SRCE system description manual

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Chapter 1

Introduction

СРЦЕ system is aimed for the use in public switching telephone network as the public exchange for higher hierarchy levels. Technical description of СРЦЕ system has been written like the description of switching system on level 1, in accordance with the recommendation CEPT T/CS 01-10 E *System overall description*).

Prior to the access into development of switching system СРЦЕ, clear aims had been set up, taking into consideration development directives as well as the status of telecommunication network in our country and in the world:

- To develop wide assortment digital switching equipment adjusted to the concept of resolving the digital network which is suitable for economical digitalization of the existing analog network in stages.
- Medium and large capacity switching system per number of terminals and traffic capabilities.
- Openness for additional programme and electronic equipment improvements.
- Modularity of exchange as a whole and some of its electronic and programmable parts.
- Competition at the market

Switching system СРЦЕ has been adjusted to the new concept of building up the digital network in such a way that it can operate as an independent system on all telephone network levels except for the international level, and that it's adjusted to decrease the number of independent switching systems in the network by the use of the remote users' ranks and concentrators. Switching system is created to digitalize a telephone network introducing *Common Channel Signaling system, CCS, type Signaling System 7, SS7.*

It is adjusted to economical introduction of digitalization of network per stages, that is, for operation in compose analog-digital network. It was made of modern components, programmable support was applied, written in language *C, C++*) and the openness for additional electronic and programmable improvements was ensured.

Chapter 2

Purpose

СРЦЕ system presents a public digital telephone exchange, intended for usage within a public switching telephone network primarily for higher hierarchy levels.

СРЦЕ may be also applied for any telephone network level, up to the lowest levels - terminal and community exchanges in decentralized local networks.

Initially developed for domestic telephony market, СРЦЕ system has been subsequently accommodated to apply for foreign world-wide market, as regarding technical solutions and its usage aspects as well.

Due to considerable system facilities and its open-for-upgrade architecture profile, capable of meeting the additional specific requests, implementation of СРЦЕ system appears to be highly recommended within special and closed networks.

2.1 Implementation scope

СРЦЕ system is primarily intended for higher levels, but may be also used for any telephone network level, to the lowest levels - terminal and community exchanges in decentralized local networks.

СРЦЕ system is profitable also when used in small capacities, amounting to 1000 terminals. For extremely small capacities, amounting to several hundreds of terminals, СРЦЕ provides the operation with parent exchange with the small capacity remote stages.

2.1.1 Specific national features

Initially developed for domestic telephony market, СРЦЕ system has been subsequently accommodated to apply for foreign world-wide market, as regarding technical solutions and its usage aspects as well. The system was designed to be capable of easy accommodation to specific requests of national administration and telephone network features. System functions are basically programmable, providing a possibility for a user to solely handle most of the special requests, selecting particular system options and ordering standard commands. For certain requests that cannot be managed this way, GVS performs corresponding system upgrades and provides a "national" system variant as a part of its offer.

Due to an extremely low consumption and dissipation the implementation of СРЦЕ system is very suitable in the areas known for high temperatures.

2.1.2 Special implementations

Due to considerable system facilities and its open-for-upgrade architecture profile, capable of meeting the additional specific requests, implementation of СРЦЕ system appears to be highly recommended within special and closed networks. For special networks (military, police etc.) a specially performed system may be delivered, complying with a harder operation conditions or a purchaser special requests.

2.2 Operation conditions

СРЦЕ system requires no special operation conditions. Common operation conditions for stationary electronic equipment will do. Following paragraphs present operation conditions in groups:

- Climate conditions
- Storage conditions
- Earthing
- Electromagnetic interference

Where "recommended" is used in the text below, note that, in case of equally voted "for" and "against" the particular usage, the manufacturer recommends this very possibility. But the recommended possibility is no compulsory one.

2.2.1 Climatic conditions

System may be installed within one room, and, when using S3000 power supply system manufactured in GVS, supplying equipment cabinet and batteries (hermetic ones) may be stored in the same room.

System was designed to operate with natural cooling, using natural air circulation. System is constructed in the way that a narrow plane is set between each two equipment shelves (racks). Plane is directing the air from a lower external frame, taking a cold air from the cabinet front side and directing it to the upper frame. This provides certain equality to the location of frames as regarding cooling conditions, having the hot air diverted out of the system frame.

Operational temperature range in stationary mode is 0°C to 40°C.

Allowed humidity is 0-90%.

It is recommended for switching equipment to be stored in a room with a 20 - 25 °C temperature.

System requires no additional requests as to the climatic conditions. There is no need to pump in any cold air toward racks. Standard split systems may be used.

2.2.2 Equipment storage conditions

Equipment storage conditions should comply with ЗЈПТТ conditions.

Minimum room height is 260 cm.

Floor capacity is 440 kg/m2.

Floor surface isolation resistance in relation to earthing is $10^4\ \Omega$ - $10^8\ \Omega$.

Antistatic raised floor and a cable inlet with bottom subscriber pairs (through the raised floor) are recommended.

Minimum height of the raised floor is 30 cm.

There are no special requests as for the dimensions of raised floor square parts.

2.2.3 Earthing

Earthing is necessary for entire СРЦЕ electronic equipment. This includes parent exchange and remote stages.

Requested operational earthing resistance for parent exchange and remote stages is 0,5 Ω, while 0,1 Ω is recommended.

Protection earthing for parent exchange and remote stages should not be exceeding 1 Ω, while 0,5 Ω is recommended.

Earthing within a telecommunication object should be installed in accordance with ITU-T K.27 recommendations.

2.2.4 Electromagnetic interference

The equipment is intended to operate in electromagnetic interference conditions causing the energy flow through supply and continuous lines in the unconventional way. Such unpredicted energy flow is referred to as electro-magnetic interference - EMI. EMI effects are conveyed in two directions:

- the equipment effecting the environment
- the environment effecting the equipment

2.2.4.1 Emission

The equipment is designed and realized to satisfy ЈУС No. 700 (VDE 0878) class B standard for electromagnetic interference conditions.

2.2.4.2 Resistance to external interference

Conditions related to external interference detected along supply lines are presented in table 2.1:

Frequency (MHz)	maximum effective value high frequency voltage
0.01 - 0.1	1.5
0.1 - 150	3

Table 2.1: Resistance to external interference induced along supply lines

Conditions related to external electric field presence are demonstrated in table 2.2:

Frequency (MHz)	maximum field strength V/cm
0.01 - 0.1	1.5
0.1 - 1000	3

Table 2.2: Resistance to external electric field presence

Chapter 3

System environment and terminals

The environment of СРЦЕ system is a complicated one. When speaking of СРЦЕ environment, remote stages and system concentrators are considered a part of system, not of the environment.

Elements of the environment may be grouped by types:

- Public switching telephone network JKTM
- СРЦЕ system users connected by means of traditional cable access network
- СРЦЕ system users connected by means of special user access equipment
- СРЦЕ system users connected by means of subscriber (private) exchanges
- СРЦЕ system operators, local and remote
- Uninterruptable power supply system
- Reference operation frequency source

The elements described here are, in a certain degree, "independent" of СРЦЕ system. Most environment elements require many other elements, often used for connection between СРЦЕ and ”environment independent element”. For example, there might be a very complicated special access equipment between СРЦЕ and its user, connected by means of another access equipment. On the other side, an access equipment is only a "connecting" equipment and should not be connected to СРЦЕ exchange unless being used for a user connection to exchange. There may be several different types of access equipment connected to the same exchange. In relation to this, had a complete technical precision been requested, this description should be interpreted in more open a manner: "СРЦЕ system users connected by means of special user access equipment and user access special equipment".

Each element of the СРЦЕ environment is provided with corresponding system terminal. As it was mentioned in the text above, the environment elements are most frequently not connected directly to СРЦЕ system terminals, but using an appropriate connecting equipment.

For certain elements, there might be more different terminal types, according to particular needs. For example, system users connected by means of traditional cable network are provided with analog and digital terminals, depending on the type or service level requested by user.

3.1 Environment

СРЦЕ system environment includes everything that is related to system in any way, without being a part of it. Certain entities in system environment are referred to as **environment elements**. Locations presenting connecting points between system and environment elements, where environment elements are connected to СРЦЕ system, are referred to as **system terminals**.

3.1.1 Environment presentation

СРЦЕ system with its environment is presented in figure 3.1.

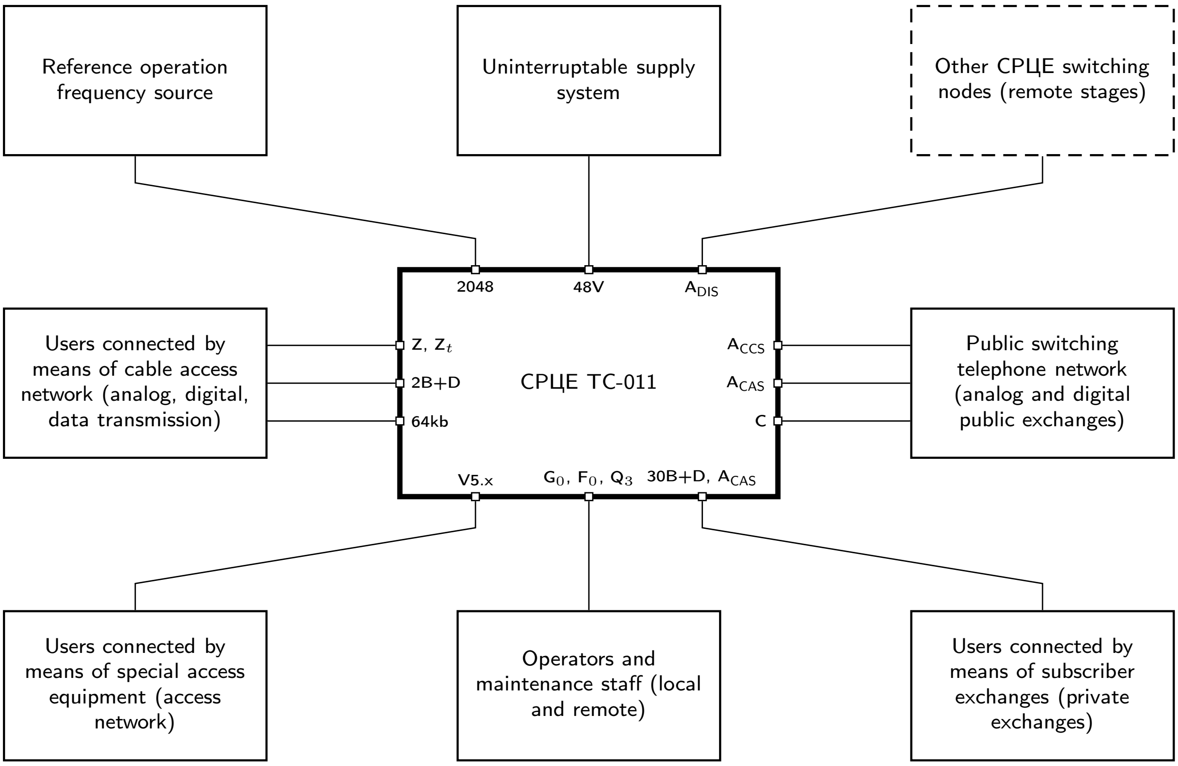


Figure 3.1: СРЦЕ system environment

Terminal types used for connection with corresponding element of the environment are marked on the block presenting СРЦЕ system. Terminals are marked with abbreviations in accordance with the international recommendations' (ITU-T, ETSI) system designation.

Abbreviation meaning is presented as follows:

2048	External reference clock
48 V	48 V direct voltage
A_{DIS}	Terminal A (2048 kbit bothway multiplex signal)
A_{CCS}	A terminal with common channel signalling
A_{CAS}	A terminal with channel associated signalling
30B+D	Terminal for primary ISDN access
G_0	Terminal for operators and maintenance staff (man-machine)
F_0	Work-station terminal for handling and maintenance
Q_3	Terminal for remote handling and maintenance equipment
$V_{5.x}$	V5.1 or V5.2 terminals for access network connecting
64 kb	Data transmission terminal, 64 kbit/s speed
2B+D	Terminal for basic ISDN access
Z	Traditional analog telephone terminal

Broken line designates the block presenting other switching nodes in СРЦЕ system. With СРЦЕ system containing mother board and remote stages, this block shall not be shown in the figure, for not being the element of СРЦЕ system environment. If we consider only one switching stage for СРЦЕ exchange (e.g. mother board), than the environment includes remote stages and corresponding connection. Since switching path toward remote stage is not considered a part of СРЦЕ system, it is than obligatory considered the element of СРЦЕ system environment. Therefore, a remote stage block is marked with broken line, as well as a corresponding terminal. This way, one figure shows СРЦЕ system both as a mother board without remote stages and as a distributed system with remote stages as its constitutional part and corresponding connecting equipment toward remote stage.

3.1.2 Environment elements

This paragraph contains short descriptions of certain environment elements. These elements are treated with no relation as to the СРЦЕ elements. Following paragraph describes connections toward environment elements. The following section presents descriptions of system terminals toward environment elements.

3.1.2.1 Public switching telephone network JKTM

In simpler terms, public switched telephone network consists of public exchanges and switching paths.

Several generations of public exchanges were designed, with different operation technologies:

- decadic-step exchanges
- crossbar exchanges

- half-electronic or quasi-electronic exchanges
- analog-digital exchanges
- digital exchanges

There are also several generations of switching paths with different operation technologies:

- transmission along physical levels
- HF multiplexed systems with frequency division
- digital transmission systems with recovery stations (PCM)
- digital radio systems (earth and satellite)
- optical transmission systems

СРЦЕ system was intended for operation with the up-to-date systems as well as with the old ones in a public switching network.

3.1.2.2 Users

Three system user types are introduced:

- СРЦЕ system users connected by means of traditional cable access network
- СРЦЕ system users connected by means of special user access equipment
- СРЦЕ system users connected by means of subscriber (private) exchanges

All three user types are discussed in this paragraph, for there are no preferences as to their connection to the system. For further description of СРЦЕ system, it becomes important whether connection is made to the system.

Users are persons using telephone services of public switching telephone network. Users may be connected to СРЦЕ in many different ways. In any case, each user is provided with user terminal device connected to СРЦЕ exchange by means of cable network, electronic access network or otherwise.

Depending on type of service used, user groups are: speech transmission, data transmission and combined. When implementing digital telephone system for user connections, some terms are widely used such as "analog subscriber" for traditional terminal for speech signal transmission and "digital subscriber" for ISDN terminal with possibility of digital speech transmission and data transmission.

3.1.2.3 Operators and maintenance stuff

System operators are technical staff performing operative work at the system. Procedure of system operating is often referred to as **operational system control**. Group of operators is often referred to as **system crew**. Operators may be serving the system continuously or periodically. In case the operators are continuously serving the system, it is than referred to as **system with crew**. For case of periodical operator presence, system is referred to as **system without crew**. While performing their work, system operators refer to document "СРЦЕ system - instruction manual". It is recommended that the operators are trained to operate with СРЦЕ system, for this system is considered a very complex one. On the other side, СРЦЕ system is quite easy to handle and operate. The experts pre-skilled in telecommunication systems area may operate this system, solely referring to system documentation.

System operators also perform some simple maintenance procedures, based on the document "СРЦЕ system - maintenance instruction".

What differs system operators from the maintenance staff is a level of their system knowledge skills. Operator mainly deal with operational system works, still familiar with and periodically performing simpler system maintenance procedures. Maintenance stuff is formed of experts trained adequately to perform all СРЦЕ system maintenance procedures, including most complicated failure recoveries.

Unlike system operators that are mainly "reserved" for a certain system facility (in a certain area), maintenance staff is mainly concentrated within technical maintenance centers serving several СРЦЕ exchanges in one larger area. According to need, maintenance experts visit some of these objects to perform particular maintenance procedures.

3.1.2.4 Uninterruptable power supply system

Power supply system should provide uninterruptable power supply of direct voltage for an exchange. This is usually done using system of rectifiers converting 220 V network voltage into direct voltage for battery loading. For the needs of this document, batteries are considered a part of power supply system.

Due to its low consumption, system СРЦЕ requires batteries of a small capacity. Considering this fact, batteries recommended for use in СРЦЕ system are leak-proof batteries for internal mounting in the exchange.

As for the power supply system, S3000 switching supply system, manufactured in GVS, is highly recommended. Being developed in the same company, this power supply system and СРЦЕ system are perfectly compatible. However any other power supply system manufactured elsewhere but GVS company which complies with international standards for telecommunication equipment supply with 48 V direct voltage may be also applied.

Inverters (converting direct into alternating voltage) are not necessary in power supply system, since the alternating 220 V voltage is not used either for the equipment or the operator access in СРЦЕ.

3.1.2.5 Reference operation frequency source

In order to attain high quality of digital network operation, it is necessary for the elements of digital network, and therefore СРЦЕ exchange itself, to synchronously operate the clock of an explicit accuracy and stability. This is achieved using reference oscillators with specified properties; most frequently these are cesium oscillators.

СРЦЕ system may be connected directly to cesium oscillator (or a high accuracy and stability oscillator developed in another technology type), also using specified distribution network. СРЦЕ system is enabled to accept external reference frequency signal using the appropriate equipment within environment to provide the signal reach the corresponding system terminal. The equipment properties may vary, depending on how distribution of reference frequency is distributed to network elements.

Reference oscillator may or may not included in СРЦЕ system environment. Thus due to the fact the system is provided with a facility of plesiochronous operation, an operation with own high frequency and stability oscillator installed, as well as the operation with reference operation frequency received from another exchange.

3.1.2.6 Private exchanges

Private (subscriber) exchanges are considered user devices and not a part of public switching network. These are most often used in companies and other economic and non-economic organizations, so-called "legal subjects" with considerably large of amount internal telecommunication traffic. In such a case, it is more payable to purchase a private exchange, rather than establish the internal calls through public network, and be charged for the external calls. These exchanges may be of a small capacity, supporting several users, or a high capacity ones for several thousands of users.

Private exchanges differ from public telephone exchanges in the matter of functionality and network connection mode. Private exchanges establish local connections between users. They may also provide other, special and nonstandard services for its subscribers. Therefore, private exchange connecting into public network (and consequently, СРЦЕ system itself) is being defined on the basis of international standards and recommendations.

Private exchange users are not considered a public network subscribers. It is preferred to say that "their private exchange is indirectly reaching the public network". As to this technical description, they ”reach” it over a СРЦЕ system connection, using system terminal.

Users connected to СРЦЕ through private exchanges have different facilities from those connected by means of cable access network or access equipment, having a private exchange as a considerably "smart intermediary", leaving the СРЦЕ system with only an indirect control over corresponding user terminals. Control level depends also on type of connection between СРЦЕ and private exchange, and the implemented signalling type.

Private exchanges may be also treated as "independent" elements of СРЦЕ system environment.

3.1.2.7 Access networks

Recent technology progress developed the alternatives for traditional cable access networks for user connection to exchanges. Users remain within СРЦЕ system environment, only with the additional equipment between user and СРЦЕ system.

In addition to this, many solutions were made in regards as to the access network equipment, wired or wireless (radio technology). Consequently, a need occurred to define corresponding international standards regarding equipment connecting to switching systems, based on the idea that a switching system may be connected to an access device or a system of any technology or manufacturer.

A term ”access network” is being used in this document since the access devices mentioned are, in a way, replacement for traditional cable access network. Access devices are very often "distributed" and therefore represent a network.

In a certain degree, concentrators in СРЦЕ system may be considered a type of access equipment.

3.1.2.8 Other СРЦЕ switching nodes

СРЦЕ switching nodes (remote stages and concentrators are considered a part of СРЦЕ system and are demonstrated with a broken line in the figure. More details on СРЦЕ switching nodes are included in section ”Concepts".

3.1.3 Connection to environment

СРЦЕ system connects to environment elements indirectly. For example, connection to users is realized by means of cable access network, terminating at the main distribution frame on the exchange side and the phone terminal on the user side. In direction 'exchange-user', following sections appear:

1. from exchange to horizontal side of main distribution frame
2. from horizontal to vertical main distribution frame side
3. from vertical side of main distribution frame to network lead
4. from network lead to phone terminal
5. from telephone terminal to telephone set

6. from telephone set to user

When dealing with exchange connection with environment, only the first section is treated. In case of a user connected over traditional cable network, this section represents 'exchange - main distribution frame' connection.

Following table shows different environment elements:

Terminal	Environment element	Connecting mode
Z, Z_t, 2B+D	Users	Multi-pair cables to main distribution frame
A_{CCS}, A_{CAS}	Public exchanges	120 Ω cables to digital distribution frame
G_0	Operators, locally	Audio-visual interface - directly
F_0	Work-stations, locally	Audio-visual interface - directly
Q_3	Equipment for remote handling and maintenance	Ethernet UTP cable, category 5 or modem (pair to main distribution frame)
48B	Power supply	Copper conductors to power supply system
2048	Reference oscillator	Pair (two-wired) to corresponding terminal
30B+D,A_{CAS}	Private exchanges	120 Ω cables to digital distribution frame
$V_{5.1}$, $V_{5.2}$	Access networks	120 Ω cables to digital distribution frame
A_{DIS}	Other СРЦЕ nodes	120 Ω cables to digital distribution frame

Table 3.1: Connection to environment

For connections with 120 Ω balanced cable, there is a possibility of 75 Ω implementation, together with an adjusting slice for СРЦЕ system.

Connection to reference oscillator is made to corresponding terminal. Terminal may be set from transmission system or network; in case of the oscillator at the location of the exchange, it may be reference oscillator terminal, or may be a special device terminal performing appropriate function.

Two possibilities were addressed for Q_3 terminal connection. The first possibility concerns local computer network (Ethernet). In this case, СРЦЕ system is cable connected to local computer network providing the access via Q_3 terminal. Further connection of the local computer network into (TMN) network is no important issue for СРЦЕ system. The other possibility implies modem provided access, when computer uses a modem to perform "switching" between Q_3 Ethernet terminal and modem connection. In this case, modem requires one pair to connect to main distribution frame (to the analog or digital user interface).

3.2 Terminals

3.2.1 Digital trunk terminals

СРЦЕ system provides a connection facility with other exchanges by means of A terminals, in accordance with ITU-T Q.511 recommendations.

A terminal is a digital terminal for the first level connection of digital trunk hierarchy.

A terminals in digital exchanges have two variants with different signaling system types. A terminal with Common Channel Signaling - CCS system is marked with A_{CCS}. A terminal with Channel Associated Signaling - CAS system is marked with A_{CAS}.

Electrical features of A terminal comply with G.703 recommendation, for any signaling type applied.

Frame structure complies with G.704 and G.705 recommendations.

In transmission direction, signal is sent along the exchange operating frequency.

Frame contains 32 time channels, counted 0 to 31.

Zero channel is used for frame alignment and indication, network synchronization and other purposes.

CRC, Cyclic Redundancy Check procedure, may be switched on/off along A terminal in accordance with G.704 recommendation. Frame alignment and CRC monitoring functions comply with G.706 recommendations.

3.2.1.1 *A* terminal with common channel signaling

When applying common channel signaling type, any channel from 1 to 31 may be used, including a possibility of using more than one channel in frame.

16th channel is primarily intended for signaling, but may be also used for speech transmission which is in case that signaling channel for object link group (object traffic direction) is found on another A group terminal. Only zero channel is reserved, while 31th channel is free for transmission.

СРЦЕ system may operate with different CCS types, which mainly considers various signaling system 7, SS7 types.

Features of A terminal with CCS system and corresponding associated СРЦЕ system facilities are discussed in details in section 6.5 of the manual.

Complete description for A terminal in СРЦЕ system is presented in document titled "A interface features".

3.2.1.2 *A* terminal with channel associated signaling

16th channel on A terminal with channel associated signaling is reserved for signaling. In addition to signaling transmission along 16th channel and depending on signaling type, signaling may be performed with tone signals along other 30 channels (1 to 15 and 17 to 31).

Features of A terminal with CAS type and corresponding СРЦЕ system associated facilities are discussed in details in section 6.5 of this manual.

Complete description of A terminal in СРЦЕ system is presented in document titled "A interface features"'.

3.2.2 $V_{5.x}$ terminals for subscriber access equipment

V_5 terminal is a digital terminal (based on 2048 kb/s) between an access network and an exchange supporting following access types:

- analog telephone access
- basic ISDN access
- primary ISDN access
- other analog or digital access types for semi-permanent connections without CAS system

These access types are supported using adjustable associating of information channel with ($V_{5.2}$) or without ($V_{5.1}$) on the access network side.

Access network is defined as a system applied between exchange and a user replacing a part of or an entire cable subscriber network. Access network may contain multiplexing, cross-connecting or transmission function.

V_5 terminal may be of $V_{5.1}$ or $V_{5.2}$ type, both supporting different access types and channel capacities. $V_{5.1}$ terminal contains one 2048 kbit transfer, while $V_{5.2}$ terminal may include several 2048 kbit transfers, maximum 16.

Terminal function features comply with ITU-T G.704 [2] and G.706 [3], 2048 kbit. CRC-4 (CRC) procedure complies with G.704 [2] and G.706 [3], including the indication of CRC error, using E bits in CRC multiframe.

Terminal functions:

- Bearer channels provide bothway transmission for ISDN B channels or PCM coded analog terminals.
- ISDN D-channel contents - bothway data transmission from ISDN basic terminals D-channels, including Ds-, p- and f- data type.
- Analog terminal signaling - bothway signaling transmission
- Subscriber terminal control - bothway transmission of status and control signals for each terminal.

- 2048 kbit connection control - frame and multiframe alignment, alarm and CRC data reporting.
- Controlling level 2 connections - bothway communication may convey different protocols.
- Supporting control of common functions - data provision and restart.
- Time form - bit transmission, byte recognition and frame alignment.
- 2048 kbit connection control procedure - link identification, blocking and unblocking (only for $V_{5.2}$).
- Channel control - connection allocation and deallocation by channel, on request (only for $V_{5.2}$).
- Communication channel protection – controlling protection switching of communication channels in case of 2048 kbit link failure (only for $V_{5.2}$).

Electric and physical terminal characteristics comply with ITU-T G.703, for 2048 kbit/s.

Types and allocations of channels and signaling types comply with ITU-T G.964 and G.965.

Structure of $V_{5.1}$ terminal or any $V_{5.2}$ terminal link complies with ITU-T G.704 and G.706. 1 to 31 channels are used for following channel types:

- transmission of ISDN B channel contents and PCM-coded analog channels (JKTM channels)
- communication channels for transmission of ISDN D channel, JKTM channel signaling and control data
- communication channels for transmission of data controlling link, connections and link protection (only for $V_{5.2}$).

There may be 1, 2 or 3 communication channels along $V_{5.1}$ terminal, in 16, 15 and 31 time channels. Channels that are not reserved for communication are used for signal transmission.

Any $V_{5.2}$ terminal link may contain 0, 1, 2 or 3 communication channels, in 16, 15 and 31 time channels. Channels that are not reserved for communication are used for signal transmission along transmission channel control protocol.

Subscriber signaling is transferred along JKTM signaling protocol, with one communication channel.

ISDN terminal signaling and p- and f-type data are transferred through communication channels by means of frame relay.

Control information for user terminals, links, transmission channels and communication processor protection are transferred along corresponding protocols and assigned communication channels. Protocols comply with ITU-T G.964 and G.965 recommendations, i.e. ETS 300 324 and ETS 300 347.

3.2.3 Primary ISDN terminals for subscriber exchange connecting (*30B+D*)

Primary ISDN terminals are referred to as 30B+D terminals, for its multiplex structure, and this term is often used in СРЦЕ documentation. As for ITU-T recommendation, this terminal is referred to as V_3 terminal and is referring to line terminal equipment.

V_3 terminal is a digital terminal for digital subscriber equipment connecting, such in case of a subscriber (private) exchange, by means of basic digital subscriber access section for a primary access convey.

Digital access section complies with ITU-T G.962 and G.963 recommendations. Maintenance procedure is performed in accordance with ITU-T M.3604.

Electrical features comply with ITU-T G.703 recommendations.

V_3 terminal frame structure complies with ITU-T G.704 recommendation.

Types and disposition of channels on V_3 terminal are: 30 B + 1 D on 2048 kbit/s, that is, 23 B + 1 D on 1544 kbit/s, in accordance with ITU-T I.431 recommendation.

In case of B-channel signaling in one primary multiplex transferred along D-channel of another primary multiplex, the channel used for signaling may be herein used as an additional B-channel.

There is always a certain number of B-channels on V_3 terminal, but one or several of them may not be used for any use.

Signaling along D-channel complies with ITU-T recommendations, Q.920 and Q.930.

3.2.4 Analog user terminals

3.2.4.1 User Z terminal

Z terminal is a basic analog terminal the subscriber equipment (telephone set or subscriber exchange) is connected to, by means of subscriber line.

Z terminal provides speech transmission, transmission of data using modem signal, tone-frequency signals etc. Z terminal provides line (phone set) power supply and other BORSCHT functions:

- B Battery
- O Overvoltage protection

- R Ringing
- S Signaling
- C Coding, filtering and decoding - Cofidec
- H two-wired/four-wired conversion - Hybrid
- T Test

СРЦЕ system contains a basic Z terminal and additional two types for special purposes. These are: Z terminal with possibility of sending charging pulses and dual Z terminal.

3.2.4.2 Z terminal with charging pulses sending

This terminal is quite similar to basic Z terminal. It only differs for its possibility of charging pulses sending along subscriber line. On subscriber equipment side, these pulses are received by a corresponding receiver. With such a possibility, subscriber may check the conversation cost. Nowadays, such check methods progressed, often leaving such terminals for traditional "analog" payphones.

Within СРЦЕ system, tariff sending for Z terminal with charging pulses sending is adjustable. Following methods may be used:

- line supply polarity change during each pulse
- 16 kHz or 12 kHz frequency pulse sending without line supply polarity change
- 16 kHz or 12 kHz frequency pulse sending with line polarity change at the beginning and at the end of a conversation

3.2.4.3 Dual Z terminal

Dual terminal provides connection and operation for two telephone devices along one subscriber line, using additional subscriber equipment, so-called "shared boxes". In this case, only one of two users may be using the line. A large number of these terminals was in use for some period of time, due to its considerable savings at the cable access network and the switching stages, extremely expensive at the time. Nowadays, some modern methods provide operation with more than two (4, 8, 10, up to 30) telephone devices on one line providing simultaneous activity for all subscribers connected over it.

Within СРЦЕ system, dual terminals are intended primarily to replace an old switching system with dual terminals. In such a case, СРЦЕ may be equipped with a necessary number of dual terminals, that are to be gradually replaced with an enhanced equipment. In a case opposite, with a modern switching system implemented without dual terminals, it is necessary to replace, together with the exchange, all shared boxes connected to it. This would imply the traffic interruption for a certain number of party subscribers.

3.2.5 Digital user terminals

3.2.5.1 Basic ISDN terminal (U terminal)

The term 'U terminal' is not used inside ITU-T recommendations, but is widely used, in accordance with the American standard ANSI T1.601. Recommendation Q.512 takes the term 'V_1 reference point', still in relation to line terminal, since the section between V_1 reference point to T reference point is referred to as 'ISDN basic access digital section'. ISDN basic access in СРЦЕ system is arranged in a way that V_1 reference point is inside the exchange, same as the line terminal, so the copper pair is directly connected to U exchange terminal. Figure 3.2 shows labels and reference points for ISDN basic access.

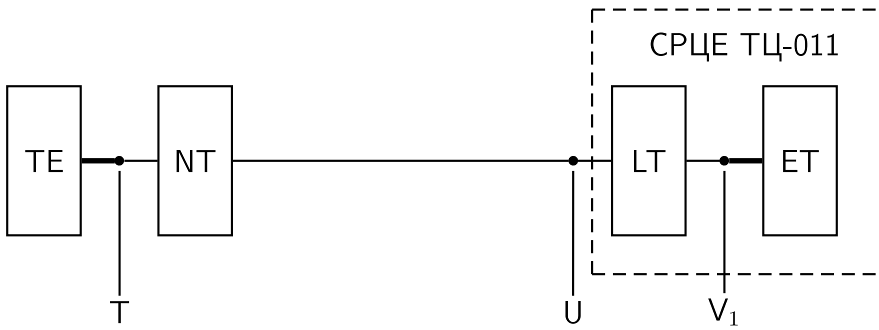


Figure 3.2: U terminal in СРЦЕ system

U terminal provides one basic ISDN access, that is, one basic ISDN subscriber connection. Basic access digital section features comply with ITU-T G.960 and G.961 recommendations.

U terminal functions:

1. 2B + D channels: providing bothway transmission of two 64kbit B channels and one 16kbit D channel, in accordance with ITU-T I.412.

2. Bit rate: provides time features of a signaling unit (bit) and a possibility for a digital section to recover data from bit rate

3. Frame: provides frame time features and a possibility for a digital section and exchange to recover time multiplex channels

4. CV_1 channel: provides transmission of control information required for a digital section, in both transmission directions, following recommendations G.960 and M.3603. CV_1 channel may contain one or more functional channels. It implies network activation, digital section activation request, exchange deactivation, control and maintenance signals.

5. Line supply: provides power supply for digital section and terminal equipment. Within СРЦЕ, power supply is optional.

Signaling along D channel complies with ITU-T recommendations, Q.920 and Q.930 series.

3.2.5.2 Data transmission terminal

СРЦЕ connects performs connection of data transmission user equipment by means of contradirectional synchro 64 kb/s terminal in accordance with G.703 [4].

Term "contradirectional" is used to describe a terminal transmitting clock signals toward subordinate equipment in both directions. Such operation method is necessary for the exchange since the exchange operates on one operation frequency and, to provide complete incoming traffic transmission, the latter one should be synchronized to the exchange operation frequency. Other two cases from G.703 [4], co-directional and central clock terminal are not implemented.

Terminal bit rate for data transmission is 64 kbit/s.

Deviation of signals transmitted over terminal is equal to ± 100 ppm.

Two symmetric pairs are used for each transmission direction, one for data transmission and the other one for composition clock transmission (64 kHz and 8 kHz).

Data signals are coded with AMI, Alternate Mark Inversion code.

Overvoltage protection complies with ITU-T K.41.

3.2.6 Handling and maintenance terminals

As for handling and maintenance terminals, СРЦЕ complies with ITU-T Q.513 recommendation.

Handling and maintenance terminals provide data transmission between exchange and location for performing handling and maintenance functions.

In direction 'exchange - handling and maintenance equipment', user data, tariff data, system state, the occupation of system facilities, system measuring results, alarms and warning for staff and many other data are transferred.

In direction 'handling and maintenance equipment - exchange', commands for system set up and configuration control, system operation modification commands, user service set up/canceling/modifying commands, commands for system state data read out and other commands are transferred.

One exchange may be connected to several handling and maintenance equipment sets. The exchange is connected to each handling and maintenance equipment set over special data links, multiplexed data links or data transmission network(s).

In case of equipment or equipment connection failure, the exchange basic functions are not disturbed.

Terminals provide basic set up, error detection and automatic recovery procedure for batch connection. Terminal enables data transmission mechanisms which perform secure transmission of data (e.g., tariff data).

It is also possible to establish certain priorities for a transmission medium (batch connection) usage, by exchange or handling/maintenance equipment. Terminal supports priority transmission for emergency messages.

3.2.6.1 G_0 terminal

G_0 terminal is no subject of ITU-T recommendations, as it was defined in Q.513.

Handling terminal provides easy and comfortable operator performances, as regarding realization of common system works. Most frequent operator activities are subscriber blocking for unpaid bills and its later unblocking. Less frequent activities are system state surveillance and administration.

Each operator has an operating location. Operating location is adjustable to operator needs. An operator may take any operating location. Depending on operating location configuration, the operator shall be using all or some of the operating location facilities.

Under failure conditions, operating location remains operational. The operator gets to know about the failure from the alarm list. All system functions are available for operator usage in failure conditions, except those related strictly to this failure.

Handling and maintenance terminal is developed to be a "multimedia" terminal using PC technology. Operating location functions as a personal computer connected to the rest of the system in local computer network technology. This terminal here gets an abstract terms and includes a bothway man-machine connection: machine-man direction conveys information using display read out, sound signals and data saving to memory media and a man-machine direction conveys commands over keyboard, mouse and memory media data files.

СРЦЕ system applies so-called WIMP environment. WIMP is abbreviation made of Windows, Icons, Menus and Pointer. Except for its modern graphic working environment, СРЦЕ also provides usage of traditional man-machine communication using parameter commands and a combination of these two techniques.

3.2.6.2 F_0 terminal

F_0 and G_0 terminal is no subject of ITU-T recommendations, as it was defined in Q.513. F_0 terminal is intended for connecting an operating station to the exchange.

Considering this, F_0 terminal is, in a way, "inside" of the exchange since the terminating one is G_0.

F_0 terminal is important for exchanges and remote stages with no operating stations. For this case, F_0 terminal is reserved for connecting a portable personal computer to realize a G_0 terminal. Portable computer should be equipped with appropriate program support which realizes a G_0 terminal.

3.2.6.3 Q_3 terminal

Q_3 terminal connects exchanges to operation systems (OS) by means of data communication network (DCN).

Terminal enables transmission of two data categories:

a) transactions: small data volume, such as for alarm messages;

b) group data transmission: large data volume, such as tariff data.

Q_3 terminal protocols are based on OSI - Open Systems Interconnection model.

In accordance with ITU-T Q.811, СРЦЕ system for lower Q_3 levels uses IETF RFC1006 TP-TCP protocol. This protocol applies IETF standard TCP/IP set of protocols (known also as ”Internet protocol group”) in order to follow protocols of the OSI network transport level. At the lower level (prior to IP protocols), Ethernet protocol *Local computer networks*, IEEE 802.2, is used. Connection may be performed via modem (ITU-T V.34, ITU-T V.90), with IETF PPP protocol (RFC1661) used at the lower level.

Lower levels Q_3 conform with ITU-T Q.812.

TMN functions are supported in accordance with ITU-T Q.82X recommendations.

3.2.7 Power supply terminal

СРЦЕ system is supplied with 48 V direct voltage, with positive end grounded. СРЦЕ regularly operates on 42 - 57 V input voltage. Depending on the exchange size, there may be several physically separated power terminals in one system. All these terminals have identical characteristics.

Power supply terminal is "dual", meaning that supply lead is realized with two pairs of cables, so that a failure of one of them shall not menace system operation.

Electrical characteristics of power supply terminal are described in section 6 of the document.

3.2.8 Reference operation frequency reception terminal

СРЦЕ performs reception and transmission of operation frequency in accordance with ITU-T Q.823.

2048 terminal is a digital terminal for reception and transmission of operation frequency on a digital transmission hierarchy level.

2048 terminal contains of reception and transmission part.
Electrical features of *2048* terminal comply with G.703.
Terminal overvoltage protection complies with ITU-T recommendation K.41.
Terminal features are described in details in section 6. of this document.

Chapter 4

Conception

СРЦЕ is a digital switching system with program control.

Modularity is applied in all system levels and aspects.

СРЦЕ system is designed to provide remote stage networks of small and large capacities.

4.1 Operation principle

СРЦЕ is a digital switching system with program control.

СРЦЕ switching system is designed as an entirely digital system with central processor control. Speech signal is converted into a digital form at the user Z-interface, transferring to switching system.

СРЦЕ switching system is based on modularity of electronic equipment and program support using modified No.7 signaling system inside СРЦЕ. This enables СРЦЕ to operate as an integrated switching system and perform the independent function of its particular sections.

System includes telecommunication and control section (see figure 1). Telecommunication section is contained of switching network, interfaces and auxiliary peripheral devices necessary for regular system functioning. Control section consists of control block and handling and maintenance interfaces.

System control is centralized and processing is distributed. Control block is designed as a multiprocessor system on several levels. Low control level processors perform common activities and are authorized for certain part of system functions, while high level processors perform more complicated activities and are authorized for the whole system or its several sections.

To realize such processing type, inter-processor communication is realized inside the control block. A processor at the higher control level has a priority in using inter-processor communication buses.

4.1.1 Survey diagram

Figure 4.1 shows СРЦЕ system survey diagram.

Continuous lines in the figure show communication signals, switched through the system, from user to trunk. Basic system purpose is to process these signals and their flow. In figure legend, these are referred to as "useful signals".

Gray lines show control streams. In certain cases, certain signals are transferred from user and trunk terminals through the system in these streams. Still, their basic purpose is to enable inter-processor communication inside the system.

Synchro signals are marked with broken lines, since only these are not obligatory in the system (operating in plesiochronous operation).

