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Point-To-Point Selection Versus Point-To-Group Selection in Link Systems

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ABSTRACT

This paper is the third paper of a 3-paper-study on the loss in link systems. The first paper /1/ derives the new and reliable PPL-method for the calculation of the point-to-point loss in link systems and presents guidelines for the dimensioning of crosspoint saving link systems operating in the point-to-point selection mode (PPS-mode). The second paper /2/ shows that folded and reversed systems (so-called one-sided systems) can be mapped into load and loss equivalent two-sided ones. Thus, the calculation of loss for point-to-point selection (PPS) mode as well as for the point-to-group selection (PGS) mode can be performed by means of the method PPL /1/ or the method CLIGS /3,4/, respectively. The aim of this third paper is to give the designers and field engineers criteria how to judge and to compare some important properties of link systems operating either in the PPS-mode or PGS-mode.

1. INTRODUCTION

In two-sided as well as in one-sided link systems, two main methods are in use to provide a free path from a calling inlet in the first stage to an idle outlet of a desired group behind the last stage. The first method is the point-to-point selection mode (PPS), i.e.:

If a call is offered to an idle inlet in the first stage, an idle outlet of the desired outgoing group is determined. As a second step, the marker has to find a chain of idle links leading from the calling inlet to the a priori determined outlet of the desired trunk group. For economic reasons, many existing PP systems allow also second or more attempts, respectively, for a certain percentage of calls.

The second method is the point-to-group selection mode (PGS), i.e.:

Each call offered to an idle inlet in the first stage can hunt all accessible idle trunks of the desired group behind the last stage.

Design methods for crosspoint saving two-sided and one-sided link systems for group selection (traffic distribution) are now at hand /1,2,3,4/. Furthermore, reliable methods for the approximate calculation of the point-to-point loss as well as for the point-to-group loss are available /1,3,4/. Therefore, basing on the above mentioned methods, the goal of this paper is to give the designers and field engineers some important hints on the different properties of link systems using point-to-point selection mode or point-to-group selection mode, resp.

The following topics are discussed:

- crosspoint requirements
- marker requirements
- design of link system structures
- internal loss and total loss
- alternate routing

2. CROSSPOINT REQUIREMENTS

Fig.1 shows the required number CPL of crosspoints per line (trunk) of optimally designed link systems plotted versus the total number of inlets N_{in} or outlets $N_{out}=N_{in}$ of two-sided link systems with 3 up to 6 stages.

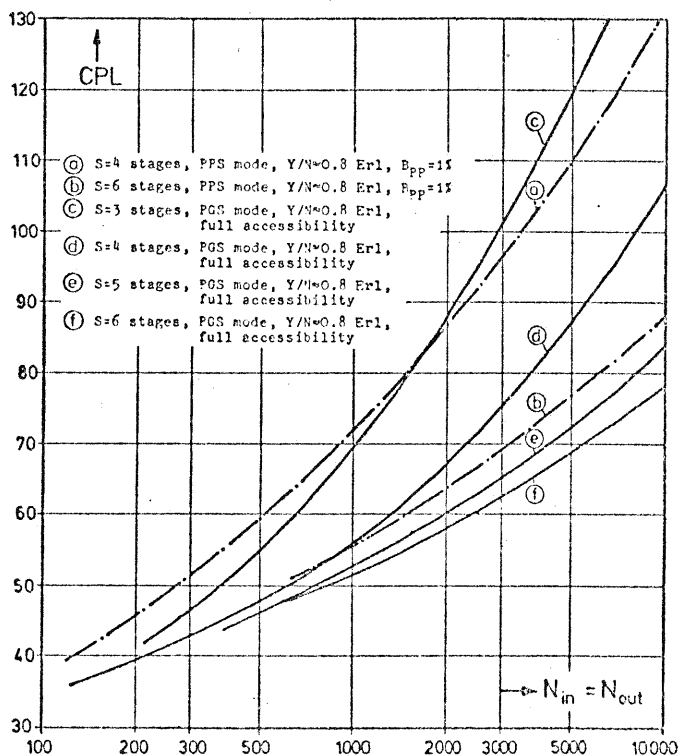


Fig.1: Crosspoint requirement per line (CPL) of two-sided link systems vs. the number of lines (inlets and outlets) $N_{in}=N_{out}$

All curves are drawn for a traffic carried of 0.8 Erl. per inlet. For link systems operating in the PPS-mode (dashed/dotted lines), a pp-loss $B_{pp}=1\%$ is the chart parameter. For link systems operating in the PGS-mode (bold lines), full accessibility i.e. negligibly small internal blocking is provided. This corresponds to a relative system transparency of about 120% /9/.

