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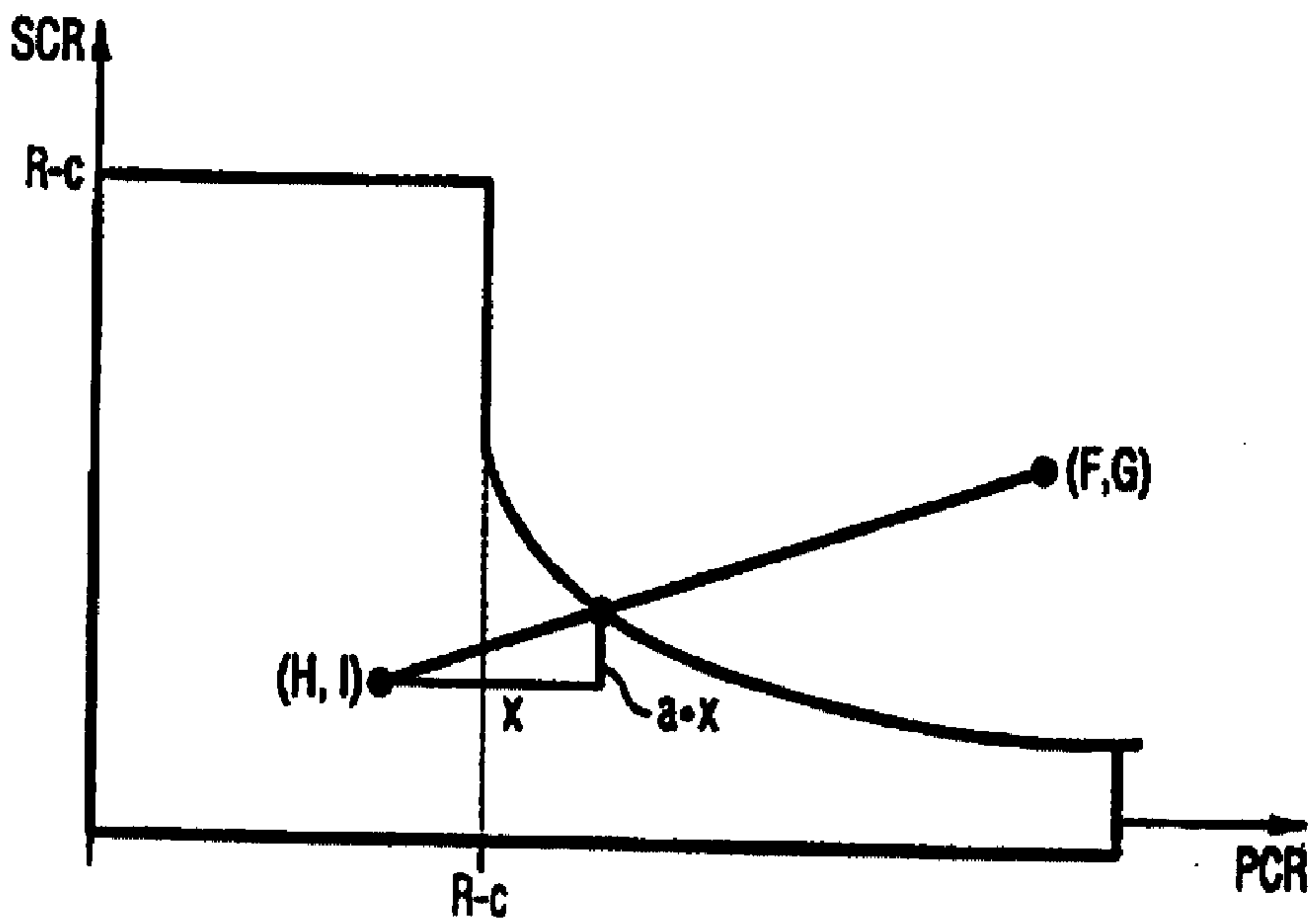
(54) **PROCEDE POUR DETERMINER LE DEBIT BINAIRE NECESSAIRE A UN CERTAIN NOMBRE DE LIAISONS DE TRANSMISSION A MULTIPLEXAGE STATISTIQUE**

(54) **METHOD FOR DETERMINING THE REQUIRED BIT RATE FOR A NUMBER OF COMMUNICATIONS CONNECTIONS WHICH CAN BE STATISTICALLY MULTIPLEXED**



(57) L'invention concerne un procédé pour la commande de l'acceptation ou du refus d'une nouvelle liaison sur un système de transmission MTA disposant d'une capacité maximale R_{max} et traitant déjà une pluralité M de liaisons à multiplexage statistique, la nouvelle liaison présentant une vitesse maximale des cellules (PCR) et une vitesse moyenne des cellules (SCR). Ce procédé consiste à déterminer la somme P_{m+1}=.SIGMA.$SPCR_i$ de la vitesse maximale des cellules (PCR) et la somme S_{M+1}=.SIGMA.SCR_i de la vitesse moyenne des cellules (SCR) des liaisons existantes (M) et de la

(57) The invention relates to a method for controlling the acceptance or refusal of a new connection on an ATM communications device having a maximal capacity R_{max} which already handles a plurality M of connections that can be statistically multiplexed, whereby the new connection has a peak cell rate PCR and a sustainable average cell rate SCR. The inventive method comprises the following steps: Determining the sum P_{M+1}=.SIGMA.PCR_i of the peak cell rate PCR, the sum S_{M+1}=.SIGMA.SCR_i of the sustainable cell rate SCR of the M existing connections, and the new

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nouvelle liaison, à déterminer la variance (V) des vitesses des cellules des liaisons M+1, à déterminer la capacité de charge$_{M+1}$ nécessaire pour les M liaisons en fonction de P_M, S_M et V, et à accepter la liaison au cas où la charge$_{M+1}$ est inférieure ou égale à R_{max}. Le calcul exact de la capacité nécessaire pour les liaisons de transmission permet d'exécuter la commande d'acceptation de la liaison plus rapidement et plus efficacement et indépendamment de la séquence des liaisons acceptées.

connection; determining the variance V of the cell rates of the M+1 connections; determining the required capacity load$_{M+1}$ for the M connections according to P_M, S_M and V, and; accepting the connection in the case when load$_{M+1}$ is less than or equal to R_{max}. The connection acceptance control can be carried out faster, more effectively and independent of the sequence of accepted connections by the exact calculation of the required capacity of the communications connections.

