

Delta Modulations Training System for e-Learning

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Abstract— Delta Modulations Training System that consists of several computer education programs is described. Two of these programs are presented in the paper. The DMTS system illustrates the operation of the delta modulators not only with step size adaptation, but also with sampling interval adaptation. Thanks to the possibilities of simulators the measurements of the dynamic range DR , SNR_{max} ratio and average bit rate (BR_{avg}) can be made. The suggested simulators are very useful for monitoring and measurement the channel errors influence on the received voice quality.

Index Terms—Adaptive modulation, Delta modulation, Sampling methods, Simulation, Virtual instrumentation.

I. INTRODUCTION

Describing advanced delta adaptation coders by means of the clear analytical model is very difficult. As internal and output parameters are very numerous, analytical investigations call for using of the very complex model.

Computations lead into the iterative solving of complex sets of equations with using the computer-aided methods for calculating [1, 2]. In the face of a lot simplifying assumptions which must be assumed to their solving, the analytic method does not provide in this case more accurate results than algorithmic simulations.

A voice encoding system based on ADM codecs has already been used in the Shuttle system. ADM modulation was chosen by NASA for source encoding of voice because of its tolerance to channel errors. Today, there are many military and commercial systems using this method [2]. They are particularly useful for applications in TDM systems, switches and phones. Bluetooth standard employs a low-cost, 64-kbps Continuously Variable Slope Delta (CVSD) modulation voice-coding scheme. Several semiconductor manufacturing companies (CML Microcircuit, National Semiconductor, and GCT Semiconductor) produce specialized telecommunication ICs based ADM codecs.

As seen from [3, 4] ADM systems with variable sampling frequency yield higher compression and SNR ratio than those with fixed frequency, especially at conversion of the highly non-stationary processes (i.e. speech and TV). The great advantage of the variable-rate delta modulations is high data-protection performance [6]. However the implementation of the delta modulators with sampling adaptation (NSDM), as well as with step size and sampling interval adaptation (ANSDM) is related with greater computational complexity. It leads to higher hardware requirements in ANSDM and NSDM modulators implementation. The extension concerns particularly the adaptation circuit logic [4].

The computational complexity for the CFDM, NSDM and ANSDM modulations have been done according to the worst case principle as shown in Table 1. Computational complexity (time of the conversion cycle and instructions number per conversion cycle) of the LDM modulation has been assumed as equal to one.

TABLE I.
COMPUTATIONAL COMPLEXITY OF THE DELTA MODULATIONS ALGORITHMS

Computational complexity	CFDM (2-bits)	NSDM (3-bits)	ANSDM (3-bits)
Relative Mean Time of the Conversion Cycle	~2	~9	~19
Relative Mean Instructions Number per Conversion Cycle	~2	~7	~20

II. EMULATION SYSTEM USED TO INVESTIGATE DELTA MODULATIONS

The block diagram of the DMTS emulation system used to investigate 1-bit delta converters is shown in Fig. 1.

The objective of DMTS is to create a simulation platform, which gives appropriate training for students without a need to access the hardware solutions. This system is valid for complicated delta modulation schemes. The DMTS includes a set of simulation instruments that allow the inspection of all output parameters.

The basic block of the DMTS system are algorithmic simulators of the converters with uniform sampling: LDM (Linear Delta Modulation), CFDM (Constant Factor Delta Modulation), CVSD (Continuously Variable Slope Delta) and the new modulators: NS-DM (Non-uniform Sampling Delta Modulation) and ANS-DM (Adaptive Non-uniform Sampling Delta Modulation). The set of input sources (Fig. 1) in DMTS system is included. Simulator generated variables are an object of the experiment and they determine the base for software calculating of the output parameters (SNR ratio, average bit rate (BR_{avg}), compression factor (CF) and dynamic range (DR)).

The audio and video cards of the computer system allow additionally, in real-time, to reflect the input and received signals. Wide ranges of the control internal parameters of the simulated delta modulators have been provided. In view of the educational character of the DMTS programs during its design, the special attention has been given to the user interface clarity and operating comfort.

