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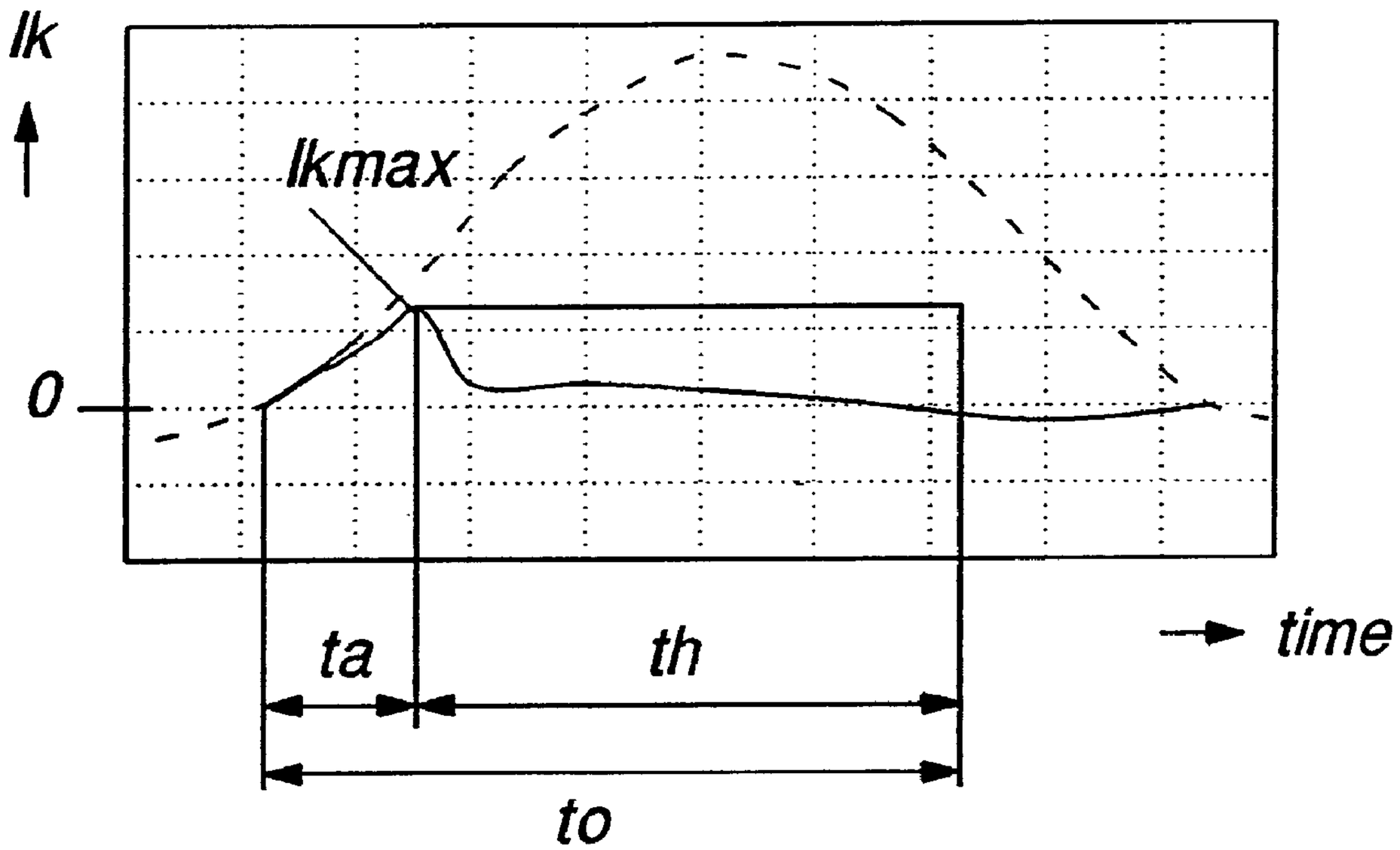
(54) Titre : METHODE ET DISPOSITIF DE PROTECTION DE BARRES OMNIBUS
(54) Title: METHOD AND DEVICE FOR PROTECTING BUSBARS



(57) Abrégé/Abstract:
In a busbar protection method and a corresponding device, the maximum values of the currents in the outgoers are determined. The maximum values Ikmax of the current characteristics are extended by a certain hold time th. Subsequently, these current characteristics are processed further vectorially. With the aid of these current characteristics Ik changed in such a way, a fault signal is calculated by means of a protection algorithm, preferably the current comparison method with current stabilization or the phase comparison algorithm. It can be uniquely determined on the basis of the extension of the maximum according to the invention whether an external fault or an internal one is concerned. The advantage of the method and of the device according to the invention resides, in particular, in that the localization of the fault is possible in a reliable fashion even in the case of strong saturation of the current transformers. Above all, false tripping can be reliably avoided even in the case of external faults.