It holds

$$T_{rel} \frac{T}{N_{in}} = k_s \cdot \frac{1}{N_{in}} \prod_{j=1}^{S-1} (k_j - y_j) \quad (1)$$

Note that in /9/ this T_{rel} is also denoted as "Meshing Coefficient M^* ".

Throughout the paper, these parameters have been used for all examples and diagrams, unless otherwise stated.

Regarding the loss $B_{pp}=1\%$, it is assumed that a small percentage of repeated attempts is permitted thus diminishing the remaining loss B_{pp} practically to zero. By means of this assumption, a fair comparison is possible between PPS-mode systems on the one side and PGS-mode systems on the other side having full accessibility, i.e. negligibly internal blocking.

Comparing 4-stage systems to each other (curves a and d in Fig.1), the PGS-mode requires significantly less CPL's. The same holds true for the curves representing 6-stage systems (curves b and f). From this viewpoint of crosspoint requirements only, PGS-mode systems are more advantageous, in any case.

Next, PPS-systems are compared to PGS-systems having the same number of inlets/outlets, but one stage less. As one can see from Fig.1, 3-stage PGS-systems (curve c) require less crosspoints up to about 1700 lines than 4-stage PPS-systems do (curve a).

Comparing curve b (PPS with S=6 stages) to curve e (PGS with S=5 stages only), one finds that the PGS-mode still needs less crosspoints than the PPS-mode. However, the different crosspoint requirements of various link systems alone are not sufficient enough to decide whether a PPS or PGS link system should be chosen. Therefore, in the following chapter the marker requirements including proportional costs for other control equipments are discussed.

3. MARKER REQUIREMENTS

It is known that PPS-mode systems require less complex and less expensive markers than PGS-mode systems do having the same number of stages and the same number of inlets/outlets. Providing the same technology, PGS-systems need - as a rule - more logical operations for the switching procedure of one call. The reason is that at most all 'idle' outlets of the considered group have to be hunted. This would - in a PPS-mode system - correspond to as many repeated attempts as further outlets in the considered group exist.

On the other hand, the higher marker costs for PGS-mode switching decrease in so far, as an equivalent PGS-mode system needs remarkably less crosspoints and, hence, less links to be hunted. The following rough estimation for costs of markers (including proportional costs of other control equipments) can be made:

Comparing systems with the same number of stages, approximately 25% less crosspoints are necessary for an equivalent PGS-system. From /6/ and /8/, it can be seen that the costs for marker and control depend about linearly on the number of links and the number of stages. Thus, a saving of about 25% crosspoints and hence 25% of links leads to a corresponding saving of costs for marker and control in PGS-systems. If these savings outweigh the more complex circuitry and/or software for the PGS-control, the same total costs for crosspoints plus control in case of PPS or PGS, resp., would be obtained.

The other comparison made in Chapter 2, namely using one stage less for a PGS-system, saves only a few or no crosspoints at all. The amount of necessary marker circuitry (hardware and/or software) will then be similar to the comparatively small one of a corresponding PPS-system having S stages. In Chapter 5, Fig.9, two link systems with S=6 (PPS) and S=5 (PGS) having the same crosspoint requirement are compared with respect to their traffic behavior.

4. DESIGN OF LINK SYSTEM STRUCTURES

The design of a PPS link system having a prescribed and constant size (which shall not be extended later on) is outlined in /1/. One obtains a system requiring a number of crosspoints very close to its theoretical minimum.

The design of PGS link systems with a minimal crosspoint requirement and prescribed transparency for full or limited access has already been derived and described in /9/.

Here, in this paper, a modified way of design for PGS-systems is dealt with. It always leads to SL-systems as the method CSE for PPS-systems /1/, Chapter 5.2.2. This concept of constant block size (CBS) leaves the link block sizes and the switch sizes unchanged (as the name implies). Thus a minimum of labor is guaranteed in the case of stepwise extension of the link system. The final extension yields a value CPL very close to the theoretical minimum /9/. Smaller extension sizes have to tolerate a certain pre-investment of crosspoints. An example makes this clear.

Be chosen S=4 and a maximum of $N=1000$ inlets and outlets of a two-sided link system. The prescribed carried traffic per inlet be 0.8 Erl. The relative transparency be $T_{rel}=120\%$, thus, guaranteeing full access, i.e. negligibly small internal blocking. One obtains according to /9/ the structure shown in Fig.2a. As to the short notations, see /1/, Chapter 3.