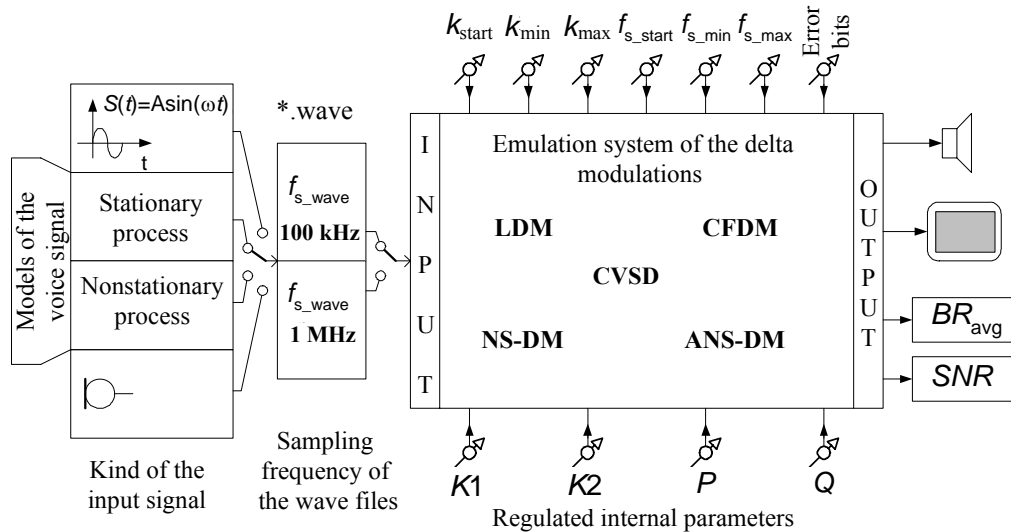
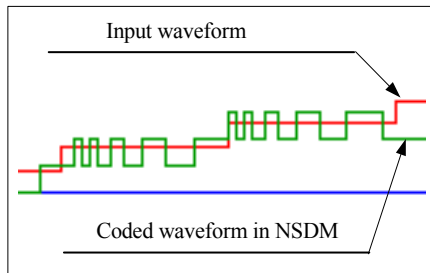


Figure 1. Block diagram of the emulation measurement DMTS system for research 1-bit delta converters

The audio editor „Cool Edit Pro” has been used to the sound files processing (16 bit mono wave file) [5]. The editor allows signal shaping, sampling frequency conversion of the wave files, spectrum analysis, power level setting and others.

A. The Sampling frequency of the wave files

a)



b)

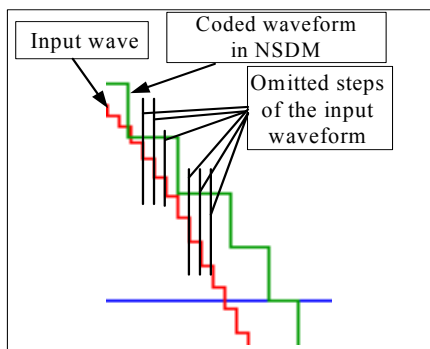


Figure 2. Coded waveform in NSDM: a) when $T_{s_max} \ll T_{s_wave}$, b) when $T_{s_min} \gg T_{s_wave}$

The value of the input wave files sampling frequency has a great influence on the accuracy (especially for NSDM and ANS-DM) of the output delta modulations parameters (SNR , BR_{avg}). Extremely small f_{s_wave} frequency is the cause that SNR [dB] values are up to 10% lower than the results of the measurements made on the original analog input signal in the hardware implementation. On the other hand, significant

increasing f_{s_wave} frequency requires higher computing power giving the unimportant gain of the SNR value. It has been experimentally established that [2]

$$f_{s_start} \leq f_{s_wave} \leq 4 f_{s_start} \quad (1)$$

Where f_{s_start} is the basic sampling rate in Zhu algorithm [4].

III. DMTS PROPERTIES

A. Mod-Delta emulator

The computer program included in "Mod-Delta" emulator has been written in C++ for 32-bits Windows®. The program was created basing on RAD (Rapid Application Development) MS Visual C++. „Mod-Delta” offers wide-ranging selection of all internal parameters. This program makes the calculation of SNR value for all delta converters and average bit rate BR_{avg} for NSDM (ANS-DM). The software automatically calculates the histogram of the adapted parameters values (P , Q , $K1$ and $K2$). Visualization of the following parameters is possible (Fig. 2): input source, staircase of the predictor waveform, reconverted signal, and binary stream on the coder output, in the transmission line and on the input of D/A converter in the decoder.

The "Mod-Delta" emulator allows the sound reproduction of the input source, predictor waveform, and reconverted signal. The synchronization of the coder and decoder waveforms is ensured by the emulator. The system is equipped with the buttons, which allow increasing or decreasing vertical or horizontal resolution of the displayed waveforms.

