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GUMARBEK DAUKEEV**

Department of
Telecommunication
Networks and Systems

COMMUNICATION NETWORKS AND SWITCHING SYSTEMS

Lectures
for students of specialty
5B071900 - Radio engineering, electronics and telecommunications

Almaty 2019

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Outlines of eleven lectures on the discipline Communication Networks and
Switching Systems are outlined. They present the principles of construction,
operation and management of communication networks and switching systems.

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Introduction

The discipline Communication networks and switching systems is the subject of choice for university students and is included in the curricula as a fundamental discipline.

This discipline is designed to teach students the principles of building and functioning of networks and switching systems of various types, the distribution of information on networks, the principles of analog and digital commutation, the principles of switching in the integration of different information types, the principles of numbering, planning, design and operation of communication networks and digital systems switching.

The purpose of the discipline is to prepare students for independent activity in the field of telecommunication networks and systems operation, as well as in research and development departments of organizations that develop and supply telecommunications equipment to the Kazakhstan market.

As a result of studying the discipline, students should clearly present the main directions and prospects for the development of communication systems and networks, and know the organization of telecommunications enterprises. Be able to perform network load calculations, analyze the reliability of switching networks and systems, plan and design telecommunications networks, systems, devices and units.

Lecture №1. Communication systems and networks and their classification

The aim of the lecture is to study the concepts of the network and the telecommunication system, the classification of networks and systems, composition, structure.

Content:

- telecommunication system, structure;
- telecommunication network, composition, structure;
- classification of networks, types of telephone networks, topologies;
- concept of a commutation system, classification, generalized structure.

Telecommunication system, structure.

Telecommunication system is a set of technical facilities that ensure the formation of a linear path and transmission channels (figure 1.1) [1, 2, 3, 4].

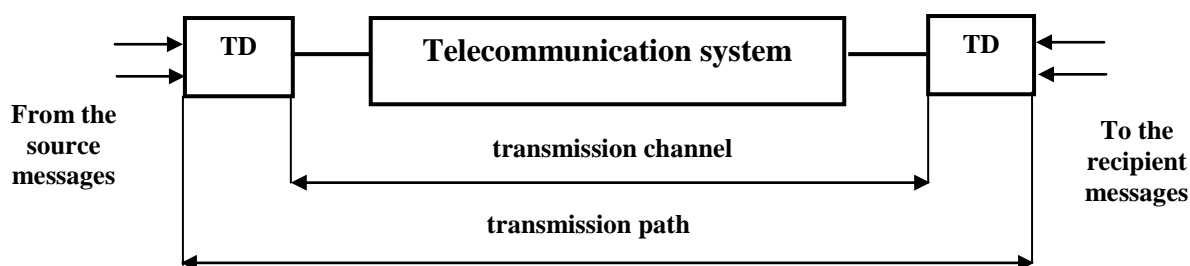


Figure 1.1- Structural diagram of the telecommunication system

The structure of any telecommunication system includes a transmitter, a transmission channel and a receiver. Telecommunication systems are divided into two groups: one-way (information is transmitted only from a source of information to a subscriber ex. broadcasting) and two-way (telephony can serve as an example).

The telecommunication system as a whole solves two problems:

- A) Message delivery - the functions of the telecommunication system;
- B) The formation and recognition of messages - the functions of terminal equipment.

A transmission trail is a set of devices and lines that provide the transmission of messages between users.

The transmission channel (link) is part of the transmission path between any two points. The end devices do not enter the transmission channel.

Telecommunication network, composition, structure.

Telecommunication network - a set of communication lines (channels) of switching stations, terminals, in a certain territory, providing transmission and messages distribution (figure 1.2) [1, 2]. Terminal devices, which ensure the conversion of messages into electrical signals and the inverse transformation, are included at the input and at the output of the communication network. The terminals

are connected to the switching station by subscriber lines. The switching stations are connected to each other by connecting lines. Switching stations connect incoming lines to outgoing lines at the appropriate address.

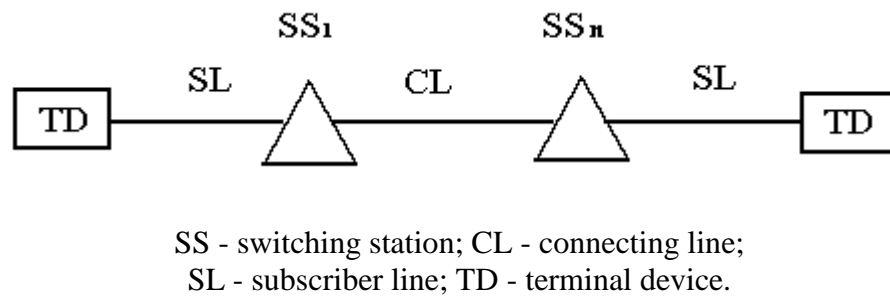


Figure 1.2 - Generalized structural diagram of the telecommunication network (telecommunications network)

In general, the message sent from the source to the recipient consists of two parts: address and information. According to the content of the address part, the switching station determines the direction of communication and selects a particular message recipient. The information part contains the message itself.

The set of procedures and processes that result in the transmission of messages is called a session, and the set of rules in accordance with which the session is organized is called a protocol.

Classification of networks, types of telephone networks.

Different types of telecommunications were developed independently for a long period of time. Each type of telecommunications was focused on the creation of its own channels, transmission systems (TS) and networks. The structure of the network was chosen in accordance with the features of the message distribution flows [1, 2].

Telecommunication networks are divided into the following types:

- telephone;
- telegraphic;
- data transfer;
- facsimile;
- television broadcasting;
- sound broadcasting.

In order to streamline network management, monitor their status and ensure their interaction, it is necessary to classify the networks according to various essential characteristics that will allow to determine the location of each network in the telecommunication system, to reveal the properties of networks from different points of view on the basis of a system approach. Table 1.1 shows the classification of networks.

By designation, the types of telephone networks are distinguished [2, 3]:

- city;

- rural;
- institutional;
- zone;
- intercity.

Table 1.1 - Classification of networks

Classification feature	Network name
Category	<ul style="list-style-type: none"> – public networks – dedicated networks – technological networks – special purpose networks
Functional purpose	<ul style="list-style-type: none"> – access network – transport networks
Type of subscriber terminals	<ul style="list-style-type: none"> – fixed-line networks – mobile network
Method of organizing channels	<ul style="list-style-type: none"> – primary networks – secondary networks
Territorial division	<ul style="list-style-type: none"> – international – long-distance – zone – local
Numbering codes	<ul style="list-style-type: none"> – network code ABC (geographical numbering system) – network code DEF (non-geographical numbering system)
Sustainability and safety	<ul style="list-style-type: none"> – I class main networks – II class backbone networks
Number of telecommunication services	<ul style="list-style-type: none"> – monoservice – multiservice
Types of switching	<ul style="list-style-type: none"> – switched – non-switched
Switching method	<ul style="list-style-type: none"> – with circuit switching – with packet switching – with message switching

City telephone networks (CTN) provide telephone communication in the city and the nearest suburbs.

Rural telephone networks (RTN) provide telephone communication within rural administrative areas.

Institutional telephone networks (ITN) provide internal telephone communication of enterprises, institutions, organizations.

These three types of telephone networks are united by the common name of *local telephone networks*.

Zonal telephone networks (ZTN) are intended for communication between subscribers of local telephone networks located in the territory of one *zone*, characterized by a single seven-digit numbering.

Long-distance telephone network (LDTN) is designed for communication between subscribers of local telephone networks located in the territory of various zones.

Figure 1.3 shows the types of telecommunications network topologies.

A fully connected type of construction, or also known as "each with each" principle is the direct connection between the switches (figure 1.3, a).

Radial type of network construction - communication between switches is carried out through the central switch (figure 1.3, b).

The radial-node type has a central switch, nodal and terminal switches (figure 1.3, c).

The ring type of network construction allows to carry out communication, both clockwise and counterclockwise (figure 1.3, d).

With a combined type - switches on the upper hierarchical level are linked by a fully connected scheme (figure 1.3, e)

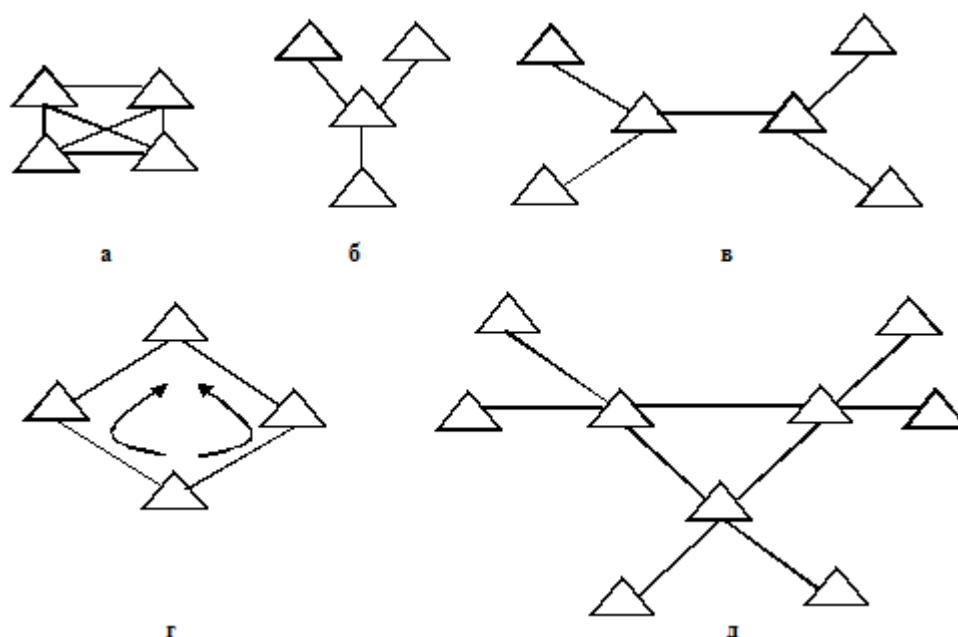


Figure 1.3 - Types of telecommunications network topologies rural

The concept of a commutation system, classification, generalized structure.

Switching system - a set of equipment designed to receive and distribute incoming information on the communication directions.

Classification of switching systems is given in table 1.2.

Table 1.2 - Classification of switching systems

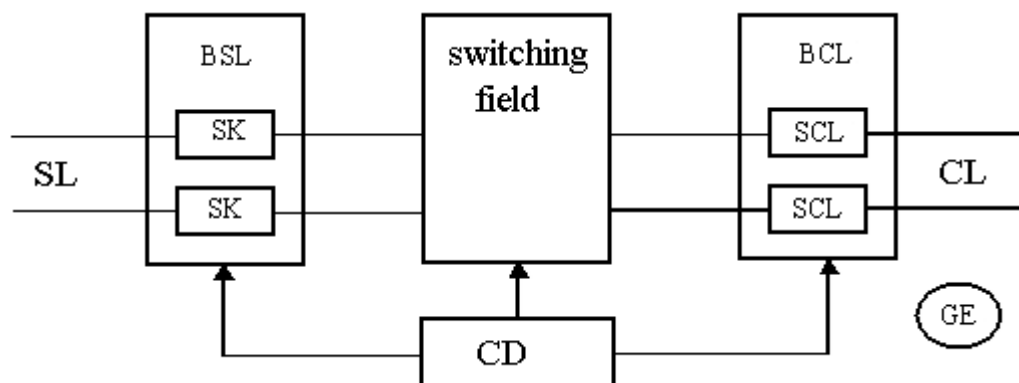
Classification feature	Switching system
Type of switching and control equipment	<ul style="list-style-type: none"> – ten-step – coordinate – quasi-electronic – electronic
Signal presentation form	<ul style="list-style-type: none"> – analog – digital
Type of transmitted information	<ul style="list-style-type: none"> – telephone – telegraphic – data transfer – broadcasting
The place occupied in the telecommunications network	<ul style="list-style-type: none"> – central – nodal – terminal – transit – inbound message nodes (IMN) – outgoing message nodes (OMN)
The territorial division	<ul style="list-style-type: none"> – long-distance – urban – rural – institutional
Capacity	<ul style="list-style-type: none"> – low-capacity – medium capacity – high capacity
Split channels	<ul style="list-style-type: none"> – with spatial separation – with time division
Method of switching	<ul style="list-style-type: none"> – circuit switching – packet switching – message switching

To perform its functions, the switching system must have the following types of equipment (figure 1.4):

- subscriber line units (SLU) connect subscriber lines (SL) to the system;
- trunk blocks (TB) which are connected through TS (trunking sets) to communicate with other switching systems;
- switching field (SF) switches the incoming lines to outgoing ones. The commutation field can be constructed on the basis of channels spatial separation, and then can be used as multiple switching elements, multiple coordinate connectors (MCC), reed switches, ferrides. The commutation field with time division of channels is built on the basis of pulse-code modulation (PCM)

application and uses semiconductor memories and logic integrated circuits as elements;

- control system (CS) performs all the logical functions for establishing connection processes;
- generating equipment forms acoustic signals.



BSL - block of subscriber lines; GE - generator equipment;
 BCL - block of connecting lines; SCL - set of connecting lines;
 SK - subscriber kit; CD - control device.

Figure 1.4 - Generalized structure of the switching system

Lecture №2. Communication networks

The aim of the lecture is: Studying of different telephone networks types and the principles of their numbering.

Content:

- principles of building urban telecommunications networks;
- principles of building rural telephone networks (RTN);
- principles of numbering on the networks of the Republic of Kazakhstan.

Principles for the construction of urban telecommunications networks [2, 3, 11]:

A) Unreleased city telephone networks are networks consisting of one automatic telephone station ATS (automatic station), (figure 2.1).

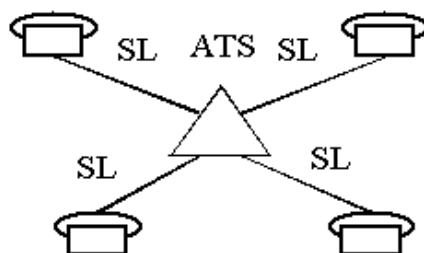


Figure 2.1 - Non-regionalized CTN

B) Regionalized city telephone networks (without nodal formation), figure 2.2, in which there are several district automatic telephone stations (DATS), connected by lines on a principle each with each.

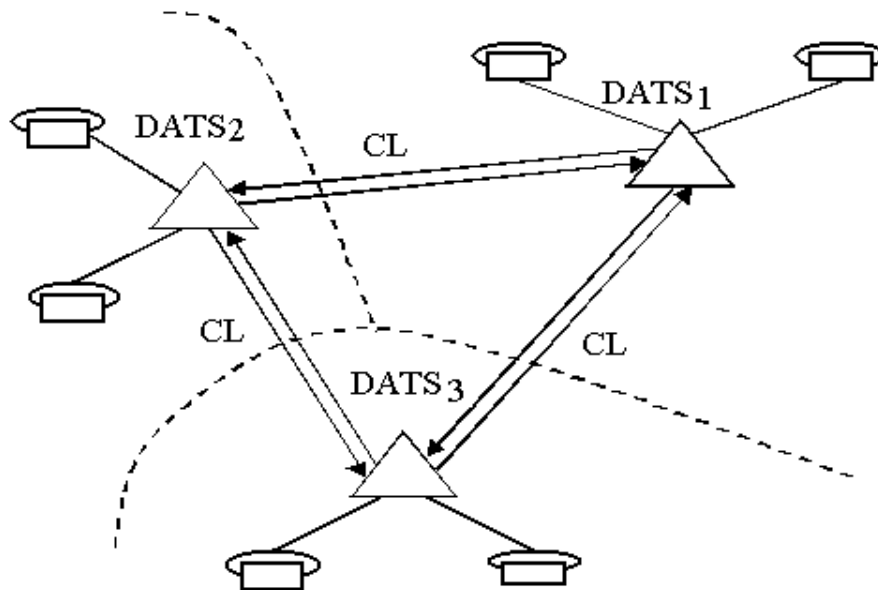


Figure 2.2 – Regionalized CTN without nodal formation

C) Regionalized urban telephone networks with nodes of the incoming message, consist of several nodal areas; the DATS within each nodal region can be linked together according to the principle of each with each (nodal region 1) or communicate through the node of the incoming message (IMN) of its nodal region (nodal region 2), figure 2.3. The capacity of each node area does not exceed one hundred thousand numbers.