4.1.2 Interfaces

Basic interface function is to convert a signal from system terminal into a form convenient for system processing. Interfaces convert the signal into a digital form. Signal at the system terminal contains both signaling contents control processed and those processed through switching network. Interfaces also convert terminal signaling contents into a form

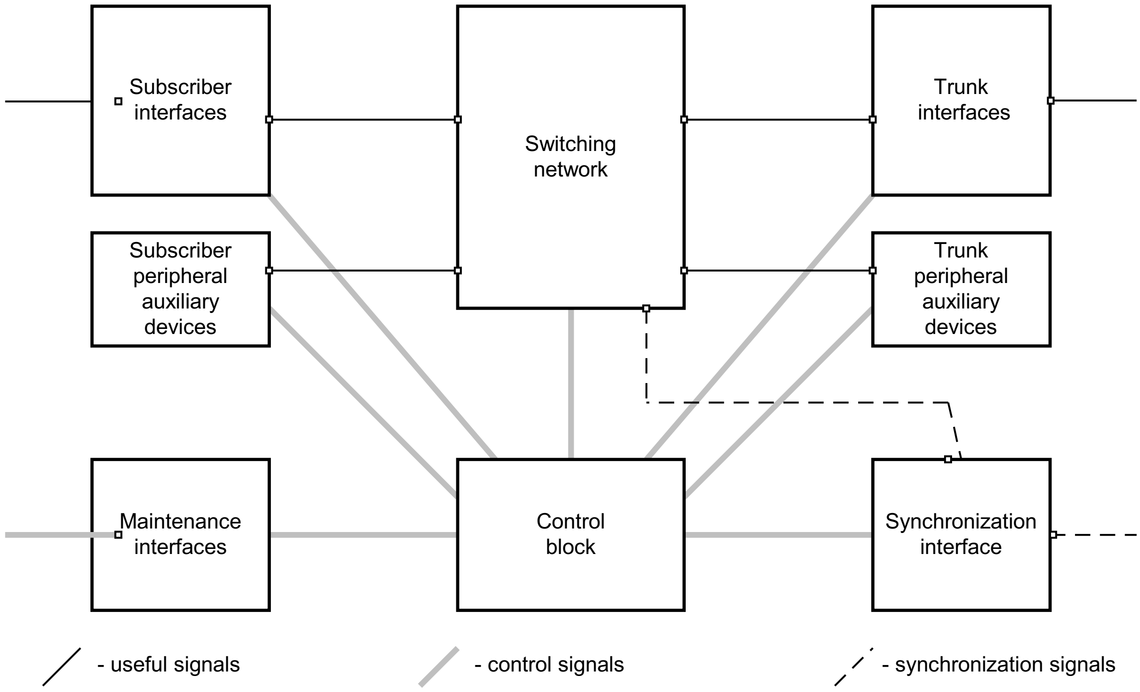


Figure 4.1: СРЦЕ ТС-011 survey diagram

convenient for system processing, mostly digital control information available for program processing.

Such an access is shown in figure 4.1. Blocks presenting user and trunk interfaces are connected to switching network and control block.

In case of analog subscribers, speech signal is converted into a digital form and vice versa. Signaling toward analog subscriber converts into inter-processor communication messages.

As for digital users, speech signal at the terminal is already in a digital form and only adjustments made are for the signal format. Signaling toward digital users is performed over messages, which are than revised into inter-processor communication messages.

Channel contents are not processed in the interface, but are transferred through the system without form modified. Signaling is revised into inter-processor communication messages. Depending on the applied signaling system at the terminal, interface processing may be unimportant or considerable.

4.1.3 Switching

Multistage switching is applied in accordance with system architecture. Nonblocking switching networks are used, with T time component exclusively.

Functional block scheme of СРЦЕ system switching is shown in figure 4.2.

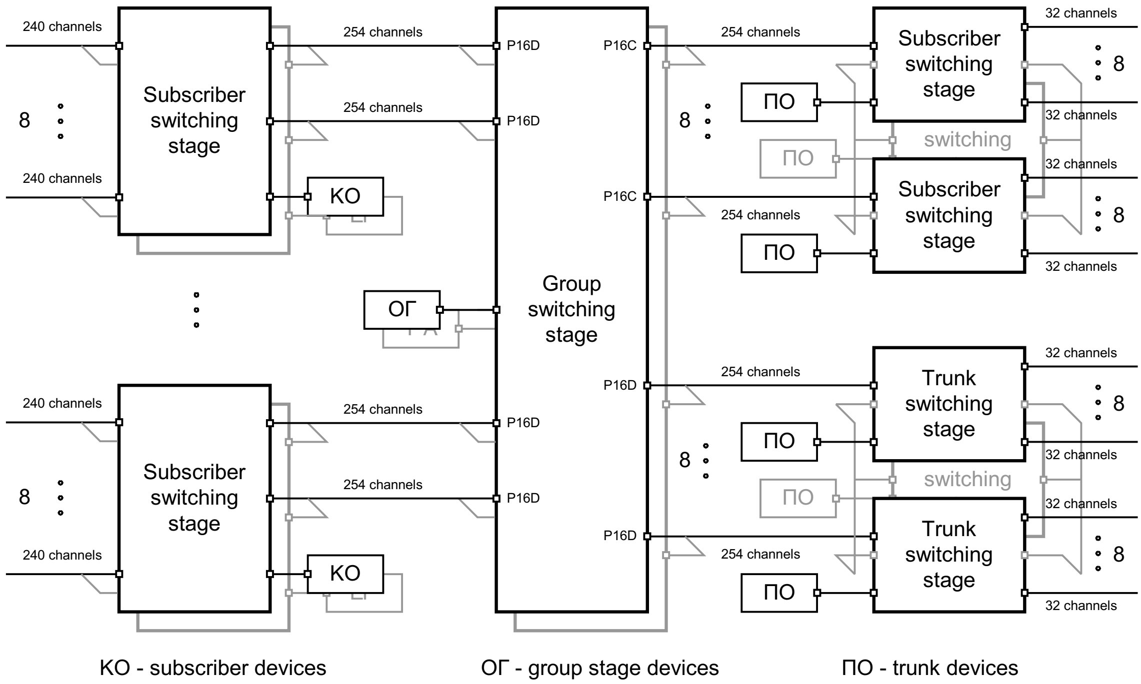


Figure 4.2: Functional block scheme of СРЦЕ switching

Switching network contains of three stages:

- user stage - КС
- group stage - ГС
- trunk stage - ПС

User stage performs connection of user leads and their concentration toward channel routes and other devices connected to outlets, in direction opposite to connection establishment direction.

Group stage performs distribution of calls to different routes of trunk and junction channels.

Trunk stage performs connection of trunk leads and their connection to other devices in a connection establishment process.

User stage and group stage, and trunk stage and group stage are mutually connected over interconnections realized in 2 Mb/s links multiplexed to 8 Mb/s.

4.1.4 Program control

СРЦЕ system is program controlled system with central control and distributed processing.

This term primarily refers to the system control mode, which is realized by means of traditional processors of basic purpose. Processors mutually communicate along corresponding channels for inter-processor communication realized using fast serial buses. All system processors (excluding card microcontrollers for special purposes and digital signal processors) together with the inter-processor communication network make a **control block**.

Term 'central control' denotes of a central location inside of system where all decisions of high priority are made, relating to system functioning. This location is doubled and may be one of two central processors. Regional processors may decide of the lower level features, solely in its own operation area. Central processors are realized as multiprocessor systems made of processors for basic purposes. More appropriate term for them might be "central computers", but the term 'central processor' has got already in use as a system location where event processing is performed.

4.1.4.1 Control block structure

Control block is designed as a central processor system with two control levels. Functional block scheme of control block is shown in picture 4.3.

The first (higher) level presents central control block CUB with dual central processors CP and an administrative computer. The second (lower) level presents regional processors. There are several types of regional processors at the second control level and these are: РПК, РПЗ, РПГ, РПП and ЗРП.

The abbreviations used for regional processors designate their function within system:

- РПК - user stage regional processor
- РПП - trunk stage regional processor
- РПГ - group stage regional processor
- ЗРП - trunk rack common regional processor
- РПЗ - regional processor of user group common devices

Communication buses follow HDLC protocol, with separated transmission and reception, providing usage of full duplex communication method. Buses toward regional

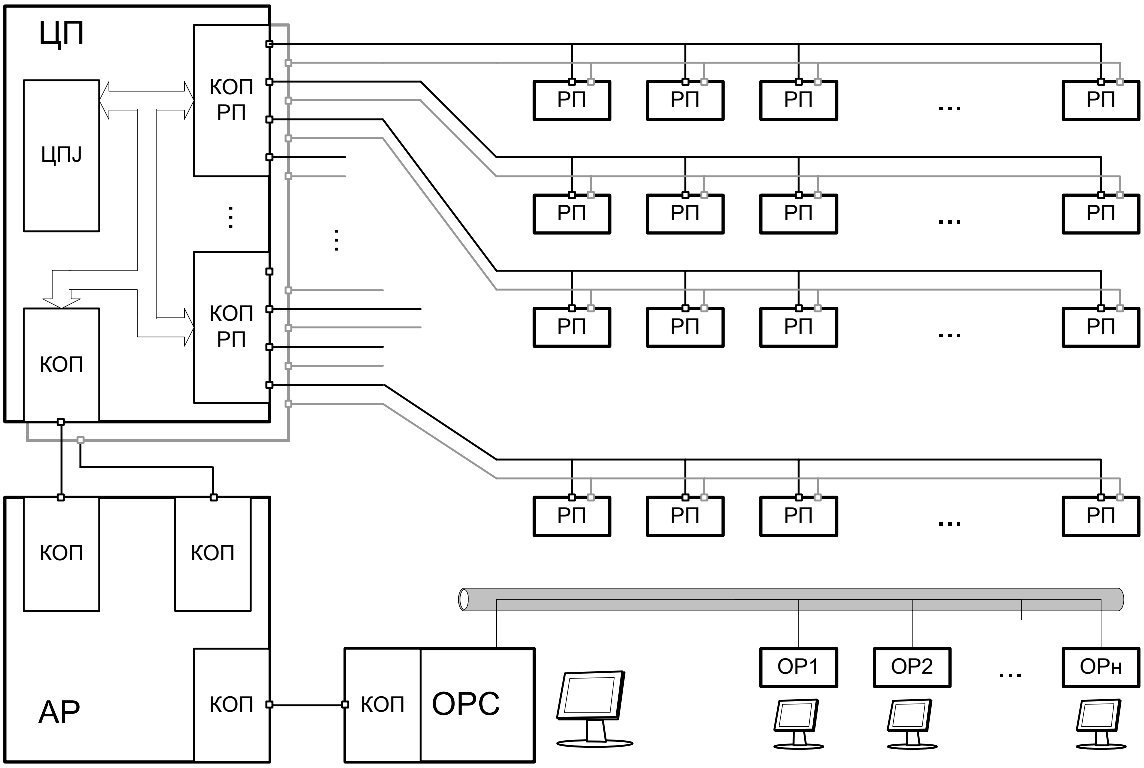


Figure 4.3: Functional block scheme of control block

processors use half duplex because of the operation mode applied - large number of bus regional processors and polling process.

4.1.4.2 High control level

High control level includes central control block - modern control structure. It is realized as a triangle of powerful processors, CP1, CP2 and AP. One of these processors, CP1, is the operating one and the other one, usually CP2 is a back-up processor taking the role of the operating one in case of CP1 failure. Central processor performs the most complicated system functions relating to call processing, diagnostics, control etc.

AR processor is an administrative computer connecting all terminals required for system communication. AR processor performs all administration and operator interface functions.

Central processors communicate with AP by means of КОП communication processors, like AP communicates with OP. Communication between CP and regional processors is also performed using КОП processors with HDLC buses connected. 30 regional processors, at the most, may be connected to one HDLC bus.

Communication processors poll regional processors, send messages from CPs and collect those from RPs to CP, ignoring those conveying no information (e.g., filling messages). Such structure enables CP to receive data from communication processors in the most appropriate form, when the time comes for their processing.

Communication processors decrease central processor load to 1 - 2%. They realize level 1, 2 and 3 of OSI reference model.

All three processors at this control level are realized with usage of industrial personal Pentium computers, produced by Intel company, with communication processors mounted in a case together with a relating computer.

4.1.4.3 Low control level

Low control levels directly control telecommunications part using regional processors.

РПК regional processor is intended to control subgroup module for 256 users of subscriber stage. РПК uses scanning process to monitor interface devices on user lines, detect dialing attempts, establish connection between DTMF receiver and calling interface through subscriber stage switching network, connect dial tone, collect dialed digits, convert user signaling into messages and communicate with central processor. After receiving a message of called subscriber state, connection is established between calling user line interface and selected interconnection subscriber stage - group stage.

For incoming calls, РПК gets message from CP, relating to specified subscriber, establishes connection through subscriber stage and connects call control toward calling subscriber to connection point of selected subscriber stage-group stage interconnection.

This РП is not doubled, for it's serving a 256 subscriber line group.

РПГ regional processor establishes connection through group stage, ГС. It is controlling central switching stage and is doubled. Group stage regional processor is mounted on the same printed board with group stage switching network.

РПП regional processor controls 240 digital channel group. Similar to РПК, it controls the state of link interfaces, detects the request for connection establishment, issues directives for connection establishment through switching network between calling digital channel and MFC transmitter, collects digits, converts applied signaling into No7 signaling, issues directives for connection establishment between calling channel and selected ГС-ПС interconnection, releases MFC transmitter and clears the connection.

In case of outgoing call processing, РПП receives calling number in the message format, issues directive for connection establishment through trunk stage, ПС, between a selected channel and MFC transmitter, converts signaling into corresponding CAS, controls digit transmission, establishes connection through trunk stage between a selected channel and ГС-ПС interconnection and releases seized MFC transmitter. On connection clearing, РПП converts applied signaling type into corresponding CAS and vice versa and releases connection through trunk stage.

There is a back-up module reserved for the case of 240 channel failure caused by an

РПП error. Such module may overtake one of РППs and all channels in its control prior to failure.

РПЗ regional processor controls common devices such as dual call generator and subscriber line testing device. РПЗ is dual.

4.1.5 Subscriber peripheral auxiliary devices

Peripheral auxiliary devices connected to subscriber stage are:

- tone signal generator for analog subscriber line signaling
- dual tone multi frequency receivers, DTMF receivers
- subscriber stage - group stage (КС-ГС) interconnections
- calling subscriber identification analog line receivers
- conference connection set up equipment
- diagnostic and auto-diagnostic circuits

Call generator, ГСП, is connected directly to interface devices, over its subscriber lines.

4.1.6 Trunk peripheral auxiliary devices

Peripheral auxiliary devices connected to trunk stage are:

- tone signal generator for trunk line signaling
- tone signal transmitters for register signaling R2 (Multi Frequency Code R2)
- trunk stage-group stage (ПС-ГС) interconnections
- diagnostic and auto-diagnostic circuits

4.1.7 Synchronization interface

Figure 4.1 shows interface synchronization connections with a broken line. These connections are not obligatory, for system may operate in plesiochronous mode as well, without using connections or synchronization equipment.

Synchronization interface is a structural part of СРЦЕ system and is delivered with the system, except if specially required by a certain purchaser to have system designed without such equipment.

Synchronization interface receives external reference operation frequency signal and accommodates it for system central oscillator usage.

4.1.8 Modularity

Modularity principle is being applied at all system levels and aspects.

Some of modularity solutions implemented in the electronic equipment construction are:

- Regional processors
- Interconnections
- Communication processors

4.2 Remote stage system operation

СРЦЕ system may operate as a traditional telephone exchange or as a "decentralized" exchange with remote stages. In the latter case, terms used shall be **parent exchange** and **remote stages** Term "exchange" encloses a parent exchange and all remote stages.

СРЦЕ system implies, in a certain degree, the equality of parent exchange and remote stages, therefore introducing the term **switching node network**. "Switching node" is a generalized term meaning "parent exchange or remote stage".

4.2.1 System survey diagram with remote stages

Figure 4.4 shows СРЦЕ system survey diagram in configuration with remote stages.

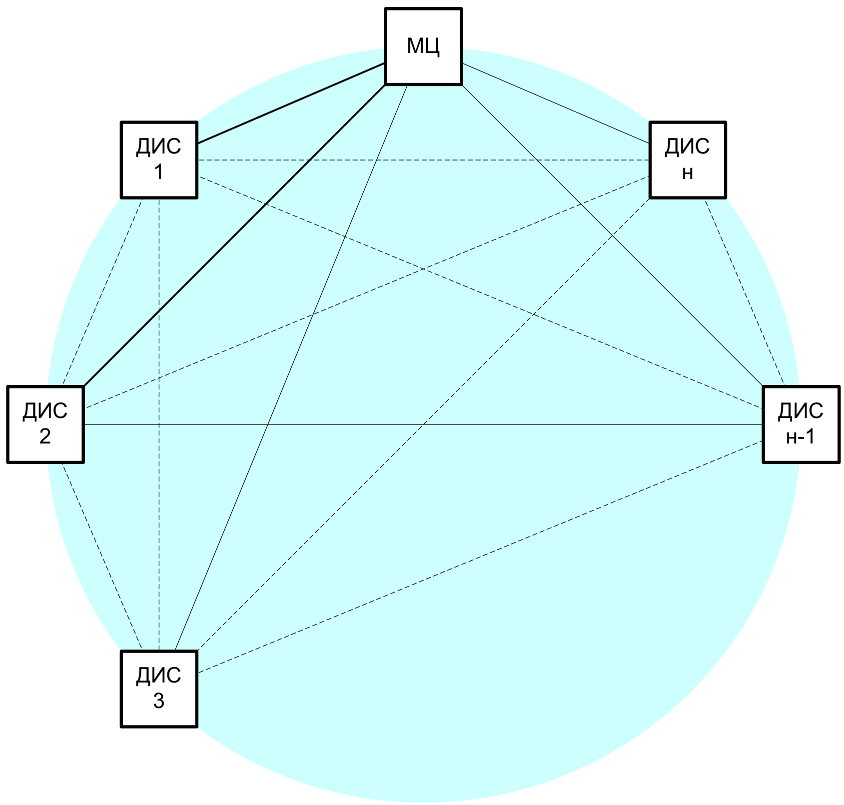


Figure 4.4: Structure of СРЦЕ system with remote stages

Figure shows connections between parent exchange and remote stages with continuous lines while broken lines demonstrate connections between remote stages of "transverse connection". Connections between parent exchange and remote stages are not necessary.

Not all remote stages should be connected directly to parent exchange. Some may be connected over another remote stage.

4.2.2 Interfaces

User interfaces may be installed both on parent exchange and remote stages. Trunk interfaces are at the parent exchange. Special interfaces are reserved for connecting parent exchange and remote stages.

4.2.3 Switching

Switching is shortest performed through the network of switching nodes and switching paths.

Connection between users at the same switching node is established inside this switching node.

Connection between users on different switching nodes is established through the direct switching path between these two switching nodes, when present.

If their is no direct switching path between users on two different switching nodes, connection shall be established through the third switching node the both are connected to, and in case there are several of those and one of them is a parent exchange, the latter one is priority.

4.2.4 Program control

Each remote stage in СРЦЕ system is provided with own program support. Remote stage program support is intended for dual-mode operation.

Regular operation mode implies communication connection between a remote stage and a parent exchange. In regular operation, remote exchange is fully controlled by parent exchange. This practically means that the central control block in parent exchange controls entire call processing, switching and all other functions of a higher level, including those realized on a remote stage.

Irregular operation mode is a state of no connection between remote stage and parent exchange, such in switching path failure conditions. In this mode, remote stage moves to autonomous operation and establishes local connections for directly connected users.

Chapter 5

Functions

СРЦЕ switching system performs a great number of functions. Following groups of functions are distinguished:

- Telephone (basic), described in section 5.1, starting from page 44
- Administrative (operator), described in section 5.2, starting from page 115
- System (internal), described in section 5.3, starting from page 131

Description of the functions in this text is quite simplified, since the detail description would take too much space. *Not all* system functions could be mentioned, but only most important ones, or several similar functions are described as one. Still, all of these functions are here listed together, thus providing their common view. Detail descriptions for particular functions are enclosed within the rest of СРЦЕ documentation, mainly treating the groups of similar functions.

5.1 Telephone functions

Telephone functions represent basic functions within a telephone exchange, and therefore are first introduced. Main telephone functions are:

1. Call processing
2. Traffic routing
3. Charging
4. Signalling

In a certain degree, these functions are related and may hardly be treated totally independently. However, it is possible to differentiate them and understand as separate functions but still in consideration with its related functions.

Other telephone functions are:

- Subscriber supplementary functions - these include all the functions not implying the basic call (which concerns the possibility for a subscriber to call another one and have a conversation). Generally, thus recorded, it has to do rather with chronological order, since the implementation of service increased with introduction of software directed digital switching systems. Still today it is quite reasonable to use the same kind of service recording, having some of them excluding each other, forcing the subscriber to choose one instead of another.

- Advanced telephone functions - this is common scope for all supplementary functions not related directly to subscribers. These are: MHG (multi-line hunt group), ringing options (depending on call type) etc.

- Signalling conversion - the two parties, making a call, may be connected by different signalling types. This results the common case of n^2 possible types of conversion (where n is the number of possible signalling types). СРЦЕ system is designed to reduce all signalling types to the common one (internal СРЦЕ signalling), so as to avoid the possibility of square incremented program support in regards to number of signallings. Although this is not an ideal solution and, in some cases, internal СРЦЕ signalling must be upgraded when implementing new signalling types, this method considerably reduces necessary activities and error situations.

5.1.1 Call processing and basic call

Basic call phases are:

1. Connection establishment
   (a) call reception
   (b) call routing
   (c) call forwarding
   (d) connection establishment
2. Connection established
   (a) waiting on answer
   (b) conversation
   (c) B hooks off
3. Connection release
   (a) usual release
   (b) forced release

Basic call management procedure may be divided into three phases, mentioned above, with its basic issues:

- *Connection establishment phase* conveys identification of the call originating point and specification of *incoming connecting point*. The incoming connecting point is being tested for its characteristics and restrictions, dialed number and its possible changes are being analyzed. Call destination point is specified, choosing between *outgoing connecting point* and *special service* and the destination point is sent a request for connection establishment. If it is not possible to establish the call, the connection is cleared, and if it is possible, a specified protocol provides entering the established connection phase.

- *Established connection phase* starts with waiting for called subscriber answer, continued with conversation between calling and called party and terminates on user request for connection clearing or forced clearing in case of system or protocol error. On user request, it is possible in this phase to temporarily suspend and restore through-connected speech path between users.

- *Connection release* provides clearing of whatever connection was initiated in the system, thus in order to release seized electronic and program resources. Clearing is performed using special signalling protocol providing all exchanges from the originating to the destination user to release through-connected speech path and clear resources, all in time specified.

5.1.1.1 Connection establishment phase

The call may originate from subscriber, talking machine or trunk channel toward previous exchange. Module for call processing is activated on reception complete of all data necessary for the call to be routed to destination exchange and the connection through-connected between called and calling party. These data would be:

- calling party category (optional)
- calling party address (optional)
- called party address (number)

Subscriber terminals, trunk channels and talking machines represent types of *logic connecting pints*. Each connecting point may establish several connections, being different by their *connection sequence number* (РБВ). Analog subscriber connecting point is restricted to establishment of two connections, digital to four for basic and sixty four for primary access, trunk to one while talking machine is not restricted to any (exceeding even the number of calls in the system).

For each established connection certain important data are saved:

- incoming and outgoing logic connecting point, their types and used connection sequence numbers
- connection sequence number state for specified connecting points in corresponding connecting point tables; possible states are: idle, seized in incoming, seized in outgoing, in reset, blocked.
- seized interconnection chains for incoming and outgoing connecting point
- calling party number
- calling party category
- charging data
- special service indicators
- call state
- values dependants on states, such as: B-analysis tree number, discrimination tree number, routing case, outgoing route,...

System includes *subscriber logic connecting point table and trunk logic connecting point table*. *Talking machine table* is connecting point table for talking machines.

In case of calling party, call originates from the specified connecting point, and the table of subscriber connecting points provides subscriber number, unless it was obtained by DSS1 set up message. In the latter case, it is checked whether the number obtained was assigned to specified subscriber and if not, the call is cleared. The subscriber number is taken to be the calling party number. It is used for charging and its characteristics are further processed. This number is a key to subscriber table. Subscriber table contains data necessary for routing and charging of subscriber calls, same as the indicators managing assigning and activation of subscriber additional services for *calling* party.

Calls originating from talking machine are routed and charged according to data contained in talking machine table.

Route is a group of trunk connecting points, all with same characteristics concerning sending and reception of calls from/to them. This practically means that, in case of the incoming route, all parameters for the call originating from any point, are the same.

After the call destination is defined and outgoing point selected, connection establishment is started on the outgoing side. Data used during establishment are: calling party category, sequence number of digit starting digit sending (for CAS signalling types) and dialed number digits.

In case of SS7 signalling, calling party number is also available same as the other information related to additional services and network facilities.

On the connection establishment initiated in the exchange, time out is started on waiting for called party state, entering state *state waiting*. Had the time out expired, connection is released and calling party is sent appropriate acknowledgement (tone, etc) through EOS analysis.

On the request for connection establishment received, destination exchange analyzes the dialed number to define the subscriber to through-connect the call to. Same exchange checks the state of called party line and performs different checks concerning the connection being allowed or not. These checks include compatibility checks and those related to additional services. Whether subscriber is ready to receive the call in destination exchange is clear on reception of state "idle".

If the connection is allowed, destination exchange establishes the connection to the called party. State "idle" is sent backward to the originating exchange, thus initiating the through-connection of complete speech path from calling to called party.

In case the connection to the called subscriber is not allowed or possible, destination exchange shall: try another attempt of call routing, or initiate release procedure toward previous and/or subsequent exchange. Message about connection failure is sent back.

The information concerning the cause for connection establishment failure is more or less precise depending on signalling type. Generally, for ISUP and DSS1 signaling types, this issue is described in ITU-T Q.850 recommendation. The information of the cause is less precise for other signalling types. But for the most of signalling types, a certain group of causes may be defined, containing following:

- Congestion signal at switching equipment
- Circuit group congestion signal
- National network congestion signal
- Address incomplete signal
- Call failure signal with forced release
- Subscriber busy signal
- Unallocated number signal
- Line out of service signal
- Send special information tone signal (in case of signalling conversion)
- Access barred signal
- Digital path not provided signal
- Misdialed trunk prefix

5.1.1.2 Connection established phase

Connection established state includes: waiting on answer, answering, hook on and re-answering.

On called subscriber answer, ring-back tone is terminated, answering is sent backward to previous exchange and if this exchange is in control for charging, charging may begin.

On the answering received, transit exchange sends appropriate message to previous exchange. If the exchange is in control for charging, charging may begin and time out on waiting for answer is terminated.

On the answering received in the originating exchange, time out on waiting for answer is stopped and charging may begin.

During the conversation, there may occur hook on and re-answering. In common telephone systems, hook off is possible only for called party, while ISDN provides possibility for calling party to perform this action, with no connection termination. Alternatively, called party hook on may be treated as a called party request for connection release.

Hook on indicates temporary interruption of communication without call release. It may be accepted only in connection established phase. Hook on is generated by the network itself as a response to indication received from conversion point or analog called party.

After hook on condition is registered or hook on signal or hook on message is received, exchange in control for the call starts time out on waiting for re-answering, in order to provide condition registered, reception of indication or re-answering message or release message.

Re-answering indicates the request to restore the communication.

Network sends re-answering message after previously sent hook on message, as a response to indication of re-answering received from conversion point or to registered condition of re-answering from analog called party.

On condition registered or reception of either signal or re-answering message or release message, the exchange in control for the call stops the time out on waiting for re-answering and proceeds with sending the charging data.

Had the re-answering message not being received before time out expiry, the exchange the time out was started at initiates release procedure.

5.1.1.3 Connection clearing and resource release

On reception of clearing or call error, following actions are taken:

- speech path is released
- charging is stopped
- clearing message is sent to subsequent exchange. Time outs are started providing reception of clearing from subsequent exchange.

On clearing received, following is conveyed:

- resources on the incoming side are released and release is sent

Had call error message being received, following is done:

- call error message is sent to previous exchange (if possible). Time outs are started, enabling reception of clearing message from the previous exchange.

State *clearing* is entered.

5.1.1.4 Other call processing procedures

5.1.1.5 Both way seizure

Some important issues concerning both way seizure are:

- message transmission or retransmission may take some time

- *both way seizure* occurs in situation when the attempt of connecting point (so called ”circuit”) seizure, is followed with the attempt of seizure from another side.
- selection of an appropriate circuit may reduce the possibility of both way seizure
- had both way seizure still occurred, and depending on particular situation, the initiated call may be continued or the attempt of connection establishment may be performed along another circuit.

As concerning the circuits with the possibility of both way seizure, it is possible for two exchanges to try seizure of the same circuit almost simultaneously.

If the exchange is not informed of the both way trunk being seized, it may be that it really isn't idle, only the exchange has not processed the information of its seizure yet. In this situation, the exchange may try to seize the trunk which results in both way seizure.

Various methods for circuit selection may be applied to minimize appearance of both way seizure. In further text, one of those methods shall be described, used in SS7 signalling.

The exchange with larger number of signalling point seizes a channel according to decreasing (increasing) CIC number values. On the other side, the exchange with the smaller signalling point number takes one available circuit according to increasing (decreasing) CIC number values.

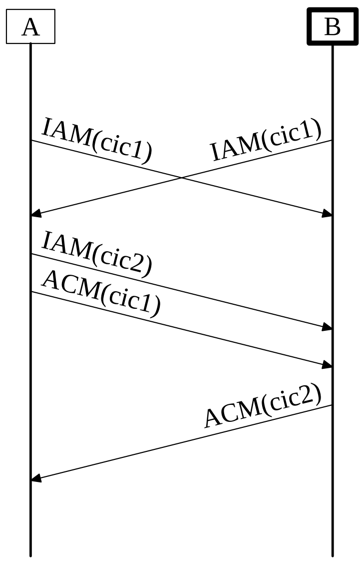
Each exchange controls half of SS7 both way circuit group. On detection of both way seizure, call is realized on the circuit controlled by the exchange, while the initially received address message is discarded.

On detection of both way seizure on SS7 circuit controlled by another party, or the circuit different from CC7, call is terminated and connection is released through switching. Clearing message is not sent. The attempt of connection establishment is repeated over another circuit, along the same or alternative route. Received initial address message is received and processed. The plan of message exchange for this case is presented in figure 5.1.

5.1.1.6 Call restriction by calling party category

There is a possibility of call restriction for specified calling party category, by specified prefixes of the dialed number. This restriction may relate to *any* call with the defined calling party category. The call may originate from subscriber, trunk or talking machine, in each case with the specified restriction applied.

For example, service types 700 and 900 for AOH category 10 are restricted in the Ukraine national network. Thereby, prefix restrictions ”8900” and ”8700” should be set for such purposes, for ”AOH 10” calling party category.



Note: bold line rounds the point controlling the circuit *cic1*.

Figure 5.1: Message exchange in SS7 both way seizure

5.1.2 Traffic routing

Figure 5.2 presents call routing diagram. Terms in boxes represent corresponding table (groups) in data base.

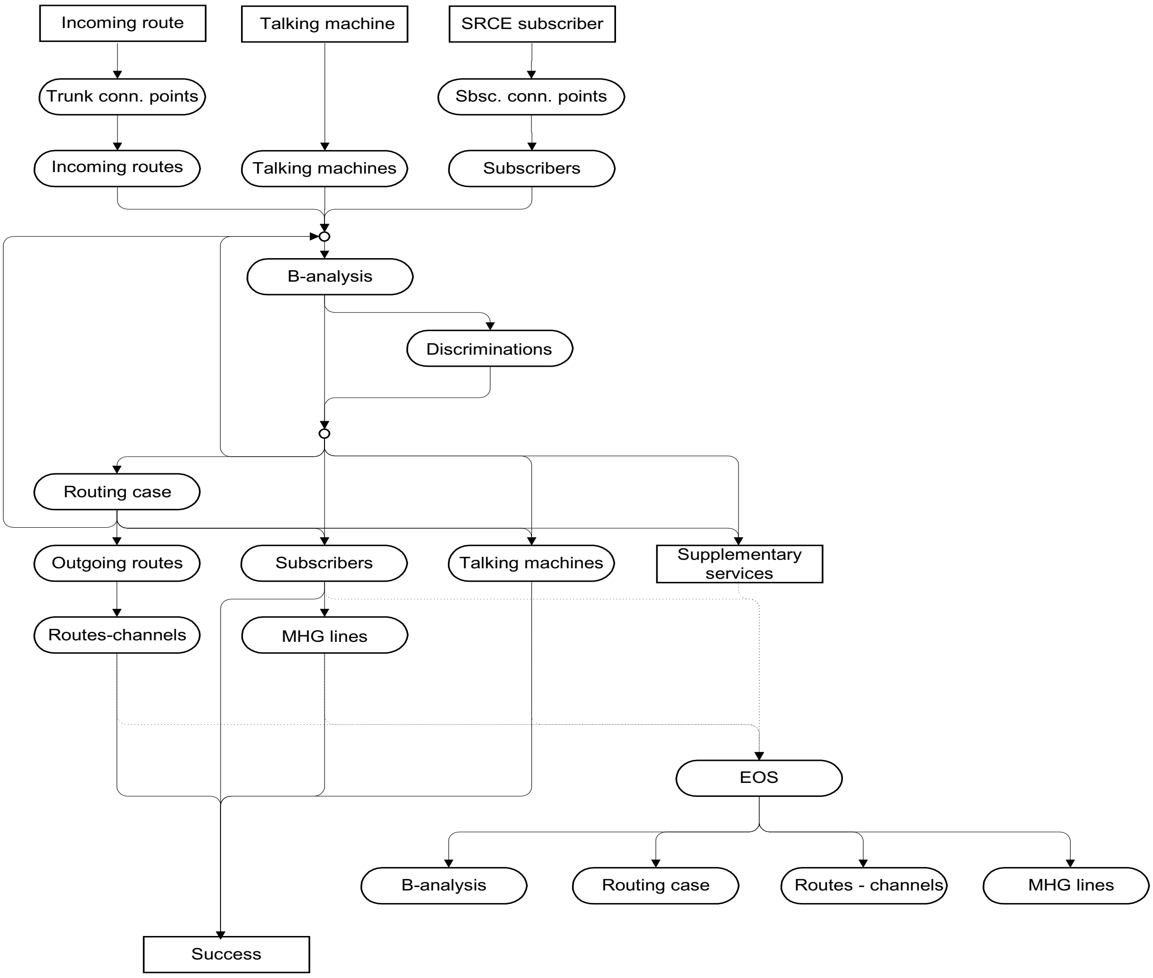


Figure 5.2: Call routing diagram

5.1.2.1 Routes

Route is a group of trunk connecting points, all with same characteristics concerning sending and reception of calls onto/from them. In practice, this means that, provided the route is incoming, all call parameters, from any point, are the same. In system СРЦЕ, routes are stored in four tables: table of all routes, table of outgoing routes, table of incoming routes and table of routes - channels.

Table of *routes* saves data common for all routes: route name, signalling, 'end to end allowed' indicator for R2 and R1 signalling routes and type (outgoing, incoming, both way). Further on, incoming routes are also stored in the table of incoming routes, outgoing - in the table of outgoing routes, and both way - in both of these tables.

Table of *routes - channels* contains the list of trunk connecting points found in a specified route, and this for all routes. The table also introduces the order of their seizure.

Table of *incoming routes* includes relevant data for the call coming from a specified route channel. These are data necessary for routing and charging of calls coming from the route, prefix for dialed digit pre-marking, default category and identification prefix, same as the indicators for certain supplementary services (calling party identification and malicious call tracing).

5.1.2.2 B-analysis

The call being analyzed brings the procedure of dialed number analysis (B-analysis). This procedure is not necessary performed all at one time, since it may begin after several digits dialed, and continue later on with each new digit received.

The dialed number is analyzed, also to conclude whether call destination is: *local subscriber, outgoing route, talking machine* or a *special service*. According to dialed prefix, this procedure provides incoming connecting point to be assigned the outgoing one, appropriate special service to be activated or error detected. In the moment the first digit is received, call is in state *free*, transiting afterwards into state *B-analysis*.

Table 5.1 presents the part of B-analysis table.

Tree	Prefix	Dis.	Cut	Paste	Min	Max	Next	Rout.
0	*	0	0		3	255	First to follow the prefix	1
0	*#	0	0		2	255	First preceding the prefix	1
0	**	3	0		4	4	Special service	6
0	**0	0	0		3	3	Special service	0
0	1	0	0		6	255	Routing case	20
0	3	0	0		3	255	Routing case	33
0	41	0	0		6	6	Terminal	0
0	9101	4	0		8	8	Special service	23
0	A	0	0		0	0	Special service	10
1	#	0	0		0	0	To beginning	2
1	*	0	0		0	0	First preceding the prefix	1
1	0	0	0		0	0	First preceding the prefix	1
1	1	0	0		0	0	First preceding the prefix	1
1	2	0	0		0	0	First preceding the prefix	1
2	#02#	0	0		0	0	Special service	2
2	#21#	0	0		0	0	Special service	12
2	#26#	0	0		0	0	Special service	15
2	*#21#	0	0		0	0	Special service	13
2	*#26#	0	0		0	0	Special service	16
3	01	0	0		0	0	Talking machine	1
3	02	0	0		0	0	Talking machine	2

Table 5.1: B-analysis table example

B-analysis within system is performed following further actions: for each call originating point (incoming route, subscriber number or talking machine) tables define so-called *initial tree* of B-analysis. B-analysis is organized in trees, which provides a certain prefix to be interpreted in different ways depending on call source. Each tree has defined actions to be undertaken in case of the particular prefix dialed. If there is more possible prefixes in the specified tree for the given dialed number, the one with biggest length is chosen, that is, the one that corresponds with dialed number in the most of preceding digits.

For specified prefix and dialed digits it is possible to perform *modification* of B number. The modification implies cutting the necessary number of digits from the beginning and pasting some digits in front of the specified sequence. These data are included in B - analysis table.

Discrimination procedure for the dialed digits performs the digit check, and in certain combinations call is cleared, and in others a number of digits is collected and processing is continued. Discrimination process enables dialling restriction of certain prefixes for defined user groups. Discrimination is specified by defining the sequence of prefixes allowed for dialling (while others remain restricted). Some of prefixes may be explicitly restricted. For example, in order to disable subscribers dialling trunk prefixes to dial the international prefix afterwards (in order to prevent misuses), certain discrimination is assigned to all trunk prefixes in B-analysis preventing from dialling digits, e.g., 99, behind the prefix. Prefixes allowed by discrimination have fixed maximum length of 2 digits and each prefix is accompanied with the number of digits to be collected before returning to B-analysis. Structurally identical tables (such as discrimination tables) are used for subscriber digit collecting. These table are referred to as ПАЦ tables (Serbian abbreviation for digit reception and analysis). Each subscriber number has two ПАЦ tables: one that is regularly used, and the other one, used on activation of the originating call restriction service.

Digits dialed by subscriber, that is, digits reaching from the trunk or talking machine, enter the initial tree of B-analysis. From the initial tree, it is moved forward to either a new tree, or routing case, terminal traffic, talking machine or another special service. Received digits may be also modified in routine case.

Routing case represents a program for call routing. Call is forwarded from B-analysis to one of the routine cases consisting of several *alternatives*. List of alternatives is arranged for each routing case, and each alternative implies one of the following actions: "jump" to a new routing case, return to a B-analysis tree, sending calls to specified outgoing route, sending calls to subscriber table (terminal traffic), a call for the talking machine or a call processed within a special service.

For calls routed toward the outgoing route, following parameters are checked: number of digits to be collected prior to seizure of an idle trunk, number of digits to collect before digit sending is started and the starting digit from which digits are sent to another exchange.

Each alternative may be time dependant, meaning that it is valid only in the specified hours and is ignored for the rest of the time. It also implies (optional) modification of dialed digits that corresponds to that of B-analysis.

It may have sense to define several alternatives in one routing case in the situation of the alternative traffic routing (e.g., the traffic that would otherwise be routed along transverse connection, in case that all connecting points are already seized, may be routed to the parent one). In this case, it is to try with the first valid alternative (the one that is not time dependant, or the time dependant one in the "right" time). Had the call failed having no free connecting points in the route, EOS analysis is entered with the appropriate code, after which the call may be continued on the next alternative. This procedure is also referred to as "traffic overflow" and is illustrated in figure 5.3.