ABSTRACT OF THE DISCOSURE

In a busbar protection method and a corresponding device, the maximum values of the currents in the outgoers are determined. The maximum values Ikmax of the current characteristics are extended by a certain hold time th. Subsequently, these current characteristics are processed further vectorially. With the aid of these current characteristics Ik changed in such a way, a fault signal is calculated by means of a protection algorithm, preferably the current comparison method with current stabilization or the phase comparison algorithm. It can be uniquely determined on the basis of the extension of the maximum according to the invention whether an external fault or an internal one is concerned. The advantage of the method and of the device according to the invention resides, in particular, in that the localization of the fault is possible in a reliable fashion even in the case of strong saturation of the current transformers. Above all, false tripping can be reliably avoided even in the case of external faults.

(Figure 1)

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TITLE OF THE INVENTION

Method and device for protecting busbars

BACKGROUND OF THE INVENTION

Field of the invention

The invention relates to the field of protection practise.

It proceeds from a method for protecting busbars according to the preamble of the first claim. It relates further to a device for protecting busbars.

Discussion of background

Such busbar protection systems have already been described in the book "Schutztechnik in Elektroenergiesystemen" ("Protection practise in electric power systems") by H. Ungrad et al., Springer Verlag 1991, on pages 182 ff.

For a busbar protection system, the currents must be detected in the outgoers of the busbar with the aid of current transformers. If, in the case of a short-circuit - inside or outside the protection zone of the busbar - high currents occur, these currents can cause a magnetic core saturation of the current transformers. This can lead to malfunction of the busbar protection system. In prior analog busbar protection systems, the current transformer saturation was detected in analog fashion and the protection system blocked.

However, because of the current transformer saturation, the system specified above does not distinguish between an external and an internal fault.

A different avenue is followed in the INX2 busbar protection system (see Brown Boveri Mitteilungen (Brown Boveri News), Volume 53, No. 4/5, pages 326 to 339) from the BBC company. Here, a voltage proportional to the current is converted into a rectangular signal

by means of so-called shapers. One shaper is provided for each half wave of the current and thus for both directions. In order to reduce the influence of the current transformer saturation, an integrator is connected downstream of the shapers which holds the digital rectangular signals in their active position during a certain time. The result of this additional device is that, for each saturation of a main transformer, even if it is so strong that the current breaks down before the actual zero crossing, the direction of the started half wave is stored until either the measurement is terminated or the next half wave begins. It is now possible from a comparison of the directions or phases of the outgoer currents to detect a fault and to determine whether an internal or an external fault is present.

This system is a very complicated, analog system which, in particular, can be used only for the protection algorithm of the phase comparison. For the rest, such a system is also described on pages 194 ff in the textbook mentioned at the beginning.

SUMMARY OF THE INVENTION

Accordingly, one object of the invention is to provide a novel method and a novel device for protecting busbars, in which external and internal faults can be reliably detected and distinguished even under the influence of saturation in the current transformers. In particular, the method is to be numerical and capable of being used for different protection algorithms.

This object is achieved in a method of the type mentioned at the beginning by means of the features of the first claim.

The core of the method according to the invention is thus that the maximum values of the currents in the outgoers are determined, and these are held for a certain hold time.

The current values can be held in this case either at the maximum value itself or at a value proportional thereto. The current characteristics corrected in such a way are subsequently processed further vectorially.

A fault signal is determined with the aid of these current characteristics by means of different protection algorithms. Preference is given as protection algorithm to current comparison with current stabilization and to phase comparison.

The device according to the invention comprises per outgoer a field unit having a maximum value detector and extension means with the aid of which it is possible to carry out the method explained above for extending the maximum value.

Further exemplary embodiments follow from the subclaims.

The advantage of the design according to the invention consists, in particular, in that the disturbing influences of the current transformer saturation can be suppressed. The result of this is a functionality of the protection system which is independent of the current transformer saturation. In particular, false tripping is reliably avoided in the case of external faults. In addition, the busbar protection system according to the invention is also suitable for different protection algorithms.

BRIEF DESCRIPTION OF THE DRAWINGS

A more complete appreciation of the invention and many of the attendant advantages thereof will be readily obtained as the same becomes better understood by reference to the following detailed description when considered in connection with the accompanying drawings, wherein

Figure 1 shows the time characteristic of an undistorted outgoer current signal and of an outgoer current signal distorted by current

transformer saturation, as well as the extension of the maximum value according to the invention;

Figure 2 shows the time characteristic of an undistorted outgoer current signal and of an extended outgoer current signal distorted by current transformer saturation, as well as the extension and overshooting of the maximum value according to the invention;

Figure 3 shows a block diagram of a protection device according to the invention; and

Figure 4 shows a block diagram of a section of the field unit.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring now to the drawings, wherein like reference numerals designate identical or corresponding parts throughout the several views, Figure 3 shows a block diagram of a protection device according to the invention. 1 designates a busbar which has k>=2 outlets 2 (3 are represented). Each outgoer 2 comprises a load 12, a consumer or a generator, which is connected via a switch 3 to the busbar 1. A current transformer 4 is provided in addition between the switch 3 and the bar 1.

