ORIGINAL

ABSTRACT

"METHOD AND APPARATUS FOR DETECTING EARTH FAULT"

A method and an apparatus for detecting an earth fault on a three-phase electric line, the apparatus comprising means (40) for determining a neutral admittance on the basis of a residual current and a residual voltage, means (40) for comparing the determined neutral admittance to a predetermined operation characteristic to detect an earth fault on the three-phase electric line (30), and means (40) for determining one or more harmonic components of the residual current and one or more harmonic components of the residual voltage, which harmonic components have frequencies n*fn such that n≥2 and fn is a fundamental frequency, wherein the means for determining a neutral admittance are adapted to use at least one of the determined one or more harmonic components of the residual current and at least one of the determined one or more harmonic components of the residual voltage for the determining of the neutral admittance.

(Figure 1)

WE CLAIM:

1. A method for detecting an earth fault on a three-phase electric line of an electric network, the method comprising:

monitoring a residual current on the three-phase electric line (30) and a residual voltage in the electric network;

detecting an earth fault in the electric network;

determining a neutral admittance, or a quantity indicative thereof, on the basis of the residual current and the residual voltage; and

comparing the determined neutral admittance, or the quantity indicative thereof, to a predetermined operation characteristic to detect an earth fault on the three-phase electric line (30), **characterized** in that the method comprises:

determining one or more harmonic components of the residual current and one or more harmonic components of the residual voltage, which harmonic components have frequencies n*fn such that $n \geq 2$ and fn is a fundamental frequency;

wherein the determining of the neutral admittance, or the quantity indicative thereof, is performed using at least one of the determined one or more harmonic components of the residual current and at least one of the determined one or more harmonic components of the residual voltage.

2. A method according to claim 1, **characterized** in that

the comparing of the determined neutral admittance, or the quantity indicative thereof, to a predetermined operation characteristic to detect an earth fault on the three-phase electric line (30) comprises:

determining whether the neutral admittance, or the quantity indicative thereof, is inside or outside an operate area defined by the predetermined operation characteristic on an admittance plane; and

detecting an earth fault on the three-phase electric line when the neutral admittance, or the quantity indicative thereof, is determined to be inside said operate area.

3. A method according to claim 1 or 2, **characterized** by selecting, according to one or more predetermined criteria, the at least one of the determined one or more harmonic components of the residual current and the at least one of the determined one or more harmonic components of the residual voltage used for the determining of the neutral admittance or the

quantity indicative thereof.

4. A method according to claim 3, **characterized** in that the one or more predetermined criteria comprise a minimum value for the harmonic component of the residual current and the harmonic component of the residual voltage.

5. A method according to claim 3 or 4, **characterized** in that the one or more predetermined criteria comprise a stability requirement for the harmonic component of the residual current and/or the harmonic component of the residual voltage and/or a ratio between the harmonic component of the residual current and the harmonic component of the residual voltage.

6. A method according to claim 3, 4 or 5, **characterized** in that, when one harmonic component of the residual current and one harmonic component of the residual voltage are selected, the neutral admittance is determined to be equal to a neutral admittance for harmonic component n obtained from the selected harmonic component of the residual current and the selected harmonic component of the residual voltage.

7. A method according to any one of claims 3 to 6, **characterized** in that, when more than one harmonic component of the residual current and more than one harmonic component of the residual voltage are selected, the neutral admittance is determined to be equal to a sum of individual neutral admittances for harmonic components n obtained from the selected harmonic components of the residual current and the selected harmonic components of the residual voltage.

8. A method according to claim 3, 4 or 5, **characterized** in that, when one or more harmonic components of the residual current and harmonic components of the residual voltage are selected, the neutral admittance is determined to be equal to a sum of a fundamental frequency neutral admittance and a sum of neutral admittance(s) for harmonic component(s) n obtained from the selected one or more harmonic components of the residual current and harmonic components of the residual voltage.

9. A computer program product comprising computer program code, wherein the execution of the program code in a computer causes the computer to carry out the steps of the method according to any one of claims 1 to 8.

