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THE EFFICIENCY ANALYSIS OF THE SWICHING FIELDS OF AN EWSD V.15 DIGITAL SWITCHING SYSTEM

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Abstract: Because of wide introduction of EWSD digital switching system on modern telephone networks, the problem of the economic efficiency of its operation is highly compelling. For the solution of this task at the stage of the digital switching system design it is necessary to select an optimal switching field structure. In this work the structures of single-, three- and five-link switching fields of digital switching system EWSD V.15 built on two standard time and three spatial modules at five capacities have been simulated. For the efficiency evaluation of the thirty switching field structures the economic criterion, determined as the cost of one digital channel in equivalent switching points, has been used. As a result of the analysis it has been established that the single-link switching fields of small capacity are more effective. Three-link switching fields are implemented effectively only for small and middle capacities. Besides, they have the quality service of input paths owing to larger connectivity. Five-link switching fields in case of large capacities are ten times less expensive than single-link ones and their cost is nearly the same as the cost of three-link switching fields.

Key words: digital switching system, switching field, time module, spatial module, equivalent switching point.

1. Introduction

The digital switching system EWSD of V.15 version is perspective and universal to be used in current public telephone networks at different levels of hierarchy as well as in mobile communication networks [1-3].

Widespread exploitation of the EWSD system means that the main problem is determination of its efficiency, as in literature on digital switching systems (DSSs), an analysis of both the station performance efficiency and its separate functional modules was not studied to the full extent [1-3]. The determination of the effeciency of DSS as a whole is a difficult task. But we can evaluate the effeciency of its individual components, in particular the efficiency of switching fields (SFs), because the their structures mainly affect the efficiency of the full DSS.

The purpose of this work is construction and analysis of the effeciency of various structures and capacities of SF SN of DSS EWSD of V.15 version according to the determined effeciency criteria for switching systems. The effeciency of digital SFs can be evaluated in terms of their economical efficiency defined as the number of equivalent switching points (P_{eq}) [4,5].

In this paper, to evaluate the effeciency of digital SFs, an economic criterion has been well-founded. This criterion defines the cost of one digital channel in equivalent switching points [7,8]. The efficiency was calculated for thirty different SFs structures built on the standard switching modules of EWSD system of V.15version. The analysis of the results obtained have been done, and the recommendations on exploatation of the investigated SFs have been proposed.

2. Peculiarities of construction and structure of the switching field of DSS EWSD

DSS EWSD has a very powerful switching field SN. A full accessible SF is built on the basis of the module principle, has little inside blockings and is dubbed. Depending on the capacity the SFs can be used at the stations of all the types and capacities. On the inputs/outputs of SF, the linear groups LTG that have 128 channel intervals with carrying capacity of 64 kbit/sec are connected. Data rate through LTG is 128×64=8192 kbit/sec. The particularity of SF SN is the fact that this SF is built (depending on its capacity) according to only two structures, namely: three-links and five-links structures. For the construction of these structures, two time ($T1$, $T2$) and two spatial (SM8 and SM16) switching modules are only used. Middle and small stations with the capacity of SF SN: 63LTG and SN: 15LTG have a three-link SF with a Time-Space-Time structure. At large capacity (SN:504LTG, SN:252LTG, SN:126LTG), SF is built based on a five-link structure Time-Space- Space-Space- Time [1,6].

A block-diagram of a three-link SF with large capacity of 512 LTG is represented in Fig 1. The time links are built on the time switching blocks (TSG), in which the time modules $T1$ with the capacity of (512×512) channels and data rate over LTG of 8192 kbit/sec or T2 modules with the capacity of (1024 × 1024) channels with the same data rate are used. The spatial links are built on the spatial switching blocks (SSG). At the process of SF construction, the interfaces LIS8 are set to decrease the time of delays of channel intervals between time blocks of aTSG link and the spatial switches of a SSG link (Fig. 1). Connection of 512 input LTGs requires 512/8=64LIS8 that form 16 time group of TSGs. In order to connect 64 LIS8, 4 spatial switches in the link of SSG of (128×128) LTG capacity are needed.

