switching systems

The concept of pulse code modulation (PCM)

- Conversion of the primary continuous analog signal into a digital code called PCM (PCM) [1, 2, 4,5]. In telecommunications in the binary sequence is selected as the code base, implemented with minimal hardware costs. The main operations in the PCM sampling operations are time quantization (sampling the level at a discrete time signal) and encoding.
- Sampling the analog signal time is a transformation in which the analog signal representing the parameter is the sum of its values at discrete points in time.
- In digital communication systems, used uniformly sampling an analog signal (the signal samples are produced at regular intervals). When used uniform sampling: Δt sampling interval (time interval between two consecutive samples of a discrete signal) and FD sampling frequency (the reciprocal of the sampling interval). The value of the sampling interval is chosen according to the Kotelnikov theorem (Shannon).

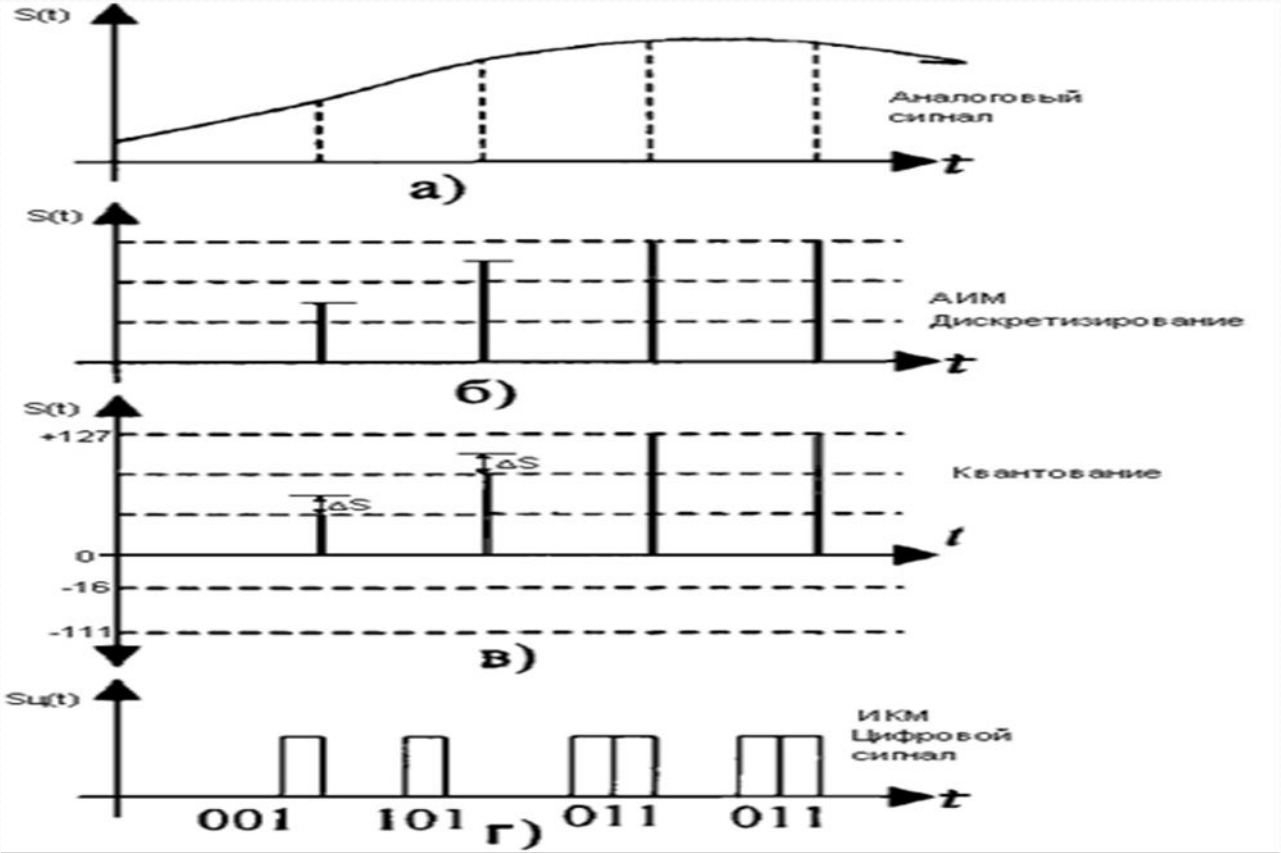
Kotelnikov Theorem

- According to the Nyquist theorem, any analog (continuous), the signal can be sampled, and rebuilt on the opposite end, if the sampling frequency is twice the upper frequency of the signal.
- Channel tone (main channel analog telephone channel) should occupy a strip of 300 ... 3400 Hz. Consequently, the sampling rate must be at least: Fs = 2h3400 = 6800 Hz. According to the recommendations of the ITU (International Telecommunication Union) for a signal transmitted on the voice channel, accepted sampling rate Fs = 8000 Hz. This facilitates the implementation of the frequency of the DSP hardware filters.

The quantization of signal

- The sampled amplitude pulses correspond to the instantaneous values of the signal. These transformations are called pulse amplitude modulation. Discrete transmitted one after another cyclically in the form of compacted temporarily PAM signals
- At any quantization of message processing appliances and transmission systems has a finite resolution, so there is no need to transmit all the infinite number of amplitude values of continuous signals, it is possible to limit a finite set. Those permitted to transmit the signal amplitude values are called quantization levels, the choice of their number determines the quality of the transmission of electrical signals
- PAM signal obtained by sampling is quantized by level. The difference between two adjacent levels permitted for transmission are called quantization step-Δ.
- The difference between the true value of the reference signal and the quantized value is called quantization error or noise.

Converting an analog signal to PCM signal



Coding the quantized reference

- Encoding the quantized frame called the identification of the frame with the code words. In practice the apparatus is used in the binary PCM codewords, wherein each binary word corresponds to a signal level of quantization. According to the recommendations of the ITU, was adopted 256 quantization levels (128 positive and 128 negative levels), and the codeword length - 8 binary digits (bits), Figure 3.1, the
- The first eight-digit code combination determines the polarity of the encoded signal amplitude (1- positive signal "+" 0 - negative "-"); 2,3,4 bits define the top of the segment in which the signal is located; 5,6,7,8 bits define the number of levels in the segment.

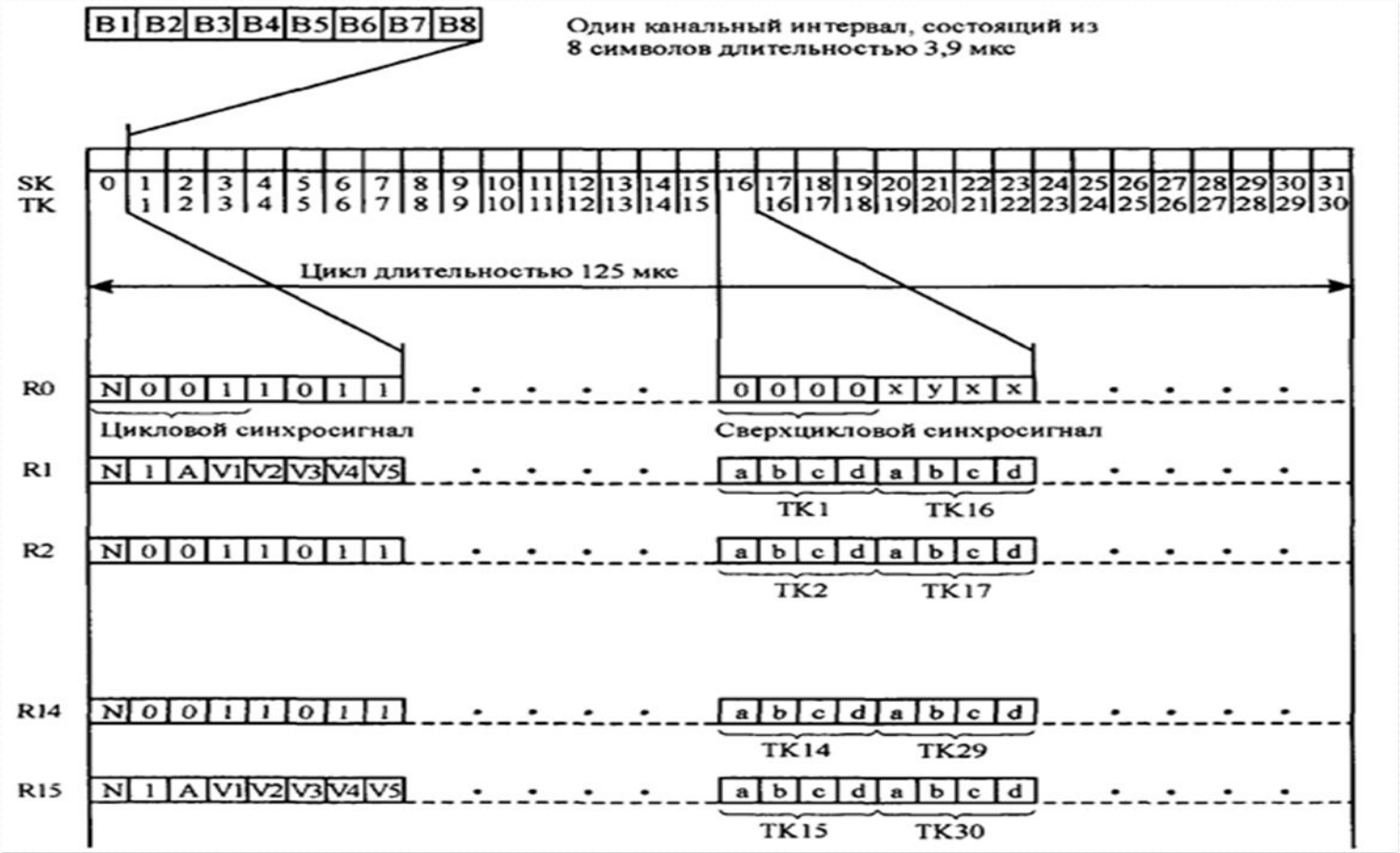
Structure of the cycle with 2 Mbit / s speed

- Voice over separate channels for voice frequency telephone network is carried out in the range from 300 Hz to 3400 Hz. For organizations using digital switching primary flow path PCM 30/32.
- And multiframe cycle structure of a PCM-30 system are shown in Figure cycle consists of 32 time slots. Multiframe consists of 16 cycles. Cycle TC = 125 ms, which determines the frequency of repetition cycles Fts = 8 kHz. The duration is multiframe 16h125mks = 2ms. For each channel in a cycle stands □K.I interval = 3.9 ms. Each channel is designed for the transmission of information of 8-bit binary code, then the duration of one bit (bit) will be □b = 0.49 microseconds. The throughput of one time slot of 64 kbit / s, then the capacity of the primary standard PCM highway is 64 * 32 = 2048 kbit / s. The loop PCM timeslots 0 and 16 are overhead channels and slots 1 to 15 and 17 to 31 are information channels.

