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DKTS DIGITAL SWITCHING TELEPHONE SYSTEM

Stanislav Matić, Tomislav Šuh, Mirjana Miletić–Vidaković and Petar Daković

Abstract. Digital switching telephone system, named DKTS, is a result of many years R & D efforts of Telecommunication and Electronics Institute IRITEL – Beograd. This paper describes the general system organization, the applied control principle and the software structure. System features, basic characteristics, technology and construction, are presented also. The system is intended to satisfy national telephone network needs. Basic applications are as local and nodal exchanges, but it enables a number of other applications.

1. Introduction

The digitalization and the software control are principal trends of modern telecommunications. Direct consequences are technological changes in the telecommunication network infrastructure including switching and transmission systems and other network elements. Most of the telecommunication network owners, first of all the PTT administration as the greatest, have started to follow these trends. It also includes our National Administration. But the complexity and the high development cost of the new generation of telecommunication equipments and systems result in their purchasing from abroad. Usually they are licensed or produced through cooperation of local manufacturers and some of big international telecommunication companies. Even in bigger and technically more developed countries telecommunication equipments and systems from own R & D are rare. DKTS is one of such special examples.

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Upon the reception of the manuscript on April 9^{th}1994 prof. dr Stanislav Matić died. At that moment he was the director of the Institute for telecommunications and electronics IRITEL – Belgrade. During his reach carier he published many scientific papers and gave great contribution to science.

Authors are with the Institute for telecommunications and electronics IRITEL – Beograd, Batajnički put 23, 11080 Beograd, Yugoslavia.

DKTS is a digital switching system intended for the lower hierarchical levels of the national telephone network. The project started at the beginning of the eighties relying entirely on home research resources. This R&D has gone through various phases their lengths depending upon the available budget. Several years ago the first DKTS generation of local (end) exchanges was accomplished and the final approval of the system achieved by getting the homologation from the National Administration. The manufacture started and the annual production has been estimated at the level of tens of thousands of subscriber lines. Last year the development of DKTS nodal exchange was successfully completed too. All that is a good basis for the continuation of the development that is expected to result in a new system generation and new applications.

2. System Organization

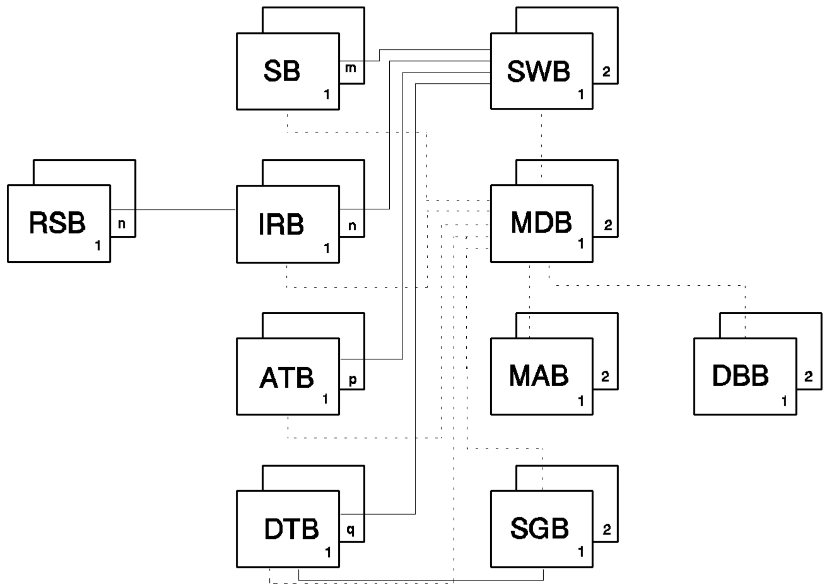
DKTS organization is based on the contemporary switching systems principles: the digital switching and the store program control. Also, the modular system organization has been accomplished in respect to hardware as well as software structures.

2.1 Block structure

Fig. 1. presents the general block diagram of the system. The modular system organization is composed of blocks. Generally there are two types of blocks: peripheral and common.