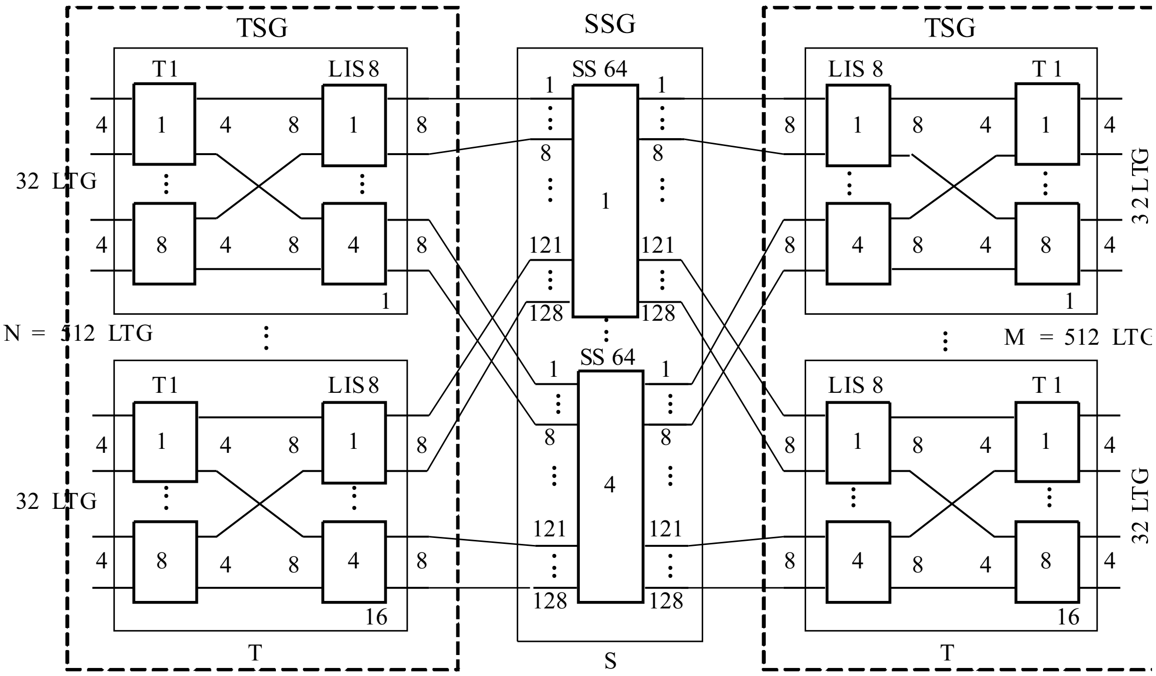

Fig 1. The block-diagram of three-link switching field SN with capacity of 512 LTG.

The total number of the equivalent switching points of the field Time-Space-Time P_{eq} (Fig.1) is equal to the sum of the equivalent switching points P_{eq} of links of time and spatial switching:

$$P_{3D} = 2\cdot P_T + P_S\,, \tag{1}$$

where P_{3D} is the cost of a three-link SF; P_T, P_S are the number of equivalent switching points of the time and spatial switching links correspondently.

The number of equivalent switching points of the time switching link can be described as:

$$P_T = \left[\frac{N_{C(T)}\cdot r}{100} + \frac{N_{C(T)}\cdot(\log_2 N_{C(T)})}{100}\right]\cdot N_{\text{mod}}, \tag{2}$$

where $N_{C(T)}$ is the capacity of the time module in channels, r is a bit cell.

The number of digital modules in links Time N_{mod}, which equals:

$$N_{\text{mod}} = \frac{N_D}{N_{C(T)}}\,, \tag{3}$$

where N_D is the capacity of the digital SF in the channels.

The number of equivalent switching points of the spatial switching links is equal to:

$$P_S = 2\cdot P_{SP} + P_{AMD}\,,$$

where P_{SP} is the number of equivalent switching points of the spatial switch; P_{AMD} is the number of the equivalent switching points of a spatial switch address memory device.

Thus,

$$P_S = \left[n1\cdot m1 + \frac{N_{C(IP)}(\log_2 m1)\cdot n1}{100}\right]\cdot k1\,, \tag{4}$$

where $N_{C(IP)}$ is the number of channels of intermediate path; $n1$ is the number of inputs of the spatial switch; $m1$ is the number of outputs of the spatial switch; $k1$ is the number of spatial switches in the Space link.

