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Modeling Noisy and Fading Channels

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Abstract*— A typical communication system designed with software defined radio techniques consists of an antenna, RF units, mixer, analog to digital converter and digital circuits for remaining processing. As most of the crucial part is carried out in digital and it can be reconfigurable the software defined radio based design is highly preferred today. However when we want to simulate the digital modules of the transmitter and receiver modules, we also need the modules related to channel. It is very useful for studying the performance of whole communication system, if these modules are synthesizable on hardware. In this project we are aiming to model the channels with their noise and fading characteristics using VHDL. Mainly the noises and fading effects observed in wireless and mobile communication band will be simulated. The Rayleigh fading model will be given more importance as it is mainly encountered in mobile communication. The issues related to multi input multi output (MIMO) systems will be considered for modeling initially GNU-OCTAVE (MATLAB scripting) will be used for simulation of such noise models. In the second stage the parameterized VHDL codes will be developed for such models. FPGA synthesis will be carried out for all these blocks for analyzing the maximum frequency of operation on a selected target FPGA. Applications of the developed models will be highlighted and will be documented.

***Index Terms*—FPGA, MIMO, VHDL.**

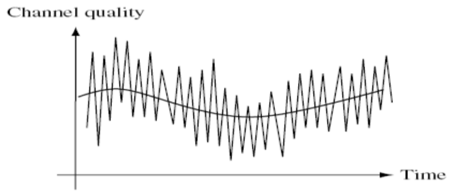
I. INTRODUCTION

As the wireless system design is becoming more challenging it is important to understand the channel and model it, which helps in simulating the system before actually making it . Fading has become biggest issue in wireless system design modeling it would allow to allow researchers to simulate new algorithms/techniques easily.

II. FADING MODELS

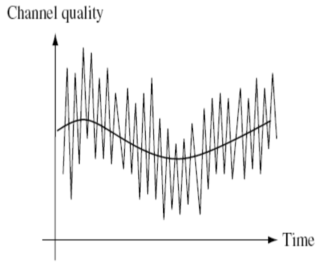
Mainly there are two types of Fading in wireless communication .The difference between Noise and Fading is Noise is an unwanted signal which interferes with actual signal. Whereas Fading is the delay produced and Doppler Effect added with original signal at Receiver.

- Large Scale Fading: Due to path loss of signal as a f



n of distance and shadowing by large objects such as buildings and hills. This occurs as the mobile moves through a distance of the order of the cell size, and is typically frequency dependant

- Small scale fading: Due to the constructive and destructive forces interference of the multiple signal paths between the transmitter and receiver. This occurs at the spatial scale of the order of carrier wavelength , and its frequency dependent

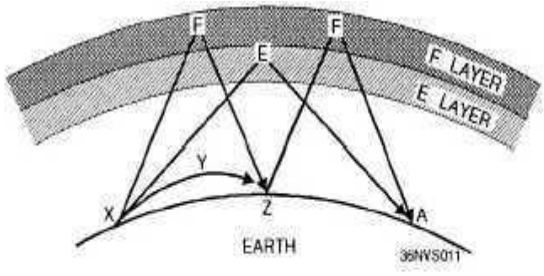


III. PHYSICAL MODELING FOR WIRELESS CHANNELS

Wireless channels operate through electromagnetic radiation from the transmitter to the receiver. In principle the electromagnetic field equations can be solved in conjunction with the transmitted signal, to find the electromagnetic field impinging on the receiving antenna.

IV. RAYLEIGH FADING

Rayleigh fading is caused by multipath reception. The mobile antenna receives a large number, say *N*, reflected and scattered waves. Because of wave cancellation effects, the instantaneous received power seen by a moving antenna becomes a random variable, dependent on the location of the antenna. A sample of a Rayleigh fading signal. Signal amplitude (in dB) versus time for an antenna moving at constant velocity. Notice the deep fades that occur occasionally. Although fading is a random process, , deep fades have a tendency to occur approximately every half a wavelength of motion.