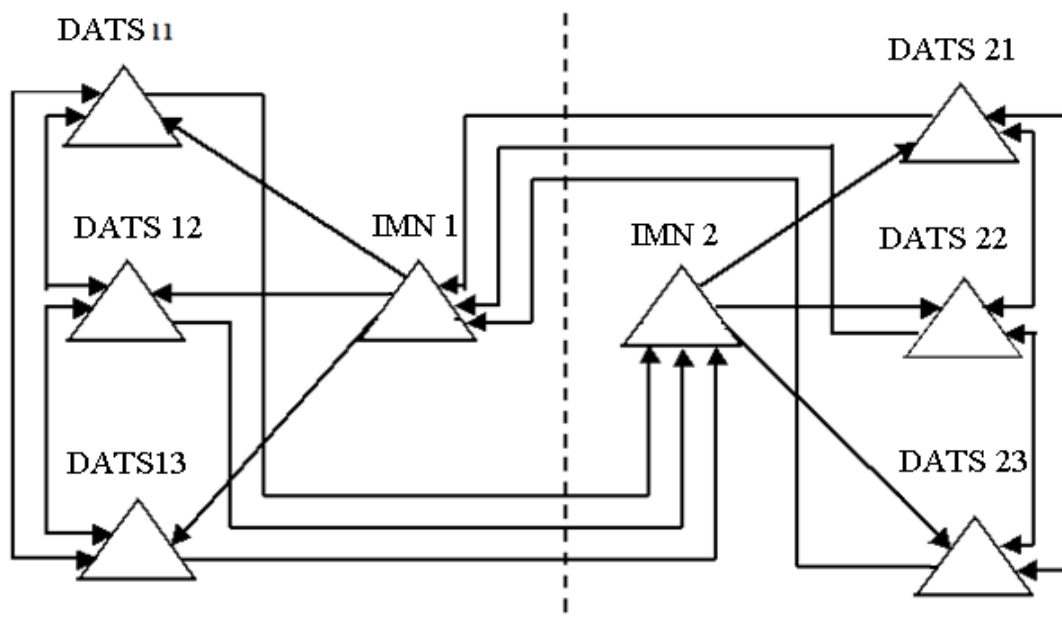


Figure 2.3 – CTN with IMN

D) CTN with nodes of outbound message (OMN) and incoming messages (IMN).

The territory of the city is divided into nodal areas with a capacity of up to 100 thousand numbers each. MIS are built in each nodal district to establish connections between the DATS of different nodal districts where the outgoing load of other nodal area stations is combined and is distributed along the directions to the UHF of its own and to the other nodal areas (maximum 10 MW in the nodal region) (figure 2.4).

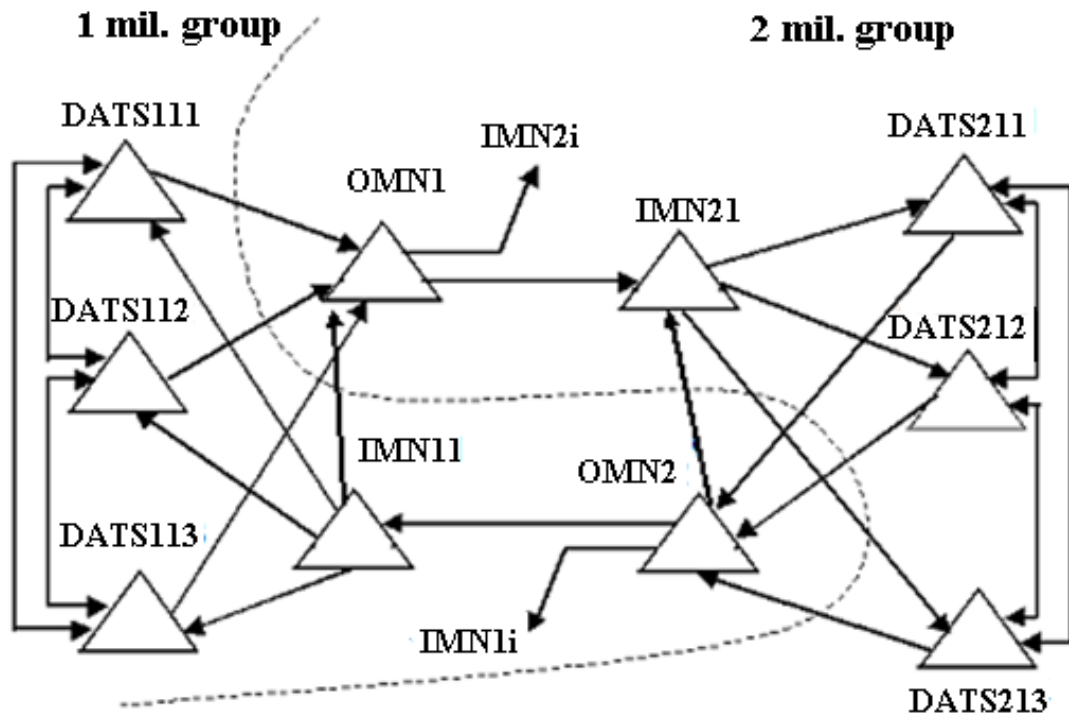


Figure 2.4 – CTN with IMN and OMN

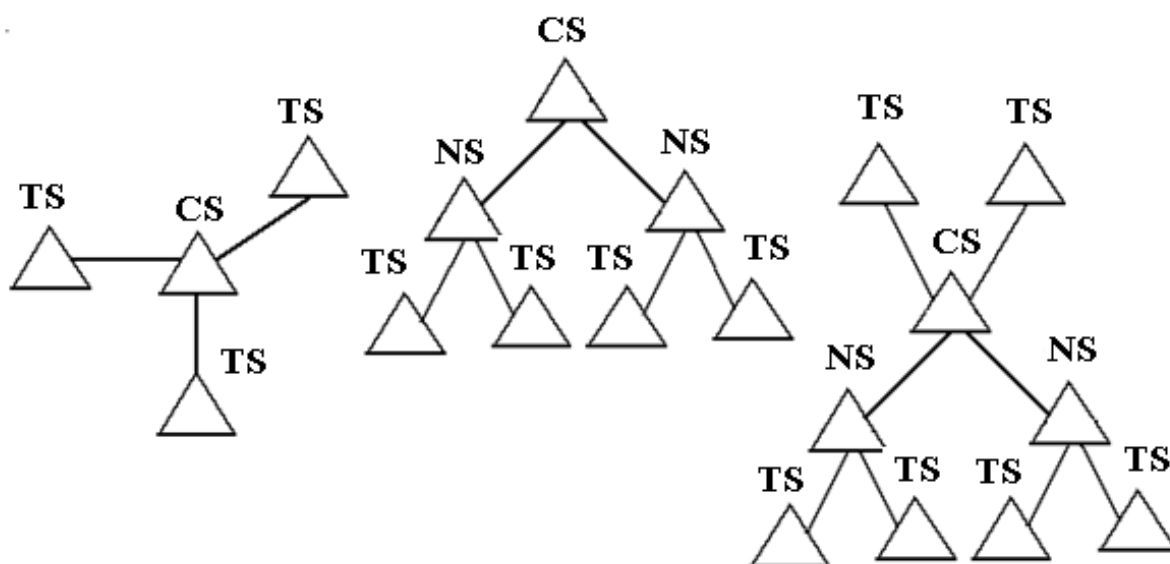
The principles of building rural telephone networks (RTN) [2, 3, 11].

Radial (figure 2.5, a), radial-nodal network construction (figure 2.5, b) are used Republic of Kazakhstan's' RTN. In addition, a combined method is possible (figure 2.5, c).

The RTN consists of: a central station (CS) located in the district Center, which simultaneously performs the functions of the district centers' telephone exchange and the transit node of the RTN. In the CS, the CL (connecting lines) are switched on in radial construction from the terminal stations (TS) or from the TS and node stations (NS) with radial-node construction; Connection is made with the DATS through the CS.

Principles of numbering in networks of the Republic of Kazakhstan [2, 3, 11].

The zoning principle of the numbering plan is applied on telecommunication networks of the Republic of Kazakhstan. In the numbering plan a three-digit ABC code (geographical numbering area) or DEF (non-geographical numbering zone) is assigned for each numbering zone.



a) radial mode; b) radial-nodal mode; c) combined mode.

Figure 2.5 - Principles of RTN construction

Connections between subscribers both within the KZ and between countries are carried out using long-distance numbering (ITU-T Recommendation E.160).

Regardless of the terminal type each user (subscriber) is assigned with a unique meaningful number.

According to the CERT recommendations, the network uses a three-digit code for emergency and reference information services 1UV.

International number consists of the country code, national destination code and subscriber number. The national assignment code ABC (DEF) corresponds to the code number of the called subscriber.

The structure of the international number is shown in figure 2.6.

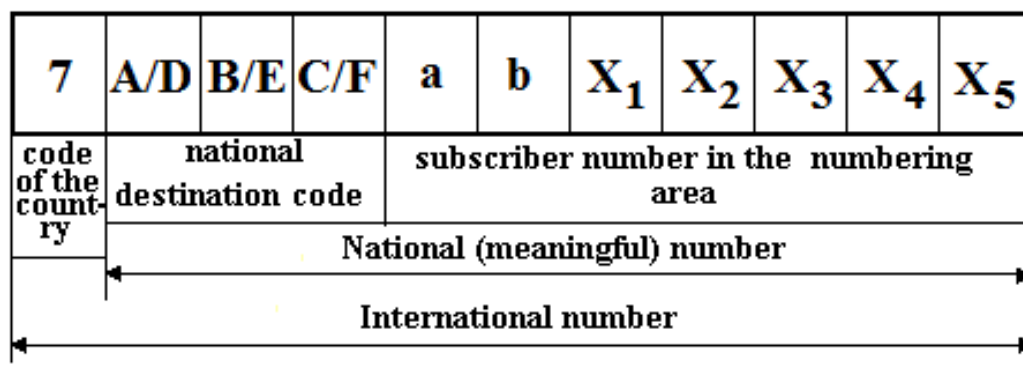


Figure 2.6

The subscriber number in the numbering zone consists of the code **ab** in the local network zone (intra-zone code) and the subscriber number on the local network of the city or rural district center.

The structure of the intrazone number is shown in figure 2.7.

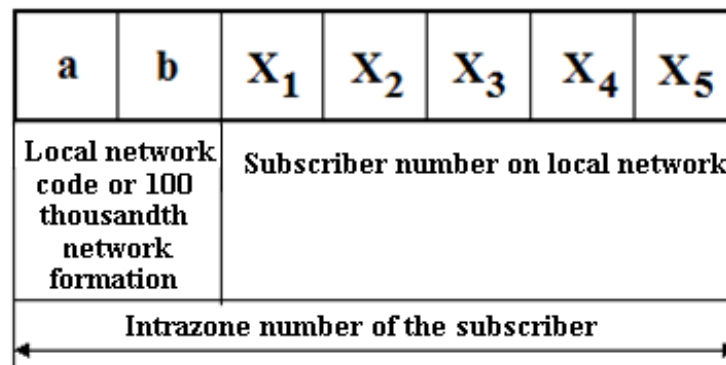


Figure 2.7

Lecture №3. Principles of switching

The aim of the lecture is to study the concepts of pulse-code modulation, the structure of the cycle with a speed of 2 Mbit / sec.

Content:

- the concept of pulse-code modulation and the principle of PCM signals formation;
- The structure of the cycle with a speed of 2 Mbit / s.

The concept of pulse-code modulation (PCM).

The transformation of a continuous primary analog signal into a digital code is called pulse-code modulation (PCM) [1, 2, 4, 5]. In telecommunications, a binary sequence is chosen as the code base, implemented with the least hardware costs. The main operations with PCM are time-sampling, quantization (discretization by the level of a discrete-time signal) and coding.

Sampling of analog signal over time is a transformation in which the representative parameter of the analog signal is given by the set of its values at discrete instants of time.

Uniform sampling of the analog signal is used in digital transmission systems (the samples of this signal are produced at identical intervals of time). In the case of uniform sampling, the sampling interval Δt (the time interval between two adjacent samples of the discrete signal) and the sampling frequency of the FD (the inverse of the sampling interval) are used. The sampling interval is selected in accordance with the Kotel'nikov (Shannon) theorem.

According to Kotel'nikov's theorem, if the sampling frequency is twice the upper frequency of this signal then any analog (continuous) signal can be sampled and reconstructed at the opposite end.

$$F_D \geq 2F_{MAX}$$

The tone frequency channel (the main channel of the analog telephone channel) should occupy the band 300 Hz ... 3400 Hz. Therefore, the sampling frequency should be not less than: $F_d = 2 \times 3400 = 6800$ Hz. According to the recommendations of ITU (International Telecommunication Union), the sampling frequency $F_d = 8000$ Hz is adopted for the signal transmitted over the tone frequency channel. This frequency facilitates the implementation of the DTS equipments' filters.

The sampled pulses correspond to the amplitude of this signal's instantaneous values. These transformations are called amplitude-pulse modulation. The discrets are transmitted one by one cyclically in the form of temporarily condensed APM signals, figure 3.1 a, b.

In quantization any technique for processing messages and transmission systems has a finite resolution so there is no need to transmit the entire infinite set of continuous amplitude values signals. It can just be limited to a finite set. These amplitude values of signals allowed for transmission are called *quantization levels*, the choice of their number determines the quality of electrical signals' transmission, figure 3.1, c.

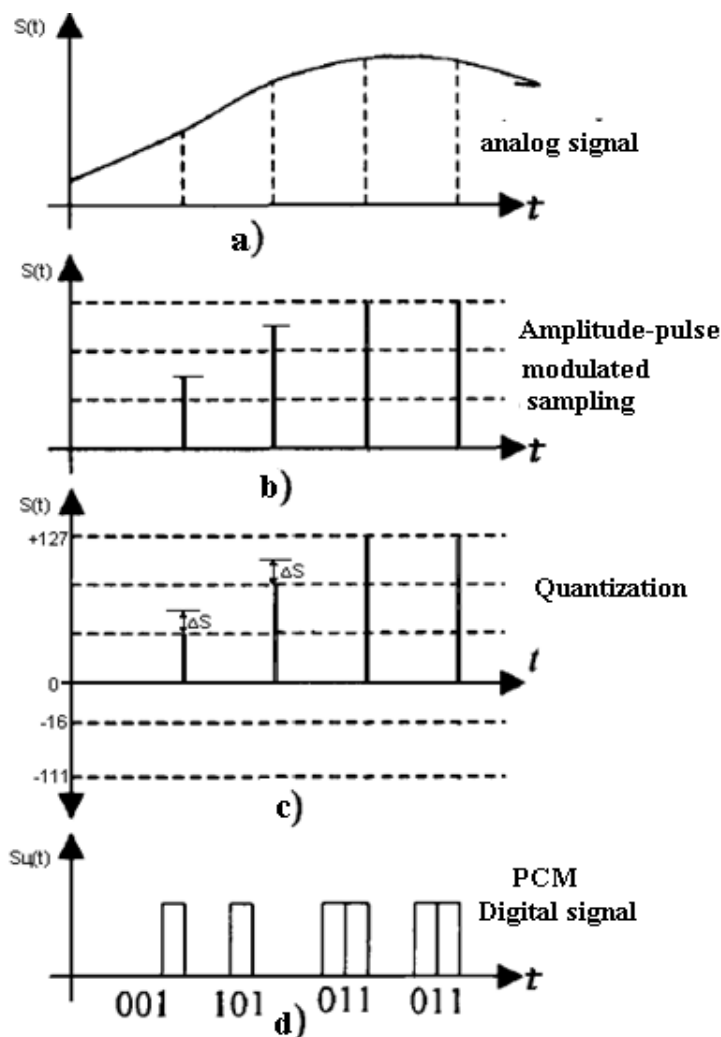


Figure 3.1- Converting an analog signal to a PCM signal

The signal obtained by sampling the APM is quantized by level. The difference between two adjacent allowed for transmission levels is called the *quantization step- Δ* .

