The solution

Owing to Dalamber's theorem for numerical sequences it we have $\lim_{n\to\infty}\left|\frac{a_{n+1}}{a_n}\right| = \lim_{n\to\infty}\left|\frac{\underbrace{\sin\sin..\sin 1}_{(n+1)\_pa3}}{\underbrace{\sin\sin..\sin 1}_{n\_pa3}}\right| = b < 1$ as, $\left|\frac{\sin t_n}{t_n}\right| < 1$ where then $t_n = \underbrace{\sin\sin..\sin 1}_{n\_pa3}$ the required limit is equal to zero.

REFERENCES

1. Nemytsky Century About, Sludsky M.N., Tcherkasov A.N. course of the mathematical analysis / M.N. Sludsky, A.N. Tcherkasov. – M., 1957. – T. 1. – 486 p.
2. Shabunin, M.I. A Course of the mathematical analysis / M.I. Shabunin, A.M. Rubbed-krikorov. – M.: Nauka, 1988. – 815 p.
3. Davidov, N.A. The Collection of problems under the mathematical analysis / N.A. Davidov, P.P. Korovkin, V.N. Nikolsky. – M.: Education, 1973. – 256 p.
4. Demidovich, B.P. The Collection of problems and exercises under / B.P. Demidovich. – M.: Nauka, 1972's mathematical analysis. – 544 p.
5. Rivkind, J.I. Of the Problem under the mathematical analysis / J.I. Rivkind // Dep. «Higher school». – 1973. – 109 p.

UDC 621.372.037.372

ASSESSMENT CRITERION OF THE INFORMATION CHANNEL AND INDUCED SIGNAL IN ADJACENT CHANNEL

D. RABENKA, V. ZHELEZNYAK

Influence of the transmission channel is estimated by induced signal attenuation in adjacent channel. It is suggested to estimate induced signal by its carrier capacity in adjacent channel using Shannon's equation and minimal carrier capacity criterion by Shannon limit.

Let us consider a Gaussian channel with maximal carrier capacity C (bit/sec). High fidelity notably the degree of conformity of a received message to a sent one is guaranteed in this type of channel. High fidelity depends on channel bandwidth as well as on signal power – noise power ratio. Meanwhile, signal bandwidth should be less than channel bandwidth and signal power – noise power ratio should be maximal. For instance that ratio should not be less than 20 dB for speech signal.

Signals with spectrum spreading are used for greater data transmission speed securing. Signals of that type have a set of advantages [2]:
- enhanced interference immunity;
- energy hiding;
- possibility of signal code division support for multistation access;
- ability to withstand intentional interference;
- enhanced carrier capacity.

Carrier capacity defined by Shannon's equation may serve as impact of the transmission channel on adjacent channel assessment criterion [1]:

$$C = W_c \log_2 (1+S/N). \quad (1)$$

As follows from equation (1), carrier capacity of a Gaussian channel C (bit/sec) is defined by signal bandwidth W_c (Hz), signal power S (watt) – average noise power N (watt) ratio. Signal is limited by signal bandwidth W_c.

Detected noise power is proportional to bandwidth W_c and noise power spectral density N_0:

$$N = N_0W. \quad (2)$$

Substituting (2) in (1) we obtain:

$$C/W_c = \log_2 (1+S/N_0W)). \quad (3)$$

Bit energy E_b – noise power spectral density N_0 ratio is examined in [1]:

$$E_b/N_0 = SW_c/NR, \quad (4)$$

where R is a bit rate.

If the carrier capacity of the channel is equal to the bit rate (R=C) then the equation (4) takes on form:

$$S/N_0C = E_b/N_0. \quad (5)$$

Then the equation (3) is transformed:

$$C/W_c = \log_2 (1+E_b/N_0\cdot C/W_c), \quad (6)$$

$$2^{C/W_c} = 1+ E_b/N_0\cdot C/W_c,$$

$$E_b/N_0 = W_c/C(2^{C/W_c} -1) \quad (7)$$

Relation of E_b/N_0 and normalized channel bandwidth is shown in Figure 1.