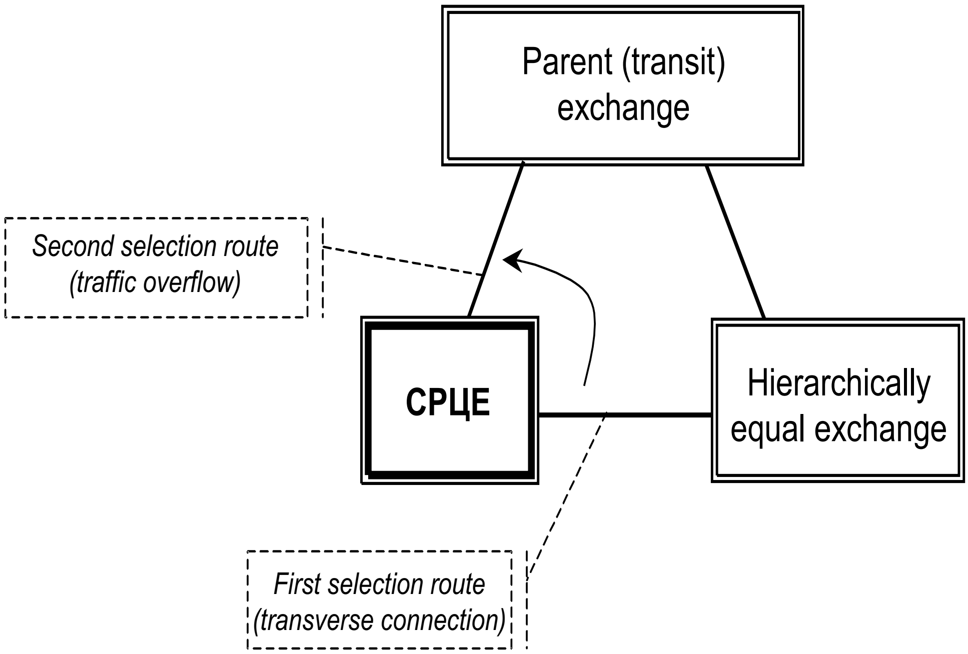


Figure 5.3: Alternative routes in a routing case - traffic overflow

Outgoing route is specified as one of alternatives in routine case. Having the route already defined and digits collected enough to perform trunk seizure, it is searched for an idle trunk. The outgoing route table contains the identifier denoting the point reached in the process of connecting point seizure in the route. The points are seized succeedingly, that is, the free point is searched for right from the first point following the last successfully seized one. Search sequence is specified in route-channel table. This is the way to obtain greater possibility that one of the first trunks checked would be free.

In case there is no idle trunk, the call with appropriate EOS code fails and is recommended for this code to enter the action 'move to following routing case alternative' in the EOS table.

One of possible call destinations defined in B-analysis procedure is terminal traffic. It is first checked whether enough digits were received for subscriber seizure, if not, it is waited until they are obtained. Subscriber table followed with subscriber logic connecting point table is analyzed to check whether the access to the subscriber is possible. Results of search for subscriber connecting point may be: found (free), seized, double seized (both РБВ seized), blocked, unable to receive calls, belongs to MHG and is seized, belongs to MHG and is blocked, belongs to MHG and is unable to receive calls. If it's free, the outgoing interconnection is seized, tariff specified and call forwarded.

Had the call destination been talking machine, the talking machine is found, new РБВ seized towards, the outgoing interconnection seized and tariff specified.

5.1.2.3 EOS analysis and automatic call attempt repeat

End of selection - EOS table is a common point reached by call processing in case of connection failure in all situations from the moment the call started processing (incoming connecting point seized) to the moment of state 'subscriber free' received. For each call source (subscriber, incoming route or talking machine) its EOS origin is specified, that is, tree number of *EOS codes* describing the reaction to connection failure. EOS table is than entered with two parameters: *EOS originating point* and *EOS code*; EOS code depends on the cause of connection failure (e.g., subscriber seized, no free connecting point found in the route, discrimination failure etc).

Actions that may be performed during EOS analysis, for specified EOS code and EOS originating point, are:

1. "Jump" to another EOS code (this is convenient in situation when more EOS codes should be treated equally)

2. Sending backwards the connection failure message: table contains the message type to be sent, as regarded from the Central processor (CP) (what exactly would be sent, depends on signalling). This also implies the indicator showing whether the release is performed "relay", meaning that release forward is sent simultaneously with connection failure message or, it is sent after release was received from the incoming direction.

3. Jump to B-analysis (into specified tree, with possible modification performed in advance)

4. Move to following alternative in the routing case. This provides the following alternative to be taken not only in situation when there's no free trunks in the outgoing route, but otherwise also (had other causes appeared for connection failure).

5. Search continued in the same route or MHG. Also containing time data defining the period between two repeated attempts of connection establishment.

Automatic repeat of connection establishment attempt is performed in following situations: after continuity check failure, on detection of both way seizure in the exchange not in control of that circuit, on reception of blocking message after the initial address message was sent and prior to any return signal received, on reception of circuit reset message after the initial address message was sent and before any return signal has been received, on reception of undefined signalling information after the initial address message being sent and prior to reception of a return signal needed for connection establishment, and in many other situations.

Automatic attempt repeat represents the selection of new outgoing circuit (if possible) in order to route the call established, while the call that failed in the first seized outgoing circuit is completed executing the appropriate procedure of the circuit release.

5.1.2.4 Advanced procedures of call routing

Call gapping is realized in a way that every alternative in a routing case has a probability of call gapping. Having this probability provided, specified alternative is "skipped" (not used) during routing. If the probability is equal to 0%, alternative is never skipped. If it is equal to 100%, alternative is always skipped.

Setting the probability of an alternative to the value different from zero provides call gapping. If it happens to be the only alternative, the percentage specified for the call gapping probability would be the percentage of calls that surely would fail. If there is several alternatives, call gapping probability enables certain calls to be routed to following alternatives although there might be a possibility that the first one could be used. For example, if both alternatives "lead" to the outgoing route, and with no call gapping applied, second route will be taken only after the first one is completely used. But with call gapping, the calls are equally distributed.

Dynamic routing is obtained by setting the variable call gapping probability. Each alternative is given lower and upper probability limit. For each failed call that used an alternative, call gapping probability is slightly increased (up to the upper limit), and for each successful call the probability is decreased (up to the lower limit). As a result, having found the calls for specified alternative mostly successful, the exchange starts routing calls to this alternative more frequently than in the case opposite (when they mostly fail).

Previously described call gapping is, practically, special case of dynamic routing, for which the lower and the upper limit of call gapping probability are equal.

Call restriction in the specified direction may be performed toward traffic destination (prior to routing to routing cases) or, within routing by routing cases, toward specified alternative in the routing case. Procedure is the same in both cases. For specified destination or alternative call counter is provided. At the beginning, this counter is set to zero. On the first call established, call restriction time out is started. With each new call made (toward specified destination or alternative), it is checked if the call counter had reached the specified maximum number of calls. When it comes to maximum, the call is cleared and forwarded to the next alternative in the routing case (the call is treated according to EOS code, although some of EOS code possibilities are not available in case of traffic destination restrictions having the routing case not defined yet). Had the counter not reached the maximum yet, it is incremented. On the expiry of call restriction time out, the counter value is decremented by the specified number (decremented value will not go under zero, e.g. , in case that the counter values 2 and should be decremented by 3, new value would be 0, but not -1). Had the counter reached zero after being decremented, time out is not restarted, and in case opposite, if it is set to zero, time out is restarted).

The exception would be in situation when the maximum number of calls specified is equal to 1, somewhere referred to as call gapping, but, obviously, with different connotation than the "call gapping" of system СРЦЕ.

5.1.3 Supplementary services

Within СРЦЕ system, ISDN subscribers and analog subscribers are treated mainly the same. Therefore, most supplementary services are provided both for analog and ISDN subscribers. However, on the lower level, the implementation of these services may vary in these two cases and in some of them remains the same. Additionally, some services may be applied either for ISDN or analog subscribers but not for both of them. For these reasons, the following text introducing supplementary services shall take separate considerations as to analog and ISDN subscribers.

5.1.3.1 Supplementary services for analog subscribers

The list of supplementary services supplied with additional information is contained in the following table.

No.	Supplementary service	Provided at one time	References
1	Tone (DTMF) dialing	100%	ITU-T Q.23
2	Abbreviated dialing, operator controlled	100%	CEPT 1.1.1
3	Abbreviated dialing, subscriber controlled	100%	CEPT 1.1.2
4	Abbreviated dialing shared list, operator controlled	100%	
5	Abbreviated dialing shared list, subscriber controlled	100%	
6	Fixed destination call, operator controlled	100%	CEPT 1.2.1
7	Fixed destination call with time out	100%	CEPT 1.2.3
8	Alarm call service, operator controlled	10 calls per sec.	CEPT 2.1.1
9	Alarm call service, subscriber controlled	10 calls per sec.	2.1.3
10	Alarm call service, every day	10 calls per sec.	CEPT 2.1.4
11	Alarm call service, specified days	10 calls per sec.	CEPT 2.1.6
12	Service restriction in the outgoing direction	100%	CEPT 3.1.1
13	Outgoing call barring, operator controlled	100%	CEPT 3.1.1
14	Outgoing call barring, subscriber controlled	100%	CEPT 3.1.2
15	Outgoing call barring, selected	100%	CEPT 3.1.3
16	Incoming call barring	100%	CEPT 3.2
17	Absent subscriber service, immediate diversion, to any number	100%	CEPT 4.1.3
18	Unconditional call forwarding	100%	CEPT 4.1.3
19	Rejection of forwarded calls	100%	CEPT 4.1.3
20	Absent subscriber service, diversion to a fixed announcement	100%	CEPT 4.1.5
21	Absent subscriber service, diversion to a selected fixed announcement	100%	CEPT 4.1.7
22	Absent subscriber service, diversion on no reply, to any number	100%	CEPT 4.1.15

23	Diversion on no reply	100%	CEPT 4.1.15
24	Absent subscriber service, diversion on no reply, to a fixed announcement	100%	CEPT 4.1.17
25	Absent subscriber service, diversion on no reply, to a selected fixed announcement	100%	CEPT 4.1.19
26	Do not disturb service	100%	CEPT 5.1.4
27	Incoming call barring, operator controlled	100%	
28	Completion of calls to busy subscriber, activation during call	100%	CEPT 6.1.3
29	Completion of calls to busy subscriber, activation after call	100%	CEPT 6.1.4
30	Number repetition	100%	CEPT 6.2.1
31	Call forwarding on busy	100%	CEPT 6.3.8
32	Call waiting, acceptance by clearing	100%	CEPT 6.4.2
33	Call waiting, acceptance without clearing	100%	CEPT 6.4.3
34	Priority	100%	CEPT 6.5
35	Priority during catastrophe	100%	
36	Trunk offering	100%	CEPT 6.7.1
37	No trunk offering	100%	
38	Subscriber call charge meter	100%	CEPT 7.1.1
39	Printed record on duration and charge of calls	100%	CEPT 7.3.3
40	Freefone	100%	CEPT 7.5
41	No charge number	100%	
42	No charge subscriber line	100%	
43	Call forwarding remote, operator controlled	100%	CEPT 7.11.1
44	Call forwarding remote, subscriber controlled	100%	CEPT 7.11.2
45	Three party service, hold for enquiry	100%	CEPT 11.1.1
46	Three party service, with 3-way conversation	100%	CEPT 11.1.2
47	Three party service, with transfer	100%	CEPT 11.1.3
48	Three party service, full	100%	CEPT 11.1.4
49	Conference call, single message number registration	100%	CEPT 11.2.3
50	Conference call, sequential set up	100%	CEPT 11.2.4
51	Conference call, separate number registration, set-up activation	100%	CEPT 11.2.5
52	Identification of all incoming calls	100%	CEPT 14.2.2
53	Malicious call identification	100%	CEPT 14.2.3
54	Calling line identification restriction	100%	ETSI ETS 300 649
55	Unidentified call rejection	100%	
56	Calling number indication	100%	CEPT 14.3, ETSI ETS 300 648
57	General deactivation service	100%	CEPT 14.8

58	Multiple subscriber number	100%	
59	Closed user group	100%	
60	Keyword modification, subscriber controlled	100%	
61	Ring-back service	1% of calls	

The fields described only with ”CEPT” as a reference indicate to CEPT document ”Subscriber manual for services and other facilities provided in modern telephone systems”. Others contain precise reference to a particular document, whether it’s of CEPT, ITU-T or ETSI standard.

СРЦЕ system provides a uniform operation of supplementary services. However, the supplementary services presented in the table above are so defined by corresponding international standard authorities or by the practice itself. Some of them were not introduced into СРЦЕ system as supplementary services and their function is conveyed using other mechanisms. This is specially indicated for each service of the kind.

Short description of main features of the above services follows. Descriptions are often grouped as to several related services.

Tone-frequency dialing

This service presents the facility of pulse or DTMF dialing for analog telephone subscribers. The service is implemented by dialing the tone digits. Had the pulse dialing being started, further tone dialing is not possible for the same call (DTMF receiver is released). Tone dialing is possible in the call to follow.

This service is treated as no supplementary service within СРЦЕ system. All subscribers are provided with DTMF dialing facility within the СРЦЕ.

Abbreviated dialing

The service allows subscribers to define the abbreviated numbers to dial instead of full digit numbers. The system stores all abbreviated numbers and on subscriber dialed the abbreviated number, replaces it with the full one. One subscriber is allowed to specify up to 90 abbreviated numbers.

The service is assigned by operator and active until canceled, by the operator the same. Both subscriber (dialing appropriate digits) and operator (using operator commands) may perform adding or clearing of abbreviated numbers.

Abbreviated dialing is allowed for MHG (multi-line hunt group) from the ”common list”. This means that all lines in MHG that are using the leading number are taking the abbreviated numbers of the leading one. The list of abbreviated numbers may be modified only from the line addressed for the leading number (which may be done by the operator, naturally).

Fixed destination call, operator controlled

The service provides subscribers to specify the number to be automatically dialed on lifting the handset.

It is assigned by operator and is active until canceled by the operator. When assigned, a number is specified the call would be directed to.

This service itself excludes the service of ”fixed destination call with time out”.

Fixed destination call with time out
This service enables subscribers to define the number to be automatically dialed on lifting the handset and after time out expiry. Had the subscriber started dialing before time out expiry, the call would not be executed.

The service is assigned by operator, and is activated either by the operator or subscriber. It is canceled by the operator. Number to be called is specified during the activation process.

This supplementary service itself excludes ”fixed destination call” (no time out) service.

Alarm call service, operator controlled
The operator may specify, on subscriber request, that another subscriber should be called, in the specified hours. For this occasion, the operator may choose the notification to be sent to subscriber.

This also is no supplementary service within СРЦЕ system and the operator may perform it for any subscriber.

Alarm call service, subscriber controlled
Subscriber may specify to be called at defined time within 24 hour period. On his/her answer, the fixed announcement is reported. This service is often called ”wake up service”.

System may generate up to ten calls per second. If needed, the number may be increased.

This is not a supplementary service in СРЦЕ system and is available for all subscribers.

Alarm call service, every day
It is similar to service ”alarm call service - subscriber controlled”, with the addition that subscriber specifies exact time of the day to be called each day, either for next couple of days or until further notice.

Alarm call service, specified days
This one corresponds to ”alarm call service - every day”, with difference that subscriber specifies the days of the week to be called, either for the next couple of weeks or until further notice.

Service restriction in the outgoing direction
This service provides subscriber prevented from making any calls, but enabled to receive calls from other subscribers.

As concerning СРЦЕ, this is not a supplementary service, but may be realized in, at least, two possible ways - as a special case of ”service restriction in the outgoing direction” service (setting restriction on all prefixes) or, setting the appropriate subscriber line one way, in direction suggested.

Outgoing call barring, operator controlled
The service enables partial or complete restriction on dialing the certain (and all) prefixes of subscriber terminal. Each subscriber has a specified restriction mode - restriction by prefixes. When dialing from specified terminal, dialed prefix is compared with those defined for restriction. Had any restriction been detected, the call is cleared.

The service is assigned by operator and is active till the operator canceling it. Restriction mode is selected during activation.

In a certain degree, this service is related to the ”fixed destination call” (no time out) service. In fact, these two services are not formally, but are practically excluding each other. That implies that these may be both active at the time, but it would make no sense.

Outgoing call barring, subscriber controlled
This service is similar to ”outgoing call barring, operator controlled” service. But in this case, subscriber may activate and deactivate restriction of dialing the digits containing code.

The service is assigned by operator. It is activated or deactivated by operator or subscriber. It is canceled only by operator. Restriction mode is selected when assigning the service.

Subscriber may modify type (number) of restrictions (selecting one of eight available types), but operator only may define each of restrictions exactly and thoroughly.

Incoming call barring
The service provides subscriber being prevented from receiving any calls, but enabled to dial and establish a call.

Within system СРЦЕ, this presents no additional service, but may be realized in, at least, four different ways - as a special case of ”incoming call barring” service (restricting all prefixes), as a special case of ”do not disturb, from the list” service (restricting all prefixes), using corresponding ”do not disturb” service or setting appropriate subscriber line one way - in corresponding direction.

Absent subscriber service, immediate diversion, to any number
Subscriber, unable to answer the call, may forward calls to another number different than his/her one, which may be a sort of service for calls’ recording (either automatic - voice mail or an agency servicing in this matter) or any other number. Calling subscriber is charged for call therefore, diversion for this case is restricted to the one within the same exchange.

This service is practically a variant of the ”unconditional call forwarding” service.

Unconditional call forwarding
The service provides that all calls for a specified subscriber are forwarded to specified number. In the period of the service being active, subscriber receives special dialing tone instead of usual one. The calling subscriber is charged for call to the subscriber that

forwarded the calls to another one, while the latter is charged for the call to the number the call was forwarded to. This is what allows subscriber to forward the call to any number wanted, including an international one.

The service is assigned by operator, and is activated either by operator or subscriber. It is canceled solely by operator. Forwarding number is defined on activation.

This service is mutually excluding with services ”diversion on no reply”, ”call forwarding on busy” and ”do not disturb”.

Rejection of forwarded calls

The service provides that all calls forwarded to a subscriber are cleared. More precisely, any call forwarded to a specified subscriber fails. Success of the service depends on whether previous exchange has forwarded an indicator of the call being forwarded.

The service is available for all subscribers and may be activated or deactivated either by operator or subscriber.

Absent subscriber service, diversion to a fixed announcement

Subscriber, unable to receive calls, may forward it from his/her own number to a fixed announcement. The call may be forwarded to default fixed announcement (specified by the operator, for the entire exchange) or, another fixed announcement may be selected (the one available, with selection code set by operator, for entire exchange).

The service is practically an alternative of ”absent subscriber service, immediate diversion, to any number”.

No answer, forwarding to non-answering, to specified number

Subscriber, while being absent and unable to answer the calls, may provide that, after some period of non-answering, calls are forwarded from his/her own number to another one, which may be an agency for call recording (either automatic - voice mail or a company servicing in this matter) or any other phone number. The calling subscriber is charged for the whole conversation, therefore, forwarding in this case is restricted to the one within the same exchange.

The service is presented as an alternative of ”diversion on no reply” service.

Diversion on no reply

The service enables call forwarding to specified number, provided that there was no answer received from called subscriber for some time. The calling subscriber is charged only for call toward subscriber which forwarded the call, and the latter one is charged for call toward specified number. For this reason, subscriber may forward the call to any number wanted, including international calls.

The service is assigned by operator, and is activated by both the operator or subscriber. It is canceled by operator. Forwarding number is defined during activation.

This service is mutually excluding with the services ”unconditional call forwarding” and ”do not disturb”.

Absent subscriber service, diversion on no reply, to a fixed announcement
Subscriber, being not sure whether he/she would be able to answer the calls or not, may forward calls from his/her number to fixed announcement, after some time of non-answering. The call may be forwarded to default fixed announcement (set by operator, for the whole exchange) or one of possible fixed announcements may be selected (the one available, with selection codes set by operator, for the whole exchange).

The service corresponds to "absent subscriber service, diversion on no reply, to any number" service.

Do not disturb service
This one provides restriction of all incoming calls for a subscriber and, optionally, their forwarding to a fixed announcement that would supply the calling one with appropriate notification.

The service is assigned by operator. It is activated or deactivated either by operator or subscriber. It is canceled by operator.

The service is mutually excluding with call forwarding services. It is similar to "incoming call barring" service.

Incoming call barring
This represents the variant of the service "do not disturb service, selective". Call is mainly forwarded to fixed announcement in case of "do not disturb" service, and for this service, the call is cleared. Therefore, this service is used in case subscriber wants to conceal the fact of "do not disturb" service activation from the calling one.

Call completion to busy subscriber
The service provides the indication of called subscriber, being busy for a while, having released ("ended the conversation"). A new call toward specified subscriber is automatically established. On receiving the busy tone, subscriber may request call completion either by hook-flash and selection of appropriate digit or, by hook-on and selection of appropriate service code. On called subscriber being released, the calling one is first called out and on his/her answer, the called and now released one is called and connection is further continued regularly.

The service is assigned and canceled by operator. It is activated by subscriber, as described above. Subscriber may also cancel the call.

Subscriber using this service may, at a time, expect only one subscriber released. For analog subscribers, this service is restricted to subscribers within the same exchange.

Number repetition
Dialing a special (short) number, subscriber may request dialing of the last dialed one. Last dialed number is always stored for subscribers provided with this service. When the number specified for activation of last dialed number is dialed system dials the last dialed number.

This service is active from the moment of its being assigned from an operator to the moment of its being canceled.

Call forwarding on busy

The service enables call forwarding to specified number for a subscriber being busy. For the time the service is active, subscriber receives special dialing tone instead of a regular one.

The service is assigned by operator, and is activated either by operator or subscriber. It is canceled by operator. Forwarding number is specified on activation.

This service is mutually excluding with "unconditional call forwarding" and "do not disturb" services.

Call waiting

This service enables subscriber to receive a call although already being busy. The busy subscriber, provided with this service and receiving another incoming call, receives call waiting tone. It is than up to subscriber whether he/she would take the call or not (holding or finishing the present one). Hanging up the phone, subscriber accepts the call and releases the present one. If he/she takes it with holding the present one, the service gets to be "three-party call" service.

The service is mutually excluding with all call diversion services and "do not disturb" service.

The service is assigned by operator, and is activated either by operator or subscriber. It is canceled solely by operator.

Priority

The service provides different processing of priority subscriber. This implies: different ringing mode for a call coming from priority subscriber and repeated attempt of trunk seizure (in case of failure), after a short break.

This is not considered a supplementary service within СРЦЕ and is performed through specification of calling subscriber category for given subscriber. Had the calling subscriber category being defined as "Priority subscriber", the above mentioned special processing would be performed.

This service is practically "overlapping" the service of multiple subscriber number - priority call always rings the same (the way it is set), without any regard as to which subscriber number, among several of them, was dialed.

Priority during catastrophe

The system may be set to casualty conditions (mostly considering natural casualties - earthquakes, floods etc). Natural casualties are defined with a level. During casualty conditions, only terminals described as priority terminals in casualty conditions, with a level higher or equal to current casualty conditions, may realize outgoing calls (others do not receive dialing tone).

The service is assigned by operator, with the level defined at the same time. It is canceled by operator as well. Its activation is indirectly performed for the whole exchange, introducing the casualty conditions, all done by the operator. Canceling the casualty conditions deactivates the service.

Trunk offering

Any subscriber terminal may be specified with an "operator" calling subscriber category, thus enabled to perform trunk offering and other procedures (reringing and others) included in the semi-automatic call establishment protocol. Trunk offering may be performed both for local calls and calls within other exchanges (over trunks), provided that specified signalling supports trunk offering. When subscriber's free, operator call rings different than the other calls.

This service is not a supplementary one within СРЦЕ system, but is assigned by operator, specifying the appropriate calling subscriber category.

On called subscriber activation of "no trunk offering", trunk offering is being denied. This service practically overlaps the service of multiple subscriber number - priority call always rings the same (the way it is set), with no regard as to which of specified subscriber numbers is dialed.

No trunk offering

Subscriber may request that calls from the operator are not accepted and thus refuse trunk offering.

This is no supplementary service within СРЦЕ and is available for all subscribers.

Subscriber call charge meter

The service provides charging pulses sent to charged subscriber. Certain types of subscriber boards are provided possibility of sending charging signal (16 kHz) "to" subscriber line. For each charging pulse, subscriber is sent the charging signal in duration of 150 ms. Further more, it is possible to perform polarity change of subscriber pair right at the beginning and to send pulses by means of consecutive polarity change instead of charging signal sending.

The service is assigned by operator and is active all until the operator cancels it.

Printed record on duration and charge of calls

This service provides recording of all charged calls. This way, subscriber gets detail report on charged calls. While making the report, it is possible to make a selection - only international calls or trunk calls or calls charged with more than specified number of pulses, etc.

This service is here listed since it is considered supplementary service in most systems. The fact is that all charged calls are continuously recorded in СРЦЕ system. Having such an operation model applied, there is no need to introduce services enabling subscriber to request recording of a certain call or all calls of the type. These are CEPT services 7.3.4, 7.3.5, 7.3.6, 7.3.7 and 7.3.8.

Freephone

Had the traffic routing and tariff sub-system being set accordingly, it is possible to specify charging of called subscriber, instead of the calling one, for one or more subscribers. Depending on settings, dialed number for called subscriber charging may be different (and, as a rule, it is) from ”exact” subscriber number.

Called subscriber charging is permanently enabled for local calls (e.g., it is used for charging the ”alarm call service”), and whether it is enabled for network calls depends on the network itself, signalling used, national tariff procedures, etc.

For all this stated above, called subscriber charging is not a supplementary service in СРЦЕ system.

Analog subscriber cannot refuse being charged for calls (he/she may only not answer the call). For this reason such subscribers are usually assigned the service of calling number display.

No charge number

Enables specified subscriber number defined as charge free number for all incoming calls. This may likely be achieved by appropriate setting of charging sub-system. However, when this service is used, and depending on signalling with calling subscriber exchange, the information of the call being charge-free may be transferred to the exchange, causing it not being charged on either side. Naturally, there are no guarantees for this service, since the exchange receiving this information of charge-free call may still ignore it. All local calls are definitely charge-free with this service used.

No charge subscriber line

СРЦЕ may specify certain subscriber line not being charged, with appropriate settings of charging sub-system. This charging represents a standard facility within СРЦЕ and is therefore not considered a supplementary service.

Call forwarding

This service functionally corresponds to ”unconditional call forwarding”. It differs in the fact that, from the operator view, the one requesting the service is in fact the one the calls are forwarded to. For this reason, the subscriber may him/herself change the number that calls from any number are forwarded to. To prevent abuses, the service is protected with a code.

Three-party line

The service enables subscriber already participating in a call to establish another one and than freely manage these two calls: ”moves” from one to another, clears one of them, through-connects those two into three-party connection, or, switches connection to other two participating subscribers with him/herself quitting the same.

This service is assigned by operator and is active until canceled by the operator as well. There may be assigned basic service and aside of it, conference (three-party line) access and switch-over facility.

Conference and switch-over are mutually excluding with ”conference call” service.

Conference call

There may be three possibilities of specifying participants in a conference call, which may include more than three subscribers:

- Specifying participants of one call, defining all numbers to be included
- Specifying participants of several calls, one from each of it, and than making a special call in order to define the set up with specified numbers.
- Introducing to an existing conference, sequentially.

This service is assigned by operator and is active until canceled by the same. The operator also defines maximum allowed number of parties in the conference.

The service is mutually excluding with conference access for "three-party line" service. On the other side, introducing to "sequential set-up" conference is related to three-party line - subscriber must have "three-party line" service assigned in order to be allowed of introducing the calls into conference.

Identification of all incoming calls

On each call incoming to specified called subscriber, the appropriate report is being made. At the end of the call, the record is being made on calling number and time of the call.

The service is assigned by operator and is active until being canceled, by the operator again.

The service depends on whether the calling subscriber (not the assigned one) has the identification restriction service activated. It is also possible that, having the calling subscriber of another exchange, the latter wouldn't send the appropriate data, from any reason (being one of old analog exchanges, for example).

Malicious call identification

This service provides the identification of calling subscriber and call related data output, when requested by the called subscriber (performing hook-flash). The service also enables call hold in case complete calling line identification has not being performed yet.

The operator assigns and terminates service being active, by canceling it.

Calling line identification restriction

With this service assigned, the calling subscriber number is not being revealed in the process of calling line identification. What it really implies, depends on signalling in the involved call - in some of them, it is a special signal, in the others, only network group code is sent.

The operator assigns and cancels this service.

Unidentified call rejection

This service enables all calls to specified subscriber, for which calling line identification has failed (caused whether by calling subscriber activation of identification restriction, or simply by the identification being incomplete), to be automatically refused and forwarded with appropriate acknowledgement.

The service is assigned by operator and is active until canceled, by the operator, as well.

Calling number indication

For subscribers equipped with appropriate devices (some phones have it built-in), this service enables calling subscriber number output on device display. The exchange forwards the time and date of the call, so these are also recorded by the device - most devices store up to several tens of calls. Data are sent along B.23 modem protocol.

The service is assigned by operator and is active until canceled, by the operator as well.

Like for any other service implying calling line identification, the service depends on whether calling subscriber has set identification restriction and whether it is possible to obtain the complete number at all.

General deactivation service

This service enables subscriber to deactivate currently activated services, using a single command. Services that cannot be activated (abbreviated dialing, for example) are neither activated using this service. Also, services requiring the code, cannot be activated with this service applied.

The services to be deactivated on this request are set for each exchange. Therefore, some services are set not to be deactivated on this request.

This is not a supplementary service within СРЦЕ and is available for all subscribers.

Multiple subscriber number

The service provides subscriber with several additional numbers, in addition to the basic one. Had any of these numbers been called, the call is forwarded to basic line number. Each call may be specified ringing signal, acknowledging subscriber of who the calling one might be.

The service is assigned and canceled by operator. Additional numbers may be added or cleared only by the operator. The sum of additional numbers assigned to a certain subscriber is not restricted.

Closed user group

Several subscribers may form the group with a restricted access. The members of a closed group (ЗГ) may call each other, but it's only with a special permission that they make calls outside the group. This way, it is possible to restrict or allow the outgoing calls outside the group and calls incoming to the group, for each subscriber. This may be also done within ЗГ. One subscriber may be a member of several closed groups. As for an ordinary outgoing call, it is considered as a call within subscriber's default group, and dialing appropriate digits, subscriber may choose to call a certain subscriber of any of group belonging.

Operator assigns this service and selects default group for specified subscriber. Service is active until canceled by the operator, as well. All settings concerning belonging to the group, group possibilities, same as the settings of the group itself, may be performed only by the operator.

This service is not mutually excluding with services of incoming and outgoing call barring, but there is no purpose in using them all together.

Keyword modification, subscriber controlled

Both the operator and subscriber may change service keywords. One subscriber is given one code for all services.

Operator assigns and cancels the service.

Ring-back service

On hanging-up the handset, the appropriate number is dialed and after establishing the connection with fixed announcement informing of the successful specifying of call back, the call is forwarded to the line that the previous call had come from. Anyone answers that call, hears the fixed announcement information. This service was intended, above all, for checks made by technical personnel in order to verify the phone (ringing) regularity.

At one time, maximum 1% of the total number of all calls realized within the exchange may "wait for ring-back". Total number of calls in the exchange depends on the exchange configuration.

This is no supplementary service within СРЦЕ and is therefore available for all subscribers, provided that ring-back number has been declared.

5.1.3.2 Supplementary services for ISDN subscribers

СРЦЕ system provides all supplementary services for ISDN subscribers in accordance with ITU-T I.250 recommendations (first definition level), Q.80 (second definition level), same as recommendations of Q.730 (supplementary services in CC7 signalling) and Q.950 series (supplementary services in ISDN subscriber signalling) together being part of the third level of definition of ISDN supplementary services.

ISDN supplementary services supported by СРЦЕ are listed in the following table:

No.	Supplementary service	Provided at one time	References
1	Indialling	100%	ETS 300 064
2	Multiple subscriber number	100%	ETS 300 052
3	Subaddressing	100%	ETS 300 061
4	Calling line identification	100%	ETS 300 092
5	Calling line identification restriction	100%	ETS 300 093
6	Called line identification	100%	ETS 300 097
7	Called line identification restriction	100%	ETS 300 098
8	Malicious call identification	100%	ETS 300 130
9	Call forwarding on busy	100%	ETS 300 207
10	Diversion on no reply	100%	ETS 300 207
11	Unconditional call forwarding	100%	ETS 300 207
12	Call diversion	100%	ETS 300 207
13	Call waiting	100%	ETS 300 058
14	Call hold	100%	ETS 300 141
15	Terminal transferability	100%	ETS 300 055
16	Conference calls	100%	ETS 300 185
17	Three-party line	100%	ETS 300 188
18	Closed user group	100%	ETS 300 138
19	User-to-user service	100%	ETS 300 286
20	Call completion to busy subscriber	100%	ETS 300 359
21	Charging information	100%	ETS 300 182
22	Freephone	100%	ETS 300 210
23	Connection switch-over	100%	ETS 300 369
24	Outgoing call barring	100%	EN 301 001
25	Keyword modification, subscriber controlled	100%	EN 301 002

Table 5.3: Supplementary services for ISDN subscribers

Services are being made upon ETSI standards as the definite recommendations, although these do not differ much from ITU-T recommendations.

Most services are also performed for ordinary subscribers, but are conveyed otherwise, mainly concerning protocols used. As concerning ISDN subscribers, it is necessary to satisfy corresponding DSS1 protocol while executing supplementary services. And as for the analog subscribers, the acknowledgements (voice or tone) are sent to one side and dialing and hook-flash to the other one.

Following services from the list below are functionally the same for both analog and

ISDN subscribers (with DSS1 protocol as only difference) and therefore shall not be additional described:

- Multiple subscriber number
- Calling line identification/calling line identification restriction
- Malicious call identification
- Call forwarding (unconditional, on no reply/busy)
- Call waiting
- Conference call
- Closed user group
- Connection switch-over
- Outgoing call barring
- Keyword modification

ISDN subscribers have some other supplementary services not contained either in recommendations or the list above and are performed identically both for analog and ISDN subscribers. These are:

- All incoming calls
- All alarm call services and ring-back service
- Trunk offering and no trunk offering
- Do not disturb service, absent subscriber services and call forwarding
- Abbreviated dialing (and shared list dialling) and number repetition
- Rejection of forwarded calls, unidentified call rejection
- Printed record on duration and charge of calls, no charge subscriber line, no charge number
- Automatic recall
- Priority and priority during catastrophe
- Identification of all incoming calls

Same codes used for activation, deactivation and check of supplementary services are used for the same services of analog and digital subscribers but, if preferred, these may be set different by system.

The services described below are those either available only for ISDN subscribers or functionally different from the same services provided for analog subscribers.

Indialling

Indialling enables calling subscriber to directly dial the ISDN subscriber in a private ISDN network (ISDN private exchange), using public ISDN number. Had indialling being used, subaddressing is not used.

If set so, the exchange may send several ending digits of the dialed number over ISDN terminal, leaving the other side equipment (most frequently the private exchange) in charge of defining the ISDN terminal called.

This is not a supplementary service within СРЦЕ but a possibility obtained for NPPC with ISDN terminals. Operator may select digits forwarded to the private network.

Subaddressing

Subaddressing enables ISDN terminal some more possibilities concerning addressing, aside from those provided using the ISDN phone number. Practically, the exchange only forwards the subaddress information, having no further concern about it. For this reason, this is no supplementary service within СРЦЕ and is available for all ISDN subscribers.

Called line identification

This service represents the identification service but in direction opposite to calling line identification. ISDN may request this identification in any call engaged.

This is a supplementary service assigned and canceled by the operator. Had an ISDN terminal requested the identification but having no service of the kind assigned, no identification shall be performed.

Called line identification restriction

ISDN terminal may request called line identification restriction by a call (in the moment the identification request is received). This service is available for all ISDN subscribers.

Furthermore, it is possible to specify the identification restriction for a terminal, applied for all calls, whether the called subscriber requested it or not. This restriction is an additional service assigned and canceled by the operator.

Call diversion

This provides ISDN subscriber to forward the incoming call to the selected number instead of receiving it. Forwarding number is selected in the moment the call reached so a different number may be selected for each call. ISDN subscriber may also answer the call.

This is a supplementary service active from the moment of its being assigned to the moment it is canceled, both by the operator.

Call hold

This service provides ISDN subscriber to hold one call and establish some other calls, at the same time. Although similar to "three-party line" service for analog subscribers, there is the difference - ISDN terminal may have several calls held.

This is not treated as a supplementary service in СРЦЕ system. It is permanently available for all ISDN subscribers.

Terminal transferability
This service enables ISDN subscriber to suspend the call for the moment, transfer it to another terminal on the same ISDN network terminal, and then resume it.

This is a supplementary service assigned and canceled by the operator. The attempt of call suspension made by the ISDN subscriber with no such service assigned shall be denied.

Three-party line
Unlike for analog subscribers, "three-party line" service for ISDN subscribers is practically the service of "three-party line, conference", which offers the possibility of joining the active call and the one of those held, into the conference.

This is a supplementary service assigned and canceled by the operator.

User-to-user service
This service enables two ISDN subscribers to exchange some limited quantities of data during call establishment (UUS 1), waiting on answer (UUS 2) or during the conversation (UUS3).

These represents several related supplementary services within СРЦЕ, assigned and canceled by the operator.

Call completion to busy subscriber
This service differs from the corresponding one applied for analog subscribers in the fact that the service may be also performed for a called subscriber belonging to another exchange, provided that the subscriber called is ISDN subscriber of the network supporting this service, in accordance with ETSI ETS 300 359. SS7 TCAP protocol is used for network operation.

Charging information
This service is similar to "subscriber call charge meter" service for analog subscribers. For ISDN subscribers, it is possible to obtain charging information on the call beginning (information of the tariff to apply), during the call (like for the analog ones, but using messages and not 16кХз tone) and at the end of the call (informing of the sum of pulses charged for the whole call).

This service is assigned by operator specifying, at the same time, how these information shall be sent.

Freephone
Comparing to the same service applied for analog subscribers, ISDN terminal (subscriber) may refuse to receive the call that would be charged for.

5.1.4 Advanced telephone functions

5.1.4.1 Special utilities

СРЦЕ system provides special utilities and advanced functions using connections performed over subscriber line, MHG, НИПС and talking machines. СРЦЕ is equipped with configurable talking machines for different types of speech data. The system also supports the possibility of connecting the special utilities and advanced functions over ISDN terminal (basic and primary rate access).

Special utilities connected as MHG are connected to the exchange over Z interface (ТФК-3 standards) or following the basic or primary rate access. Interfaces for ISDN connection are standard (recommendations I.430 and I.431, G.703).

Talking machines are the structural part of the exchange, and their connection interface devices are the subject of internal system organization. Passive and active talking machines may also be connected to the exchange externally, over Z, ISDN or A interface.

Talking machine and voice mail are realized as one system module. This module contains a regional processor controlling the functions of talking machine and voice mail (like all other regional processors, it has a signalling connection to central processor performing the control from the higher level). Connection to group switch is of adjustable size. It is within the range of 30-508 channels.

Speech samples of short service information are kept in non-volatile memory. Maximum memory capacity is 30 Gb which corresponds to speech duration of approximately 60000 minutes (1000 hours).

For each passive talking machine which message is not necessary heard from the very beginning, *only one* connection channel with group switch is used, with no regards as to the number of calls reaching the talking machine.

Short service messages may be modified using operator command. To perform the modifications, it is necessary to specify the data file with the message stored in one of supported formats of the music data file. Operator message may be stored at the operator computer equipped with the music card with microphone.

Wake-up service (call received in specified exact time) in СРЦЕ system is limited with the capacity of wake-up execution table, defined in accordance with the exchange capacity. Selecting the appropriate central control block, it is possible to provide over 5000 wake-up requests daily. The exchange generates wake-up calls in such a manner not to overload the central control block. The estimated flow is equal to 10 calls generated per second. In other words, СРЦЕ system is capable of executing 600 wake-up requests in minute or 36000 per hour.

No special equipment is needed for the automatic wake-up utility. This is standard facility of СРЦЕ system.

5.1.4.2 Malicious call tracing

СРЦЕ switching system provides ”malicious call identification” service for an arbitrary number of subscribers at a time (100% maximum).

On subscriber request the operator assigns the service with two realized levels of its activity:

1. All available information of calling subscriber address are obtained (for digits at least), using techniques for digit information transmission, if being provided by the incoming signalling. Called subscriber may ”mark” the call as a malicious one performing hook flash while the call is still in the established phase or up to 10 seconds after the calling subscriber has hung up the handset. Had the call been malicious, the report with detail information of the incoming call is printed. Connection is cleared as usual.

2. All available information of calling subscriber address are obtained (for digits at least), using techniques for digit information transmission, if being provided by the incoming signalling. Called subscriber may ”mark” the call as a malicious one performing hook flash while the call is still in the established phase or after the calling subscriber has hang up the handset, in which case the connection remains under control of called (B) subscriber. Had the call been malicious, the report with detail information of the incoming call party is printed. Called subscriber is released on hanging up the handset. Had the complete number of calling subscriber not been defined, the connection between the exchanges is ”held” and may be released only on the operator command for connection release. Had the calling subscriber number been defined, the system refuses to ”hold” the call even when explicitly requested by the operator or subsequent exchange. These techniques are used only in the local traffic, in case that the first ones do not provide necessary information, and are activated by the operator setting the appropriate parameter of the incoming route.

Both mentioned technique are realized for all signalling systems supported by the СРЦЕ. The system provides regular functioning of these techniques in all possible combinations of different signalling types at the incoming and outgoing side of a certain call.

The service is realized in the way that the system is enabled of easy adding of new techniques of malicious call tracing or modification of the existing ones.

5.1.4.3 MHG (multi-line hunt group)

Multi-line Hunt Group (for PBX) represents the connection between public and subscriber exchange.

СРЦЕ switching system provides connection of subscriber exchanges on the level of analog subscriber, trunks (of any signalling type) and ISDN subscribers (with basic or primary rate access). Each subscriber exchange is considered to be MHG, and for each group cumulative counter may be set.