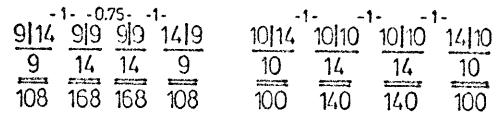


Fig.2a

Fig.2b

As one can see from Fig.2a, this structure has 12 link blocks. An average of only 0.75 links leads from a multiple in stage 2 to a link block on the right hand side. For wiring and marking purposes, this is often undesirable. Therefore, one chooses a similar single linkage structure (SL) /1/ having exactly one link from a multiple in stage 2 to a link block on the right hand side, as it is shown in Fig.2b. Both systems have a relative transparency of about 120%, and CPL=56. Up to now, the maximum size in the case of stepwise extension has been regarded. The CBS concept suggests /1/, that the initial (smallest) size consists of one link block on the left hand side and one link block on the right hand side. Hence, in this example, the initial sizes is $N_{in}=N_{out}=100$. The links between the middle stages now have to be wired either in a parallel manner or in a meshed manner.

Consequently, the next extension sizes have $N_{in}=N_{out}=200, 300$, etc. These intermediate sizes have smaller losses than the final ones. They can be calculated according to /3,4/.

Fig.3 shows a diagram for link systems with S=4 stages, operating in the point-to-group selection mode. Each horizontal bar represents a CBS-family of link systems. The left end of the bar gives the initial size, the right end the planned final size. The pair of numbers at each bar describes this CBS structure, e.g. the bar denoted with $i_1|k_1=10|14$ corresponds to the above example, where the minimum size is $N_{in}^1=i_1^1=10$, the maximum size is $i_1^3=1000$. Analogously, for a final size of 4096, one finds a switch $16|21$, hence its initial (minimum) size is $16^2=256$. It should be recalled that this diagram holds for a relative transparency of 120% and a carried traffic per inlet of $Y/N=0.8$ Erl.

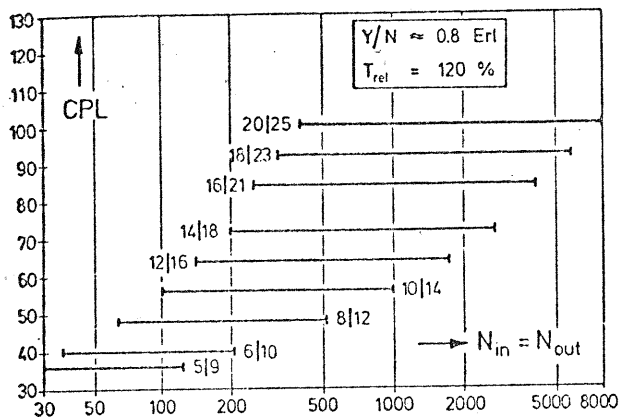


Fig. 3: Diagram for the choice of a CBS-family with suitable initial and final size, operating in the PGS-mode

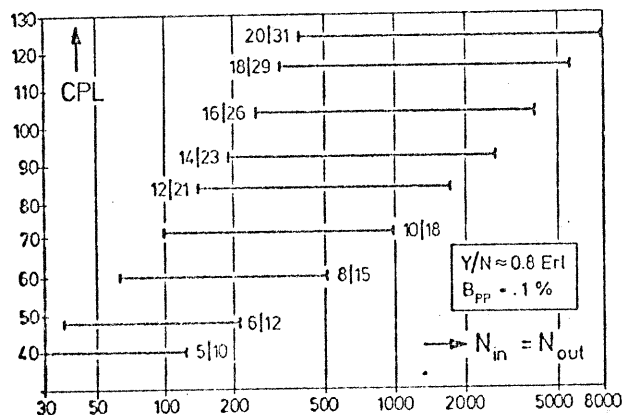


Fig. 4: Diagram for the choice of a CBS-family with suitable initial and final size, operating in the PPS-mode

Fig. 4 gives the analogous diagram for the point-to-point selection mode. As mentioned earlier, a loss $B_{pp}=1\%$ is the chart parameter here, and the carried traffic per inlet Y/N is 0.8 Erlang. Using Fig. 4, one gets the link system shown in Fig. 5 for a planned maximum size of $N=1000$ inlets/outlets.

$$\frac{10|18}{100} \quad \frac{10|10}{180} \quad \frac{10|10}{180} \quad \frac{18|10}{100}$$

Fig. 5

This system yields a loss B_{pp} of 1% for a carried traffic per inlet of 0.8 Erlang. It requires 72 crosspoints per line. The corresponding link system operating in the PGS-mode (cf. Fig. 2b) only needs 56 crosspoints per line.