The difference between the true value of the signal reading and its quantized value is called the *error or quantization noise*.

The encoding of a quantized reference is the identification of this reference with codewords. In practice, PCM hardware uses binary code words with each binary word corresponding to a certain level of signal quantization. According to the recommendations of the ITU, 256 quantization levels (128 positive and 128 negative levels) were accepted, and the length of the code word is 8 binary symbols (bit), figure 3.1, d.

The first digit of the eight-digit code combination determines the polarity of the encoded signal's amplitude (1- positive "+", 0 - negative "-"); 2,3,4 bits determine the vertex of the segment in which the signal is located; 5,6,7,8 bits define the level number in the segment.

The structure of the cycle with a speed of 2 Mbit/s.

The transmission of speech via separate frequency channels on the telephone networks is carried out in the range from 300 Hz to 3400 Hz. Organizations of the digital commutation path uses primary PCM stream 30/32 [1, 2, 4].

The structure of the cycle and the super cycle of the PCM-30 system is shown in figure 3.2. The cycle consists of 32 time slots. The super cycle consists of 16 cycles. The duration of the cycle is $T_C = 125 \mu s$, which determines the repetition rate of the cycles $f_c = 8 \text{ kHz}$. The duration of the super-cycle is $16 \times 125 \mu s = 2 \text{ ms}$. For each channel in the cycle, the interval $\tau_{C.I} = 3.9 \mu s$ is allocated. Each channel is designed to transmit information 8-bit binary code, then the duration of one bit is $\tau_b = 0.49 \text{ microseconds}$. Bandwidth of one time slot is 64 kbit / s , then the bandwidth of the standard primary PCM path is $64 \times 32 = 2048 \text{ kbps}$. In the PCM cycle, the time slots 0 and 16 are service channels, and the intervals 1 to 15 and 17 to 31 are information channels.

As can be seen from figure 3.2, the digital clock signal takes positions 2-8 of the zero channel interval in each second cycle. The cycle clock is a combination of 0011011. Value 2 is assigned to symbol 1 in the intervals to eliminate the possibility of simulating a frame clock signal by symbols 2 - 8 zero intervals of odd cycles. The super-cycle clock which allows counting cycles in the super-cycle is 0000 and occupies the 1- 4 of the channel interval 16 in cycle 0.

The channel spacing 16 serves to transmit the signaling. In each cycle, signaling signals are transmitted in two telephone channel.

Notations in figure 1.2: TC - telephone channel number; RO, RI5 - cycles in the super cycle; SK - channel spacing; B1, .. B8 - a code word with a length of 8 bits; N-bit is reserved for international use (the value of the symbol is not defined, currently it must be set to 1); A - transmission of the alarm signal to the PCM equipment at the end of the communication line; VI, V5 are symbols intended for national use (on digital paths crossing state boundaries) these symbols should have the value 1; X - the reserved character (in case it does not use I value);

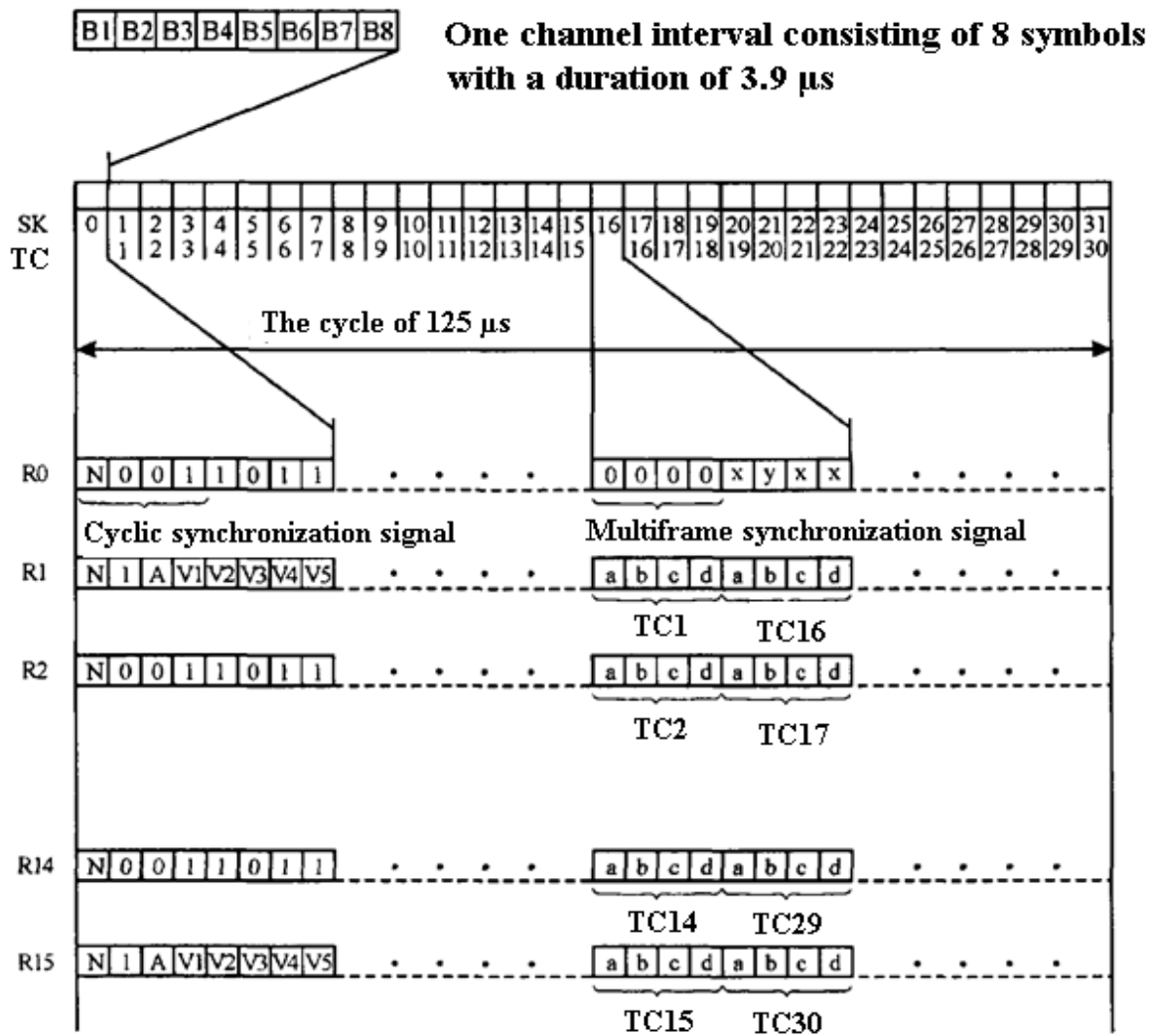


Figure 3.2 - Structure of the cycle and the superframe of the PCM-30 equipment

Y is the symbol used to indicate the output from the super cycle clock signal; A, b, c, d-symbols for organizing a common signaling channel (CSC), if b, c and d are used for CSC, they should have the following values: b = 1, c = 0, d = I.

Lecture №4. Digital switching principles

The aim of the lecture: studying of the basic concepts and definitions of switching and principles of coordinates of a digital signal transformation.

Content:

- basic definitions and concepts of switching;
- the principle of converting the time coordinate of a digital signal;
- the principle of transforming the spatial coordinate of a digital signal;
- the principle of space-time commutation.

Definitions and concepts of commutation.

Switching is the process of establishing a connection between a specific input and output of the system and maintaining it for the duration of the transfer of user information, and then disconnecting. There are the following switching methods [1, 2, 4]:

- channel Switching (literal translation switching circuits);
- message Switching;
- packet Switching.

For *channel switching*, firstly a through communication channel is created, then this communication channel realizes the exchange of information in real time and after the completion of the exchange the communication channel collapses.

For *message switching*, data is not exchanged in real time, a through connection between the input and the output of the system is not required and redundant messages are not lost, but are stored and transmitted with a delay.

For *packet switching*, the message is divided into blocks of a certain size - packets. Each packet is transmitted independently as soon as the available communication channel is freed. On the receiving side, the message is recovered from packets received at different times and can be in different ways.

One-coordinate is called switching, in which the connecting paths in the system are divided from each other by one separating feature, where by the separating feature is meant the parameter by which the system separates the connecting paths between the input and the output.

Digital switching is a process in which the connection between the input and output of the system is established by the operation of a digital signal without converting it to an analog one.

The principle of converting the time coordinate of a digital signal (the principle of time switching).

A block or module that performs the function of temporary switching of a digital signal is called a *time switching stage* or a *T-stage (from time- time)* [1, 2, 4].

Changing the order of one channel interval of the outgoing PCM line in comparison with the incoming one means the transmission of voice information from one subscriber to another, figure 4.1. This is the principle of temporary switching (*sometimes we talk about rearrangement of the channel intervals or the transfer of information from the channel to the channel*).

Using of the vector representation of digital switching, figure 4.2, in space-time coordinates allows us to describe the principle of temporary switching somewhat differently. If we assume the orthogonality of the transformations of the time and spatial coordinates of the digital signal, we obtain the expression:

$$\Psi(S, T) = \Psi(T) + \Psi(S).$$

For time switching $\psi(s)=0$. Operation $\psi(\tau)$ is simply an operation of delaying a particular code word at a predetermined time. The disadvantage of the temporary switching module is that it is able to switch the channels of only one digital line. Therefore, N modules need to be switched for N PCM lines. And for the

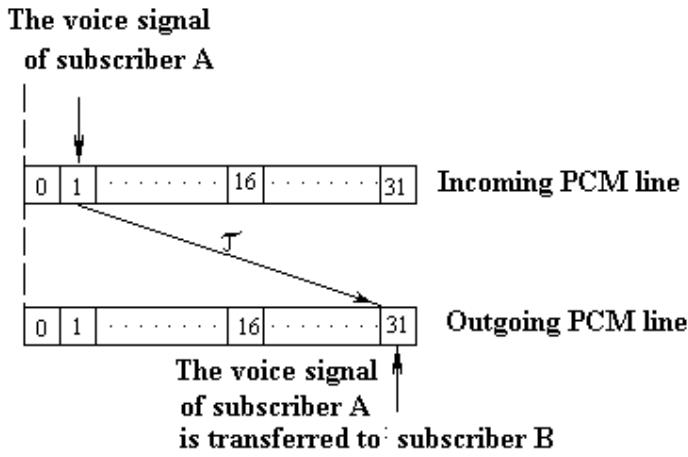


Figure 4.1- Illustration of time switching principle

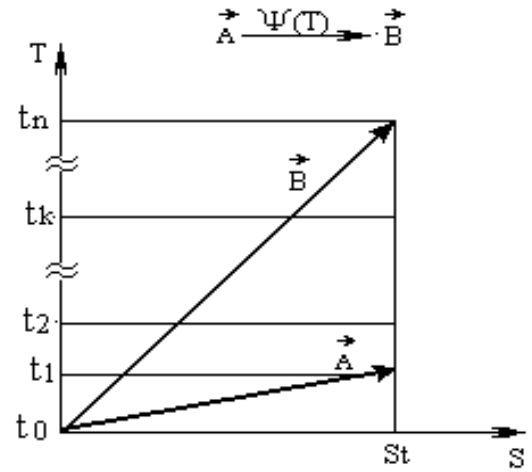


Figure 4.2 - Vector representation of time switching

of connection among themselves different PCM lines in series with it, it is necessary to include additional equipment - blocks of spatial or space-time switching.

The principle of transforming the spatial coordinate of a digital signal (the principle of spatial switching).

A block or digital switching field module that performs spatial switching of a digital signal is called a spatial switching step or an S-step (from the word “space”) [1, 2, 4].

The essence of the transformation of the spatial coordinate of digital signals is to move the given channel interval from one PCM line to another with the order of the channel interval remaining in the cycle structures of both lines, figure 4.3.

The vector representation of such a transformation is shown in figure 4.4. In this case, the orthogonality of the transformations of the temporal and spatial coordinates of the digital signal is again assumed:

$$\Psi(S, T) = \Psi(T) + \Psi(S) = |\Psi(T) = 0| = \Psi(S).$$

Digital SFs built on the modules of spatial switching were widely used at the first stages of the creation of digital exchanges, in view of the simplicity of implementation and inexpensive implementation. However, the lack of a spatial switch in which only one channel of the same name for all incoming and outgoing PCM lines is switched (which means interlocks when connecting different channels) has led to the fact that these modules are currently used only in combination with other types of switching modules.

The principle of space-time switching.

A block or module that realizes the space-time transformation of the coordinates of a digital signal is called the S / T-step.

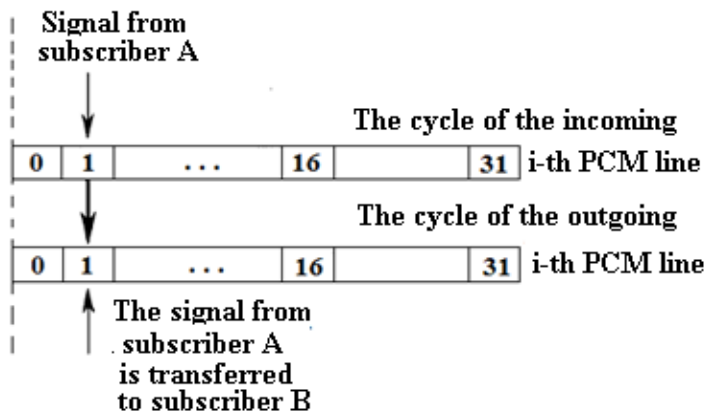


Figure 4.3- Illustration of spatial switching principle

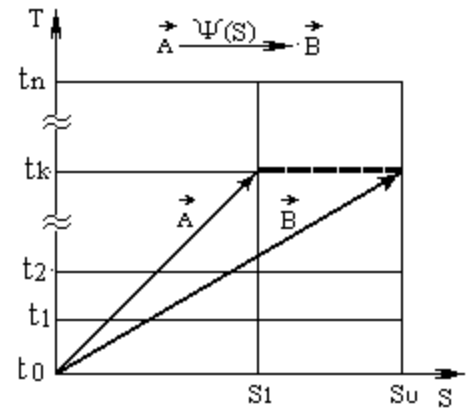


Figure 4.4 - Vector representation of spatial switching

The essence of the transformation of the space-time coordinate of digital signals is to move the given channel interval from one PCM line to another with the change in the order of the channel interval in the structures of the cycle of both lines, figure 4.5 [1, 2, 4].

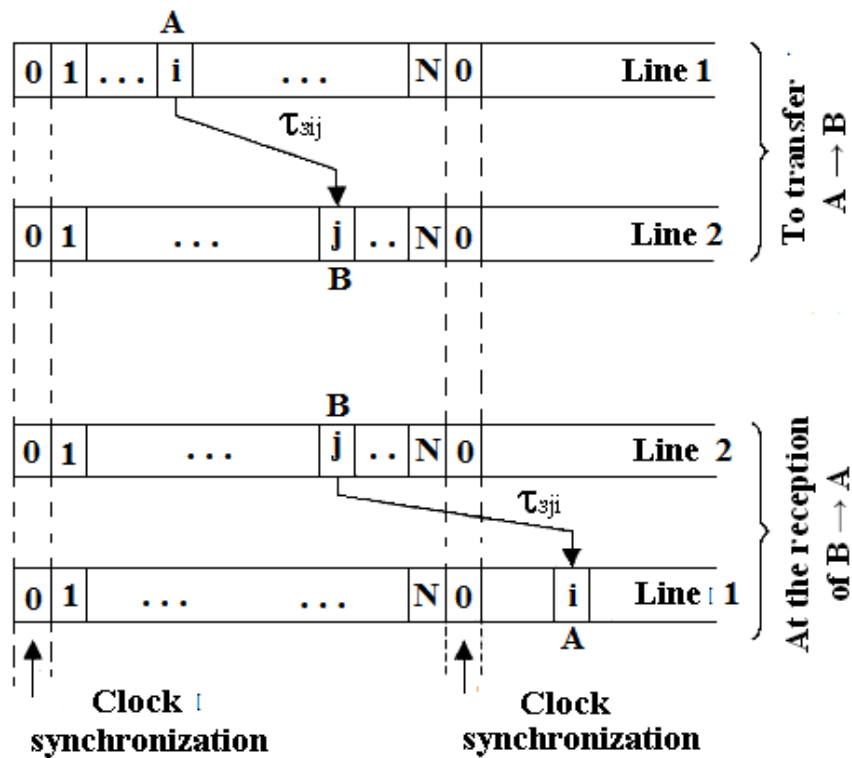


Figure 4.5 - Illustration of the principle of space-time switching

The vector representation of space-time switching is shown in figure 4.6. The block implementing this principle is a single constructive block. That is why $\psi(s, \tau)$ is impossible to be represented as the sum of orthogonal transformations $\psi(\tau)$ and $\psi(s)$.

