

LINE CODES IN DIGITAL TRANSMISSION SYSTEMS

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Annotation: *This paper discusses line codes in digital transmission systems, focusing on the conversion of binary signals into different coding schemes such as NRZ (Non-Return-to-Zero), RZ (Return-to-Zero), AMI, and HDB-3 (High Density Bipolar of order 3). The principles of coding, spectrum characteristics, error detection, and synchronization issues are analyzed. Special attention is given to HDB-3 coding, which solves the problem of long sequences of zeros in AMI by replacing them with specific bipolar patterns. The paper also examines scrambler techniques for improving statistical signal properties, ensuring reliable transmission, and compatibility with regenerators. The advantages, disadvantages, and application areas of unipolar and bipolar line codes in communication systems are presented.*

Keywords: *Digital transmission, Line codes, NRZ, RZ, AMI, HDB-3, Bipolar coding, Synchronization, Scrambling, Error detection, Spectrum efficiency.*

At the entrance of the line tract intended for transmitting a digital signal, a converter is poured into the digital line signal of the secondary signal. On the output, a device is installed that does the opposite of it. When choosing the type of line signal, it will depend on the type of line. It should also be considered to pass regenerators, control regenerators. At the entrance of the line tract intended for transmitting a digital signal, a converter is poured into the digital line signal of the secondary signal. On the output, a device is installed that does the opposite of it. When choosing the type of line signal, it will depend on the type of line. It should also be considered to pass regenerators, control regenerators. Linear Code must be recovered in such a way that the energetic spectrum of the line signal must occupy as small a band as possible. This does not require the spectrum maximum to lie at low frequency limits and be in a fixed part of the spectrum. Beyond that, the sum of symbols of the signal must be minimal. This means that the invariant part must be transmitted continuously. This action is achieved by cross – compensating successive code symbols at a very short time. Given this, the linear Code must have opposite polar pulses. That is, the opposite polar sequence of pulses must be uniformly generated. It is impossible to put a limit on the formation of binary code pulses. Therefore, the linear Code must be with the excess his action is achieved by cross – compensating successive code symbols at a very short time. Given t.

There are several views of such line codes. The most common is HDB-3 (High Density Bipolar Excess 3). The principle of building this code is just like ChPI. This similarity continues until more than 3 zeros appear between secondary symbols. here are several views of such

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Table.1.

<i>Final impulse signal</i>	<i>Odd</i>	<i>Pair</i>
Positive (+)	--- P	N -- N
Negative (-)	--- N	P -- P

The principle of converting a secondary code into an HDB-3 code

Table.2.

<i>Binary code</i>	<i>HDB - 3 code</i>	<i>Consecutive selection condition</i>
0000	000 B	If there is an odd number of B symbols before the previous B symbol
	B00 B	If the previous symbol is B, then the symbol B is preceded by an even number.

Through B in Table 2, a symbol is defined that repeats the pole of the previous symbol B. A sequence of 4 zeros is replaced by two different sequences of line code. This is done so that the sequence of symbols V, which appear at different positions of the line signal, changes the pole alternately. This eliminates the effect of similar symbols on the meanrough B in Table 2, a symbol is defined that repeats the pole of the previous symbol B. A sequence of 4 zeros is replaced by two different seque2. In HDB-3 code, random errors generated in the digital signal being transmitted from the line can be checked. This can be done by examining non-compensable B distortions. Random errors when converting linear code into binary code result in additional errors at the end of the digital track HDB-3 code, random errors generated in the digital signal being transmitted from the line can be checked. This can be done by examining non-compensable B distortions. Random errors when converting linear code into binary code result in additional errors at the end of the digital track. For example, a sequence in linear code allowed an error in Symbol 3 in B + OB – B + (alternating to 0 koldi.), from which a b+ OOB + sequence is formed. This is understood by "decoder B + Oo B and replaces this sequence with 0000. Thus, 3 errors were generated in place of one error. The number of errors can also increase on March 2. At some point, it is also possible not to multiply the error and cause the error to disappear [1]. Depending on the method of conversion, the mean value of the decoder multiplication coefficient in the process of decoding linear code error can be from 1.18 to 1.26.