10. An apparatus for detecting an earth fault on a three-phase electric line of an electric network, the apparatus comprising:

means (40) for monitoring a residual current on the three-phase electric line (30) and a residual voltage in the electric network;

means (40) for detecting an earth fault in the electric network;

means (40) for determining a neutral admittance, or a quantity indicative thereof, on the basis of the residual current and the residual voltage; and

means (40) for comparing the determined neutral admittance, or the quantity indicative thereof, to a predetermined operation characteristic to detect an earth fault on the three-phase electric line (30), **characterized** in that the apparatus comprises:

means (40) for determining one or more harmonic components of the residual current and one or more harmonic components of the residual voltage, which harmonic components have frequencies n*fn such that n≥2 and fn is a fundamental frequency; and

in that the means for determining a neutral admittance, or a quantity indicative thereof, are adapted to use at least one of the determined one or more harmonic components of the residual current and at least one of the determined one or more harmonic components of the residual voltage for the determining of the neutral admittance or the quantity indicative thereof.

11. An apparatus according to claim 10, **characterized** in that

the means (40) for comparing the determined neutral admittance, or the quantity indicative thereof, to a predetermined operation characteristic to detect an earth fault on the three-phase electric line (30) comprise:

means for determining whether the neutral admittance, or the quantity indicative thereof, is inside or outside an operate area defined by the predetermined operation characteristic on an admittance plane; and

means for detecting an earth fault on the three-phase electric line (30) when the neutral admittance, or the quantity indicative thereof, is determined to be inside said operate area.

12. An apparatus according to claim 10 or 11, **characterized** in that the apparatus comprises means (40) for selecting, according to one or more predetermined criteria, the at least one of the determined one or more harmonic components of the residual current and the at least one of the determined one or more harmonic components of the residual voltage used for the determining of the neutral admittance or the quantity indicative thereof.

13. An apparatus according to claim 12, **characterized** in

that the one or more predetermined criteria comprise a minimum value for the harmonic component of the residual current and the harmonic component of the residual voltage.

14. An apparatus according to 12 or 13, **characterized** in that the one or more predetermined criteria comprise a stability requirement for the harmonic component of the residual current and/or the harmonic component of the residual voltage and/or a ratio between the harmonic component of the residual current and the harmonic component of the residual voltage.

15. An apparatus according to claim 12, 13 or 14, **characterized** in that, when one harmonic component of the residual current and one harmonic component of the residual voltage are selected by the means for selecting, the means for determining a neutral admittance are adapted to determine the neutral admittance to be equal to a neutral admittance for harmonic component n obtained from the selected harmonic component of the residual current and the selected harmonic component of the residual voltage.

16. An apparatus according to any one of claims 12 to 15, **characterized** in that, when more than one harmonic component of the residual current and more than one harmonic component of the residual voltage are selected, the means for determining a neutral admittance are adapted to determine the neutral admittance to be equal to a sum of individual neutral admittances for harmonic components n obtained from the selected harmonic components of the residual current and the selected harmonic components of the residual voltage.

17. An apparatus according to claim 12, 13 or 14, **characterized** in that, when one or more harmonic components of the residual current and harmonic components of the residual voltage are selected, the means for determining the neutral admittance are adapted to determine the neutral admittance to be equal to a sum of a fundamental frequency neutral admittance and a sum of neutral admittance(s) for harmonic component(s) n obtained from the selected one or more harmonic components of the residual current and harmonic components of the residual voltage.

18. An apparatus as claimed in any one of claims 10 to 17, **characterized** in that the apparatus comprises a protective relay (40).

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(Anuradha Salhotra)
Of LALL LAHIRI & SALHOTRA
AGENTS FOR THE APPLICANT

FIELD OF THE INVENTION

The present invention relates to detecting an earth fault on a three-phase electric line of an electric network.