The peripheral blocks accomplish interfaces towards subscribers lines and trunks enabling control functions of corresponding connections. There are several types of peripheral blocks: subscribers block (SB), remote subscribers block (RSB) and the appropriate interface block (IRB), analogue trunks block (ATB) and digital trunks block (DTB). A number of blocks of the same type is defined depending on the system capacity i.e. numbers of subscribers lines and trunks.

Differing from peripheral blocks, each of them handing just a limited number of subscribers lines or trunks, the common blocks perform functions for the entire system. There are five common blocks: switching block (SWB), message distribution block (MDB), maintenance & administrative block (MAB), data base block (DBB) and signalling block (SGB). All common blocks are doubled providing in that way the reliability of centralized function performances.



——— information path
SB- subscriber block
RSB- remote subscriber block
IRB- RSB interface
ATB- analog trunk block
DTB- digital trunk block

- - - - control data path
SWB- switching block
MDB- message distribution block
MAB- M & A block
DBB- data base block
SGB- CCS No.7 block

Fig. 1. General block diagram of the system

In order to make the manufacturing and the maintenance of the system easier the emphasis has been set on the unique hardware structure of all blocks. Each block includes:

– control unit,
– functional hardware, specific for the block functions,
– control unit interface to the functional hardware,
– functional hardware interface to other blocks.

Such general block organization is shown on Fig. 2.

2.2 Peripheral blocks

Hardware structures of different peripheral blocks differ only in the functional hardware.

The functional hardware of the subscriber block primarily consists of

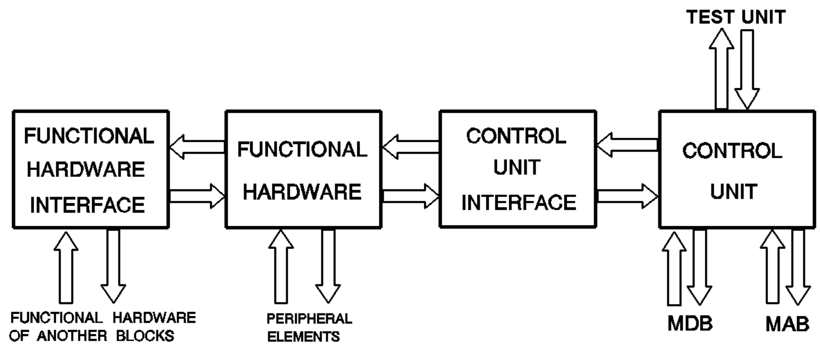


Figure 2. General block organization

subscriber units. The subscriber unit provides connecting of a two-wire analogue subscriber line (Z interface) performing the so called BORSCHT functions (battery feed, overvoltage protection, ringing, supervising, coding, hybrid transformer and testing). The main functions are A/D and D/A conversions of speech signals and signalization criteria interchanges between the line and the system. The signalization criteria are transmitted through the block in digital form meaning that the support units in this block, tone signal generators and DTFM receivers, are based on the digital signal processing principle. Fig. 3. shows the subscriber block organization.

The analogue trunk block enables analogue trunks accesses (C11 interface) and performs appropriate signalling. The functional hardware of this block consists of analogue trunk units and MFC receivers/transmitters if R2 system signalization is used. The analogue trunk units provide functions which correspond to those of the subscriber units, including A/D and D/A conversions. MFC receivers/transmitters operate on the digital signal processing principle and use special microprocessor for communication with the block control unit as DTMF receivers.

The digital trunk block enables digital trunks accesses in form of 32-channel multiplex signals (A interface). Within this block signalization criteria extractions/insertions are performed from/to the associated channel. Fig. 4. shows the digital trunk block organization.