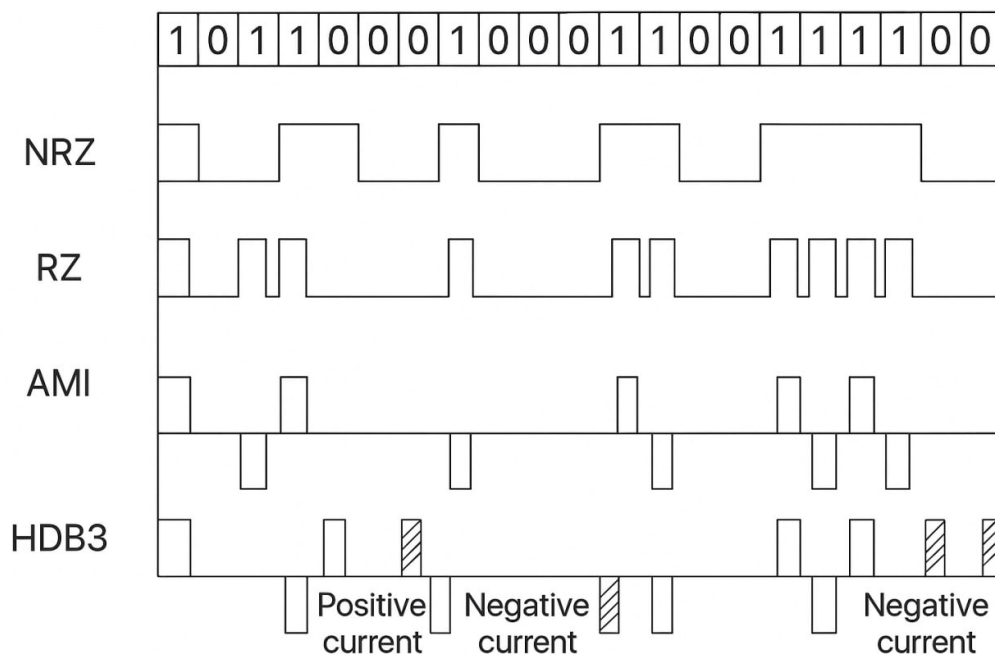


Fig.1. Types of linear codes.

There is another linear code representation close to the HDB – 3 code. It is the code Z b So6 (Bipolarwith Sik Zeto Sitbstition) used in the United States. This code cannot contain more than 6 consecutive zeros. Each 7-zero combination is replaced by one of two sequences of linear code. here is another linear code representation close to the HDB – 3 code. It is the code Z b So6 (Bipolar with Sikh Zeta Substation) used. NRZ (Non Return to Zero) – nolga qaytmaslik kodi. In this case, "0" is relative, "1" is positive. Its disadvantage:

- large constant composition;
- takt signals are not specified in the bit stream.

This code requires a simple manual. It is mainly used for transmitting signals over short distances. In this case, the equipment has a separate synchronous system. PZ is the code with return to zero.

Non return to Zero (NRZ) is the simplest linear code consisting of a simple binary sequence and is the most common code in practice. An important feature of the NRZ signal spectrum is when the value of the spectral density is limited at the zero frequency.

There are two types of this code – unipolar and bipolar NRZ codes. In bipolar NRZ code, a positive polar right - angle pulse corresponds to the logical one, and a negative polar right-angle pulse corresponds to the logical zero. The length of the pulses is equal to the length of one bit. There are two types of this code – unipolar and bipolar NRZ codes. In bipolar NRZ code, a positive polar right - angle pulse corresponds to the logical one, and a negative polar right-angle pulse corresponds to the logical zero. The length of the pulses is equal to the length of one bit. T.