Multipath is simply a term used to describe the multiple paths a radio wave may follow between

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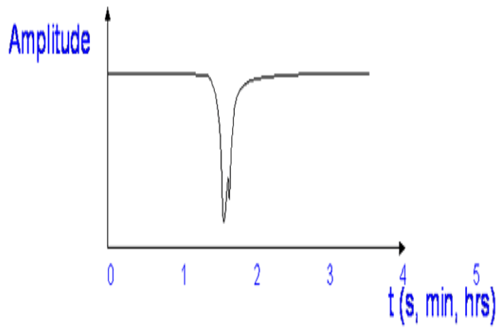
transmitter and receiver. Such propagation paths include the ground wave, ionospheric refraction, reradiation by the ionospheric layers, reflection from the earth's surface or from more than one ionospheric layer, and so on. Figure 1-11 shows a few of the paths that a signal can travel between two sites in a typical circuit. One path, XYZ, is the basic ground wave. Another path, XFZ, refracts the wave at the F layer and passes it on to the receiver at point Z. At point Z, the received signal is a combination of the ground wave and the sky wave. These two signals, having traveled different paths, arrive at point Z at different times. Thus, the arriving waves may or may not be in phase with each other. A similar situation may result at point A. Another path, XFZFA, results from a greater angle of incidence and two refractions from the F layer. A wave traveling that path and one traveling the XEA path may or may not arrive at point A in phase. Radio waves that are received in phase reinforce each other and produce a stronger signal at the receiving site, while those that are received out of phase produce a weak or fading signal. Small alterations in the transmission path may change the phase relationship of the two signals, causing periodic fading.

V. FADING CHANNELS

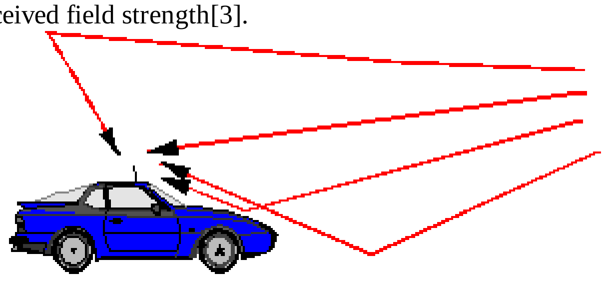
The signal amplitude at the receiver varies over time, we generally call this signal fading. We split this into slow fading and fast fading. Everything is relative, but this generally means variations in amplitude that change slowly with time. e.g slowly compared to the transmission frame length. Often engineers think of slow fading as being fading where the system might have time to react in some way, for example using an AGC system. Fast fading is signal variation that is considered too rapid for the system to follow.



Rain fading is an example of slow fading – with time variability measured in seconds and minutes. Mobile operators tend to consider shadowing by buildings as slow fading, periods of seconds while passing buildings. Fast fading generally means variations in the signal amplitude that change rapidly with time, E.g. times of the order of a packet, or even a symbol. Fast fading typically varies about a mean value and often fast fading is superimposed on slow fading. Multipath can cause fast fading in mobile systems. Tropospheric scintillation is another example of fast fading, though it is really a form of multipath too.

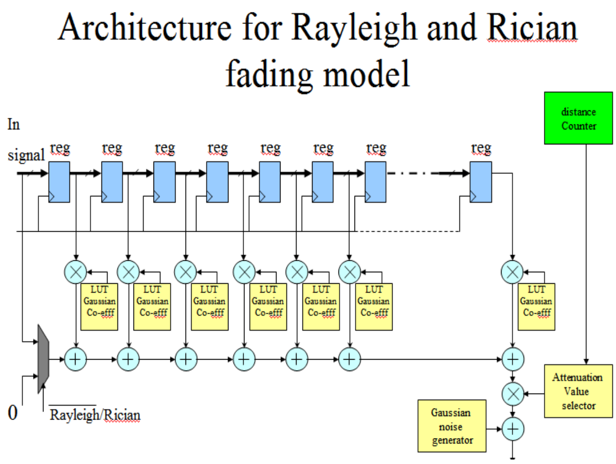
VI. MULTIPATH RECEPTION

Experiments with mobile communication were done at VHF frequencies, near 50 MHz, already in the 1920s. Results of these tests revealed a very hostile propagation environment, particularly in urban centers. The signal quality varied from "excellent" to "no signal". Moving the vehicle over a few meters resulted in dramatic changes of the received field strength[3].