BACKGROUND OF THE INVENTION

In some countries, neutral admittance protection has become a common earth fault protection function. It has been reported to provide improved effectiveness in earth fault detection when compared to the traditional residual current based earth fault protection in unearthed and compensated distribution networks. Document J. Lorenc et. al, Admittance criteria for earth fault detection in substation automation systems in Polish distribution power networks, CIRED 97, Birmingham, June 1997, discloses examples of the implementation of the neutral admittance based earth fault protection.

The admittance-based earth fault protection can be based on evaluating the quotient between fundamental frequency phasors of residual current $\overline{I}_o$ and residual voltage $\overline{U}_o$:

$$\overline{Y}_o = \overline{I}_o \big/ -\overline{U}_o$$

Alternatively, the admittance calculation can be made by utilizing so called delta quantities, i.e. the change in residual quantities due to the earth fault:

$$\overline{Y}_o = (\overline{I}_{o\_fault} - \overline{I}_{o\_prefault}) \big/ -(\overline{U}_{o\_fault} - \overline{U}_{o\_prefault})$$

where “fault” denotes the time during the fault and “prefault” denotes the time before the fault.

The result can then be compared with operating boundaries on an admittance plane. The admittance protection, similar to other earth fault protection functions, can use a U_o overvoltage condition as a common criterion for the initial fault detection. The setting value for U_o start should preferably be set above the maximum healthy U_0 level of the network in order to avoid false starts.

The admittance protection can provide many attractive features such as inherent immunity to fault resistance, generally universal applicability, good sensitivity and easy setting principles. However, in some cases the sensitivity of the admittance protection might not be good enough.

In document Jozef Lorenc, Kazimierz Musierowicz, Andrzej Kwapisz, Detection of the Intermittent Earth Faults in Compensated MV Network, 2003 IEEE Bologna Power Tech Conference, an admittance criterion utilizing wavelets is proposed. A drawback related to this solution is that it is dedicated on intermittent earth faults and as such it is not applicable to permanent earth faults.

BRIEF DESCRIPTION OF THE INVENTION

An object of the present invention is to provide a method and an apparatus for implementing the method so as to overcome the above problem or at least to alleviate the problem. The objects of the invention are achieved by a method, a computer program product and an apparatus which are characterized by what is stated in the independent claims. The preferred embodiments of the invention are disclosed in the dependent claims.

The invention is based on the idea of using one or more harmonic components of residual current and one or more harmonic components of residual voltage in the neutral admittance determination either independently or to complement the fundamental frequency based admittance determination.

An advantage of the invention is that it can provide additional sensitivity compared with the fundamental frequency component based neutral admittance criterion when harmonics are present in the electric network.

BRIEF DESCRIPTION OF THE DRAWINGS

In the following the invention will be described in greater detail by means of preferred embodiments with reference to the accompanying drawings, in which

Figure 1 is a simplified diagram illustrating an example of an electric network;

Figure 2 is an example of an operation characteristic according to an embodiment;

Figure 3 is an example of an operation characteristic according to an embodiment; and

Figure 4 is an example of an operation characteristic according to an embodiment.

DETAILED DESCRIPTION OF THE INVENTION

The application of the invention is not limited to any specific system, but it can be used in connection with various three-phase electric systems to detect a phase-to-earth fault on a three-phase electric line of an electric network. The electric line can be a feeder, for example, and it may be an overhead line or a cable or a combination of both. The electric power system in which the invention is implemented can be an electric transmission or distribution network or a component thereof, for example, and may comprise several feeders or sections. Moreover, the use of the invention is not limited to systems employing 50 Hz or 60 Hz fundamental frequencies or to any specific voltage level.