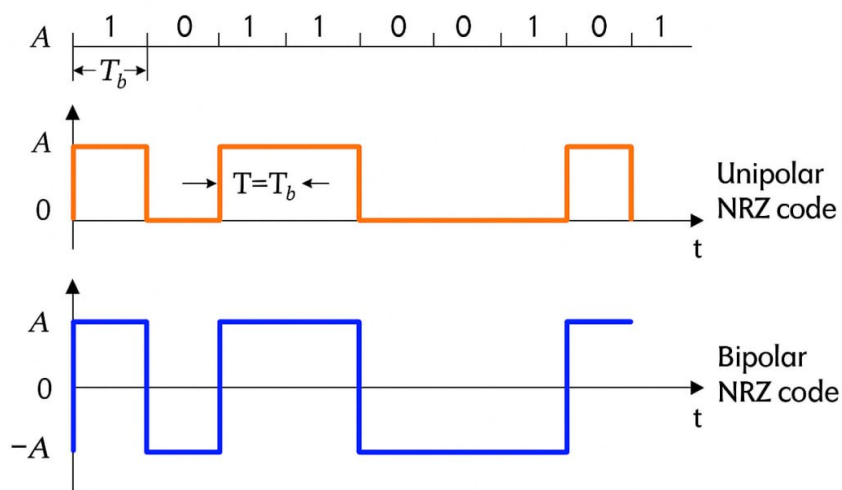


Fig.2. NRZ code that does not return to zero.

a_k – The coefficient determines the K symbol in the sequence of symbols transmitted over the communication channel, T -mark length. The length of one bit of information transmitted by TV. Unipolar NRZ differs from the spectrum of the code in the presence of a discrete spectral line of zero frequency.

In a code that returns to zero-Return to Zero (RZ) is transmitted by one double small-length pulse. Spectra of ordinary codes have the following disadvantages: small power of the tactile frequency (synchronization frequency); the possibility of the presence of a long sequence of zeros; RZ code requires a wider conduction corridor relative to NRZ code, but has a smaller value of its invariant organizer. In a code that returns to zero-Return to Zero (RZ) is transmitted by one double small-length pulse. Spectra of ordinary codes have the following disadvantages: small power of the tactile frequency (synchronization frequency); the possibility of the presence of a long sequence of zeros; RZ code requires a wider conduction corridor relative to NRZ code, but has a smaller value of its invariant organizer. For work on metal cables, three codes are widely used in bolted transmission systems. Their use is based on the possibility of various polar connections of the EYuK generator to the load (metal cable). The code has two different views – bipolar RZ code and unipolar RZ code [2]. The unipolar RZ code differs from bipolar in that the Mantic is not a negative impulse to zero, the zero voltage corresponds. The bipolar RZ signal has a spectrum similar to that of the bipolar NRZ signal as well as a fixed organizer. Their use is based on the possibility of various polar connections of the EYuK generator to the l

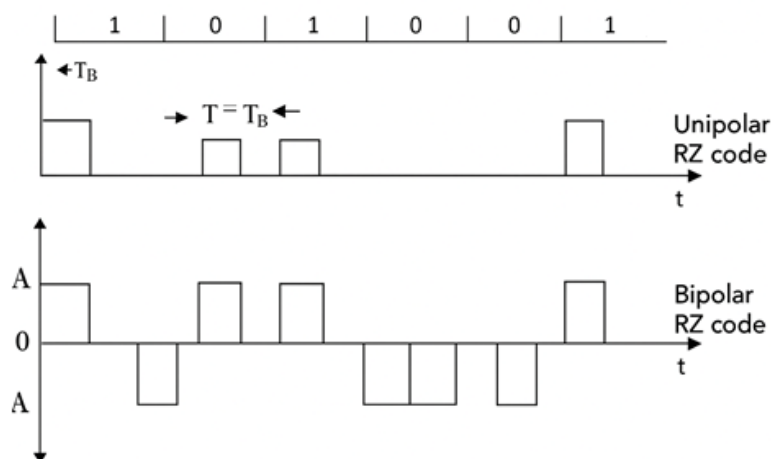


Fig.3. RZ code that returns to zero.