The current characteristics I1, I2, I3, in general Ik, are determined in the current transformer 4 by the k outgoers 2. If a fault occurs anywhere, that is to say a short-circuit (indicated by the arrow), the currents Ik increase within a short time and can change their direction or their phase angle. The aim of the busbar protection is to detach the outgoers 2 as quickly as possible by means of the switches 3 in the case of an internal fault, that is to say a short-circuit in the region of the monitored busbar 1, in order to keep damage and operational interruptions as slight as possible.

Since the currents Ik become very large in the case of a fault, magnetic core saturation can occur

in the current transformers 4. As a result, the current no longer varies sinusoidally, as represented by dashes in Figures 1 and 2, but assumes a maximum and decays again (represented by a continuous line).

In order to be able to compare the currents of the various outgoers with one another, the further processing of the currents Ik must be performed vectorially. For this purpose, the vectorial fundamental frequency component $\underline{Ik}$ of the currents Ik are determined. This is preferably undertaken by means of a Fourier filter. However, the current transformer saturation cannot be detected from the fundamental frequency component $\underline{Ik}$, and the influences therefore also cannot be minimized.

In the event of saturation of the current transformers, the phase and amplitude of the fundamental frequency components $\underline{Ik}$ of the currents Ik deviate strongly from the undistorted characteristics. Without additional stabilization, this can possibly lead to false trippings of the protection system. The aim of the method and of the device according to the invention is therefore to stabilize the current values numerically.

This is achieved when the maximum Ikmax of the outgoer currents Ik is determined and this maximum Ikmax is extended for a certain hold time th (see Figure 1). If this method is applied in the case of a numerical busbar protection before determination of the fundamental frequency component $\underline{Ik}$, the influence of the current transformer saturation on the functioning of the protection system can be substantially reduced.

To extend the maximum Ikmax, the current value can be held either at its maximum value Ikmax itself ("simple maxima extension", Figure 1) or at a value proportional thereto ("dynamic maxima extension", Figure 2).

It is common to both variants that the hold time th is calculated as the difference between a maximum hold time to prescribed from outside and the instant of the occurrence of the maximum ta.

Experiments have shown that the optimum maximum hold time to in a 50 Hz system is 12.5 ms. If a valid maximum Ikmax has been detected, this value is held during the period th, with the result that a type of rectangular signal is produced.

In the case of the dynamic maxima extension, the maximum value Ikmax is held at a value proportional thereto. The proportionality factor v is calculated using the formula

$$v = \frac{1}{\sin\left(\frac{2\pi\ ta}{To}\right)}$$

ta corresponding to the instant of the occurrence of the maximum Ikmax, and To corresponding to the period of the system frequency.

After the extension of the maximum values in accordance with the method described above, the current characteristics Ik are processed further vectorially, that is to say only the fundamental frequency component Ik is taken into account.

Two preferred protection algorithms are addressed below, by means of which it is possible to generate a fault signal from the current characteristics Ik.

A stabilization factor kst is calculatd in the case of current comparison methods with current stabilization, kst corresponding to the quotient of the geometrical sum of the current characteristics and the arithmetic sum of the current characteristics. Expressed by formulae:

$$kst = \frac{|\Sigma\ Ik\ |}{\Sigma\ |Ik|}$$

k = 1.. number of outgoers
Ik = current characteristic in outgoer k.

In the case of an internal fault, kst reaches at most the value 1, while in the case of an external

fault it reaches the minimum value of zero. It is possible to distinguish between an external fault and an internal one with the aid of a threshold value. In the case of methods without maxima extension, the regions of kst for an internal fault or an external one overlap, with the result that no unambiguous distinction is possible. A measure of how clearly internal faults can be distinguished from external ones is the difference dkst between the minimum kst factor for internal faults and the maximum kst value for external faults.

Listed in the following tables are values which were obtained during experiments, and it becomes clearly visible which advantage the method according to the invention confers with respect to distinguishing internal and external faults.

Method	dkst	max.kst for ext. faults	min.kst for int. faults
without maxima extension	-0.12	0.91	0.79
simple maxima extension	0.17	0.79	0.96
dynamic maxima extension	0.35	0.61	0.96

In the case of the method without maxima extension, the result is a negative dkst, that is to say the ranges of kst for external and internal faults overlap and an error-free distinction is not possible. In the case of dynamic maxima extension, dkst is approximately twice as large as in the case of simple maxima extension. The dynamic method is thus clearly more robust and substantially less sensitive with respect to saturation influences.

A second, preferred protection algorithm is the phase comparison algorithm. In this case, the current direction is determined with the aid of the phase angle ϕk from the current characteristics $\underline{Ik}$ of the individual outgoers. It can now be decided from the differences in the phase angles ϕk whether an external or an internal fault is present. In the case of a system having two outgoers, an internal fault is present if the absolute value of the phase difference of the currents is smaller than $\pi/2$. If the absolute value of the difference lies above this value, the fault is external.