Figure 1 is a simplified diagram illustrating an electric network in which the invention can be applied. The figure shows only the components necessary for understanding the invention. The exemplary network can be a medium voltage (e.g. 20 kV) distribution network fed through a substation comprising a transformer 10 and a busbar 20. The illustrated network also comprises electric line outlets, i.e. feeders, of which one 30 is shown separately. Other possible feeders as well as other network parts, except the line 30, are referred to as a 'background network'. The figure also shows a protective relay unit 40 at the beginning of the electric line 30. The protective relay unit 40 may be located inside the substation. It should be noted that there may be any number of feeders or other network elements in the electric network. There may also be several feeding substations. Further, the invention can be utilized with a switching station without a transformer 10, for example. The network is a three-phase network, although, for the sake of clarity, the phases are not shown in the figure. In the exemplary system of Figure 1, the functionality of the invention may be located in the relay unit 40, for example. It is also possible that, for instance, only some measurements are performed at the location of the relay unit 40 and the results are then transmitted to some other unit or units (not shown in the figure) in another location for further processing. In other words, the relay unit 40 could be a mere measuring unit, while the functionality of the invention, or part of it, could be located in some other unit or units.

Current and voltage values that are needed in the following embodiments may be obtained by a suitable measuring arrangement including e.g. current and voltage transducers (not shown in the figures). In most of the existing protection systems, such values are readily available and thus the implementation of the various embodiments does not necessarily require any additional measuring arrangements. The residual voltage of the electric network may be determined from phase voltages or by measuring it from an open delta winding formed by voltage transformers, for example. The residual current of the electric line 30 may be determined with a suitable current measuring arrangement at a measuring point such as the relay unit 40. How these values are obtained is of no relevance to the basic idea of the invention and depends on the particular electricity system.

According to an embodiment, the residual current I_o on the three-phase electric line 30 and the residual voltage U_o in the electric network are monitored. Further, one or more harmonic components of the residual current $\overline{I}_o^n$ and one or more harmonic components of the residual voltage $\overline{U}_o^n$ are determined from the monitored residual current and residual voltage which harmonic components have frequencies n*fn such that n≥2 and fn is the fundamental frequency (for which n = 1, normally e.g. 50 Hz or 60 Hz). The term 'harmonic component' generally refers to a component frequency of the current or voltage signal that is an integer multiple of the fundamental frequency fn of the signal. The harmonic components may be determined from n=2 up to n=*((sampling frequency)/2)/fn*, where sampling frequency is the sampling frequency of the monitored current or voltage signal. The determination of the harmonic components may be performed by utilizing Discrete Fourier Transform (DFT, FFT).

Further, according to an embodiment, an earth fault is detected in the electric network. An earth fault occurring in the electric network may be detected e.g. by the protective relay 40 associated with the electric network and the detection may be based on the value of the residual voltage U_o of the electric network, for example. The particular way how earth faults are detected is, however, of no relevance to the basic idea of the invention.

After an earth fault has been detected in the electric network, a neutral admittance, or a quantity indicative thereof, is determined. According to an embodiment, the determining of the neutral admittance, or the quantity indicative thereof, is performed by using at least one of the determined one or more harmonic components of the residual current and at least one of the determined one or more harmonic components of the residual voltage. According to an embodiment, said at least one of the determined one or more harmonic components of the residual current and said at least one of the determined one or more harmonic components of the residual voltage used for the determining of the neutral admittance or the quantity indicative thereof are selected according to one or more predetermined criteria. Thus, only some of the determined one or more harmonic components of the residual current $\overline{I}_o^n$ and one or more harmonic components of the residual voltage $\overline{U}_o^n$ may be selected to be used in the determination of the neutral admittance. Such a selection may be performed on the basis of one or more predetermined criteria. Such predetermined criteria may be alternatives to each other or they may complement each other. Possible criteria, which can be used alone or as a combination of two or more criteria, are given in the following:

According to an embodiment, the one or more predetermined criteria can comprise a minimum value for the harmonic component of the residual current and the harmonic component of the residual voltage. In other words, it is possible to select such harmonic components of the residual current and the residual voltage that exceed a predetermined minimum value. Thus, it is possible to select harmonic components which have a sufficient amplitude.