Structure of the cycle with 2 Mbit / s speed

- As shown in Figure 1.2, a digital clock positions 2-8 takes zero time slot in every second cycle. Cyclic clock signal is a combination 0011011. To eliminate the possibility of cyclic odd clock cycles simulate zero symbols 2-8 2 symbol intervals in these ranges is given the value 1. multiframe clock allowing to carry out cycles per superframe count is a combination of 0000 and occupies bit intervals 1- 4 slot 16 in the loop 0.
- Timeslot 16 is used for transmitting signaling. In each cycle two alarm signals transmitted voice channels.
- The designations in Figure 1.2: TC - telephone channel; RO, ... RI5 - cycles in the superframe; SK - timeslot; B1, .. B8 - code word length of 8 bits; N - bit is reserved for international use (the symbol is not defined, now has to take the value of 1); A - Transfer of alarm signal to the equipment end of the PCM link; VI, ... V5 - symbols intended for national use (on digital paths crossing the state borders), these symbols should have a value of 1); x - the symbol of the reserve (in the case when not in use "must be set to I); y - the symbol used to indicate a way out of multiframe clock; a, b, c, d- code for common channel signaling Organization (ACS), if b, c and n d are used for ACS, they must have the following values: b = 1, c = 0, d = I.

The structure of the cycle and multiframe of PCM-30 equipment



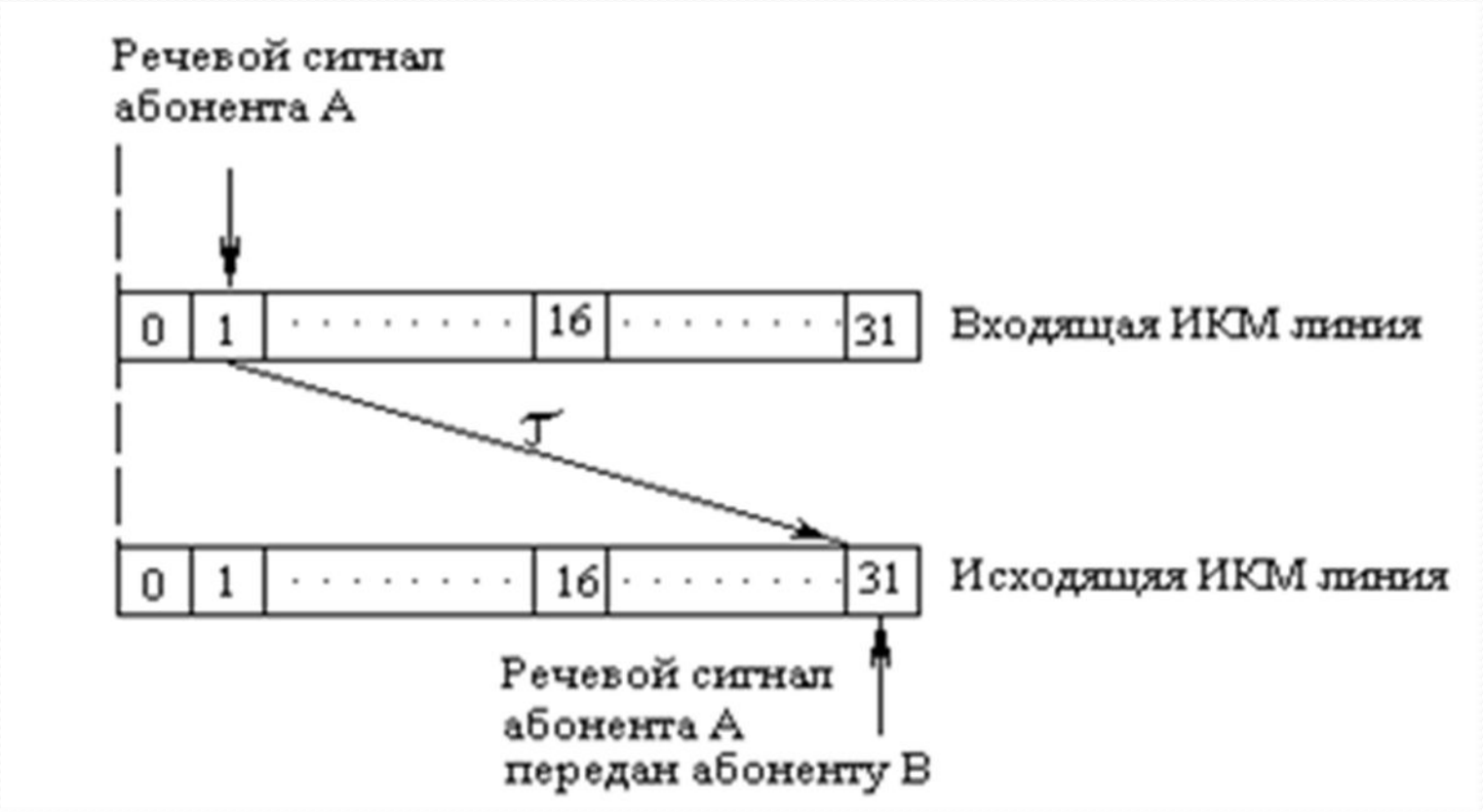
Definitions and concepts of the switching

- Switching - is a process of establishing a connection between certain input and output of the system and maintain it for the duration of the transmission of user information, and then disconnect. There is the following switching techniques [1, 2, 4]:
- - Switching channels;
- -Switching messages;
- - Packet switching.
- When switching channels, first through the link is created, then the communication channel in real time, and information can be exchanged after the exchange of communication channel collapses.
- When switching communications: communication is performed not in real time, through the connection between the input and output of the system is not required and redundant messages are not lost, but saved and passed on with a delay.
- With packet switching message is divided into blocks of a certain size - packages. Each packet is sent independently, once freed available communication channel. On the receiving side are restoring messages from packets received at different times and can be in different ways.
- It is called switching one-coordinate at which the connecting paths in the system are separated from one another by separation basis, where the sign of separation is meant the parameter on which separation occurs in the system connecting paths between input and output.
- Digital switching is a process in which the connections between the input and output of the system is set by the operation of the digital signal without converting it to analog.

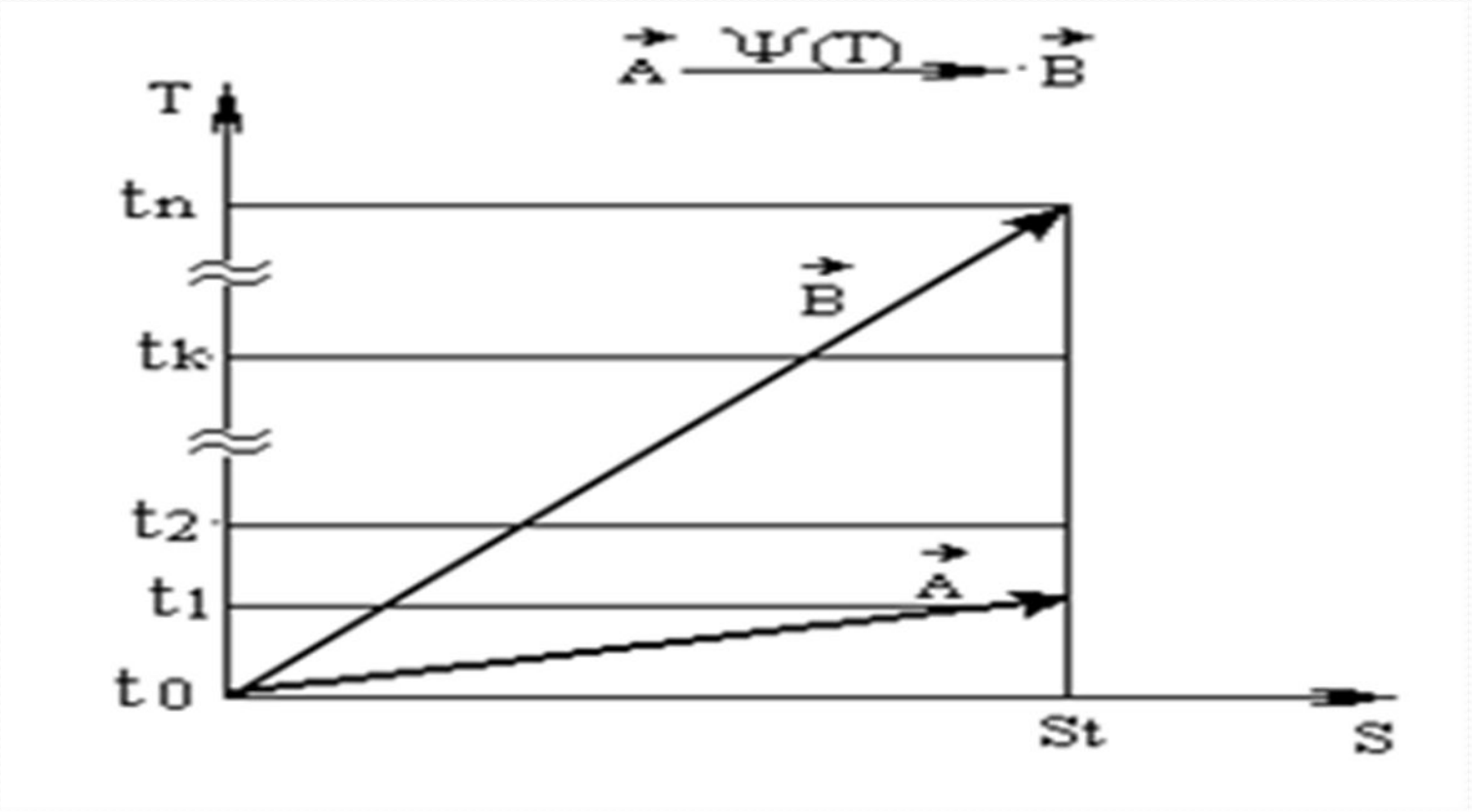
The principle of transformation of the time coordinate of the digital signal (the principle of time switching)

- Unit or module performing the function of the switching time of the digital signal is called a time switching stage or T-stage (from time- time).
- Reorder one timeslot outgoing PCM lines compared with the incoming voice data transmission means from one subscriber to another. This is the time switching principle (sometimes referred to interchange time slots or moving information from channel to channel).