The mobile or indoor radio channel is characterized by 'multipath reception': The signal offered to the receiver contains not only a direct line-of-sight radio wave, but also a large number of reflected radio waves. Even worse in urban centers, the line-of-sight is often blocked by obstacles, and a collected of differently delayed waves is all what is received by a mobile antenna. These reflected waves interfere with the direct wave, which causes significant degradation of the performance of the link. If the antenna moves the channel varies with location and time, because the relative phases of the reflected waves change. This leads to fading: time variations of the received amplitude and phase

VII. ANALYSIS AND DEIGN



Digital filters are two types an FIR (Finite Impulse Response) filter and IIR (Infinite Impulse Response) filter. Note that non recursive filter are always FIR, but recursive

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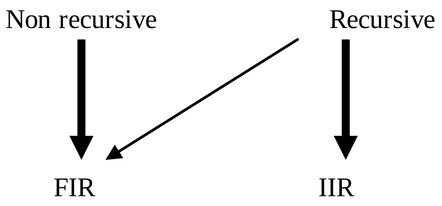
filter can be either FIR or IIR. The following figure illustrates this dependence



Recursive means feedback will be there , where as for non recursive
For FIR filter

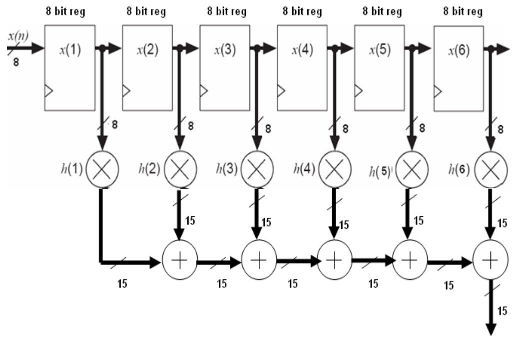
$$y[n] = x[n]*f[n] = \sum_{k=0}^{L-1} x[k]f[n-k]$$

Direct form FIR filter

The direct form of FIR filter is standard linear convolution, which described the output as convolution of input and impulse response of the filter.

$$y[n] = x[n]*c[n] = \sum_{k} x[k]c[n-k] = \sum_{k} c[k]x[n-k].$$

Where c[n] values represent filter coefficients, and x[n] represents the input samples. The figure shows the direct form FIR structure.



VIII. MODEL OF IDEAL CHANNEL

Here a fixed antenna radiating into free space, in the far field the electric field and magnetic field at any given location are perpendicular to each other and to the direction of propagating from the antenna. In response to the transmitted sinusoid cos2πft we can express the electric far field at the time *t* as

$$E(f,\, t,(r,\, \theta\, ,\psi)) = \frac{\alpha\, (\theta,\, \psi,\, f)\, \cos 2\pi f(t-r/c)}{r}$$

Here , *,(r, θ ,ψ)* represents the point u in space at which the electric field is being measured , where r is the distance from transmitting antenna to u and where the (θ ,ψ) represents the vertical and horizontal angles from the transmitting antenna to u respectively .The constant c is the speed of light and α (θ, ψ, f) Represents the radiation pattern of the sending antenna at a frequency *f* in the direction of (θ ,ψ) it also contains a scaling factor to account for antenna losses. The phase of the field varies with *fr/c*, corresponding to the delay caused by the radiation traveling at a speed of light.

As the distance *r* increases the electric field decreases by 1/ *r*. and thus the power per square meter in free space reduces by $1/r^2$ .The total power radiated through the sphere remains constant, but the surface area increases by r^2 .Then the power per unit area must decrease as

$1/r^2$ .Suppose there is fixed receiving antenna at a location

u=*(r, θ ,ψ)*

The received waveform (in absence of noise)in response to the above transmitted sinusoid will be

$$E(f,\, t,\, u) = \frac{\alpha\, (\theta,\, \psi,\, f)\, \cos 2\pi f(t-r/c)}{r}$$