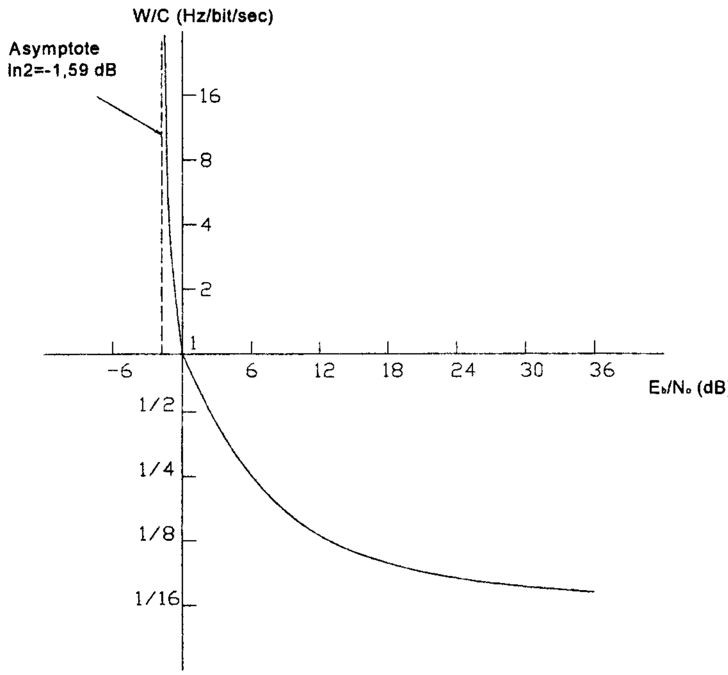

Fig. 1. Relation of E_b/N_0 and normalized channel bandwidth

Let us compute boundary value E_b/N_0 with the help of relation (8):

$$\lim_{x\to\infty}(1+x)^{\frac{1}{x}} = e. \quad (8)$$

Substituting $x = E_b/N_0$ (C/W_c) in (6) we obtain:

$C/W_c = x\log_2(1+x)^{1/x}$

$1 = E_b/N_0\log_2(1+x)^{1/x}$

If C/W_c is close to 0 then

$E_b/N_0 = 1/\log_2 e = 0{,}693$

It is impossible to make an error-free data transmission on no speed if innermost limit $E_b/N_0 = -1{,}6$ dB.

For the reason of the equation (1) carrier capacity in adjacent channel should be minimal. Minimal carrier capacity in such a channel is ensured by the conditions when signal bandwidth exceeds channel bandwidth and signal power – noise power ratio is minimal.

As follows from equation (1), the replacement of the signal power – noise power ratio by a carrier capacity of the channel is possible. In such conditions Gaussian channel can run even when noise power considerably exceeds signal power. Under given fidelity it is possible to guarantee reliable information interchange subject to its hiding requirements.

Widespread adoption of digital technology as compared with analog technology offers a number of advantages [2]:

- increase of quality and quantity of transferred information;
- complete automation of technique both individual units and system in whole;
- application of new formats of information processing;
- creation of systems with conventional access and feedback channels.

One of the requirements for the digital data transfer channel is high reliability, which is characterized by error probability per data bit. Error probability should be minimal, about $10^{-6}\ldots10^{-8}$.

For example let us consider a channel with phase modulation. Output error probability of demodulator for antipodal phase modulated signals with coherent reception can be found [4]:

$$P_{ош} = Q(\sqrt{(2RE_c/N_o)}), \quad (9)$$

where $E_b/N_o = h_o^2 = P_cT/N_o$ – signal-noise ratio; P_c – average signal power; T – symbol duration; N_o – spectral-noise density; R – code rate.

$$Q(t) = 1/\sqrt{(2\pi)}\int_x \exp(-t^2/2)dt. \quad (10)$$

Output error probability of demodulation for antipodal phase modulated signals with optimal noncoherent reception can be found:

$$P_{ош} = 0{,}5\exp(-0{,}5RE_c/N_o). \quad (11)$$

Minimal symbol energy – spectral-noise density ratio should match the equation [3]:

$$E_c/N_o > 1/2R(2^{2R} - 1). \quad (12)$$

Equation (12) defines the relation of Shannon limit (minimal signal-noise ratio) and encoding rate R.

The formula for the binary channel with antipodal signal looks like:

$$h_o^2 = f(R), \quad (13)$$

where $h_o^2 = E_b/N_o$, $R = k/n$, k – input number of symbols (entry of encoder), n – output number of symbols (output of encoder) (k < n).

The carrier capacity in the adjacent channel should be minimal and should be defined by Shannon limit for phase-shift keyed signal subject to error probability.

Energy benefit Z is a coding gain indicator for information channel (Fig. 2) [4]. Energy benefit can be found as a difference between signal-noise ratios for encode and decode transmission.

