The description
of demo version for the program DY4, which illustrates operation principles of multithreshold decoder.

The purpose of a program designed was the demonstration of a successful decoding capability with the help of MTD for linear block codes in conditions of very high level of a noise in a binary symmetrical channel (BSC) without memory, which one is a simple, but the precise model of rather expensive space and satellite communication channels. Density of channel errors, when high MTD characteristics are demonstrated, is close to 0,06 both for information, and for control characters of a code. Now there are no data about a possibility of an effective work at so high probability of an error in a channel for other error correcting algorithms with reasonable complexity of implementation.

The program represents an **exe**-module working under the control of an operating system MS-DOS, which one demonstrates work of the multithreshold decoder (MTD) in case of its application for decoding a block code with length n=2000 bit , code rate R=1/2 and minimum code distance d_m=23. Before starting the program it is necessary preliminary to unpack by standard means the zip-file, after its transferring to a hard disk of the computer. An occupied disk memory is less than 100 Kbytes.

After that the program may be started by a double «mouse» clicking on a module **dy4.exe**. The file **egavga.bgi** at the moment of demo start should be in the same directory, as **exe**-module. The program works under the control Windows 95 - 98 too.

The program imitates continuous transmission and subsequent decoding of lengthy sequence of code blocks and its work can be finished at any moment by pressing the key "e" (English register).

It is possible to select convenient for observation work speed for demonstration model, pressing some times "g" (greater) key for acceleration of its activity and "l" (lesser) key (both - English registers) for the diminishing activity of model.

The work of the program starts with creating at the display screen three colored data arrays, consisting with 1000 small squares corresponding to the binary flow of the received code, in information and control bits which ones contain precisely 1000 bits. The first upper array under a title “difference” is necessary for monitoring and its role will be clear from the further description.

The demoprogram starts the work from imitation of data transmission through communication channel. The middle informational 1000-bit array with a name "information" at first is fulfilled. In process of information bits reception the color of filling of the corresponding small squares varies, and near this array appeares a text «-=BSC=-», the continuously changing color as a result of receipt is correct or is erroneous (red small squares) "received" bits. Then there is a filling by control bits,

coming from a channel, of the lowermost control array with a name «check symbols». The transmission errors in its control symbols are marked by small squares of cyan color.

Then, as it is always done in linear codes, the syndrome of the received block is calculated. The computed result is saved in the same lower array, which one is called further "syndrome". “Ones” of a syndrome representing errors in check bits, still remain cyan. All “ones” of a syndrome, i.e. the small squares, arisen because of errors in information symbols, are colored in red. From the assembly view of a syndrome before the beginning of process of decoding it is clear, that the most number “ones” in an array of a syndrome corresponds to errors in information symbols of a code.

After calculation of a syndrome the multiple decoding attempts for all informational code bits start. The purpose of decoding is correcting all information errors located in the middle array of a screen picture. In a presented demodecoder version the transmission over a binary symmetrical channel without memory (BSC) with average error probability about p=0,06 is imitated, which one is a very high for selected code rate R=1/2.

The considered below decoder, as it is possible to see due to results of its work, does not commit any errors at all even at a selected very high noise level. But the absolute absence of errors for a long but very restricted time interval of decoder’s work is not the evidence of its always right decisions. “Movies" only demonstrates MTD capabilities to work in a proper way in a channel with a large noise.

Let's remind in this context, that the good choose of MTD’s adjustments is very essential for achievement of success in implementation of idea of the repeated decoder solutions improvement. Let's point out also, that used in MTD code also should be constructed in accordance to all requirements and limitations ensuring a minimal level of an error propagation effect when decoding in the majority schemes.

The basic process of decoding starts with appearance of one black small square in the average information block and 22 same small squares (cells) in lowercase of a syndrome. These small squares correspond to selected an information character for the given step of decoding, for which one MTD is ready to compute the sum on a threshold scheme (TS), and also that to 22 checks, which are inputs for the TS that is ready to calculate the sum of these checks. From the very beginning of a main cycle of error correction position of a threshold scheme in the information array starts to displace, that corresponds to completion of attempt of one informational bit decoding and transition to the next information bit with new group of checks connected with it, etc. In process of TS’s movement background tones vary in the mean array, that allows to distinguish already decoded bits from those ones, which still are not checked up.