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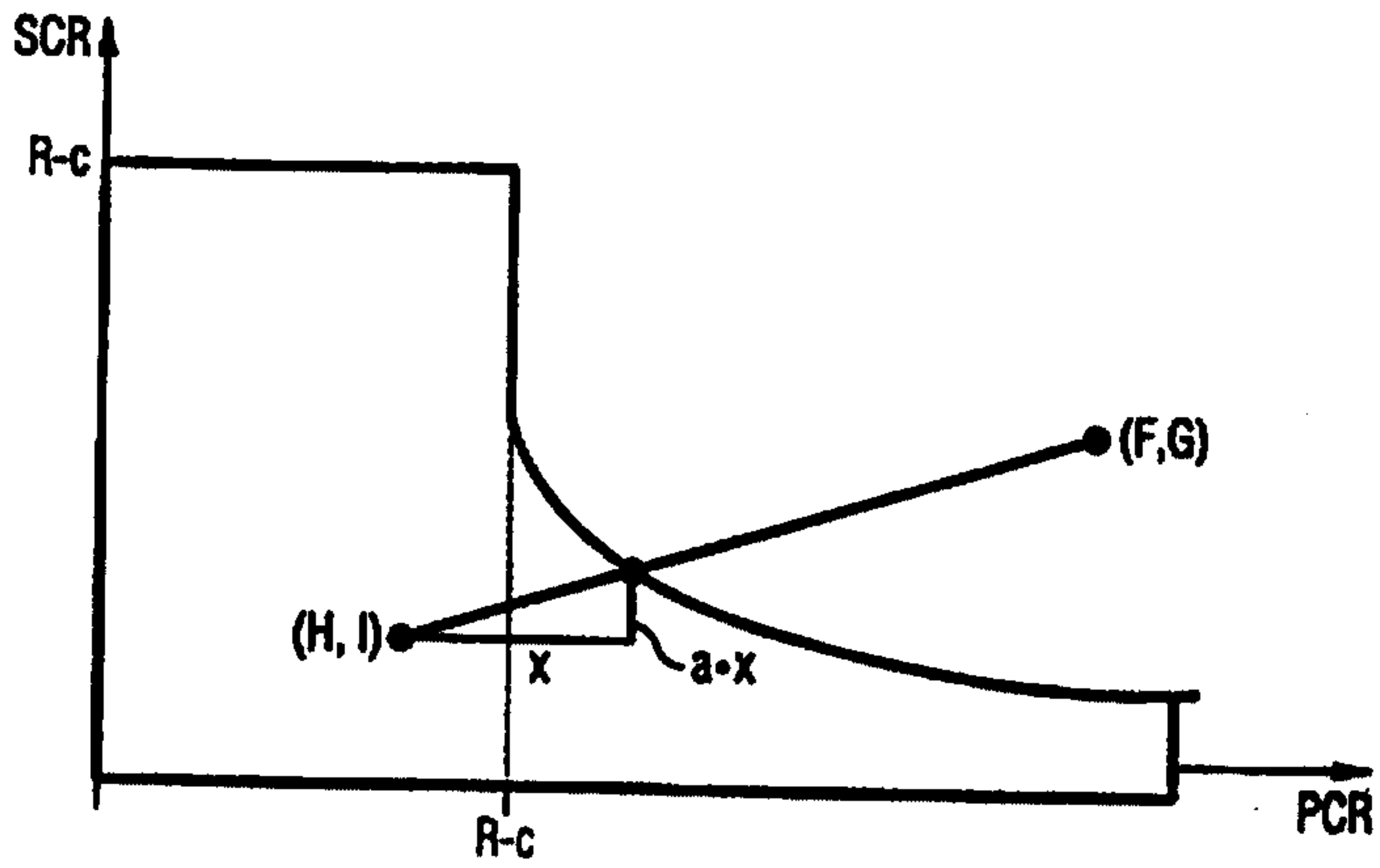
(54) Title: METHOD FOR DETERMINING THE REQUIRED BIT RATE FOR A NUMBER OF COMMUNICATIONS CONNECTIONS WHICH CAN BE STATISTICALLY MULTIPLEXED

(54) Bezeichnung: VERFAHREN ZUR BESTIMMUNG DER ERFORDERLICHEN BITRATE FÜR EINE ANZAHL STATISTISCH MULTIPLEXBARER KOMMUNIKATIONSVERBINDUNGEN

(57) Abstract

The invention relates to a method for controlling the acceptance or refusal of a new connection on an ATM communications device having a maximal capacity R_{max} which already handles a plurality M of connections that can be statistically multiplexed, whereby the new connection has a peak cell rate PCR and a sustainable average cell rate SCR. The inventive method comprises the following steps: Determining the sum $P_{M+1}=\Sigma PCR_i$ of the peak cell rate PCR, the sum $S_{M+1}=\Sigma SCR_i$ of the sustainable cell rate SCR of the M existing connections, and the new connection; determining the variance V of the cell rates of the M+1 connections; determining the required capacity $load_{M+1}$ for the M connections according to P_M, S_M and V, and; accepting the connection in the case when $load_{M+1}$ is less than or equal to R_{max}. The connection acceptance control can be carried out faster, more effectively and independent of the sequence of accepted connections by the exact calculation of the required capacity of the communications connections.



GR 98 P 1272

Description

Method for determining the required bit rate for a number of communication connections which can be statistically multiplexed

The invention relates to a method for calculating the required bit rate of a number of communication connections which can be statistically multiplexed and to a method for controlling the acceptance or refusal of a new connection on an ATM communication device with a capacity R_{max} which is already handling a number M of connections which can be statistically multiplexed.

In the Asynchronous Transfer Mode (ATM), data are transmitted independently of the information represented by them (voice communication, data communication, multimedia) in cells of 53 bytes (48 bytes of useful data and 5 bytes of control data). The network resources of a communication device, such as for example a multiplexer, a line or a switching matrix, are in this case shared by connections with different grade-of-service and bit-rate requirements. At the same time, it must be ensured by a so-called traffic control that, in spite of the joint transmission of data cells of various origin, various bit rates and various bit rate statistics, the required grade of transmission performance of the ATM layer is ensured. In particular, it must be ensured that the probability of cell loss is very low, for example less than 10^{-10}, and the transmission time variations of the cells do not exceed a certain value.

