depends upon filter coefficients. The channel model can be accurate if the filter coefficients are accurate and vice versa.

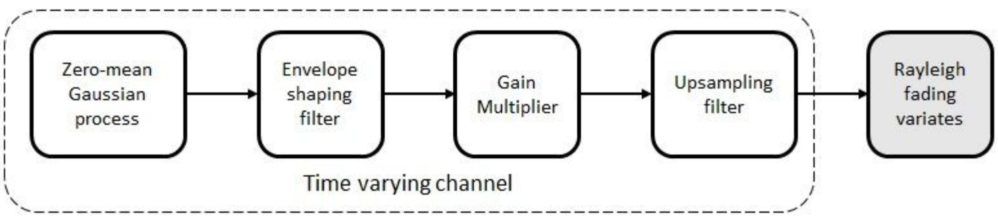

Fig.2.3. Block diagram for the proposed channel model

The reduce the complexity channel model, filter processing is done by creating separate filter for performing spectral shaping then up sampling filter to create the Rayleigh fading variates from the Gaussian process. The envelope shaping filter can be designed using finite impulse response (FIR) or infinite impulse response (IIR) filters respectively. The IIR filter requires lesser order for implementing a function than the FIR counterpart [6], and moreover the pass band ripple must be very low as per [9]. The apt filter which can be used is the elliptic IIR low pass filter, and the up sampling filtering can be performed by using interpolation filter. The elliptic IIR filter can be realized using the following equation [10].

$$H(e^{j\omega}) = \prod_{k=1}^{\Gamma/2} g_k \times \left\{ \frac{1+b_1^k e^{-j\omega}+b_2^k e^{-2j\omega}}{1+a_1^k e^{-j\omega}+a_2^k e^{-2j\omega}} \right\} \quad (4)$$

The equation (4) represents the elliptic IIR filter where Γ represents the order of the IIR filter. The envelope shaping filter can be modelled using equation (5).

$$H(e^{j\omega}) - \prod_{k-1}^{\Gamma} g_k \times \left\{ \frac{1 \;\; b_1^k e^{-j\omega}}{1-a_1^k e^{-j\omega}} \right\} \quad (5)$$

The poles and zeros of equations (4) and (5) can be accurately computed using the FDATool [4], in which the filter coefficients can be found out. The design can be extended for modelling isotropic scattering and Rican fading by adding a bias value to the filter coefficients. By using the FDATool the filters stability can be easily checked even under the quantization effects. The elliptic filter can be replaced into simple IIR filter but elliptic filter is having a sharp transition or fall from the pass band to stop band than other filter designs [7], [8].

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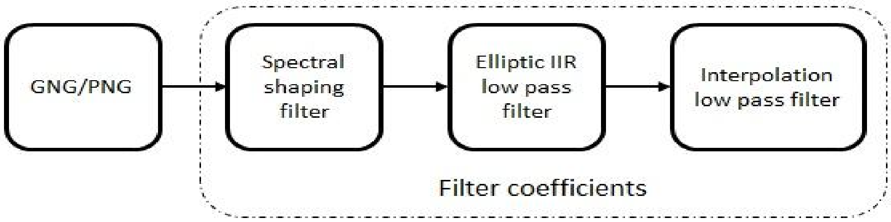

Fig.2.4. Fading Channel Model for the proposed design

Fig 2.4 shows the fading channel model which was modelled using VHDL, GNG (Gaussian noise generator) or PNG (pseudo noise generator) were used to generate the complex random process. The filter coefficients are generated and stored in memory modules or the look up tables which is shown in fig 2.5.