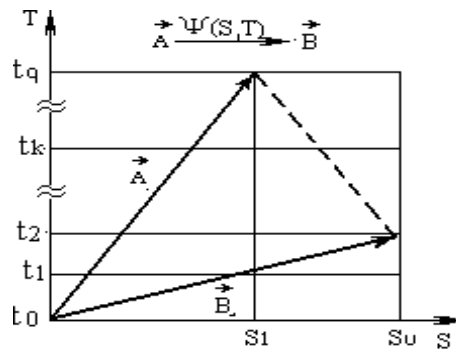


Figure 4.6 - Vector representation of space-time switching

Lecture №5. Digital switching fields 1, 2, 3, 4, 5-th class

The aim of the lecture is to study the classes of the digital switching field:

- principles of construction of the DSF;
- classification of the DSF;
- features of the operation of the DSF.

Principles of construction of the digital switching center.

The switching system reflects the principles of the internal construction of the switching station and is a collection of technical facilities intended for operational switching [1, 2].

The switching system which realizes the function of digital commutation, has been called the *digital switching system* (DSS).

In the digital switching system, the switching function is carried out by a *digital switching field* (DSF). The management complex manages all processes in the switching system.

The digital SF is usually built on a link principle. The link of the digital SF is a group of steps (S-, T- or S / T-), which realize the same function of converting the coordinates of a digital signal. Depending on the number of links distinguish two-, three- and multi-link SF.

A digital SF is called *homogeneous* if any connection in it is established through the same number of links. Most modern DSSs have homogeneous digital SFs.

Features of building multi-link digital gearbox:

- 1) Digital SFs are built using a certain number of modules.
- 2) Digital SFs have a *symmetrical* structure. The symmetric is understood as the structure in which the links 1 and N, 2 and N-1, 3 and N-2 ... are identical in type and number of switching units.
- 3) Digital SFs are usually *duplicated*, due to the criticality of the malfunctions in the switching field to the functioning of the entire system as a whole.
- 4) Digital SFs are four-wire, since the digital lines through which PCM-compressed signals are transmitted are also four-wire.

Taking into account the symmetry and modularity of the construction, the

entire set of synchronous digital SFs with the functional completeness of switching can be divided into *five classes* [1, 2]. In each class, the basic structure and substructures formed can be distinguished by the addition of an extra switching elements with pre-multiplexing (MUX) and subsequent demultiplexing (DMUX) of digital group paths.

1. Basic structure: $S \times k - T \times r - S \times k$.

Substructure: MUX - $T \times k - S \times r - T \times k$ - DMUX.

A special feature of the field is the presence of the S-stage in the first and last links, the order of the T and S-steps within the field is arbitrary with observance of the symmetry rules.

2. Basic structure: $T \times k - S \times r - T \times k$.

Substructure: MUX - $T \times k - S \times r - T \times k$ - DMUX.

A special feature of the field is the presence of the T-stage in the first and last links, the order of the T- and S-stages within the field is arbitrary with the observance of the symmetry rules.

3. Basic structure: $S/T \times k - S \times r - S/T \times k$.

Substructure: MUX - $S/T \times k - S \times r - S/T \times k$ - DMUX.

4. Basic structure: $S/T \times k$.

Substructure: MUX - $S/T \times k$ - DMUX.

5. Ring digital commutation fields.

Ring gearboxes are built on S/T -stages (ring connectors), and in fact are a variety of Class 4 fields, but in case of their importance and design features, it is customary to separate them into a separate class.

First-class DSF.

Initially, the links of the spatial switching stages were taken as a basis for these types of DSFs: Sintel and DEX-T. They had a S-S type field structure with a parallel switching method. However, spatial switches have a high probability of internal locks, so in practice they got propagations of the structure where the spatial S-steps of switching are separated by temporary T-steps, i.e. such DSFs combine symmetrical fields, figure 5.1.

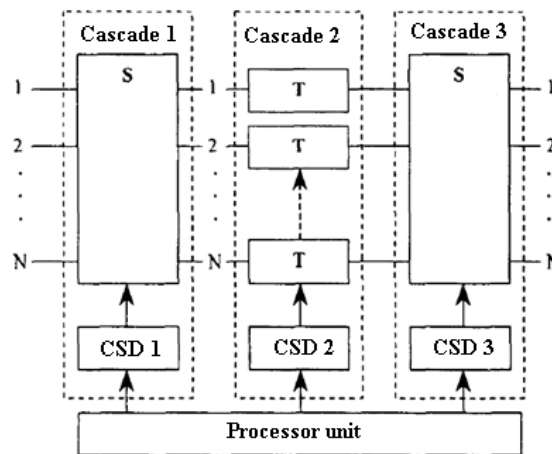


Figure 5.1 - Basic structure of the first category DSF

Second category DSF.

These types of DSF s include systems: NEAX 61 (Japan), No.4 ESS (USA), ACHE 10, D70, FETEX150.

Features of the Second category DSF:

- the use of additional S-stages increases the capacity and field capacity but does not affect the principles of its operation;
- pre-multiplexing at the inputs actually provides a secondary multiplexing of the incoming digital paths and subsequent demultiplexing at the outputs restores them which leads to an increase in the capacity of the DSF without the use of additional S-steps;
- to increase the processing speed of data in the SF at the input serial code is converted into parallel. For this purpose a serial-to-parallel converter is installed on each incoming line and a parallel-to-serial converter on the incoming line.

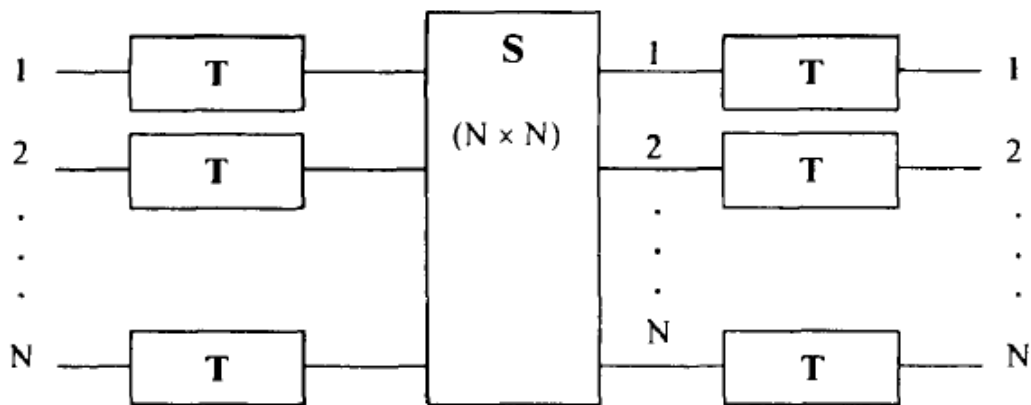


Figure 5.2 - Basic structure of the second-class CCR

Third category DSF.

These types of DSFs include systems: MT 20/25 (France), System X (DSS) (Great Britain), EWSD (Germany), GDTs (USA), DTS-11 (Japan) and a number of others on the basis of which it is possible to build local , Intercity and transit stations.

The DSFs of this class are universal since they allow the same switching systems to be built for almost the entire range of capacities: small, medium and large. At the same time, capacity expansion occurs due to an increase in the number of links in spatial commutation, moving from simpler S/T-S-S/T structures to more complex S/T-S-S-S/T.

During the design of a switching field, the stages of time and space switching are often combined into the corresponding blocks: a temporary switching unit and a spatial switching unit. Then, the capacity of the SF grows by simply adding a certain amount of TSU и SSU.

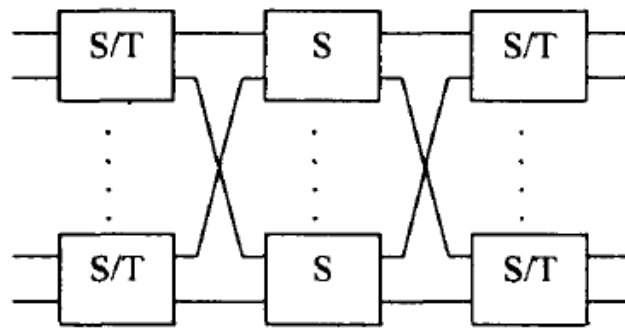


Figure 5.3 - The basic structure of the third category DSF

Fourth category DSF.

These types of DSFs include systems: PROTEL UT and others. The fourth category DSFs are widely used due to the convenience of increasing the field capacity by simply adding S / T-steps made in the form of universal integrated circuits (ICs).

The basis of the S / T-stage consists of switching elements or modules. When designing a small-capacity DATE, their SF can be built using one S / T-link with only one module (typically 8/8 to 32/32 in / out of the PCM lines), figure 5.4.

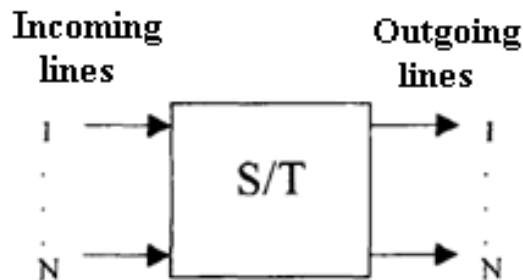


Figure 5.4 - The basic structure of the fourth category DSF

The fifth category DSF.

These types of DSFs include systems: ITT1240 (USA), S12 Alcatel, however ring DSFs are not widely used. The links of the ring field are most often built on ring digital switching elements (DSE). The structure of the ITT1240 system is shown in Figure 5.5. Such DSF consists of connection units (CU) and a group switching unit (GSU). One CU consists of two DSEs. The number of CUs and steps in DSE depends on the number of connected terminal modules (TM). The number of planes depends on the average load created by the TM and on the specified quality of service.

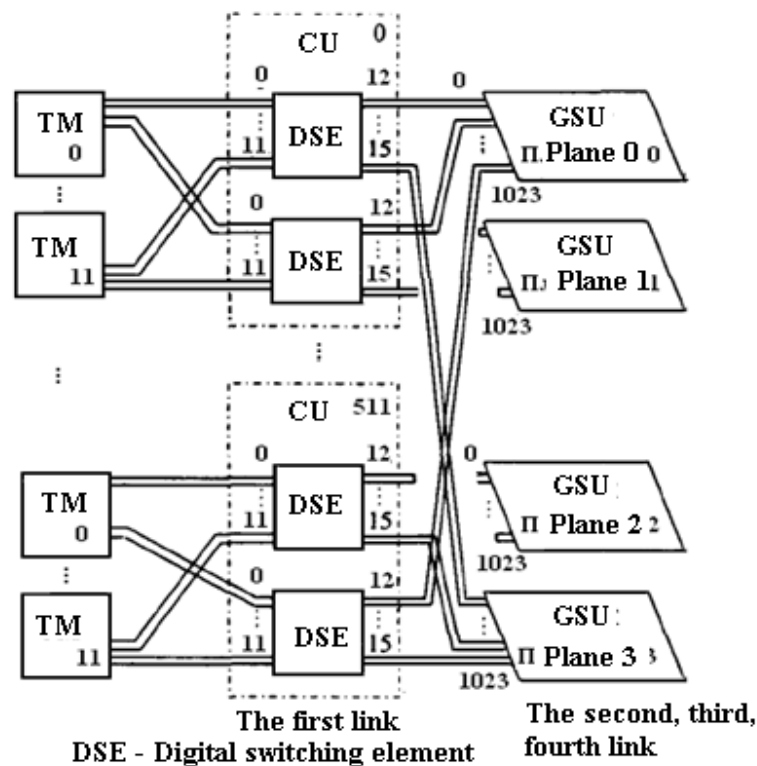


Figure 5.5 - Basic structure of the fifth category DSF

Lecture №6. Constructing a subscriber interface in digital switching systems

The purpose of the lecture: studying the concept DSF interface and DSF subscriber interfaces.

Content:

- interfaces of digital switching systems;
- analog subscriber interface and the BORSCHT problem;
- digital subscriber interface;
- ISDN subscriber interface.

Interfaces DSS.

The operation of digital switching systems occurs in the environment of a variety of telecommunications equipment: other automatic telephone exchanges (digital and analog), various subscriber devices, transmission systems. The DSS should provide an interface (interface) with analog and digital subscriber lines (SL) and transmission systems [1, 2, 4].

The interface is the boundary between two functional blocks, which is specified by the functional characteristics, the general characteristics of the physical connection, the characteristics of the signals and other characteristics, depending on the specifics.

The interface provides one-time determination of the connection parameters between two devices. These parameters are related to the type, number and functions of the connecting circuits, as well as to the type, shape and sequence of signals that are transmitted over these circuits.

Interfaces of the digital automatic telephone exchange, figure 6.1:

- analog subscriber interface;
- digital subscriber interface;
- ISDN subscriber interface;
- network (digital and analog) interfaces.

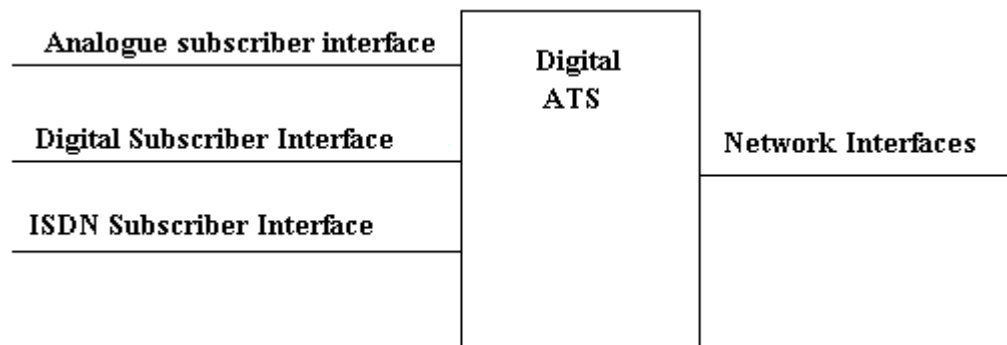


Figure 6.1 - Interfaces of digital switching systems

To connect analog lines (subscriber or from institutional ATSS to devices providing access to a digital station) Z interfaces (Z1, Z2, Z3) are used.

U and V interfaces have been defined to enable digital lines. They are used to enable AL for basic access to ISDN networks. The V2 interface is designed to enable digital substations at a speed of 2048 kbit / s. Digital equipment is switched on with primary access to integrated networks via V3 interface. For example digital ATSS. Multiplexer equipment in digital ATS is enabled via the V4 interface. V5 interface is used for ATS multiplexers to connect digital access networks which are used to connect analog remote stations and analog ATSS.

Analog subscriber interface and the BORSCHT problem.

When creating and implementing digital exchanges occurs a problem of including an analog subscriber line (SL) in the digital exchange with an analog telephone set (TS). These problems are described by the abbreviation BORSCHT (table 6.1) [1, 2].

When the analogue AL is switched on in the DATS, following problems in the organization of the analog subscriber interface have to be solved:

- matching by the type of the transmitted speech signal (function Coding - encoding) and in this connection the transition from the two-wire circuit of the talk path to the four-wire and vice versa (Hybrid function - the function of the differential system);
- matching on the levels of transmitted signals: high-level signals (Battery feed and Ringing functions) are sent to the TA side; these signals should not be

transmitted to the ATS (DATS are built on a BIS and VLSI with a power supply of 5 V ... 12 V);

- provision of subscriber signaling (Signaling function). The functions Testing and Overvoltage protection do not relate directly to the organization of the analogue AL interface, however their implementation allows to automate the operation of AL and TA, and also to protect the DATS from dangerous voltages.