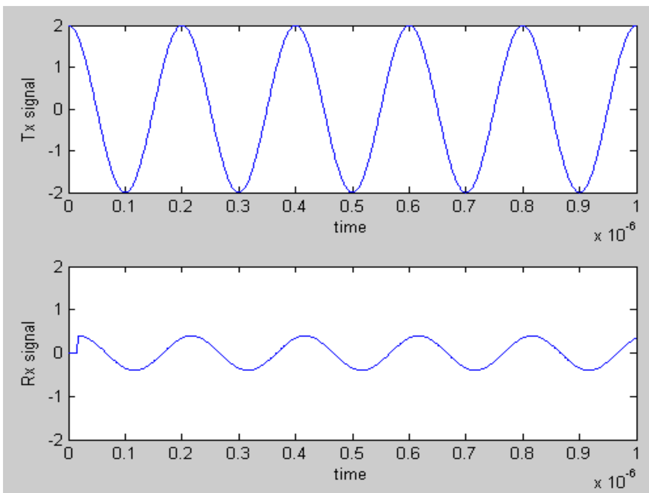
Where the product of the antenna patterns of is receive and transmit antennas in the given direction. Placing a receive antenna there changes the electric fielding the vicinity of u.

VIII. MODEL OF CHANNEL WITH MOVING RECEIVER

Consider the fixed antenna and free space model above with a receiving antenna that is moving with a velocity of *v* in the direction of increasing distance from transmitting antenna. That is we assume the receive antenna is at a moving location described by $u(t) = r\,(\,(t)\,,\, \theta,\, \psi)$ with $r(t)=r_0 + vt$

Thus the sinusoid at a frequency of f has been converted to a sinusoid of frequency of

f(1-v/c) ;there has been a Doppler shift of –fv/c due to motion of observation point. Intuitively, each successive crestin the transmitted sinusoid has to travel a little further before it gets observed at the moving observation point. If the antenna is now placed at u(t) , and the change of field due to antenna presence is again represented by receive antenna pattern.



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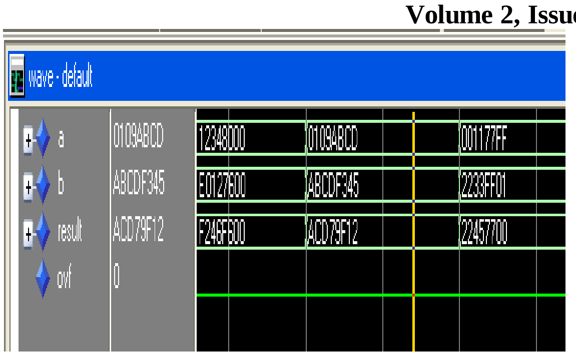
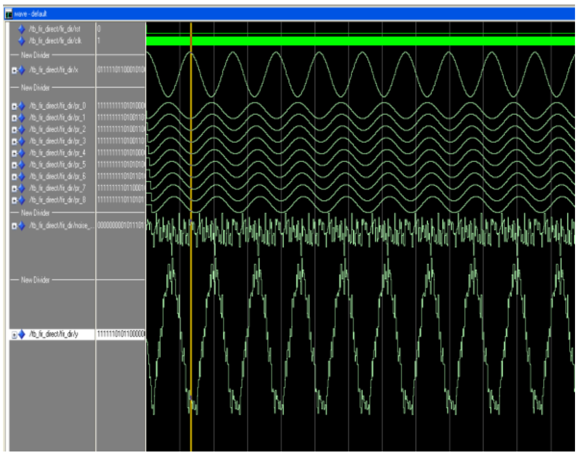


Simulation result for FIR Direct Filter



IX. CONCLUSION

APPLICATIONS

- Wireless system level simulation
- Characterization of channels with specific characteristics
- Verification of new algorithms/schemes against fading/noise
- FPGA prototyping of the whose system with transmitter, receiver and channel

ADVANTAGES

- The understanding of the channels is more practical (adding to the mathematical equations)
- Estimation of the system performance before actually making the system

Allows the designer to explore the algorithm by fine tuning the parameters in it.

X. FUTURE WORK

VHDL – AMS can be used to make the models more powerful. Some graphical user interface can be designed to allow the designer for describing the environment easily. In future a model driven development can be made for the reference of these models to other programmers

REFERENCES

[1] A Rigorous Analysis of the Statistical Properties of the Discrete-Time Triply-Selective MIMO Rayleigh Fading Channel Model by Jan Mietzner, Associate Member, IEEE, and Peter A. Hoeher, Senior Member, IEEE 2007.

[2] Modeling wireless channel fading by William Turin, Rittwik Jana, Carol Martin, Jack Winters, IEEE 2001.

[3] Fundamentals of wireless communication by David David Tse and Pramod Viswanath Cambridge University.