According to an embodiment, the one or more predetermined criteria can comprise a stability requirement for the harmonic component of the residual current and/or the harmonic component of the residual voltage and/or a ratio between the harmonic component of the residual current and the harmonic component of the residual voltage, i.e. the neutral admittance. In other words, it is possible to select such harmonic components that fulfil a predetermined stability requirement. The stability requirement may require that the harmonic component of the residual current and/or the harmonic component of the residual voltage and/or a ratio between the harmonic component of the residual current and the harmonic component of the residual voltage, i.e. the neutral admittance, is stable during a predetermined time period, i.e. that the magnitude difference and/or the phase angle difference and/or the derivative difference between consecutive samples of predetermined criteria or otherwise predefined samples of predetermined criteria is/are within a predetermined limit.

According to an embodiment, the one or more predetermined criteria can comprise a criterion to select one or more harmonic components of the residual current and/or harmonic components of the residual voltage which have the highest magnitude.

In the selection process described above, harmonic components of the residual current and harmonic components of the residual voltage are preferably selected in pairs having the same order number (e.g. n = 5) to enable the determination of the neutral admittance. Thus, if the predetermined criteria only concern the harmonic components of the residual current and if according to the selection criteria the n^{th} harmonic component of the residual current is selected, then preferably also the corresponding n^{th} harmonic component of the residual voltage is selected. And vice versa, if the predetermined criteria only concern the harmonic components of the residual voltage and if according to the selection criteria the n^{th} harmonic component of the residual voltage is selected, then preferably also the corresponding n^{th} harmonic component of the residual current is selected.

According to an embodiment, corresponding neutral admittance(s) $\overline{Y}_o^n$ for the harmonic component(s) n is/are determined for the selected at least one of the determined one or more harmonic components of the residual current and at least one of the determined one or more harmonic components of the residual voltage. It is possible to perform the determination of the neutral admittance(s) $\overline{Y}_o^n$ for the harmonic component(s) n before or after the possible selection. Thus, the neutral admittance(s) $\overline{Y}_o^n$ for the harmonic component(s) n could initially be determined even for each one of the determined one or more harmonic components of the residual current $\overline{I}_o^n$ and one or more harmonic components of the residual voltage $\overline{U}_o^n$ and then, after selecting possibly only some of the harmonic components, only the corresponding neutral admittance(s) for these harmonic component(s) n are utilized. According to an embodiment, the neutral admittance $\overline{Y}_o^n$ for the harmonic component n can be determined from the harmonic component of the residual current and the harmonic component of the residual voltage according to the following equation:

$$\overline{Y}_o^n = \frac{\overline{I}_{o\_fault}^n}{-\overline{U}_{o\_fault}^n},$$

or

$$\overline{Y}_o^n = \frac{\overline{I}_{o\_d}^n}{-\overline{U}_{o\_d}^n},$$

where

$$\overline{I}_{o\_d}^n = \overline{I}_{o\_fault}^n - \overline{I}_{o\_pre-fault}^n$$

$$\overline{U}_{o\_d}^n = \overline{U}_{o\_fault}^n - \overline{U}_{o\_pre-fault}^n$$

$\overline{I}_{o\_fault}^n$ = the n^th harmonic component of the residual current during the earth fault

$\overline{I}_{o\_pre-fault}^n$ = the n^th harmonic component of the residual current before the earth fault

$\overline{U}_{o\_fault}^n$ = the n^th harmonic component of the residual voltage during the earth fault

$\overline{U}_{o\_pre-fault}^n$ = the n^th harmonic component of the residual voltage before the earth fault.

The selection between the above two alternative equations for determining the neutral admittance $\overline{Y}_o^n$ for the harmonic component n can be made by an operator of the system or it may be based on some predefined criteria.

According to an embodiment, when only one harmonic component of the residual current and one harmonic component of the residual voltage are selected, the neutral admittance $\overline{Y}_o$ is determined to be equal to the neutral admittance $\overline{Y}_o^n$ for the harmonic component n obtained from the selected harmonic component of the residual current and the selected harmonic component of the residual voltage, i.e. $\overline{Y}_o = \overline{Y}_o^n$.