Illustration of time switching principle



Vector representation of time switching



The principle of transformation of the time coordinate of the digital signal (the principle of time switching)

- Using a vector representation of a digital switch, Figure 2.2, into the space-time coordinates allows a somewhat different principle to describe the time of switching. If we assume an orthogonal transformation of temporal and spatial coordinates of the digital signal, we obtain the expression:

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

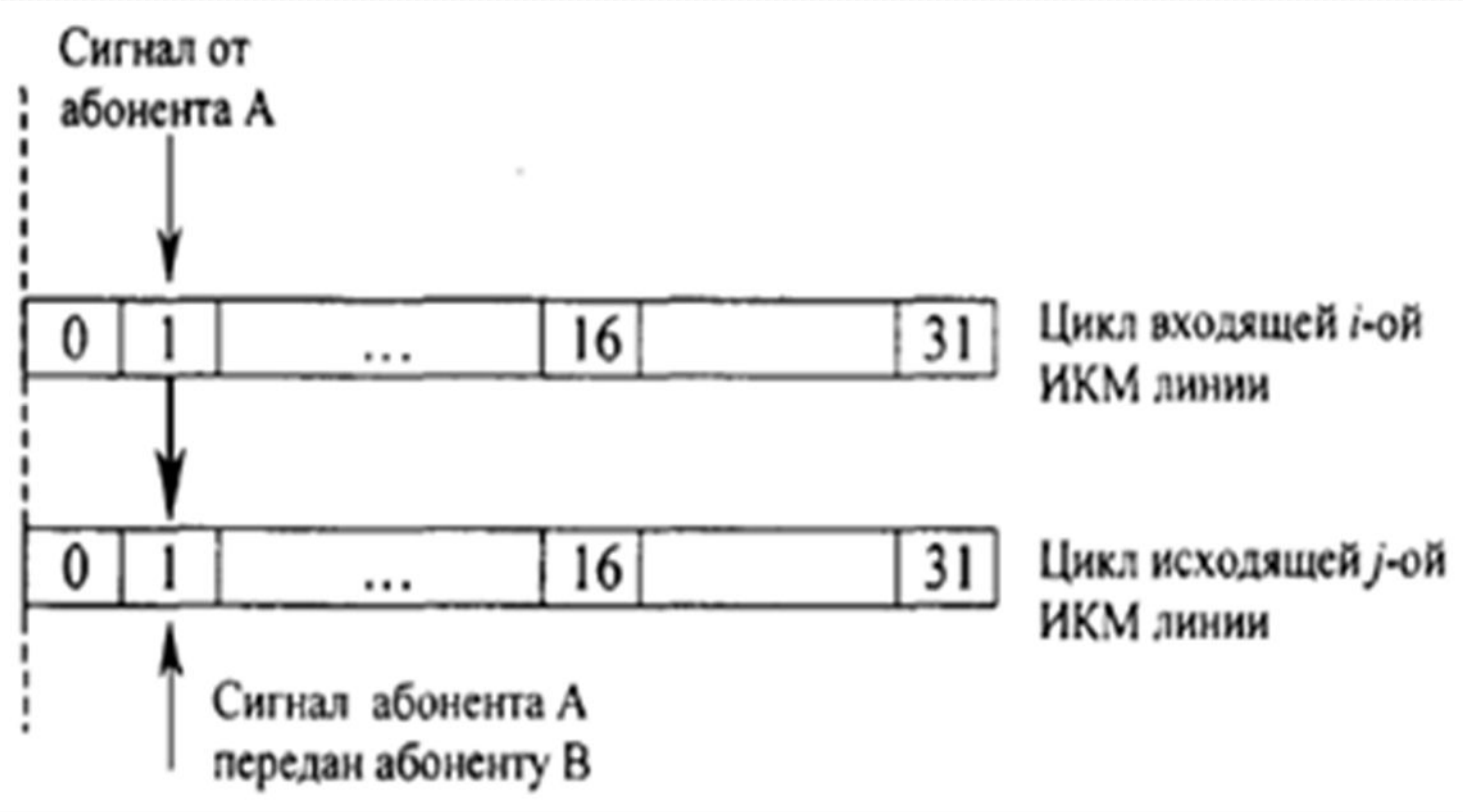
Deciphering formula

- For time switching ψ (s) = o. Operation ψ (t) is a delay operation on a specific codeword set time.
- Time switching module disadvantage is that it is able to switch channels only one digital line. Therefore, switching N PCM lines must be N modules. A organization for interconnecting different PCM lines in series with it is necessary to include the additional equipment - unit of spatial or space-time switching.

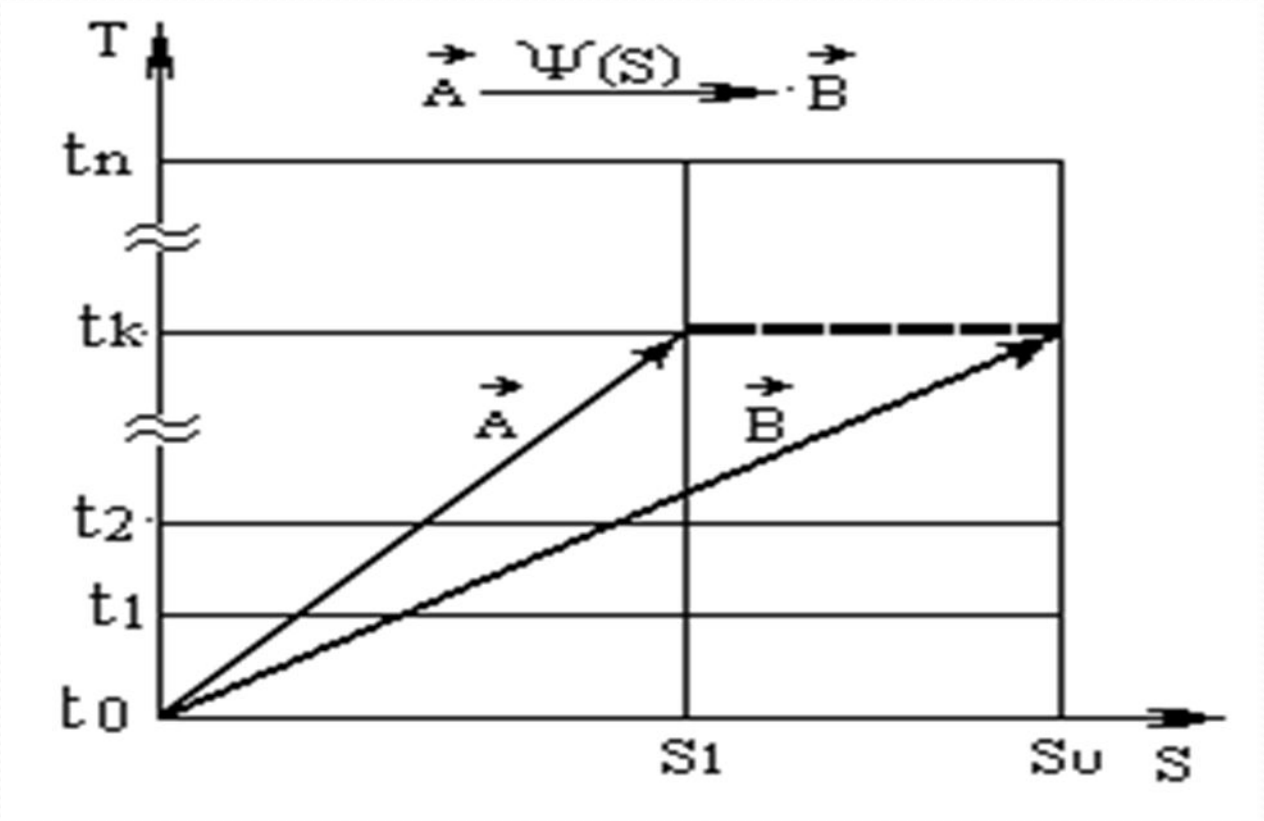
The principle of conversion of the spatial coordinates of the digital signal (the principle of spatial switching)

- Unit or module of the digital switching field, performing spatial switching digital signal is called a spatial switching stage or S-stage (from space- space).
- The essence of the spatial coordinate conversion of digital signals is to move the time slot of the PCM line into one another while maintaining the order of the slot in the loop structures of the two lines, Figure 4.3.
- Vector representation of this transformation is shown in Figure 4.4. In this case, once again assumed an orthogonal transformation

Illustration of the principle of spatial switching



Vector representation of spatial switching



The principle of conversion of the spatial coordinates of the digital signal (the principle of spatial switching)

- Vector representation of this transformation is shown in Figure 4.4. In this case, once again assumed an orthogonal transformation