The two diagrams shown in Fig. 3 and Fig. 4 enable the design engineer to dimension a link system (PGS-mode and PPS-mode, resp.) and to make a realistic comparison regarding the crosspoint costs, the marker costs, etc.

As to two-sided 6-stage systems, analogous diagrams can easily be drawn considering the fact that for $S=6$ a CBS-family has $N_{min}=i_1$ and $N_{max}=i_1^4$ inlets and outlets, where $i_1=i_2=i_3=i_4=i_5$ and $k_2=k_3=k_4=k_5=k_6$.

With regard to PPS-systems, the missing parameter $k_4=i_6$ has to be read off the Nik-Charts in /1/.

With regard to PGS-systems one designs a system for N_{max} by means of the "optimum link" method /9/. Then, one modifies the obtained structure, if necessary, such that one obtains a SL-structure having nearly the same number CPL and nearly the same relative transparency $T_{rel} \approx 1.2 \approx 120\%$.

5. INTERNAL LOSS AND TOTAL LOSS

The probability of loss E_{tot} of an outgoing trunk group behind a link system is - as it is known - composed of two parts, being defined as follows:

- the probability $p(n_p)$ that all n_p trunks of the considered outgoing group are occupied. By experience, $p(n_p)$ can be rather well approximated by $E_{1,n_p}(A_{o,r})$ where

$$A_{o,r} = \frac{y_r}{1 - E_{1,n_p}(A_{o,r})} \quad (2)$$

to be determined by iteration.

- the probability that calls get lost because of internal blocking. If the link system is operated in the PPS-mode, this probability of loss is identical with the point-to-point loss B_{pp} (one attempt provided). In case of strictly full access, $B_{pp}=0$.

If the link system is operated in the PGS-mode, the internal blocking B_{int} is also zero in the case of "strictly full accessibility" (e.g. by using a structure according to C. Clos /5/). The normally used PGS-link systems have "practically full access". Such link systems have a very small remaining probability of internal loss. This remaining internal loss comes only from those events, where the last hunted idle trunk of a desired group cannot be accessed and occupied if necessary. This loss is denoted as B_{int} , in contrast to B_{pp} .

Both parts of the total loss B_{tot} are superimposed as it is given by equations (3) and (4), respectively.

$$B_{tot} = E_{1,n_p}(A_{o,r}) + (1 - E_{1,n_p}(A_{o,r})) \cdot B_{pp} \quad (3)$$

- if PPS is applied

$$B_{tot} = E_{1,n_p}(A_{o,r}) + (1 - E_{1,n_p}(A_{o,r})) \cdot B_{int} \quad (4)$$

- if PGS is applied.

Fig. 6 shows B_{pp} and B_{int} drawn vs. the carried traffic per trunk y_r/n_p for a group having $n_p=64$ trunks. The bold lines marked with the number ① through ④ shows the loss calculation for B_{pp} of 4 various link systems operating in the PPS-mode. Their structure is given in Fig. 7. The dashed lines marked with ① and ② show the internal loss B_{int} , if the link systems ③ and ④ are operated in the PGS mode. The curves denoting B_{int} for the systems ③ and ④ could not be included in Fig. 6, because their loss B_{int} is far below 0.2%.

It should be emphasized that in Fig. 6 as well as later on in Fig. 8 the curves are drawn vs. the carried traffic per inlet Y/N . In these diagrams, a uniform carried traffic per trunk of each outgoing group is prescribed. Hence, it holds $y_r/n_p = Y/N$.