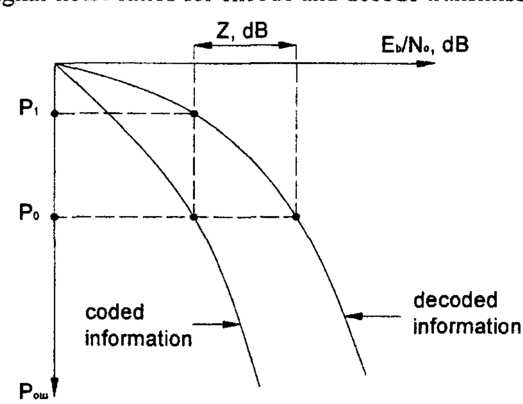

Fig. 2. Signal-noise ratio – error probability relation

As data transmission with minimal error probability is possible only if V < C (V – data flow rate coming to the entry of encoder ($V = 2W_cR$)), formula (1) takes on form [4]:

$$2W_cR < W_c\log_2(1+S/WN_0); \quad (14)$$

$$2W_cR < W_c\log_2(1+2RE_b/N_0). \quad (15)$$

Inequality (16) defines the relation of minimal signal-noise ratio and encoding rate [4].

$$E_b/N_0 > 1/2R(2^{2R} - 1). \quad (16)$$

Degree of approximation of data signals characteristics and Shannon limit reflects coding gain. Shannon limit defines minimal signal-noise ratio for fixed encoding rate.

Summary: It is suggested to estimate carrier capacity of Gaussian channel using Shannon's equation. Shannon limit determines potentially reachable signal-noise ratio for fixed encoding rate. You also can judge quality of signal encoding (using any code) by Degree of approximation of data signals characteristics and Shannon limit.

REFERENCES

1. Sklar, B. Digital communications. Fundamentals and Applications. Second edition. Williams / B. Sklar. – 2007.
2. Noise immunity of spread-spectrum broadcasting by pseudorandom sequence modulation / V. Borisov [et al.]. – M.: Radio and Communications, 2003.
3. Kovalgin, U. Digital encoding of digital signal / U. Kovalgin, E. Vologdin. – SPb.: Korona-print, 2004.
4. Serdukov, P. Protected radio systems of digital data link / P. Serdukov, A. Belchikov, A. Dronov. – M.: AST, 2006.

UDC 681.3.06(075)

LOSSES IN OPTICAL FIBRE CONNECTIONS

A. SMULKEVICH, P. GARBUZOV, D. DOVGIALO

The problem of qualitative connection in optical fibre joints has been and is urgent today. Present paper is considering the circumstances of non-qualitative performance of processes of optical fibre connection. The below stated article will help to get the idea of binding processes and to avoid gross errors in joining optical fibre.

Introduction. Nowadays the demand of consumers is oriented towards high-speed communication lines which possess a high degree of resistance against outer destabilizing factors – electromagnetic fields, heightened and lowered temperature conditions, high humidity. The most appropriate solution of the set task for the provider is optical fibre (OF). While laying optical communication fibres for long distances one should take into account not only inner losses of fibre but losses in their connections as well, because losses in one joint can be equaled to inner losses of one kilometer of OF. Long attenuation for single-mode fibre at the wave-length of 1310 nm is 0,3 – 0,4 dB/km, and at the wave-length of 1550 nm is only 0,2 – 0,3 dB/km. It is worth noting that in one mechanical connection of fibres there appears attenuation up to 0,5 dB, in a welded joint up to 0,02 dB, and losses in adapters reach as high as 1,5 – 2 dB [1].

In present days mechanical and welded connections are the most widespread. For mechanical as well as for welded connections the processing of OF consists in removing of protective coat and recoating OF, and splitting OF ends. Besides, it is necessary for a mechanical connection to perform qualitative OF positioning into the connecting socket and to compress it. In a welded connection one should evaluate the quality of the end, adjustment of fibres, welding its elf and checking the quality of the connection.

The main part. The appearance of gross losses can be facilitated by the connection of fibres from different manufacturers, or even different consignments from one and the same manufacturer. The reason for that is the use of various materials and technologies for OF production. Of course, technologies are unified and standardized, but there always exists allowance for these or those characteristics. It is connected with different quantity of admixtures in OF core, with the difference in refraction coefficients, which in its turn will lead to the appearance of big attenuations at the joins, for the reason of light transition from one medium into another. The best result of connection is possible when one uses OF from one reel.

Contamination at optical fibre connections (Pict. 1, a) is one of the most serious reasons for optical line failures, which in its turn facilitates return to the use of copper-conductor cable.

An example of one of the most undesirable kinds of contamination is hydroxyl ions (HI) that make an absorption line at the wave-length of 2730 nm (its harmonic waves and combination components are 1390, 1240 and 950 nm). The essence of water maximum is decomposition of water and penetration of hydrogen removed from water into glass. As a result glass becomes turbid, which considerably increases losses. The presence of the so-called water levels is detected with the help of comparison of measuring at the length of 1244 nm from 1310 nm up to 1550 nm. Water vapours can provoke considerable losses at approximately one water peak – 1390 nm – even with such a low density as one millionth. One can avoid this kind of losses by decreasing the quantity of extrinsic admixtures. However, the decrease of light wave-length leads to Rayleigh scattering that is conditioned by the presence of air bubbles, cracks and discontinuities in OF connections.