Table 6.1- Description of the BORSCHT function

Letters abbreviations	Function name in English	Functions description
B	Battery feed	The voltage is applied to the subscriber line for the supply of carbon microphones ($U = 60 \text{ V}$, $I = 20 \text{ mA}$ in the countries of the former USSR)
O	Overvoltage protection	The equipment of the digital automatic telephone exchange with the help of special devices protects against the contact of the subscriber line voltage 220 (380) V, as well as the voltage with a lightning strike
R	Ringing	The called subscriber receives a "Call" signal with a frequency of 25 Hz and a voltage of 95 V (in some countries the voltage is 110 V)
S	Supervision, sometimes Signaling	ATS devices must record the facts of raising and lowering the handset by the calling and called subscriber, and also to ensure the reception of digits of the number of the called subscriber
C	Coding	The analog signal coming through the subscriber line is converted to a digital signal and vice versa
H	Hybrid	The analog subscriber line is two-wire, and the transmission, switching of signals in digital exchanges is four-wire. Therefore, the transformation is carried out using differential systems
T	Testing	The monitoring of subscriber line and telephone operation, as well as devices performing the above functions

Digital subscriber interface.

Each firm creates for its digital stations a specific interface that supports a

"native" protocol for its "own" digital TS. Therefore, the digital subscriber interface can be described by the general principles of the organization of digital exchange over the subscriber line [1, 2].

For two-way transmission of digital information over subscriber lines, four types of systems are possible:

- four-wire system;
- two-wire system with frequency separation of transmission directions;
- two-wire system with time separation of transmission directions;
- two-wire system with adaptive echo cancers.

Four-wire system. Advantages of digital transmission over four wires consist in rather free connection of subscriber terminals that are at a considerable distance from each other and from the reference station, and also in the simplicity of circuit solutions. The system is sufficiently resistant to transient interference and allows you to cover a large range of attenuation of the line without signal regeneration. However, it is characterized by a low use of cable transmission capabilities.

Two-wire system with frequency separation of directions. This system should have a bandwidth twice as wide as the transmitted information for one channel. Really implemented systems use diffusion systems, which made it possible to reduce the mutual influence of the transmission directions, figure 6.2. The transmission of information is carried out by a biphasic code. In one direction X1, the transmission is carried out by the code one period / symbol (BiPh1), and in the other direction X3, the code is three periods / symbol (BiPh3).

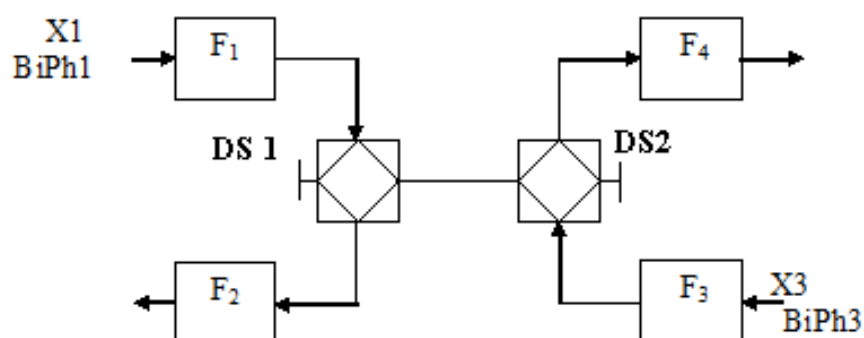


Figure 6.2 - Transmission system with frequency separation of directions and diffusers

Subscriber interface ISDN.

ISDN (Integrated Services Digital Network) networks allow you to: transmit telephony, data, merge remote local area networks (LAN), provide access to the Internet, and transfer videoconferencing traffic [1, 4, 5].

ISDN technology includes basic access (BRI or BA) and primary access (PRI or PA). Basic access involves providing the subscriber with two 64 kbps channels for the transmission of a graphic (type B) and one 16 kbit / s signaling channel (channel D). The primary access is provided to the subscriber 30 B-channels of 64

kbit / s for transmission of the graph and one D-channel signaling (also 64 kbit/s).

Connection of subscribers to digital exchanges is usually carried out by means of an electric two-wire cable:

- for basic access via interface type U_0 ;
- for primary access through the interface U_{k2} .

Lecture №7. Network interfaces of digital automatic telephone exchanges

The purpose of the lecture: Studying the network interfaces of digital ATS.

Content:

- the concept of network interfaces of digital ATS;
- features of connecting network interfaces with DTS;
- interface with analog trunks and transmission systems;
- interface with access network;
- interface with the TMN network.

The concept of network interfaces of digital automatic telephone exchanges.

According to the recommendations of Q.501-Q.517, analog and digital trunks are connected to the ATS via A, B and C network interfaces [1, 4].

Through the A interface, digital paths are connected, packed with PCM-30 (2048 kbit / s) or PCM-24 (1544 kbit / s).

Interface B is intended for connection of digital paths sealed with PCM-120 equipment (844 8 kbit / s).

Analog two- and four-wire lines are included in the station termination of the digital exchange through the C interface. Analog-to-digital converters for these lines are part of the digital ATS equipment.

Features of connecting network interfaces with DTS.

When connecting a digital ATS to another digital exchange, or when establishing of digital transmission system between a digital ATS and an analog ATS, the first uses a digital interface. In this case, one of the most important advantages of DTS is realized, which consists of creating a single digital representation of information in the transmission-commutation path.

Thus, the representation of a speech signal in the form of a PCM signal (64 kbit / s, 8 bits in a codeword) is analogous to both digital switching systems and DTS equipment. But there are a number of problems with respect to DTS interfaces and digital switching systems. First, the DTS s that are not part of the hierarchy of the ITU transmission systems (for example, PCM-15, special DTS s) can be used (and actually used) in the telephone network. Secondly, due to the peculiarities of the construction of digital CPs, the structure of the cycles inside them differs from the structure of the DTS cycles. ITU has determined that no requirements will be put forward regarding to the structure of the cycles of the PCM paths within the DTS. Developers of digital ATSS have the ability to implement, at their discretion, the temporary multiplexing of PCM streams (secondary multiplexing) in the ATS, changing the length of the codeword. Third, the coding of words in the PCM line

and inside the ATS varies.

To the digital interface of the DTS and the digital automatic telephone exchange are set two types of requirements: electrical and logical.

The need for coordination of cycle structures means that cycles must be created at the input of the DTS, which meet the requirements of this DTS. Such matching is usually done during secondary demultiplexing within the ATS.

Logical matching includes converting the linear signal of the HDB3 code to a binary code and vice versa, synchronizing the input signals in accordance with the station clock signals.

Interface with analog trunks and transmission systems.

Analog physical trunks (SLs) are used for analogue and digital ATS communication, for existed or newly created. In this case, a separate interface is organized for each analog trunk signaling system. Figure 7.1 shows the principles of matching digital EATS 200 with urban stations such as ATSC and ATSCC over two-wire physical connecting lines with DC signaling [1, 4].

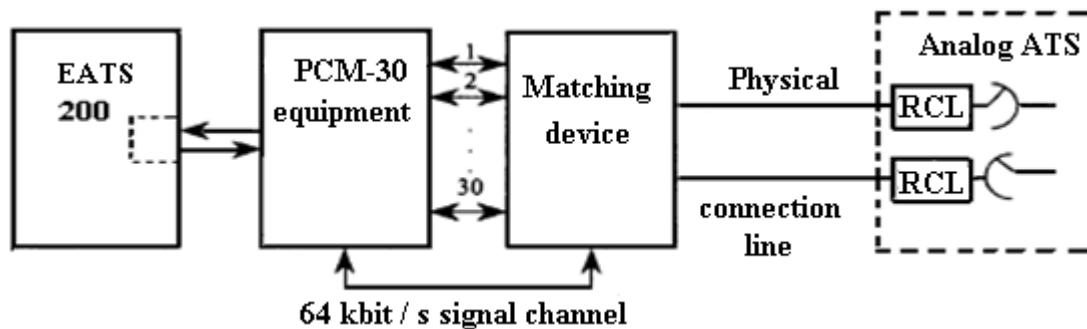


Figure 7.1 - EATS 200 communication scheme with electromechanical automatic telephone exchange (RCL - relay CL)

The matching device (figure 7.2) can be divided into two parts: channel and signal-synchronization. The circuits placed in the channels of the matching device convert the DC signaling of the physical connecting lines into signals applied to the control unit. The channel part does not produce any logical processing of signals coming from the lines.

The control unit gates the signal information of each trunk line after 2 ms. After executing the report, it processes it and sends the corresponding code parcels (according to the codes of the 16-channel PCM interval 30) to the matching block, which coordinates the control unit with the PCM equipment according to the principle of the counter-directional interface. All the necessary matching devices, synchronizing signals, create a clock synchronization block.

Interface with access network.

Under the access network is understood the nomenclature of categories of subscribers (voice, data, video) and transmission media (metal and fiber optic cable, wireless access). The universal interface, which allows to combine all subscriber

access technologies into a single network - the access network, was called V5 - *the interface of the access network* [1, 4].

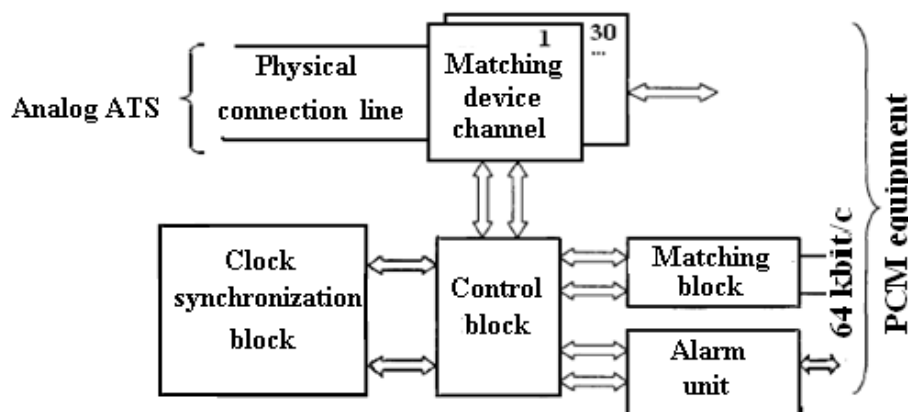


Figure 7.2 - Diagram of the matching device

The V5 interface has two versions - V5.1 and V5.2. Interface V5.1 allows to connect to the ATS on a digital path of 2048 kbit / s to 30 analogue AL without concentration. In this case, the signaling is carried out on a common channel. The V5.2 interface contains several (up to 16) 2048 kbit / s links and supports a concentration of no more than 8 and a dynamic assignment of the time slots. This is the fundamental difference between the interfaces V5.1 and V5.2. The channel intervals (in the interface specification - carrying channels) of the V5.1 interface are rigidly assigned to the digital channels of subscriber paths, i.e. There is a permanent connection between these channels. In the V5.2 interface, there are no fixed carrier channels for the subscriber port channels. At the same time, due to the possibility of concentration, the number of used carrier channels in the interface is always less than the number of served subscriber port channels. The bearer of the V5.2 interface channel is provided only to the subscriber port channel for which the communication service is requested and only for the time of using this service. At the same time, in each 2048 kbit / s path, several signaling channels can be provided. Comparative characteristics of interfaces V5.1 and V5.2 are given in table 7.1.

Interface with TMN network.

Telecommunication management network - TMN is offered by ITU as a single management concept for a wide range of network equipment and various class of tasks. The TMN network provides standardized interfaces, control functions, routing for networks with different equipment, different versions from different vendors [1, 4, 5].

TMN conceptually represents a separate network (figure 7.3) connected through specialized interfaces (Q3 interfaces) to multiple points of the telecommunications network to obtain information and control its operation. The network operator has the ability to manage a large number of distributed equipment from a limited number of control nodes.

Table 7.1 - Comparative characteristics of interfaces V5.1 и V5.2

Interface V5.1	Interface V5.2
Allows you to connect to the ATS one E1 path (30 B-channels)	Allows you to connect to a ATS a group of paths (up to 16) 2048 kbit/s
Does not provide the function of concentrating subscriber lines. Direct ratio between the channel intervals of the E1 path and the subscriber transmission system	Provides the load concentration of subscriber lines. Dynamic assignment of time intervals
Does not support primary ISDN access	Supports primary ISDN access
The signaling is carried out on a common channel in the interface path	For each 2048 kbit / s path, there are several signaling channels
Does not provide a redundancy function if the interface path fails	Provides redundancy in the case of a path failure by switching to another interface path

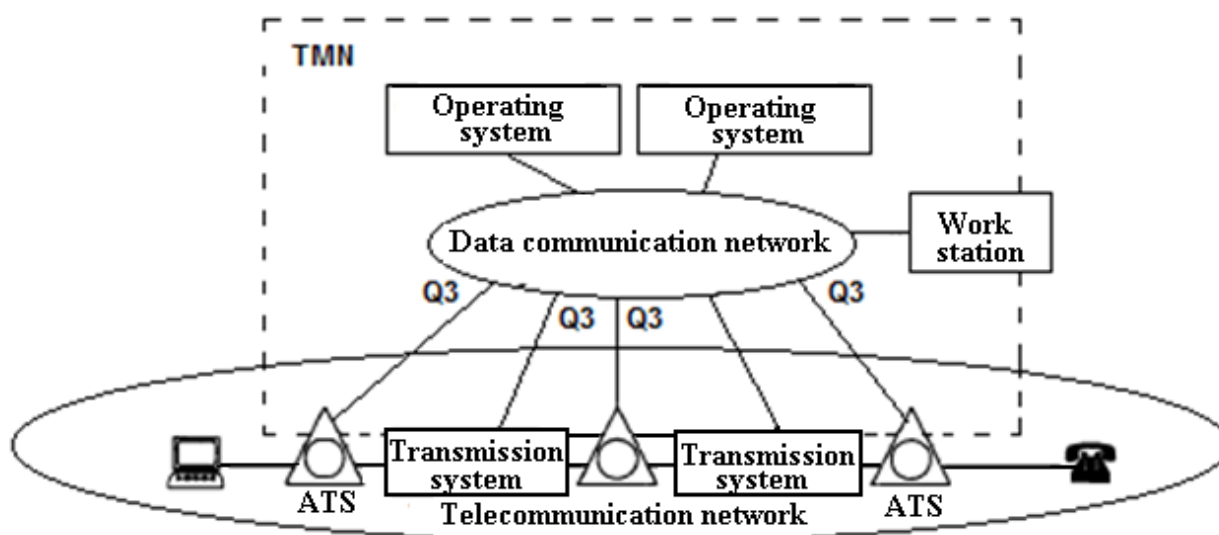


Figure 7.3 - Interaction between the telecommunications network and TNM

The Q3 interface is a subsystem and contains two functions:

- built-in Q-adapter designed for transcoding messages coming from the TMN operating system to internal ATS messages and back (for example, converting the MML commands of the ATS operating system to the Q3 interface format and vice versa);
- Q3 protocol stack, providing the required communication capabilities, corresponding to the Open Systems Interoperability (OSI) concept.

Lecture №8. Signaling in digital switching systems

The purpose of the lecture: Studying of the basic concepts of signaling by students.

Content:

- basic concepts of signaling;
- signaling in DSS;
- classification of alarm systems, signaling on a dedicated channel.

Basic concepts of signaling.

Signaling is a prerequisite for the network to perform its functions: the distribution and delivery of individual messages to the address in compliance with various requirements for this delivery [1, 3, 4, 7].

Signaling is a combination of signals that ensures the interaction of stations and nodes at various stages of creation and destruction of connecting paths. In other words, the alarm system supports the joint existence of switching nodes and stations in the network to provide subscriber maintenance functions. The connection path between the terminal subscriber units can be established through one or several same or different types of ATS, which must exchange signals during the establishment and disconnection of the communication.