There are two basic possibilities:

1. Private exchange connected over several subscriber terminals (analog or basic ISDN)

2. Private exchange connected over trunks (one or more links or primary ISDN terminals)

In both cases, charging may be performed using common counter (leading number). Recording of charged calls is also performed for all MHG conversations.

Connection over separate terminals

This group of functions is in accordance with CEPT 12.2 ("line search")

There might be two possible cases. The first one is when СРЦЕ operates as if the private exchange is providing the supplementary services and not the system. In the second one, СРЦЕ assigns these supplementary services - the private exchange is either too simple of operation or is not existing at all; there is only a group of terminals instead. In the latter case, СРЦЕ may provide practically all CENTREX services.

Furthermore, MHG is a group of connecting points with the first idle one seized on the call routed to the leading number. Had any other connecting point been called, possessing the number, it would be the first connecting point to attempt its seizure.

The procedure of an idle connecting point definition in MHG is:

- from the beginning - CEPT 12.2.1

- circular - CEPT 12.2.4 (last seized plus one)

The points within the group may be incoming (cannot receive the call), outgoing (may receive the calls but cannot dial) and both-way (both outgoing and incoming calls provided). Each of them may have the separate number (if not, the leading number is used in the outgoing calls).

Charging may always be performed on the leading number (with no regards as to whether other lines of group have the number or not), or "each on its separate number" (naturally, all lines without a separate number will be charged on the leading number).

Connection over "multiple" terminals (links, primary ISDN)

In another case mentioned, СРЦЕ considers the private exchange to provide supplementary services. MHG is then totally treated as any other route.

5.1.4.4 Special ringing

The analog subscriber may have different ringing patterns for different call types. Possible types are:

- Local call
- Incoming call (from the trunk)
- Call from the priority terminal
- Forwarded call
- Calling the MHG leading number
- Call from the operator
- Called subscriber charged call

Some of these types are mutually excluding. For those not excluding each other (the call may come from the priority terminal and be forwarded to the leading number, with the called subscriber charged), the order of ringing type definition is defined within program support and is not adjustable.

Using the "multiple subscriber number" service, the subscriber may select different ringing patterns for each of his/her numbers.

5.1.4.5 Forwarding unlimited

For a specified subscriber, the number of forwarded calls at one time is not limited. Had the subscriber activated, for example, the unconditional call forwarding resulting in a certain call forwarded and than subscriber changed the forwarding number, the latter one is also forwarded although the first one has not been completed yet.

The same applies for calls forwarded on "different bases". For example, had the subscriber further activated the unconditional forwarding, and also activated the forwarding for busy subscriber to a third party, after which a certain connection has been established, the call for a subscriber shall be forwarded in this busy state even though it is quite possible that none of these previous two has been completed.

5.1.4.6 Waiting tone

Analog subscribers may have the "waiting tone" set which is sent at the moment the exchange has verified that all digits have been dialed (end of dialing). This way the subscriber is acknowledged of having sent all of the digits, after which the call is routed through the network. What happens next is either ring-back tone (subscriber free) or any of connection failure signals (or talking machine acknowledgments of failure conditions). This avoids the inconvenient long silence on the line in case of a considerable duration of forwarding through the network as it is the case with, for example, international calls.

Waiting tone is activated and deactivated for the entire exchange.

For ISDN subscribers, waiting tone is not necessary since the corresponding information are transferred along with DSS1 protocol, while the terminal is in charge of providing the appropriate acknowledgement for a subscriber.

5.1.4.7 Forwarded call acknowledgement

On the call being forwarded, the calling subscriber shall receive, instead of a ring-back tone, the other corresponding tone or acknowledgement informing that the call is forwarded, and that another number answered but not the one dialed.

The duration of this tone ("replacing tone") is adjustable.

The forwarded call ringing pattern may be set to be different for the terminal the call is forwarded to. This applies for analog subscribers as well.

5.1.5 Charging

5.1.5.1 Basic features

Charging Origin represents numerical labels of all tariffs used in the system. Charging origin classifies all possible call originating points (tariffs). Charging origin is assigned to:

- subscriber
- incoming route
- talking machine

Charging Destination numerically represents all charging destination points used in the system. Charging destination classifies all possible call destinations (tariffs). Charging destination is assigned to B-analysis (analysis of the dialled number) record.

Charging origin and charging destination define **charging case**. For each charging case separately it is specified whether the tariff is received or sent (tariff may be both received and sent at one time - so called tariff transfer), the initial charging pulse is canceled and called subscriber charged. The exact time of charging pulse to be sent within charging interval is defined.

Charging categories generally resemble the standard privileged period in the telephone traffic (there may be much more than two). Charging category is a permanent unique system category. It is defined with the system time and date, based on the day of the year/week and daily/weekly/annual time intervals.

Destination, origin and time is analyzed for each call. As a result of this analysis, charging case and charging category are defined, which further specify the **tariff** to be used for this call (number of pulses on answering, pulse frequency).

СРЦЕ switching system is equipped to perform the detail records of charging data relating to all originating calls. The record format shall be further described.

5.1.5.2 Charging records

СРЦЕ charging system records charging data relating to all originating calls, of whatever type. The report of the originating calls is formed as following:

Calling number	Dialled number	Beginning date	Beginning time	Ending date	Ending time	ТИ	ТО	ТС	ТС	Number of pulses
...	...	...	...	...	...	...	...	...	...	...

ТИ - charging origin

ТО - charging destination

ТС - charging case

ТК - charging category

The operator may select only those records satisfying the specified criteria:

- calls with the specified calling subscriber number
- calls made in specified time interval
- calls charged with more than specified number of pulses
- etc.

Furthermore, the system may perform the overview of all meters' states, grouped in sequence of matrixes formatted 10x10. This overview may be stored directly in the disk data file, floppy or otherwise. Monitoring (read out) of each and every charging meter is enabled.

СРЦЕ is designed to perform easy and rapid adding of a new report type, providing a possibility of defining an additional report type on the buyer's request.

СРЦЕ also provides recording of charging data for the incoming calls. The recording is executed using the trunk prefix, received digits (if possible) or the incoming route.

Other periodical charging reports, including single, national, international or complete, same as many other statistic reports made according to specified criteria are also enabled.

5.1.5.3 Connection to charging data processing center

System may be connected to charging data processing center in many ways. One way is using the usual command for storing the charging data in a specified format. Other may be using the detail records about the originating calls and related additional processing, according to need. СРЦЕ provides easy and fast adding of new reports and other facilities connecting with the center for charging data processing, on buyers' request.

5.1.5.4 Tariff sending

For any incoming route and its assigned charging origin, the corresponding charging case the tariff is sent for is defined.

This procedure may be applied for all incoming routes necessary, in order to enable tariff definition for all subordinate exchanges of the area. Tariff may be sent in the individual pulses (with 150 ms duration each) but also supports other ways for tariff sending defined in signaling systems ITU-T No.7, such as sending the charging program number or solely the charging program and the message acknowledging the tariff change to subordinate exchange.

5.1.5.5 Tariff reception

For any incoming route and its assigned charging origin, different charging cases may be defined according to different charging destinations in B-analysis. For some charging cases tariff is sent, for some others sent; for some of them the tariff is calculated, for others received. These parameters are set by the operator, depending on СРЦЕ positioning within a telephone network.

СРЦЕ may receive charging pulses (of 150 ms duration) in CAS signalling systems, and the corresponding messages in CCS signalling systems (SS7) containing the charging program number, number of pulses or the charging program.

On reception of "B hooks on" signal time out is started only in the case of СРЦЕ being in the position of charging center for the call (tariff is not received but is sent). In this case, "B hooks on" signal shall not be forwarded backwards. In all other cases, the signal is transferred toward the previous exchange.

5.1.5.6 Charge-free calls

СРЦЕ offers several definitions of charge-free calls:

1. for defined incoming line (incoming route, single analog or ISDN subscriber, automatic call generator, MHG) specifying the corresponding charging origin

2. for defined prefix specifying the corresponding charging destination

3. charge-free call is an additional service for called subscriber (analog or ISDN), within СРЦЕ. In case of such subscriber been called, with no regards as to the other charging parameters, system shall not charge for the call. Had such subscriber been the calling one, B-7 signal is sent (R2 signalling) or ACM (SS7) with the indication "free-charge call".

5.1.5.7 Called subscriber charged

СРЦЕ provides the possibility of charging the called subscriber, instead of the calling one. It is defined within the charging case. Called subscriber charging is possible when the tariff is not received. Tariff sending in this case is allowed for local subscribers and signalling systems providing tariff sending in direction of connection establishment (which is not the case of CAS signalling systems, while for SS7 TUP and ISUP this depends on national specifications).

Furthermore, СРЦЕ supports the corresponding called subscriber charging protocol for DSS1 subscribers, presenting the possibility for called subscriber not to receive such call.

5.1.5.8 Special facilities

Different calls toward special facilities may be presented with deferent records in B - analysis, therefore may be assigned different charging destinations which in further case define different charging cases and tariffs (e.g., 3 pulses for "exact time" service, 7 for "automatic wake up"...). All service elements (requiring, execution, check...) shall be treated as calls, thus enabling the partial recording of the number of charged pulses (e.g., for the automatic wake up service: 3 pulses for requiring and for 4 for execution).

5.1.5.9 Special processing of call answering

Operator command sets the parameter "Cancel the initial pulse" for any charging case. This practically means that the first pulse shall not be sent. It is used for connection with the exchanges charging the answering with one pulse. This parameter is important only with the tariff being calculated and sent for specified charging case, otherwise the parameter is ignored.

Same pattern is applied to set the parameter "answer pulse reception" for any charging case. This parameter causes the answering to be processed as one received pulse. It is used for connection to the exchanges charging the answering with the first pulse without sending it separately. This parameter is important only when performing the tariff reception, otherwise is ignored.

5.1.5.10 Several charging meters by a subscriber

There may be several charging meters set along the incoming (or both way route) or any other charging "object".

System is provided with an adjustable number of charging meters. There is always a principal one and several auxiliary meters (although unrestricted by the system, the number of ten meters is optimally used). Record of each call is always performed at the principal charging meter. Within a charging case, there may be an auxiliary meter optionally defined, also used to record charged number of pulses.

Most frequently, one auxiliary meter is reserved for the international, one for trunk and one for supplementary services. Having this possibility totally adjustable, the operator may cancel all auxiliary charging meters, if needed.

5.1.6 Signaling types

Signaling may be one of two types: subscriber (signaling along subscriber lines) and trunk (signaling toward another exchange).

Subscriber signaling may be:

1. Analog subscriber signaling, in several different variants
2. Digital DSS1 signaling for ISDN basic (2B+D) and primary (30B+D) rate access

Signaling toward another exchanges may be:

1. Channel Assigned Signaling, CAS
2. Common Channel Signaling, CCS

And as for the digital signaling, a group of trunks uses a single interface (for E1 interface - 30 for CAS and 30/31 for CCS).

Further descriptions relate to signaling types contained in СРЦЕ.

5.1.6.1 Analog subscriber signaling

This is traditional signaling along two-wire subscriber lines. Subscriber involved in such signaling may send some of following signals:

1. Lifting the handset. Recognition limited to 150 ms (adjustable)
2. Hanging up the handset. Recognition limited to 350 ms (adjustable)
3. Hook flash (register recall). Recognition limited from 100 ms until handset hang up (default to 350 ms).
4. Pulse dialed digit. Enables dialing of 10 - 20 pulses per second. Pause between digits in duration of 300 mc (adjustable).
5. Tone dialed digit. Dual tone multi frequency, according to ITU-T Q.23.

The operator sends following signals:

1. Ringing signal (90 V efficiently, 25 Hz). Ringing pattern is adjustable (see 5.1.4.4 Distinguished ringing and 5.1.3.1 Multiple subscriber number).
2. Tone signal
3. Polarity change - for purposes of operation with two-party lines or related equipment for charging pulses register (at certain talking machines types)

4. Charging pulse (16 kHz) - in duration of 150 ms (adjustable), pause 150 ms (adjustable)
5. Addressing (of two-party lines) - sending the feeding signal for two-party line selection (standard line feeding)

Available tones:

1. Dialing tone - received on lifting the handset to indicate that the number may be dialed.
2. Ringing tone - received on the called subscriber state acknowledged "free"
3. Busy tone - received on the called subscriber state acknowledged "busy"
4. Blocking tone - received on the blocking signal (in switching equipment, network, etc.).
5. Special information tone - received on the information indicating incorrect dialing (missing prefix, missing number,subscriber disconnected, etc.)
6. Intrusion tone - received in occasion of trunk offering
7. Special dialing tone - received instead of dialing tone in case of subscriber activation of a call forwarding service, reminding subscriber of further not receiving any incoming calls.
8. Acknowledgment tone - used mainly to inform the subscriber of a successful activity related to supplementary services (activation, deactivation, check, etc.)
9. Waiting tone - may be sent after the exchange having recognized the end of dialing and started routing the call (further dialed digits shall be ignored).
10. Call waiting tone - tone received while waiting

Acknowledgement tone is continuous, while other tones may be either continuous or contained of cadences.

It is also possible to adjust the signals and their meaning (purpose).

Since the basic analog signaling is generally quite familiar, it won't be further explained in this case, except for some of its features and variants.

Subscriber time outs are listed in the table 5.4.

Time out duration is adjustable, within the range defined (as a rule, -50% / +100%).

Analog two-party (duplex) subscriber signaling is executed along two-party (duplex) terminals.

Time out	Default duration (sec.)
Time out for line test ending	4
Time out for hot line sending	5
Time out for first digit waiting	20
Time out between digits	15
Time out for total dialing	90
Time out for waiting on answer	120
Time out for busy tone sending	15
Time out for blocking tone sending	15
Time out for information tone sending	15
Time out for called subscriber hook-on	120
Time out for DTMF receiver release	40
Time out for special information tone (trunk offering)	0.5
Time out for connection selection (call waiting)	15

Table 5.4: Time outs for analog subscriber signaling

This implies the recognition of a subscriber lifting the handset in the incoming call process, same as the addressing (and setting the appropriate polarity) of related dual-party, either after recognition, or on the incoming call reception. Other actions are the same as for the ordinary analog subscribers.

Dual-party line is recognized within 20 ms of the closed loop and than addressed. In case of both subscribers lifting the handset at the same moment, B party is given the advantage by the electronic equipment.

After connection completion (including hanging up the handset and regular release), the dual-party line is "unaddressed" - i.e., set back to default initial state (including the initial polarity).

Furthermore, had one of subscribers seized subscriber pair, the other one shall be given no further signaling at all. If there was an incoming call for the latter one, the call shall be completed with the busy tone.

Subscriber tariff may be sent either with:

- Solely charging pulses (16 kHz) or
- Polarity change first, followed with charging pulses (16 kHz) or
- Polarity change for each pulse

Tariff sending is adjustable for each subscriber, but depending on subscriber board type (not all boards are provided with each and every possibility).

СРЦЕ supports sending the calling party number and other data relevant for displaying on subscriber devices, using modem B.23 protocol, in accordance with ETSI ETS 300 659.

5.1.6.2 Digital subscriber signaling - DSS1

DSS1 signaling type is used for ISDN subscribers.

This signaling type is actually the same for both terminal types - basic (2B+D) and primary rate (30B+d) access. Those mainly differ as regarding the throughput - D channel remains in basic rate access for 16 kb/s, and 64 kb/s in primary access.

DSS1 signaling signals are those exchanged along D channel but some other data (packet, user data) may also be exchanged.

For basic access, following configurations are possible:

- ”Point-to-point” - single ISDN terminal is connected
- ”Point-to-several points’ - several ISDN terminals connected to the terminal

For case ”point-to-several points”, subscribers use passive bus.

In both cases, the terminal is connected to the exchange over ordinary pairs, same as for the analog subscribers.

For primary access, applied for connection of subscriber exchanges, same configuration is always used - ”point-to-point”.

This terminal is practically identical to the standard 2 Mb PCM terminal (E1 - ITU-T G.703).

Subscriber exchange may be connected over several basic and primary terminals.

ISDN terminal communication levels are generally arranged according to OSI reference model, with the level three reached furthest:

1. First level is described within recommendation I.430 (basic access) and I.431 (primary access). The first level defines digital data transmission format between ISDN subscribers and the exchange on the lowest (physical) level.

2. Second level is specified within recommendation Q.920 and Q.921 and is referred to as LAPD. This level is applied for provision of data channel establishment between subscriber and the exchange as well as for data (message) transmission completion between them.

3. Third level is specified within recommendations Q.930 and Q.931 and is referred to as DSS1. DSS1 defines signaling data exchange protocol between subscriber and exchange. Basic elements of DSS1 message are: call label, message type and information items. Call label is the same for all messages of a call (it is assigned to

every call). Message type specifies the message involved, and the information items include additional data. For example, the information items within SETUP message include, among other information, dialed digits information. Both compulsory and optional elements are defined for each message.

Supplementary service protocols are defined within recommendations of Q.95x series. Almost each recommendation introduces certain supplements to the basic DSS1 protocol.

СРЦЕ system was designed in accordance with ITU-T recommendations with the final implementation arranged to copy with ETSI standard. ETSI standards mainly define precise protocol elements.

Time outs correspond to those of the analog subscribers, with the following exceptions:

1. No line testing is performed for ISDN subscriber - similar function is performed by level 1 or level 2 - and if these are out of order, the line is considered irregular and therefore discarded.

2. ISDN subscriber, as a rule, sends several digits at one time

3. ISDN subscribers require no DTMF receivers

4. СРЦЕ may select whether tones are sent to ISDN subscribers or not.

In addition to these time outs, certain time outs defined within DSS1 standards (recommendations) are also supported.

5.1.6.3 Channel associated signaling types

In this signaling type, signals are exchanged by means of so-called signaling bits and in some cases, using a tone through a speech channel (trunk).

Most channel signaling associated types are digital variants of corresponding analog ones. The only "quite" digital is R2D (ИКМ R2) signaling type.

Note that the application of analog/digital converter provides any analog signaling type to be converted into a CAS signaling type.

The following issues shall be raised on the subject of each digital CAS signaling type supported by СРЦЕ, separately.

Signal	Direction	Duration
Seizure	→	short
Seizure acknowledgment	←	short
Address signal	→	decadic pulse
Blocking	←	long
Dialed sbsc. free	←	short
Called sbsc. busy	←	long
Answering	←	short
Hook on	←	long
Forced release	←	long
Release	→	long
Clearing	←	long
Blocking	←	continuous
Unblocking	←	-
Trunk offering	→	short
Trunk offering completed	→	short
Called sbsc. cleared	←	long
Call back	→	short
Charging pulse	←	short

signal	nominal duration	allowed range
decadic pulse	50ms	20ms - 80ms
short	150ms	100ms - 200ms
long	600ms	450ms - 1750ms
continuous	$>$ 1750ms	-

Table 5.5: D1/D1 signaling type signals

Digital D1/D1 signaling

Primary purpose of this signaling type is connection to analog exchanges by means of signaling converter.

Signals are presented in table

On the logic level, this type is the equivalent of the analog D1/D1 signaling. **A** signaling bit is used, where ”1” is inactive and ”0” is the active state (signal is therefore transferred ”lowing” the A bit for some time from 1 to 0).

Digital D1 with blind seizure

This signaling is often referred to as ”blind seizure”. Unlike D1/D1 signaling, the acknowledgement seizure is not waited for. The seizing party may start sending digits immediately after the seizure signal been sent. The other party is supposed to through-connect the dial tone.

Digital D1/R2 signalling

Primary purpose of this signaling type is connection to analog exchanges by means of signaling converter.

On the logic level, this type is the equivalent of the analog D1/R2 signaling. **A** signaling bit is used for the line part, similar to D1/D1 signaling.

Digital D4/R2 signaling

This signaling type provides connection to analog exchanges using signaling converters. It is the equivalent of analog D4/R2 signaling type.

Digital D2/D2 signaling

This signaling type is reserved for connection to analog exchanges using signaling converters.

On the logic level, it is the equivalent of analog D2/D2 signaling.

This signaling type is reserved for connection with analog exchanges over signalling converters.

On the logic level, this type is the equivalent of the analog D1/R2 signaling. Line and register signaling are of a continuous type, except for the digit information transferred by means of decadic pulses. Pulse relates to pause as 50ms : 50ms.

Digital bothway combined two-bit signalling BCT-R22

This signalling type is one of those applied in networks at the ex SSSR teritories. Two variants were designed, to apply in local and trunk exchange. Table 5.6 contains the list of signals for local network application.

One-bit digital signaling Norca (Норка OBS-R11, OBS-R12, OBS-R13)

This is one of signalling types applied in networks at the ex SSSR teritorries. Three variants were designed, to apply for three trunk types (for СЛ trunks OBS-R12, for СЛМ trunk OBS-R13 and for ЗСЛ trunks OBS-R11).

Signaling line section is always the same, while the registering one may be ”part of Norka" or R1,5 register signaling named ”pulse shuttle” ("импулсни челнок") may be used.

Two-bit one-way digital signalling 2BCK

This is also one of signaling types applied in networks of the ex SSSR territories. Three variants were designed, to apply for three trunk types (СЛ, СЛМ and ЗСЛ).

Signaling line section is always the same one, while the registering one may be ”part of 2BCK" or R1,5 register signaling named "pulse shuttle" may be used.

Definitions of signals applied in the outgoing direction (along СЛ and СЛМ trunks) are presented in table 5.7.

Signal or state	Channel condition				Direction	Note
	forward		backward			
	a_f	b_f	a_b	b_b		
Idle	1	0	1	0	←→	
Seizing state 1 (incoming call blocking)	1	1	1	0	→	Time out T01=70-80ms started
Seizing state 2	0	1	1	0	→	Seizure signal recognition time on the incoming side is 10-30ms.
Seizure acknowledgement	0	1	1	1	←	1s waiting for seizure acknowledgement on the outgoing side.
Decadic pulse	1	1	1	1	→	Pulse (pause) duration is 50±3ms.
Pause	0	1	1	1	→	Digit pause recognition time is 400ms.
Answering	0	1	0	1	←	Recognition time is 10-30ms.
Hook on (answering interrupted)	0	1	1	1	←	Recognition time is 10-30ms.
Clearing	1	1	0 (1)	1 (1)	→	Recogniton time on the incoming side is 120-500ms.
Clearing acknowledgement	1	1	1	1	←	Sent on receiving the clearing signal in *conversation* state.
Release (unblocking) of the outgoing and incoming side	1	0	1	0	←→	Outgoing side released at least 20ms after sending the *clearing acknowledgement* in *conversation* state.
Outgoing call blocking	1	0	1	1	←	Recognition time is ≥30ms.

Table 5.6: BCT-R22: Local call - states and procedures under normal conditions

Signal	Forward		Backward		Direction	Note
	a_f	b_f	a_b	b_b		
Line free	1	1	0	1		
Seizure	1	0	0	1	→	

Seizure acknowledgement	1	0	1	1	←	Seizure acknowledgment is on the outgoing side, 1s waiting
Pulse (pulse digit sending)	0	0	1	1	→	Duration must be shorter than 150ms
Pause (pulse digit sending)	1	0	1	1	→	When shorter than 150ms, pause is the one between pulses; when longer than 150ms, pause is between digits.
Answering	1	0	1	0	←	Recognition time is 70-90ms.
Calling party identification	1	0	1	0	←	Answering signal following 500Hz tone sending
Answering interrupted	1	0	1	1	←	
Hook on	1	0	0	0	←	
Seizure	1	0	0	0	←	
Clearing	1	1	X	X	→	Clearing signal may be sent on any combination of reception bits
Release	1	1	0	1	←	
Blocking	1	1	1	1	←	

Table 5.7: Signal definitions for 2BCK signaling, outgoing call

Tone signaling 2600Hz (OVF-R11, OVF-R12)

One of signaling types applied in networks of the ex SSSR territories. Signals are transmitted in 2600Hz frequency tone pulses. Two variants were designed, to apply for two trunk types (OVF-R12 for СЛМ trunks, OVF-R11 for ЗСЛ trunks).

Signaling line section is always the same one, while the registering one may be ”part of 600Hz" or R1,5 register signaling "pulse shuttle" may be used.

Signal definitions for ЗСЛ trunk application (OVF-R11) are presented in table 5.8.

SIGNAL	DURATION TIME (ms)	RECOGNITION TIME (ms)	DIRECTION
LINE SEIZURE	one pulse 200±5	100-150	→
DIALING	40-46 for pulse 31-103 for pause	400 (an interval between recognition of two continuous digits)	→
CLEARING IN DIRECTION OF CONN. ESTABL. (first 20sec)	min. 700 (550-850) max. 20sec (20-40)	280-420	→
CLEARING IN DIRECTION OF CONN. ESTABL. (after 20sec)	1sec for pulse 5 min. for pause	280-420	→
ANSWERING	one pulse 200±5	100-150	←
ANSWERING INTERRUPTION	200±5 for pulse 100±5 for pause (sequence of pulses)	100-150 for 1. pulse 120-180 for 2. pulse 20-30 for pause	←
CLEARING IN DIRECTION OPPOSITE TO CONNECTION EST. DIRECTION	200±5 for pulse 100±5 for pause (two pulses)	100-150 for 1. pulse 120-180 for 2. pulse 20-30 for pause	←
CLEARING SIGNAL	>650	100-150	←
BLOCKING SIGNAL	unlimited	100-150	←

Table 5.8: Definition signals for 2600Hz signaling ЗСЛ trunks

Register signalling R1,5

Register signalling *R1,5* was derived as "combination" of *R2* signaling which provides signal transmission logics and *R1* signalling providing signals (tones).For data transmission, same frequences are used for both communication directions, for which reason the request and response to request should be time separated.

Each signal contains two of six frequences:

$$f_0 = 700\ \text{Hz} \quad f_1 = 900\ \text{Hz} \quad f_2 = 1100\ \text{z}$$
$$f_4 = 1300\ \text{Hz} \quad f_7 = 1500\ \text{Hz} \quad f_{11} = 1700\ \text{Hz}$$

Table 5.9 reviews the signaling code R1,5.

Signal number	Freq.	Signal	
		Outgoing direction (A group signals)	Incoming direction (B group signals)
1	f_0, f_1	Digit 1	Request for the called subscriber's first digit
2	f_0, f_2	Digit 2	Request for following digit
3	f_1, f_2	Digit 3	Request for previously sent digit
4	f_0, f_4	Digit 4	Called sbsc. free
5	f_1, f_4	Digit 5	Called sbsc. busy
6	f_2, f_4	Digit 6	Request for previously sent digit (repeat request)
7	f_0, f_7	Digit 7	Overload signal (no free path)
8	f_1, f_7	Digit 8	Request for whole number transmission (starting from the first digit) in dec. code
9	f_2, f_7	Digit 9	Request for sending the next digit and all remaining ones of the called number, in dec.code
10	f_4, f_7	Digit 0	Request for previously sent digit redialing, followed with all other digits of the called subscriber, in dec.code
11	f_0, f_{11}	Reserve	Reserve
12	f_1, f_{11}	Acknowledgement of return direction signal, no. 4, 5, 8, 9, 10	Reserve
13	f_2, f_{11}	Repeat request for previously sent signal	Reserve
14	f_4, f_{11}	Reserve	Reserve
15	f_7, f_{11}	Reserve	No reception of multifrequency information

Table 5.9: *Signaling code R1,5*

Signal	forward a_f	forward b_f	backward a_b	backward b_b	Notes	Direction
Line free	1	0	1	0		←→
Seizure	0	0	1	0		→
Seizure acknowledgement	0	0	1	1		←
Answering	0	0	0	1		←
Hook on	0	0	1	1		←
Forced release	0	0	0	0	recognition period 240-250ms	←
Release	1	0	0 or 1	1 or 1	recognition time 240-250ms	→
Clearing	1	0	1	0		←
Blocking	1	0	1	1		←
Unblocking	1	0	1	0		←
Trunk offering	1	0	1	1	pulse, 150±30ms	→
Trunk offering complete	1	0	1	1	pulse, 150±30ms	→
Called party released	0	0	0	1	pulse, 150±30ms	←
Reanswering	1	0	1	1	pulse, 150±30ms	←
Charging	0	0	1	1	pulse, 150±30ms	←

Table 5.10: Line signals ИКМ-R2 (R2D)

Digital R2D (ИКМ R2) signaling

Digital R2D signaling is provided for connection of digital exchanges over digital transmission systems.

This is two-bit signaling in forward and backward direction.

Signaling of this type may be performed along one-way and both-way channels (trunks).

R2 is register signaling part (transferred along speech channel) and is the same as for any other signaling type.

Line signals are listed in the table 5.10.

Notes:

- Blocking and unblocking signals are sent only with the circuit being in state *free, unavailable.*
- *Trunk offering* signal is used with the call subscriber being busy.
- *Trunk offering complete* signal is sent only with previously sent *trunk offering* signal.

- *Called released* signal may be sent in backward direction only with previously sent *trunk offering* signal.
- *Reanswering* signal may be sent only with previously received *called released* signal.
- *Charging* signal is sent during the conversation, in the period between *answering* signal and *clearing* signal, otherwise ignored.

5.1.6.4 R2 register signaling

Being used as register part of many other signaling types, description of R2 register signaling is given a separate view in this chapter.

Each inter-register signal contains two tones of different frequencies (*dual-tone*) taken from a 6 frequency group for each direction. Dual-tones are sent and received using multi-frequency signaling equipment connected to registers controlling switching equipment on both connection ends between the exchanges.

R2 register signaling is different as regarding the direction *forward* and direction *backward*. For each of these two directions tones are taken from different frequency groups.

What's characteristic for this signaling type is the *acknowledgement* system - each tone sent forward is acknowledged with backward tone sent. This provides successful communication between two parties and prevents the event of a signal being "lost" or "skipped".

			[Hz]	[Hz]	[Hz]	[Hz]	[Hz]	[Hz]
		Outgoing direction (group I and group II signals)	1380	1500	1620	1740	1860	1980
Seq. number	Numeric values	Incoming direction (group A and group B signals)	1140	1020	900	780	660	540
	$x + y$	Index (x)	f_0	f_1	f_2	f_3	f_4	f_5
		Significance (y)	0	1	2	4	7	11
1	0 + 1		x	y				
2	0 + 2		x		y			
3	1 + 2			x	y			
4	0 + 4		x			y		
5	1 + 4			x		y		
6	2 + 4				x	y		
7	0 + 7		x				y	
8	1 + 7			x			y	
9	2 + 7				x		y	
10	3 + 7					x	y	
11	0 + 11		x					y
12	1 + 11			x				y
13	2 + 11				x			y
14	3 + 11					x		y
15	4 + 11						x	y

Table 5.11: R2 signaling tones

R2 tones

Each inter-register signal implies simultaneous sending of two frequencies out of group of six (dual tones).

This signal coding enables detection and rejection of signals containing other than two frequencies.

To apply the system along two-wire lines, two different groups of 6 frequencies are defined to form the signal forward and the signal backward.

Table 5.11 introduces all dual tones that may be derived of 6 signaling frequencies for each direction, system provided.

Inter-register signal meaning

Dual-tone forward

Two different groups of meaning may be reserved for dual-tones forward: group I and group II. Group I may be replaced with group II meaning sending A-3 or A-5 signal backward. Return to group I is possible only after signal A-5 previously being sent to replace the group.

Group I forward

Combinations	Signal	Signal meaning
1	I-1	Digit 1
2	I-2	Digit 2
3	I-3	Digit 3
4	I-4	Digit 4
5	I-5	Digit 5
6	I-6	Digit 6
7	I-7	Digit 7
8	I-8	Digit 8
9	I-9	Digit 9
10	I-10	Digit 0
11	I-11	never sent; on reception acknowledged with A4 signal
12	I-12	as the first one: calling the international transit center; other signals: request denied
13	I-13	never sent; on reception acknowledged with A4 signal
14	I-14	never sent; on reception acknowledged with A4 signal
15	I-15	if not the first one: identification complete

Signals I-1 to I-10 are numeric signals denoting:

- address signal required for call establishment (international country code, national number); address signal sends outgoing R2 register or international R2 register, immediately after connection seizure or as a response to a backward signal: A-1, A-2, A-7, A-8 or A-9.
- international country code (or, possibly, trunk code) containing outgoing R2 register, as a response to signals requiring call origin. In the national traffic, this is the phone number of a calling subscriber.
- in the automatic operation, discrimination digit and in semi-automatic operation, operator language (i.e., language digit).

Group II forward

Combinations	Signal	Signal meaning	Note
1	II-1	Subscriber without priority	These signals are used in national traffic
2	II-2	Subscriber with priority	
3	II-3	Maintenance equipment	
4	II-4	Reserved for national use	
5	II-5	Operator call	
6	II-6	Data transmission	
7	II-7	Subscriber or working station with no possibility of the operator assistant call	These signals are used in international traffic
8	II-8	Data transmission	
9	II-9	Subscriber with priority	
10	II-10	Working station with the possibility of the operator assistant call	
11	II-11	Pay phone	
12	II-12	Subscriber with priority and own charge meter	
13	II-13	Subscriber with own charge meter	
14	II-14	Forwarded call	
15	II-15	Reserve	

Note - Signals II-7 to II-10 are used only in the international traffic. Other group II signals are used solely for national needs and are compiled into signals II-7 to II-10 in the outgoing international R2 register. This fact is used to differentiate the national and the international call within R2 register in the incoming exchange.

Group II forward signals provide the category and identification of calling subscriber as a response to A-3 or A-5 signal backward. Group II signals also provide the information of the operation mode applied (national or international).

Dual-tone backward

Two groups of meanings are distinguished: A and B multi-frequencies backward. Transition to B group meaning is announced with A-3 signal backward. Return to the initial meaning of multi-frequency combinations backward is not possible.

Group A signals backward

Combinations	Signal	Signal meaning
1	A-1	Send digit $n+1$
2	A-2	Send digit $n-1$
3	A-3	Address complete, proceed with B signal reception
4	A-4	National network congestion
5	A-5	Send category and calling subscriber identification
6	A-6	Address complete, charging - establish speech connection
7	A-7	Send digit $n-2$
8	A-8	Send digit $n-3$
9	A-9	Send first digit
10	A-10	Not used
11	A-11	Not used
12	A-12	Not used
13	A-13	Not used
14	A-14	Not used
15	A-15	Not used

Group A signals backward are necessary response to group I signals forward and, under certain conditions, to group II signals forward.

Signal A-1, *send next digit (n+1)* requests sending of the next digit (n+1) on reception of n digit.

Signal A-2, *send next to last digit (n-1)* requests sending of digit (n-1) on reception of n digit.

Signal A-3, *address complete, proceed with B signal reception* denotes that the incoming R2 register requires no additional address digits to proceed with B group signal sending thus sending the information of the incoming exchange equipment state or subscriber line state. On B group signal sending started, no return to A group signal sending is possible.

Signal A-4, *national network congestion* denotes:

1. national link congestion
2. congestion during call routing
3. time out expiry or R2 register release caused by the irregular conditions

Signal A-5, *send category and calling subscriber identification*, requires sending of group II signals. Sending it as the first one, the A-5 signal represents the request for calling subscriber category. Repeated sending of A-5 signal represents the request for calling subscriber identification.

Signal A-6, *address complete, charging - establish the speech connection* denotes that the incoming R2 register requires no additional address digits but won't be sending any B group signal either. Call charging should start.

Signal A-7, *send digit (n-2)* requests sending of (n-2) digit on reception of n digit.

Signal A-8, *send digit (n-3)* requests sending of (n-3) digit on reception of n digit.

Signal A-9, *send from the beginning* requests sending the first digit of the called subscriber identification number. When used in the international traffic, A-9 indicates the request for sending of I-12 and all international number digits. In national traffic, it is the request for sending all national number digits.

Group B backward signals

Combinations	Signal	Signal meaning
1	B-1	Preparation for malicious call tracing
2	B-2	Send special information tone
3	B-3	Subscriber line busy
4	B-4	Congestion (blocking)
5	B-5	unallocated number
6	B-6	Subscriber free, charging
7	B-7	Subscriber free, no charging
8	B-8	Subscriber line failure
9	B-9	Information service
10	B-10	Direction unavailable
11	B-11	Not used
12	B-12	Not used
13	B-13	Not used
14	B-14	Not used
15	B-15	Not used

All group B signals backward represent the acknowledgement of II group signals forward and necessary follow after A-3 signal being sent denoting of the incoming R2 register having received all group I signals forward, requested from the outgoing R2 register. In addition to these functions of the inter-register acknowledgement supplied signaling, group B signals convey information of the incoming exchange equipment state or called subscriber line state forward to the outgoing international R2 register, in charge for further activities.

Signal B-1, *preparation for malicious call tracing*, requires call hold in order to perform malicious call tracing.

Signal B-2, *send special information tone*, requires the special information tone to be forwarded to calling subscriber. Special information tone indicates of the dialed number being unavailable, for a certain period of time (see Recommendation Q.35).

Signal B-3, *subscriber line busy*, indicates of the line between called subscriber and the exchange already being used.

Signal B-4, *congestion*, indicates congestion after transition to group B signal sending.

Signal B-5, *unallocated number*, denotes of the dialed number not used as a subscriber one.

Signal B-6, *subscriber free, charging*, denotes of the called subscriber line being free, therefore *conversation* charging should be started.

Signal B-7, *subscriber free, no charging* indicates of the called subscriber line being free, but no conversation charged. This enables free-charge calls, without sending a special line signal.

Signal B-8, *subscriber line failure*, indicates that the certain line cannot be used.

Signal B-9, *information service*, enables the outgoing R2 register receiving this signal to forward the call so as to provide a required service.

Signal B-10, *direction unavailable*, indicates of the specified direction not being available.

5.1.6.5 Channel associated signaling

Within CCS signaling types, СРЦЕ supports signaling system no.7 (SS7).

Instead of signals, signaling no.7 uses messages transferred between two connected exchanges. Communication is organized in several levels, following the principles similar to OSI communication reference model, but not entirely the same. Figure 5.4 presents the architecture of SS7 and the approximate resemblance of its sections and OSI layers.

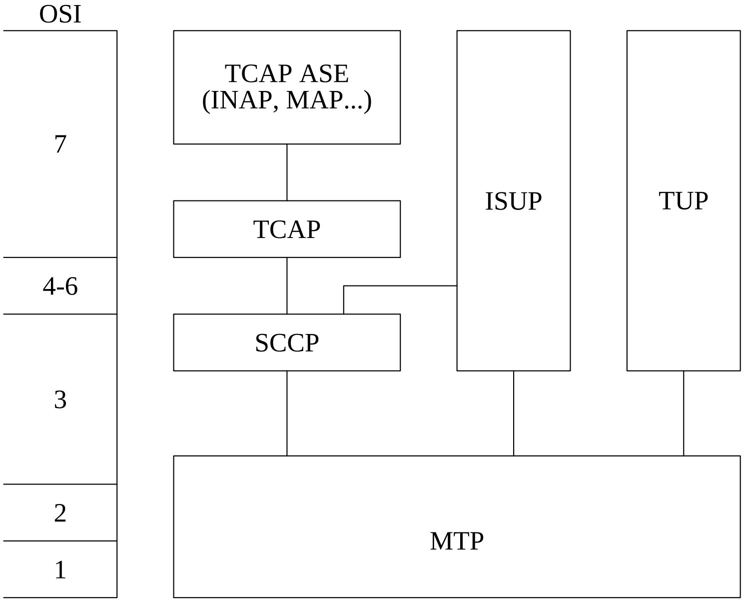


Figure 5.4: SS7 architecture and resemblance to OSI layers

Signaling system no.7 is described in ITU-T and ETSI recommendations. SS7 within СРЦЕ is performed in accordance with the following ITU-T and ETSI recommendations:

- message transfer part (MTP), recommendations Q.701/Q.709 and Q.752 (section referring to MTP)
- telephone user part (TUP), recommendations Q721 - Q.724
- ISDN user part (ISUP), recommendations Q.730, Q761 - Q.764 and Q.850, ETS 300 356 (Part 1 and Part 2) and ETS 300 360, service support and special EuroISDN service support

- signaling connection control part (SCCP), recommendations Q.711 - Q.714, Q.716 and Q.750 - Q.755 (section referring to SCCP)
- transaction capabilities application part (TCAP), recommendations Q.771 - Q.775 and Q.752 (section referring to TCAP)

SS7 signaling in СРЦЕ system may be arranged in accordance with corresponding national specifications, when needed (if being different or containing additional elements within specified signaling type).

5.1.7 Signaling conversion

СРЦЕ is enabled to perform necessary signaling conversions, thus providing the same call received along, for example, analog signaling and be sent along, for example, CCS digital signaling. No special settings are needed regarding it.

Not all possible conversions shall be described, since there is a great number of combinations. To illustrate some of them, conversions of digital CCS and CAS signaling types are presented. NOTE: Conversions for corresponding analog variants of CAS signaling types are similar to those used for digital ones.

SRCE system regularly performs necessary signaling conversions, providing the call originating along one (e.g, CAS) signaling, and proceeding along another signaling type (e.g, CCS). No special settings are needed for this matter.