In an ATM network, various types of connection are possible, distinguished by their bit rate statistics. A connection with a **constant bit rate** or deterministic bit rate has a fixed transmission bit rate (cell rate) over the entire duration of the connection. This bit rate must be constantly provided by the network. This type of connection is particularly suitable for real-time applications, such as voice communication for example, in which strict requirements are imposed on the cell delay variations and which have a virtually constant transmission rate.

A further type of connection is the **available bit rate**, the data being transmitted according to the network capacity available at a given time. This type of connection is not suitable for real-time applications, but for example as a low-cost data transmission, such as e-mail for example.

With the **statistical bit rate** type of connection, the data to be transmitted are transmitted on a virtual connection with a transmission rate varying over time. Examples of such a type of connection are video connections in which the video signals are encoded with a variable bit rate and voice communication with pause suppression and certain data transmission services. Connections with a statistical bit rate, in which the average bit rate is significantly below the maximum bit rate are suitable for **statistical multiplexing.** In this case, many connections are carried with a statistical bit rate over a common line or a common switching matrix, it not being necessary for each individual connection to reserve the maximum bit rate, since many uncorrelated connections with a low average bit rate in comparison with the maximum bit rate share the available transmission capacity on average. It is thus possible to "overbook" the line to a certain extent. The network infrastructure can be better utilized overall in this way.

To enable the network operator to provide adequate capacity for a number of communication connections with a statistical bit rate that are independent of one another, the maintenance of certain traffic parameters must be ensured by technical precautionary measures at the terminal devices or the like in a so-called traffic agreement. The traffic agreement regulates among other things the maximum bit rate (or peak cell rate, PCR) and the average bit rate or corresponding average sustainable cell rate (SCR). The peak cell rate PCR in this case gives the maximum number of ATM cells per unit of time taken up by the connection and the average sustainable cell rate SCR gives the average number of ATM cells per unit of time permissible over a prolonged period of time.

The problem with the connection acceptance control of connections which can be statistically multiplexed, i.e. connections with a statistical bit rate for which the ratio of the maximum bit rate to the average bit rate is above a certain value, is that on the one hand it is necessary to avoid cell losses, which may occur due to the simultaneous transmission of many connections at a high bit rate, and on the other hand it is necessary to make it possible for the ATM connection or the ATM communication device to be utilized to the greatest possible extent. Various connection acceptance methods of this kind are known.

One possibility is to reserve the peak cell rate PCR for each communication connection. Consequently, cell losses caused by overloading of the communication connection cannot occur, but the advantages of statistical multiplexing, i.e. the better utilization of the communication device by connections with a varying cell rate that are independent of one another cannot be exploited.

If, on the other hand, only the average sustainable cell rate SCR is reserved for each connection, intolerable cell losses occur even when there are small variations in the overall cell rate. Only when there is a very high number of connections that are independent of one another does the capacity required for transmission of the connections without any cell loss come close to the sum of the average sustainable cell rates of the individual connections.

One known method for controlling the acceptance of connections which can be statistically multiplexed is the so-called sigma rule, which is described in European Patent EP 0 433 699 B1 and in Rathgeb, Wallmeier "ATM-Infrastructur für die Hochleistungskommunikation" [ATM infrastructure for high-performance communication], pages 148 to 150. In this method, an additional connection is still accepted along with a number M of already existing connections if an upper estimate of the transmission bit rate necessary for the transmission of the M+1 connections is less than or equal to the maximum bit rate R_{max} of the communication device.

The estimate of the required capacity in the case of the sigma rule is given by the addition of the sum $S_{M+1}=\Sigma SCR_i$ of the average sustainable cell rates of the M+1 connections which can be statistically multiplexed to a factor $Q(R)*\sqrt{V_{M+1}}$, where Q(R) is a quantile function which indicates the statistical behavior of the connections in dependence on the required bit rate, and V is an estimate of the variance of the bit rates of the M+1 connections.

If the capacity of a transmission device is shared with other types of traffic, for example traffic at an unspecified bit rate or available bit rate, the capacity R available for the traffic to be multiplexed is no longer known.

Until now, the sigma rule has been extended to cope with this problem and the capacity of the M already reserved connections used as the decision parameter for the acceptance of the M+1th connection. This capacity is iteratively increased when setting up further connections, to be precise by the average sustainable cell rate of the connection to be added if the sigma rule will accept the connection for this capacity, otherwise by the peak cell rate. By this procedure, the capacity determined is dependent on the setting-up sequence.

The invention is therefore based on the object of proposing a method for controlling the acceptance or refusal of a new connection of an ATM communication device with a given capacity R_{max} which is independent of the sequence of the acceptance of the connections of the communication device.

The object is achieved by a method described in claim 1 for controlling the acceptance or refusal of a new connection on the ATM communication device.

The new connection is characterized by its peak cell rate PCR and its average sustainable cell rate SCR. By the method according to the invention, the sum $P_{M+1}=\Sigma PCR_i$ of the peak cell rates and the sum $S_{M+1}=\Sigma SCR_i$ of the average sustainable cell rates of the existing and new connections and the variance V of the cell rates are determined. In dependence on these variables, the required capacity $load_{M+1}$ of the M+1 connections is determined and the new connection is accepted if the required capacity $load_{M+1}$ is less than or equal to the maximum capacity R_{max} of the ATM communication device.

By contrast with the known sigma rule, in the method according to the invention the overall required capacity $load_{M+1}$ is calculated exactly. It is not just determined whether or not a new connection can be set up. Consequently, the result achieved by the method according to the invention is independent of the sequence in which the connections are set up.

Since the required capacity is calculated, and consequently also the free capacity available at a given time, users or management centers of the communication device can be notified of this, making it possible for the network to be utilized more effectively.

In a variant of the method according to the invention as claimed in claim 2, the connection is accepted if the minimum of the variables $load_{M+1}$ and P_{M+1} is less than or equal to the maximum capacity R_{max}. If the calculated capacity $load_{M+1}$

is greater than the sum of the maximum bit rates P_{M+1}, it is sufficient to reserve the sum of the maximum bit rates P_{M+1}.

The required bit rate $load_M$ for M connections can be calculated with the assumption of a fictitious bit rate $R=S_M \times Q(R) \times \sqrt{V}$, where Q(R) is a fixed, empirically determined so-called quantile function of R. The required bit rate $load_M$ is that fictitious bit rate R for which the relationship

$$R = S_M + Q(R) \cdot \sqrt{V})$$

is satisfied.