Signaling signals - these signals are considered as carriers of information relating to a certain channel, a specific input message or to a network management procedure, they are divided into three types:

- linear;
- management;
- information;

Linear signals are used for inter-station communication to inform the station about the status of the line or the communication channel in the course of the call service. These signals mark the main stages of establishing a connection and are transmitted at any stage between the line sets that equip trunks on the ATS. The composition of the line signals depends on the type of switching equipment; transmission equipment; structure and purpose of the network and its individual sites. They are transmitted on the linear signaling channels in both forward and reverse directions from the moment when the connection is established and until the entire line is completely released. In switching systems, linear signals can be transmitted sequentially from one link to another and, if necessary, transition from one linear signaling system to another. The sequence of transmission of linear signals is determined by the process of establishing of the connection.

Control signals are used to establish a connection in the communication network by the request of the calling subscriber and contain information about the number of the necessary subscriber's line (address information), operating mode of control devices on the ATS, mode of operation of the network, type of communication channels, etc. The composition of these signals strongly depends on the intellectual ability of the switching system and with increasing intelligence is constantly expanding in order to increase the reliability of the transmitted information, the correctness of establishing the connection, improving the quality of the conversation.

The control signals include information about the connection route, exchange control signals, network control signals. When you manage a connection, the following tasks are performed:

- receiving a call from the subscriber;
- receiving information about the number of the called subscriber;
- analysis of the information received;
- determination of the direction of communication;
- search for connecting paths in the switching field of the automatic telephone exchange and the required direction;
- establishing a connection when the called party answers;
- disconnection when receiving a clear tone.

Control signals include route information (address information); exchange control signals; network management signals.

The *routing signals* include the digits of the called number, the station code, the telephone area code, the call category signals, the caller ID in case of long-distance calls, the type of connections being established (automatic or semi-automatic), the method for transmitting of the control information, and etc. Some signals are used to create a path that provides high-quality information transfer.

Information signals (subscriber information signals) are used to notify the caller about the call setup process, and about free or busy lines of the called subscriber. Information signals include the signals "Station response - SR", "Call transmission - CT", "Calling control - CC", "Busy signal - BS", occupation of directional channels, etc.

The concept of signaling refers to the operation of the DSS (digital ATS) in the communication network, figure 8.1.

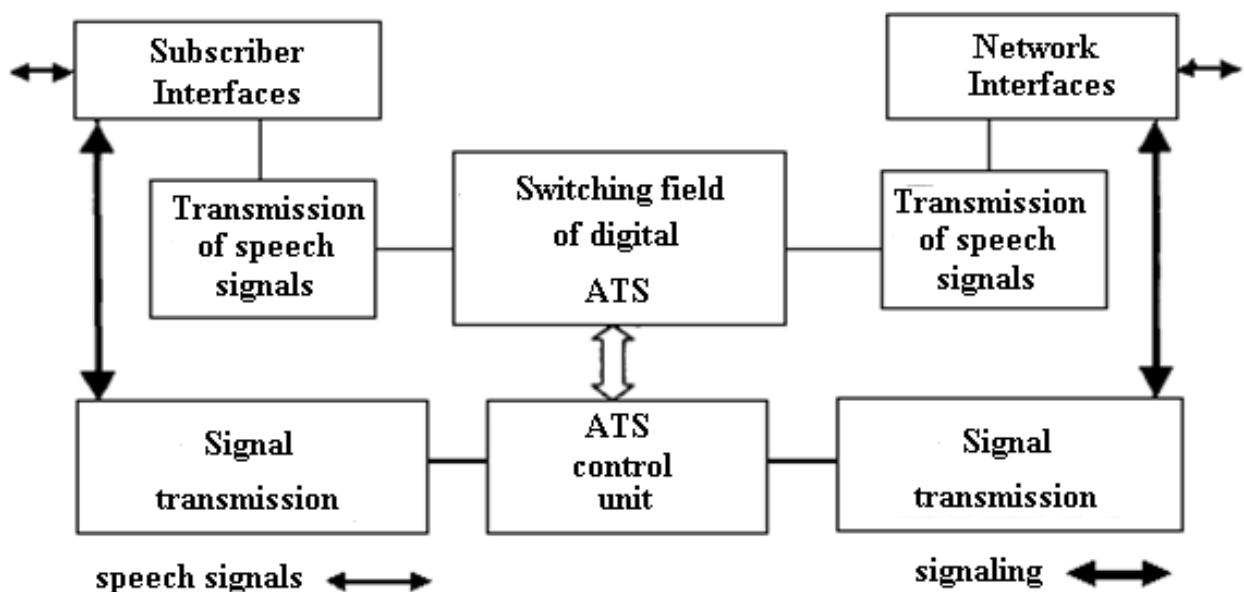


Figure 8.1 - Passage of speech signals and signaling signals in DATS

Classification of signaling systems.

Two main methods are used for organizing a channel for signaling transmission on the communication network, figure 8.2:

- signaling via dedicated channel;
- common channel signaling.

Signaling via dedicated channel.

At signaling via dedicated channel, the signaling signals which are necessary for the operation of a particular channel are transmitted via this channel or through a dedicated channel that is rigidly assigned to the information channel.

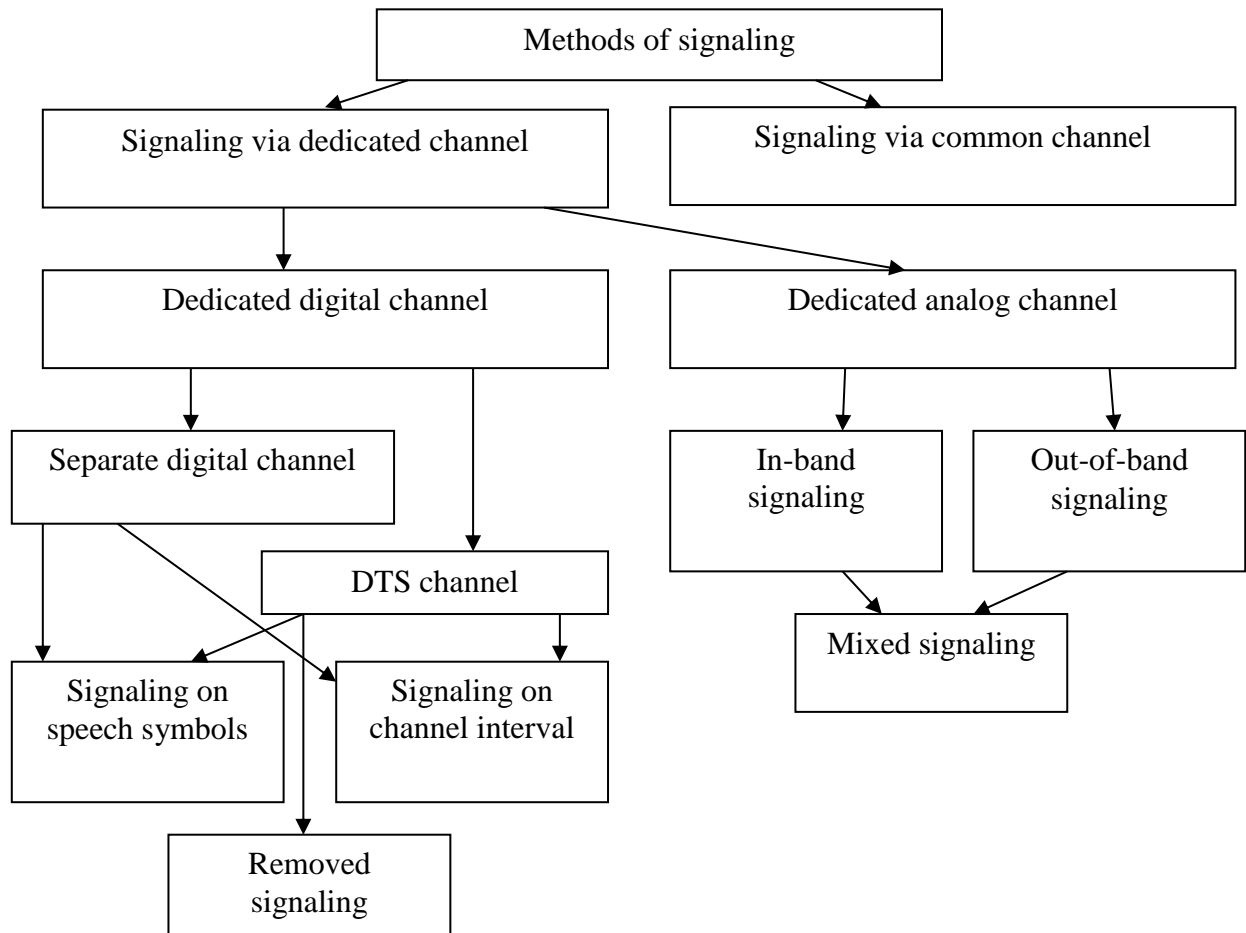


Figure 8.2 - Classification of signaling systems by the channel allocation method for signaling signals

If the transmission channel is analog, then the signaling on the dedicated channel is divided into three methods:

- *signaling in the band of conversational frequencies (signaling in the band, in-band signaling)*. The band of the standard analogue telephone channel is 3.1 kHz (for the physical channel, the cut-off frequencies are 300 Hz and 3400 Hz, and this channel has the special name "tone frequency channel"). Therefore, for telephony with signaling in the band, signaling signals must have parameters that would allow them to be transmitted in the 3.1 kHz band with the required quality;

- *signaling outside the band of conversational frequencies (signaling "out of band", out-of-band signaling)*. For transmission of signaling signals, a channel is strictly assigned to the information channel and has a bandwidth outside the information channel band. For network signaling systems is used a channel located above the bandwidth of the information signal (for example, in the band 3600 - 4000 Hz);

- *mixed signaling*. In such a signaling system, a part of the signaling signals is transmitted in-band of information channel, and a part is outside its band. An example is a user-to-network signaling system for a basic telephone set in which a ringing signal is transmitted outside the information signal band at a frequency of 50 Hz.

If the transmission channel is *digital*, a separate digital channel or a digital channel of a transmission system with combined time-division channels (SRC) can be used to transmit the signaling signals.

When using a *separate digital channel*, two basic signaling methods can be used:

- *signaling on speech symbols*, in which the clock intervals (primarily intended for the transmission of encoded speech signals) are periodically used for the transmission of signaling signals;

- *signaling in the channel interval* at which the signaling information is continuously transmitted in a clock interval located in the channel interval.

In case of using DTS as a dedicated signaling channel, it is possible to use three methods:

- *signaling on speech symbols* for one channel;

- *signaling in the channel interval* (for example, the format of the internal DTS of the ITT 1240 station, in which each channel contains 8 bits of overhead information and 8 bits of speech symbols);

- *removed signaling*, when a separate channel interval is allocated for signaling with its division into subchannels for constant signaling of individual channels. Example: PCM-30/32, which provides a 16-channel interval for the implementation of the outgoing signaling, four bits of which in the super-cycle are alternately provided for the signaling of each voice channel (lecture 1, figure 1.2).

Lecture №9. Signaling system SS7

The purpose of the lecture: Studying of the signaling system SS7 by the students.

Content:

- principle of common channel signaling;
- SS7 signaling network;
- SS7 stack of protocols.

Principle of common channel signaling.

Signaling system 7 (SS7) is a signaling system in which the connection control information (signaling) for all conversational channels and/or data transmission channels is transmitted as data blocks (signal messages) along one common signaling channel that can be organized in any time interval (except for zero) of one of the primary paths of the PCM entering in the beam, which directly connect two interacting ATS, figure 9.1 [1, 4, 5, 7, 8].

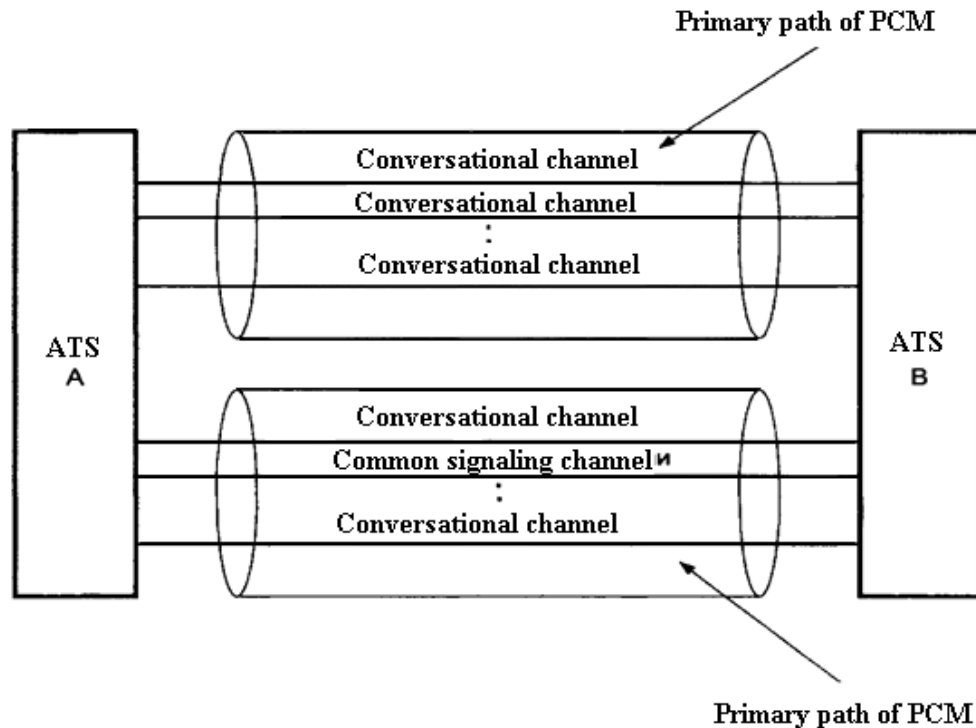


Figure 9.1 - Principle of common channel signaling

Common channel signaling can be considered as a special type of data transmission, specialized for signaling and information exchange between processors of communication nodes for various purposes. To ensure reliability, the system SS7 has the functions of detecting and correcting errors caused by interference with transmission media, and automatic reconfiguration of routes in the case of failures of network elements.

As a rule, in order to increase the reliability in another beam of PCM path is organized a backup channel for the transmission of SS7 data. All other time intervals of the transmission system (except for zero ones) in case of using SS7 can be used to transmit voice or user data. One channel SS7 can serve about 1000 conversational channels.

Network signaling.

The basic concepts of SS7 [1, 4, 5, 7, 8]:

- the functions of the source and receiver of signaling messages are provided by the *user subsystem* (User Part - UP);

- *signaling point SP* - any node of the signal network that implements the signal processing functions of the SS7, that is, the node on which the message transmission sub-system and the user subsystem operate;

- the signaling point is uniquely determined by its unique code (*Signaling Point Code*);

SL signaling link - data transmission channel connecting signaling points among themselves;

- several parallel signaling links directly connecting two signal points form a *signaling link set*;

STP (Signaling Transfer Point) is a signaling point that performs only the functions of signaling routing between different signaling links and does not have user subsystems;

- signaling information is transmitted between signaling points in the form of variable length messages, called *signaling units*.

The signal network node can combine the functions of the signaling point and the transit point of the signaling.

The signaling network 7 consists of *signaling points* and signaling channels connecting them. The signaling point (SP) is usually a switching station that communicates with adjacent stations using the signaling system No. 7. There are terminal and transit PS. The terminal MS, depending on the direction of the transmission of the signaling message, can act as Originating Signalling Point (OSP) and Destination Signaling Point (DSP).

The world signaling network is divided into two independent levels - *international* and *national*. This structure allows us to share the responsibility for managing the signaling network and to plan the numbering of the signal points of the international network and different national networks independently of each other.

Two signal points have *Signal Relation (SR)*, if their user subsystems have the ability to exchange signaling messages. The signal relation can be carried out directly between signaling terminal points or through one or more transit points. The concrete realization of the signal relation in the network determines the (*Signaling Route-SR*). For one signal relation, you can use several signal routes through different transit points. These routes for this signal relation form a *Signaling Routing Set (SRS)*.

The protocol stack is SS7.