The cost of one channel of a three-link structure of SF is:

$$P_{1C} = \frac{P_{3D}}{N_D}\,. \tag{5}$$

Let us construct a three-link SF of five capacities [16×16], [64×64], [128×128], [256×256], [512×512] of LTG linear groups or (2048×2048), (8192×8192), (16384×16384), (32768×32768), (65536×65536) channels correspondently. Let us denote these fields as $D1$, $D2$, $D3$, $D4$, $D5$, and the number of input/output channels as N_{D1}=2048, N_{D2}= 8192, N_{D3}=16384, N_{D4}=32768, N_{D5}=65536 channels respectively. For all built SFs, whose structure parameters are shown in [7,8], their costs and the cost of one channel are calculated in the equivalent switching points. Coefficient $K_{T1\ (3Di,1)}$, shows how much the cost of one channel of SF $3D1,1$ with capacity (2048×2048) built on time module (512×512) differs from the cost of one channel of SFs $1D2,1$, $1D3,1$, $1D4,1$, $1D5,1$. The obtained data are shown in Table 1 and in consolidated Table 3.

Table 1

Indices of efficiency of a three-link SF

i is the number of SF	1	2	3	4	5
The capacity of SF, (LTG)	[16×16]	[64×64]	[128×128]	[256×256]	[512×512]
The capacity of SF, the time slots	(2048×2048)	(8192×8192)	(16384×16384)	(32768×32768)	(65536×65536)
$N_{mod(3Di,1)}$,mod.	4	16	32	64	128
$N_{mod(3Di,2)}$), mod	2	8	16	32	64
$P_{3Di,1}$, eq.sw.p.	1034,24	4137	10486	29491	92406
$P_{3Di,2}$, eq.sw.p.	1075	4300	10650	30147	93716
$P_{1C(3Di,1)}$,eq.sw.p.	0,505	0,505	0,64	0,9	1,41
$P_{1C(3Di,2)}$,eq.sw.p.	0,525	0,525	0,66	0,92	1,43
$K_{T1\ (3Di,1)}$, ratio	1	1	1,26	1,78	2,8

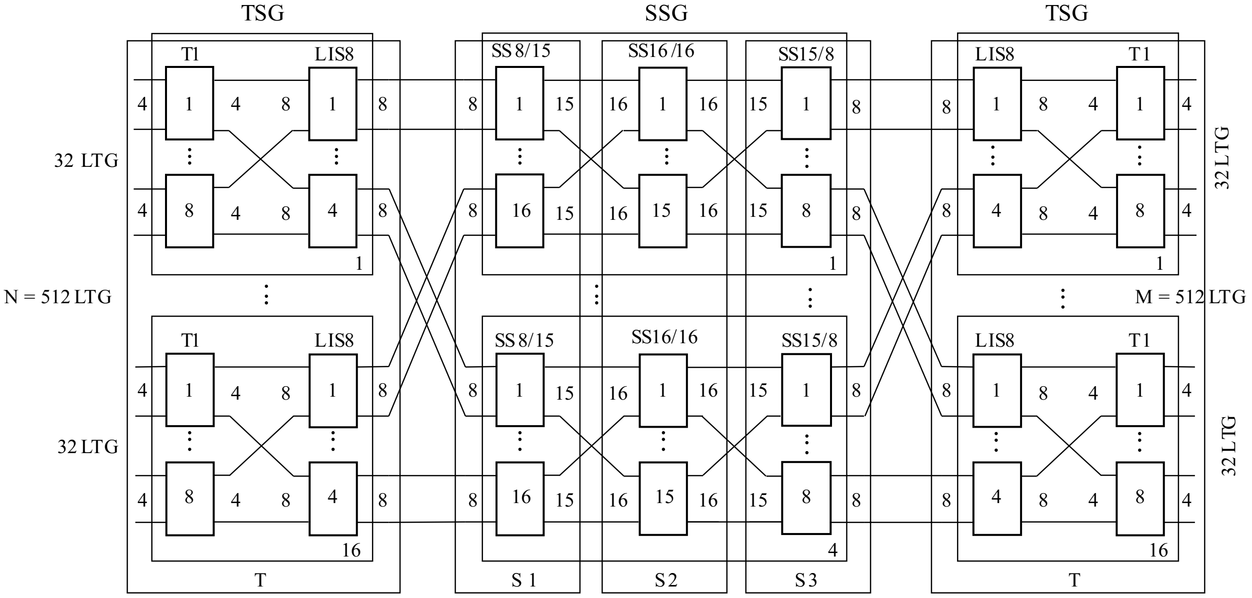

Fig 2. The block-diagram of five-link SF with capacity of 512 LTG.