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

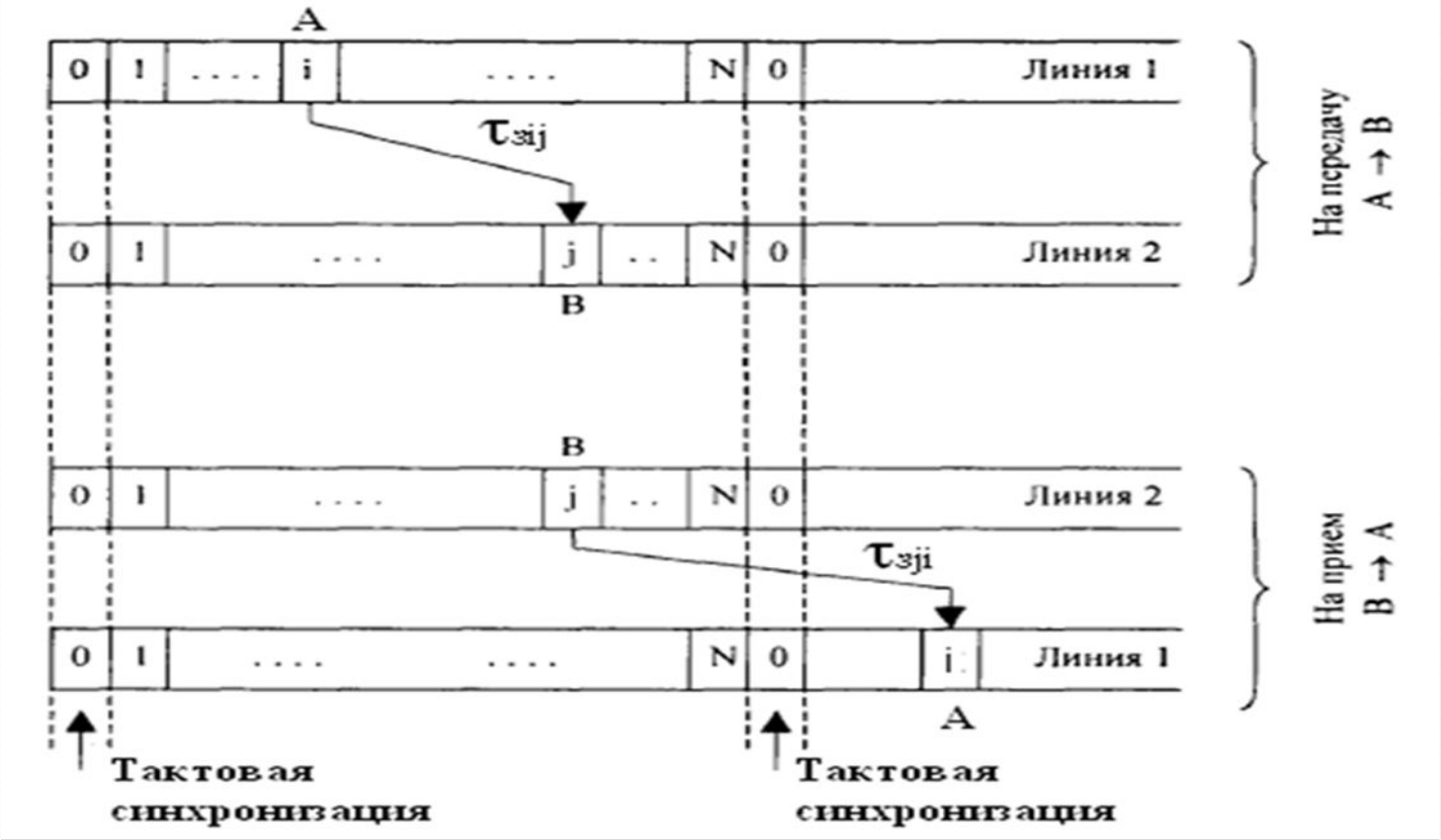
Deciphering formula

- CP Digital, built on the space switching modules are widely used in the early stages of the digital exchanges, due to ease of implementation and low cost of implementation. However, the lack of space switch, which is switched in only one channel of the same name for all incoming and outgoing PCM lines (which means the lock when connecting dissimilar channels), led to the fact that at present, these modules are used only in combination with other types of switch modules

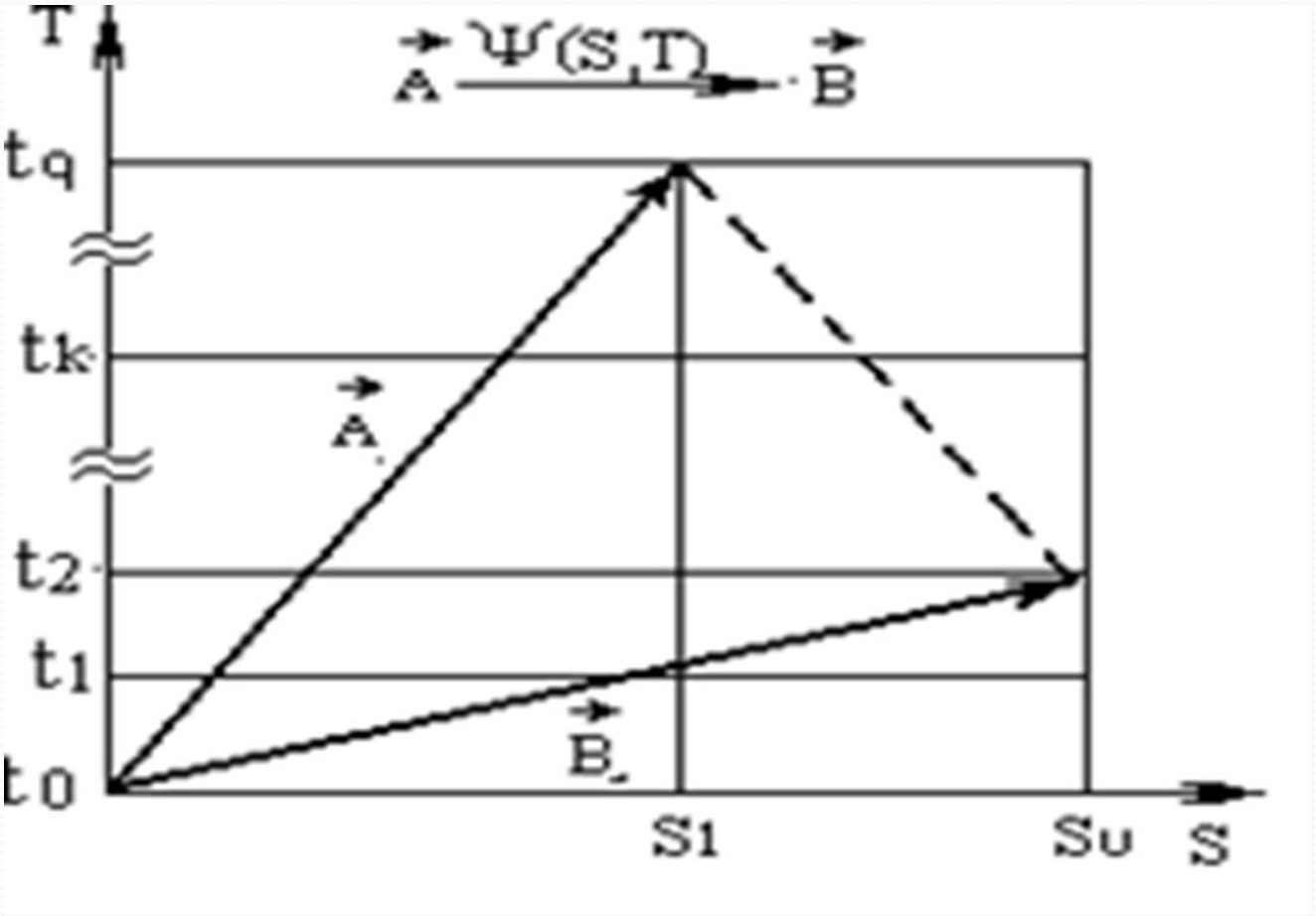
The principle of the space-time switching

- Unit or module implements a space-time coordinate transformation of a digital signal, called S / T- stage.
- The essence of the conversion coordinates space-time digital signals is to move a predetermined time slot of a PCM line to another to change the order of the slot in the loop structures of the two lines, Figure 4.5.

Illustration of the principle of space-time switching



Vector representation of space-time switching



Digital switching fields 1, 2, 3, 4, 5 th grade

Principles of the construction of DSF

- Switching the system reflects the principles of the internal construction of switching stations and is a collection of hardware designed for operational switching.
- Switching system implementing digital switching function, called a digital switching system (DSS).
- In a digital switching system switching function provides a digital switching network (DSN). Management of all processes in the switching system carries out control complex.
- Digital manual is based usually on the basis of the link. Digital link manual steps referred group (S-, T or S / T-), realizing the same function of coordinate transformation of the digital signal. Depending on the number of units are distinguished double, triple and multi-tier manual.
- Digital manual called uniform if any connection to it is established through the same number of units. Most modern DSS have homogeneous digital manual.

Features of construction of multi-digital manual

- 1. Digital manuals are built using a certain number of modules.
- 2. The Digital manuals have a symmetric structure. Under understand symmetrical structure in which the units 1 and N, N-2 and 1, 3, … N-2 are identical in type and number of switching units.
- 3. Digital manuals almost always are duplicated because of the criticality problems in the connection box to the functioning of the whole system.
- 4. Digital manuals are four- because digital lines that carry time multiplexed PCM signals as four-wire.