According to an embodiment, when more than one harmonic component of the residual current and more than one harmonic component of the residual voltage are selected, the neutral admittance $\overline{Y}_o$ is determined to be equal to a vector sum of individual neutral admittances $\overline{Y}_o^n$ for the harmonic components n obtained from the selected harmonic components of the residual current and the selected harmonic components of the residual voltage, i.e. $\overline{Y}_o = \sum \overline{Y}_o^n$. For example, if harmonics of the order of n = 5 and n = 7 are selected, then the neutral admittance $\overline{Y}_o$ is determined to be equal to $\overline{Y}_o = \overline{Y}_o^5 + \overline{Y}_o^7$.

According to an embodiment, when one or more harmonic components of the residual current and harmonic components of the residual voltage are selected, the neutral admittance $\overline{Y}_o$ is determined to be equal to a sum of a fundamental frequency neutral admittance $\overline{Y}_o^1$ and a sum of the neutral admittance(s) $\overline{Y}_o^n$ for the harmonic component(s) n obtained from the selected one or more harmonic components of the residual current and harmonic components of the residual voltage, i.e. $\overline{Y}_o = \overline{Y}_o^1 + \sum \overline{Y}_o^n$. The fundamental frequency neutral admittance $\overline{Y}_o^1$ can be determined by using either of the above alternative equations for determining the neutral admittance(s) $\overline{Y}_o^n$ for the harmonic component(s) n and by setting n=1.

According to an embodiment, once the neutral admittance $\overline{Y}_o$, or a quantity indicative thereof, has been determined as described above, it is compared to a predetermined operation characteristic to detect an earth fault on the three-phase electric line 30. According to an embodiment, the predetermined operation characteristic, when presented on an admittance plane, defines an operate area and a non-operate area. According to an embodiment, the comparing of the determined neutral admittance $\overline{Y}_o$, or the quantity indicative thereof, to the predetermined operation characteristic to detect an earth fault on the three-phase electric line 30 comprises determining whether the determined neutral admittance $\overline{Y}_o$, or the quantity indicative thereof, is inside or outside an operate area defined by the predetermined operation characteristic on an admittance plane, and detecting an earth fault on the three-phase electric line 30 when the neutral admittance, or the quantity indicative thereof, is determined to be inside said operate area. In other words, if the determined neutral admittance $\overline{Y}_o$, or the quantity indicative thereof, is within the operate area, an earth fault is detected to be on the three-phase electric line 30. On the other hand, if the determined neutral admittance $\overline{Y}_o$, or the quantity indicative thereof, is outside the operate area, i.e. within the non-operate area, then no earth fault is detected to be on the three-phase electric line 30.

The predetermined operation characteristic to be used depends on the system in which the invention is used. It may be selected by the operator of the system. Alternatively, it may be selected automatically, e.g. adaptively according to predetermined criteria.

According to an embodiment, when the neutral admittance $\overline{Y}_o$ is determined by using only the neutral admittance(s) $\overline{Y}_o^n$ for the harmonic component(s) n, i.e. $\overline{Y}_o = \overline{Y}_o^n$ or $\overline{Y}_o = \sum \overline{Y}_o^n$, then the operation characteristic shown in Figure 2 may be used. The operation characteristic of Figure 2 comprises a threshold level for the susceptance B while there is no limit for the conductance G. The operate area is above the set threshold level for the susceptance B.

According to an embodiment, when the neutral admittance $\overline{Y}_o$ is determined by using a sum of fundamental frequency neutral admittance and a sum of neutral admittance(s) for the harmonic component(s) n, i.e. $\overline{Y}_o = \overline{Y}_o^1 + \sum \overline{Y}_o^n$, in the case of an unearthed network, the operation characteristic of Figure 2 may be used.