The structure scheme of a five-link SF of large capacity is depicted in Fig 2. In this scheme, to construct a SSG link, which consists of three-link spatial switching sections, *S*1 link is made of (8×15) spatial switches of M8/15 modules, *S*2 spatial link is made of (16×16) spatial switches of M16 modules, *S*3 spatial link is made of (15×8) spatial switches of M8/15 modules.

For the analysis of efficiency, we construct the five-link SFs of all the five capacities that are denoted as *D*1,1-*D*5,1 and *D*1,2-*D*5,2 respectively and use equations (1-5) and modify them for the correspondent SF structure. Let us analyze which scheme is effective for the use and compare the efficiency of five-link SFs with that of single-link and three-link SFs. The cost of a single SF channel in the equivalent switching point is defined as a criterion of efficiency [9].

The total number P_{eq} of Time-Spatial-Spatial-Spatial-Time field equals the sum of equivalent switching points of links of time and spatial switching, that is

$$P_{5D} = 2\cdot P_T + 2\cdot P_S + P_{S2}, \qquad (6)$$

where P_T is the number of equivalent switching points of the time switching link; $P_{S1} = P_{S3} = P_S$ is the number of equivalent switching points of the spatial links $S1$ and $S3$; P_{S2} is the number of equivalent switching points of the spatial link $S2$.

Let us calculate the number P_{5D} of the five-link SF of maximum capacity *D*5,1 (let us note this as 5*D*5,1). The capacity of the field is (65536×65536) channels. At the time link of this field, the module *T*1 with the (4×4) capacity of linear paths LTG ((512×512) slots) are used.

Let us calculate the number of time modules in the Time link of SF 5*D*1,1:

$$N_{\text{mod}} = \frac{N_{5D5,1}}{N_{C(T1)}} = \frac{65536}{512} = 128 \text{ modules.}$$

The number of outputs from the Time link is equal to $N_{out.l(T)} = n \cdot N_{\text{mod}} = 4 \cdot 128 = 512$. For the connection of 512 outputs to *S*1 link, it is necessary to have 64 spatial switches (8×15) that compose 4 SSG. Each block consists of 16 switches (8×15) ($k1$=16) and 15 switches (16×16) (Fig. 2). The Time link has 16 TSG. Each TSG has 4 LIS8 interfaces to be joined as 8 blocks *T*1. The interface LIS8 is connected to *S*1 link using 8 intermediate paths with connectivity of LIS8 being f_L=8, and connectivity of *T*1 block being f_T=1. Further we can calculate the cost of one digital channel of all the SFs 5*Di*,1, 5*Di*,2; the cost is measured in equivalent switching points. The calculation results we show in Table 2. In addition, Table 2 represents costs of the coefficients $N_{T1(i,j)}$, $N_{T2(i,j)}$ that indicate a cost difference of a digital channel of SFs of different capacities which are built on different *T*1 and *T*2 time modules. The indices *i* and *j* take on values of all the SFs numbers from 1 to 5.

Table 2

Indices of efficiency of a five-link SF

i is the number of SF	1	2	3	4	5
The capacity of SF, (LTG)	[16×16]	[64×64]	[128×128]	[256×256]	[512×512]
The capacity of SF, slots	(2048×2048)	(8192×8192)	(16384×16384)	(32768×32768)	(65536×65536)
$N_{mod(5Di,1)}$, mod.	4	16	32	64	128
$N_{mod(5Di,2)}$, mod.	2	8	16	32	64
$P_{(5Di,1)}$,eq.sw.p.	6409	10249	15790	31580	63760
$P_{(5Di,2)}$,eq.sw.p.	6449,9	10593	16118	32236	64271
$P_{1N(5Di,1)}$, eq.sw.p.	3,129	1,27	0,9617	0,9738	0,9618
$P_{1N(5Di,2)}$, eq.sw.p.	3,15	1,29	0,9837	0,9837	0,9837
$N_{T1(i,1)}$,times	1	0,405	0,307	0,31	0,307
$N_{T1(i,2)}$,times	2,46	1	0,75	0,76	0,75
$N_{T1(i,3)}$,times	3,25	1,32	1	1,01	1
$N_{T1(i,4)}$,times	3,21	1,3	0,987	1	0,98
$N_{T1(i,5)}$,times	3,25	1,32	1	0,96	1
$N_{T2(i,1)}$,times	1	0,41	0,31	0,31	0,31
$N_{T2(i,2)}$,times	2,44	1	0,76	0,76	0,76
$N_{T2(i,3)}$,times	0,32	0,76	1	1	1
$N_{T2(i,4)}$,times	3,2	1,31	1	1	1
$N_{T2(i,5)}$,times	3,2	1,31	1	1	1
$N_{1,2(5Di,1)}$,%	12,5	50	100	100	100