With so many combinations, description of all possible conversions would not have much sense. To illustrate only, digital CCS and certain CAS signaling conversions are presented.

5.1.7.1 Conversions between R2 and SS7 signaling types (TUP and ISUP) within СРЦЕ

Incoming TUP signaling

TUP	Direction	Signal	ISUP	R2D
IAM	→	Seizure, dialed digits, category	IAM	$a_f b_f$=00, waiting for seizure acknowledgement, reg. signal exchange
IAI	→	Seizure, dialed digits, category, calling subscriber digits	IAM	$a_f b_f$=00, waiting for seizure acknowledgement, reg. signal exchange

TUP	Direction	Signal	ISUP	R2D
SAM	→	Dialed digits	SAM (IAM for outgoing trunk free)	Register signal I-1 to I-15[1]
SAO	→	Single dialed digit	SAM	I-1 to I-15
GSM	→	Category, calling party identity	INF or IRS (depending on GRQ)	I-1 to I-15 or I-12[2]
GRQ	←	Identity and calling party category query	INR or IDR	A-5 or repeated A-5 or B-1[3]
ACM	←	Address complete	ACM	B-1, A-6, B-6 or B-7[4]
COT	→	Continuity check complete	COT (complete)	none
CCF	→	Continuity check failure	REL (18) (release)	$a_f b_f$=10 (release)
SEC	←	Switching-equipment congestion signal	REL (42)	none
CGC	←	Circuit-group congestion signal	REL (34, 38, 41, 44, 47, 58)	none
NNC	←	National network congestion	REL (2, 3)	A-4 or B-4
ADI	←	Address incomplete	REL (28)	none
CFL	←	Call failure	REL (16, 18, ..., 127)	B-10 to B-15, forced release
SSB	←	Subscriber busy	REL (17)	B-3
UNN	←	Unallocated number	REL (1, 22)	B-5
LOS	←	Loss of signal	REL (27)	B-8
SST	←	Send special information tone	REL (4)	B-2, B-9
ACB	←	Access barred	REL (21, 29, 55, 57, 87, 88)	none
DPN	←	Digital path not provided	none	none
MPR	←	Misdialed prefix	REL (5)	none
ANU	←	Answering	ANM	$a_b b_b$=01
ANC	←	Answering	ANM	$a_b b_b$=01
ANN	←	Answering	ANM	$a_b b_b$=01
CBK	←	Clear back signal	SUS	$a_b b_b$=11
CLF	→	Clear forward signal	REL (18)	$a_f b_f$=10
RAN	←	Reanswering	RES	$a_b b_b$=01

[1] Signal I-15 is compiled ST signal denoting the ”end of dialing” with 15 code
[2] I-12 is sent when there is no available calling party digits at the time
[3] Signal B-1 invokes GRQ/GSM sequence with call hold request, followed with ACM
[4] depending on ”subscriber free” and ”charging” indicators in ACM message

TUP	Direction	Signal	ISUP	R2D
RLG	←	Release guard signal	RLC	$a_b b_b$=10

СРЦЕ returns clearing message along incoming circuit immediately after release reception, without waiting for clearing from the outgoing circuit.

Forced release in the phase after the address complete signal (tariff reception) is compiled into CFL.

Hook on is not transferred in charging center, but the time out is started.

ANM is compiled as ANU, ANC or ANN, depending on charging indicator.

Incoming signaling ISUP

ISUP	Direction	Signal	TUP	R2-D
IAM	→	Seizure, dialed digits, category	IAM (IAI, with calling identity)	$a_f b_f$=00, waiting for seizure ack., register signal exchange
SAM	→	Following digits	SAM (IAM)	Register signals I-1 to I-15[5]
COT	→	Continuity check indication	COT (success), CLF (failure)	Failure: $a_f b_f$=10 (release)
INF	→	Category, calling party identity	GSM	Register signal I-1 to I-15 or I-12[6]
INR	←	Identity and calling party category request	GRQ	A-5 or repeated A-5 or B-1[7]
ACM	←	Complete address	ACM	B-1, A-6, B-6 or B-7[8]
ANM	←	Answering	ANU, ANC, ANN	$a_b b_b$=01
CON	←	Through-connection	none	none
CPG	←	Call progress	none	none
SUS	↔	Suspend	CBK (only ←)	$a_b b_b$=11 (only ←)
RES	↔	Reanswering	RAN (only ←)	$a_b b_b$=0 (only ←)
REL	→	Release	CLF	$a_f b_f$=10
REL	←	Release backward	Call failure	A or B signal, forced release
RLC	→	Clearing	CLF, waiting for RLG	$a_f b_f$=10, waiting for clearing
RLC	←	Clearing	RLG	$a_b b_b$=10

Other ISUP messages are either circuit oriented (not connection oriented) or have no equivalents in other signaling types and are not compiled.

Call failure signal mapping in ISUP is presented in a separate table

[5] Signal I-15 is a compiled ST signal denoting the ”end of dialing”, with code 15
[6] I-12 is sent when there is no available calling digits at the moment
[7] Signal B-1 provokes GRQ/GSM sequence with call hold request, and than ACM sending
[8] Depending on ”subscriber free” indicator and ”charging” indicator in ACM message

Table presenting call failure signal compiled into ISUP cause value

ISUP	TUP	R2
REL (1)	UNN	B-5
REL (2)	none	none
REL (3)	NNC	A-4, B-4
REL (4)	SST	B-2, B-9
REL (5)	MPR	none
REL (16)	none	none
REL (17)	SSB	B-3
REL (18)	none	none
REL (19)	none	none
REL (21)	none	none
REL (22)	none	none
REL (27)	LOS	B-8
REL (28)	ADI	none
REL (29)	none	none
REL (31)	none	none
REL (34)	CGC	none
REL (38)	none	none
REL (41)	none	none
REL (42)	SEC	none
REL (44)	none	none
REL (47)	DPN	none
REL (50)	none	none
REL (55)	none	none
REL (57)	none	none
REL (58)	none	none
REL (63)	none	none
REL (65)	none	none
REL (69)	none	none
REL (70)	none	none
REL (79)	none	none
REL (87)	none	none
REL (88)	ACB	none
REL (91)	none	none
REL (95)	none	none
REL (97)	none	none
REL (99)	none	none
REL (103)	none	none
REL (111)	none	none
REL (127)	CFL	B-10,..., B-15

Cause value is given in brackets.

Incoming signaling R2-D

R2-D	Direction	ISUP	TUP
Seizure ($a_f b_f$=00)	→	IAM (not directly)	IAM (not directly)
Seizure acknowledgement ($a_b b_b$=11)	←	none	none
Signals I-1 to I-15 as a response to A-1, A-2, A-7, A-8 or A-9	→	IAM, SAO	IAM, SAO
Signals I-1 to I-15 - response to repeated A-5	→	GSM	INF, IRS
Signals II-1 to II-15	→	IAM-with calling category	IAM-with calling category
A-1, A-2, A-7, A-8, A-9	←	none[9]	none
A-5	←	GRQ	INR, IDR
A-4, B-4	←	SEC, CGC, NNC, CFL, ADI, ACB, RSC	REL (2, 3, 21, ..., 88), RSC
B-1	←	ACM (with call hold request)	INR (with call hold request)
B-2	←	SST	REL (4)
B-3	←	SSB	REL (17)
B-5	←	UNN	REL (1, 22)
A-6	←	ACM (without "subscriber free")	ACM
B-6	←	ACM	ACM
B-7	←	ACM ("no charging")	ACM
B-8	←	LOS	REL (27)
B-9	←	none	none
B-10	←	DPN, MPR	REL (5)
Answering ($a_b b_b$=01)	←	ANU, ANC, ANN	ANM
B hung up ($a_b b_b$=11)[10]	←	CBK	SUS
B reanswered ($a_b b_b$=01)	←	RAN	RES
Forced release ($a_b b_b$=00)[11]	←	CFL, RSC	REL backward
Release ($a_f b_f$=10)	→	CLF	REL (18)
Clearing ($a_b b_b$=10)	←	RLG	RLC

Clearing signal on the incoming circuit is sent immediately after release signal reception, not waiting for clearing signal reception from the subsequent exchange.

[9] Incoming trunk sends automatically A-1, A-2, A-7 or A-8 according to data base contents and current call processing information. In case of conversion toward TUP or ISUP solely A-1 is sent.

[10] For case tariff is not sent

[11] Tariff is sent

For REL message, numbers in brackets denote cause value.
Other signals backward in TUP and ISUP are not compiled.

5.2 Administrative functions

Administrative functions are those executed by the system operator. These include:

1. System and environment surveillance
2. System control
3. System parameters' report
4. System parameters' settings

Following notes describe СРЦЕ administrative functions, as regarding particular system sections or terminals and not according to the previous list. Such approach was taken as it appeared easier to manage by those it was intended for in the first place - system operators.

5.2.1 Subscribers

СРЦЕ system enables many administrations functions performed for subscribers. These include:

- Various reports (single or group) processing subscriber data
- Subscriber connection and disconnection
- Subscriber blocking and unblocking
- Subscriber state surveillance (subscriber may be free, busy, blocked)
- Subscriber signaling exchange surveillance
- Electrical measuring of subscriber lines and corresponding system interfaces
- Supplementary service setting
- MHG (multi-line hunt group) administration
- Charging data (charging meters and recorded charged calls) view
- Other common settings, such as ringing type for analog subscribers

ISDN and analog subscribers' operation within СРЦЕ is quite the same. Differences are made where necessary but mainly concerning less important details. Operation mode and even commands available for system operation are mostly the same for ISDN and analog subscribers.

Some more important subscriber administration functions shall be further described.

5.2.1.1 Subscriber connection and disconnection

Phone number assigning to subscriber connecting points within СРЦЕ is performed in a random mode. During its connection, connecting point is assigned a number from the set of available numbers (numerations). Connecting point and a number must be currently unassigned. It is determined whether to select both-way or one-way terminal (one-way terminal is used either for call sending (CEPT 3.2) or reception of the incoming calls (CEPT 3.1.1)).

It is also possible to change the connecting point for a specified number, as to support the function ”permanent subscriber number” (CEPT 13.2).

On disconnection, phone number and connecting point get disconnected. Disconnection is not allowed while subscriber is still talking. For this reason, subscriber is usually blocked and disabled to establish another call, this way disconnected immediately on the current call being finished. Definitely, disconnection is possible even without blocking the subscriber.

5.2.1.2 Subscriber blocking and unblocking

Subscriber may be blocked and thus disabled to participate in new calls (outgoing or incoming). Had blocking been performed while subscriber participating a call, such conversation shall not be forced released. Most frequent reasons for blocking are:

1. Unpaid bills
2. On subscriber request (e.g., to avoid misuses while being absent)
3. Temporary blocking in failure conditions (until repaired)

Several subscribers may be blocked in one time, which is mainly useful in failure conditions blocking, having most frequently several terminal failure.

Unblocking is unconditional. Unblocked subscriber may participate in new calls (both originating and incoming) immediately after. Several subscribers may be unblocked in one time.

Except for this blocking, also referred to as manual blocking, other blocking types are introduced:

- Line blocking - subscriber forgot to hang up the phone, or there was some other reason causing the system detect low-resistance closed terminal
- Control blocking - in processor failure conditions, terminal blocked by a failed processor gets blocked

- Automatic - had the automatic line testing (preceding each call) been provided for a specified subscriber line, and in case of detecting the line failure for three times in turn, corresponding terminal is automatically blocked

All blocked subscribers in the system may be listed in a special view, with selected blocking types envolved (manual, line, control or all types). Especially, it is possible to activate blocking monitoring function, performed in user groups. Each group with blocking monitoring activated is assigned a subscriber number in line blocking representing the upper limit for the alarm to be reported, thus causing the operator action. In particular, single line (or any other) blocking is not an alarm and the previously described facility was introduced in case of group network failure, so the system may inform the operator of the event of failure.

5.2.1.3 Subscriber monitoring

It is possible to make the enquiry for current subscriber state (one or several subscribers) or to perform subscriber signaling exchange surveillance.

On subscriber state enquiry, following information are obtained:

1. Phone number and connecting point number
2. Whether belonging to MHG or being MHG leading number
3. Whether being free, busy for outgoing, busy for incoming, busy as two-party
4. Blocking types, if active

Following signals are subject to subscriber signaling monitoring:

- Subscriber loop state changed (open/closed - with no failure events, open loop implies handset hung up and closed loop when handset lifted)
- Detected handset activity (hook off, hook on, hook flash)
- Automatic line testing request and testing results
- Two-party line events
- Charging pulses and ringing current sending
- DTMF receivers' events (seizure, release, detected digits)
- Tone sending
- Conference call (establishment, release)

Monitoring is selected for each group of signals mentioned above or for each specified signaling for a specified terminal.

5.2.1.4 MHG (multi-line hunt group)

These functions provide introduction of new MHGs, current MHG settings and its clearing, specifying the appropriate options in accordance with description of MHG telephone functions.

It is possible to:

- View all detected MHGs
- Perform single MHG data report
- Introduce another MHG
- Introduce an MHG line (terminal) - this practically is the variant of subscriber connection (to MHG)
- Discard an MHG line - the variant of subscriber disconnection
- Modify MHG common parameters
- Cancel an MHG

MHG is identified either by its name (specified when implemented), or by MHG leading number.

5.2.1.5 Charging data view

This view introduces the list of charging meters and charged calls data. Charge meters' states are recorded in the format appropriate for further processing (first of all for subscriber account issuing).

Charge meter view may be performed:

- for a single subscriber
- for several subscribers (or for all - treated as a special case)

The report may be executed:

- For the main charge meter only
- For all charge meters (main and all auxiliary meters)
- Specified auxiliary charge meter

In the list of charged calls data, it is possible to view:

- All charged calls recorded in the system (number of charged calls recorded is limited, and is designed to cover at least a two-month period)
- Charged conversations within a specified period of time (most frequently, for the previous month)
- Charged calls for specified calling numbers (mostly one of them, requesting the charged calls' list)
- Calls toward certain destinations (international, talking machines with fixed contents, etc)
- Conversations charged with more than the specified number of pulses

For purposes of subscriber account issuing, the report of the charge meters' state may be issued, in a format appropriate for further processing. These reports include only main charged meter state.

5.2.2 Trunks

СРЦЕ system performs various trunk administration functions. These include:

- Various trunk data reports
- Trunk connection to and disconnection from the trunk routes
- Trunk blocking and unblocking
- Trunk state surveillance (trunk may be free, seized, blocked)
- Trunk signaling exchange surveillance
- ITU-T No.7 CAS signaling (MTP and SCCP) settings.
- Setting the trunk route parameters
- Message transfer surveillance for all ITU-T No.7 signaling levels (MTP level 2 and 3, TUP, ISUP, SCCP, TCAP level 4)

As a special facility, a function is provided executing held trunk call release - call is held in case of malicious call tracing function being activated but calling party identification not being acquired. Such call is held until the calling party identification is complete (using held channel). Since the system itself cannot recognize the moment of this completion, it must be given an order in regard as to the moment the trunk should be released.

The operation of routes containing channels performing No.7 signaling message transfer is practically the same as the operation of the ”ordinary” routes and trunks. Differences are rather details. No.7 signaling network is administrated separately, as it was mentioned.

Some more important trunk administration functions are further described.

5.2.2.1 Trunk connection and disconnection

Trunks are connected into routes. The trunk, if connected, is consequently contained in a route. An arbitrary number of trunks is contained in a route. A route may include selected trunks, meaning that it's not necessary to connect entire links, nor their halfs. It is quite possible, if needed, to connect the first three trunks into one route, next ten into the second one, and as for the rest of them, even trunks into the third and odd into the fourth route.

While connecting into a SS7 route, it is necessary to specify the mode for CIC assignment and also to define the SS7 point/exchange controlling each channel, since SS7 routes are mostly both-way. During both-way seizure, channel is seized by corresponding exchange in charge of its control. Note that СРЦЕ system may also include one-way routes.

One or more channels may be connected at one time.

To disconnect trunks, it is necessary to block them first. For this reason, after connection, all trunks are blocked and should be unblocked.

One or more channels may be disconnected at one time.

5.2.2.2 Trunk blocking and unblocking

Each trunk may be blocked, resulting in no further calls established. If there was a call in progress in the moment of trunk blocking, it is regularly completed (not forced released).

Blocking is obligatory prior to disconnection, and is otherwise used for testing purposes (e.g., all trunks in a route are blocked except one specified, thus causing all calls to be routed along one single trunk), or in failure conditions (mostly, in case of irregular transfer, where link is in one time irregular, and the moment after invokes the alarm, having, as a consequence, the connection established and immediately after cleared).

Single trunk or more trunks may be blocked at a time. Having the blocking frequently used, different possibilities are provided:

- entire link blocking
- blocking of all trunks in a route
- blocking of all trunks of a specified link belonging to a specified route

Corresponding possibilities are provided for trunk unblocking. When unblocked, the trunk is free to establish a new call.

Except for this blocking, referred to as manual blocking, other trunk blocking types are possible, resulting either from signal exchange irregularities in direction to another party (exchange) or from a system failure.

All blocked system trunks may be sorted in a special view, selecting certain blocking types. Surveillance function may be activated for specified blocking, performed along the route. Trunk blocking percentage is specified for each route with activated blocking surveillance, presenting an upper limit which, when exceeded, causes the alarm report, resulting in the operator reaction.

5.2.2.3 Trunk surveillance

Current trunk state report may be requested for one or more trunks. Surveillance of trunk signaling transfer is also provided.

On trunk state report request, following information are obtained:

1. System position
2. Belonging link and its sequence number
3. Connected route, if connected into any
4. Channel CIC, if connected into SS7 route and the exchange controlling the channel (home exchange or the other one)
5. State (free, seized, line blocking)
6. Blocking states (manual and others)

Following signals are subject to subscriber signaling surveillance:

- Tone reception and sending
- Silence (tone cease states) reception and sending
- Signaling reception bit change
- Signaling sending bit change
- Decadic digit reception
- Decadic digit sending
- Short signal (seizure signal in most signaling types) reception
- Short signal transmission
- Long signal (release signal in most signaling types) reception
- Long signal transmission

Monitoring is selected for each group of signals mentioned above or for each specified signaling for a specified terminal.

As concerning SS7 signals, signaling transfer surveillance may be performed either along trunk channel or signaling point. All messages are surveiled, with detail message contents (not bits, but the interpreted contents). This illustrates surveillance of level 4 signal transfer but it's provided for lower level signal transfer as well, as it was described within No.7 administration function report.

5.2.2.4 SS7 signaling network

SS7 signaling network settings within СРЦЕ system are performed apart from trunk channels. Settings define:

1. Exchange signaling point code
2. Signaling channels (adding, clearing, checking)
3. Signaling routes, each representing a signaling channel group toward same destination (adding, clearing, checking)
4. Other network signaling points, available from the current signaling point (adding, clearing, checking)
5. Message routing for specified signaling point (signaling routes used, their priorities)

Various reports may be performed for routing, in order to determine routing direction and cause.

These settings are made in Message transfer part (MTP) of No.7 signaling. СРЦЕ also performs other settings, regarding signaling connection control part (SCCP) features:

1. Destination signaling points and its subsystems available for SCCP
2. Originating signaling points and its subsystems where SCCP is available
3. Activation, deactivation and settings for SCCP subsystem user within the exchange.
4. Global title translation table setting. Table is used for routing to specified signaling point, subsystem within a point, or another global title

Signaling surveillance may be performed for:

- two MTPs' level (line state signals, level 2 events and higher level messages in course)
- three MTPs' level (signaling network control message)
- four MTPs level (TUP, ISUP, SCCP)

5.2.3 Calls

СРЦЕ system provides settings for a great number of parameters relevant for system operation as regarding its basic function - call establishment. This mainly refers to routing and charging.

Following surveillance functions may be performed over calls:

- surveillance of call establishment in the system
- monitoring the various specific call types in the part of or the whole exchange
- view currently active calls according to their state
- read out the number of calls processed in the previous hour.
- short recording of a current conversation, for audibility check

Following described functions concern settings for traffic routing and call charging.

5.2.3.1 Traffic routing settings

Traffic routing settings relate to:

- B-analysis directly defining dialed prefixes, incoming terminals and outgoing terminals. Calls are routed to routing cases, talking machines, subscribers, supplementary services. Transitions to other parts of B-analysis are possible as well (in order to distinguish a common routing for various types of incoming connecting points). B-analysis also defines codes and activation digit collecting mode, deactivation and subscriber setting of supplementary services.
- Discriminations restricting digits to dial for some prefixes
- ПАЦ tables defining digit directing to central processor processing (practically, to B-analysis) while dialed, in addition to originating call restriction
- Routine cases enabling traffic overflow between several routes, talking machines, subscribers returns to B-analysis and supplementary services.
- EOS tables defining the processing mode for certain failure situations, depending on terminal the call was coming from. These tables also arrange processing of completed or failed activation, deactivation and setting of supplementary services performed by subscriber (dialing digits)

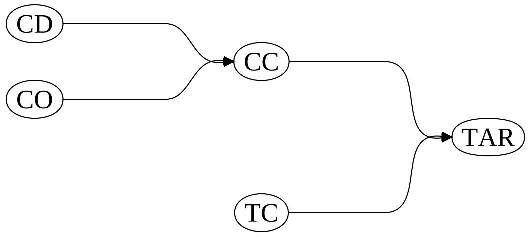
5.2.3.2 Call charging settings

These settings manage:

- Charging origins and destinations. Each incoming connecting point is assigned certain charging origin, determined within B-analysis
- Connection between charging origins and destinations, defining a charging case for origin/destination pair
- Charging cases. For each charging case, it is defined whether the tariff is received or sent (if both, than called ”tariff transfer”), called subscriber charged (opposite to usual charging of calling subscriber) and some other charging case options appearing less frequently
- Tariff, defined with charging case and current charging category. Tariff represents the charging ”program”. An initial number of pulses and a period between two charged pulses is specified.
- Charging categories represent charging in relation to current time of the day, on different bases. Most frequently used categories are so-called ”expensive” and ”cheap” tariff, but there is no limits in СРЦЕ system as to the number of categories implemented (although more than ten is considered rather less useful). There must be at least one charging category implemented. Charging categories are specified according to:
  - Time of a day
  - Day of the week
  - Day of the year (holidays)
  - Time in a specified day of the week
  - Time in a specified day of the year

Figure 5.5 illustrates tariff definition of a call, based on the above data.
Some other common options within СРЦЕ charging subsystem may also be set:

- Pulse normalization mode. If the tariff is only charged, not sent or received, than the number of pulses at the end of conversation is non integer. It is for the operator to define whether such number of pulses is recorded, or rounded (mathematically correct, to closest bigger or smaller number)
- Whether it's allowed to charge with less than one pulse. In precise, the operator may allow the input of 133,33 pulses for charge meter, but in case of 0,33 and such, it is always at least 1,00.



Legend:

CO *Charging Origin*

CD *Charging Destination*

CC *Charging Case*

TAR *Tariff*

TC *Tariff Category*

Figure 5.5: Tariff definition

- System may be set not to use the auxiliary charge meters, although detected within system. This may help more rapid system operation, since a considerable time is spent for the auxiliary charge meter input.

5.2.4 Traffic statistics and measuring

5.2.4.1 Operation concept

СРЦЕ is highly equipped for system events registering. Event receivers may be configured to receive all or some of the events from the program support involved in call processing. All events are kept within system data files. These may be accessed and all necessary data obtained using corresponding commands at the operator computer.

5.2.4.2 Facilities

Digital switching system СРЦЕ provides traffic measuring and statistic data recording regarding:

- subscriber
- subscriber group
- duration of connection phases
- MHG (multi-line hunt group)

- directions
- traffic dispersion along trunk codes
- BHCA
- answering percentage
- occupation of all resources (physical or program support ones) in the system in charge for call processing,
- SS7 links' occupation,
- signaling point occupation counted in number of messages/sec,
- measuring the signaling message length depending on traffic case,
- processing of the exchanged signaling messages

Some other data may be acquired:

- statistics in relation to connection establishment failure conditions, based on specified criteria (subscriber, trunk, group, route, prefix, etc)
- percentage of "B free-s", based on specified criteria
- list of all or a selected group of calls with *all* recorded events during a call
- tabular view (of all or a selected group of calls) with most important events and call features

The last mentioned one, tabular view, is specially convenient for further processing in standard (commercial) applications for data base operation (FoxPro, VisualDBase, etc) and commercial applications for statistic data processing and generating (MathCad).

Statistics may be executed for a specified time interval. The interval may be a daily category this way collecting several days' data (which may be the whole month, since one interval may be equal to one entire day)

As concerning the simultaneous measuring, it is possible to record *all* statistics data of the *entire system* within a specified period of time.

5.2.4.3 Subsequent processing of statistics data

As previously mentioned, statistics data tabular view is specially convenient for further processing and is therefore used in the special relating software - KM.

KM arranges the list (in relation to different characteristics, so-called keys), view, reports and read-out of a call. Processing may be performed in regards as to EOS codes (connection establishment failure conditions), traffic, calls. Processing results include matrixes for calls, called subscriber answering percentage, call duration, erlang traffic etc. Very important function is the one considering selective processing, that is, ”filtering” of certain data in order to locate the traffic problem type. This provides call statistics and traffic from a specified incoming route for a defined initial part of dialed number, under one condition: calls must have a corresponding EOS code. Statistics may be performed for calls beginning with predefined prefix, from the specified outgoing route. Each defined and located problem may be solved using the filtering function.

KM enables the operator to select processing type. More qualified the operator is, more information may he/she obtain using subsequent processing of statistics data. Results may be printed using the ink jet or laser printer. Subsequent processing of statistics data KM is supported with Help topics.

5.2.5 System

System administrative functions include practically all other administrative functions not mentioned before. These functions are particularly described for СРЦЕ and refer solely to СРЦЕ, since any other system may be different. Other administrative functions are considerably similar to corresponding functions in other systems. Each system should have functions like: subscriber blocking and unblocking, signaling trunk route disposition, traffic routing, call charging, collecting and processing of statistics data of all administrative functions existing in a switching system. However, each system may be organized in a different manner, thus deciding of the administrative functions to be applied within a specified system.

Some administrative function groups within СРЦЕ system are further described.

5.2.5.1 Database

СРЦЕ system database is distributed, organized according to relating database model. Administrative functions for system database provide:

- Database back up
- Database loading from a recorded beck up
- Database contents view

- Database contents recording in a special format, for further processing

Database contents may be directly modified, but this opportunity is reserved only for СРЦЕ system expert team, since it is necessary, in order to perform these modifications without some bad results, to be familiar with system operation in a considerable degree. In precise, the only regular way to operate the system is possible using the operator commands, which, aside from keeping database contents integrity, ensure system integrity as well. Therefore, the possibility of direct system modifications is mainly provided in failure conditions causing the database inconsistency, since the inconsistency cannot be removed using the operator commands requiring a consistent state.

5.2.5.2 Alarms

Alarm reports the irregularities within system or its environment, informing the operator in order to perform some actions, had the system itself failed to remove these irregularities.

There are four alarm levels:

- warning (A0) - rather warning than alarm, indicating to irregularities during the operation, mainly regarding system parameter settings
- less important alarms (A3) - these alarms relate to certain smaller sections within system, indicating either a failure removed with appropriate system actions performed, or an error detected in the exchange part or terminal, relating to a small number of subscribers or trunks.
- important alarms (A2) - these relate to larger system sections indicating either a failure removed with appropriate system actions performed, or an error affecting a considerable number of subscribers or trunks. These alarms conditions should be treated as fast as possible
- critical alarms (A1) - alarms denoting of a system section complete failure requiring an urgent operator solution, unless provided by the system itself (some level four alarms are managed by the system solely). Such alarms are necessary to be treated promptly.

Basic point of system alarm operation represents the list of active alarms. Alarms may be viewed, selecting some specific alarms or those belonging to a specified level. More important alarms remain in the list even after their expiry, until confirmed by the operator. This mainly relates to important alarms and those important for the operator just to be informed of their presence, requiring simple solution, without requiring the alarm log view.

5.2.5.3 Time and date

Time and date are extremely important for switching system charging purposes. Time and date administrative functions provide view and settings for current system time and date. Both time and date may be modified, or time only.

5.2.5.4 System log

СРЦЕ system supports event log recording all important data, such as:

- alarm start and termination
- automatic activities in failure conditions
- operator commands and corresponding reactions

Log view may be complete or made according to certain criteria: time range, event type, etc...

System log may be saved in a specified format (text, HTML), for a subsequent processing, or recorded on a high-capacity data carrier.

5.2.5.5 Synchronization

Synchronization represents a highly important issue for all digital switching systems. Had the digital system not been mutually (or individually, internally) synchronized, it may cause the conversation contents' loss. This effects the speech transmission, causing the audibility problems. However, it would considerably more effect the data transmission, producing transmission errors.

СРЦЕ system is equipped with two central clock generator (ЦГТ), operating generator and the one synchronized with the operating one, in regular operation. Operating ЦГТ may operate in plesiochronous mode, not quite recommended for the reasons above, or in a clock reception mode, either from another exchange (slave mode), or from a high-accuracy clock terminal (cesium, rubidium) in which case other systems synchronize with the СРЦЕ system (master mode).

Administrative functions within СРЦЕ perform view of synchronization state, first of all for central clock generators. Also, it is possible to switch the operating ЦГТ or to check and change the operation mode. In case of synchronization with another exchange, the links ("reference directions") used and their priorities may also be defined. For example, had a failure occurred in the highest priority reference direction, system automatically takes the reference direction of the subsequent one, with a lower priority. Had all reference directions failed, system switches to plesiochronous operation. On failure termination of any higher level reference direction, at any moment, systems gets synchronized to such (restored) reference direction.

5.2.5.6 System section directing

Basic system organization may be generally represented like:

- Administrative computer
- Dual central processors
- Regional processors
- Periphery

In the same general and imprecise manner, each item of the above list directs the one preceding. Operator computers are no parts of system but terminals controlling the system and directing its operation.

Directing facilities depend on the corresponding processor type and peripheries. More significant facilities are:

- Loading of any system processor (reset and repeated sending of program and relevant data)
- Selection of the operating processor in charge
- Read out of processor load, in percents
- Processor state read out
- Setting the activity performed on specified alarm types' activation on E1 (ITU-T G.703) interfaces (AIS, LOS, BER, etc). Setting may be different for each E1 system interface
- E1 links executing into digital loops, to the outside and the inside
- Subscriber card administration

Note that the system directing and administration facilities depend on system configuration and the electronic equipment version implemented in the system.

5.3 System functions

System functions are performed by the system, independently and solely. Some of those may be controlled by corresponding administrative functions, but most of them are autonomous functions, directing system operation.

System functions are specially designed for each system. Unlikely, telephone functions are mostly, sometimes very precisely, regulated within international standards and recommendations. This is partially done for administrative functions, remaining similar for all systems, especially those related to subscribers, trunks and other systems in relation to telephone functions. System functions for two different systems resemble each other only by chance.

Therefore, the one being familiar with other system features may recognize the similarity between СРЦЕ system functions and those of other switching systems or distributed systems with real time program control. But this is only similarity, not the equality.

5.3.1 Loading, back up, restart

These functions are primarily reserved for system recovery in case of irregularity conditions. That includes system booting performed on irregularity conditions (e.g., power dump), which is practically the same as the initial system booting when first put into service.

Operator is given access to these functions over corresponding administrative functions, but the system itself may perform it solely.

5.3.1.1 Loading

СРЦЕ switching system is loaded with programs. Each СРЦЕ processor is provided with its own program, stored at the administrative computer (AP). Additionally, СРЦЕ system is highly configurable, introducing a considerable amount of complex data, defining the system operation. All of these data are kept in system data base, some referring to system as a whole, some to a particular part of it.

Processor is loaded with a particular executing program and immediately after, operation relevant data. Prior to loading, it is checked whether the program to be loaded is identical to previous one (by means of check sum and length) and is loaded only if it appears to be a different one. Had the program proved to be identical to previous one, execution of the latter is started.

The loading "execution chain" functions in the following manner:

1. AP is loaded from data base back up. Loaded program may be modified only using corresponding administrative functions

2. Central processor (CP) loads AP with related contents of data base (most of data base tables), program for CP itself and programs for regional processors (RP).

3. CP loads programs for RPs (over communication processors, KOПs) and, after loading is completed, gathers administrative data in the format required. That means that RPs are not loaded with direct data base contents, but only with the previously processed parts.

Loading is performed after processor failure, detected on communication termination or on the operator command.

In order to detect possible communication termination in the loading execution chain, each parent one polls its subordinate one - AP polls CPs, CP polls RPs (over KOПs). Failure may be caused by program support operation irregularity, causing its termination. Operator switches off the power for testing or maintenance reasons, or the equipment failure. In case of the equipment failure, repeated loading probably won't work. System may perform several continuous attempts of loading before giving it up (processor brought into "reset" condition). Another loading must be ordered by the operator or is performed at the time all processors in this (reset) condition are loaded, periodically, for each processor separately.

As for dual processors (preferably CPs and certain RPs), loading of the operative processor causes the automatic CP swap, meaning that the back up processor gets to be the operative one (receiving related necessary dynamic data). If the back up processor is not capable of taking up the function of the operative one, the loaded processor, after loading complete and administrative data received, is taken for the operative one.

Special case of loading is the entire system booting, mainly caused by power dump conditions. It is special for subscriber but, as for the system, procedure is the same as in any other situation. With everything performed well, following occurs:

1. AP is loaded from the recent regular back up

2. AP loads CPs and defines CP1 as the operative one

3. CP1 is started and is now loading all its RPs

4. AP synchronizes CP2, introducing it into back up state

5.3.1.2 Back up

System СРЦЕ performs data base back up. This includes disk recording at the administrative computer (AP). AP data base is synchronized, with CP contents. AP also has some additional tables in data base, excluding those contained at CP. All those tables are recorded in data base back up.

As a rule, back up is performed automatically, in specified periods (preferably, each two hours). Operator may also restrict automatic back up.

Back up may be performed on operator command as well.

СРЦЕ has a definite number of back-ups saved. The number is exchange adjustable. On new back up made, the recent one shall be overwritten. Certain back-ups may be protected from erasure ("marked") - remaining for the operator later use as once checked and approved back up. Operator may attach a description to such a back up, for later identification (and this is mostly done for marked back-ups).

Back-ups, containing data base contents, are used for AP and CP loading. As a rule, AP and CP are loaded with the recent back up, but the operator may direct loading with a specified back up. This may be indirectly performed - deleting all subsequent back-ups or directly - using corresponding administrative functions for CP controlling.

5.3.1.3 Restart

Within СРЦЕ, central processor is executing system restart and the rest of the system only experiences restart results.

Restart may be: minor or major. They are mostly identical, except for the fact that connections in conversation (connection established) state, during minor restart, are kept and during the major one, all connections are cleared.

Restart is performed after a considerable irregularity appeared during the operation, that may not be ignored (and is followed with the warning alarms), nor processed correctly (each hardware failure must be correctly processed). Almost every restart results from software irregularity and represents specific protection from an occurrence of critical operation errors (most evident are those relating to charging, but there may be some others as well) or software operation interruption when used to avoid system reload.

Most error conditions require minor restart, while the major one is performed when it comes to need a little after the minor restart is performed. More serious failures imply immediate major restart.

Operator may also specify both restart types, when the estimation is made on system not operating properly, unable to detect the problem either.

During restart, CP synchronizes all data, both in data base and own processing data. System is informed of synchronization results. As far as it concerns call processing, call states are compared within system as a whole (including RPs) during minor restart. Had the states synchronized, calls are kept, if not, calls are cleared. During major restart, CP clears all connections. All cleared connections are regularly charged.

5.3.2 Data storing

СРЦЕ stores following data:

1. Data base back up

2. System operation log
3. Charged calls
4. Statistic data

In a certain degree, programs for processors contained in СРЦЕ switching system may be understood as data, but are not included in the list above for being quite specific. Anyhow, these data are stored as well.

5.3.2.1 Storing - location and procedure

All data are stored in administrative computer, basically intended for such purposes.

All data are kept on dual magnetic carrier, prevented from data loss in case of a single carrier failure.

Carrier capacity is sufficient for all necessary data stored, of all types. This especially depends on data type.

All data may be read out from administrative computers and stored to any available carrier for archiving (tapes, optic disks, spare magnetic carriers).

5.3.2.2 Data base back up

System stores up to a hundred (100) data base back-ups. One back up stores complete data base contents and, if needed, some of its parts.

New data base back up clears the oldest stored one. Every single back up may be protected from clearing. It makes no sense, however, to protect all back-ups, for this would prevent creation of new ones.

5.3.2.3 System operation log

All events relevant for system operation are recorded in system log. These are all operator commands, detected alarms and automatic system actions.

System capacity covers at least 30 days of operation.

System log allows no modifications, unless performed using operator commands for new system log entry. This excludes the possibility of clearing any system log entry. System clears the oldest entries at the time the new ones should be entered.

5.3.2.4 Charged conversation

System capacity is sufficient to cover, at least, one month entries of charged conversations.

Charged conversations' entries cannot be modified otherwise but adding a new call entry, charged and recorded. Charged call entries cannot be erased on command. System clears the oldest entries at the time the new ones should be entered.

5.3.2.5 Statistic data

No special mechanism is needed for statistic data operating. There will be as much entries as the place available on the administrative computer. Statistics function is considered less important than the basic ones and is therefore provided with any space left after all other data entered.

As a rule, system may record at least one hour of statistic data entries. Most frequently, it may record up to several days of statistic data entries.

Newly entered statistic data do not imply any clearing of the old ones. These are not recorded before the operator is informed of it. This leaves time for their clearing. The operator may record some old entries to an auxiliary data carrier, if needed, before clearing from the administrative computer.

5.3.2.6 System processor programs

System processor programs are also stored. Programs may be modified solely using a special procedure, ”Operating software modification”.

System provides sufficient space for all needed programs to be stored (note that the programs do not take much space and are not great in number).

5.3.3 Synchronization

СРЦЕ synchronization equipment features are:

- in autonomous operation, initial clock generator frequency deviation is not exceeding $5*10^{-10}$
- clock generator stability is equal to $2*10^{-10}$ daily.

Digital switching system СРЦЕ may take over an external source clock and synchronize it, following hierarchical control synchronization method.

When operating in clock generator controlled mode, СРЦЕ system may take over an external synchronization using:

- two (2) inlets for signal reception from an external clock signal generator, of 2048 MHz frequency
- five (5) inlets for incoming clock signal reception, of 2048 Mbit/s
- one (1) inlet for analog signal reception on a ITU-T G.811 recommendation frequency (1MHz, 5MHz, 10MHz).

Operator may use operator computer to define inlet priorities in regards as to the external synchronization Based on results verifying clock signal quality and regularity and according to priorities assigned, system automatically selects a synchronization inlet. An inlet may be selected manually, executing an operator command. In case of clock signal loss or irregularity detection along selected external synchronization inlet, system automatically selects the next regular inlet according to defined priority order.

In case there is no regular clock signal at any external synchronization inlet, system automatically switches to autonomous operation.

While operating in control clock generator mode, СРЦЕ system may generate and send 2048 MHz frequency clock along 4 inlets.

СРЦЕ is equipped with two reference clock generators with previously described features. These clock generators are mutually synchronized and may also be doubled.

System provides precise synchronization of switching systems, network devices and terminal user equipment in PDH and SDH network, exclusively in the *slave* mode.

The system may take over any synchronization from each specified source, at any level.

Relative time interval error (TIE) at A interface corresponds to one defined in ITU-T Q.541, 3.4.

5.3.4 On-line diagnostics

During its operation, СРЦЕ system performs diagnostics treating all its important sectors that support such diagnostics, within tolerated limits, with no effects as to the basic system functions (primarily telephone functions).

Diagnostic routines detect possible failures. Depending on cause of failure, alarm is reported and possibly a certain automatic action is performed in order to remove failure conditions. In addition, diagnostic routines detect failure termination, whether caused by an automatic system reaction or an operator intervention, executed after the alarm was reported. On failure termination detected, corresponding alarm is canceled.

As for dual processors, the operative processor is the only one to perform diagnostics and report alarms. Still, there are some resources uncommon for both processors but important for back up processor operation and these are diagnosed and alarms are reported even for a back up processor. Note that there is few such resources.

Previously described diagnostic pattern is the one used while loading. When polling, parent processor detects whether a subordinate one is in operation or not. This part of diagnostics is quite important for system functioning and is therefore described along with one of most important system function, loading.

Diagnostic may be performed in many other ways, mostly by certain processors and over its controlled resources. To avoid detail system architecture survey, only more important, system independent diagnostics, shall be described (besides the one already mentioned) and, where necessary, processors in charge shall be defined. Although, being familiar with СРЦЕ system architecture, it's no hard to conclude as to the processor in charge for diagnostic executing, based on resource information.