The solution to this equation can be determined iteratively by suitable methods of approximation.

The quantile function Q(R) can be chosen to be q_1+q_2/R, the hyperbolic quantile q_1 and the hyperbolic factor q_2 of the associated sigma class being empirically determined by simulation calculations.

Then, $load_M$ can be determined by numerical extraction of the root

$$load = x_0/2 + \sqrt{q_2} \cdot \sqrt{V} + x_0^2$$

where x0 is equal to $q_1 \cdot \sqrt{V}$.

The invention is described below with reference to the drawing, in which

Figure 1 is a graph to explain the calculation of the required capacity of a number of connections which can be statistically multiplexed;

Figure 2 is a graph to illustrate an iteration method for calculating the required capacity; and

Figure 3 is a graph to explain application of the method according to the invention.

A communication device, such as for example a communication line, a switching matrix or the like, has an overall available capacity R_{max}, i.e. a connection with a constant bit rate R_{max} can be accepted.

A number M of communication connections which can be statistically multiplexed are transmitted via the communication devices, characterized by a peak cell rate PCR and an average sustainable cell rate SCR. $P_M = \Sigma PCR_i$ then denotes the sum of the peak cell rates of the M connections and $S_M = \Sigma SCR_i$ denotes the sum of the average sustainable cell rates of the connections.

$$V = \Sigma SCR_i \ (PCR_i - SCR_i)$$

is the estimate of the variance of the cell rates of the M connections.

If

$$S_M + \sqrt{V} \cdot Q(R) \leq R \qquad (1)$$

is satisfied for a bit rate, this capacity is sufficient for all M connections to be accepted. In this case, Q(R) is an empirically determined quantile function. For Q(R), the function $q_1 + q_2/R$ is known as a good approximation, the factors q_1 and q_2 being determined by simulations and depending on the ratio of the peak cell rate to the average sustainable cell rate of the connections. q_1 is, for example, of the order of magnitude of 10, q_2 is of the order of magnitude of 10^5. Inequation 1 can then be written as:

$$(q_1 + q_2/R) \cdot \sqrt{V} + S_M \leq R \qquad (2)$$

The right and left sides of the inequation are graphically represented in Figure 1. The function $y(R)=R$ is a linear, monotonously rising function, while the function $y=q_1+q_2/R\cdot\sqrt{V}+S_M$ falls hyperbolically with higher values of R. The intersection point of the two graphs is the value R=load, which gives the required capacity exactly (within the accuracy of the assumptions made). By determining this intersection R=load, the capacity required by the M connections which can be statistically multiplexed can consequently be determined exactly, while in the case of the sigma rule it is just determined whether or not a new connection can be accepted at a given time. The exact calculation of the overall capacity has the advantage that it does not depend on the sequence in which the connections are accepted. Furthermore, the required capacity, and consequently also the free capacity available at a given time, can be indicated and users of the communication device can be notified of it.

For the calculation of load, there are the following possibilities. On the one hand, the equation

$$(q_1 + q_2/\text{load}) \cdot \sqrt{V} + S_M = \text{load} \quad (3)$$

can be resolved for load if $x0:=q_1\cdot\sqrt{V}$ is defined:

$$\text{load} = x_0/2 + \sqrt{q_2} \cdot \sqrt{V} + x_0^2 \quad (4)$$

Alternatively, R=load can also be determined iteratively. The method is schematically represented in Figure 2. From the starting point $\text{load}_0=q_1\cdot\sqrt{V}+S_M$, load is determined iteratively as

$$\text{load}_{n+1} = (q_1 + q_2/\text{load}_n) \cdot \sqrt{V} + S_M \quad (5).$$

A C program for executing this algorithm is enclosed with the patent application as an annex. In 10^7 calculations for the acceptance of a connection, the relative error

of load in three iterations was below 3×10^{-4}. An odd number of iteration steps ensures that the required capacity is overestimated and not underestimated.

The exactly calculated capacity $load_M$ at a given time for M connections of the communication device can in turn be used for effective acceptance control of the communication device. Since the capacity $load_M$ required for M existing connections is continuously available, when there is a new request for a connection with a peak cell rate PCR and an average sustainable cell rate SCR, the connection can be accepted without further calculation if the free capacity $R_{max}-load_M$ is greater than PCR and can be refused without further calculation if $R_{max}-load_M$ is less than SCR. Only if the load of the communication device is in the range lying in between is a new calculation of the load $load_{M+1}$ of the M+1 connections required before acceptance. As soon as the connection has been set up, the load calculation is extended to all the existing connections.

A further application of the present invention is explained with reference to Figure 3.

In the case of a connection with a variable bit rate, it may be characterized not only by the peak cell rate F and average sustainable cell rate G but also by a peak cell rate required as a minimum H_{min} and an average sustainable cell rate required as a minimum I_{min}. An example of this is a video telephone service, which requires a minimum transmission bandwidth of, for example, 64 KB per second to be able to build up a picture at all. A high bandwidth is desirable, but not absolutely necessary, for real-time transmission of the mimic or the like.

In Figure 3, the average sustainable cell rate SCR is plotted against the peak cell rate PCR in a diagram. The peak cell rate F and the average sustainable cell rate G form the point (F, G) which characterizes the ideal state of the connection. The point (H, I) formed by the minimum cell rates H_{min} and I_{min} gives the minimum requirements for the connection. The task of the connection acceptance control is to accept the connection with a variable (as great as possible) bandwidth if it is ensured that the minimum conditions H_{min}, I_{min} are always satisfied. This acceptance control can be realized on the basis of the exact calculation of the available capacity $load_M$.

If the combination of parameters at the edge of the gray area with the straight-line through (H, I) and (F, G) is assumed, the capacity available is fully utilized and the prescribed rates are taken well into account. a is the slope of the straight-line (H, I)-(F, G) and x is the difference between the peak cell rate sought and H_{min}. Then, the sought average sustainable cell rate c is obtained as the sum of the minimum cell rate and a·x:

$$c = (q_1+q_2/c) \cdot \sqrt{V+(I+a\cdot x)(H+x-(I+a\cdot x))} + S_M + I + a \cdot x \qquad (6)$$

where x corresponds to the required capacity load and can be calculated from equations (3) and (5). Equation (6) is equivalent to a quadratic equation in x and can be calculated by suitable numerical iteration methods.