The remote subscriber block includes the standard subscriber block structure and digital trunk units enabling connections with the system through digital trunks. On the system side there is an appropriate inter-

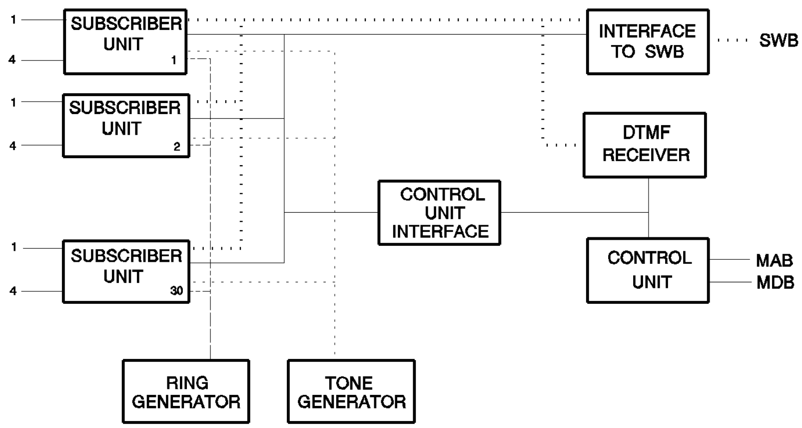


Fig. 3. Subscriber block organization

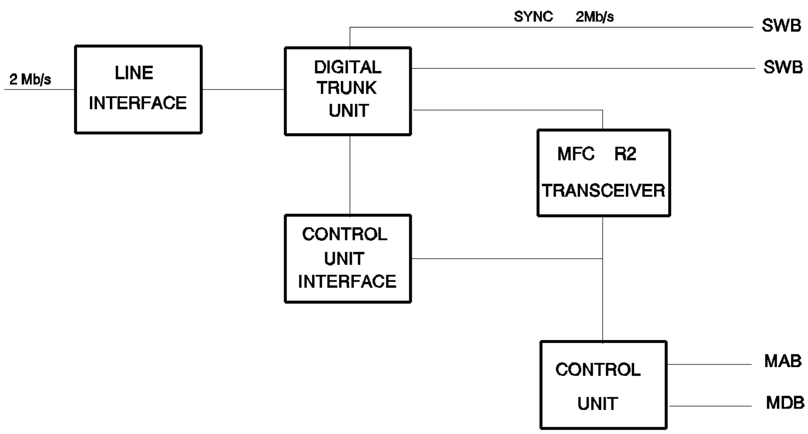


Fig. 4. Digital trunk block organization

face block based on a simplified version of the digital trunk block.

2.3 Common blocks

Unlike the peripheral blocks resemble each other as to their functions and structures, the common blocks are all different.

The data base block has the simplest structure, it consists only of a standard control unit. When required by other blocks of the system, particularly the peripheral ones, this block provides the data on: routing, charging, internal and external addresses, subscriber class of services and so on.

The main function of the switching block is speech signals digital switching. For that purpose, besides a standard control unit, it also contains a digital switching network of T-S-T structure, accepting 32-channel multiplex signals from all peripheral blocks. In the switching block there is a clock generator that can be synchronized from a higher level exchange. Signals from this generator are distributed to all other blocks.

The message distribution block provides interprocessor communications between the control units from all other blocks of the system. Therefore, besides the control unit, it contains message transceivers based on HDLC protocol, as well as a digital space switching network for message switching. Fig. 5. shows the organization of this block.

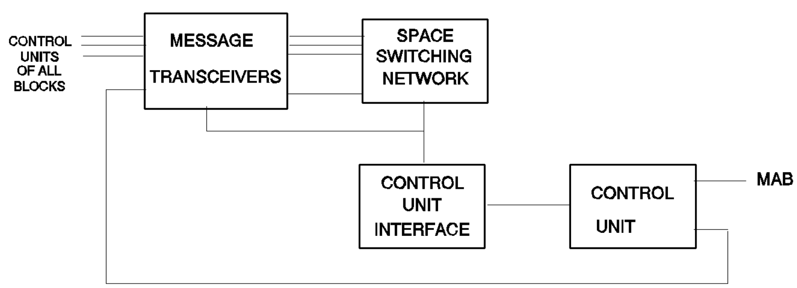


Fig. 5. Message distribution block organization

The maintenance & administrative block has the most complex structure, which is conditioned by various functions that it performs. A set of supervision and maintenance functions use transceivers for asynchronous supervision messages, transmitters of commands for other blocks (e.g. reset), as well as receivers of alarm signals from other blocks (e.g. watch dog timer). There are a set of functions performing operations with input/output units (video-display unit, printer, alarm panel, magnetic disc units, etc.). A separate microprocessor enables the clock handler and calendar functions performing even specific requests, as subscriber calls at a definite time (alarm call), determination of lower tariffs periods, and so on. Fig. 6. shows the block organization.