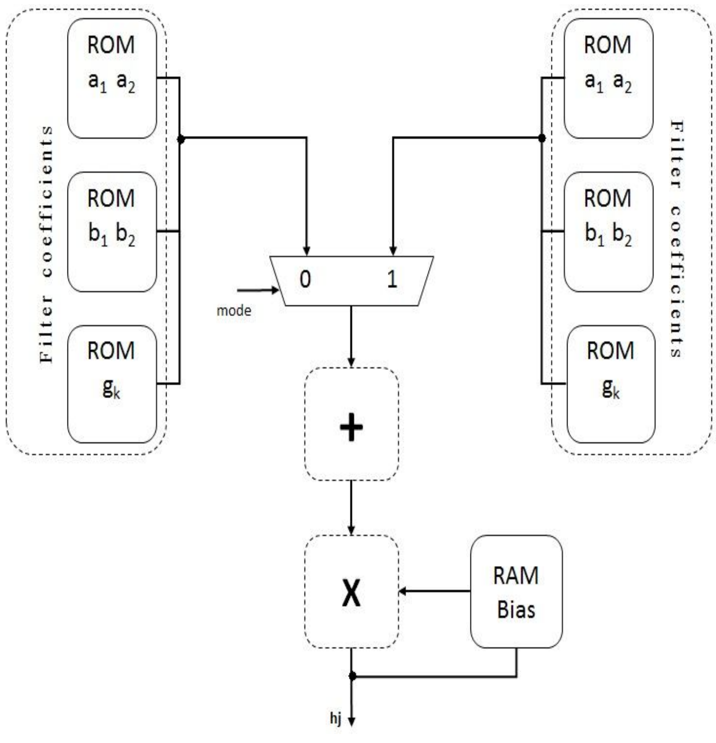

Fig.2.5. Hardware archetypal for the proposed channel model

a_1 a_2 are the denominator values, b_1 b_2 are the numerator values and g_k is the gain of the filter, these values are stored in ROMs as they are not altered and the value which gets updated is the bias value which decides the Rayleigh or Rican fading condition and changes the overall values which are produced, mode selects the filter coefficients between SOS (second

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order sections) and FOS (First order sections) structures whose filter coefficients are obtained by converting the filter structures in the FDATool thus creating less complex filter parameters.

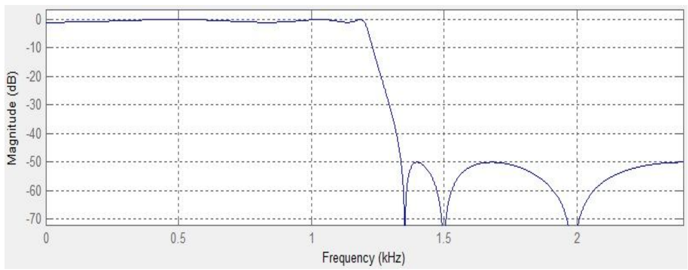

Fig.2.6. Elliptic IIR low pass filter for the proposed channel model

Fig 2.6 shows the magnitude response of the designed elliptic IIR filter using the FDATool. To design the EILPF and SSF for a minimum order, sampling frequency of 4600Hz, pass frequency of 1100Hz, stop frequency of 1400Hz, stop band attenuation of 1 dB and pass band attenuation of 55 dB were chosen.

III. RESULTS AND DISCUSSION

A. Simulated waveform

The hardware model described in fig 2.5 was simulated in ModelSim 6.2b by writing the VHDL code for the channel model. The memory modules were modelled as look up tables (LUTs) and the values in the LUTs were obtained from the FDATool.