The invention makes possible for the first time an exact calculation of the required capacity $load_M$ of a number M of connections which can be statistically multiplexed, characterized by a peak cell rate PCR and an average sustainable cell rate SCR.

Patent claims

1. A method for determining a required capacity $load_M$ on an ATM communication device by which a plurality M of connections which can be statistically multiplexed is being handled, according to which the capacity $load_M$ required for the M existing connections is determined by resolving an equation G_Z: $\mathbf{load_Z = S_Z + Q(load_Z) * \sqrt{V_Z}}$ for Z = M, where the following applies:

- $load_M$ is a capacity of the M connections,
- $S_M = \Sigma [SCR_i]$ with $1 <= i <= M$,
- $Q(load_M)$ is a fixed function of $load_M$,
- $V_M = \Sigma [SCR_i * (PCR_i - SCR_i)]$ with $1 <= i <= M$,
- PCR_i is a peak cell rate and SCR_i is an average sustainable cell rate of the connection with index i.

AMENDED SHEET

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Patent claims

~~1. A method for determining a required capacity $load_M$ on an ATM communication device by which a plurality M of connections which can be statistically multiplexed is being handled, according to which the capacity $load_M$ required for the M existing connections is determined by resolving an equation G_Z: $\mathbf{load_Z = S_Z + Q(load_Z) * \sqrt{V_Z}}$ for Z = M, where S_Z is a sum of average sustainable cell rates SCR_i of Z connections, $load_Z$ is a capacity of the Z connections, $Q(load_Z)$ is a fixed function of $load_Z$, and V_Z is a variance of the average sustainable cell rates SCR_i of the Z connections.~~

2. The method as claimed in claim 1, characterized in that, given a maximum capacity R_{max} of the ATM communication device, a new connection with an average sustainable cell rate SCR_{M+1} is accepted if a fictitious capacity $load_{M+1}$, which is determined for the M existing connections and the new connection by resolving the equation G_Z for Z = M+1, satisfies the condition: $load_{M+1} <= R_{max}$.

3. The method as claimed in one of claims 1 or 2, characterized in that P_{M+1}, a sum of the peak cell rates PCR_i of the M existing connections and the new connection, is additionally determined and the new connection is accepted if the following condition is satisfied:

$$\text{minimum}\ (P_{M+1}, load_{M+1}) <= R_{max}.$$

4. The method as claimed in one of claims 1 to 3, characterized in that the required capacity $load_M$ is continuously available, the new connection has a peak cell rate PCR_{M+1} and the new connection is already accepted before determination of the fictitious capacity $load_{M+1}$ if the following condition is satisfied:

$$load_M + PCR_{M+1} <= R_{max},$$

REPLACEMENT SHEET

IPEA/EP

and the new connection is refused without determination of the fictitious capacity $load_{M+1}$ if the following condition is satisfied:

$$load_M + SCR_{M+1} > R_{max}.$$

5. A method for determining a still transmissible average sustainable cell rate SCR_C and a still transmissible peak cell rate PCR_C for a new connection with an average sustainable cell rate SCR_{M+1}, a peak cell rate PCR_{M+1}, an average minimum sustainable cell rate SCR_{MIN} and a minimum peak cell rate PCR_{MIN} on an ATM communication device, by which a plurality M of connections which can be statistically multiplexed is being handled, according to which the still transmissible average sustainable cell rate SCR_C and the still transmissible peak cell rate PCR_C are determined by resolving an equation G_Z: $\mathbf{load_Z = S_Z + Q(load_Z) * \sqrt{V_Z}}$ for Z = C, where

- $load_C = SCR_C$,
- $S_C = S_M + SCR_{MIN} + a*x$,
- $Q(load_C)$ is a fixed function of $load_C$,
- $V_C = V_M + (SCR_{MIN} + a*x) * [(PCR_{MIN} + x) - (SCR_{MIN} + a*x)]$,
- S_M is a sum of average sustainable cell rates SCR_i of the M connections,
- $a = (SCR_{M+1} - SCR_{MIN}) / (PCR_{M+1} - PCR_{MIN})$,
- $x = PCR_C - PCR_{MIN}$, and
- V_M is a variance of the average sustainable cell rates SCR_i of the M connections.

6. The method as claimed in claim 5, characterized in that the still transmissible average sustainable cell rate SCR_C and the still transmissible peak cell rate PCR_C are determined if the new connection with the average sustainable cell rate SCR_{M+1} and the peak cell rate PCR_{M+1} is refused and would be accepted with the average minimum sustainable cell rate SCR_{MIN} and the minimum peak cell rate PCR_{MIN}.

5. A method for determining a still transmissible average sustainable cell rate SCR_C and a still transmissible peak cell rate PCR_C for a new connection with an average sustainable cell rate SCR_{M+1}, a peak cell rate PCR_{M+1}, an average minimum sustainable cell rate SCR_{MIN} and a minimum peak cell rate PCR_{MIN} on an ATM communication device, by which a plurality M of connections which can be statistically multiplexed is being handled, according to which the still transmissible average sustainable cell rate SCR_C and the still transmissible peak cell rate PCR_C are determined by resolving an equation G_Z: $\mathbf{load_Z = S_Z + Q(load_Z) * \sqrt{V_Z}}$ for Z = C, where the following applies:

- $load_C = SCR_C$,
- $S_C = S_M + SCR_C$ with $S_M = \Sigma [SCR_i]$ and $1 <= i <= M$,
- $Q(load_C)$ is a fixed function of $load_C$,
- $V_C = V_M + (SCR_C) * (PCR_C - SCR_C)$ with $V_M = \Sigma [SCR_i * (PCR_i - SCR_i)]$ and $1 <= i <= M$,
- $SCR_C = SCR_{MIN} + a*x$
- $PCR_C = PCR_{MIN} + x$,
- $a = (SCR_{M+1} - SCR_{MIN}) / (PCR_{M+1} - PCR_{MIN})$,
- $x = PCR_C - PCR_{MIN}$,
- PCR_i is the peak cell rate and SCR_i is the average sustainable cell rate of the connection with index i.