3. Comparative analysis of efficiency of multi-link switching fields

In order to make a comparative efficiency analysis, let us use the results from Tables 1 and 2. Single-link SFs of five capacities to take into consideration the two time modules *T*1 i *T*2 (ten structures) are also constructed. The analysis of the single-link structures gives, in the first place, a possibility to evaluate magnitudes of the obtained efficiency indices, in the second place, it shows which SFs of the EWSD system are more effective to be built as single-link ones. All the data obtained are represented in the consolidated Table 3 displaying the efficiency indices using the following notation:

– $T_{1Di,1}$, $T_{1Di,2}$, $T_{3Di,1}$, $T_{3Di,2}$, $T_{5Di,1}$, $T_{5Di,2}$ are the costs of digital fields, where figures 1, 3, 5 before the symbol D denote SF structures (single-link, three-link, five-link respectively), the costs *i* are the numbers of a certain SF capacity, figures 1 and 2 after *i* are the types of the time module (*T*1 or *T*2) to be used to build the Time link;

– P_{1N} is the cost of a slot of all the above enumerated digital SFs;

– the coefficients $N_{1,i(T1,T2)}$ denote the ratio of costs of single-link SFs of different capacities denoted by subscript *i* and built on the time modules *T*1 and *T*2; the coefficients $N_{3,i(T1,T2)}$, $N_{5,i(T1,T2)}$, show the same ratios for three- and five-link SFs;

– the coefficients $N_{1,3(i,T1)}$ ($N_{1,5(i,T1)}$) denote the ratio of costs of one channel of the single-link and three-link (five-link) SFs built on modules *T*1;

Table 3

Consolidated table of SFs indices

i is the number of SF	1	2	3	4	5
SF capacity, (LTG)	[16×16])	[64×64]	[128×128]	[256×256]	[512×512]
SF capacity, channels	(2048×2048)	(8192×8192)	(16384×16384)	(32768×32768)	(65536×65536)
$T_{1Di,1}$, eq.sw.p.	880,64	11551	44237	172690	681570
$T_{1Di,2}$, eq.sw.p.	552,96	6307	23265	88801	346030
$T_{3Di,1}$, eq.sw.p.	1034,24	4137	10486	29491	92406
$T_{3Di,2}$, eq.sw.p.	1075	4300	10650	30147	93716
$T_{5Di,1}$, eq.sw.p..	6409	10249	15790	31580	63760
$T_{5Di,2}$, eq.sw.p.	6449,9	10593	16118	32236	64271
$P_{1N(1Di,1)}$, eq.sw.p.	0,43	1,41	2,7	5,27	10,4
$P_{1N(3Di,1)}$, eq.sw.p.	0,505	0,505	0,64	0,9	1,41
$P_{1N(5Di,1)}$, eq.sw.p.	3,129	1,27	0,9617	0,9738	0,9613
$P_{1N(1Di,2)}$, eq.sw.p.	0,27	0,77	1,42	2,41	5,28
$P_{1N(3Di,2)}$, eq.sw.p.	0,525	0,525	0,66	0,92	1,43
$P_{1N(5Di,2)}$, eq.sw.p.	3,15	1,29	0,9837	0,9837	0,9837
$N_{1,i(T1,T2)}$, times	1,6	1,83	1,9	1,94	1,98
$N_{3,i(T1,T2)}$, times	0,96	0,96	0,97	0,97	0,97
$N_{5,i(T1,T2)}$, times	0,96	0,98	0,97	0,98	0,977
$N_{1,3(i,T1)}$, times	0.85	2.8	5.346	8,5	11,5
$N_{1,5(i,T1)}$, times	0.137	1.11	2.8	5.44	10.8
$N_{5,3(i,T1)}$, times	6.196	2.51	1,5	1,08	0,68
$Q_{3(i,T1)}$, LTG	1	4	4	4	4
$Q_{3(i,T2)}$, LTG	1	4	4	4	4
$Q_{5(i,T1)} = Q_{5(i,T2)}$, LTG	1	1	1	2	4
$f_{3(i,T1)}$, LTG	4	1	1	1	1
$f_{3(i,T2)}$, LTG	8	2	2	2	2
$f_{5(i,T1)}$, LTG	4	4	4	2	1
$f_{5(i,T2)}$, LTG	8	8	8	4	2