5.3.4.1 E1 interface diagnostic

E1 interfaces are designed to connect digital, two-megabit PCM links (according to ITU-T G.703), used for exchange connections. E1 interface diagnostics detects corresponding alarms, defined in recommendations. These are:

- LOS - signal loss
- AIS - alarm indication signal (all units)
- FAS - RAM synchronization loss (frame)
- BA - other side remote alarm
- AIS16 - alarm indication signal along 16th channel
- BER - bit error rate
- CRCMF - CRC multi-frame bit error rate
- MF - multi-frame synchronization loss
- CRC - CRC bit error rate
- BCRC - CRC bit error rate received from the other side
- BMF - multi-frame synchronization loss remote alarm from the other side
- SLIP - RAM loss

E1 interface alarms form certain hierarchy and not all may be reported at the same time (higher level alarm excludes the lower level alarm) and are mutually excluding. Hierarchy pattern is shown in figure 5.6.

5.3.4.2 System clock diagnostic

One digital system requires a clock, and preferable a stable one. The clock should be synchronized for the whole network, as it was described in the section relating to synchronization function description.

СРЦЕ functions in the way that the clock is distributed from central clock generators to all system processors requiring it (these are all regional processors). Two signals are

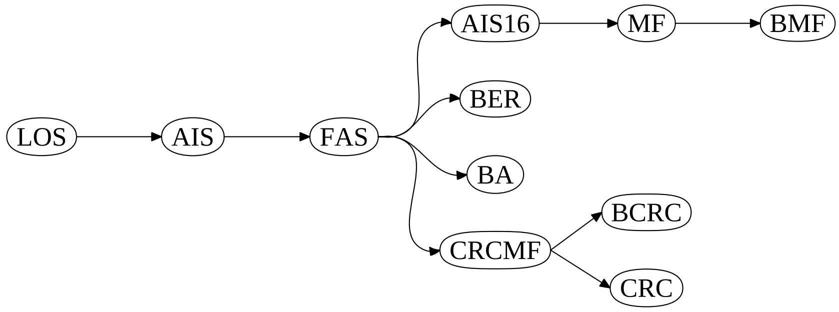


Figure 5.6: E1 link alarm hierarchy

distributed together - clock and synchro signal. Diagnostics are performed for both at the time.

Being familiar with the clock (and synchro signal) frequency distributed along the system, each RP is provided with own diagnostics unit detecting the clock presence and whether it is within specified variance limits. In case of the clock not being present or varying considerably, an error is detected.

Each RP separately reports corresponding alarm (and its termination).

5.3.4.3 System interconnection diagnostics

СРЦЕ system parts are connected by means of the interconnections, presenting 16-Mbit PCM links. Speech and data transmission is conveyed along corresponding (64-kbit) link channels.

Therefore a great importance lies upon system interconnections, requiring certain diagnostics. This sort of diagnostics is much simpler than E1 interface diagnostics, having quite simplified interconnection structure, unlike the E1 link complicated structure. As regarding diagnostics performed along E1 link interface, both clock diagnostics and synchro signal diagnostics may be considered the interconnection diagnostics (with no clock detected, no interconnection functions).

As a rule, interconnections are diagnosed according to certain incoming contents expected. This causes the alarms reported mainly for incoming interconnections. Each RP receiving the interconnections has its corresponding diagnostics and reports the corresponding alarm separately. In case of cable failure, both RPs (on each interconnection end) shall report interconnection failure in the incoming direction.

Certain RPs are enabled to perform interconnection signal transmitter diagnostics, when reporting interconnection failure in the outgoing direction. Such failure is rather of internal cause and has nothing to do with failure caused by contact loss.

5.3.4.4 Tone signalling receiver diagnostics on transmitters

Different trunk signalling types use different tones for signal transmission. In order to enable regular functioning of such signalling types, it is necessary to provide regular operation of corresponding receivers.

Receiver diagnostics is performed in a way that a certain receiver is seized for testing, specified tone is through-connected and is waited for a while to determine whether the receiver has recognized this very tone. Tones used in a such a case depend on specified tone signalling. It is most often sufficient to check one tone of a tone group.

Corresponding alarm is reported for each receiver failure.

Note that with detection of tone digits in СРЦЕ system performed on digital signalling processors (DSP), the alarms, as a result, shall be mainly reported in groups, since failure strikes primarily processors, followed with all processor receivers.

5.3.4.5 DTMF receiver diagnostics

In its basic terms, this diagnostic type is quite similar to tone receiver diagnostics for trunk signalling types.

Differences occur as concerning the tones used (in this case these are subscriber signalling tones) and the processor performing the diagnostics.

5.3.4.6 Subscriber card diagnostics

This issue may involve discussing the system architecture, but it is of quite general an aspect and is far from a serious architecture ”examination”. Due to its complexity, every switching system has subscriber cards. What differs in various systems is the number of subscriber interfaces included, their composing into frames and cabinets, concerned technology and etc.

In case of failure of any subscriber card, certain number of subscribers (16 in СРЦЕ system) shall not be in function.

Subscriber card failure in СРЦЕ system may be caused by:

- Card not detected (ZOVD)
- Irregular communication with card (ZINV)
- Clock loss (З2M)
- Synchro signal loss (ЗF0)
- Emergency power supply loss (З5V)

Subscriber card alarm hierarchy is shown in figure 5.7.

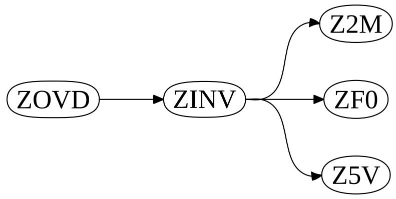


Figure 5.7: Subscriber card alarm hierarchy

5.3.5 Failure automatic reactions

Diagnostic routines detect a failure. Depending on failure type, the automatic failure recovery action may be performed.

One of these actions is described together with loading process - on parent processor detection of subordinate processor not working (responding to polling), processor loading is started. Such system reaction in failure conditions is very important for its operation and therefore described with one of most important system functions - loading.

Many other actions are possible, depending on failure conditions, and are performed by different processors, over controlled resources. Without any detail introduction of the system architecture, some more important reactions shall be described in further text (except for previously mentioned processor loading) with, where necessary, processors in charge for performing it. According to concerned resource, it is easy to conclude of the processor performing the automatic failure reaction.

5.3.5.1 E1 interface failure

For each E1 interface alarm, several different actions may be realized. Due to variety of trunk and switching systems, reaction to these failures is adjustable for each E1 interface. These are possible reactions:

- trunk blocking of the link (with no connection clearing)
- trunk locking and complete connection clearing
- AIS signal sending
- remote alarm sending (BA)
- sending the AIS16 (AIS along 16th channel)
- BMF sending (remote alarm of multi-frame synchronization loss)
- clock extraction termination (as to enable ЦГТ synchronization for specified link)

Each reaction may be selected or not. Some are mutually excluding (blocking with and without clearing, AIS and BA, AIS16, BMF), and others may be used in combination.

Only part of E1 interface alarms may be reported at the time - others are mutually excluding. Corresponding activity shall be performed for the active alarms.

5.3.5.2 System clock failure

There is no reaction to RP clock failures. RP clock failure generally causes interconnection failure, followed with the appropriate reactions.

However operative ЦГТ clock failure causes automatic CP swap.

5.3.5.3 System interconnection failure

Reaction to interconnection failure is quite simple of concept - all calls through-connected along the interconnection are cleared. Nevertheless, this might be complicated an action, for the interconnection calls may be reaching from different system locations.

Furthermore, the interconnection is blocked and cannot be used for any new call, until failure recovery is performed.

Certain activity is performed only on first reported failure of specified interconnection. Had several RPs reported the interconnection failure, no activity is done except storing it. Later on, in order to unblock the interconnection, all processors having reported its failure are obliged to report the alarm termination.

5.3.5.4 Tone signalling trunk receiver failure

Failed receiver is blocked to prevent its usage in tone recognition, until failure recovery is reported.

For the time being, it is checked for the failure termination, though within less frequent intervals than those reserved for failure detection. On failure recovery detected, receiver is brought back to regular use and corresponding alarm is canceled.

Additionally, had all DSP receivers' failure lasted for a while, DSP is loaded as well.

5.3.5.5 DTMF receiver failure

Reactions are similar to those realized for trunk signalling tone receivers, only with a different processor in charge.

5.3.5.6 Subscriber card failure

On subscriber card failure, all calls along card terminals are cleared and terminals are blocked. This action is performed only at the first failure. Any other failure is stored and no further actions are performed as to this matter.

Terminals are unblocked on failure termination.

Chapter 6

Features

СРЦЕ ТЦ-011 system version 2 is a digital telephone network intended for operation in public telephone network. It is covering all levels from terminal to transit exchange and in a latest organization, national and regional exchange networks. СРЦЕ exchange operates in remote stage configuration.

Parent exchange maximum capacity is 60.000 subscriber terminals or 32.000 trunk channels.

6.1 Capacity

System СРЦЕ is projected thus that the system's central equipment has been produced in several versions for different systems' capacities. Version of central equipment that corresponds to systems with greatest capacities are given in further text.

6.1.1 Master exchange with remote stages

If the exchange СРЦЕ is applied in version - master exchange with remote stages, there is a possibility to configure system for traffic less than 0,2E by defining interconnection between remote stage and master exchange. In this way, it is possible to increase significantly systems' capacities related to number of subscribers.

For different versions of traffic per subscriber less than 0,2E, following maximum configurations of master exchange with remote stages are possible:

Version	Subscribers	Trunks	Traffic
1	250.000	15.000	0,05
2	200.000	15.000	0,07
3	150.000	15.000	0,1
4	120.000	15.000	0,12
5	100.000	15.000	0,15

Table 6.1: Capacity of system СРЦЕ

As for the traffic from 0,2E and above, capacities of the exchange with remote stages are equal to capacities of the exchange without remote stages; they are described in the following paragraph.

The other features of the system СРЦЕ are shown in the following table:

Performance description	Value
Maximum number of remote stages on MC	unlimitied *
Operators positions	30
Traffic capacity	16.000 E
Call Handling capacity	500.000 ПУГСЧ

Table 6.2: Performances of СРЦЕ regarding capacity

* Maximum number of remote stages is theoretically unlimited, but practically limited by capacity of CP memory and physically by number of 2-megabits connectors on system's group switch stage. However, since CP memory is very large, it is possible to neglect this

restriction (it is possible to connect over million remote stages). Other restriction - 32768 / 32 = 1024 remote stages is more objective, because it is not anticipated that connection to remote stage has less than one 2-megabit connector.

6.1.2 Master exchange without remote stages

As regards the master exchange without remote stages, there is no possibility to configure the system for traffic per subscriber less than 0,2E.

Performance description	Value
Subscribers, maximum	60.000 with up to 15.000 trunks
Trunks, maximum	32.000 without subscribers
Operators positions	30
Traffic capacity	16.000 E
Call Handling capacity	500.000 ПУГСЧ

Table 6.3: Capacity of master exchange without remote stages

If it is necessary to increase the traffic per subscriber over 0,2E, following maximum configurations of the master exchange are possible:

Version	Subscribers	Trunks	Traffic
1	60.000	15.000	0,25
2	50.000	16.000	0,3
3	40.000	16.000	0,4
4	32.000	16.000	0,5
5	16.000	16.000	1,0

Table 6.4: Capacity for traffic above 0,2 E

6.1.3 Remote stage

In up-to-date telecommunication networks, capacity of remote stages decreases, because the price of electronic equipment goes down and it is obvious that it is more profitable to place small remote stage connected by optical connection than to lay copper cables up to the subscribers. In this way, length of subcriber line is shortened, as well as number of cable joints, i.e. extensions in cable network; at the same time, quality and reliability of subscribers line port, i.e. services provided to subscriber are increased.

Besides the abovementioned tendency, there is also tendency to consolidate hierarchy levels in network in order to simplify the network, and above all to decrease the price of maintenance, and to increase the reliability of network. During this process, existing exchanges with relativelly big capacities are replacing with remote stages of new exchanges. Therefore, it is necessary that the exchange has remote stages with big capacities.

Maximum capacities of remote stages in the system СРЦЕ are shown in the following table.

Performance decription	Value
Subscribers, maximum	60.000 with up to 15.000 trunks
Trunks, maximum	32.000
Operators' positions	30
Traffic capacity	16.000 E
Call handling capacity	500.000 ПУГСЧ

Table 6.5: Capacities of remote stages

6.2 Traffic performances

СРЦЕ system provides huge traffic performances, concerning both call processing and call establishment.

6.2.1 User group traffic performances

User group contains up to 1920 subscribers and is connected to group stage by 508 channel interconnection.

According to Serbia and Montenegro national regulations, interconnection capacity is taken as the worse case derived from two calculations:

Total traffic of the group with allowed loss of 0,002=0,2%.

Total group traffic increased for 25% with 0,01=1% loss.

With parameters used in calculations for interconnection capacity (large traffic - expressed in hundreds of Erlangs, great number of lines - 508 channels) the case of 25% increased traffic always appears as the worse case.

For 508 channel interconnection, provided that all channels are used in telephone traffic (without dedicating some of them for batch transmission), maximum calculated traffic for different values of the estimated overload and allowed loss is shown in table 6.6.

Loss	**Traffic overload**								
%	**0%**	**5%**	**10%**	**15%**	**20%**	**25%**	**30%**	**35%**	**40%**
0,01	438,8	417,9	398,9	381,6	365,7	351,1	337,6	325,1	313,4
0,02	443,4	422,3	403,1	385,6	369,5	354,7	341,1	328,4	316,7
0,03	446,3	425,0	405,7	388,1	371,9	357,0	343,3	330,6	318,8
0,05	450,1	428,7	409,2	391,4	375,1	360,1	346,2	333,4	321,5
0,1	455,8	434,0	414,3	396,3	379,8	364,6	350,6	337,6	325,5
0,2	462,2	440,2	420,1	401,9	385,1	369,7	355,5	342,3	330,1
0,3	466,4	444,2	424,0	405,5	388,6	373,1	358,7	345,4	333,1
0,5	472,3	449,8	429,3	410,7	393,6	377,8	363,3	349,8	337,3
1	481,9	458,9	438,1	419,0	401,6	**385,5**	370,7	356,9	344,2
2	494,4	470,9	449,5	429,9	412,0	395,5	380,3	366,2	353,2
3	504,0	480,0	458,2	438,3	420,0	403,2	387,7	373,3	360,0

Table 6.6: User group traffic performances

Shaded values in the table are those generated when using parameters defined for national network. Worse case is printed bold.

Average traffic per subscriber, for 1920 subscribers in one group, is a result of dividing the total traffic by the number of subscribers in a group. Maximum

traffic by subscriber for cases relating to the previous table is shown in table 6.7.

Loss	Traffic overload								
%	**0%**	**5%**	**10%**	**15%**	**20%**	**25%**	**30%**	**35%**	**40%**
0,01	0,229	0,218	0,208	0,199	0,190	0,183	0,176	0,169	0,163
0,02	0,231	0,220	0,210	0,201	0,192	0,185	0,178	0,171	0,165
0,03	0,232	0,221	0,211	0,202	0,194	0,186	0,179	0,172	0,166
0,05	0,234	0,223	0,213	0,204	0,195	0,188	0,180	0,174	0,167
0,1	0,237	0,226	0,216	0,206	0,198	0,190	0,183	0,176	0,170
0,2	0,241	0,229	0,219	0,209	0,201	0,193	0,185	0,178	0,172
0,3	0,243	0,231	0,221	0,211	0,202	0,194	0,187	0,180	0,173
0,5	0,246	0,234	0,224	0,214	0,205	0,197	0,189	0,182	0,176
1	0,251	0,239	0,228	0,218	0,209	**0,201**	0,193	0,186	0,179
2	0,258	0,245	0,234	0,224	0,215	0,206	0,198	0,191	0,184
3	0,263	0,250	0,239	0,228	0,219	0,210	0,202	0,194	0,188

Table 6.7: Traffic per user group subscriber

Shaded values in the table above are those generated when using parameters defined for national network. Worse case is printed bold and is equal to 0,201E per subscriber.

This is why СРЦЕ system declares the traffic capacity of 0,2E per subscriber in standard variant.

Had the traffic exceeding 0,2E per subscriber being required, the number of subscribers in group is decreased. This is performed in steps of 240 subscribers, discarding the user frames. Traffic that may be realized for different cases of frame number, thereby, the total number of subscribers in a group, is demonstrated in table 6.8.

First row in the table shows the traffic in case of user group full capacity. Last three columns provide traffic results for characteristic traffic per subscriber values in full configuration. For the case of two user frames, traffic may be 1E per subscriber, therefore, there is no need to discuss any loss or traffic overload conditions.

6.2.2 Trunk part traffic performances

Trunks in СРЦЕ system are directly connected to group stage, each occupying one connecting point of the group stage. Such solution provides traffic per trunk equal to 1E. Traffic per trunk is not analyzed further, for no less traffic or loss are expected.

Subscribers	Frames	Traffic increasing factor	Example 1	Example 2	Example 3
1920	8		0,2E	0,25E	0,16E
1680	7	1,14	0,228	0,285	0,182
1440	6	1,33	0,266	0,333	0,213
1200	5	1,6	0,32	0,4	0,256
960	4	2	0,4	0,5	0,32
720	3	2,66	0,533	0,666	0,426
480	2	5 (up to 1 E)	1	1	1

Table 6.8: Traffic exceeding 0,2E per subscriber

6.2.3 Group stage traffic performances

Group stage is selected in relation to the exchange size. All group stages are non-blocking. Maximum traffic that may be in service for a group stage is equal to the half of the number of connecting points available on a group stage, since one connection is occupying two connecting points.

No.	Label	Points (channels)	Port channels	Traffic	Relating ПГСЧ
1	ГП4О	4.096	3.556	1.778	106.680
2	ГП8О	8.192	7.620	3.810	228.600
3	ГПЦО	12.288	11.176	5.588	335.280
4	ГПФО	16.384	15.240	7.620	457.200
5	ГПЕО	32.768	30.988	15.494	929.640

Table 6.9: Group stage traffic performances

No loss is considered for group stage traffic as well. Relating number of calls in the main traffic hour is presented for the average time of conversation - 1 minute (60 seconds), which is a very strict condition.

6.2.4 Central processor traffic performances

Central processors participate in traffic as relating to call processing (call establishment and clearing). Processing abilities are expressed with the number of calls in the main traffic hour. Same as the group stage, central processors are selected in relation to the exchange size. Each central processor is given a declared processing capacity, shown in table 6.10.

Seq. number	Central processor	Call processing capacity	Relating traffic
1	ЦП1	120.000 ПГСЧ	2.000
2	ЦП2	250.000 ПГСЧ	4.166
3	ЦП3	400.000 ПГСЧ	6.666
4	ЦП4	500.000 ПГСЧ	8.333
5	ЦП5	1.000.000 ПГСЧ	16.666

Table 6.10: Central processor processing capacity

Declared processing capacity of central processors is calculated with 40% of traffic overload.

6.2.5 Subscriber device traffic performances

Subscriber devices are stored on user group level and are dimensioned to entirely serve the user group traffic. Subscriber devices are:

- DTMF receivers
- Tone generator
- Ring signal generators
- Calling party ID transmitters
- Conference call establishing equipment

6.2.6 Trunk device traffic performances

Trunk devices are stored on trunk card level (120 or 240 channels) and are dimensioned to serve the traffic of corresponding trunk channels, with the maximum traffic (1E). Trunk devices are:

- Tone receivers (R2, R1 and others)
- Tone generators

- CCS signaling controllers
- Calling party ID (AOH) transmitters

6.3 Functional features

6.3.1 Features of telephone functions

6.3.1.1 Numbering, discrimation and identification

Features of numbering and related notions are given in the table 6.11.

Numbering	
Length of subscriber number	8 digits
Length of network group code	4 digits
discrimination	
Discrimation	255
Discrimination prefix	1000
Digits in discrimation prefix	6
Identification	
Maximal length of the prefix of unavailable A number	11

Table 6.11: Numbering features

6.3.1.2 Routing

Features of traffic routing are given in the table 6.12.

Analysis of dialed number	
Maximal length of dialed number	22 digits
Records for B-number analysis	2000
Trees for B-number analysis	255
Digits for attaching during routing	6
Routes	
Length of premarking prefix	6
Maximum routes	255
Route mark	8 characters
Maximum alternative routes	1000
Maximum route cases	255
Maximum PBX series	255
Maximum signal channels SS7	1000
Routing in signal routes	4000

Table 6.12: Routing features

6.3.1.3 Additional services

Features of additional services are given in the table 6.13.

Code length	4 digits
Length of abbreviated number	2 digits
Total abbreviated numbers	1000
Total numbers for rerouting	1000
Total numbers for connections without dialing	1000
Total last dialed numbers	1000
Total codes	1000
Total rerouting to busy	100
Bi-directional connections	100
Total multiple subscriber numbers	100

Table 6.13: Features of additional services

6.3.1.4 Charging

Charging features are given in the table 6.14.

Types of charging	100
Length of charged identifier	8
Charging categories	10
Charging origins	100
Charging destinations	100
Charging cases	100
Time category of the day within a year	20
Time category of the day within a week	10
Time category of the interval within a day	10
Time category of the interval within a week	20
Time category of the interval within a year	20
Charging connections	1000

Table 6.14: Charging features

Unlike some other systems, in the system СРЦЕ doesn't exist special charging clock. Charging calculation is made on the basis of system time. System time clock works according to system central clock, which is extremely punctual and stable.

6.3.2 Administrative functions

Majority administrative functions don't have special features, i.e. values. Therefore, in this paragraph are given features related to those administrative functions, or groups of administrative functions, that have defined, so-called limits in the system.

6.3.2.1 Supervision, tracing and control

Features of supervision, tracing and control are given in the table 6.15.

Features	Value
Simultaneous supervision of EOS	10
Operators' computers	255
Alarm panels	20
Operators' group	20
Call tracing	10
Traced cases	10
Incoming connection points under control	10000
Outgoing connection points under control	10000
Simultaneously supervised SS7 points	100
Simultaneosly supervised SPC	10
Simultaneously supervised SS7 channels	100

Table 6.15: Features of supervision, tracing and control

6.3.2.2 Measuring and statistics

Features of supervision, tracing and control are given in the table 6.16.

Features	Value
Maximum lentgh of call "history"	150 octets
Maximum statistical cases in the system	100
Maximum statistical cases for a call	10

Table 6.16: Features of measuring and statistics

6.3.3 System functions

System functions include function of controlling system working frequency i.e synchronization working frequency with reference frequency from defined source.

6.3.3.1 Start and system protection

- Maximum backups: 100
- Times of automatic backups: 100
- Active alarms: 1000
- Defined restarts times: 10
- Total duration of central processor restart (with consequences): 10 seconds
- Duration of administrative computer restart: 4 seconds

6.3.3.2 System data

Maximum regional processors in the system: 1000.

6.3.3.3 Working frequency and synchronization

Features of system working frequency and synchronization are given in the table 6.17.

Features	Value
Synchronization type	Master-slave
Possibility to synchronize with master exchange	from 20 directions
Nominal frequency of the local oscillator	8192 MHz
Frequency stability:	
code	0 °C up to +40 °C
code	5 V ± 0.25 V
Absolute accuracy of the internal oscillator	$2x10^{-10}$ (without adjustment).
Thermal frequency stability	10^{-10}
Voltage frequency stability	$0.25x10^{-1}$
Annual frequency stability (ageing)	$5x10^{-8}$
Synchronization	ITU-T G.823 и Q.541

Table 6.17: Features of synchronization working frequency

6.4 Subscriber Interfaces

In the system СРЦЕ there are:

- Analog direct interface
- Analog interface with charging counter on the subscriber side
- Analog, double interface
- Digital interface with based access
- Digital interface for data transmission

6.4.1 Analog direct interface

A type of matching circuit for analog direct interface is called **Z-interface**. Characteristics of Z-interface are given in further text.

6.4.1.1 Line feed

The line is fed with direct voltage 48 V, through AC bridge 2*400 Ω.

Minimum current in subscriber loop is 15 mA, and maximum , when wires are short circuited, 60 mA.

6.4.1.2 Line resistance

Resistance of subscriber loop, minimum	0 Ω
Resistance of subscriber loop, maximum	1500 Ω
Resistance of subscriber loop, with telephone	1800 Ω
Isolation resistance between wires *a* and *б*	> 20 KΩ
Isolation resistance wires to ground	> 20 KΩ

Table 6.18: Subscriber line resistance

6.4.1.3 Impedance

Impedance is real, the nominal value is from 600 Ω to 900 Ω, or complex and real part is from 600 Ω to 900 Ω.

Reflected attenuation corresponds to ITU-T Q.552 §2.1.1.2.

Minimum asymmetry toward the ground in the range from 300-600 Hz is 40 dB and in the range from 600-3400 Hz is 46 dB (according to ITU-T Q.552 §2.1.2.).

6.4.1.4 Nominal levels

For all types of connections (internal, local, national and international) incoming relative level is in range from 0 dBr to 2 dBr (ITU-T Q552.§2.2.4.1.1. and ITU-T G.121, Annex C).

For international connection, outgoing relative level is in the range from 5 dBr to - 8 dBr (according to ITU-T Q.552 §2.2.4.1.2.).

For local and international connection, outgoing relative level is in the range from 0 dBr to - 8 dBr (according to ITU-T Q.552 §2.2.4.1.3.).

Difference between actual and nominal relative level is in accordance to ITU-T Q.552 §2.2.4.2.:

- incoming relative level L_i=–0.3 dBr ÷ +0.7 dBr
- outgoing relative level L_o=–0.7 dBr ÷ +0.3 dBr

6.4.1.5 Characteristics of bidirectional connections

Nominal transmission attenuation for connection through the exchange is equal to difference between levels at input and output (according to ITU-T Q.552 §3.1.1.1.).

Difference between actual and nominal transmission attenuation for incoming or outgoing connection shall be within the limits from -0.3 dB to 0.7 dB (according to ITU-T Q.552 §3.1.1.2.).

Short-time variation of loss with time

When sine wave test signal at frequency 1020 Hz, level -10 dBm0 and admittance +2 Hz - 7 Hz (ITU-T O.6) comes to double-wire analog interface of any incoming connection, or digitally sine wave signal of the same characteristics comes to the exchange test point T_i of any outgoing connection, the level at corresponding exchange test point T_o and level in double-wire analog interface should not relatively vary more than ±0,2 dB during any 10-minutes interval of standard operation under stable conditions related to permitted conversion of the power supply voltage and temperature (according to ITU-T Q.552. §3.1.1.3.).

Variation of gain with input level

When sine wave test signal at frequency 1020 Hz, level between -55 dBm0 and +3 dBm0 comes to double-wire analog interface of any incoming connection, or digitally simulated sine wave signal of the same characteristic comes to the exchange test point T_i of any outgoing connestion, the gain variation of that connection regarding gain at input level -10 dBm0 is in accordance to ITU-T Q.552 §3.1.1.4.

Loss distortion with frequency

The loss distortion with frequency of an incoming connection during use of test signal with input level of -10 dBm0 is in accordance with ITU-T Q.552 §3.1.1.5.

The loss distortion with frequency of an outgoing connection during use of test signal with level of -10 dBm0 is in accordance with ITU-T Q.552 §3.1.1.5.

Group delay

Group delay is time of propagation between two defined position of a certain point of the envelope of two sine wave at close frequences.

Absolute group delay is minimum group delay measured in the frequency band 500Hz - 2800Hz. Absolute group delay depend on the type of connection and exchange architecture and it is in accordance with ITU-T Q.551 §3.3.1.

Taking as reference minimum group delay in frequency band from 500 Hz to 2500 Hz of the input level of -10 dBm0, group delay distortion of the outgoing and incoming connection is in accordance with Q.552 §3.1.2.2.

Single frequency noise

Single frequency noise (particularly frequences 8000 Hz and its multiples) measured selectively at the interface of an outgoing connection shall not exceed -50 dBm0 (ITU-T Q.552 §3.1.3.).

In frequency band from 300 Hz to 3400 Hz, the level of any frequency measured selectively and corrected by psophometric weighting factor shall not exceed -73 dBm0 (ITU-T Q.552 §3.1.3.). Psophometric weighting factors are given in ITU-T O.41 §3.5.

6.4.1.6 Crosstalk

The following test signals are used for crosstalk measurements (in accordance with ITU-T Q.552 §3.1.4.):

- a quiet code, which represents bit sequences 0xD5 (in accordance with ITU-T Q.551 §1.2.3.1. and ITU-T G.711.3)
- low level activating signal, i.e. sine wave signal at a level in the range from -33 dBm0 to -40 dBm0

Far-end and near-end crosstalk measured with analog test signal

When sine wave test signal at frequency 1020 Hz and level -10 dBm0 comes to double-wire analog interface, level of interfering signal in any bidirection should not exceed 73 dBm0 for near-end crosstalk i.e. -70 dBm0 for far-end crosstalk (ITU-T Q.552 §3.1.4.1.).

Far-end and near-end crosstalk measured with digital test signal

When simulated sine wave test signal at level 0 dBm0 and referent frequency 1020 Hz comes to the exchange test point T_i level of referent signal in any bidirection should not exceed -70 dBm0 for near-end crosstalk, i.e. -73 dBm0 for far-end crosstalk (in accordance with ITU-T Q.552 §3.1.4.2.).

Total distortion including quantizing distortion

When sine wave test signal at referent frequency 1020 Hz comes to double-wire analog interface of incoming connection or digitally simulated sine wave signal of the same characteristic comes to the exchange test point T_i of outgoing connection, signal-to-total-distortion measured at corresponding outputs of bidirection with proper noise weighting is above the limits given in ITU-T Q.552 §3.1.5.

Signal loss out of voice band

This recommendation is applicable only to incoming connection.

When sine wave signal at the level -25 dBm0 and frequency from 4.6 kHz to 72 kHz comes to doubled-wire analog interface of incoming connection, level of signal at any frequency that appears in period of time at test point of corresponding incoming connection should be at least for 25 dB below the level of input signal (ITU-T Q.552 §3.1.6.1.).

Interfering signal out of voice band

This recommendation is applicable only to outgoing connection.

When digitally simulated wave signal at level 0 dBm0 and frequency from 300 Hz to 3400 Hz comes to the exchange test point T_i of bidirection, the level of interfering signals out of voice band measured selectively at doubled-wire analog interface of an outgoing connection should be lower than -25 dBm0 (ITU-T Q.552 §3.1.7.1.).

Interfering signals out of the voice band should not cause inadmissible influence in the equipment connected to digital exchange. Particularly, intelligible and unintelligible crosstalk in a channel connected to the exchange should not exceed the level of -65 dBm0 as a consequence of interfering signals out of voice band in bidirection connection (in accordance with ITU-T Q.552 §3.1.7.2.).

Echo and stability

Stability loss is in accordance to ITU-T Q.552 §3.1.8.1.

Transmission loss

Nominal value of transmission loss is in accordance to ITU-T Q.552 §3.3.1.:

- $NL_i = 0$ dB÷2 dB for all types of connections
- $NL_o = 5$ dB÷8 dB for international connections
- $NL_o = 0$ dB÷8 dB for local, internal and national connections

6.4.1.7 Noise

Weighted noise

The worst case of Z-interface is used for calculation of noise (according to ITU-T G.552 §3.3.2.1.).

1. Outgoing connection

   Two components of noise should be taken into consideration. First is noise arised from decoding process. This noise depends on the output relative level. Second is power supply noise, from the feeding bridge and circuit noise. This noise is independent of the output relative level. First component is limited to -70 dBm0p (according to ITU-T G.712 §9.) and second to 200 pWp (-67 dBm0p) (according to ITU-T G.123 Annex A and §3.). As for the output relative level -7,0 dBr the resulting total noise level for outgoing connection is -66,6 dBmp (according to ITU-T G.552 §3.3.2.1.1.).

2. Incoming connection

   Two components of noise should be taken into consideration at test point T_o. First is noise arised from decoding process.This noise is independent of the input relative level. Second is power supply noise, from the feeding bridge and circuit noise. It depends on input relative level. First component is limited to -67 dBm0p (according to ITU-T G.712 §9.) and second to 200 pWp (-67 dBmp) (according to ITU-T G.123 Annex A and §3.).
   The total psophometric power of weighted noise in the test point T_o for input relative level from 0 dBr is 451 pW0p (according to ITU-T G.552 §3.3.2.1.2.).

   The total level of weighted noise is -64.0 dBm0p (according to ITU-T G.552 §3.3.2.1.2.).

6.4.2 Analog interface with charging counter on the subscriber side

Signal frequency used for tariff pulse transmission is 16 kHz.

Pulse duration is 150 ms ± 10%.

The other characteristics are the same as for the analog direct interface.

6.4.3 Analog, double interface

During inactive state of line both wires are in state of high impedance.

Selection of participant is made on the basis of polarization certain wire.

The other characteristics are the same as for the analog direct interface.

6.4.4 Signalling on analog subscriber lines

6.4.4.1 Pulse dialing

6.4.4.2 Tone dialing

Tone dialing is realized in accordance to Recommendation ITU-T, Q.23. Basic feautures are given in the table 6.20.

Identification of low-resistance closed loop	9 mA
Dialing time-out	(30-60):(40-80) ms
Waiting time for answer	> 50ms
Waiting time for disconnect signal	> 300ms

Table 6.19: Features of pulse dialing

Frequency	(697-1633 Hz ± 1.8%)
Time-out	tone: > 20 ms; pause: > 40 ms
Input level	> -28 dBm

Table 6.20: Tone dialing

6.4.4.3 Subscriber tone signals

SRCE system provides selection among several tone tables for subscriber signalling.

Tone signals used in subscriber signalling for serbian (and other compatible networks) are addressed in table 6.21.

Tone signals used in subscriber signaling for Russian, Ukrainian and other compatible network (primarily the ex SSSR countries) are shown in table 6.22.

6.4.4.4 Ringing current

The are two way of sending ringing current. First is sending "ordinary" ringing current, and second is sending ringing current according to special program. The way of sending ringing current according to special program in the system СРЦЕ is called "expressive ringing". As for the "expressive ringing", operator can program cadence for ringing current related to the duration signal/pause. The other parameters of call signal are equal for "ordinary" and for "expressive" ringing:

- Frequency of call signal 25 Hz 5Hz
- Level of call cignal 80 to 90 Veff
- Bridge for connecting ringing current 100 Ω in b wire, 1K in a wire

6.4.4.5 Expressive ringing

System СРЦЕ supports 16 types of ringing.

Every type has from one to 4 pairs "pulse-pause". Defined pairs applies one by one, than from the beginning, "in circles".

Tone type	Frequency (Hz)	Level (dBm) од	до	Pulse (msec)	Pause (msec)
Dialing tone	425 ± 15 425 ± 15	-12 -12	-8 -8	200 ± 10% 700 ± 10%	300 ± 10% 800 ± 10%
Special dial tone	425 ± 15	-12	-8	400 ± 10%	40 ± 10%
Ring-back tone	425 ± 15	-12	-8	1000 ± 10%	4000 ± 10%
Busy tone	425 ± 15	-12	-8	500 ± 10%	500 ± 10%
Blocking tone	425 ± 15	-12	-8	200 ± 10%	200 ± 10%
Special information tone	950 ± 50 1400 ± 50 1800 ± 50	-20 -20 -20	-16 -16 -16	330 ± 70% 330 ± 70% 330 ± 70%	0 - 30 0 - 30 1000 ± 25%
Trunk offering	425 ± 15	-20	-16	200 ± 10% 700 ± 10%	300 ± 10% 800 ± 10%
Call waiting	425 ± 15	-20	-16	300 ± 10%	8000 - 10000
Charge tone	425 ± 15	-20	-16	500 ± 10%	10000 - 15000 *
Acknowledgement tone	425 ± 15	-12	- 8	continuous tone	
Line blocking	no tone - silence				
Test tone I	300 ± 15	- 9	- 5	continuous tone	
Test tone II	1020/1140 ± 15	- 9	- 5	continuous tone	
Test tone III	1000 ± 15	- 9	- 5	continuous tone	

* - prior to the expiry of charged conversation time

Table 6.21: Subscriber tone signals for Serbian network

The shortest pulse duration is 20 milliseconds. The shortest pause duration is 20 milliseconds. The longest pulse duration is 32 seconds. The longest pause duration is 32 seconds.

The type of ringing is determined according to a type of call or additional number of the subscriber with several numbers. The types of calls that determine type of ringing:

- Local call (both subscribers are connected to the same exchange СРЦЕ)
- Incoming call (calling subscriber is outside the exchange СРЦЕ)
- Call from operator
- Call from priority subscriber
- Call inside the same remote switch stage

Tone type	Frequency (Hz)	Level (dBm)		Pulse (msec)	Pause (msec)
		from	to		
Dialing tone	425 ± 15	-12	-8	continuous tone	
Special dial tone	425 ± 15	-12	-8	400 ± 10%	40 ± 10%
Ring-back tone	425 ± 15	-12	-8	1000 ± 10%	4000 ± 10%
Busy tone	425 ± 15	-12	-8	250 ± 10%	250 ± 10%
Blocking tone	425 ± 15	-12	-8	200 ± 10%	200 ± 10%
Special information tone	950 ± 50 1400 ± 50 1800 ± 50	-12 -12 -12	-8 -8 -8	330 ± 70% 330 ± 70% 330 ± 70%	0 - 30 0 - 30 1000 ± 25%
Trunk offering	425 ± 15	-20	-16	250 ± 10% 250 ± 10%	250 ± 10% 1250 ± 10%
Call waiting	425 ± 15	-20	-16	200 ± 10%	4000 - 5000
Charge tone	425 ± 15	-20	-16	500 ± 10%	10000 - 15000 *
Acknowledgement tone	425 ± 15	-12	-8	continuous tone	
Line blocking	no tone - silence				
Test tone I	300 ± 15	- 9	-5	continuous tone	
Test tone II	1020/1140 ± 15	- 9	-5	continuous tone	
Test tone III	1000 ± 15	- 9	-5	continuous tone	

* - prior to the expiry of charged conversation time

Table 6.22: Subscriber tone signals for Russian, Ukraine and compatible networks

- Call transfer
- Call to leading number of MHG

If there is no special request from the customer, types of ringing in the system СРЦЕ will be programmed in the way shown in the table 6.23. Time is in milliseconds.

6.4.4.6 Sending calling number identification

Calling number identification is sent after the first interval of applying ringing every 200 msec.

6.4.5 Based ISDN connection

The line simbol rate is 80 kbauds ±5 ppm (according to ITU-T G.961, Appendix II §II.2)

Type of call	Current	Pause	Current	Pause	Current	Pause	Current	Pause
Local call	1000	4000						
Incoming call	1000	4000						
Leading number	200	400	200	2000				
Priority call	200	200	400	400	800	800		
Operator	500	200	500	1000	500	200	500	2000
Call inside the same RSS	1000	100	100	1000				
Call transfer	2000	4000						

Table 6.23: Implicits types of ringing

Line code is 2B1Q (ITU-T G.961, Appendix II §II.1)

This is 4-level code and is used without redundancy. The B- and D-channel bits are scrambled before coding. M_1 through M_6 bits of the C_L channel, are also paired, coded and scrambled in the same way. The bit stream shall be grouped into pairs of bits for conversion to quaternary simbols that are called quats. The conversion of bits in the B- and D- channel to quats is shown in the table 6.24.

First bit (sign)	Second bit (magnitude)	Quaternary symbol symbol (quat)
1	0	+3
1	1	+1
0	1	-1
0	0	-3

Table 6.24: Converting pair of bits to quaternary symbols

At the receiver, quaternary symbols are converted to a pair of bits and decrambled.

The impedance is 135 Ω symmetrical (ITU-T G.961, Appendix II §II.13.1.)

6.4.5.1 Output characteristics

Nominal peak of the signal at the connector of matching circuit is 2,5 V (ITU-T G.961, Appendix II §II.12.1.).

Signal shape is in accordance with ITU-T G.961, Appendix II §II.12.2.).

If a frame sequence at the output of matching circuit consists of frame word, when equiprobable symbols are at all other positions, than power of signal at the output should be between 13 dBm and 14 dBm in the frequency band from 0 to 80 kHz (ITU-T G.961, Appendix II §II.12.3.).

The upper bound of the power spectral density is in accordance to ITU-T G.961, Appendix II §II.12.4.

6.4.5.2 Transmitter/receiver termination

- Nominal impedance is 135 Ω (according to ITU-T G.961, Appendix II §II.13.1.).
- Minimum return losses with respect to impedance of 135 Ω in frequency band from 1 kHz to 200 kHz are in accordance to ITU-T G.961, Appendix II §II.13.2.
- The longitudinal balance is in accordance to ITU-T G.961, Appendix II §II.13.3.

6.4.5.3 Jitter

Maximum magnitude of jitter at the network output, for single jitter frequences in the range of 0,1 Hz to 20 kHz, at bit rate 80 kbaud/s ±5 ppm is in accordance to ITU-T G.961, Appendix II §II.11.

Maximum wander per day at the network output is 1.44 UIpp, where maximum rate of change of phase is 0,06 UI/houre.

Maximum magnitude of jitter at the network input at bit rate 80 kbaud/s ±5 ppm is defined in the following way:

- jitter should be equal or less than 0,04 UIpp and less than 0,01 UIr.m.s. when measured with high-pass filter having a 6 dB/octave roll-off below 80 Hz
- jitter relative to the phase of the signal at the network output shall not exceed 0,05 UIpp and 0,015 r.m.s. when measured with a band-pass filter having a 6 dB/oct per octave roll-off above 40 Hz and belowe 1 Hz.
- the maximum departure of the phase of the signal at the network input from its nominal difference (long term average) from the phase of the signal at the network output shall not exceed 0,1 UI.