and the new connection is refused without determination of the fictitious capacity $load_{M+1}$ if the following condition is satisfied:

$$load_M + SCR_{M+1} > R_{max}.$$

5. A method for determining a still transmissible average sustainable cell rate SCR_C and a still transmissible peak cell rate PCR_C for a new connection with an average sustainable cell rate SCR_{M+1}, a peak cell rate PCR_{M+1}, an average minimum sustainable cell rate SCR_{MIN} and a minimum peak cell rate PCR_{MIN} on an ATM communication device, by which a plurality M of connections which can be statistically multiplexed is being handled, according to which the still transmissible average sustainable cell rate SCR_C and the still transmissible peak cell rate PCR_C are determined by resolving an equation G_Z: $\mathbf{load_Z = S_Z + Q(load_Z) * \sqrt{V_Z}}$ for Z = C, where

- $load_C = SCR_C$,
- $S_C = S_M + SCR_{MIN} + a*x$,
- $Q(load_C)$ is a fixed function of $load_C$,
- $V_C = V_M + (SCR_{MIN} + a*x) * [(PCR_{MIN} + x) - (SCR_{MIN} + a*x)]$,
- S_M is a sum of average sustainable cell rates SCR_i of the M connections,
- $a = (SCR_{M+1} - SCR_{MIN}) / (PCR_{M+1} - PCR_{MIN})$,
- $x = PCR_C - PCR_{MIN}$, and
- V_M is a variance of the average sustainable cell rates SCR_i of the M connections.

6. The method as claimed in claim 5, characterized in that the still transmissible average sustainable cell rate SCR_C and the still transmissible peak cell rate PCR_C are determined if the new connection with the average sustainable cell rate SCR_{M+1} and the peak cell rate PCR_{M+1} is refused and would be accepted with the average minimum sustainable cell rate SCR_{MIN} and the minimum peak cell rate PCR_{MIN}.

7. The method as claimed in one of the preceding claims, characterized in that the variance V_Z is chosen as

$$V_Z = \Sigma [SCR_i * (PCR_i - SCR_i)]$$

where PCR_i are peak cell rates of the Z connections with $1 <= i <= Z$.

8. The method as claimed in one of the preceding claims, characterized in that the fixed function $Q(load_Z)$ is chosen as

$$Q(load_Z) = q_1 + q_2 / load_Z,$$

where q_1 is a hyperbolic quantile and q_2 is a hyperbolic factor.

9. The method as claimed in one of the preceding claims, characterized in that the solution of the equation G_Z is determined iteratively.

10. The method as claimed in claims 8 and 9, characterized in that the iteration is begun at a starting point

$$load_0 = S_Z + q_1 * \sqrt{V_Z}$$

and $load_i$ is determined in each iteration step by

$$load_i = S_Z + (q_1 + q_2 / load_{i-1}) * \sqrt{V_Z}.$$

11. The method as claimed in claim 10, characterized in that the iteration is ended after an odd number of iteration steps.

12. The method as claimed in claim 8, characterized in that the capacity $load_Z$ is determined by the solution of a further equation GW_Z:

$$load_Z = x_0/2 + \sqrt{q_2} \cdot \sqrt{V_Z} + x_0^2,$$

where $x_0 = q_1 * \sqrt{V_Z}$.

13. An ATM communication device with a maximum capacity R_{max}, with a device for indicating a still available residual capacity R_{rest} of the ATM communication device, where $R_{rest} = R_{max} - load_M$ and $load_M$ is determined for M existing connections according to the method as claimed in claim 1.