In conclusion, it is further explained with the aid of Figures 3 and 4 which devices are required for a protection system according to the invention. Three outgoers 2, for example, in which the currents I1..I3 flow, branch off from a busbar 1. These current characteristics, in general IK, are detected in the current detecting means. The current detecting means can, for example, comprise a current transformer 4 and an A/D converter 11. The A/D converter is provided for each outgoer 2 in a field unit 5 and connected to the corresponding current transformer 4. Connected upstream of the A/D converter 11 is a low-pass filter 14 which acts as an anti-aliasing filter. Connected downstream of the A/D converter 11 is a maximum value detector 10 in which the maximum value Ikmax is determined. This value is held in the extension means 9 during the hold time th. It is preferable to connect downstream of the extension means 9 a Fourier filter 8 to determine the vectorial fundamental frequency component $\underline{Ik}$. The current characteristics $\underline{Ik}$ thus prepared are fed by the field units 5 via a process bus 7 to a central unit 6 in which the fault signal is determined according to one of the protection algorithms presented above. The field units 5 are instructed via the process bus 7 by the central unit 6 to open the switches 3 when an internal fault is present. This is performed by means of a control unit 13 provided in each field unit 5.

The invention thus makes available overall a method and a device for protecting busbars, which, independently of saturation phenomena in the current transformer, can reliably detect and distinguish external and internal faults and, in addition, can be used for different protection algorithms.

Obviously, numerous modifications and variations of the present invention are possible in the light of the above teachings. It is therefore to be understood that within the scope of the appended claims, the invention may be practiced otherwise than as specifically described herein.

LIST OF DESIGNATIONS

1	busbar
2	outgoer
3	switch
4	current transformer
5	field unit
6	central unit
7	process bus
8	Fourier filter
9	extension means
10	maximum value detector
11	A/D converter
12	load
13	control unit
14	low-pass filter

I1..3	outgoer currents
Ik	outgoer current of the outlet k
<u>Ik</u>	vectorial outgoer current
Ikmax	outgoer current maximum value
th	hold time
to	maximum hold time
ta	instant of the occurrence of the maximum Ikmax
To	period of the system frequency
v	proportionality factor

CLAIMS,

1. A method for protecting busbars (1) having at least two outgoers (2), in which method

a) current characteristics Ik are determined in the outgoers (2);

b) a fault signal is determined with the aid of a vectorial current characteristic Ik;

wherein

c) maxima Ikmax of the current characteristics 1k are determined;

d) after the determination of the maxima Ikmax, the current characteristics Ik are held at these maxima Ikmax, or at a value proportional to the corresponding maxima Ikmax, during a specific hold time th; and

e) the current characteristics Ik corrected in this manner are subsequently further processed vectorially.

2. The method as claimed in claim 1, where the hold time th is calculated in accordance with th=to-ta, ta corresponding to the instant of the occurrence of the maximum Ikmax, and to corresponding to a maximum hold period prescribed from outside.

3. The method as claimed in claim 1 or 2, wherein the outgoer current characteristics Ik are held during the hold time th at a value proportional to the corresponding maximum Ikmax.

4. The method as claimed in claim 3, wherein the maximum values Ikmax are multiplied by the factor

$$v = \frac{1}{\sin\left(\frac{2\pi\ ta}{To}\right)}$$

ta corresponding to the time of the occurrence of the maximum value Ikmax, and To corresponding to the fundamental period of the system frequency.

5. The method as claimed in one of claims 1 to 4, wherein there is calculated as the fault signal a stabilization factor kst which corresponds to a quotient of the geometrical sum of the vectorial current characteristics Ik and the arithmetic sum of the vectorial current characteristics Ik.

6. The method as claimed in claim 5, wherein it is determined with the aid of the value of kst whether an internal fault or an external fault is present, wherein in particular upon undershooting of a lower limiting value of kst, it is concluded that there is an external fault and, upon overshooting of an upper limiting value, it is concluded that there is an internal fault.

7. The method as claimed in any one of claims 1 to 4, wherein, with the aid of the vectorial current characteristics Ik one item Φk of phase information is calculated and it is determined with the aid of the item Φk of phase information whether an internal fault or an external one is present.

8. The method as claimed in claim 1, wherein a Fourier filter is used to determine the vectorial current characteristics Ik.

9. A device for protecting a busbar (1) to which at least two outgoers (2) are connected via in each case one switch (3), comprising

a) per outgoer (2), a current detecting device for detecting current characteristics Ik in the outgoers;

b) one field unit (5) in each case, which field units are connected to the switches (3) and opening the latter in accordance with a fault signal;

c) a central unit (6) which is connected via a process bus (7) to the field units (5) and in which the fault signal is determined from a vectorial current characteristic Ik;

wherein

d) there are provided in the field units (5) extension means (9) and maximum value detectors (10) which determine the maxima Ikmax of the current characteristics Ik and hold the current characteristics Ik at these maxima Ikmax, or at a value proportional to the corresponding maxima Ikmax, for a specific hold time th; and

e) there is provided a means (8) for further processing vectorially the current characteristics Ik corrected in this manner.