The signalling block is intended for the common channel system signalization CCITT No.7. It provides handling of 2., 3. and partly 4. level functions of that signalization.

All common blocks are duplicated in order to obtain the required availability. It is done according to different principles, depending on the block purposes. The load sharing principle is applied in the message distribution block and in the data base block, solving possible overload problems at the same time. The switching block uses the principle of synchronous duplex operation. The maintenance & administrative block and the signalling block employ the worker/standby mode. The call losses in common blocks are reduced to minimum by the application of redundancy units in such a manner.

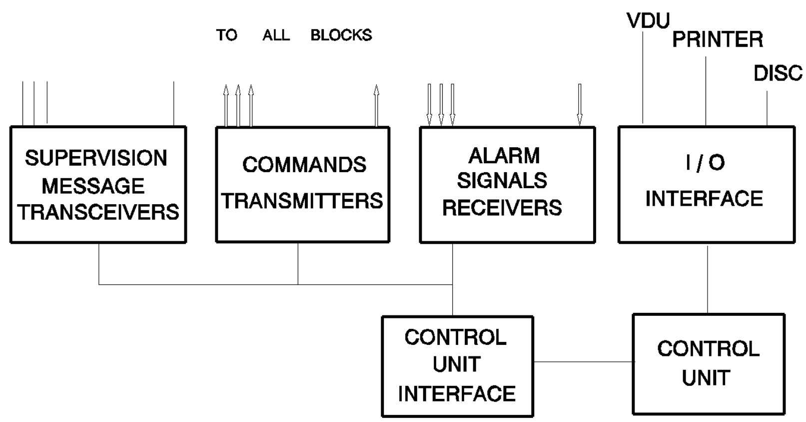


Fig. 6. Maintenance & administrative block organization

2.4 Decentralized control organization

All blocks in the system have not only the same structure (block diagram in fig.2), but they have identical control units. Such control unit, besides a microprocessor, contains elements for interprocessor communications, local and central supervision, timing, error detection, as well as a connection for a test equipment (RS 232 C interface).

Interprocessor communications among different blocks are accomplished by the serial data rate of 500 Kb/s through the message distribution block. Direct memory accesses and a specific protocol based on HDLC are used for that.

Local and central supervision of each block are under control of the maintenance & administrative block. Therefore, each block control unit has an interface for the asynchronous serial connection with that block.

Functions depending on time (timing, charging etc.) are performed with interrupt pulses generated by timers. The corresponding clock cycle is 10 ms.

At first sight the system architecture seems to be standard, but its control organization is specific. Namely, calls are processed under exclusive control of the calling party peripheral block. All other blocks, peripheral or common, that participate in call processing are activated at a request of the calling party peripheral block. In this way, the complex and, the most time-consuming processing activities are taken over by the peripheral blocks. On the other hand, the time engagements of the processors of the common blocks are significantly reduced.

2.5 Software organization

Modularity is the main characteristic of the software architecture. The software is structured from a series of program modules, each representing a complete functional entity. The software of each block contains: standardized operating system software package and both, block specific application software package, as well as maintenance & administrative software package. Special attention is drawn to the simple introduction of new functions without greater interferences with the already existing ones. Therefore, the organization of the application software was especially taken care of. A defined set of standard program modules is outlined in each block of the system. Every block function is realized by the connection of corresponding subset program modules according to a sequence specified in the connection table. The introduction of a new function is simple. It is achieved by forming a sequence of standard program modules combined with a few of the new ones. In this way the field-proven software modules need not be changed. That is a significant convenience in case of designing new applications and, generally, it increases the level of software availability in the system.

3. System Features

Regarding the characteristics, DKTS entirely satisfies all requirements essential for modern digital switching systems of the same classification. The typical system features are shown in Table 1.