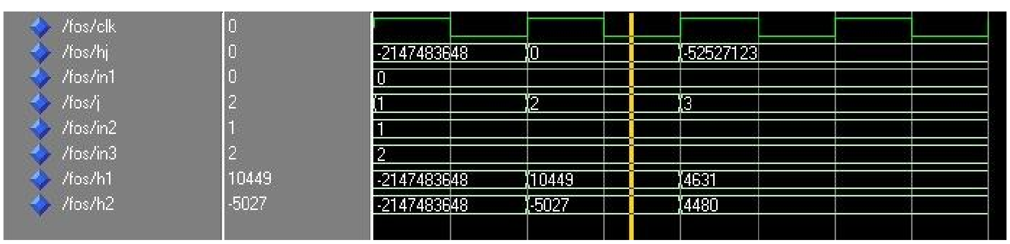

Fig.3.1. Simulated waveform for the elliptic IIR filter

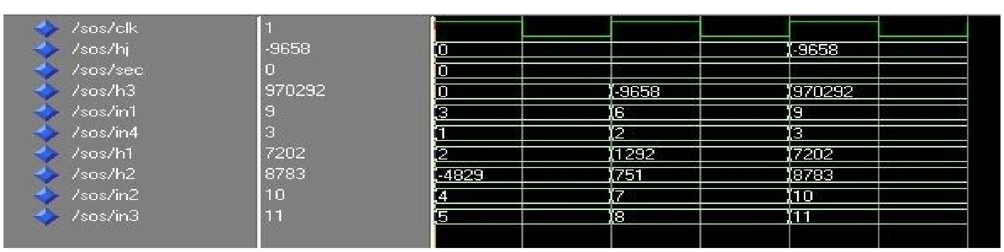

Fig.3.2. Simulated waveform for the envelope shaping filter

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Fig 3.1 and fig 3.2 shows the simulated waveforms for the elliptic IIR filter and the envelope shaping filter, the signal hj shows the output value. The arithmetic units which are used for modelling the design are in built units.

B. FPGA parameter analysis

The simulated HDL code was synthesized in Xilinx 14.6 ISE tool to study and compare the clock frequency, flip flops, number of slices and 4 input LUTs of different FPGA devices such as Spartan 3E, Virtex-2 and Virtex-4 were performed. There is very less literature which deals with the HDL based modelling of the channel model thus a comparative study with the proposed work with another literature is relatively fewer.

FPGA parameters	Spartan 3E	Virtex-4	Virtex-5
Slices	4.43%	2.56%	2.32%
Flip Flops	1.26%	0.96%	0.57%
4 input LUTs	4.25%	2.33%	1.96%
Overall Delay	9.417 ns	5.689 ns	5.432 ns
Clock Frequency	112.342 MHz	227.475 MHz	247.896 MHz