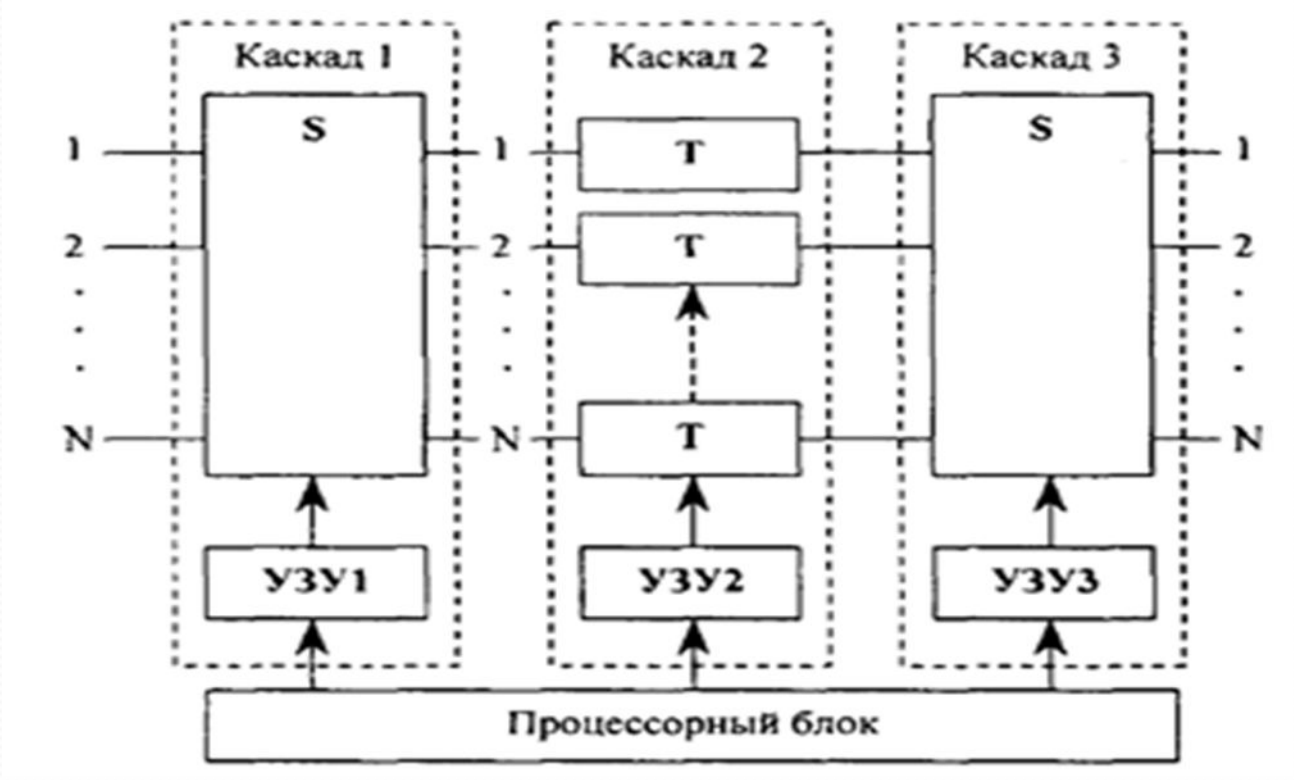
Five classes

- Taking into account the symmetry and the modular construction of the entire set of synchronous digital manual switching with the functional completeness can be divided into five classes [1, 2]. In each class, you can select the basic structure and substructure formed by adding additional switching elements with advanced multiplexing (MUX) and the subsequent demultiplexing (DMUX) group of digital paths.
- 1. The basic structure: S 'k - T' r - S 'k.
- Substructure: MUX - S 'k - T' r-S 'k - DMUX.
- A special feature of the field is the presence of S-stage in the first and the last link, the order of the T- and S-levels within a field - a random compliance with the rules of symmetry.
- 2. The basic structure: T 'k - S' r - T 'k.
- Substructure: MUX - T 'k - S' r - T 'k - DMUX.
- A special feature of the field is the presence of T-stage in the first and the last link, the order of the T- and S- steps within the field - voluntary compliance with the rules of symmetry.
- 3. The basic structure: S / T 'k - S' r - S / T 'k.
- Substructure: MUX - S / T 'k - S' r - S / T 'k - DMUX.
- 4. The basic structure: S / T 'k.
- Substructure: MUX - S / T 'k - DMUX.
- 5. Ring digital switching fields.
- Although ring manuals are based on the S / T-stages (ring connector), and are in fact a kind of field grade 4, but in view of their importance and features of construction decided to allocate them in a separate class.

CSF of the First Class

- Initially, the basis for these types of units CSF spatial switching stage were taken, such as: PBX Sintel, DEX-T had a structure field type S-S with parallel switching method. But spatial switches have a greater probability of internal blocking, so in practice become widespread structure where space switching stage S-divided time T stages such CSF combined symmetric field.

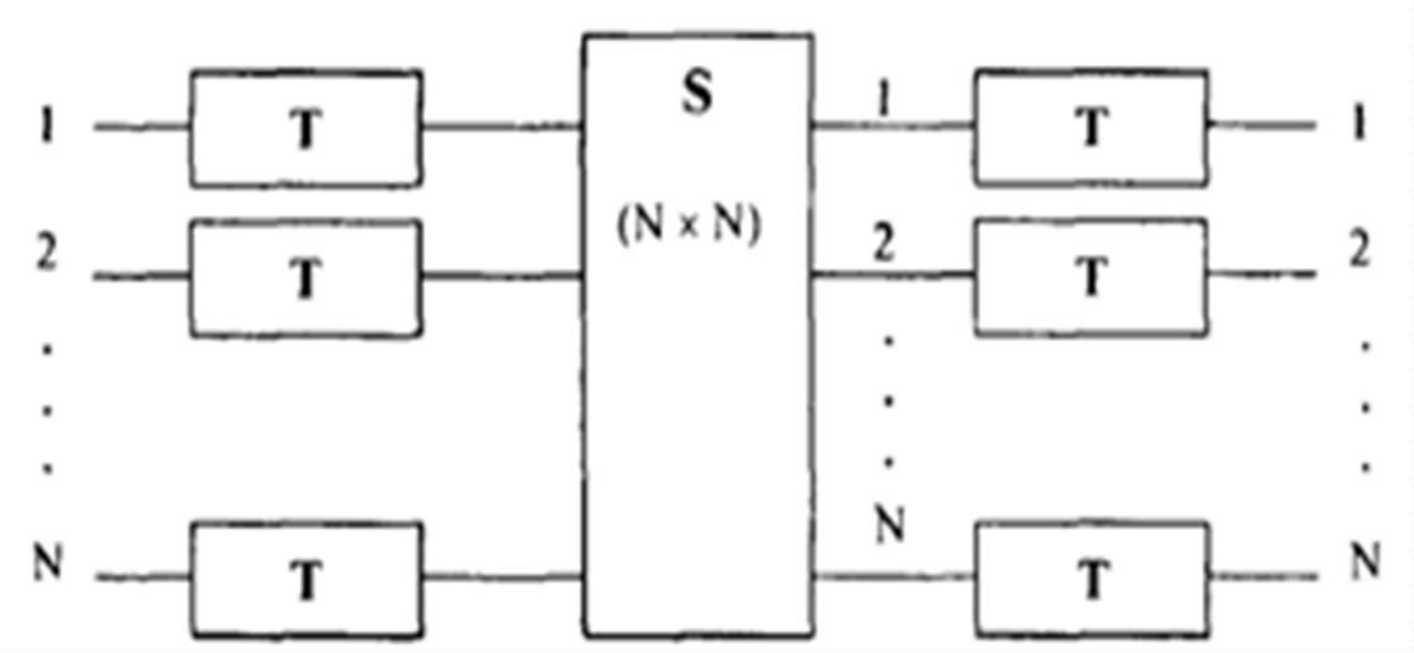
The basic structure of a first-class CSF



CSF of the second class

- These types of systems are CSF: NEAX 61 (Japan), №4 ESS (US), AXE 10, D70, FETEX150.
- Features CCU second class:
- - The use of additional S-steps increases the capacity and throughput capacity of the field, but do not affect the principles of its functioning;
- - Inputs prior multiplexing actually provides a secondary seal incoming digital lines, the subsequent demultiplexing and restores them at the outputs, resulting in increased throughput without additional S-stages;
- - To increase the data processing speed of the gearbox on the input, tends to produce sequentially convert to parallel. For this purpose, each incoming line is installed converter serial-parallel type, and on the output - parallel to serial.

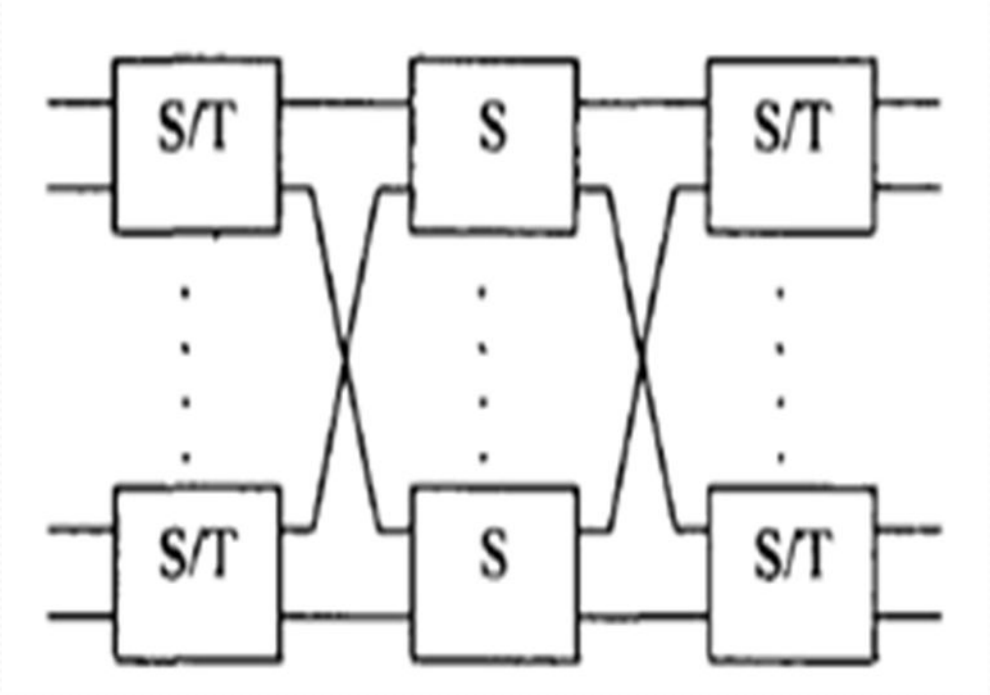
The basic structure of the second class CSF