After each change of an information symbol in the mean array in the upper monitoring register “difference” it is marked by white color if the solution of a threshold scheme was right, and it is marked by green if the solution of TS was erroneous. If wrongly changed at first symbol will be again changed during following iterations, the color of the corresponding cell again will change to background one for this array. Since value of every check cell in the array of a syndrome each time also varies, if the

information character of a code is restored, in process of successful progression of decoding process there are changes, basically, of red colored cells of a syndrome to a background, though other color replacements are probable also.

The process of decoding is accompanied by runtime check of its parameters, which one are displayed in the unit of current values of decoding processes in the lower right screen corner. Number of the decoding block is shown, number of iteration, and current distance between the MTD solution and received block. Last parameter is a key for this algorithm and corresponds to the main theoretical states about properties of this algorithm. It only decreases at all steps of decision made about decoded symbols, even if at some steps the decoder makes the error solution about some information bit. The continuously displayed value of distance changes from initial weight of a syndrome, which one is determined at once after its forming, and up to final minimum weight of errors in the decoded block. At each step of decoding current distance is equal to quantity of colored (distinct from background tone) small squares in arrays “difference” and "syndrome".

Weight of a noise vector and initial weight of a syndrome are demonstrated during decoding of the current block in the left-hand lower corner of the display.

There is a limited number of repeated symbol control in the decoder of the received block (decoding iterations), equal to 10. In case after some number of reviews of a code block on the following, for example, 7-th iteration does not change any information characters of the block, the decoding ceases and they consider that the procedure for this block is finished. Thus a distance between the MTD solution and received block is calculated too.

After completion of a decoding procedure of every coded block in a lower left-hand corner the reference value of the random-number generator RAND=X, length of the information block K=1000 and code distance d=23 are demonstrated. The line is keeping number of decoded characters (always equal to 1000), further at first number of errors in received information characters, then in check characters of the given block and at last number of errors after each iteration of decoding is demonstrated even below. The zero values on positions of last iterations correspond to absence of errors in the decoder after completion of a procedure of its processing.

On the lowermost line at the left – weights of a syndrome. The first number is a start weight (distance to the received block) syndrome, and then, since the fourth stand - weights of a syndrome after each iteration. In case of right decoding after last iteration (and it takes place during the all real time of demodecoder working) it appears, that weight of a syndrome coincides with number of errors in verifying characters. As “ones”, conditioned by errors in information characters, in a syndrome are absent, then all final states of the decoder arrays, when red cells in the unit a syndrome too no, correspond to the right resulting solutions of MTD. As all information errors in selected for demonstrating MTD blocks are corrected, all observed MTD’s solutions coincide with the solutions of optimum decoding with complete enumeration for a used code. At an incorrect end result of decoding final distance of the MTD’s solution would not coincide

with the weight of a vector of the error, and in information and syndrome arrays after completion of decoding there would be errors- “ones”, which one are imaged by red small squares in these arrays.

It is important to point out, that at usage MTD there is an exact decoding of all blocks, total number of errors in which one is close to 120. In some corrected code blocks the initial number of errors is 128 and more. It 10 times exceeds number of errors, the correcting which one is guaranteed for a code distance d=23, that is indicated for a code used in MTD. It is well-known that the effective algorithms at a large noise level should necessarily have capability to correct a considerable part of errors with weight, that is much more than half of minimum code distance. Demoprogram for MTD algorithm successfully demonstrates such a very important quality of the decoder.

After decoding of the every new block there is a temporary erasure of the upper monitoring array on the display screen. On its place the integral data for all blocks treated during decoding, with the indicating of a total number of information characters, received from a channel, errors in information and verifying characters, and also total number of information errors remaining after each iteration of decoding are displayed. During demonstrating the integral data it is possible to click any push button of the keyboard and to detain thereby transition to process of “transmission” and decoding of the following block with the purpose, for example, of more in-depth analysis of these data. For the beginning processing of the following block they need once again to click any push button of the keyboard.

The author has special demoversion of the error correction program suitable for laboratory job realization for learning multithreshold decoding methods. It enables to be fulfilled by the students or trained specialists on courses of improvement there qualification and admits to solve different tasks to choice codes and intensity of channel errors flows with the purpose of analysis of MTD operation principles and so capabilities of this effective algorithm.

Special variant of demodecoder only for Windows realizes the same MTD algorithm and may be controlled by special commands, which they may see in menu “File”.

All remarks and proposals on a given demoversion of the MTD program may be directed to the author in Moscow, Russia:

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