10. The device as claimed in claim 9, wherein a Fourier filter (8) is provided in each field unit (5) in order to determine the vectorial current characteristics Ik, the filter (8) being connected downstream of the extension means (9).

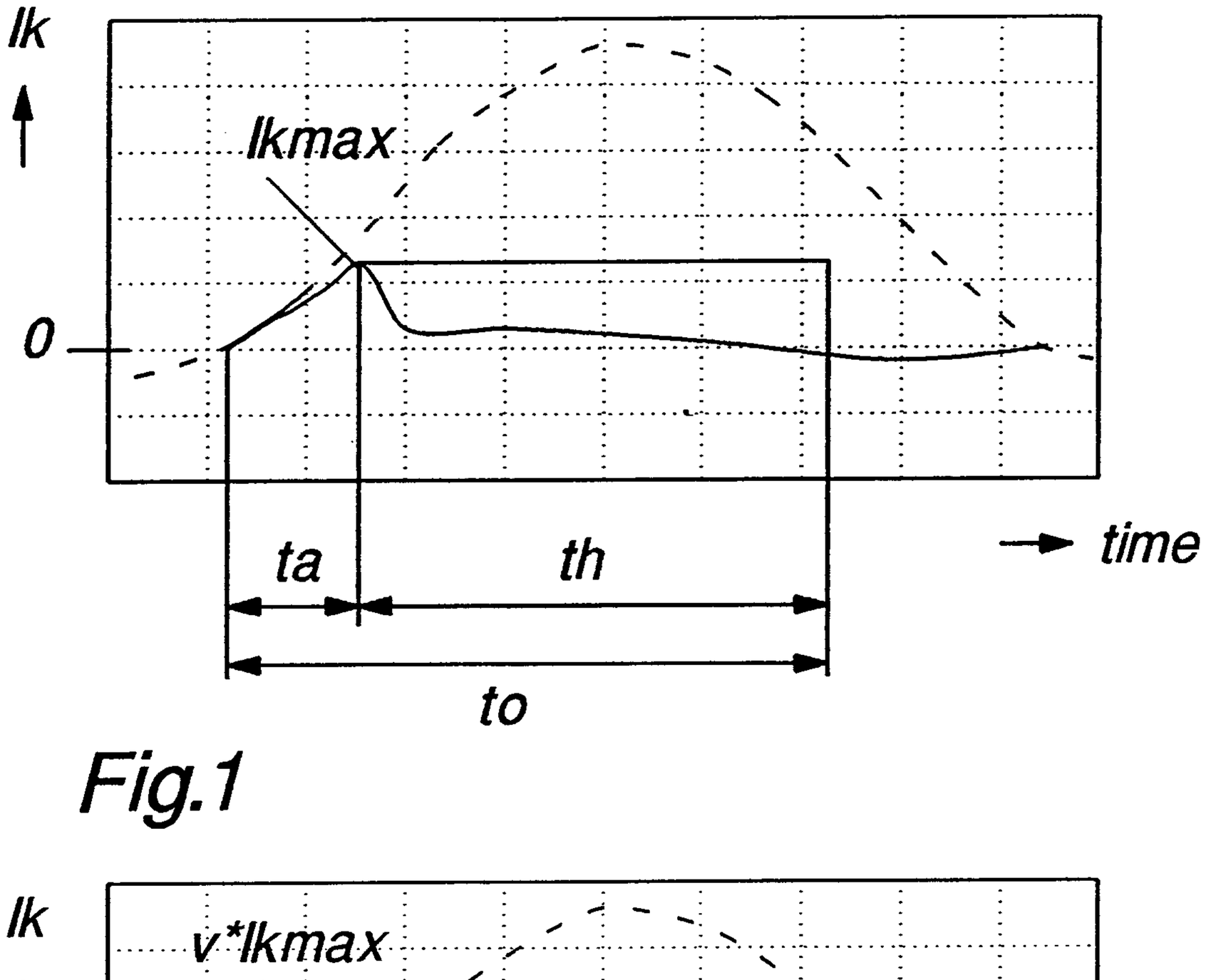

Fig.1

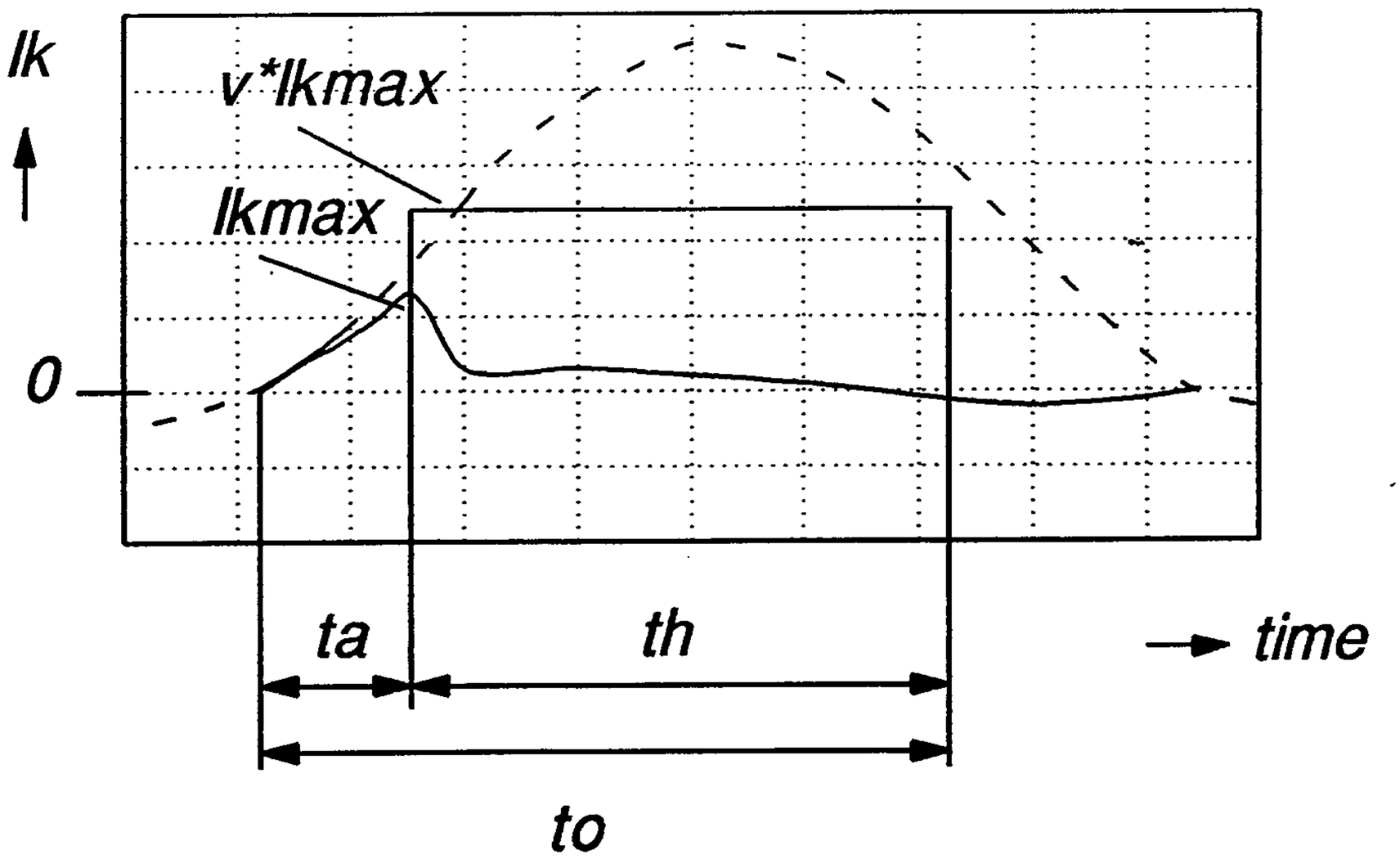

Fig.2