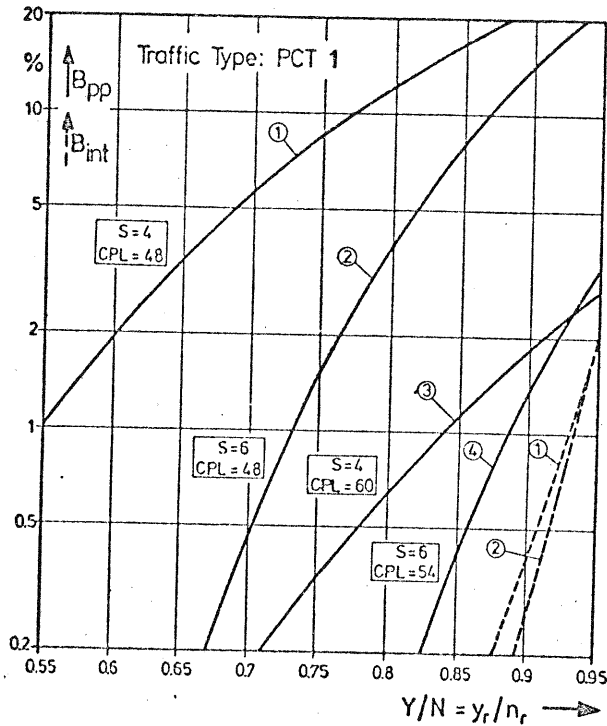


Fig. 6: Point-to-point loss B_{pp} and internal loss B_{int} vs. carried traffic per inlet Y/N , here equal to the carried traffic per trunk y_r/n_r (uniform trunk group size $n_r=64$)

PPS-mode ——— } $n_r=64$ trunks
 PGS-mode - - - - - }
 Considered structures see Fig. 7

In Fig. 8, the total loss B_{tot} of the previously discussed structures is drawn vs. the carried traffic per trunk y_r/n_r . Here, the dashed line represents the loss of a full accessible group having 64 trunks. The bold lines marked with the numbers ① through ④ denote the total loss B_{tot} of the same 4 link systems as in Fig. 6 all operating in the PPS-mode. The corresponding curves of the four structures operating in the PGS-mode, practically coincide with the dashed line representing Erlang's loss of a full accessible group.

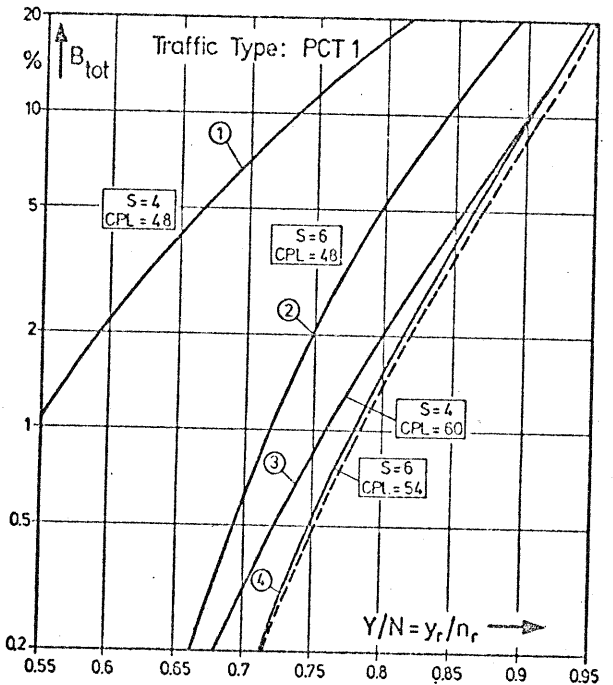


Fig. 8: Total loss B_{tot} per group with $n_r=64$ trunks vs. carried traffic per inlet Y/N , here equal to the carried traffic per trunk y_r/n_r

PPS-mode ——— } $n_r=64$ trunks
 full accessible group - - - - - }

- ① $\frac{8|12}{8} \frac{-1}{12} \frac{-1}{12} \frac{-1}{12} \frac{-1}{8}$
- ② $\frac{5|8}{5} \frac{-1}{8} \frac{-1}{40} \frac{-1}{40} \frac{-1}{40} \frac{-1}{40} \frac{-1}{5}$
- ③ $\frac{8|15}{8} \frac{-1}{15} \frac{-1}{15} \frac{-1}{15} \frac{-1}{8}$
- ④ $\frac{5|9}{5} \frac{-1}{9} \frac{-1}{45} \frac{-1}{45} \frac{-1}{45} \frac{-1}{45} \frac{-1}{5}$

Fig. 7: Structures considered in Fig. 6 and Fig. 8

Comparing the traffic behavior of the above 4 investigated examples it can be seen from Fig. 6 and Fig. 8 that any link systems operating in the PGS-mode instead of the PPS-mode can carry significantly more traffic for a certain prescribed grade of service.

Of course there are also other viewpoints like marker requirements, operational considerations etc. that have an influence on the choice of the selection mode.