CSF of the third class

- These types of systems are CKP: MT 20/25 (France), System X (DSS) (United Kingdom), EWSD (Germany). GDTS (USA), the DTS-11 (Japan) and many others, on which you can build local, long distance and transit stations.
- NBI in this class are universal, because they allow to build the same type of switching system for virtually the entire range of capacities: small, medium and large. When this occurs the container capacity by increasing the number of spatial switching units, passing from simpler structures S / T-S-S / T to more complex S / T-S-S-S / T. Often the design of the switching field temporal and spatial switching stage are combined into respective blocks: a block time switching and space switching unit. Then build CP capacity is done by simply adding a certain amount of BTS and BSS (block of time switching and block of space switching)

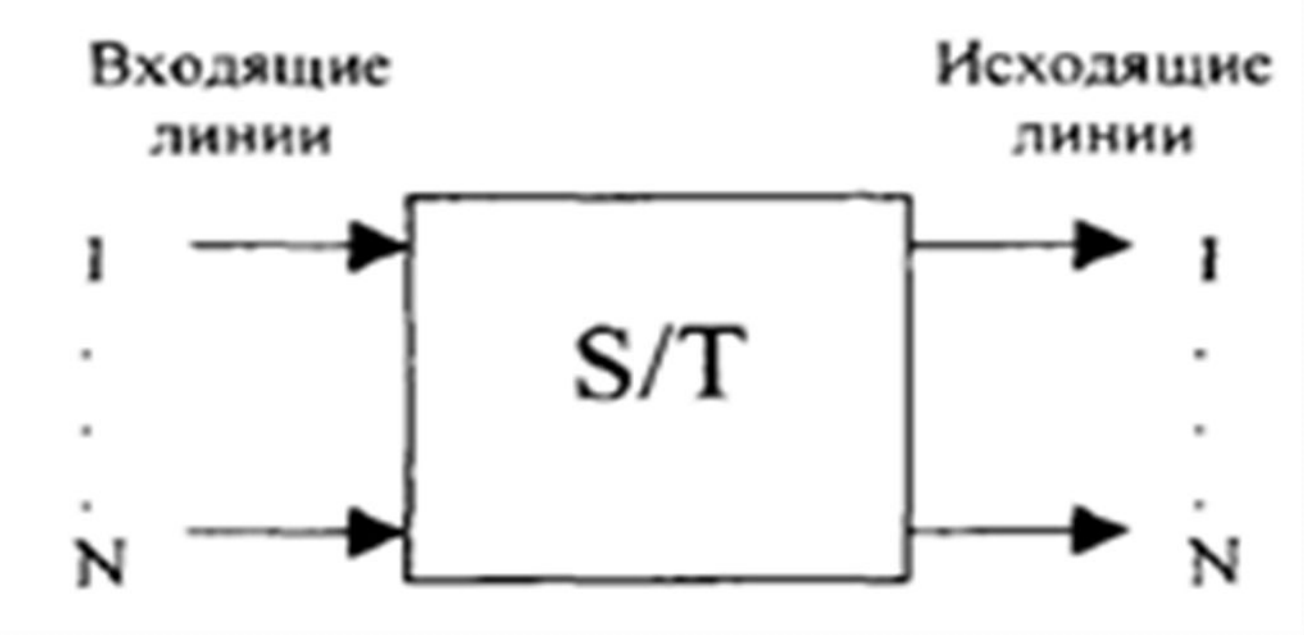
The basic structure of the third class CSF



CSF of the fourth class

- These types of systems are CSF: PROTEL UT and others. fourth grade MSC are widely used due to the facilities to increase capacity of the field simply by adding S / T-stages performed in a universal integrated circuit (IC).
- The basis of the S / T-stage switching elements comprise or modules. When designing the capacity of a small PBX manual can be built using a single link S / T-stage having only one module (capacity typically 8/8 to 32/32 incoming / outgoing PCM lines)

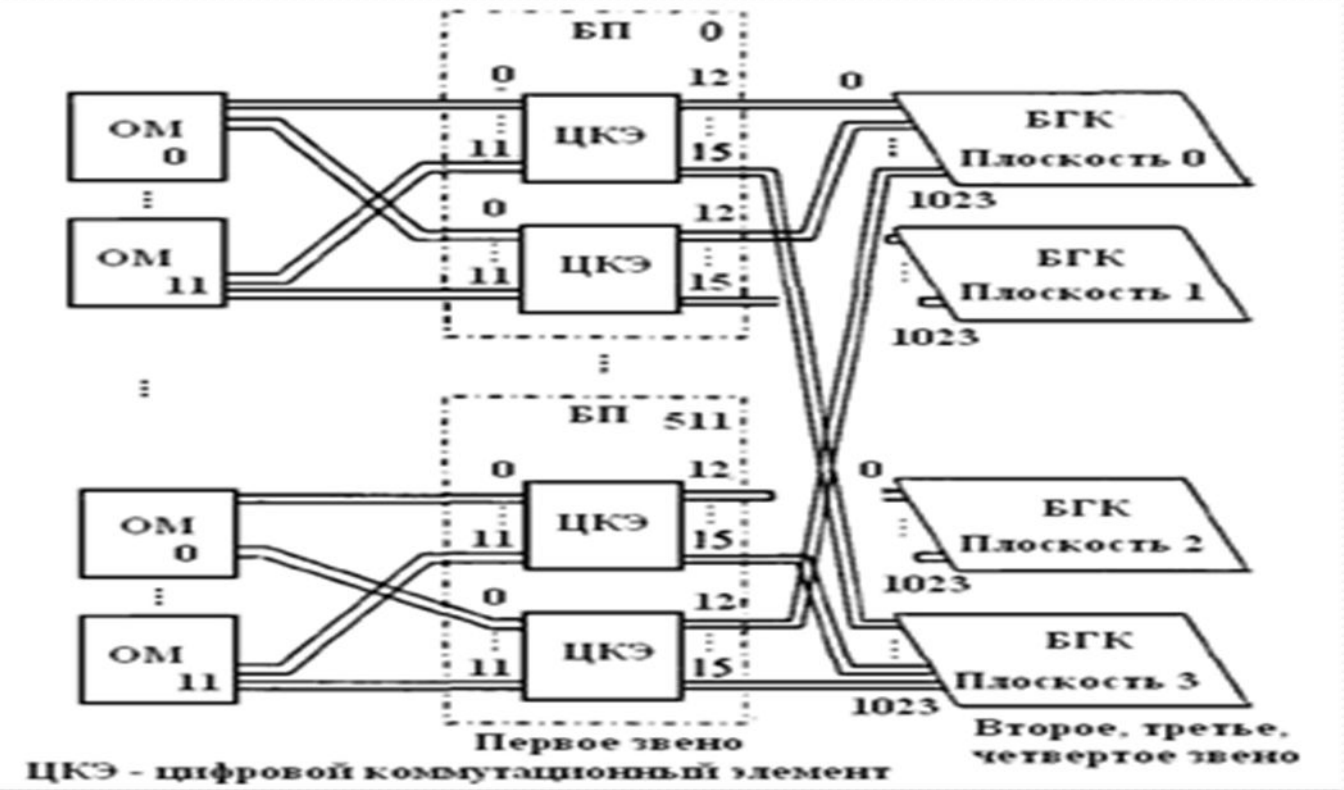
The basic structure of the fourth class CSF



CSF of the fifth class

- These types of systems are CSF: ITT1240 (USA), S12 Alcatel, but the ring CSF not widespread. Links annular fields are built mostly on the ring of digital switching elements (DSE) .Such DSE consists of connecting units (CU) and Group Switching Unit (GSU). One power supply consists of two DSE. Number of BP and BGK in stages depending on the number of connected terminal units (TU). The number of planes depends on the average load induced TU and predetermined Quality of Service from

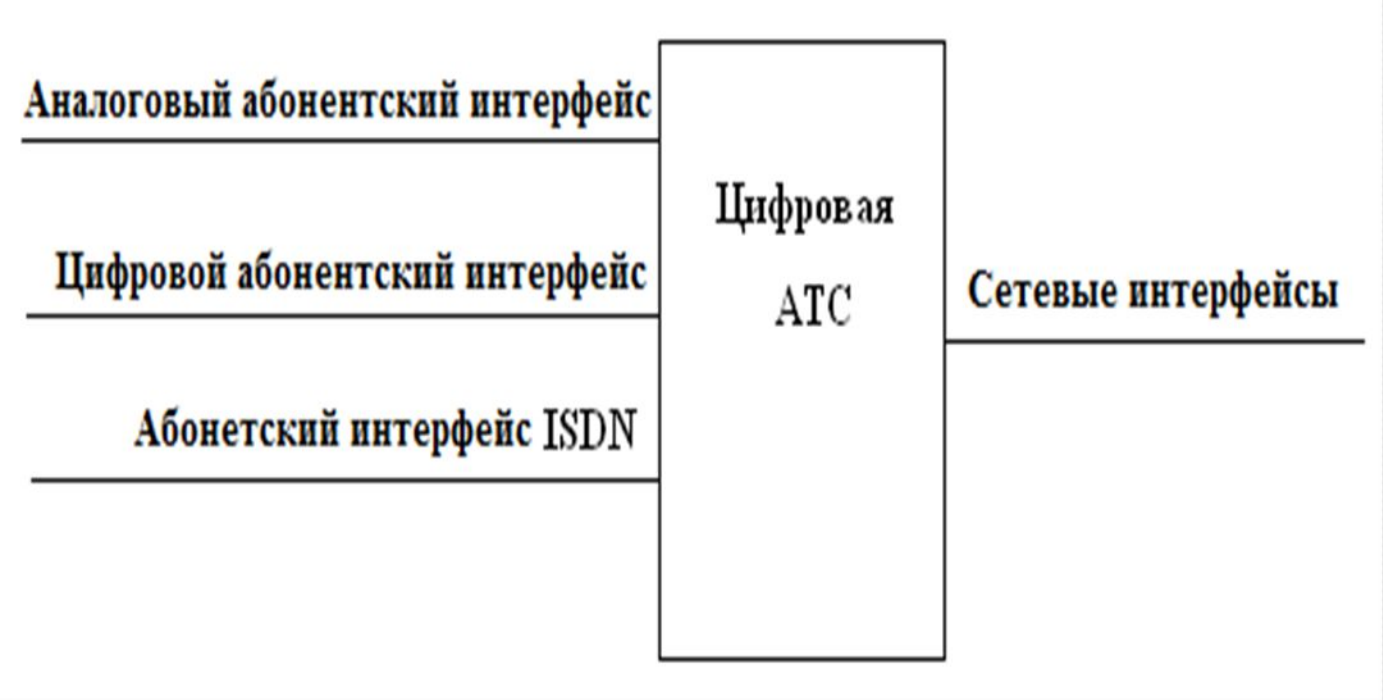
The basic structure of the fifth class CSF



Construction of a subscriber interface in digital switching systems

- Digital Switching Systems Operation is surrounded by various telecommunication equipment other ATS (digital and analog), different user devices, transmission systems. CSC must provide an interface (interface) with analog and digital subscriber line (AL) and transmission systems [1, 2, 4].
- Called interface or boundary between two functional units, which is defined by functional characteristics, common characteristics of the physical connection, signal characteristics and other characteristics depending on the specifics.
- The interface provides a one-time definition of connection settings between the two devices. These parameters include the type, number and function of connecting circuits, and the type and form of a sequence of signals that are transmitted by these circuits.
- Interfaces digital ATS Figure 6.1:
- - An analog subscriber interface;
- - Digital subscriber interface;
- - ISDN subscriber interface;
- - Network (digital and analog) interface.

