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A WIDEBAND RADIO CHANNEL MODEL FOR TESTING NEW COMMUNICATION SCHEMES

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Abstract - A general purpose wideband radio channel model implemented in MATLAB has been designed specifically for testing the performance of wideband chaotic communication systems utilising a radio interface. The channel model is based on a number of time-varying taps modelling the signal dispersion in a multipath environment. Generation of the tap fading process is implemented using a simple method based on summation of a number of complex phasors.

INTRODUCTION

A wideband channel model has been designed in MATLAB, based on the experience gained in channel modelling acquired during the years 1993-1996 within the project SARF (New Radio Communication Systems and their RF-technology, Contract No. 27503) sponsored by the Academy of Finland. The model uses a simple tap generation method, and utilises subroutines written in C language in order to maximise the speed of the program. This model was originally developed for testing chaotic communication systems [1], but contains all the essential features for general purpose wideband channel modelling and simulation [2].

The wideband channel model is based on the FIR (Finite Impulse Response) transversal filter structure, which has been used extensively for simulation of mobile communication systems, regardless the different radio environments (indoor, urban, rural, mobile satellite), different bit rates (several kbit/s to several Mbit/s) and different system technologies (TDMA, CDMA, FDMA) or system concepts (GSM, DECT, IS-54, IS-95, UMTS) existing or envisioned.

THE WIDEBAND CHANNEL MODEL

The wideband (dispersive) multipath radio channel is modeled by a transversal filter with unit tap delay $T \leq 1/W$, where W is the rf-bandwidth of the transmitted signal, "equality" corresponds to the Nyquist sampling frequency and "less than" implies oversampling. The tap delays need not necessarily be uniformly spaced, as long as the spacing between two adjacent taps is an integer multiple of T. For example, the GSM TU (Typical Urban) six tap channel model, utilised extensively for conformance testing of GSM equipment, is characterised by a unit tap delay of T = 0.1 μs (corresponding to an rf-bandwidth of 10 MHz designed to cover the frequency band of a frequency hopping system) and tap delays at 0, 0.2, 0.5, 1.6, 2.3 and 5.0 μs [3].

Due to (a) the necessity of using equivalent low-pass signal domain in software simulation and (b) the time-variant behaviour of a mobile channel, the envelope of each tap is drawing a more or less random trajectory in complex plane as a function of time. The conventional solution for generating this tap fading process is to apply two independent Gaussian random generators and to feed the output signals through two equivalent Doppler filters shaping the spectrum of the process. In our model, however, the fading process of each tap is generated by summing a number of complex phasors, each with magnitude *A*, randomly selected initial phase ϕ, and Doppler frequency ν randomly selected from a specified distribution. Through suitable choice of phasors, taps with Rayleigh or Rice envelope distributions are easily obtained. Also, the average relative power of a tap is easily evaluated, since it is equal to the sum of the square of the magnitudes of the phasors encompassed by the tap in question. As an example, a simulation run of the MATLAB program emulating the GSM TU six tap channel model is shown in Figure 1. Each tap fades independently with an approximately Rayleigh distributed envelope. As specified by [3], the average relative powers of the taps are -3, 0, -2, -6, -8 and -10 dB, respectively.

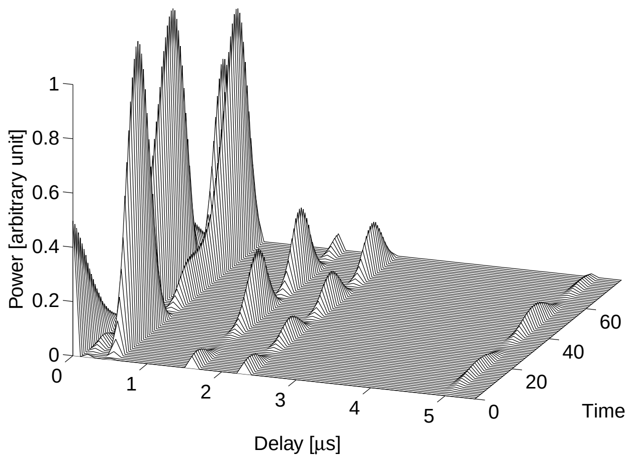

Figure 1. Impulse response of the simulated GSM channel as a function of time (in units of 128 sample intervals).

DISCUSSION AND CONCLUSIONS

A simple but versatile general purpose wideband channel model has been implemented in MATLAB. The channel model is useful for simulation of the radio interface of communication systems employing novel concepts in modulation, multiplexing, multiple access, coding or diversity reception. In such cases flexibility considerations, such as adjustability of the severity of delay dispersion and adjustability of the fading speed, are of greater importance than exact statistical or physical characterisation of the actual radio environment.

The complexity of the model can be increased as required, or reduced all the way down to the narrowband (one tap) non-fading trivial case. The fading process can also simulate the situation where one or several specular paths are present within the delay resolution of a specific tap, which may result in a non-Rician, non-Rayleigh envelope distribution. In this respect this model makes it easier to test and visualize the effects of multipath on system performance, as when compared to standard statistical channel modeling methods.

REFERENCES

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