The code-(IKNN), in which the pulse Poles take turns, is a type of bipolar code, with the non - existence of pulses to zeros, which are followed by negative and positive polar corrective pulses that change alternately. Since the invariant organizer in the pulsed sequence is zero, transmission over lines with separator Transformers is possible. The code-(IKNN), in which the pulse Poles take turns, is a type of bipolar c. Code HDB -3 with high density of unit arrival is common, in which $n = 3$. The main requirement for linear codes of optical fiber transmission systems (TOUS) is the use of two significant levels of this signal, since the light source (laser or nurdiode) operates in two power orders - in the order in which the radiation is present or not. Direct NRZ and RZ code usage in TOUS is limited. Codes with multiple correlation connections are distributed, notably the CMI - Coded Mark Inversion code: a non-zero binary code in class 1v2v. Direct NRZ and RZ code usage in TOUS is limited. Codes with multiple correlation connections are distributed, notably the CMI - Coded Mark Inversion code: a non-zero binary code in class 1v2v. In CMI code, zeros are transmitted in a sequence of zeros and units sharing between one takt, whi.

Systems with large speeds use a screw-wired signal in NRZ form. Let's take a closer look at the scraping algorithm. The meaning of screwing consists in the formation of a certain sequence, in which the statistics of the occurrence of zeros and ones approach a random voqye, which makes it possible to mine the requirements for reliable separation of the fixed spectral power and tactile frequency of the power of the transmitted signal assembled in the field of given frequencies. It should be noted that screwing is widely used in many types of communication systems to improve the statistical properties of the signal. Screwing is usually done directly before modulation. Skrembler is performed on the switch side using a device called a reverse operation - disrembler disrembler on the receiving side. The discrembler extracts the original from the sequence being received [3]. The bulk of the skrembler is a sohtatasodif sequence generator (STK), which will be executed in the form of an inverted n-cascade linear register forming a sequence of maximum length $2n-1$. When synchronization is lost between a Skrembler and a descrembler, the time to restore synchronization is equal to the number of skrembler register yachts. Batavsil information about the AMI and HDB-3 codes in the AMI li code makes a queue of positive and munfiy

polar pulses when changing unit symbols in the initial binary sequence independent of the number of zeros between them. Due to the principle of modification shown, the invariant organizer from the line is removed from the energetic spectrum of the code. Atavsil information about the AMI and HDB-3 codes in the AMI li code makes a queue of positive and munfiy polar pulses when changing unit symbols in the initial binary sequence independent of th. AMI ni allows you to easily find errors that occur in regenerating due to the use of the principle of alternating arrival of the poles of code impulses, since if an arbitrary sign regenerates, this case leads to a violation of the principle of alternating arrival of the poles of signs in the linear tract. The coefficient of errors in the linear tract can be estimated based on the number of such violations in a certain period of time. In this case, it should be noted that in some cases, errors may remain undetected (if, for example, there are errors in the regeneration of signs coming one after the other, and they did not violate the structural principle of this code). One of the most important defects of AMI li code is the transmission of long series zeros on a linear track, which can damage the normal operation of regenerators, since the process of separating the tactile frequency becomes more difficult. Several modifications of the AMI li code have been developed in order to eliminate the specified defect, the common one within which is the HDB-3 code. The structure principle of HDB-3 code is exactly the same as AMI li code until more than three one-to-one zero characters appear between the two unit characters. he structure principle of HDB-3 code is exactly the same as AMI li code until more than three one-to-one zero characters appear between the two unit characters. In this case, each sequence of four zeroes (0000) characters in the initial binary code is replaced by one of two sequences in the form of V00U or 000u, where V denotes the polar pulse opposite the pole of the previously arriving pulse, and V denotes the pulse repeating the previous v Pulse pole. The use of two alternating sequences ensures that the poles of the V symbols arriving at different locations of the linear signal come in turn, which in turn eliminates the effect that these symbols have on the mean. The combination 000V is used if an even number of V symbols appears after the previous V symbol, and the combination V00U is used if an even number of V symbols appears after the previous V symbol.

But the numerical sum of the HDB-3 Code can be $2(+1/2)$ or $(-1/2)$ as large as the AMI li code due to the inclusion of V characters. But the numerical sum of the HDB-3 Code can be $2(+1/2)$ or $(-1/2)$ as large as the AMI li code due to the inclusion of V characters. Thus when the HDB-3 code is used, the variation range of the probability of occurrence of unit characters in a linear signal is significantly reduced, which is limited to $0.25 < p(1) < 1$ boun.

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