6.4.5.4 Power source

Power source of NT1 and/or regenerator is optional. Power source NT1 is constant voltage source with current limitations. Maximum value of the output voltage at the connectors of matching circuit is 120 V. Current limitation is at 50 mA (according to ITU-T G.961, §8.6.). Supply voltages at the output of matching circuit are in accordance with ETSI ETR 080 §10.5.1).

6.4.5.5 Scrambling

The data stream in each direction of transmission shall be scrambled with a 23rd-order polynomial before insertion of frame word (according to ITU-T G.961, Appendix II §II.9.).

- in direction LT-NT1 polynomial is: $1 \oplus x^{-5} \oplus x^{-23}$
- in direction NT1-LT polynomial is: $1 \oplus x^{-18} \oplus x^{-23}$

$\oplus$ is module 2 summation.

6.4.5.6 Frame structure

Each frame contains 2B+D channels, frame word and inverted frame word and C_L channel, which contains M bits for maintenance. Organization of 2B+D field is shown in the following table (ITU-T G.961, Appendix II §II.3.).

Frame contains 120 quaternary symbols transmitted within nominally 1.5 ms. Frame structure is shown in the table 6.25.

Frame	FW/IFW	12x(2B+D)	C_L
Function	Synchro реч	2B+D	Overhead
Quat number	9	108	3
Quat position	1-9	10-117	118-120
Bit number	18	216	6
Bit position	1-18	19-234	235-240

Table 6.25: Frame structure of the basic rate ISDN interface

Every frame consists of 12 2B+D fields. Every 2B+D field consists of 18 bits (according to ITU-T G.961, Appendix II §II.3.1.).

6.4.5.7 Frame word

The frame word is used to allocate B, D and C_L channels. It may be also used for the baud synchronization (according to ITU-T G.961, Appendix II §II.4.).

Frame word in direction LT-NT1 is same in every frame except in the first frame of multiframe. Frame word is:

FW = +3+3-3-3-3+3-3+3+3

Frame word in the first frame of a multiframe in direction LT-NT1 is:
IFW = -3-3+3+3+3-3+3-3-3
Frame word in direction NT1-LT is the same as in direction LT-NT1.

6.4.5.8 Multiframe

To enable the allocation of the C_L channel bits over more than one frame, a multiframe is used. Multiframe start is determined by the inverted frame word (IFW). The number of frames in the multiframe is 8 (according to ITU-T G.961, Appendix II §II.6.).
Multiframe duration is 12 ms.

NT1 should synchronize its transmittion with received frames (direction LT-NT1). Transmitted frames shall be offset with respect to received frames by 60 ± 2 quaternary symbols (according to ITU-T G.961, Appendix II §II.7.).

6.4.5.9 C_L Channel

It consists of last threee quaternary symbols (6 bits) in each frame of the multiframe (according to ITU-T G.961, Appendix II §II.8.).

Bit rate of the C_L channel is 4 kbit/s (according to ITU-T G.961, Appendix II §II.8.1.).

C_L channel contains 48 bits of a multiframe and they are referred to as M-bits (according to ITU-T G.961, Appendix II §II.8.2.).

6.4.5.10 Start-up and control

In accordance to ITU-T G.961, Appendix II, §II.10.

6.4.6 Digital interfaces for data transmittion

AMI code with a 100% duty ratio is applied. The composite timing signals transmit 64 kHz bit-timing information using AMI code with 50% duty ratio and 8 kHz octet-phase information by introducing violation into the code rule.

The data pulses received from the line will be somewhat delayed in relation to the corresponding timing pulses. Received data are detected at the leading edge.

6.4.6.1 Transmitting side

Characteristics at the output ports of the interface for data transmittion are given in the table 6.26.

Parameter	Data	Clock
Pulse shape (nominally rectangular)	Picture 8, G.703	Picture 9, G.703
Pair for each direction	One symmetric pair	One symmetric pair
Test impedance	120 Ω resistive	120 Ω resistive
Nominal peak voltage of a "mark" (pulse)	1.0 V	1.0 V
Peak voltage of a "space" (no pulse)	0 V ± 0.1 V	0 V ± 0.1 V
Nominal pusle width	15.6 ms	7.8 ms
Ratio of the amplitudes of positive and negative pulses at the centre of interval	0.95 to 1.05	0.95 to 1.05
Ratio of the widths of positive and negative pulses at the nominal half amplitude	0.95 to 1.05	0.95 to 1.05
Maximum peak-to-peak jitter at the output port	In accordance to the item 2 G.823	

Table 6.26: Output ports of the interface for data transmittion

6.4.6.2 Receiving side

Digital signals at the receiving side should be as signals at the transmitting side, modified only by the characteristics of the interconnecting pairs. The attenuation of these pairs at a frequency of 32 kHz should be in the band of 0 to 3 dB. Attenuation should include the attenutation on digital distribution frame.

The return loss at the input ports should have minimal values given in sthe table 6.27.

Frequency range (kHz)		Return losses (dB)
Data signal	Composite timing signal	
1.6 to 3.2	3.2 to 6.4	12
3.2 to 64	6.4 to 128	18
64 to 96	128 to 192	14

Table 6.27: The input ports of the interface for data transmittion

The wanted signal shall be combined at the nominal impedance 120 Ω with interfering signal of the same shape as wanted signal, with bits rate inside the limits of the wanted signal, but should not be synchronous with the wanted sigal; the binary content of the interfering signal should comply to ITU-T O.152 relating to the signal-to-interference ratio of 20 dB, There shall be no errors in receiving combined signal, if attenuation of the interconnecting cable is at maximum.

The requirement relating to the return loss applies for both the data signal and composite timing signal.

6.4.6.3 Cable grounding

If the symmetrical pairs are screened, the screens should be grounded at the transmitting and receiving side.

6.5 Terminals toward telephone network

6.5.1 Digital trunk terminal

СРЦЕ system applies programmable terminals.
Bit rate: 2048 kbit/s ± 50 ppm
Line code: High density bipolar of order 3 (HDB3)
Over-voltage protection: in accordance with K.41.

6.5.1.1 Transmission side

Pulse form (nominally rectangular)	Figure 15, G.703	
Pairs	Coaxial cable	Symmetric pair
Testing impedance	75 Ω thermal	120 Ω thermal
Nominal peak-point voltage (pulse)	2,37 V	3 V
Peak-point voltage (no pulse)	0 V ± 0,237 V	0 V ± 0,3 V
Nominal pulse length	244 ns	244 ns
Amplitude ratio of positive and negative pulses at the middle of interval	0,95 to 1,05	0,95 to 1,05
Length ratio of positive and negative pulses at the nominal amplitude half	0,95 to 1,05	0,95 to 1,05
Allowed jitter from the peak to the output	In accordance with section 2, G.823	

Table 6.28: Transmission features of digital trunk terminal

6.5.1.2 Reception side

Digital signals at the reception side should be equivalents of transmission side signals, with modified connecting pairs' features. Pair attenuation conforms with $\sqrt{f}$ law. The 1024 kHz frequency attenuation is within 0 - 6 dB range. The attenuation includes the attenuation at the distribution frame.

Clock reception terminal receives a signal with the above mentioned electrical features, jitter modulated, in accordance with section 3, ITU-T G.823.

Reflection attenuation:

In combination: *useful signal of 75 Ω nominal impedance for coaxial cable or 120 Ω for symmetric pair and disturbing signal of the same form, with a bit rate in range defined for useful signal, but not synchronous with useful signal, with binary contents complying with ITU-T O.151 in signal/disturbance ratio 18 dB,* there should be no errors in combined signal reception, with maximum attenuation of connection route.

Frequency kHz	Attenuation reflection dB
51 to 102	12
102 to 2048	18
2048 to 3072	14

Table 6.29: Reflection attenuation for digital trunk terminal

6.5.2 Common channel signaling devices

6.5.2.1 No7 signaling

Terminals toward telephone network may be programmed to operate according to TUP or ISUP protocol of No7 signaling system.

СРЦЕ system supports SCCP and TCAP protocols.

Maximum signaling channels in the system	255
Maximum signaling channels on E1 multiplex	8
Maximum signaling channels on board (4 or 8 multiplex)	8
SCCP segments	1000

Table 6.30: СРЦЕ No7 signaling features

6.5.3 Channel associated signaling devices

Signaling systems using tones for data transmission, apply tone signal transmitters and receivers. In this modern era of digital telecommunications, some transmitter and receiver characteristics that were once hard to attain and maintain, are now performed easily. On the other side, some of those are still inaccessible, with all the effort of the advanced technologies.

Certain devices serving channel associated signaling, such as R2 and R1 transceivers and corresponding line sections, should satisfy relating international recommendations.

6.5.3.1 R2 transmitters and receivers

R2 transceivers in СРЦЕ system are derived in accordance with ITU-T recommendations Q.451 - Q.452.

R2 transmitter feature	Value
MFC code	2/6
Frequency forward	1380, 1500, 1620, 1740, 1860, 1980 Hz
Frequency backward	1140, 1020, 900, 780, 660, 540 Hz
Frequency deviation	$<$ 4 Hz
Transmission level (4 wired)	-11.5 dBm $\pm$ 1 dB
Transmission level (2 wired)	-8 dBm $\pm$ 1 dB
Signal frequency level difference	$<$ 1 dB
Signal frequency beginning difference	$<$ 1 msec
Signal frequency termination difference	$<$ 1 msec
Total level of distortion and intermodulation 300 - 3400 Hz	$<$ -48,5 dB
Minimum time from backward signal termination to the pulse signal beginning	100 msec
Pulse signal duration	150 $\pm$ 50 msec

Table 6.31: R2 transceiver features

Special requests were designed for receiver in order to prevent the recognition of "false" signal. Accordingly, СРЦЕ system receivers' features equal or better from those shown in table 6.33.

6.5.3.2 Line signals in R2D signaling

As for the line section of R2 signaling, nonrecognition time for switch on (0 at the channel, active channel state) or switch off signal (1 at the channel, passive channel state) is 20 $\pm$ 10 msec.

Certain line signals are introduced in table 6.34.

6.5.3.3 R1 transmitters and receivers

R1 transceiver characteristics are presented in table 6.35.

R2 receiver features	Test signal A	Test signal B
Receiver sensitivity	-20 dBm to -5 dBm	-35 dBm to -5 dBm
Reception frequency deviation	<= 5 Hz	<= 10 Hz
Response + release time	70 msec	80 msec
Allowed signal interruption	7 msec	7 msec
Signal frequency level difference	3 dB	5 dB adjacent, 7 dB nonadjacent

Table 6.32: R2 receiver features

Feature	Value
Nonrecognition level	< -42 dBm
Short signal reflection	< 7 msec (-5 dBm)
Level reflection	>= 20 dB

Table 6.33: R2 receiver nonrecognition features

6.5.4 Specific features of Serbia and Montenegro telephone network

6.5.4.1 D1 line signaling

All line signals used in D1 signaling are implemented as pulse signals. Their classification, nominal duration and tolerance are shown in the following table. For forward direction, pulse is sent by setting, after certain period of time, the af channel state from "1" to "0" and, after the time expiry, resetting the af channel state to "1". For backward direction, ab channel state is changed. In the event of pulse recognition at the reception side, tolerances applied are those shown in the table.

Address signals (digits) are received as the sequence of decadic pulses and 50 msec pause with ± 30 msec tolerance. Pause between digits, that is, between sequences of pulses is equal to 300 - 500 msec. Signals: seizure, B free, answering and operator signals (trunk offering, trunk offering termination and call back) are transmitted as short signals.

Minimum time interval between trunk offering beginning and termination and between beginning and terminating signal of call back sending is at least 240 msec.

Signals: blocking, B busy, forced release, release, clearing and called party clearing are transmitted as long signals.

Blocking signal is transmitted as a continuous signal to the unblocking signal recognition. Charging pulses are transmitted as short signals with maximum three charging pulses sent in one second.

Signal	Signal code				Remark	Signal direction
	Forward		Backward			
	af	bf	ab	bb		
Free line	1	0	1	0		both-way
Seizure	0	0	1	0		forward
Seizure acknowledgement	0	0	1	1		backward
Answering	0	0	0	1		backward
Hook on	0	0	1	1		backward
Forced release	0	0	0	0	Recognition 240-450 ms	backward
Release	1	0	0 1	1 1	Recognition time 240-450 msec	forward
Clearing	1	0	1	0		backward
Blocking	1	0	1	1	bb=1 longer than 100 msec	backward
Unblocking	1	0	1	0		backward
Trunk offering	1	0	1	1	a_f=1 pulse 150±30 ms	forward
Trunk offering terminated	1	0	1	1	a_f=1 pulse 150±30 ms	forward
Called released	0	0	0	1	a_b=0 pulse 150±30 ms	forward
Call-back	1	0	1	1	a_f=1 pulse 150±30 ms	forward
Charging pulse	0	0	1	1	a_b=1 pulse 150±30 ms	backward

Table 6.34: Line signal features

6.5.4.2 One-way decadic D2 signaling

For D2 signaling, two signaling bits are used. Decadic D2 signaling is not that often used in public telephone network, therefore relating table containing signal meaning and features is presented in separate document "СРЦЕ system terminals toward telephone network”.

Address signals are transmitted as a sequence of pulses and 50 ms pause, while the pause between sequences of pulses (digits) is exceeding 300 ms (when operating on trunk - local relation the pause is 600 - 700 ms).

Hook on signal is applied only for circuits following the charging center.

Forced release signal is applied only for circuits prior to charging center.

Operator signals are applied only for trunk-local relation.

Minimum time between signals of trunk offering and trunk offering termination is 240 ms.

R1 transmitter feature	Value
MFC code	2/6
Signal frequency	700, 900, 1100, 1300, 1500, 1700 Hz
Signal duration	45 msec ± 5 msec
Frequency deviation	< 0,25%
Transmission level	-7.3 dBm ± 0,8 dB
Signal frequency beginning difference	< 1 msec
Signal frequency termination difference	< 1 msec
Signal missing level	< -50 dB

Table 6.35: R1 transceivers

R1 receiver feature	Value
Receiver sensitivity	-17 dBm ± 1 dBm
Reception frequency deviation	<= 15 Hz
Response + release time	70 msec
Signal frequency level difference	6 dB adjacent, 7 dB and more, others
Reflection out of range	> 100 Hz
Short signal reflection	< 16 msec

Table 6.36: R1 receiver characteristics

6.5.5 Specific features for ex SSSR telephone networks

СРЦЕ system terminals toward telephone network are programmed to operate with signaling specific for telephone network of ex SSSR countries. Special devices (transmitters and receivers) are dedicated for such operation and their features are quoted in relating documents.

- Two-bit one-way CAS signaling 2BCK with R1,5 register signaling
- Both-way combined two-bit CAS signaling (BCT-R22)
- One-way one-bit CAS signaling, "Норка"
- Single frequency one-way 2600 Hz tone signaling

Signal	Nominal duration	Tolerance
Decadic pulse	50 msec	20 - 80 msec
Short pulse	150 msec	100 - 200 msec
Long pulse	600 msec	450 - 1750 msec
Uninterruptable	$>$ 1750 msec	-

Table 6.37: D1 signaling signal characteristics

6.6 Systems terminals

6.6.1 Control and Maintenance units

There are units for local and remote maintenance in the system СРЦЕ.

Type of maintenance equipment	**Connecting**
Local Operator Computers	Local Area Network, Fast Ethernet 100Mb/s, cable and port UTP (eng. *Unshielded Twisted Pair*), four-paired connection
Remote Operator Computers	Modem 56 K, data communication network
Portable Computers (eng. *laptop*)	Local Area Network, Fast Ethernet 100 Mb/s, it connects to the same port as Local Operator Computer

Table 6.38: Types of maintenance equipment

Control Object	**Description**
Manually	Supply units
Informatics	I/O operators terminals, local and remote
Graphic workstation	Linux (eng. *Linux*) and Windows 95/98/Me/NT/2000/XP
Operative adjustments	Programm
Systems adjustments	Mostly programm and by shorting plugs on boards
Operator's signalling	Sound, digital display, sense light
Operations	Handling plug-in modules: slots, connectors

Table 6.39: Control Objects

There can be 20 alarm panels in the system. It is recommended to put alarm panel in every operator's room (in case if operators are placed in several rooms).

Frequency	2048 kHz ± 50 ppm	
Pulse shape	according to the picture 20 G.703, where V corresponds to maximum peak value V_1 corresponds to minimum peak value	
Pair's type	Coaxial	Symmetrical
Test impedance	75 Ω thermal	120 Ω thermal
Maximum peak voltage (Vop)	1.5	1.9
Minimum peak voltage (Vop)	0.75	1.0
Maximum outgoing jitter	0.05 IO peak-to-peak, in band 20 Hz to 100 kHz	

Table 6.40: Synchronous signal transmission

6.6.2 Synchronization and supply units

6.6.2.1 Synchronous signal transmission

6.6.2.2 Synchronous signal reception

Digital signals on receiving side should look like signals on transmitting side, changed by the characteristcs of connecting pairs. As for the attenuation of these pairs, it is presumed that they follow the $\sqrt{f}$ rule and that attenuation on frequency 2048 kHz is in band from 0 to 6 dB (minimum values). This attenuation includes attenuation on MDF.

Connector for receiving a clock, receives signal with abovementioned electrical characteristics, modulated by appropriate jitter.

Reflected attenuation on 2048 kHz $\geq$ is 15 dB.

6.6.3 Supply

In system, there is at least 1 supply unit for central equipment, and one for every "begun" three subscribers groups, i.e. 6000 subcribers.

Every supply unit consists of four ports for copper high flexible conductors, section 10 mm^2. Two ports for positive supply termination, and two ports for negative supply termination. In that way, every supply unit has doubled supply (two pairs of conductors).

6.7 Electrical features

Connectors' electrical features are given in paragraphs related to the connectors features. In this paragraph are given others electrical features, these are electrical features of the "system".

6.7.1 Transmission features

Transmission features of the system correspond to the ITU-T Recommendations G.712, G.507 for long distance and Q.517 local connections and Q.552.

Described requirements refer to anny connection passing through the exchange including analogue inlets and outlets that should be closed by nominal impedances 600 Ω. "Connection through the exchange " is connection between incoming and outgoing trunks, that belong to the exchange; this includes cables and wires.

6.7.1.1 Connection attenuation

Attenuation on a frequency 1020 Hz and nominal impedance during any connection, passing through the exchange, doesn't exceed 7 dB (from -0,3 dB to +0,7 dB), recommendation ITU-T Q.552, article 3.1.1.2.

6.7.1.2 Non-linear distortions

Attenuation of the long distance connection, measured through the exchange (anny connection), doesn't swing more than ±0,5 dB if we change the test tone from -55 dB_{mo} and +3 dB_{mo} (Recommendation ITU-T Q.552, article 3.1.1.4).

6.7.1.3 Attenuation - frequency distortions

Complies with ITU-T Q.552, article 3.1.1.5. for long distance and local connections.

6.7.1.4 Crosstalk attenuation

Crosstalk attenuation between any two connections, going through the exchange exceeds 73 dB; this is measured on frequency 1020 Hz and corresponds to TΦK-III article 6.6.1.6. and 6.6.2.2.1.d

6.7.2 Noise

6.7.2.1 Psophometrically measured noise

Psophometrical level of noise during busy hour and for any connection, going through the exchange, measured on the main distribution frame, doesn't exceed -72 dB_m (400 pW). (ITU-T recommendation Q.507, Q 517 , G.123, section 3, Q.552, article 3.2.2.1.2., - 72 dB_{mop}.).

6.7.2.2 Noise(non-psophometrically measured)

Level of noise (non-psophometrically) during busy hour, measured in the same way as noise at the point a) doesn't exceed -40 dBm (100 000 pW), (ITU-T recommendation Q.45 article 5.1).

6.7.2.3 Empty channel noise

Level of the empty channel noise, measured psophometrically according to Q.552, is less than -62 dB_{mop}.

6.7.2.4 Impuls noise

Number of impulses, measured during five minutes, doesn't exceed 5; detection level is adjusted to -35 dB_{m0} (ITU-T recommendation Q.45 article 5.2 paragraph VI).

Noise of the only one frequency, including sampling frequency, is less than -50 dB_m (according to Q.517, Q.507 article 3.4.1.4), TΦK III article 6.6.1.2.1.e.

6.7.3 Four-lane parameters

6.7.3.1 Impedances

Nominal impedance for all analogue inlets and outlets of the exchange is 600 Ω.

6.7.3.2 Reflected attenuation

Reflected attenuation on two-wire analogue inlets and outlets is:
from 300 to 600 Hz: $>$ 17 dB
from 600 to 3400 Hz: $>$ 18 dB
Reflected attenuation on four-wire analogue inlets and outlets in the frequency band from 300 to 3400 Hz is higher than 20 dB TΦK III, article 6.6.2.1.8.6.

6.7.3.3 Assymetry

Assymetry measured on distribution frame corresponds to ITU-T Q.552 article 2.1.2., and Q.553:
from 300 to 600 Hz: $>$ 50 dB
from 600 to 3400 Hz: $>$ 54 dB
Measurements are performed according to TΦK III, article 6.6.2.1.2.

6.7.3.4 Intermodulations

As for the two signals: $f_1 = 900$ Hz and $f_2 = 1020$ Hz, level -6 dB_{m0} on any inlet, intermodulation products: $2f_1 - f_2$ or $2f_2 - f_1$ dont't exceed values -41 dB_{m0}. (ITU-T Q.507 and Q.517 article 3.5.2.).

6.7.3.5 False signals in voice band

As regards the sinusoidal signal, at the inlet with frequency band from 700 Hz to 1100 Hz (separated subharmonic frequency from 8 kHz) and level 0 dB_{m0}, at the outlet, level of the disturbing frequency, measured selectively, in the band from 300 to 3400 Hz, is less than -49 dB_{m0}. This is valid for the signal frequency at the inlet. (ITU-T Q.517, Q.507, article 3.4.1.4.).

6.7.3.6 Quantization distortion

According to Q.507 and Q.517 article 3.5. and Q.552, Q.553, article 3.1.5.

6.7.3.7 Point of overloading

Point of overloading (at 1000 Hz), expressed as relation between the coding rules (A) and the level of audio signal, is adjusted to $+3{,}14$ dBm0 (in accordance to ITU-T G.712).

6.7.4 Consumption and dissipation

Constructive unity	Consumption at 48 V
Subscriber rack	0.27 A
Common frame	0.91 A
Trunk rack	0.22 A
Group switch stage	0.6 A
Central Clock Generator	0.6 A
Total consumption	$<$ 0.2 W/subscriber (with 0.1 Erl/кор)

Table 6.41: Review of systems' elements consumption

6.7.5 Electromagnetic compatibility

Unnecessary emissions	According to YUS No.700 (VDE 0878) class B
Allowed disturbances in voltage lines	0.01- 0.1 MHz, 1.5 mV maximum 0.1 - 150 MHz, 3 mV maximum
Allowed disturbances of EM field	0.01- 0.1 MHz, 1.5 mV/cm maximum 0.1 - 1000 MHz, 3 mV/cm maximum

Table 6.42: Electromagnetic compatibility

6.8 Environmental and mechanical features

6.8.1 Environmental span

Working temperature span	0°C to 40°C
Working relative humidity	0 to 90%
Storage temperature span	-20°C to 60°C
Relative humidity during storage	0 to 95%

Table 6.43: Environmental span

6.8.2 Dimensions

Electronic boards dimensions	351 x 233.4 mm
Racks dimensions	628 x 387.5 x 254 mm
Cabinets dimensions	661 x 620 x 2150 mm
Ceiling height	2600 mm
Permissible load of floor	440 kg/m^2
Boards capacity format length height different	 16 subscribers/boards 351 x 233,4 mm (quadruple European format) 351 mm 233,4 mm (double European format) 16 types
Racks capacity width height different	 240 subscribers/rack 23 inch 233,4 internal measures 5 types
Cabinets capacity different	960 subscribers/cabinet 5 racks 3 types

Table 6.44: Mechanical dimensions

6.9 Reliability and maintenance

Failure rate, per board:	
Complete exchange	4,27 [10^{-6}/h]
Units that perform function of local connection	3,59 [10^{-6}/h]
Units that perform function of outgoing-incoming connection	1,46 [10^{-6}/h]
Units that perform function of transit connection	1,31 [10^{-6}/h]
Stock of spare boards: (7-days reserve)	
with probability of 90,0% to be violated	0,14% of total number of boards
with probability 99,0% to be violated	1,11% of total number of boards
with probability 99,9% to be violated	2,45% of total number of boards
Failure detection in doubled units	automatically
time of detection	approximately 50-200 ms
Failure detection in other units	functional
average time of detection	15 min
Method of failure correction	replace of the boards
Diagnosis	manually, semi-automatic
average time	45 min
Method of repair	replacement of elements on the board
Board testing	
Semi-automatic testers	average time 15 min
Automatic testers	average time 2,5 min

Table 6.45: Reliability and maintenance

Chapter 7

Structure

Best technical solutions are structural ones. СРЦЕ system is designed with an idea of system structure providing easy operator handling and maintenance.

Such aims are easy to understand, but very complicated in realization. Large number of system requests results in considerable system complexity. As for the СРЦЕ system, this idea was realized introducing multi-level system structure with no restrictions as to the number of structural levels, consistently and carefully performing structurally designed system.

This document describes the first level of СРЦЕ system structure - system level. Description deals with all system structure aspects, except for the first level ones. In other words, first level structure elements are in this document considered samewhat as "black boxes". Consequently, a certain kind of introduction is created in documents treating the first level structural elements. Similar procedure is further used for all system levels, to the last one.

First level structure is further discussed in relating documents. For each level structure there is a relating document containing all relevant data, considering the lower level structures as "black boxes".

7.1 Block diagram

Block diagram of the system СРЦЕ is given in the picture 7.1.

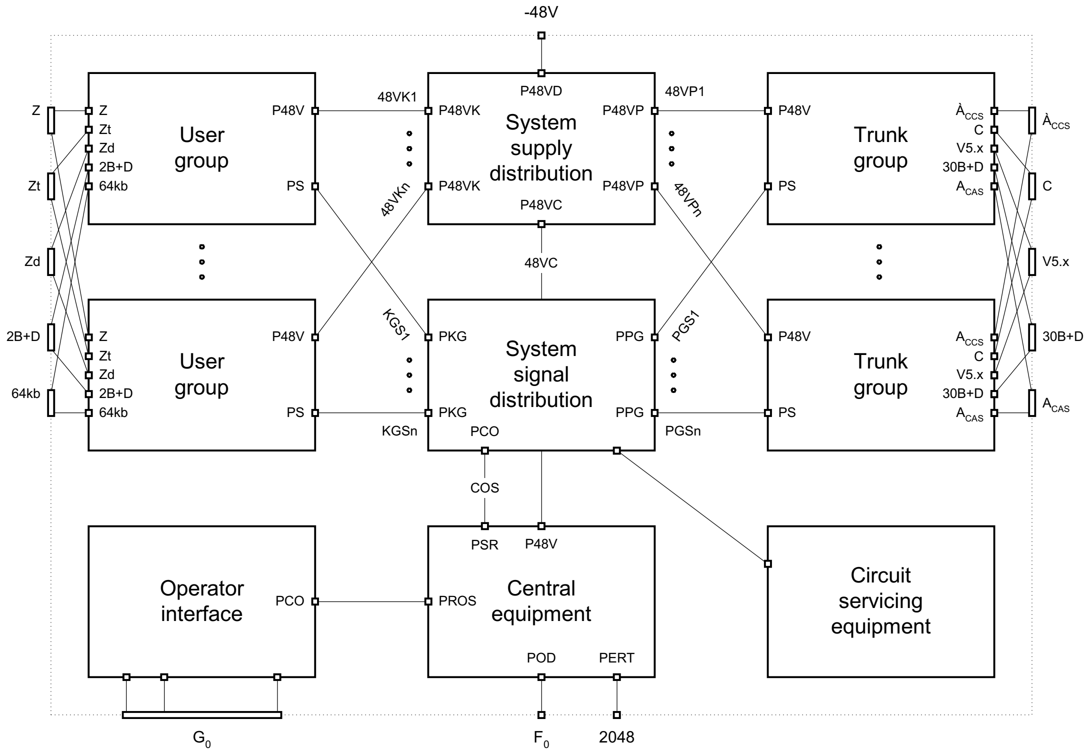


Figure 7.1: Block diagram of the switching system СРЦЕ

There are two types of subscribers groups, and they are shown in the picture with the same symbol:

- Analog subsrciber group, ГАК, for interfaces *Z, Zt, Zd* or *64kb*
- Digital (ISDN) subscriber group, ГИК, for interfaces *2B+D*

There are two types of digital trunk groups, and they are shown in the picture with the same symbol:

- Digital trunk group, ГДП, for interfaces *A* or *30B+D*
- Analog trunk group, ГАП, for interfaces *C*

Subscriber interfaces for primary ISDN access in the system СРЦЕ are realized in the trunk groups.

The following signs for connection points of the system's structural integrities are used in the picture:

Sign	Meaning
P48V	Power lead for 48 volts system's power supply. It is placed in susbcriber groups, trunk groups and central equipment.
PS	Connector for system signal distribution in subscriber groups and trunk groups.
P48VD	Power lead for 48 volts power supply.
P48VK	Power distribution lead for the subscriber group.
P48VP	Power distribution lead for the trunk group.
P48VC	Power distribution lead for the central equipment.
PKG	System signal distribution terminal for the subscriber group.
PPG	System signal distribution terminal for the trunk group.
PCO	System signal distribution terminal for the central equipment.
PSR	System signal distribution terminal on the central equipment.
PROS	Interface on the central equipment for connecting operator's coupling.
POD	Maintenance terminal.
PERT	Terminal for connecting external reference working frequency.

Other interfaces are marked according to signs which are used in ITU-T Recommendations, i.e. in a chapter related to the environment of a system:

Sign	Meaning
-48V	48 volts direct voltage for supply
Z	Standard analog telephone set
Zt	Analog telephone set with a capability to send tariff pulses
Zd	Two party analog telephone set
2B+D	Port for the based ISDN access
64kb	Terminal for data transmission at 64 Kbit/s
A_{CCS}	A interface with common channel signalling
A_{CAS}	A interface with channel associated signalling
30B+D	Interface for primary ISDN access
C	Analog trunk interface
$V_{5.x}$	V5.1 or V5.2 interfaces for connecting access networks
A_{DIS}	Interface A (2048-Kbit bidirectional multiplexed signal)
G_0	Interface for operators and maintenance staff (man-machine communication)
F_0	Interface for workstation for control and maintenance
Q_3	Interface for remote equipment for control and maintenance
2048	External reference clock

The block diagram 7.1 illustrates a way of connecting certain parts of the system. The meaning of the signs of interconnections in the picture:

Sign	Meaning
$48VK_1..48VK_n$	Connections from system power supply to subcriber groups, one for each group.
$48VP_1..48VP_n$	Connections from system power supply to trunk groups, one for each group.
48VC	Connections from system power supply to central equipment.
$KGS_1..KGS_n$	Connections of the system signal distribution and subscriber groups, one for each group.
$PGS_1..PGS_n$	Connections of the system signal distributions and trunk groups, one for each group.
COS	Connection between system signal distribution and central equipment.

Some elements od the block diagram are described further in the text.

7.2 Subcriber groups

The are two types of subcriber groups:

- Analog subscriber group, ГАК, for interfaces *Z, Zt, Zd* or *64kb*
- Digital subscriber group (ISDN), ГИК, for interfaces *2B+D*

7.2.1 Analog subscriber group, ГАК

The equipment of analog subscriber group performs conversion of signals from subscriber interfaces into a shape appropriate for processing in the system.

Subscriber group consists of matching circuit, circuit for signal conversion (for example analog-digital conversion), switching field (subscriber stage), organs, necessary for signal processing and other auxiliary peripheral organs. Also it contains its own power distribution unit and signal distribution table. Subscriber group connects to the system's central equipment by telecommunication and control connections.

Switching field in subscriber group enables cross-connecting of signals from subscribers to to appropriate auxiliary peripheral organs and vice versa - from auxiliary peripheral organs to subscribers. Line signal concentration is realized in the subscriber switch stage; it is realized at the rate of 4:1, which enables traffic up to 0,2 E per subcriber set.

Auxiliary peripheral eqipment in the subscriber group:

- Tone signal generator for signalling on analog subscriber lines
- Dual Tone Multi Frequency Receivers, DTMF receivers
- Interconnections: subcriber stage - group stage, КС-ГС
- Transmitters for calling number identification on analog line
- Equipment for line testing during every call
- Equipment for establishing conference calls
- Diagnostic and autodiagnostics units
- Ringing current generator ГСП
- Equipment for electrical measurement on subscriber lines

7.2.1.1 Subscriber group software

Subscriber group contains one common frame and up to eight subscriber frames. There is one regional processor **РПЗ**, in the common frame; in a fact, there are two, but they work in hot standby mode. РПЗ has its own software, but it also has software for auxiliary DSP for recognizing DTMF digits and for work on V.23 protocol, for sending *caller ID*). Except РПЗ, there is also a board for electrical measurements - ILC, with its own software. This software is a part of the ILC board and can not be replaced without replacement of the board itself. The regional processor **РПК** is placed in the subscriber frame. РПК performs its assignments in cooperation with its РПЗ and CP. There is no other software in the subscriber frame.

7.2.2 ISDN subscriber group, ГИК

The equipment of ISDN subscriber group performs conversion of signals from subscriber port into a shape suitable for processing in the system.

ISDN group contains matching circuits, organs necessary for signal processing and other auxiliary peripheral organs. Also, it contains its own power distribution unit and signal distribution table. ISDN group connects to the system's central equipment by telecommunication and control connections.

Switching field in ISDN group enables cross-connecting of signals from digital subscriber ports to appropriate auxiliary peripheral organs and vice versa - from auxiliary peripheral organs to digital subscriber ports. Line signal concentration toward the group stage doesn't perform in the switch stage. Every digital port is connected to the group stage by separate channel. In that way there is no limit regarding traffic per digital subscriber.

Auxiliary peripheral equipment in the ISDN group:

- Tone signal generator for signalling on digital subscriber lines
- Interconnections: subcriber stage - group stage, КС-ГС
- Diagnostic and autodiagnostics units
- Equipment for electrical measurement on digital lines

7.2.2.1 Digital (ISDN) subscriber group software

Digital (ISDN) subscriber group contains one ISDN frame **ISOK**). There are up to 15 boards with matching circuits for ISDN primary (basic) access **UPP** in the ISOK. Regional processor placed in the ISOK, is called **RPI**; it controls UPP boards. Only RPI has software.

RPI performs functions of control and management of the frame (above all the control of UPP boards) as well as of the ISDN matching circuits (by UPP). RPI carries out whole LAPD (level 2 ISDN), as well as the connection LAPD with DSS1 (level 3 ISDN), for all the ports that controls. DSS1 protocol is performed in the Central Processor.

As for the call handling, RPI performs cross-connecting (and releasing) of the connections between B-chanels of the ISDN ports and channels of interconnections toward the group stage, through its own switching field, as well as cross-connecting (and releasing) of conference calls. All these cross-connectings (and releasings) are performed at the command of the Central Processor.

7.3 Central equipment

Central equipment contains:

- Central telecommunication unit, ЦТБ
- Power distribution unit of the central cabinet
- Signal distribution table of the central cabinet
- Mechanical construction of the central cabinet

7.3.1 Central telecommunication unit, ЦТБ

Central telecommunication unit (abbrev. **ЦТБ**) performs basic function of the system - signal switching.

It contains central clock generator and group stages. Group stage is realized as non-blocking switching field with time element.

There are several types of central telecommunication units depending on the system's capacity. The review is given in the table 7.1

No	Mark	Channels	Connecting
1	ЦТБ2	4.096	16 Mb/s CMOS and RS-485 links
2	ЦТБ3	8.192	16 Mb/s CMOS and RS-485 links
3	ЦТБ4	16.384	256 Mb/s LVDS links (4)
4	ЦТБ5	32.768	256 Mb/s LVDS links (8)
5	ЦТБ6	65.536	2,5 Gb/s optical links (2)
6	ЦТБ7	131.072	2,5 Gb/s optical links (4)
7	ЦТБ8	262.144	2,5 Gb/s optical links (8)

Table 7.1: Types of ЦТБ depending on the system's capacity

7.3.1.1 Central telecommunication unit - software

Group stage contains regional processor **РПГ**. There are two РПГ that work in hot standby mode. РПГ software is at the same time the only software in the group stage.

Central clock generators have software, which is a part of ЦГТ. This software can not be replaced unless the ЦГТ itself is replaced. ЦГТ is connected to РПГ (one ЦГТ with one РПГ).

7.3.2 Central control unit, ЦУБ

Central control unit (abbrev. **ЦУБ**) controls work of all units in the system.

It consists of doubled central processors and administrative computer.

There are several types of central control units, depending on the system's capacity. They are compatible with central telecommunication units, ЦУБ2 to ЦУБ8. Some of the versions of the central control units are designed thus that satisfy the needs of the system with corresponding capacities.

7.3.2.1 Central processor - software

Central processor contains software for central processing unit (abbrev. **CPU**) and communication processors (abbrev. **КОП**).

CPU software is often called CP's software and it represents heart of the system. All important processings and decisions are performed here.

There are two sofwares for КОП in CP. These are software for КОП toward regional processor (abbrev. **КОПРП**) and software for КОП for connection to AP or OP (abbrev. **КОПЦАР**). КОПРП communicate utilizing HDLC *High level Data Link Control*) trunks. Each trunk is connected to up to 30 RP. КОПЦАР communicate utilizing HDLC connections between two КОПs.

7.3.2.2 Administrative computer software

Administrative computer contains software for administrative computer unit (abbrev. **APJ**) and for communication processors (КОП).

APJ software is often called AP software, and it is very important part of the system. APJ stores data and controls CP hot standby mode. AP contains only КОПs for connection with CPs and operator's coupling (they are completely identical), since it is not connected to РП. AP contains software only for the КОПЦАР.

7.4 Trunk groups

There are two types of trunk groups, and they are shown in the picture with the same symbol:

- Digital trunk group, ГДП, for interfaces *A* or *30B+D*
- Analog trunk group, ГАП for interfaces *C*

7.4.1 Digital trunk group, ГДП

The equipment of digital trunk group performs conversion of signals from trunk interfaces into a shape appropriate for processing in the system.

Digital trunk group contains matching circuits, circuits for demultiplexing and multiplexing digital signals, switching field (trunk switch stage), organs, necessary for signal processing and auxiliary peripheral organs. Trunk group connects to the system's central equipment by telecommunication and control connections.

Switching field in the digital trunk group is called trunk switch stage, abbreviation is trunk stage. It enables cross-connecting of signals from trunks to appropriate auxiliary peripheral organs and vice versa - from auxiliary peripheral organs to trunks. Line signal concentration toward the group stage doesn't perform in the trunk switch stage. Every trunk is connected to the group stage by separate channel. In that way there is no limit regarding traffic per trunk.

Auxiliary peripheral equipment in the digital trunk group:

- Tone signal generator for signalling on trunk lines
- Tone signal transceivers for register signalling R2 *Multi Frequency Code R2*
- Interconnections: trunk stage - group stage, ПС-ГС
- Diagnostic and autodiagnostics units

7.4.1.1 Trunk group software

Trunk group contains one trunk frame (abb. **ПРОК**). There are up to eight regional processors **РПП**in the ПРОК. They work independently, and each of them serves certain trunk interface. РПП has its own software; it also has a software for auxiliary DSP for recognizing (and sending, i.e. transmitting) tone signals of different tone signallings (R1, R2...), as well as the software for the part MTP - level 2 of the signalling system 7 (SS7) ITU-T.

For Channel associated signallings - CAS, РПП performs a function of conversion (translating) CAS signalling into internal signalling toward the central processor. Internal signalling, if necessary, can be modified when embedding new CAS signalling; in this way, translating will be as good as possible.

As for the Common Channel signallings - CCS, i.e. for the ITU-T signalling system, РПП realizes only level 2 MTP, and the rest realizes CP. In connection to this, CP performs conversion of ITU-T signalling system 7 into internal signalling, which is simpler than conversion of CAS signallings, because internal signalling is similar to SS7.

Group stage is situated in one of the trunk frames; it is completely placed on the board of the group stage regional processor **RPG**. This ПРОК is often called ГС-ПРОК. РПГs are doubled, and basically perform simple functions of cross-connecting and releasing of connections through the group stage, as well as appropriate diagnostics of the interconnection link.

There is no functional connection between РПП and РПГ, they are just mechanically in the same frame in one ПРОК (ГС-ПРОК).

7.4.2 Analog trunk group, ГАП

The equipment of analog trunk group performs conversion of signals from trunk interfaces into shape appropriate for processing in the system.