Interfaces of digital switching systems



Analog and digital terminals

- To enable analog lines (Subscriber or institutional production exchanges (PBXs) in the device, providing access to
- Digital station) uses Z-type interfaces (Z1, Z2, Z3).
- To enable digital lines U interfaces have been identified and V. They are used to activate the AL at the main access to the ISDN network. V2 interface is designed to enable digital substations rate of 2048 kbit / s. Through V3 interface include digital equipment at the primary access to integrated networks, such as digital PBX. Multiplexer equipment to digital PBX interface is activated through V4. For PCM multiplexers used to connect analog remote substations and analog PBX, the interface used for connecting digital access networks

Analog subscriber interface and the problem BORSCHT

- With the creation and implementation of digital exchanges have a problem switching to a digital PBX analog subscriber line (AL) to an analog telephone (SLT). These problems are described by the acronym BORSCHT

Description of BORSCHT function

Буквы аббревиатуры	Имя функции по-английски и его русский перевод	Описание функции
B	Battery feed (Запитка микрофонов)	К абонентской линии прикладывается напряжение, необходимое для запитки угольных микрофонов (U=60В, I=20мА в странах бывшего СССР).
O	Overvoltage protection (Защита от опасных напряжений)	Оборудование цифровой АТС с помощью специальных устройств защищает от попадания со стороны абонентской линии напряжения 220 (380)В, а также напряжения при ударе молнии
R	Ringing (Посылка вызывного сигнала)	Вызываемому абоненту посылается сигнал "Вызов" частотой 25Гц и напряжением 95В (в некоторых странах напряжение может быть 110В)
S	Supervision, иногда Signalling (Наблюдение или сигнализация)	Приборы АТС должны зафиксировать факты поднятия и опускания микротелефонной трубки вызывающим и вызываемым абонентом, а также обеспечить прием цифр номера вызываемого абонента
C	Coding (Кодирование)	Аналоговый сигнал, поступающий по абонентской линии преобразуется в цифровой сигнал и наоборот

Description of BORSCHT function

1	2	3
H	Hybrid (Функция дифсистемы)	Аналоговая абонентская линия является двухпроводной, а передача и коммутация сигналов в цифровых АТС - четырехпроводным. Поэтому осуществляется преобразование с помощью дифференциальных систем (дифсистем)
T	Testing (Контроль)	Осуществляется контроль работы абонентской линии и телефонного аппарата, а также устройств, выполняющих вышеперечисленные функции.

Addressing of organizations analog subscriber interface implementation

- - Approval by the form of the transmitted voice signal (function Coding - coding) and in connection with the transition from a two-wire circuit speech path to the four-and vice versa (feature Hybrid - feature difsystem);
- - Agreement on the levels of transmitted signals: in the direction of the TA sent to the high-level signals (function Battery feed and Ringing), in the direction of the PBX signals must not be sent (ATSC built on LSI and VLSI powered 5 ... 12 V).
- - Providing subscriber signaling (Signalling function - alarm). Testing functions (control) and Overvoltage protection (protection from hazardous voltages) do not apply directly to the company analog interface of the SL, but their implementation allows you to automate the process of operation of the SL and TA, as well as ATSC protect against hazardous voltages.

Network interfaces of digital ATS (STS)

The concept of network interfaces of STS

- According to the recommendations Q.501-Q.517 analog or digital trunks through the STS includes a network interface types A, B and C [1, 4].
- Connected via an interface A digital paths, multiplexed PCM-30 apparatus (2048 kbit / s) or PCM-24 (1544 kbit / s).
- The interface for connecting digital paths multiplexed PCM-120 apparatus (8, 844 kbit / s).
- Analog two or four wire line included in the station end digital exchange via interface C. The analog-to-digital converters for these lines are part of a digital STS equipment.

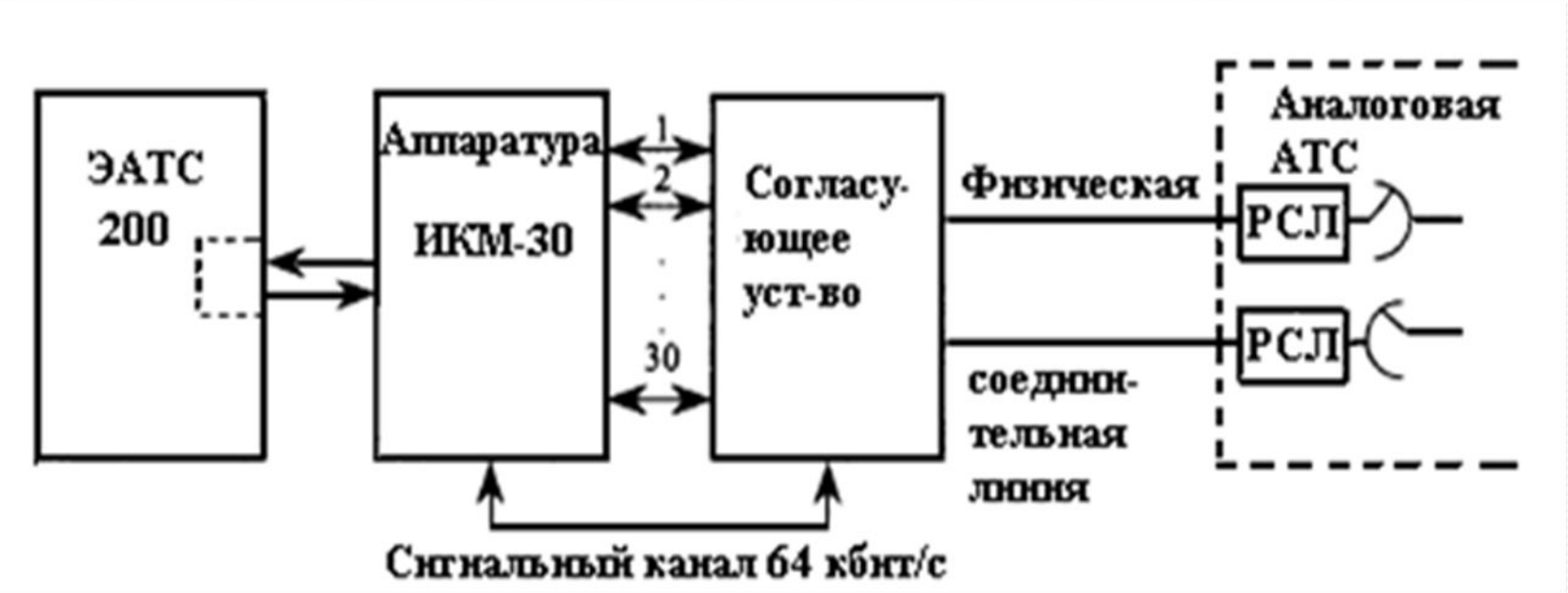
Features connecting network interfaces with a DSP

- In conjunction with other digital STS digital STS, or when establishing between analog and digital STS digital transmission system arranged on the first digital interface. In this case, it realized one of the most important advantages of CSF, which is to create a single digital representation of information in a path of "transmission - switching".
- Thus, the representation of the speech signal as a PCM signal (64 kbit / s, 8 bits in the code word) is similar both for digital switching systems, and apparatus for the DSP. But there are several problems with regard to interfaces and DSP digital switching systems. In - First, the telephone network can be used (and are actually used) DSP are not included in the hierarchy of the ITU transmission systems (eg, PCM - 15, special DSP AL). In - the second, due to the peculiarities of construction of digital manual cycles structure inside them is different from the structure of DSP cycles. ITU has determined that they will not put forward any demands regarding the structure of the PCM cycle paths within the CSK. Digital PBX Developers have the ability to carry out at its own discretion temporary seal PCM streams (secondary Multiplexing) STS, change the length of the codeword. B - Third, encoding words in the PCM line and inside the STS varies.
- To the digital interface, DSP and digital STS imposed two sets of requirements: power and logic.
- The need to harmonize structures cycles indicates that the input should be formed DSP cycles corresponding to the requirements of this DSP. This agreement is usually carried out in the secondary demultiplexing within the STS.
- The logical transformation comprises matching NDV3 linear code signal into a binary code and vice versa to synchronize the input signals in accordance with clock signals stations.