Table 1. DKTS features

Maximal capacity	
common blocks number:	10
peripheral blocks number:	63
Peripheral blocks	
subscriber block capacity:	120 subscriber or dual-party lines
	16 DTMF receivers
digital trunk block capacity:	30 PCM channels
	30 MFC (R2) receivers/transmitters
analog trunk block capacity:	30 analog trunks
	30 MFC (R2) receivers/transmitters
Switching block	
architecture:	TST
I/O channel number:	2048
Message distribution block	
protocol based on:	HDLC
data bit rate:	500 kb/s
Traffic data	
total handled traffic:	1512 E
BHCA:	57000
Signalling systems	
channel associated:	CCITT R2
	E/M code
common channel:	CCITT No.7
Facilites	
according to national and international standards	

3.1 Basic characteristics

DKTS is primarily intended for the lower hierarchical levels of the national telephone network: local and nodal exchanges. Its basic characteristics are:

– completely digital switching system,
– capacity from few hundreds to thousands of subscriber lines,
– modular structure,
– possibility of operating in pure digital as well as in pure analogue environments,
– all vital parts of the system are duplicated for required availability,
– facilities of standard public telephone network as well as some additional services e.g. short code dialing, alarm calls, call diversion etc.
– fulfillment of specific requirements of the national telephone network concerning great number of dual
– party lines,

– signalization systems, typical for the existing telephone network,
– different charging possibilities (local, or from higher level exchange),
– fulfillment of all digital network synchronization recommendations,
– openness for all capacity and application modifications etc.

3.2 Technology and construction

In the course of the entire DKTS development, efforts have been made in technological modernization of the system. First of all, that includes maximal application of up-to-date semiconductor components. Besides, standard VLSI, components specialized for telecommunication functions (SLIC, COFIDEC, FRAC) and interprocessor communication (ADLC, DMAC) have been used. Following the modern trends in the development of components, system technological improvements are being made.

With regard to mechanical construction, the system has followed the modular principle. The basic mechanical elements are printed circuit boards. There are 25 board types, each having standard dimensions $340mm \times 233mm$. Printed circuit boards are placed in racks and each contains maximum 36 boards. Wiring between the boards in one rack is realized by back plane, and connections among the racks by cables. The largest mechanical element is the cabinet containing 6 racks. The cabinet dimensions are $2200mm \times 700mm \times 600mm$. One cabinet includes all common blocks, so that two are needed for doubled common blocks. Regarding the peripheral blocks, one cabinet contains 4 subscriber blocks, or 6 analogue trunk blocks, or 12 digital trunk blocks. Other combinations of peripheral blocks in one cabinet are also possible.

4. Application

Having the basic aim to fulfill the digitalization requirements of the lower hierarchical levels of the national telephone network, the research and development at DKTS project that started in the beginning of the eighties, are carried on. Though some of these activities have been realized slower because of a limited budget, the expected results have been fully accomplished. Gained is the own technological base for production of small capacity digital switching systems enabling various applications. The basic applications of the system are as local and nodal exchanges at corresponding levels of the national telephone network. The system offers considerable possibilities for its application in rural areas, as well as for ISDN. Besides, parts of the developed system can be also used for some other applications.

4.1 Primary aim

DKTS is a small capacity digital switching system that can operate in a fully independent manner in its environment. Its connections with other exchanges in the network are realized through standard interfaces, using recommended signalization and charging systems. So, DKTS type exchanges can operate in the pure analogue and the pure digital environment including all combinations of these two extreme cases.

Thus conceived switching system provides National Administration a systematic approach in digitalization from the lower levels of its network. This process can be achieved without imposing any preconditions upon the existing network infrastructure (level of development, configuration, technological solutions, etc.), but in agreement with the available budget. It is very important for the realization of technically poor networks, where the national telephone network is also included.

4.2 Local exchange

The development of digital local exchange that can satisfy all requirements in the lowest level of the national telephone network was the first task of DKTS project realization.