– the parameter Q directly characterizes quality of SFs switching (internal blocking); it shows how many input liner groups (LTG) are served by an intermediate path; the parameter Q for this SF is calculated as $Q = N_{inp.T1}/f_T = 4/1 = 4$ of LTG; the parameter $Q_{3(i,T1)}$ equals to the number of input group paths of module *T*1 in the three-link SF of capacity denoted by the subscript *i*; these SFs are served by an intermediate path between module *T*1 and spatial module of Space link. As we can see from Table 3, the parameter Q in the five-link SFs of small and middle capacities equals to 1 (one) what means that these fields provide service of high quality. In the two SFs of large capacity the parameter Q increases and is 2 and 4 respectively.

– the parameter f characterizes the connectivity between block *T*2 of TSG and SSG; the coefficient of connectivity $f_{3(i,T1)}$ shows the number of intermediate paths between the time module *T*1 in a three-link SF of the capacity denoted by the subscript *i* and the spatial module of the Space link, the coefficient of connectivity $f_{5(i,T1)}$ shows the number of intermediate paths between the time module *T*1 in a five-link SF of the capacity denoted by the subscript *i* and the spatial module of the Space link.

4. Conclusion

Thirty structures of the EWSD system switching fields were constructed for the analysis in this paper. The use of standard time and spatial modules was the main condition for their construction. The efficiency (the cost of a digital channel in an equivalent switching point) of single-, three- and five-link SFs structures of five capacities ([16×16], [64×64], [128×128], [256×256], [512×512] LTG linear groups) using two time modules *T*1 and *T*2 (with the capacity of 512 and 1024 digital channels and data rate of 64 kbit\s) and three spatial modules (with the capacity of (16×16), (8×15), (15×8) TLG) is calculated. It is establised that one-link SFs with small capacity are the most efficient, but their structure needs non-standard solutions concerning the construction of structures of SFs of EWSD system. Three-link SFs are efficient with small and middle capacity. Besides, high efficiency in terms of a small cost of one channel, they also have a qualitative service of input paths as a result of larger connectivity. It is efficiently to construct five-link SFs only with large capacities of SF. In this case the five-link SFs are dozens of times cheaper than the single-link ones and are almost of the same cost as three-link SFs, but these SFs of large capacity can not be constructed on the standard time and spacial modules of EWSD system. The capacity of time modules *T*1 and *T*2 has a significant influence on the efficiency of single-link SFs only, the efficiency of these SFs increases in 1.6 - 2 times with increasing the efficiency of time modules in two times. In the three- and five-link SFs with *T*1 or *T*2 the efficiency changes by 1-5 percent.

The results obtained in the course of analysis concerning the efficiencies of SFs of different structures and capacities of the EWSD V.15 system provide the possibility to choose an optimal switching field structure in the process of switching digital systems design.

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ДОСЛІДЖЕННЯ ЕФЕКТИВНОСТІ КОМУТАЦІЙНИХ ПОЛІВ ЦИФРОВОЇ СИСТЕМИ КОМУТАЦІЇ EWSD V.15

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Внаслідок широкого впровадження цифрової системи комутації EWSD на сучасних телефонних мережах, актуальним постає питання економічної ефективності її експлуатації Для розв'язання даної проблеми, на етапі проектування цифрових систем комутації слід оптимально обирати структуру комутаційного поля. У роботі змодельовано структури одно-, трьох- і п'ятиланкових комутаційних полів п'яти ємностей цифрової системи комутації EWSD V.15, побудованих на основі стандартних двох часових і трьох просторових комутаційних модулів. Для оцінки ефективності тридцяти структур комутаційних полів обгрунтовано економічний критерій, який визначається вартістю одного цифрового каналу в еквівалентних точках комутації. В результаті аналізу встановлено, що одноланкові комутаційні поля малої ємності є найефективнішими, а трьохланкові структури ефективно реалізовувати тільки малої та середньої ємності, крім того, вони мають якісне обслуговування вхідних трактів за рахунок більшої зв'язності. П'ятиланкові комутаційні поля ефективно будувати тільки при великих ємностях, у цьому випадку, вони в десятки разів дешевші одноланкових і майже однієї вартості з трьохланковими структурами.

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