PATENT AGENTS

Armbrecht Ogilvy Renault

Fig.3

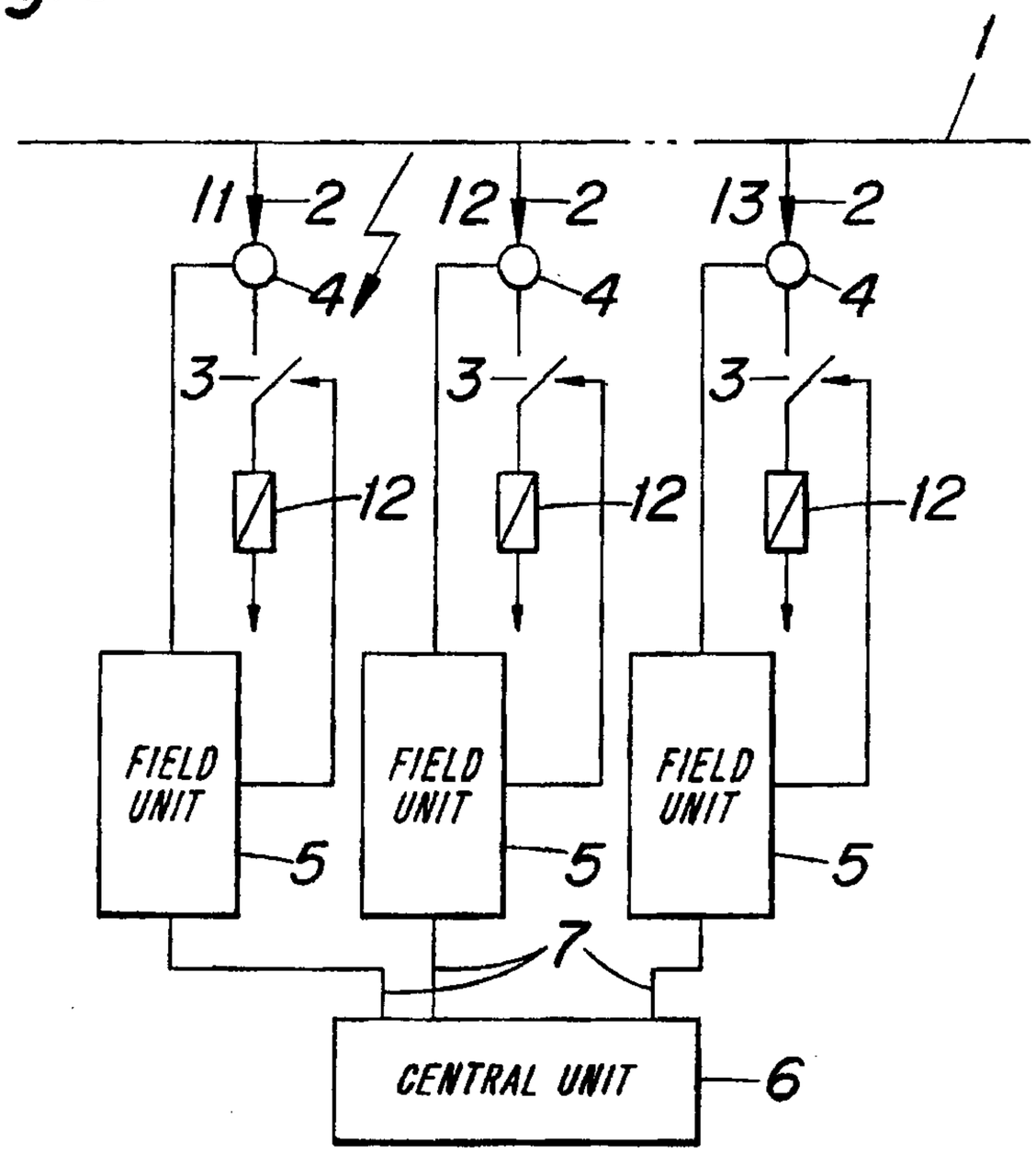
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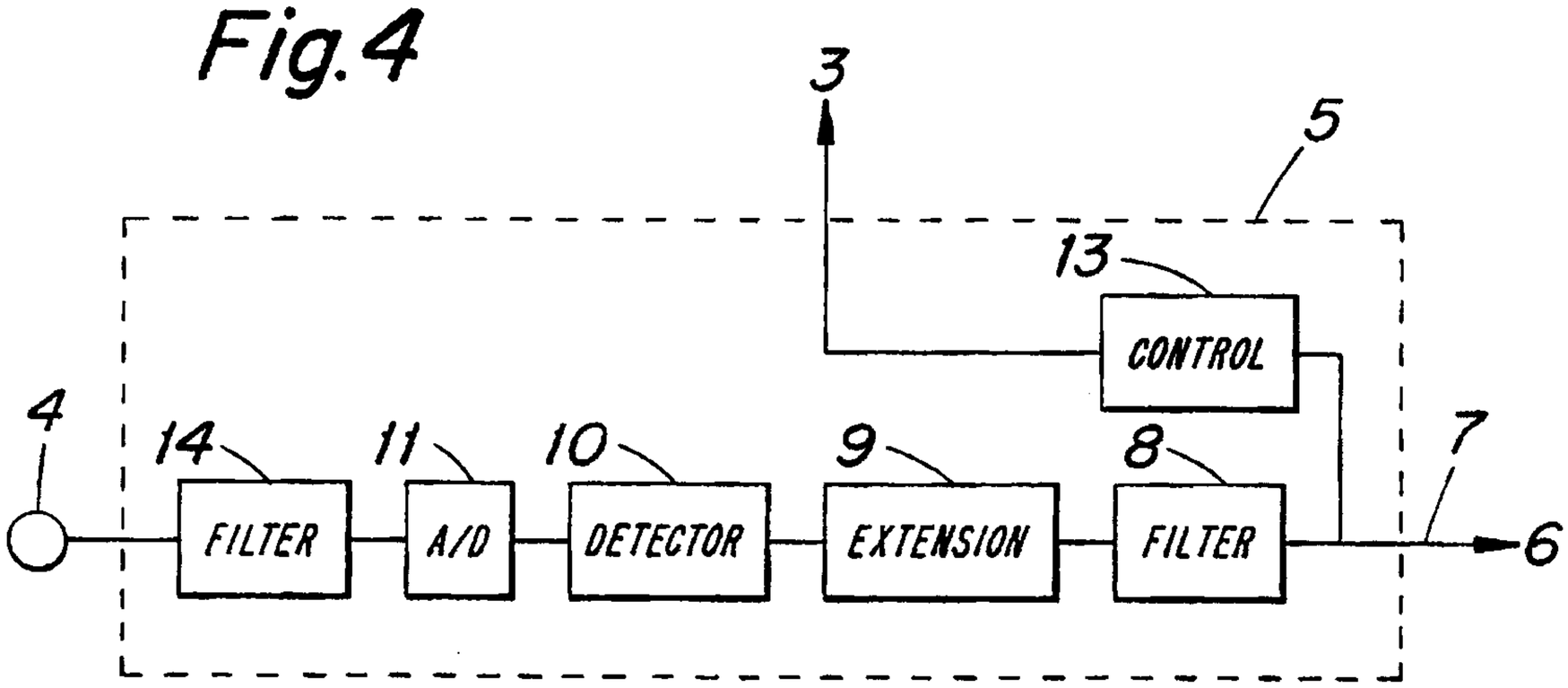