Before the introduction of digital switching systems, electromechanical systems were installed at locations of local exchanges. As a rule their operation depended on the higher level exchange and they had pure features. Relatively late, small quasi electronic switching systems appeared at the market. They brought up significant improvements in the functional sense, but they were intended for operation in an analogue environment. Finally, the introduction of large capacity digital switching systems at higher network levels has enabled solutions with remote concentrators and switching blocks in the lowest network level. But, such solutions do not offer complete functional comfort and, what is worse, they are applicable only at locations with digital infrastructure.

An autonomous small capacity digital switching system, as DKTS, is a universal solution for local exchange positions, eliminating shortages of the above mentioned options. DKTS provides an extensive choice of functions resolved at the store program control. Because of that, besides the primary task, the digitalization of the end network level, it offers a variety of comfortable facilities for the users and the network operator.

DKTS local exchange got the homologation from National Administration for capacities up to 7000 subscriber lines, what is equivalent to the handled traffic of cca 1500 E. The attested system version complies with all exchange requirements of the lowest network level.

4.3. Nodal exchange

An additional DKTS development has been carried out regarding the local exchange to enable performances of the node level exchange. Changes of the system hardware mainly resulted in satisfying the required capacities and block configurations typical for nodal exchanges, e.g. a larger number of trunk blocks. The additional software enables more complex charging and signalization options, operation with more trunk groups, plenty of administration and maintenance functions etc.

A very important feature is the newly developed remote subscriber block. It provides the solution flexibility of the entire node area.

The only possible shortcoming of DKTS for the nodal exchange application could be a very large capacity of such an exchange. Therefore, the process of DKTS technological innovations has started, aiming at a significant expansion of the system capacity.

4.4 Rural application

Some network locations of local and even nodal exchanges belong to so called rural areas for which adequate operating conditions are required. Regarding the fact that in the national telephone network there are no extreme rural requirements (deserts, swamps, polar areas and so on) DKTS can be used for that purpose without special adapting. Such an application is convenient owing to the modular system construction enabling very small exchange capacities, as well as the possibility of remote subscriber blocks installation.

DKTS container version could be specially interesting for rural areas. All required technical conditions exist, but financial analyses must show the justification of the corresponding development.

4.5 ISDN application

Another possible DKTS application is in the integrated services digital network (ISDN). The system organization is convenient for the development of ISDN functions. The peripheral block is the one where subscriber interfaces and supporting calls processing software are installed. Owing to that, DKTS modification for the narrow band ISDN application has essentially resulted in a development of a corresponding subscriber block requiring minimum changes in the common blocks. The advantage of this approach is a relatively simple introduction of the already installed DKTS exchanges into ISDN. It only requires new ISDN subscriber blocks and some software modifications in the signalling block and in the data base block.

4.6 Other applications

Besides different switching applications within the national telecommunication network, DKTS can also be a good resource for other applications. Two of them are presented here.

One is the enquiries and calls assistance system. This system enables manual and semiautomatic telephone call assistance providing information and special services to subscribers. In the national telephone network these services are known as 900, 901, 902, 905, 988, 989..... and so on. Some DKTS blocks are used for the realization of such system enabling a solution based on digital switching and store program control. That system, offering all modern technological conveniences, is installed in the national telephone network.

Another possible application of DKTS technology is for the business switching system. Corresponding analyses show that most DKTS hardware and software parts (modules) can be used for this purpose. In accordance with that, a small business switching system with voice and data facilities is taken into consideration.

5. Conclusion

DKTS is an own developed small digital switching system. It is mainly intended for the national telecommunication network to enable the systematic network digitalization starting from the lower hierarchical levels. Its open and flexible organization offers other applications too.

The system organization and its features are verified in the best possible form - through exploitation. By getting the homologation, the system has officially entered the process of production. Although there are some objective reasons, primarily financial, this production is not having the intent progression. A number of exchanges have been installed into the national telephone network. Some of them have been operating for years, and the experiences drawn from their use are positive. That confirms DKTS as a solid national technological resource for construction of contemporary digital telecommunication networks.

DKTS research and development works continue. Their primary aim is technological improvement of the system. The main courses are increasing the processing capacity of control units, increasing the basic modules package density, the application of a higher programming language in the software, etc. An anticipated result is a significant expansion of the system applications.

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