The "Mod-Delta" emulator provides a valuable possibility to insert the error bits into the Transmission Line (Figure 2) and is very useful for monitoring and measuring the channel errors influence on the received voice quality.

Though the "Mod-Delta" emulator is used as educational system it can be used for research purposes, too [1, 6].

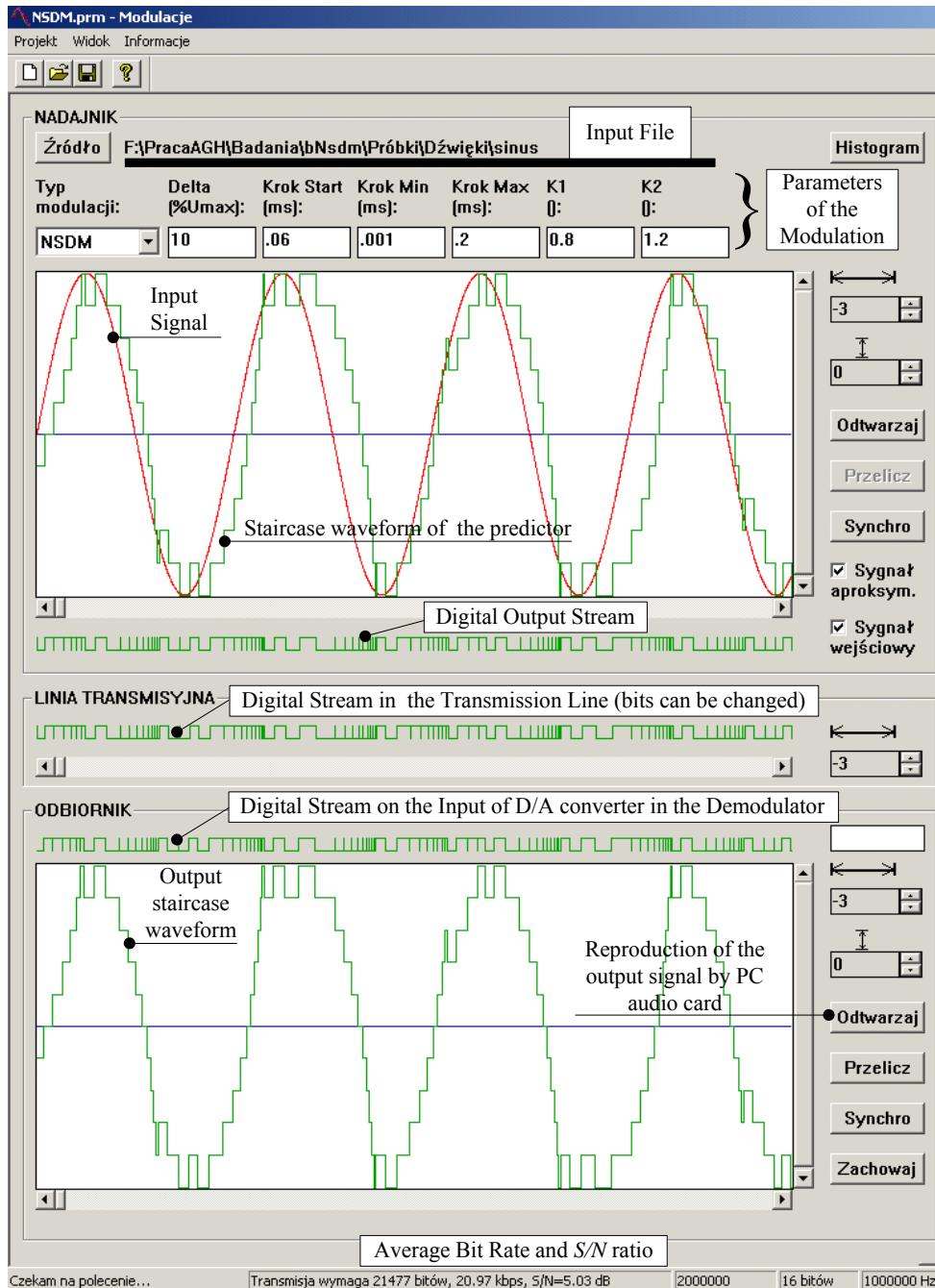


Figure 3. User interface of the "Mod-Delta" emulator

B. „Nsdm-Sym” Simulator

The „Nsdm-Sym” simulator is an advanced algorithmic simulator application. The program has been written in C++ for 32-bits Windows®.