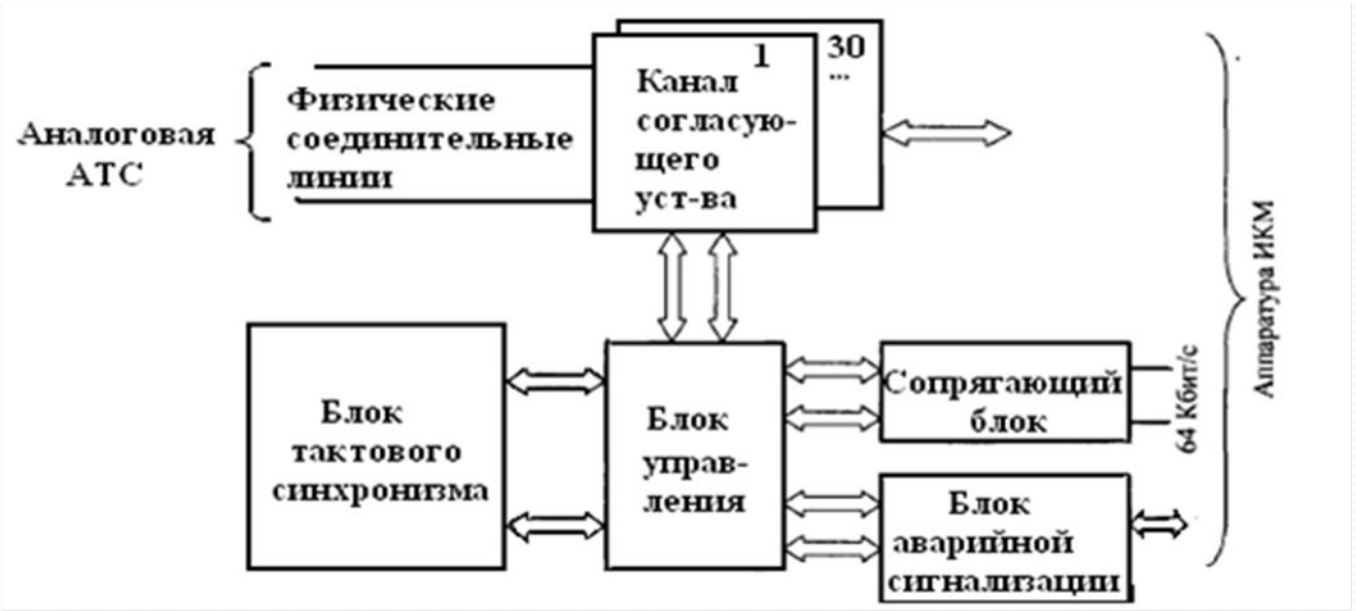
Interface with analog trunks and connecting lines (CL)

- For connection of analog and digital PBX using existing or newly created analog physical connecting line (SL). In this case, for each analog trunk signaling system organized a separate interface. Figure 7.1 shows the principles of coordination of digital EATS 200 urban stations such as ATSC and ATSKU for two-wire physical trunks with signaling DC

EATS 200 communication scheme with electromechanical STSC (RSL - CO relays)



Driving matching device



Interface with analog trunks and transmission systems

- Matching device, Figure 7.2, can be divided into two parts: the channel and signal synchronization. Scheme placed in channels matching device is converted DC signal sending physical connecting line signals supplied to the control unit. The channel portion does not produce any logical processing signals coming from the line.
- The control unit gates signaling information of each trunk in 2 ms. By carrying out a report, it processes it and sends a corresponding message frames (according to code 16 of the slot 30 PCM) in conjugating unit that performs block matching control apparatus for a PCM interface oppositely principle. All necessary for matching devices, timing signals generates a block clock synchronism.

The interface with an access network

- Under an access network subscriber categories understand the nomenclature (voice, data, video) and communication media (metallic and fiber optic cable, wireless). Universal interface that allows to combine all subscriber access technologies into a single network - access network, called the V5 - interface access network [1, 4].
- V5 interface has two varieties - V5.1 and V5.2. V5.1 interface can be connected to the PBX via a digital path 2048 kbit / s up to 30 analog AL without concentration. In this signaling is carried over a common channel. V5.2 interface comprises a plurality (16) paths of 2048 kbit / s, and supports a concentration ratio of not more than 8 and dynamic assignment of time slots. This is the fundamental difference between V5.1 and V5.2 interfaces. Timeslots (in the interface specification - bearers) V5.1 interface is rigidly fixed to the digital TV subscriber paths, ie, between the channels there is a constant connection. The V5.2 interface rigid fixing bearers of the subscriber channels missing ports. Thus, due to the possibility of concentration, the amount used in the interface bearer channels is always less than the number of served channels subscriber ports. The carrier channel V5.2 interface is available only to the user port channel for which communication service is requested and only for the duration of use of this service. In each path 2048 kbit / s signaling channel number may be provided. Comparative characteristics of the V5.1 and V5.2 interfaces, are shown in Table 7.1.

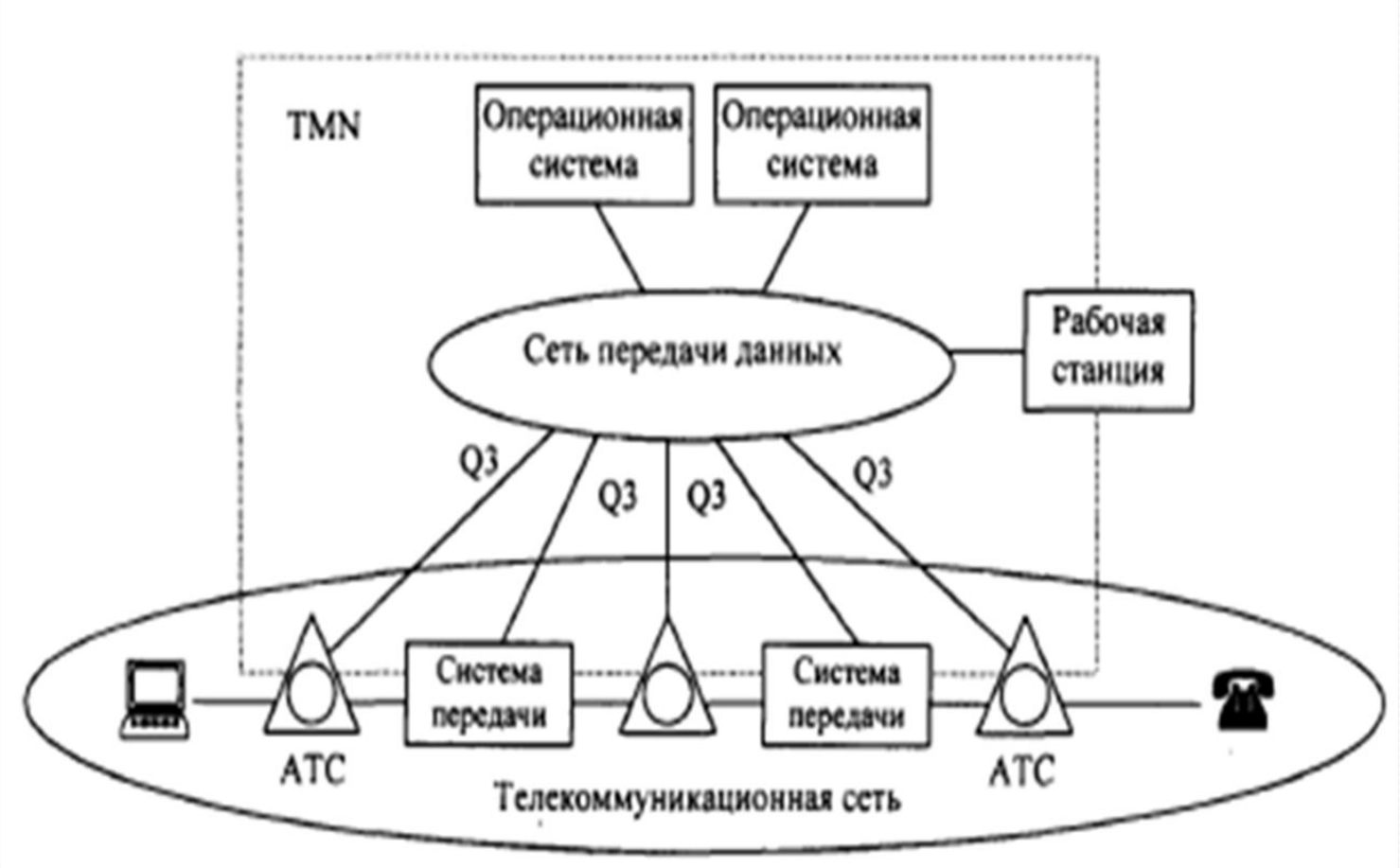
Table 7.1. - Comparative characteristics of V5.1 and V5.2 interfaces

Интерфейс V5.1	Интерфейс V5.2
Позволяет подключать к АТС один тракт Е1 (30 В-каналов)	Позволяет подключать к АТС группу трактов (до 16) 2048 Кбит/с
Не обеспечивает функцию концентрации абонентских линий. Прямое соответствие между канальными интервалами тракта Е1 и системой передачи абонента	Обеспечивает концентрацию нагрузки абонентских линий. Динамическое назначение канальных интервалов
Не поддерживает первичный доступ ISDN	Поддерживает первичный доступ ISDN
Сигнализация осуществляется по общему каналу в тракте интерфейса	Для каждого тракта 2048 Кбит/с предусмотрено несколько каналов сигнализации
Не обеспечивает функции резервирования при отказе тракта интерфейса	Обеспечивает резервирование при отказе тракта путем переключения на другой тракт интерфейса

Interface with TMN network

- Telecommunications Management Network - TMN (Telecommunication Management Network) proposed by the ITU as a unified concept of management for a wide range of network equipment and different class of problems. TMN network provides standardized interfaces, management, routing for networks with different equipment, different versions from different manufacturers TMN is conceptually a separate network, drawing 7.3, connected through a special interface (Q3 interfaces) in a variety of points of a telecommunications network for its information and management functioning. The network operator has the ability to manage a large number of distributed equipment with a limited number of control units Q3 interface is a subsystem and provides two functions:
- - Built-in Q-adapter designed to transcode the messages coming from the TMN operating system in the internal PBX messages back and forth (eg, conversion of MML commands PBX operating system in Q3 interface format and back).
- -stek Q3 protocol, which provides the required connectivity, relevant concept Open Systems Interconnection (OSI).

Figure 7.3 - The interaction between the telecommunications network and TNM



Alarm digital switching systems