FIG 1

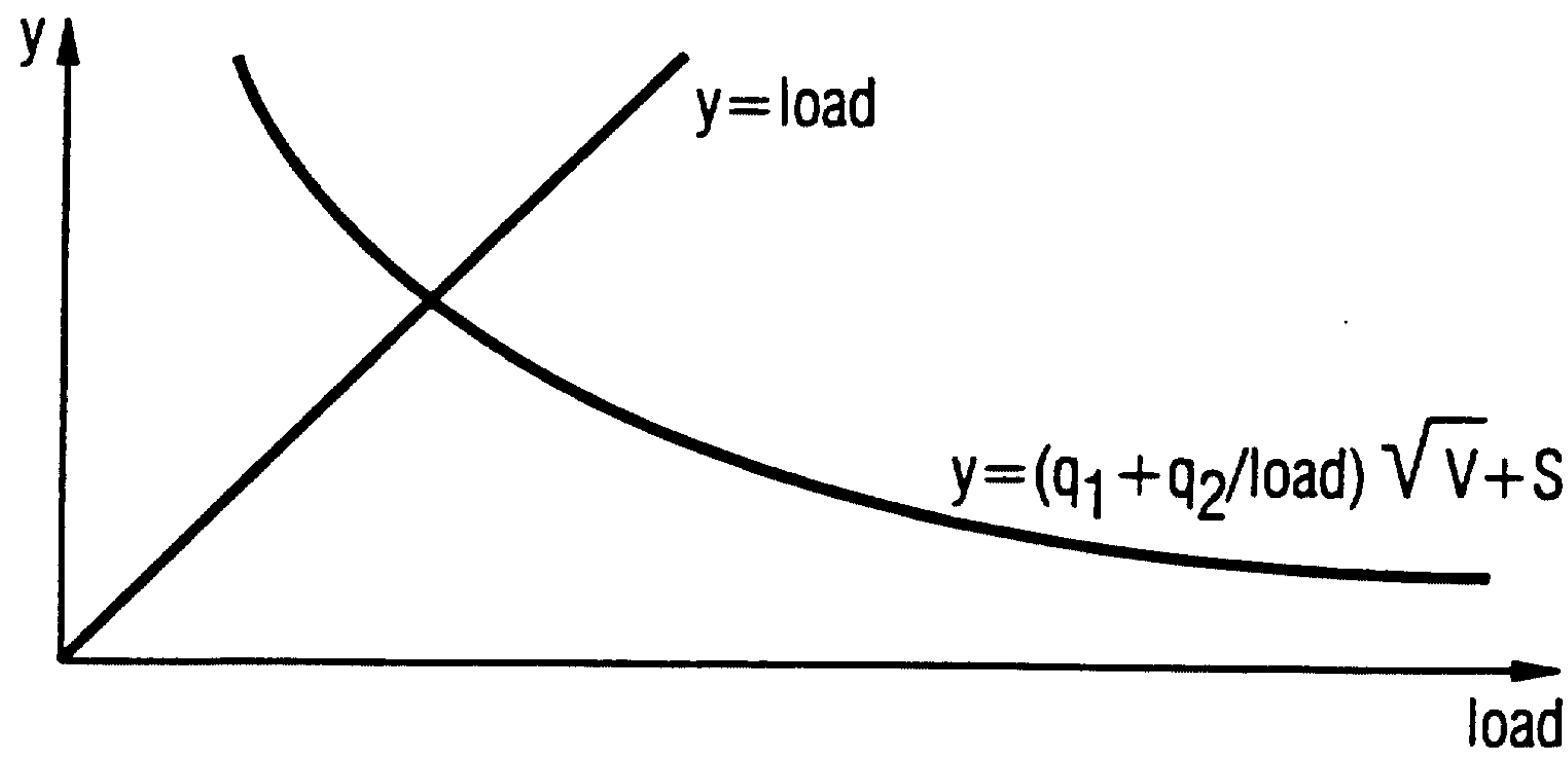

y
y=load
y=(q1+q2/load) √V+S
load

FIG 2

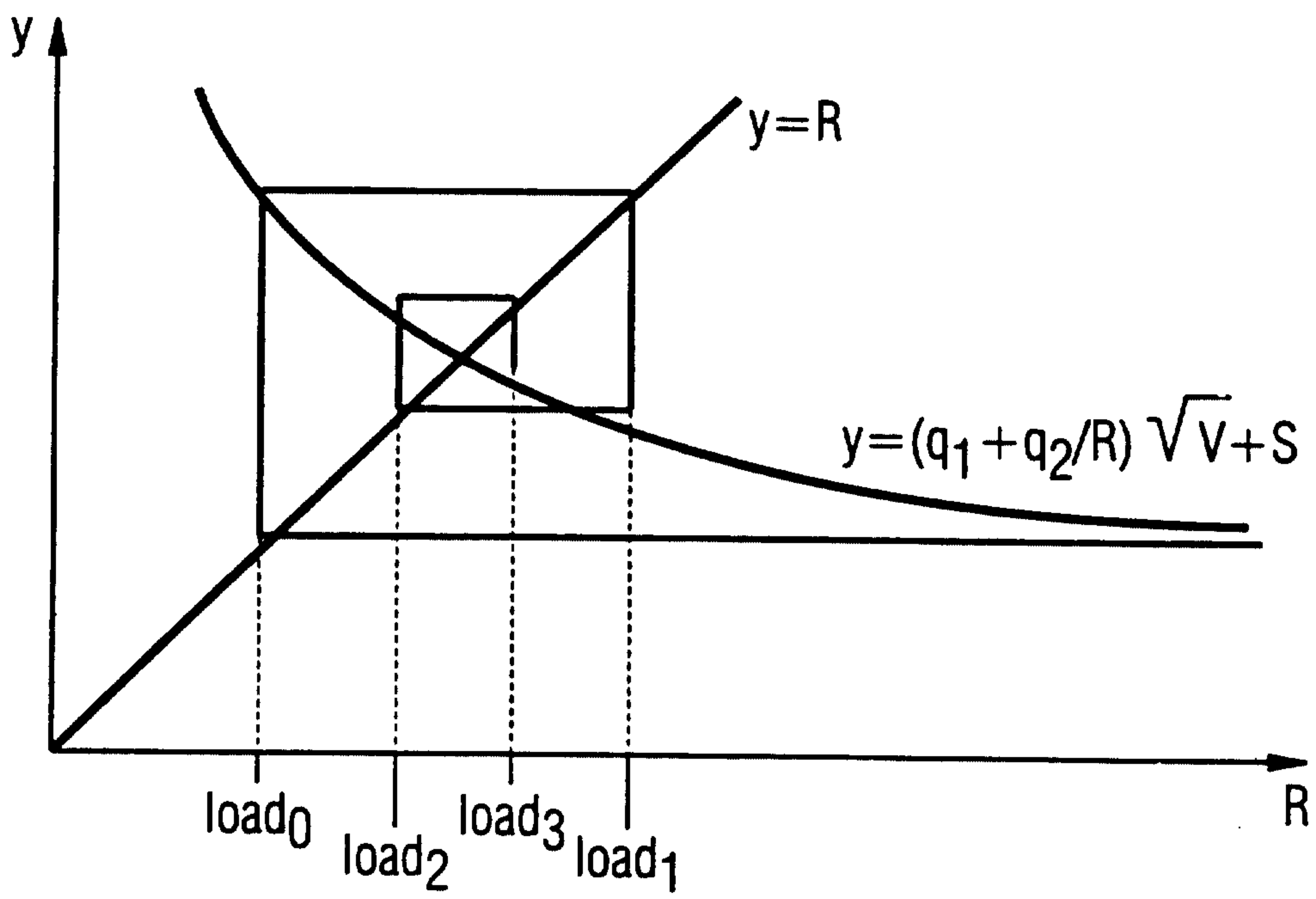
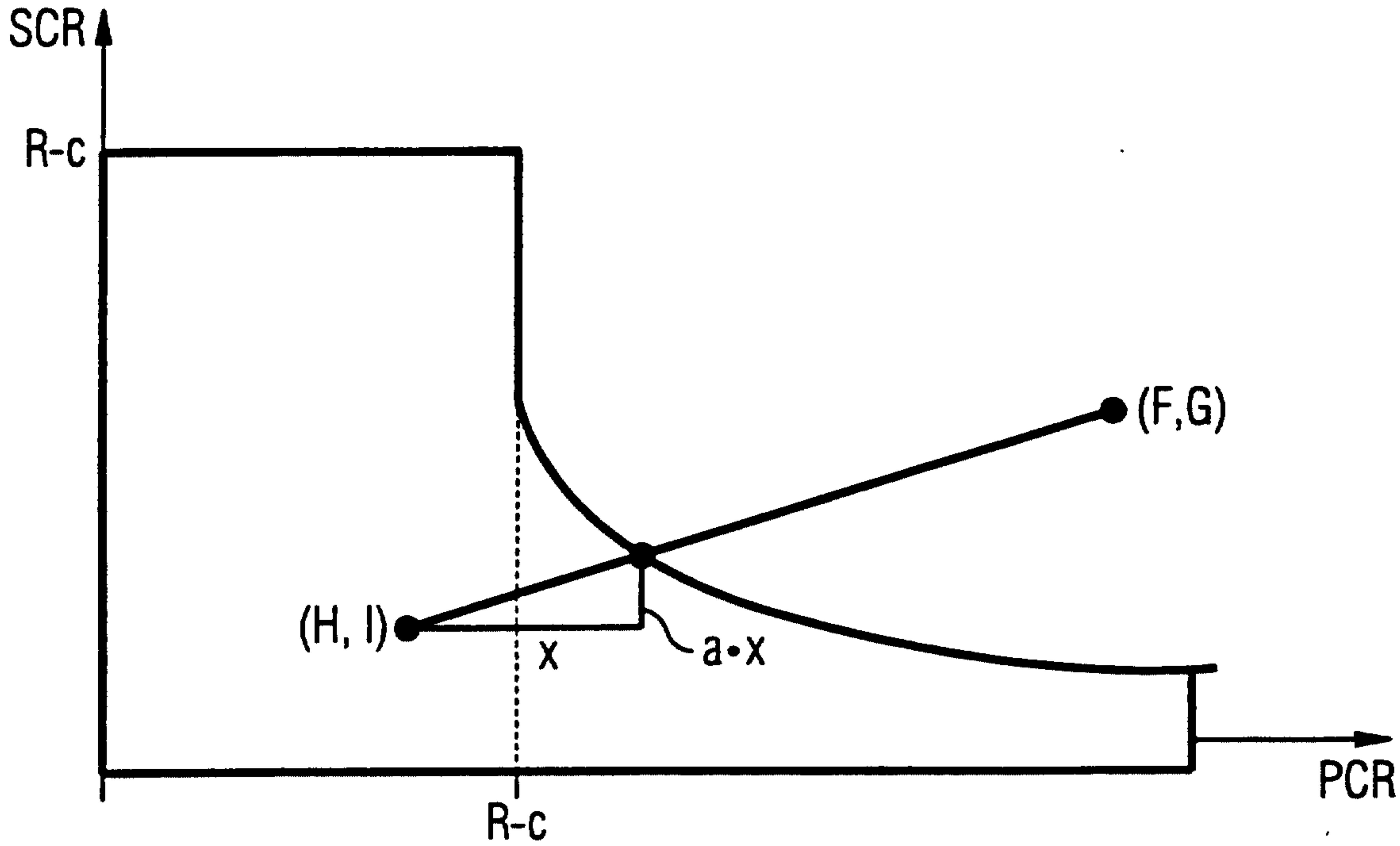