Nsdm-Sym works as a simulator and an analyzer system thus offering the following possibilities:

- Creating various types of input signals (sine, triangle, rectangle, and speech source approximated

by a white noise signal having the integrated power spectrum and Gaussian amplitude distribution),

- Control of the amplitude, phase and frequency values for periodical signals, and power level of the "speech signal",
- Visualization of the input, reconstructed and error signals, output digital stream, and SNR value (simultaneously for all modulations)
- Measurements of BR_{avg} and SNR ratio (Figure 3).

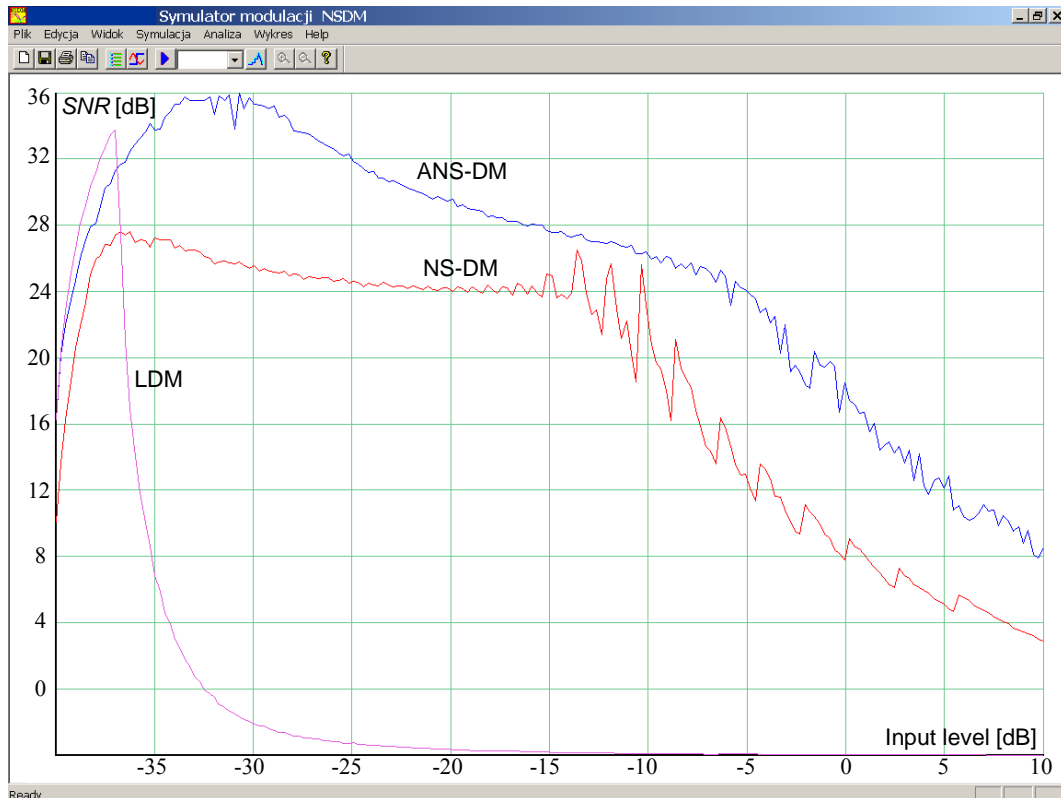


Figure 4. User interface of the "Nsdm-Sym" simulator - SNR characteristics

IV. CONCLUSIONS

Delta Modulations Training System consisting of several computer education programs has been described.

DMTS differs from previous proposals because it allows a research of the property of delta converters with non-uniform sampling (NSDM) and converters with step-size and sampling frequency adaptation (ANSDM).

Moreover, thanks to the possibility of the erroneous bits loaded to the Transmission Line (Fig. 2), DMTS helps to observe and measure of their effect on the restoring quality.

Though the DMTS is an educational system for can be used in research purposes, too.

The DMTS gives appropriate training to students without requiring the direct use of the hardware solutions, instead of using simulation instruments. At home students learn to select internal parameters and observe their impact on the output parameters.

The providing of simulators in virtual instruments allows making measurements of DR , SNR , BR_{avg} and compression factor CF as well. It enables the evaluation of each kind of the delta modulations.

"Nsdm-Sym" and "DELTASYM" systems are available on the Web page <http://ke.agh.edu.pl/~lab301/>.

Auxiliary materials in the form of instructions with the basic theoretical knowledge can also be found on the page.

Several years of experiences allow to conclude, that thanks to the DMTS application, the considerable

improvement of the capture degree of the thematic concerning the delta modulations have taken place.

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