Trunk group conttains matching circuits, circuits for signal conversion (for example, analog-digital conversion), switching field (trunk switch stage), organs necessary for signalling processing and auxiliary peripheral organs. Analog trunk group connects to the system's central equipment by telecommunication and control connections.

Switching field in the analog trunk group enables cross-connecting of signals from trunks to appropriate auxiliary peripheral organs and vice versa - from auxiliary peripheral organs to trunks. Line signal concentration doesn't perform in the trunk switch stage. Each trunk is connected to the group stage by separate channel. In that way there is no limit regarding traffic per trunk.

Auxiliary peripheral equipment in the trunk group:

- Tone signal generator for signalling on trunk lines
- Tone signal transceivers for register signalling R2 *Multi Frequency Code R2*)
- Interconnections: trunk stage - group stage, ПС-ГС
- Diagnostic and autodiagnostics units

7.4.2.1 Analog trunk group software

Analog trunk group sotware is very similar to a digital trunk group software. There are differences in the parts of the software regarding processing of signals, typical for analog trunks and in controlling electronic equipment on physical level.

7.5 Operator interface

Operator interface provides an access to the system for operators and maintenance personnel to perform system handling and maintenance. In relating literature, such access is referred to as *Man Machine Language*.

The equipment for operator interface consists of computer workstation network and corresponding input-output devices. Every workstation is regularly equipped with basic input-output units: keyboard, mouse, monitor, floppy disk drive, compact disk drive. In addition, it is recommended to use an alarm panel, special output system unit used for explicit alarm announcement and warning to the system's operators. Alarm panel is regularly delivered as a standard part of the system СРЦЕ, unless required otherwise.

Computer network is realized with appropriate connecting cables and network equipment and the additional input-output units may be, at the customer request,:

- mounted in workstations or
- independent, connected to workstations by standard input-output terminals (for example RS-232, USB, IEEE1394).

Operator interface connects to the central control block. Connecting mode is determined according to needs, system capacity and organization of maintenance service.

Workstations are realized in personal computer (PC) technology, providing use of personal computer considerable facilities, i.e. generation of intelligent workstations.

Operator interface equipment enables adjustment of equipment capacity (number of operator working locations) to the system capacity. This way, it is possible to realize the operator interface with only one working location, or, to organize several working locations, with several workstations at each of it.

It is recommended to supply the operator interface equipment with direct voltage directly from uninterruptable power supply system.

7.5.0.2 Operator interface software

Operator interface may be very complex regarding the equipment used. As to its software, it is quite simple.

Operator interface requires only the operator computer software (OP). Same one is used for OP directly connected to the system (so-called OP server) and OPs, connected to OP server through Local Area Network (LAN). It is necessary to perform appropriate adjustments to enable the operator interface functioning, but the software is the same. Note that the operator computers are standard personal computers (PC) with belonging operating systems; the latter ones and its executing programs are not considered СРЦЕ system software, for there is no connection between them.

7.6 System supply distribution

System supply distribution is a part of system distributing supply from an uninterruptable power supply system from reception terminal into the system, to particular structural system units:

- User groups
- Central equipment
- Trunk groups

Structural units distribute supply further to its lower level structural units, excluding from system supply distribution.

System supply distribution is entirely passive one, containing cables for supply distribution and corresponding passive protection elements - automatic fuses, Automatic fuses are placed on the front system board. This makes any reaction of fuse within system supply distribution visible from the front side of the system.

To improve reliability, system supply distribution is doubled, failure of any part of system supply distribution can not harm system functioning as a whole, or any part of the system.

System supply distribution is physically distributed through the system. It is placed on highest cabinet shelves, depending on the exchange layout plan.

Note that there are certain structural units excluded from the previous list, therefore, not provided with system supply. These are:

- System signal distribution
- Operator interface
- Circuit servicing equipment

System signal distribution is entirely passive cable distribution, not using system or any other supply.

Operator interface equipment may be realized in several ways, depending on customers' request. It may be supplied with AC voltage, even with no connection to uninterruptable power supply when not using the operator interface while system is working with emergency power supply. In the other variant, it may be connected to system supply distribution, which is barely recommended. Manufacturer recommends the equipment for operator interface connected directly to uninterruptable power supply system. When needed, a special supply distribution box may be designed for larger groups of operator interface equipment.

The equipment for СРЦЕ circuit servicing may be placed inside of system central equipment, when supplied internally, within central equipment. For considerably high capacities of circuit servicing equipment, the equipment may be located in a special cabinet(s) and supplied from system supply distribution. This case is rather rare, therefore not presented in the figure.

7.7 System signal distribution

System signal distribution is a system part performing unifying of certain system structural units:

- User groups
- Central equipment
- Trunk groups
- Operator interface
- Circuit servicing equipment

Certain structural units are provided with own signal distribution, excluding from system signal distribution.

7.7.1 System signal distribution subject

As considered functionally, subject of the signal distribution are signals of:

- Interprocessor communication (control buses)
- Communication (multiplex signals transmitting useful contents)
- Operating frequency (system clock)
- Multiplex and switching stage synchronization along certain system structural units

In СРЦЕ system, the above mentioned elements of system signal distribution are physically separated, meaning that they are transferred along separated signalling lines.

7.7.2 Realization of system signal distribution

System signal distribution is completely passive, consisting of signalling cables and corresponding passive connecting elements - connectors. Unified connectors are used for different types of signals, marked correspondingly. Paired high quality cables are used, capable of high speed signal transmission.

System was constructed to enable access to system signal distribution elements from the rear side of the system.

To improve reliability, system signal distribution is completely doubled; failure of any part of system signal distribution can not harm system functioning as a whole, but only a limited part of the system.

System signal distribution is physically distributed through the system. It is placed on the highest cabinets racks.

7.7.3 System signal distribution marking

Regarding СРЦЕ system connection marking, the important and basic fact is that system cables are ended with appropriate plugs applied to sockets in certain structural units. Sockets are marked accordingly. Socket labels, in combination with corresponding structural unit label, are printed on system cable plugs. For example, for system cable connected in one end to user group 2, socket UCP1, than this end of system cable is marked with KG2-UCP1.

Each cable and cable connection point is defined with unique labels at cable ends. A cable is also marked with type label located at the target in the middle of the cable.

7.8 Equipment for line servicing

This equipment provides various services to system's users on the circuit level. It includes talking machine, voice mail, recording and reproduction of conversations, etc.

The equipment is connected to the central telecommunication unit, more precisely to the group stage. Central control unit, rather central processor controls the equipment.

Chapter 8

Performance

As for СРЦЕ system performance, it was important to coordinate requests for modern functions, need for a large switching system and maintenance facilities. Accordingly, basic СРЦЕ system features are:

1. СРЦЕ system is designed in the up-to-date related technology
2. СРЦЕ system operates with a minor consumption, not exceeding 0,2W per terminal
3. СРЦЕ system construction is performed in a traditional manner
4. СРЦЕ contains a small number of different slide-in units

These and many other СРЦЕ system characteristics are presented in this capter.

8.1 Electronic equipment

8.1.1 Technology

СРЦЕ system is designed in the up-to-date related technology.

8.1.1.1 Internal communication

Internal system communication is a fast serial digital one. Such technique is applied in point-to-point variant to transfer useful system signals, and in bus connection variant to perform interprocessor communication.

High speed serial communication considerably decreases the number of physical connections within the system.

8.1.1.2 Integrated devices

High integrated digital circuits are implemented in СРЦЕ system.

To reduce the number of components used, and herewith reduce the complexity and price and improve system reliability and its ability to meet special needs of the end users, system is provided with the programmable logic circuits.

In order to perform digital signal processing, system uses *Digital Signal Processors, DSP*. Such processors considerably improve signal processibility, to cope with relating requirements.

8.1.2 Consumption and dissipation

СРЦЕ system is designed to have a low consumption, not exceeding 0,2 W by terminal. Low consumption reduces needs for air conditioning of the storage.

Low consumption of СРЦЕ system additionally results in improved reliability and longer mean time between failures.

Such low consumption is being achieved switching off the non-functioning circuits, switching it on according to needs. This method provides an extremely reduced consumption in no traffic conditions (for example, by night).

8.1.3 Equipment storing

СРЦЕ system, and especially the central equipment, is provided with small dimensions and mass. Central equipment is stored in a cabinet containing a group stage, central oscillator and entire central control block. Central cabinet also contains interface circuits for digital trunk channels.

One user cabinet may contain up to 960 interfaces for analog subscribers.

8.1.4 Processing units

Microcontrollers for basic use with integrated communication periphery organs are used as system regional processors. These are equipped with fast static memory of high capacity and operate on high operating frequency. Each processor is designed to perform any processing required in its part of the system. Such method simplifies system construction, allowing its being a huge one, since the issue is all reduced to processibility of central control block processor.

Central processor is arranged as a multi-processor system. A powerful processor for basic use, approved by industrial standards, is used as a central processing unit. It is equipped with fast dynamic memory and operates on a high operating frequency.

Digital signal processors are applied for transmission of signaling tones, serial communication controllers, and other purposes. As a rule, these processors are auxiliary ones for another regional processors.

8.1.5 Access equipment

Access devices are provided with personal computer technology. Operator computer is designed to serve as an intelligent terminal. Intelligent terminals realize certain system functions, thus unload the administrative computer and central processor functionality and improve their processibility. Operator computers are equipped with own input/output units. Intelligent terminals enable operator work in graphic workstation, with available *on-line help.*

8.2 Construction

СРЦЕ system design is a traditional one, with module construction. System modules are designed independently and always the same for all system capacities and configurations. As for their construction, modules in different systems differ only by the interconnections between modules. There are three types of interconnections:

- power connections (power supply and equipotential bonding)
- signaling connections (control and communication buses)
- mechanical connections (panels, slots and mechanical strengthening)

In accordance with valid technical standards, СРЦЕ system construction is three level modular one, with slide-in units, racks and cabinets.

Basic construction units are slide-in units realized as standard format printed boards applying quadruple "Europe" format.

Slide-in units are placed in slots, arranged in racks.

Racks are further contained in cabinets. One cabinet may contain up to five racks.

Cabinets are placed next to each other in one or several lines, according to need. Cabinet lines form the exchange.

8.2.1 Slide-in units

СРЦЕ system contains a small number of different slide-in units, presenting:

1. Subscriber unit
2. Trunk unit
3. Group stage
4. Central clock generator
5. User frame regional processor
6. Common frame regional processor
7. Testing equipment
8. Call generator
9. Communication processor

8.2.2 Cabinets and racks

There may be only one type of cabinets and racks for entire system. Mechanical construction of cabinets/racks is identical but the contents (equipment) are different.

8.2.2.1 Cabinets

Cabinets are designed to fit the racks of 23 inch width and double "Europe" height. A cabinet may include five (5) racks one over another. Narrow planes may be placed between the racks in order to direct the air flow and improve system cooling, if required.

User cabinet in СРЦЕ system is realized in two variants, forming a user group. Trunk cabinet is used only when more than 3840 trunk channels is required in a certain exchange.

8.2.2.2 Racks

Racks are II level construction elements in СРЦЕ system. Term *rack* relates to a functional unit, such as user frame, trunk frame, etc.

There are several terms used to denote such functional unit, presented by different manufacturers. For the needs of СРЦЕ system, term *frame* denotes the functional unit, term *rack* refers to construction unit (mechanical construction), and term *shelf* is a place in cabinet the rack is placed onto.

СРЦЕ system uses standard 23 inch rack for telecommunication equipment, 233,4 mm height (double ”Europe”).

СРЦЕ presents following frame types:

1. user frame
2. user group common frame
3. trunk frame
4. group stage frame
5. central clock generator frame

Certain construction units in СРЦЕ system may also be considered racks (frames):

1. central processors
2. administrative computer with periphery
3. operator computer with periphery
4. supply distribution with line power supply

Construction of central processors and administrative computer is strengthened to improve reliability. Industrial PC cases for heavy operating conditions are used, having larger temperature range, dust concentration and strong mechanical vibrations.

8.2.3 Internal connecting

СРЦЕ uses a small number of cable types, all in small quantities.

Traditional cable types are used, for easier system maintenance.

Cables endings are connected by ”pinching”, improving contact safety.

Internal connecting may be signal or power connecting. Power connecting distributes power supply to system elements. Signal connecting may be control, channel (”useful” signal transmission), clock distribution or test connecting.

Physical organization of internal connecting provides route of cables containing all necessary signal and power cables from central equipment to each user group and trunk frame.

Internal connecting is doubled, meaning that each internal system connection is provided with two cables. In case of a connection failure, system still operates by another connection, with appropriate alarm activated.

8.3 Software

СРЦЕ system software was developed on the basis of the best latest tested acknowledges and achievements in the program control area. In particular, this relates both to program languages and tools and the software developing process.

СРЦЕ system is a distributed system containing a great number of processors performing certain activities. There might be several types of processors in a system and the frequency of a certain type depends on system configuration.

An approximate preview on this matter may be presented as:

1. Central processor (CP) and Administrative computer (AP) are processors of Central Control Block (ЦУБ). AR is reserved to deal with possible long lasting but not so important jobs (back storage), leaving basic functions to be performed by CP. CP controls resources indirectly. AR performs controlling using dual CP.

2. Operator computer (OP) - used by operators to administrate the system

3. Communication processor (КОП), part of CP, AP or OP, contained in a certain number, depending on the exchange configuration (primarily, its size).

4. Regional processors (RP) control relating parts of the system. Different RP types control different areas, still having some common characteristics.

Regional processors and КОПs realize some software in ROM memory, performing initialization and reception of the operating program. Operating program performs all regular functions.

Same could be applied for CP and AP, only with a higher level and more complicated performance.

Operator computer uses standard personal computer and an application developed for corresponding operating system as a software.

8.3.1 Basic features

Basic set up of СРЦЕ software concept is modularity. Program languages and the quality of program support (software) are also very important concept issue. The latter one shall be discussed separately.

8.3.1.1 Modularity

Modularity is practiced primarily in the system distribution (great number of processors operating simultaneously and independently). However, such modularity is caused by the electronic equipment set up. Modularity within certain processors results from realization of the software concept.

In these terms, differences are made between **system modularity** and **local modularity**.

System modules may be moved from one processors to another one, with minimum changes and no suspension of its functions. Basic module activity is message transfer to/from other system modules. Message transfer, with contents defined for each of it, enables modules' being completely independent one from another. Functionally, modules are mutually dependent as much as it is required relating to certain functions.

Local modularity denotes module development process. Both theory and practice approve that a certain development process improves modularity, resulting in more software quality improvements. Modularity in СРЦЕ system software may be realized as:

1. Information hiding
2. Loose coupling
3. Strong cohesion
4. Orthogonal interfaces
5. Interface minimalism
6. Design by contract
7. Internal consistency checks

Modularity advantages:

1. Precise organization of activities
2. Easy development
3. Improved maintenance
4. Better error detection and recovery
5. Simplified module testing

8.3.1.2 Program languages

Due to its limited resources (memory, processor speed, etc) and close connection with electronic equipment, software for regional processors is is written in program language C, while those time critical parts (far less than 1% of code) in assembler. Same is done for communication processors.

Some software for central control block processors (central processor - CP and administrative computer - AP) is written in program language C++ (approximately 80%

of code), and some (closer to electronic equipment) in C. Minor sections were written in assembler.

Entire operator computer software is created in C++, for OP performances are not so important, having only one user. Standard personal computers are used, with no assembler code required.

Certain program languages, primarily C++, provide easier code development and its later maintenance and upgrade. Additionally, expressing in codes is closer to the issue and therefore, much easier for understanding, thus reducing the time required for development and improving reliability. Code created this way may be applied for new, developed processor versions, enabling easier system upgrade in microprocessor technology development era.

8.3.2 Software quality

Like any other product, software may be characterized with same basic features such as quality, price, creation time, etc.

Most important area of activity is the one ensuring quality. This may be described using following definitions:

- Quality implies all software characteristics denoting whether specified requirements were satisfied. Quality is presented with quality features.
- Quality features define whether certain requirement is satisfied. These features may be very complicated, and further divided to sub-features
- Quality assurance include group of activities performed during development process, providing the specified quality level achieved in a final software version

Basic provisions for assuring software specified quality level were defined with basic СРЦЕ system software set up.

8.3.2.1 Quality features

Basic СРЦЕ system quality features are:

1. Functionality - complying with functionality requests (base call, subscriber and trunk signaling, administrative functions...)
2. Reliability - accuracy in completing requirements, operation without (program) failures, reactions in electronic equipment failure conditions (relating to provision of system functions), overload prevention...

3. Maintenance facilities - modularity, easy testing and error detection, introduction of new functions...

4. Efficiency - maximum usability of available resources (processor power, memory, etc.)

5. Processor switching - easy switching to another processors, in case of processor change (for example, from 16bit to 32bt processor)

6. Operator usability - easy usage, possibility for getting to know about user environment step by step (improving from easy to complicated functions), usage error safe, available on-line help...

Quality features are very important aspect during software development and quality assurance. There are many others considered, although there is a great number of these features. However, development process has adopted the realization and control mode for quality features previously listed.

8.3.2.2 Quality assurance

During the development process, quality assurance procedures are:

1. Code and record check (requirements, realization, documentation)

2. Inspection of code and important records

3. Using tools for static code analysis (in the event of source code compiling)

4. (System) testing - final control described in a separate section for its large scope and necessity. The testing may denote only error presence but not its source and is therefore considered less important procedure among those practiced in СРЦЕ system development.

Note that a special team of experts is provided for quality assurance activities, in addition to development team members supporting the assurance procedures (primarily those prior to system check).

8.3.2.3 Checks

After its completion, record check is forwarded for check by another member(s) of team. At least one of them belongs to quality assurance team.

After record check is completed certain remarks are made and the record is sent for corrections. The author performs these corrections and submits a new version for another check. The process is repeated to the final accepted version of the document.

Basically, same process is applied for source code. Note that the source code is formalized according to corresponding program language rules, while the records are less formalized.

8.3.2.4 Inspection

Inspection is a formalized check type and is primarily applied for code, although some other important records are subject to the inspection process as well.

The inspection includes separate checks of several (usually three) team associates, followed by their meeting, together with the author, where particular problems are discussed. One member is appointed inspection team leader. Meeting should be a brief and efficient one.

After the meeting, the author is correcting the document according to remarks. Inspection leader decides whether another meeting is necessary. Further meetings are very rear.

Inspection advantages are numerous and are described in several researches (the best known is M.E. Phagan "Design and Code Inspections to Reduce Errors in Program Development", *IBM Systems Journal 15(3),* 1976).

8.3.2.5 Tools for static code analysis

These tools may indicate frequent coding errors (e.g., usual error in program language C is usage of assignment (=) instead of comparison (==)). With some additional information, besides the program language code, the tools may indicate certain errors in a module usage.

Furthermore, another tool type may detect complicated code sections (procedures, functions, modules, etc) Complexity results in the increased error probability.

The tools are used by development team, for certain code sections. Members of the quality assurance team use these tools for the entire code.

8.3.3 Development process

8.3.3.1 The importance of development process

Software development process is an extremely important issue, for being related to a huge and distributed system.

Development process irregularity causes inconsistency of certain system sections, unreliable operation, even some basic system functions' failure. Irregularities may occur as a consequence of a considerable number of employees engaged in system development process, each being occupied for certain system sections. Successful development process synchronizes their operation.

Basic problem is introduced with a number of possible communication paths in a system, which is equal to $\binom{n}{2}$ if n is number of communication participants. This is illustrated in figure 8.1.

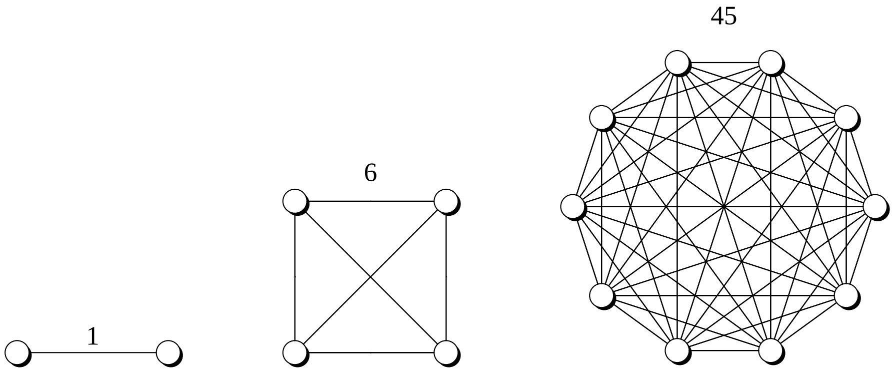


Figure 8.1: Number of comm. paths in relation to number of comm. participants

Four participants are sufficient to cause "collision" of communication paths. With ten participants, there is too many communication paths colliding. Such complicated communication is arranged with an appropriate development process.

8.3.3.2 Development process survey

Development process contains following phases:

1. Defining requirements (Analysis)
2. System architecture corrections
3. Design
4. Coding
5. Module testing
6. Integration testing (Integration)
7. System check (System testing)

Depending on job complexity, certain phases may be further divided to sub-phases and some of them may be excluded. The minimum required includes: defining requirements, coding and system check.

As regarding quality insurance, each phase is subject to corresponding control. Control mode is defined by system development team and its leader.

8.3.3.3 Defining requirements

Requirements may be made by:

1. Purchaser
2. End users
3. Internally, according to specified needs

Purchaser requirements may vary from concise but complicated ones ("the exchange should be provided with ISDN functions") to very diffused but simple ones. End user requirements usually relate to simplicity in usage for system operators, mainly referring to operator computer.

The above mentioned requirements imply certain procedure to place system requests. However, some other requirements are caused by particular need, without processing certain requests by end users or a purchaser. These requirements mostly deal with incomplete purchaser or user requirements (relating to some important system sections not covered by their analysis).

8.3.3.4 System architecture correction

On the basis of the specified requests, system architecture is realized. This rather is an architecture correction since the basic and original architecture was specified initially and is subject to no changes - other architecture applied would imply another system. Frequently, for simple and limited functions, no corrections are made.

System architecture denotes the operating organization of processors, relating message (data) transfer protocols etc.

8.3.3.5 Design

Design introduces coding preparations and is performed by leading team engineers, each in charge for certain part of the job.

Design process precisely defines modules, interfaces, algorithms and data structures to be used in coding. For less complicated jobs, existing designs shall do and this phase may be skipped.

8.3.3.6 Coding

Coding is realized according to requirements, architecture and design. Time needed for coding, although presenting the elementary part of the process, takes no longer than 20% of total time needed for developing a certain function.

Entire source code is stored in version control system, preventing misunderstandings relating to the actual (or previous) version of its source code, software.

8.3.3.7 Module testing

Module testing is performed to reduce time spent in integration testing. Errors detected in module testing are hardly detected by any other testing methods (system check etc.).

Module tests in СРЦЕ system are always performed automatically in the event of software compiling (from source code made in a program language to the final, executing code for system execution). Consequently, executing code cannot be realized in case of error detected from a test module.

8.3.3.8 Integration testing

Integration testing is performed on СРЦЕ system reference module, after making certain software modifications.

Integration testing should help the author remove frequent integration errors (inconsistent message formats, incomplete modifications in particular system sections etc.), that are scarcely detected before system start up.

Integration testing is no replacement for system testing. It is almost necessary and for less detailed functions, its duration is very short.

8.3.3.9 System check

System tests are defined together with the system architecture, based on requirements.

System tests are defined and then classified to those run automatically (tool directed) and those manually run. It is preferable to run automatically as many tests as possible, but regardless of that, all tests are performed eventually.

Tests are further coded for specified tool performances. This code is considered a part of system software and is subject to common rules.

System tests defined according to a specified request are executed after the integration testing was completed for relating software.

Prior to delivering a new software version/revision to another system, all system tests are performed and only after all detected errors removed, delivery is realized.

System tests include different types of tests:

- Functional test (related to requests fulfillment)
- Boundary test (difficulties for request fulfillment are most frequent in critical conditions, for which reason they are specially tested)
- Load test (testing the operation under permanent load not overwhelming system endurance)
- Stress test (short exposure to a load overwhelming system endurance)

- Performance test (checking whether specified performances were satisfied)
- Configuration test (checking system operation in different configurations in usage)
- Statistical tests perform statistic evaluation of particular quality features, (most frequently, reliability). These tests are based on a complicated method defining the type and amount of tests, the automatic test execution and and the additional statistical processing of test results.
- Reliability tests are delivered with unexpected contents, form, time periods etc, in order to test whether the system remains in its regular operation in the unpredicted circumstances
- Safety tests, similar to reliability tests, only relating to system operation and access safety
- Compatibility tests, specifying compatible systems among the variety of telecommunication systems.

System tests are mostly run by СРЦЕ system reference module, but may also be run by another system modules, if needed.

8.3.3.10 Tools

Huge distributed telecommunication system for real time operation, such as СРЦЕ system, implies certain specific features. There are few successful systems of the kind in the world. Consequently, there are no widely used tools for this software type.

Certain system manufacturers introduce their own program languages specially for this purpose. СРЦЕ system experts did none of this, for C and C++ languages proved to be high-developed and corresponding to electronic equipment.

Still, using standard program languages implies that certain problems should be resolved "manually", for these were not considered the time relating program language was created.

As a consequence, it was necessary to develop the auxiliary tools, most operating on the basis of C/C++ code. These evaluate with the system and some of them are created while others are rejected. The only reference here is made as to their usage:

1. Specifying finite state machine. Regular view method in telecommunications area relating to processing is the finite state machine. C and C++ are not very convenient for such a purpose. They may be used to create finite state machines but there are certain rules to be obeyed in this mater. Additionally, certain difficulties appear as regarding the machine created in C program language.

2. Specifying operator interface and documentation. There are certain, program restricted basic tools reserved for such purpose. For СРЦЕ system, synchronization of interface, documentation and system functions are extremely important. Corresponding tools provide an up-to-date view of the operator interface, documentation and system operation mode.

3. Tools performing the automatic system testing. For complicated systems such as СРЦЕ, manual function testing is hardly completed in a decent time period. Only those functions without corresponding automatic testing tools created, are tested manually.

8.3.4 Software maintenance

Two different types of activities are performed relating to СРЦЕ software maintenance: **development maintenance** and **operation maintenance**.

Development maintenance includes error detection, certain corrections and provision of operation of the existing functions while introducing new ones. This implies continuous activity of development team, together with its basic task: introduction of new functions and other facilities.

Operation maintenance represents replacement of the operating software. СРЦЕ system software is presented in versions and revisions. A version is one system architecture type and all corrections making no considerable change to it are included as new revisions of a same version. There are no definite specifications as to the duration of a version and its revision, but in practice, this may be reduced to 3-6 years for version and 2-8 weeks for revision.

The entire software may be replaced with a certain procedure. СРЦЕ system has no "patch" system, resulting, in usage, in an infinite "patched" software being no longer the same as its original software. СРЦЕ system is organized to operate with a specified version and revision, uniquely defining the software. All old versions/revisions are stored in the project archive and are available in any circumstances.

8.4 Documentation

СРЦЕ system relating documentation is made according to CEPT T/CS 01-10 E.

СРЦЕ system is delivered with one copy of paper documentation and 4 copies of electronic CD documentation.

Electronic documentation is adjusted for operator computer usage. Standard HTML and PDF data file formats are used.

On user request, several paper/electronic copies may be delivered.

Chapter 9

Life cycle

System life cycle includes all events related to particular СРЦЕ system, from the moment of its implementation to the point where СРЦЕ system life duration is completed.

Basic phases in СРЦЕ system life cycle are:

- Phase prior to startup, described in chapter 9.1, beginning on page 222
- Setup and startup, described in chapter 9.2, beginning from page 226
- Regular operation, chapter 9.3, page 227
- Upgrades, chapter 9.4, page 230

9.1 Prior to startup

9.1.1 Defining system requirements

СРЦЕ system is entirely customizable. User may set system requirements in order to define system configuration to correspond with specified system application.

Based on specified requests system design is started.

9.1.2 System design

System design represents a procedure starting with system requirements, resulting in set of data entirely and unambiguously defining, in technical sense, system configuration complying with specified requirements.

Data obtained in system design procedure include detailed equipment specification and the equipment connection method. With corresponding input data provided, data may also include specifications for:

- Spare parts
- Installation work
- Acceptance work
- Recommended slave equipment
- Recommended maintenance equipment
- Equipment setup plan

СРЦЕ system design is presented in document "СРЦЕ ТЦ-011 system design".

9.1.3 Training

User training is organized in courses contained of theory and practice. Courses are held in the location with the technical support provided.

Training is realized through lectures and exercises at the switching system and the special consultations. Trainees get teaching material (notes and assignment notebooks) and disposable supplies (paper, fascicles, floppies).

Number of trainees taking the same course is maximum 10. Every trainee has its own place for exercises within the exchange. On training complete, trainees are tested and certificates are provided for all.

There are several different courses organized for different user needs. Short description of each of these follows in further text.

9.1.3.1 Basic course for system operator

Trainees for system operator do not necessary need prior knowledge of СРЦЕ system facilities but basic knowledge of telecommunications is desirable.

CONTENTS:

- Getting familiar with the exchange system level
- Getting to know about functional structure and related tasks
- Learning about functional system architecture and the equipment and software architecture
- Detail inspection of traffic and basic exploitation characteristics
- System redundancy, reliability and reaction to failures
- Getting knowledge and routines for system control, surveillance and maintenance, both in regular conditions and in the error detection event

AIM:

- Trainee is capable of discussing different architecture and exploitation features of a switching system
- Trainee is qualified to configure and reconfigure exchange parameters and surveil exchange operation and relating operation features
- Trainee is capable of maintaining the system, performing error detection and repair

9.1.3.2 Advanced course for system operator

This course requires knowledge obtained during Basic course for system operator.

CONTENTS:

- Detail study of the exchange equipment and software, signaling types
- Possible database treating/correction
- System communication protocols

AIM:

- Trainee is competent in presenting the switching system and performing complicated interventions

- Trainee is capable of analyzing the system functioning using surveillance methods, traffic statistic monitoring, diagnostics, measuring etc.

- Trainee realizes an optimum system operation, reconfiguring system parameters or performing other system corrections

9.1.3.3 Course for system designing

This course requires knowledge obtained during Basic course for system operator. Experience of the Advanced course for system operator may use as well.

CONTENTS:

- Detail study of data related to system design and getting familiar with system architecture and traffic restrictions

- Training to calculate and define exchange parameters and spare parts according to initial requests

- Providing information about exchange startup.

AIM:

- Trainee is qualified to design optimum configuration for exchange equipment, complying with specified traffic requests.

9.1.3.4 Course for system installation

This course requires knowledge obtained during Basic course for system operator. Experience of the Advanced course for system operator may use as well.

CONTENTS:

- Learning about system installation features, facilities and system regularity check up methods

AIM:

- Trainee is capable of the exchange installation

- Trainee performs configuring of network functions

- Trainee realizes the exchange startup

9.1.3.5 Course for the final system testing

This course requires knowledge obtained during Basic course for system operator. Experience of the Advanced course for system operator may use as well.

CONTENTS:

- Learning about possibilities and methods for testing regularity of system functioning
- Studying information, technical parameters, traffic parameters, signaling, special functions, reconfiguration

AIM:
Trainee is qualified to perform exchange tests, primarily:

- measuring and diagnostics of the electronic equipment function regularity
- testing the exchange software functioning
- signaling check
- testing the exchange traffic capacities
- processor load

9.1.3.6 Course for system maintenance

This course requires knowledge obtained during Basic course for system operator. Experience of the Advanced course for system operator may use as well.

CONTENTS:

- Learning about needs for servicing and maintenance
- Training to design and organize system service
- Learning about serviced components
- Getting to know about measuring, locating failures and system repair

AIM:

- Trainee is qualified to detect the equipment failure and cure it
- Trainee is capable of evaluating the exchange element reliability and needs for spare part supplies

9.2 Setup (installation)

In СРЦЕ system production process, a method of ”pre-installation” is introduced. After all necessary system components were produced, including standard elements (slide-in-units, for example) and elements specific for the subject exchange (cables connecting certain system parts), the system is integrated to entirely comply with the project. Only after all necessary checks made, the ”pre-installed” system is delivered to a final destination for setup and startup.

System installation is described in document ”СРЦЕ ТЦ-011 setup instruction”.

9.3 Life duration

9.3.1 Handling

Powerful personal computers are used as the operator computers and provide the operator graphical user interface, WIMP (Windows, Icons, Menus and Pointer). Graphic user interface transfers the operator activity into system commands.

Over 500 commands are available. Some of those are very complicated and specified in several turns.

Introduction of intelligent terminals for operator computers provides a customizable man-machine language. Available languages are Serbian, Russian, English etc.

Operator may use, in any moment of operation, an interactive, detail and ample *on-line help*. On-line help contains the entire documentation for operating the system, adjusted for the interactive operation mode.

Operator software performs detailed analysis of the operator commands and alerts the operator for the possible negative results of the issued command.

Operator workstation is provided with electronic document of complete system documentation.

9.3.2 Maintenance

СРЦЕ system maintenance is quite simplified.

Operator computer provides various commands for viewing system errors (alarms) and different kinds of procedure (measuring, statistics etc) for the operator to detect these errors. These commands are described within on-line help section.

Certain commands may be used to execute temporary traffic blocking of a certain section part during the failure/error recovery process, thus preventing traffic interruption (when possible).

Maintenance procedures are described in details in the system documentation. Within СРЦЕ system training program, special course is dedicated to maintenance procedures providing users with necessary knowledge and practice related to system maintenance.

9.3.3 User technical support

9.3.3.1 ”Live” support

”Live” support is term used for a 24 hour possibility of consulting a factory expert. User may communicate with a person in charge for technical support in case any problem occur regarding system equipment of software.

9.3.3.2 Electronic support

Any questions related to certain problems in СРЦЕ ТЦ-011 system operation may be submitted in the electronic form, either by means of the electronic mail or filling the web site form.

9.3.3.3 Object records

Object records represent a database relating to systems in operation. The database contains all necessary data for certain objects, such as:

- list of equipment deliveries
- list of software deliveries
- list of spare part deliveries
- specification of main and digital distribution frame
- power supply system and battery data
- list of mounted material
- list of delivered maintenance tools and equipment
- list of delivered measuring equipment
- complete design documentation
- specification of performed installation work
- final testing documentation
- list of delivered documentation
- records about training courses organized for trainees at the particular object.

All of the above mentioned data are synchronized promptly. Time records, together with quality and quantity ones, are made for each object activity.

Special consideration exists for databases in the operating exchanges, relating activities and its evidence and system software modifications.

9.3.3.4 Records and error detection

Special activity of technical support service is keeping records and detection of errors, failures and irregularities in system operation.

Technical support service collects and classifies all user data concerning operation irregularities, converting it into a form appropriate for further processing in technical sector. This may imply certain system corrections in database, system software or equipment. Records are made about noticed system irregularities and corresponding corrections.

9.3.3.5 Documentation

Technical support center distributes all new variants of documentation, paper or electronic, to users with corresponding system version or revision. These may be additional instructions, descriptions or corrections of previously delivered documentation.

9.4 System upgrades

System upgrades may relate to:

- capacity enhancement
- system equipment modifications
- software

Capacity enhancement is easy performed, with the basic pre-conditions provided (enough storage place etc.). Basically, new system requirements are designed, using available results of the original design. New equipment may be set without interfering the system operation, except in cases of a huge enhancement, including central control block replacement. Even in this, latter case, the operation is not interrupted.

Upgrades relating to system equipment modifications are rather uncommon. System is designed with software to perform most of potentially changeable requirements and system needs. Most frequently, it is related to new equipment revisions of a particular version, which is in fact, system enhancement. Replacement of a part of the equipment is not so complicated, but is generally requiring appropriate software upgrades.

System software upgrade is provided delivering and installing a new system software variant with performed corrections, using standard installation procedure. СРЦЕ system uses no software ”patches”.

Chapter 10

ABBREVIATIONS

Cyrillic abbreviations

- АОН - Automatic number definition
- АР - Administrative computer
- АРЈ - Administrative computer unit
- БПУГСЧ - Number of calls in main traffic hour
- ВФ - High frequency
- ВК - Time control
- ВСК - Dedicated signalling channel (Russian signalling type)
- ГАК - Analog subscriber group
- ГАП - Analog trunk group
- ГДП - Digital trunk group
- ГИК - ISDN user group
- ГС - Group stage
- ГСП- Call generator
- ДИС - Digital remote stage
- ЗГ - Closed group
- ЗЈПТТ - Yugoslav post, telephone and telegraph community

- ЗРП - Common regional trunk frame processor
- ИКМ - Pulse code modulation
- ИЛЦ - Exchange line testing
- JУС - Yugoslav standard
- JKTM - Public switching telephone network
- КОП - Communication processor
- КС - User stage
- МТК - Handset
- МЦ - Parent exchange
- НИПС - Announcement informational system
- НППЦ - Multiline hunt group
- ПАЦ - Digit reception and analysis
- ПГСЧ - Number of calls in the main traffic hour
- ПИМП - WIMP
- ПРОК - Trunk frame
- ПС - Trunk stage
- РБВ - Connection sequence number
- РиО - Handling and maintenance
- РП - Regional processor
- РПК - User stage regional processor
- РПП - Trunk stage regional processor
- РПГ - Group stage regional processor
- РПЗ - Regional processor of use group common devices
- РБВ - Connection sequential number
- СЗК - Common channel signalling

- СПК - Channel associated signalling
- СРЦЕ - Serbian exchange
- ТЦ - Telephone exchange
- ТИ - Charging origin
- ТО - Charging destination
- ТС - Charging case
- ТК - Tariff category
- ТФК - Telephone switching
- ЦГТ - Central clock generator
- ЦП - Central processor
- ЦПЈ - Central processing unit
- ЦТБ - Central telecommunication block
- ЦУБ - Central control block

Latin abbreviations

- ACB - Access barred signal
- ACM - Address complete message
- ADI - Address incomplete signal
- AIS - Alarm indication signal
- AMI - Alternate mark inversion
- ANC - Answer signal, charge
- ANM - Answer message
- ANN - Answer signal, no charge
- ANSI - American National Standards Institute
- ANU - Answer signal, unqualified

- BCT - Bidirectional combined trunk
- BER - Bit error rate
- BHCA - Busy hour call attempts
- BMF - Basic multi-frame
- BORSCHT - Battery, Overvoltage protection, Ringing, Signalling, Cofidec, Hybrid, Test
- CAS - Channel associated signalling
- CBK - Clear-back signal
- CC - Charging case
- CCF - Continuity-failure signal
- CCS - Common channel signalling
- CD - Charging destination
- CEPT - Conference of European postal and telegraph administrations
- CFL -Call-failure signal
- CGC - Circuit-group-congestion signal
- CIC - Circuit Identification Code
- CLC - Cyclic redundancy check
- CLF - Clear-forward signal
- CMOS - Complementary metal-oxide semiconductor
- CO - Charging origin
- CON - Connect message
- COT - Continuity signal
- CPG - Call progress
- CRC - Cyclic redundancy check
- DCN - Data communication network

- DPN - Digital path not provided signal
- DSS - Digital signalling system
- DSP - Digital signal processor
- DTMF - Dual tone multi-frequency receivers
- EMI - Electromagnetic interference
- EOS - End of selection
- ETSI - European telecommunications standards institute
- FAS - Frame alignment signal
- FDM - Frequency-division multiplex
- GRQ - General request message
- GSM - General forward set-up information message
- HDLC - High level data link control
- HTML - Hypertext markup language
- IAI - Initial address message with additional information
- IAM - Initial address message
- IDR - Identification request message
- INF - Information message
- INR - Information request message
- IRS - Identification response message
- ISDN - Integrated services digital network
- ISUP - ISDN User Part
- ITU - International telecommunications union
- LAPD - Link access protocol, D-channel
- LAPB - Link access protocol, balanced
- LAN - Local-area network

- LOS - Loss of signal
- LVDS - Low Voltage Differential Signaling
- MF - Multi-frame
- MFC - Multi frequency code
- MHG - Multi-line hunt group (for PBX)
- MPR - Misdialled trunk prefix
- MTP - Message transfer part
- NNC - National-network-congestion signal
- OS - Operating systems
- OSI - Open systems interconnection
- PC - Personal computer
- PCM - Pulse code modulation
- PDH - Plesiochronous digital hierarchy
- RAN - Reanswer signal
- REL - Release message
- RES - Resume message
- RLC - Release complete message
- RLG - Release-guard signal
- ROM - Read only memory
- RS-485 - Recommended standard 485
- RSC - Reset-circuit signal
- SAM - Subsequent address message
- SAO - Subsequent address message with one signal
- SCCP - Signalling connection control part
- SDH - Synchronous digital hierarchy

- SEC - Switching-equipment-congestion signal
- SPC - Signalling point code
- SSB - Subscriber-busy signal (electrical)
- SST - Send-special-information tone signal
- SUS - Suspend message
- TAR - Tariff
- TC - Tariff category
- TCAP - Transaction capabilities application part
- TIE - Time interval error
- TMN - Telecommunications Management Network
- TUP - Telephony user part
- UNN - Unallocated-number signal
- UTP - Unshielded twisted pair
- WIMP - Windows, icons, menus and pointer

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