The SS7 protocol stack consists of four layers (figure 9.2). The lower three levels are united under the general name of "Message Transfer Part (MTP). Three levels of MTP correspond to the three lower levels of the seven-level OSI model [4, 5, 7, 8]:

- level 1 of the function of the data link;
- level 2 functions of the signal link;
- level 3 of the signaling network function.

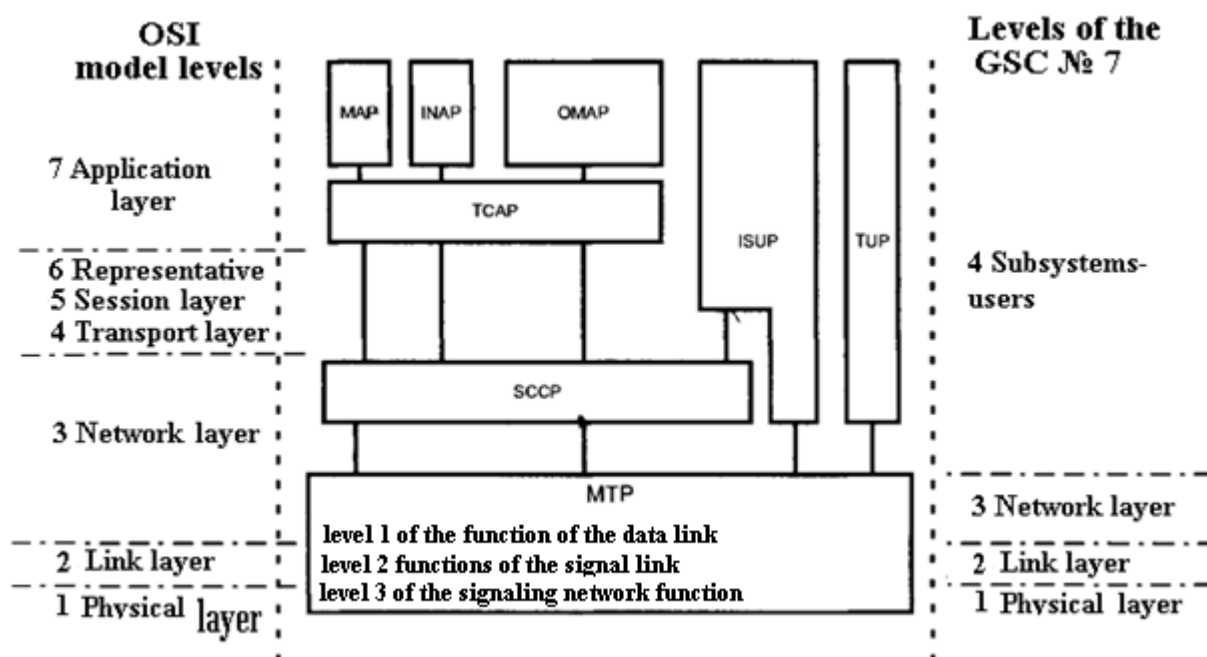


Figure 9.2 - Comparison of the levels of the OSI model and the levels of the SS7

Level 1 of the signaling data transmission link - the MTP subsystem defines the physical, electrical and functional characteristics of the data link for the signaling link. Usually, 64 kbit / s channels of the PCM path are used. Execution of the functions of the 1st level which are defining the interface with the transmission medium means independence of the functions of higher levels (levels 2-4) from the used transmission medium.

The level 2 of the signaling link, the MTP subsystem, defines the functions and procedures relating to the transmission of signaling messages through the signaling link between two directly connected signaling points. Level 2 functions define the structure of the transmitted information for each link and procedures for detecting and correcting errors. The combination of the functions of levels 1 and 2 organizes the signaling unit for the transmission of alarm messages.

The level 3 of the signaling network - the subsystem 3 of the MTP is oriented to the functions of the signaling network. Level 3 procedures provide reliable transmission of signaling information from one ATS to another even in the event of failures at levels 1 and 2. Level 3 provides control of the signaling links and includes signal processing functions for their routing in the signaling network, as well as control functions of the signaling network itself.

The fourth level of the SS7 model is formed by user subsystems by MTP and / or SCCP services:

- TUP (Telephone User Part) - Subsystem-user that supports telephone network signaling;
- DUP (Data user part) - a subsystem-user that supports signaling of the data network;

- ISUP (ISDN User Part) - Subsystem-user that supports signaling of telephone network, data network and digital integrated service network (ISDN);
- TSAP (Transaction capabilities application part) - an application support subsystem for transactions;
- B-ISUP (B-ISDN user part) - Subsystem-user that supports broadband ISDN signaling (B-ISDN);
- MAP (Mobile application part) - application subsystem-user that supports signaling of mobile networks of GSM standard;
- INAP (Intelligent network application part) - application subsystem of the Intelligent Network;
- OMAP (Operation Maintenance and administration part) - applied subsystem of operational control;
- SCCP (Signaling connection control part) - the signaling management subsystem provides logical connections for the transmission of signaling data blocks oriented to a connection or not connected to a connection.

The MTP and SCCP subsystems together form a network service part (NSP). Using the services of MTP, the SCCP subsystem provides signaling in the network of SS7 virtual connections and can provide network services that are oriented to such connections and do not require their creation.

TCAP provides a set of options for serving a call without establishing a connection. These capabilities can be used in one node to cause the procedure to run in another node. An example of such use is a service 800 in which the remaining digits of the number after code 800 are converted by a centralized database to a physical address.

Lecture №10. Design and technical operation of digital switching systems

The purpose of the lecture: studying the issues of design and maintenance of DSS.

Content:

- design tasks for digital switching systems;
- stages of designing of DSS;
- features of technical operation of DSS;
- requirements for the technical characteristics of DSS.

Design tasks of DSS.

Designing DSS is to solve a number of interrelated problems [9, 10]:

- drawing up a task for design, preparation of initial data;
- drawing up the structural diagram of the DSS and the scheme of communication organization;
- calculation of the number of equipment, selection of values of other internal parameters of the DSS;
- development of plans for the location of DSS equipment in the autostation and other rooms of the station;

- development of cable connections;
- Drawing up schemes of crossings on intermediate shields, designing reference information bases;
- Drawing up of specifications, estimates and an explanatory note to the set of project documentation.

Stages of DSS design.

The design of the DSS is carried out in several stages [9, 10]:

- 1) Development of the structural diagram of the projected switching system in accordance with its purpose, types of subscriber access, types of inter-station signaling, etc.
- 2) Calculation of the equipment of subscriber units located at or remote from the station.
- 3) Calculation of the equipment of blocks of connecting lines taking into account the type of interstation signaling.
- 4) Determination of the composition of signaling equipment taking into account inter-station signaling and the availability of telephone sets with DTMF tone dialing.
- 5) Calculation of the switching field equipment taking into account the serviced load or the number of linear blocks to be connected.
- 6) The composition of the control system, as a rule, is already known for each type of DSS, therefore when designing, the performance of the control complex is checked, based on the magnitude of the arising and interstation loads.
- 7) Calculation of SS equipment is performed based on the number of directions operating using the SS7 signaling and the number of signaling units serving the inter-station load of these directions.
- 8) The composition and volume of the equipment of station tones and clock sequences is predetermined for each type of DSS.
- 9) Placement of the calculated volume of equipment for standard cabinets, as well as the placement of cabinets in the respective production facilities.
- 10) Selection of the type and calculation of the parameters of the power supply unit.

Calculation of the volume of equipment DSS is performed on the basis of the following initial data:

- the name of the projected DSS;
- installed capacity and structural composition of subscribers;
- number of lines of interstation links and interstation load matrices, allowing to determine the corresponding inter-station bundles of connecting lines;
- the number of lines for communication with an automatic long-distance telephone exchange (ALTE) and a center of special services (CSS);
- used signaling systems in interstation directions.

Features of technical operation of modern digital switching systems:

- 1) Operational and technical services.

2) Maintenance service.

3) Administrative management.

The objective of the operational maintenance is to maintain the state of the station's operability by continuously monitoring and evaluating the results of monitoring, as well as replacing faulty cards.

The following functions are included in the maintenance:

- routine maintenance to obtain data characterizing the work of the station;
- preventive works at separate nodes of the station equipment;
- software and production checks;
- implementation of a change in operation (re-routing, changing the category of subscribers, introduction of new types of services, etc.).

As part of the operation, functions are performed on a network scale, for example: channel redistribution, development and modernization of the station, replacement of software units (software), implementation of additional services (AS), etc.

Administrative management is understood as a function performed sporadically and associated with radical changes in the process of technical operation, the need of which is determined on the basis of analysis of data on the operation of digital switching systems with IP for a long period.

Implementation of all types of systems for technical operation of stations with program control is provided by means of software and hardware.

As hardware are widely used external computers or the following devices: typewriters; Teletypes; Screen consoles (display); Information input-output devices from intermediate media.

In some cases, are used display devices implemented in the form of specialized light boards.

The software of the system of technical operation of digital ATS includes the means that make up the operating system and the programs implementing the individual operational procedures.

The objectives of the operating system is to provide a human-machine dialogue and dispatching the execution of all procedures based on the status and operation of digital telecommunication nodes.

The operator of modern ATS at the accessing to the system for the purpose of implementing a procedure is the drawing up of a directive in the maintenance display.

A great part of work on the standardization of Man Machine languages used for modern digital switching systems has been carried out by the International Telecommunications Union (ITU).

Requirements for the technical characteristics of DSS.

In the technical operation of DSS, there are requirements for the technical characteristics of DSS [11]:

- preferential service of priority calls;
- establishing connections on networks with bypasses;

- use of various alarm systems;
- the implementation of operational management;
- implementation of load control;
- the ability to display statistics in the control center;
- the ability to output data for mutual settlements.

The digital switching systems must provide:

- connection establishment time for long-distance communication 4 s ... 17s;
- losses when establishing a connection from a subscriber to a subscriber (excluding occupation of the called subscriber's line) for local communication - 3%, for intra-zone communication - 16%, for long-distance communication - 10%;
- the error rate when transmitting digital information is no more than 10^{-6} .

Losses should not exceed:

- for in-house connection 0,02;
- with outgoing connection 0,005;
- with incoming connection 0,007;
- with incoming long-distance connection 0,002;
- when connecting to emergency special services 0,001.

In the normative and technical documents: " Instructions for the design of linear-hardware workshops of terminal intercity stations (TIS), network nodes (NN) and reinforcing points (RP) (regeneration points (RP) and "Departmental norms of technological design" (DNTD), Wire communication facilities, Stations of city telephone networks ", approved by the order of the Ministry of Transport and Communications of the Republic of Kazakhstan from 26.02.98, № 17, are given the loss rates for certain sections of telephone networks.

The software of digital switching equipment must be built according to a modular hierarchical principle.

Digital switching systems should contain a subsystem of operation and maintenance that allows station personnel (operators) to interact with the station. The operation functions should be designed for normal operating conditions of the switching system. These functions should provide: cost accounting; Routing; Load measurement and performance; Functioning of peripheral devices; Station management.

Switching equipment must ensure the operation of the station in a synchronous digital network using a method of forced hierarchical synchronization.

Switching equipment must have the following synchronization devices:

- Synchronization via incoming PCM connection;
- Synchronization from an external reference signal.

The switching equipment used at the highest level of the network must contain PRGs that meet the requirements of ITU-T Recommendations G.811, G.703.

The switching equipment used at the UTN RK should be equipped with software for recording traffic of calls (connections) (billing system for calculating the cost of calls). The general requirements for the equipment for recording the cost

of calls (connections) are given in the normative document "General technical requirements for the equipment for time recording of the cost of local telephone calls for electromechanical ATS of urban and rural telephone networks of the Republic of Kazakhstan".

The switching equipment should provide quality indicators in accordance with ITU-T Recs Q.514 and Q.504.

Lecture №11. Digital switching systems

The aim of the lecture is to study digital switching system of the SI2000 type.

Content:

- characteristics of the digital switching system type SI2000;
- the structure of the system, the composition of equipment;
- assignment of functional units, technical characteristics.

The SI2000 is a digital telecommunications system with the functions of SS7 and ISDN, which provides telecommunications services for analogue subscribers and ISDN subscribers, as well as the management and maintenance functions [12, 3, 10].

The SI2000 system is characterized by the following properties:

- modular construction of hardware and software;
- digital switching for transferring of conversation, data, control signals, acoustic and speech signals;
- compatibility with existing digital and analog telephone stations;
- unified structural and technological solutions, a single element base and materials for all switching equipment;
- a unified system of technical operation using the centers of technical operation;
- full compliance with the standards and recommendations of international regulatory bodies (ITU-T, ETSI, ECMA) and specifications for the national network of the Republic of Kazakhstan.

The SI2000 system provides the construction of switching equipment within the following boundaries:

- up to 40,000 subscriber lines (B-channels);
- up to 7200 digital or analog trunks;
- up to 240 digital streams of 2048 kbit / s (G.703);
- up to 120 signal channels of the OKS-7 signaling system.

Structure of SI2000 switching system.

In accordance with the recommendation of ITU-T Q.512, the SI2000 system functionally divided into a *Switch Node* (SN) and *Access Nodes* (AN). To manage all nodes of the system, was developed a universal management node (Management Node - MN).

Switching node - SN, is intended for switching of connecting lines and management of telecommunication services of access nodes, as well as performing a part of management and maintenance functions. The system and application software of the switching node is executed in real time mode and provides the telecommunication services, as well as the management functions, the generation of statistical and tariff information, maintenance and monitoring of emergencies, COPM functions. Used as a group switching stage. Can be used both for the formation of a city ATS of medium capacity (up to 40,000 ports), and as an independent transit node. The hardware node is represented by the MCA module.

Analog and ISDN subscribers connect to the switching node only through the access nodes. To connect analog subscribers it is possible to use analog subscriber concentrators such as AXM. To connect the access nodes, in accordance with the recommendations of ITU-T Q.512, ETSI standards and specifications for the national network of Russia, developed the interface V5.2. To connect analog subscriber hubs, the ASMI interface is implemented. The V5.2 interface can contain from 1 to 16 E1 streams. The required number of streams in the V5.2 interface is chosen based on the number of subscriber lines connected to this access node (PRA and BRA) and the average total load on the subscriber line.

To ensure the inclusion of the SI2000 system in the public telephone network, the following network interfaces are implemented:

- digital network interface with the signaling of SS-7 (subsystems MTP, ISUP and SCCP). Complies with ITU-T Recommendations and specifications for the national network of Russia;

- digital network interfaces with the caller ID procedure and signaling via one or two dedicated signal channels (urban and rural universal) with the transmission of the decade code control signals (SL - connecting lines, SLM - intercity connecting lines, CCL - custom-connecting connecting lines), the SM -shuttle method (SL, SLM lines) or the impulse packet (CCL line). They meet the specifications for the national network of Russia.

In addition, the switching node has the following interfaces:

- interface for connecting the control center;
- interface type ETHERNET - for local connection of the control node;
- interface for connecting remote control nodes through the organization of a PPP channel in a 2Mbit / s stream;
- interface for connecting the SORM control panel.

To ensure more reliable operation, the switching node has two equivalent control groups. When the system is turned on, one of the control groups becomes active or working state, and the second one enters the cold standby state. If the active control group fails, the standby control group automatically enters into operation.

To connect E1 streams, are used removable TPC blocks. Each such unit has 16 ports for connecting E1 streams. Maximum 16 TRS units can be used in the switching node. Of these, 15 units can be in operation, and one will always be in a

state of cold reserve. If any TRS fails, the backup unit will automatically start working.

Up to 240 E1 streams can be connected to one switching node.

The access node (AN), intended for connection to the switching node and further to the network of analog and ISDN subscriber units, as well as institutional exchanges via primary (PRA) or basic (BRA) ISDN access. It is implemented by the MLS module.

To connect subscriber lines, three types of peripheral removable units are designed:

- peripheral removable unit for connection of 32 analogue subscribers. Equipped with 32 Z-interfaces;
- peripheral removable unit for connection of 16 ISDN subscribers. It is equipped with 16 interfaces U_{k0} ;
- peripheral removable unit for connection of 16 ISDN subscribers. It is equipped with 16 interfaces S_0 .