Fig.4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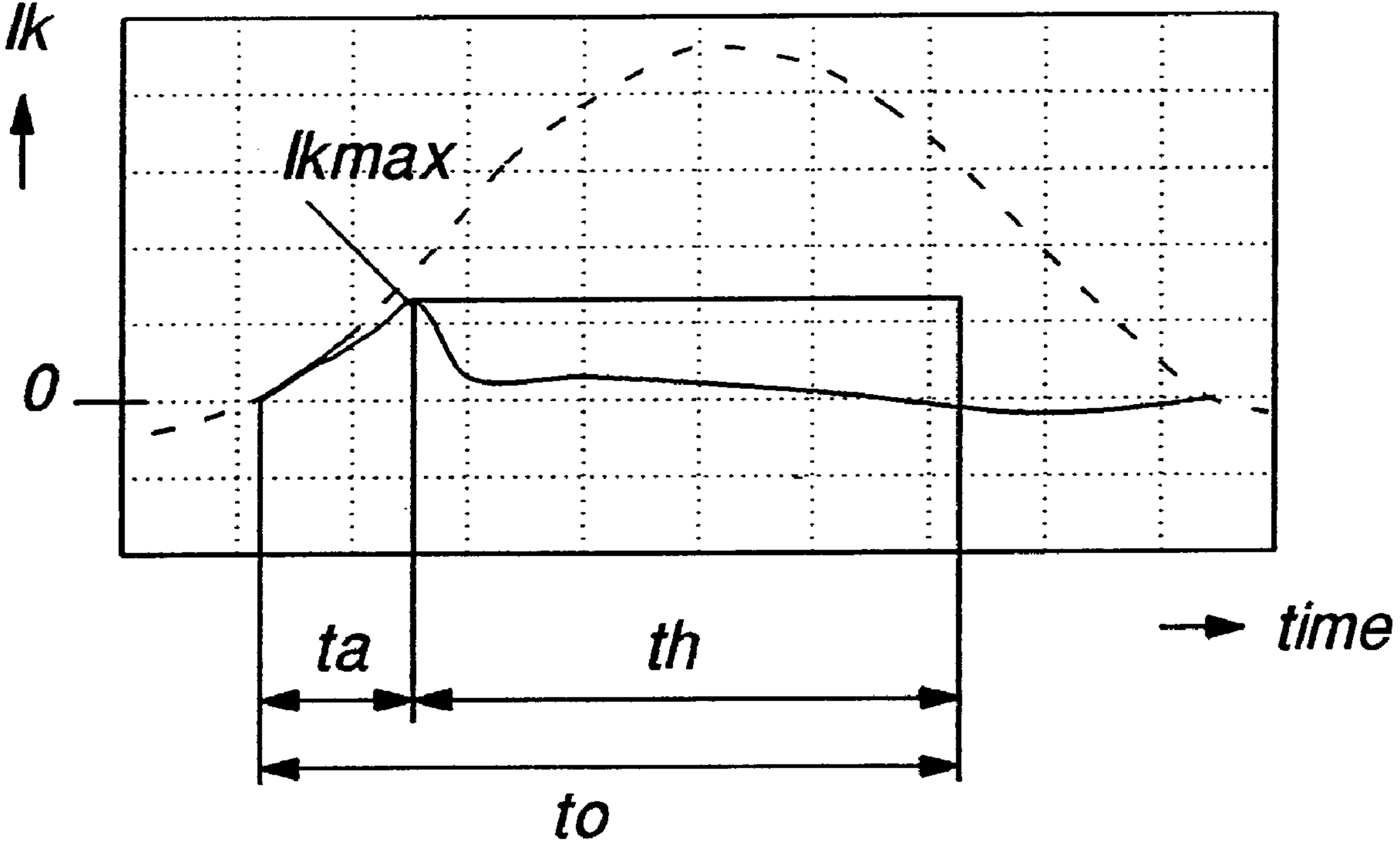
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