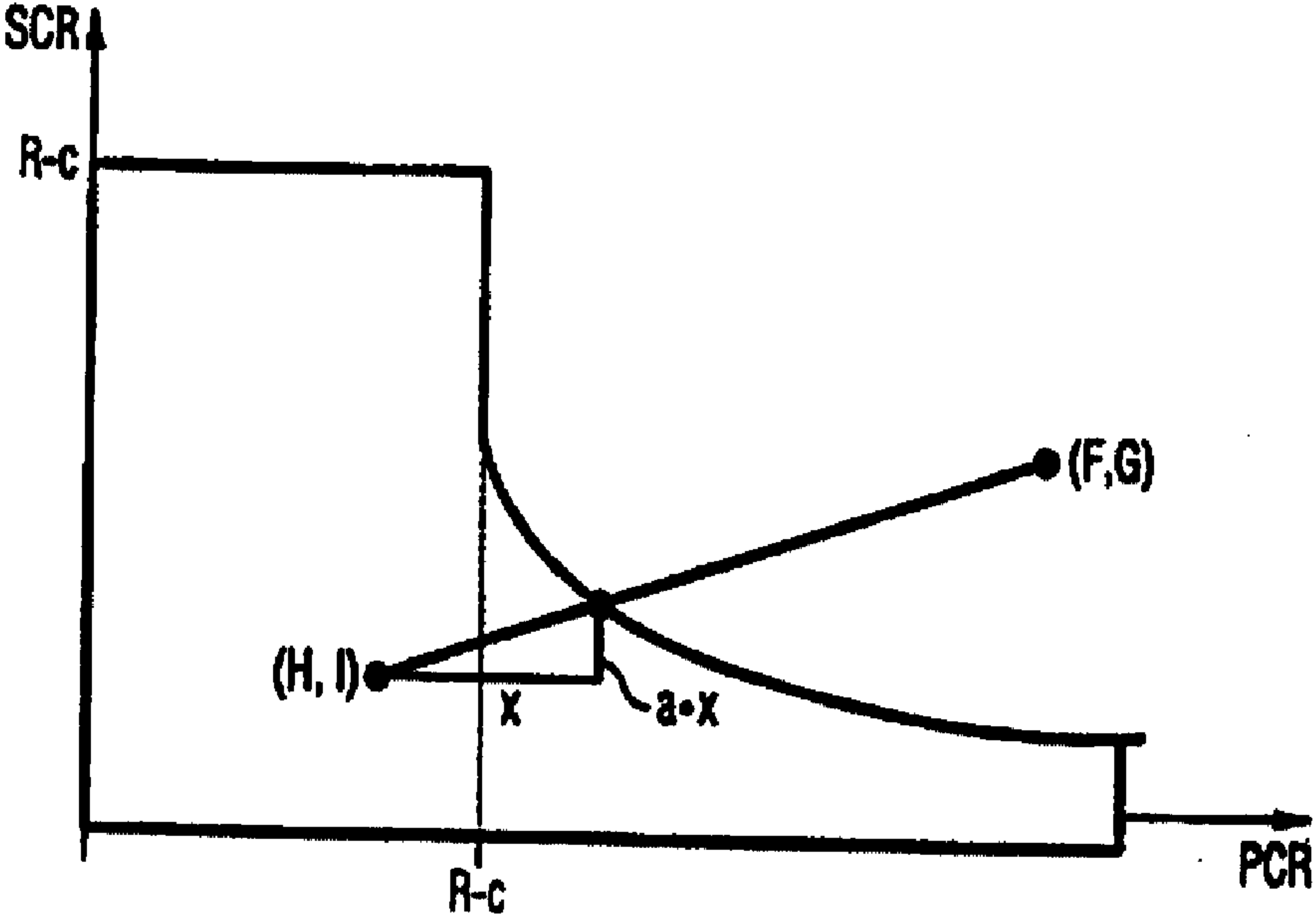

y
y=R
y=(q1+q2/R) √V+S
load0
load2
load3
load1
R

FIG 3





SCR
R-c
(F,G)
(H, I)
X
a•X
R-c
PCR