Table.1. FPGA parameters for different devices

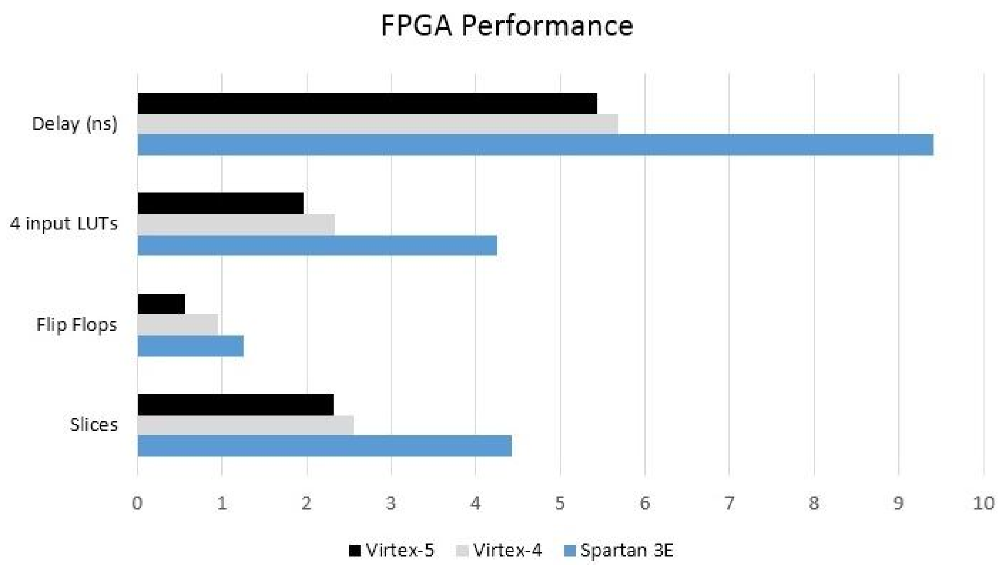

Fig.3.3. FPGA performance analysis

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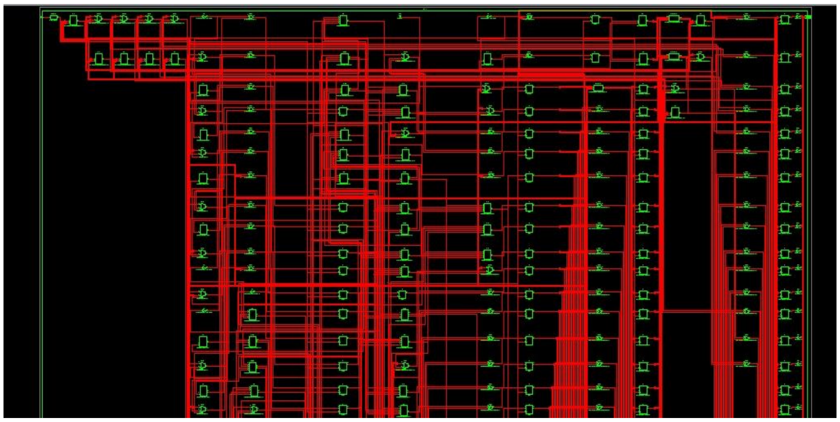

Fig.3.4. Technology Schematic for the proposed work in Spartan 3E device

Fig 3.3 shows the FPGA performance analysis for different devices and fig 3.4 shows the technology schematic for the proposed work in Spartan 3E device.

IV. CONCLUSION

The testing and simulation of wireless systems are hindering the overall deployment of communication systems to the market. The wireless communication systems can be tested and verified in laboratory settings by modelling the communication channel. Channel model must accurately replicate the overall behaviour of the real-time channel, if the replication is accurate and effective then the wireless communication system can be effectively tested and deployment can be made faster. In this paper a filter based channel model for nonisotropic scattering under Rayleigh fading has been proposed and can be extended to Rican fading. The channel model used envelope filters and interpolation filters to model the statistical correlation and power spectra of the real-time channel. The filter coefficients were taken from FDATool and FPGA parameters were analysed for different devices by designing the model using VHDL.

REFERENCES

[1] John G. Proakis Digital Communications, USA: McGraw Hill international ed.,2001,ch 14.
[2] Alimohammad, S. F. Fard, and B. F. Cockburn, "FPGA implementation of isotropic and non-isotropic fading channels," *IEEE Trans. Circuits Syst. II*, 2013, pp. 796-800.
[3] P. Bello, "Characterization of randomly time-variant linear channels," IEEE Trans. Commun., vol. COM-11, no. 4, pp. 360–393, Dec. 1963.
[4] MATLAB Filter Design Toolbox, User's Guide, the Mathworks, Natick, MA, USA, 2005.
[5] T. Saramaki and J. Yli-Kaakinen, "A novel systematic approach for synthesizing multiplication-free highly-selective FIR half-band decimators and interpolators," in Proc. IEEE Asia Pacific Conf. Circuits Syst., 2006, pp. 920–923.
[6] V. Oppenheim, R. W. Schafer, and J. R. Buck, Discrete Time Signal Processing. Englewood Cliffs, NJ, USA: Prentice-Hall, 1999.
[7] T. S. Rappaport, Wireless Communications: Principles and Practice. Englewood Cliffs, NJ: Prentice-Hall, 2002.
[8] B. Surendra et al., "A prototype architecture for the accurate modeling of Rayleigh fading waveforms," in Proceedings of the Fourth Pacific Rim Conference, vol. 2, pp. 1101-1105, 2003.
[9] Alimohammad, S. F. Fard, B. F. Cockburn, and C. Schlegel, "A compact and accurate Gaussian variate generator," IEEE Trans. Very Large Scale Integr. Syst., vol. 16, no. 5, pp. 517–527, May 2008.
[10] Alimohammad and B. F. Cockburn, "Modelling and hardware implementation aspects of fading channel simulators," IEEE Trans. Veh.Technol., vol. 57, no. 4, pp. 2055–2069, Jul. 2008