Up to 22 peripheral removable units can be installed in one module. Therefore, up to 352 ISDN subscribers or up to 704 analog subscribers, as well as their various combinations, can be connected to one access node.

In accordance with ITU-T Recommendation Q.512, it is possible to connect to an access node of ISDN subscriber units via primary access (PRA) using DSS1 signaling. As a subscriber unit, in this case, a ATS with ISDN functions, a remote Internet access server, or any device that satisfies the EuroISDN standards can be considered.

Connection to the switching node is made via the V5.2 interface (Complies with ITU-T Q.512 Recommendations, ETSI standards and specifications for the national network of Russia). One interface can contain from 1 to 12 (for a given implementation of the access node) E1 streams. The required number of streams in the V5.2 interface is chosen based on the number of connected subscriber lines (PRA and BRA) and the forecast load on each subscriber line. For example, in case of connecting to an access node only 640 analog subscribers with an average total telephone load per subscriber line of 0.1 Erl, it is necessary to use 3 E1 streams in the V5.2 interface.

Up to 12 E1 streams can be connected to one access node.

The combined switching and access node - SAN, is a full-featured telecommunication system of small capacity with the functions of SS-7 and ISDN. It simultaneously performs the functions of the switching and access node. All types of digital and analog interfaces are implemented which are specified for the description of the switching node and access node. It can be used as a rural terminal or hub exchange, as a ATS or a substation on a city telecommunications network. It is implemented by the MLC module.

Up to 22 different peripheral removable units can be installed in one module. Therefore, up to 352 ISDN subscribers or up to 704 analog subscribers, as well as their various combinations, can be connected to one combined switching and access node.

To expand the subscriber capacity to a combined switching and access node, up to 4 standard access nodes or analogue subscriber hubs can be connected via V5.2 or ASMI interfaces. However, to ensure the requirements for the required total load per subscriber line, it is not recommended to connect more than two full-access access nodes.

To connect analog trunks has been designed a special type replacement element, equipped with 8 C11 interfaces for in-band signaling systems.

Up to 12 E1 streams can be connected to one combined switching and access node (interfaces V5.2, ASMI, or interconnection).

The management node (MN), it is intended for centralized control and management of switching nodes, access nodes, combined switching and access nodes, uninterruptible power supply system UPS. It is implemented on the basis of one or several personal computers with the operating system Microsoft Windows NT, united in a local network. To the monitored nodes is connected via a TCP / IP network.

It consists of one or several works, each of which can be used to solve the following tasks:

- supervision and administration;
- diagnostics and maintenance;
- collection, processing and storage of statistical and tariff information.

The central database is located in the management node. Using the application programs in the management node, you can change the data stored in the central database. The system software in the control node and in the communication node coordinates the data stored in the central database and the local databases of the communication nodes.

The control node connects to the monitored nodes via a TCP / IP network (the physical layer is Ethernet). To connect to remote communication nodes in one of the E1 stream channels (V5.2 interface or inter-station connection), a control channel running at 64 kbit / s through the PPP protocol is created instead of the talk channel.

The uninterruptible power supply system - UPS is designed for uninterrupted power supply of telecommunication equipment with a constant voltage of 48 V or 60 V. In the presence of mains voltage, it provides power to consumers and batteries, and when the mains voltage fails, it provides power to consumers from batteries.

Application A

List of abbreviations and acronyms

ALTE - Automatic Long-distance Telephone Exchange
AN - Access Nodes
APM - Amplitude-pulse modulation
AS - additional services
ATS - automatic telephone station
BA - basic access
BCL - block of connecting lines;
B-ISUP - B-ISDN user part
BRA - basic rate access
BRI - basic rate interface
BS - Busy signal
BSL - block of subscriber lines;
CC - Calling control
CCL - custom-connecting connecting lines
CD - control device.
CL - connecting line;
COT - center operation technical
CS - central station
CS - control system
CSC - common signaling channel
CSS - Center of special services
CT - Call transmission
CTN - City telephone networks;
CU - connection units
DATS - district automatic telephone stations
DC - device convert
DMUX - demultiplexing
DNTD - Departmental norms of technological design
DSE - digital switching elements
DSF - digital switching field
DSP - Destination Signaling Point
DSS - digital switching system
DTS - Digital Transmission Systems
DUP - Data user part
ECMA - European Computer Manufacturers Association
ETSI - European Standards Organization setting International Standards
GE - generator equipment;
GSU - group switching unit
ICs - integrated circuits
IM - incoming messages

IMN - inbound message nodes
INAP - Intelligent network application part
ISDN - Integrated Services Digital Network
ISUP - ISDN User Part
ITN - Institutional telephone networks
ITU - International Telecommunication Union
ITU – Telecommunication Standardization Sector
LAN - local area networks
LDTN - Long-distance telephone network
MAP - Mobile application part
MN - Management Node
MTP - Message Transfer Part
MUX - multiplexing
NN - network nodes
NS - node stations
OM - outbound message
OMAP - Operation Maintenance and administration part
OMN - outgoing message nodes
OSP - Originating Signalling Point
PA - primary access
PCM - pulse-code modulation
PRA - primary rate access
PRG - Primary reference generators
PRI - primary rate interface
RCL - relay connecting lines
RP - regeneration points
RP - reinforcing points
RTN - rural telephone networks
SAN - The combined switching and access node
SCCP - Signaling connection control part)
SCL - set of connecting lines;
SF - switching field
SK - subscriber kit;
SL - connecting lines
SL - signaling link
SL - subscriber line
SLM - intercity connecting lines
SLU - subscriber line units
SM -shuttle method
SN - Switch Node
SP - signaling point
SPC - Signaling Point Code
SR - Signal Relation
SR - Signaling Route

SR - Station response
SRS - Signaling Routing Set
SS - Signaling system
SS - switching station;
SSU - spatial switching unit
STP - Signaling Transfer Point
TB - trunk blocks
TC - telephone channel
TD - terminal device;
TIS - terminal intercity stations
TM - terminal modules
TMN - Telecommunication management network
TN - Telecommunication network
TS - Telecommunication system;
TS - terminal stations
TS - transmission systems
TSAP - Transaction capabilities application part
TSU - temporary switching unit
TUP - Telephone User Part
UPS - Uninterruptible Power System
US - user subsystem
UTN RK - Unified Telecommunications Network of the Republic of Kazakhstan
ZTN - Zonal telephone networks

Application B

Dictionary of new words and phrases

Table B1

1	2
ALTE - Automatic Long-distance Telephone Exchange	- АМТС – Автоматическая междугородная телефонная станция
AN - Access Node	- Узел доступа
APM - Amplitude-pulse modulation	- АИМ - амплитудно-импульсная модуляция
AS - additional services	- ДУ - дополнительные услуги
ATS - automatic telephone station	- АТС – Автоматическая телефонная станция
Automatic number identification	- Автоматическое определение номера - АОН
BA - basic access	ВА - базовый доступ
BCL - block of connecting lines	БСЛ - блок соединительных линий
B-ISUP - B-ISDN user part	Подсистема-пользователь, поддерживающая сигнализацию широкополосной ISDN (B-ISDN)
BRA - basic rate access	BRA - базовый доступ
BRI - basic rate interface	BRI - базовый интерфейс
BS - Busy signal	СЗ - Сигнал «Занято»
BSL - block of subscriber lines	БСЛ - блок абонентских линий
CC - Calling control	КПВ - «Контроль посылки вызова»
CCL - Custom-connecting connecting lines	ЗСЛ – заказно-соединительные линии
CD - control device	Устройство управления
CL - connecting line	СЛ - Соединительная линия
COT - center operation technical	ЦТЭ -Центр технической эксплуатации
CS - central station	ЦС - центральная станция
CS - Control signals	Сигналы управления
CS - control system	СУ -система управления
CSC - common signaling channel	ОКС - общий канал сигнализации
CSS - Center of special services	УСС - Узел специальных служб (спец. служб)
CT - Call transmission	ПВ - «Посылка вызова»
CTN - City telephone networks;	ГТС - городские телефонные сети;
CU - connection unit	БП - блок подключения
DATS - District automatic telephone station	DATS – Районная автоматическая телефонная станция
DC - device convert	Устройство конвертирования (согласования)
DMUX - Demultiplexing	Демультимплексирование
DTMF- Dual-Tone Multi-Frequency	Двухтональный многочастотный набор
DNTD - Departmental norms of technological design	ВНТП - Ведомственные нормы технологического проектирования
DSE - Digital switching element	ЦКЕ - цифровой коммутационный элемент
DSF - Digital switching field	ЦКП - Цифровое коммутационное поле
DSP - Destination Signaling Point	Пункт назначения сигнализации

1	2
DSS - digital switching system	ЦКС - Цифровая система коммутации
DTS - Digital Transmission System	DTS - Цифровая система передачи
DUP - Data user part	Подсистема-пользователь, поддерживающая сигнализацию сети передачи данных
ECMA - European Computer Manufacturers Association	ЕСМА - Европейская ассоциация производителей компьютеров
ETSI - European Standards Organization setting International Standards	ETSI - Европейская организация по стандартизации, устанавливающая международные стандарты
GE - generator equipment	ГО - генераторное оборудование
GSU - group switching unit	БГК - блок групповой коммутации
ICs - integrated circuits	ИС - интегральные схемы
IM - incoming messages	ВС - входящие сообщения
IMN - inbound message nodes	УВС - узлы входящих сообщений
INAP - Intelligent network application part	Прикладная подсистема Интеллектуальной сети
Information signals	Информационные сигналы
ISDN - Integrated Services Digital Network	ISDN - цифровая сеть интегрального обслуживания, цифровая сеть с интеграцией служб
ISUP - ISDN User Part	Подсистема-пользователь, поддерживающая сигнализацию телефонной сети, сети передачи данных и цифровой сети интегрального обслуживания (ISDN)
ITN - Institutional telephone networks	УТС - Учрежденческие телефонные сети
ITU - International Telecommunication Union	МСЭ - Международный союз электросвязи
ITU-T- Telecommunication Standardization Sector	МСЭ-Т- Международный союз электросвязи сектор стандартизации телекоммуникаций
LAN - local area network	LAN - Локальная вычислительная сеть (локальная сеть)
LDTN - Long-distance telephone network	МТС - междугородняя телефонная сеть
Linear signals	Линейные сигналы
MAP - Mobile application part	Прикладная подсистема-пользователь, поддерживающая сигнализацию сетей подвижной связи стандарта GSM
Matching device	Согласующее устройство
MN - Management Node	Узел управления
MTP - Message Transfer Part	Подсистема передачи сообщений
MUX - multiplexing	Мультиплексирование
NN - Network node	СУ - сетевой узел
NS - Node station	УС – узловая станция
NSP – network service part	Подсистема сетевых услуг
OM - outbound message	ИС - исходящее сообщение

1	2
OMAP - Operation Maintenance and administration part	Прикладная подсистема эксплуатационного управления
OMN - outgoing message nodes	УИС - узлы исходящих сообщений
OSI - Open System Interconnection	Сетевая модель базовой эталонной модели взаимодействия открытых систем
OSP - Originating Signalling Point	Исходящий пункт сигнализации
PA - Primary Access	РА - первичный доступ
PCM - Pulse-Code Modulation	PCM - Импульсно-Кодовая Модуляция
PRA - Primary Rate Access	PRA - Первичный доступ
PRG - Primary reference generator	ПЭГ - Первичный эталонный генератор
PRI - primary rate interface	PRI - первичный интерфейс
RCL - relay connecting lines	Реле соединительных линий
Routing signals	Сигналы маршрутизации
RP - regeneration points	РП – регенерационный пункт
RP - reinforcing point	УП - усилительный пункт
RTN - rural telephone networks	СТС - сельские телефонные сети
SAN switching and access node	SAN - узел коммутации и доступа
SCCP - Signaling connection control part	Подсистема управления сигнальными соединениями обеспечивает логические соединения для передачи блоков данных сигнализации, ориентированных на соединение или не ориентированных на соединение
SCL - set of connecting lines	КСЛ - комплект соединительных линий
SF - switching field	КП – коммутационное поле
SK - subscriber kit	АК - абонентский комплект
SL - Connecting line	СЛ – соединительная линия
SL - Signaling Link	Звено сигнализации
SL - subscriber line	АЛ - абонентская линия
SLM - Intercity connecting lines	СЛМ - Междугородные соединительные линии
SLU - subscriber line unit	БАЛ – блок абонентских линий
SM -shuttle method	МЧН-метод челнока
SN - Switch Node	Узел коммутации
SP - Signaling Point	Пункт сигнализации SP
SPC - Signaling Point Code	Код пункта сигнализации
SR - Signal Relation	Сигнальное отношение
SR - Signaling Route	Маршрут сигнализации
SR - Station response	ОС – «Ответ станции»
SRS - Signaling Routing Set	Группа (пучок) маршрутов сигнализации
SS - Signaling system	СС - Система сигнализации
SS - switching station	КС - Коммутационная станция
SSU - spatial switching unit	БПК - блок пространственной коммутации
STP - Signaling Transfer Point	Транзитный пункт сигнализации
TB - trunk blocks	БСЛ – блок соединительных линий

1	2
TC - telephone channel	ТК - телефонный канал
TD - terminal device;	ОУ - оконечное устройство;
TIS - terminal intercity stations	ОМС - оконечные междугородные станции
TM - terminal modules	ОМ - оконечные модули
TMN - Telecommunication management network	Телекоммуникационная сеть управления
TN - Telecommunication network	ТС - Телекоммуникационная сеть
TS - Telecommunication system;	ТС - Телекоммуникационная система
TS - terminal stations	ОС - оконечные станции
TS - transmission systems	СП - системы передачи
TSAP - Transaction capabilities application part	Прикладная подсистема поддержки транзакций
TSU - temporary switching unit	БВК - блок временной коммутации
TUP - Telephone User Part	Подсистема-пользователь, поддерживающая сигнализацию телефонной сети
UP - User Part	Подсистема пользователя
UPS - Uninterruptible Power System	СБП - Система бесперебойного питания
US - user subsystem	Пользовательская подсистема
UTN RK - Unified Telecommunications Network of the Republic of Kazakhstan	ЕСТ РК - Единая сеть телекоммуникаций Республики Казахстан
ZTN - Zonal telephone networks	ЗТС - Зоновые телефонные сети

Bibliography

- 1 Баркун М.А., Ходасевич О.Р. Цифровые системы синхронной коммутации. - М.: Эко-Трендз, 2001.
- 2 Сети связи и системы коммутации: Учебное пособие / Е.В. Букрина. - Екатеринбург: УрТИСИ ГОУ ВПО «СибГУТИ», 2007. – 186 с.
- 3 Б.С. Гольдштейн, Н.А. Соколов, Г.Г. Яновский. Сети связи: Учебник для ВУЗов. – СПб., БХВ-Петербург, 2010. – 400 с.
- 4 Гольдштейн Б.С. Системы коммутации. – СПб.: Радио и связь, 2004.
- 5 Шувалов В.П. Телекоммуникационные системы и сети. Т.1 Современные технологии. - М.: Радио и связь, 2005.
- 6 Ершова Э.Б., Ершов В.А. Цифровые системы распределения информации – М.: Радио и связь, 2000.
- 7 Гольдштейн Б.С. Сигнализация в сетях связи – М.: Радио и связь, 2001.
- 8 Б.С. Гольдштейн, И.М. Ерхиль, Р.Д. Рерле. Стек протоколов ОКС7. Подсистема МТР. Справочник. – М.: Радио и связь, 2003.
- 9 Игнатьев В.О. Методы проектирования современных цифровых систем коммутации: Учеб. пособие. – СПб.: ЭИС, 2000.
- 10 В.Г. Карташевский. Цифровые системы коммутации для ГТС/ под ред. В.Г. Карташевского и А.В. Рослякова. – М.: Эко-Трендз, 2008.
- 11 Руководящий документ единой сети телекоммуникаций Республики Казахстан. Книга 1. Общие положения и концептуальные основы развития ЕСТ РК. – Астана. 2003.
- 12 Докучаев В.А. и др. Основы построения АТСЭ типа SI 2000. - М.: Радио и связь, 2000.

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