Noise signal simulation with Octave

Lapich S.V., Derechennik S.S., Menshih T.J., Divinets A.A.

Brest State Technical University

Simulated model was designed to find Gaussian and Rayleigh noise probabilistic characteristics. The project is based on GNU Octave. The main fields of application for this project are the microelectronics and radio-engineering.

The noise is a random signal that exists at all frequencies. Currently noise signal used as a carrier instead of harmonic one are of the utmost interest for the information transfer. Specifically, the noise is most promising as a candidate for data carrier in terms of data protection on the first layer of OSI model [1].

Due to the rise of popularity noise signals simulation is becoming even more urgent, for example at development of multichannel noise modules with a solid-state diode generator used as a random signal source.

At present, mathematical apparatus for this simulation is developed rather in details. Most common mathematical models of random signals and noise are the telegraph signal, "white" noise, Gaussian noise, and Rayleigh noise. In real-life tasks of the radio technology, telecommunications and in other fields (including computer science) the model of Gaussian noise is typically used, which is created by summation of statistically independent "white" noises [2]. The "white" noise in its turn is a stationary random process q(t) with autocorrelation function described by the Dirac delta function, and with frequency-independent spectral power density which has a constant value Gq(w)=σ2 equal to q(t) values dispersion.

"White" noise model fits into the AR model [3] which can be described by a following difference equation: $F_t = \sum_{n}^{i=0} (a \cdot x_{t-i}) + \sigma$, which involves AR model parameter a, a random value xt-i, and dispersion σ .

In noise signals computer simulation cases the developer bumps into a considerable variety of software packages which are satisfactory for this purpose. However, search does not show specialized software for noise signals simulation, and so universal mathematical packages become an option. In theory, large data packets with functionality for all occasions should contain tools to simplify and automate this simulation. However, the experience gained by authors while dealing with Matlab have shown that its built-in generators allow to create standard model, while any deviation from standard parameters requires implementing noise source from scratch. Obviously the rejection of commercial mathematical package in favor of free software is a significant advantage in such case. On the one hand, it addresses issues of affordability of the software, and on the other hand, open source improves verifiability of the model (for example, when it is necessary to substantiate some unexpected results).

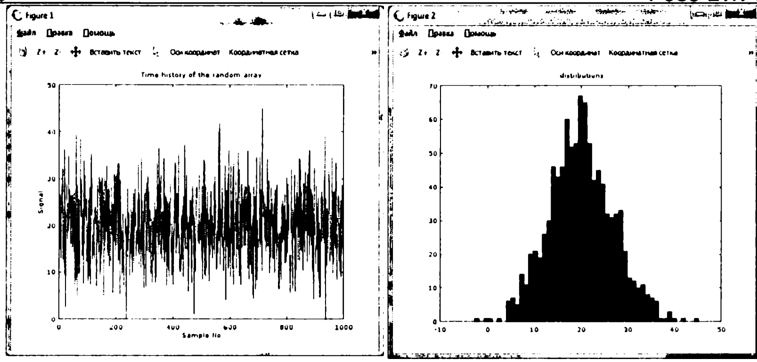

Figure 1 – Gaussian random process of "white" noise and density histogram (Number of samples - 1000, Give the average - 20, Give the variance - 50)

These considerations were the main argument for choosing the programming environment for analysis of the experimental sample parameters of noise modules manufactured in Belarus, based on crystals of the ND201L silicon diode noise generators [2]. As a result the Gaussian noise model was implemented with help of the open source GNU Octave package [4].

Octave provides an interactive command line interface for solving linear and nonlinear mathematical problems and numerical experiments. In the simulation of Gaussian noise randn() function generating an array of random variables was used, as well as standard tools for noise visualization (plot) and histogram distribution density (hist). Gaussian random process of "white" noise and density histogram simulated with Octave are shown in Figure 1. Figure 2 shows the similarly simulated Rayleigh noise (built on the same apparatus but having differently defined mathematical function) and the corresponding histogram of the distribution density.

As an advantage of the used software we can note the high compactness of the code (typical implementations of our the models can be found at https://github.-com/svlapich/signal) as well as a simple parallelization of computational load in Octave which is relevant to noise signal generation problems.

References:

1. Корчинский В.В. Модель шумового сигнала для передачи конфиденциальной информации / В.В Корчинский // Вестник НТУ "ХПИ", 2013. – №11. – С. 89–94.
2. Разумейчик В.С. Оценка вероятностных характеристик случайных сигналов микроэлектронного шумового модуля / В.С. Разумейчик, В.В. Буслюк, С.С. Дереченник, В.И. Поляков, С.В. Лапич // Вестник Брестского государственного технического университета, 2014. – № 5 : Физика, математика, информатика. – С. 4145.
3. Громаков Ю.А. Структура TDMA кадров и формирование сигналов в стандарте GSM / Ю.А. Громаков // Электросвязь, 1993. – №10. – С. 9–12.
4. Алексеев Е.Р., Чеснокова О.В. GNU Octave для студентов и преподавателей. –