Finally, Fig. 9 gives the comparison, mentioned in Chapter 3, between two link systems with 6 stages (PPS-mode) and 5 stages (PGS-mode), respectively. Both link systems were designed for about 0.5 Erl. per inlet where $B_{pp}=1.6\%$ was tolerated for the 6-stage PPS-system. One can see, that the PGS-system has practically full access at least up to 0.65 Erl. per inlet. The large difference of B_{tot} in Fig. 9 is mainly caused by the internal loss B_{pp} of system 6, which - in practice - will be very much reduced by means of repeated attempts.

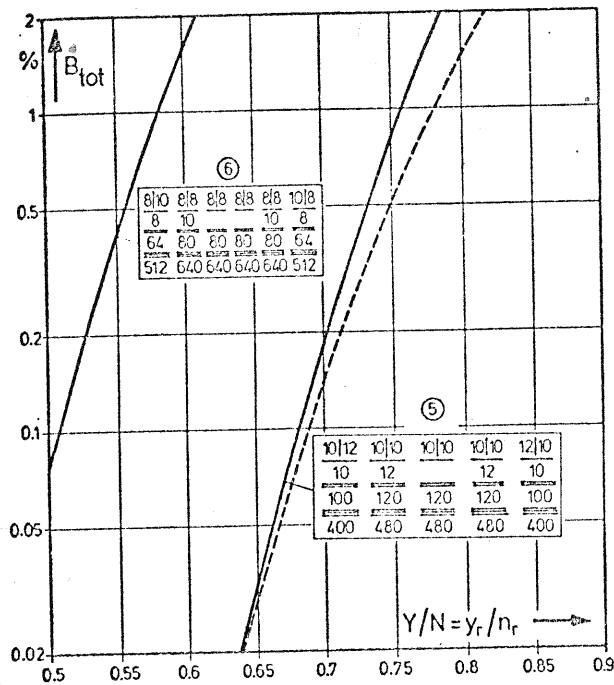


Fig. 9: Comparison between two systems of equal size ($N=4096$ and $N=4000$) and with equal crosspoint requirement $CPL=60$

——— B_{tot} ⑤ PGS-mode
 - - - - B_{tot} ⑥ PPS-mode
 - - - - full accessible group

$n_r = 64$ trunks

6. ALTERNATE ROUTING

As to high-usage groups and overflow to final groups, PGS-mode link systems with practically full access do not cause special problems. The best economic distribution of the traffics among the various high-usage and final groups, respectively, furthermore the dimensioning of groups for offered peaked overflow can simply be done by the tables [7] published at the 7th ITC in Stockholm.

PPS-mode link systems operating with alternate routing (mostly in toll exchanges) should be dimensioned such that for the highest expected total traffic of the system the loss P_{pp} remains still very small ($P_{pp} < 1\%$). Already a limited number of repeated attempts, e.g. at most two per trunk group causes up to 8 repeated attempts to be performed by the marker if a call hunts three high-usage and one final group.

Otherwise, a larger number of necessary point-to-point markers in case of alternate routing is unavoidable. Also such increased PPS-marker costs could be a reason to compare them with PGS-marking which never needs repeated marker attempts.

The well-known problems of common control overload caused by nervously repeated calls from subscribers, also causes a traffic overload in all toll exchanges between the subscriber and the bottle-neck in the DDD network. This overload in traffic distribution link systems operating in the PPS-mode increases, of course, the loss B_{pp} and therewith the necessary number of repeated marker attempts. It increases also the marker traffic and eventually causes undesired marker delay. Such PPS-markers are overloaded twice in such cases,

first by the increased carried traffic of the system (actual traffic), and second by the waste traffic caused by repeated subscriber attempts.

Operating in the PGS-mode, this marker is not influenced by the above first mentioned overload effect. Only the second effect (many repeated attempts by the subscribers) causes a marker overload. This makes the PGS-mode less sensitive against overload.

7. SUMMARY

Some characteristic features of link systems operating with point-to-point selection (PPS) or point-to-group selection (PGS) have been compared.

For the time being, it seems that many administrations and many manufacturing companies prefer link systems for traffic distribution operating in the point-to-point selection mode. The reason seems to be (among others) their less complex and therefore cheaper and comparatively faster marker techniques.

On the other hand, the advantages of PGS-mode link systems which can be seen from the comparisons in this paper may have a better chance in the future regarding the decreasing costs of semiconductor circuitry and/or software facilities for PGS-markers.

8. ACKNOWLEDGMENT

The authors wish to express their thanks to the Federal Ministry of Research and Technology (BMFT) of the F.R. of Germany as well as to the Federal German Research Association (DFG) for supporting these studies for many years.

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