According to an embodiment, in a compensated network, when the neutral admittance $\overline{Y}_o$ is determined by using a sum of fundamental frequency neutral admittance and a sum of neutral admittance(s) for the harmonic component(s) n, i.e. $\overline{Y}_o = \overline{Y}_o^1 + \sum \overline{Y}_o^n$, the operation characteristic of Figure 3 or Figure 4 may be used. The operation characteristic of Figure 3 comprises a threshold level for both the susceptance B and the conductance G. In the operation characteristic of Figure 4 the conductance G has two threshold levels and also two slopes defined by angles α and β. The higher threshold level for the conductance G may be determined e.g. based on conductance of a parallel resistor of a compensation coil and the conductance representing the losses of the background network. The lower threshold level for the conductance G may be based on, for instance, the minimum measurable conductance of an IED (Intelligent Electronic Device). The slopes defined by the angles α and β are used to maximize the operate area when the measured susceptance has a low value and then to increase the non-operate area when a higher amplitude susceptance is measured. Such a characteristic provides an optimal compromise between sensitivity and security of the protection. The set threshold level for the susceptance B may be based on the minimum measurable susceptance of the IED. In case there are distributed coils located on the electric line 30, then the setting may be set based on the maximum possible overcompensation situation, which occurs when the electric line 30 has its minimum configuration and the distributed coils are connected. It should be noted that the operation characteristics shown in Figures 2, 3 and 4 are only examples of possible operation characteristics. Other kind of operation characteristics could be used instead.

An apparatus according to any one of the above embodiments, or a combination thereof, may be implemented as a single unit or as two or more units that are configured to implement the functionality of the various embodiments. Here the term 'unit' refers generally to a physical or logical entity, such as a physical device or a part thereof or a software routine. One or more of these units may reside in the protective relay unit 40, for example.

An apparatus according to any one of the embodiments may be implemented by means of a computer or corresponding digital signal processing equipment provided with suitable software, for example. Such a computer or digital signal processing equipment preferably comprises at least a working memory (RAM) providing storage area for arithmetical operations and a central processing unit (CPU), such as a general-purpose digital signal processor. The CPU may comprise a set of registers, an arithmetic logic unit, and a control unit. The control unit is controlled by a sequence of program instructions transferred to the CPU from the RAM. The control unit may contain a number of microinstructions for basic operations. The implementation of microinstructions may vary depending on the CPU design. The program instructions may be coded by a programming language, which may be a high-level programming language, such as C, Java, etc., or a low-level programming language, such as a machine language, or an assembler. The computer may also have an operating system which may provide system services to a computer program written with the program instructions. The computer or other apparatus implementing the invention further preferably comprises suitable input means for receiving e.g. measurement and/or control data, which input means thus enable e.g. the monitoring of current and voltage quantities, and output means for outputting e.g. fault alarms and/or control data e.g. for controlling protection equipment such as switches, disconnectors and circuit-breakers. It is also possible to use a specific integrated circuit or circuits, and/or discrete components and devices for implementing the functionality according to any one of the embodiments.

The invention can be implemented in existing system elements, such as various protective relays or similar devices, or by using separate dedicated elements or devices in a centralized or distributed manner. Present protective devices for electric systems, such as protective relays, typically comprise processors and memory that can be utilized in the functions according to embodiments of the invention. Thus, all modifications and configurations required for implementing an embodiment of the invention e.g.

in existing protective devices may be performed as software routines, which may be implemented as added or updated software routines. If the functionality of the invention is implemented by software, such software can be provided as a computer program product comprising computer program code which, when run on a computer, causes the computer or corresponding arrangement to perform the functionality according to the invention as described above. Such a computer program code may be stored or generally embodied on a computer readable medium, such as suitable memory means, e.g. a flash memory or a disc memory from which it is loadable to the unit or units executing the program code. In addition, such a computer program code implementing the invention may be loaded to the unit or units executing the computer program code via a suitable data network, for example, and it may replace or update a possibly existing program code.

It will be obvious to a person skilled in the art that, as the technology advances, the inventive concept may be implemented in various ways. The invention and its embodiments are not limited to the examples described above but may vary within the scope of the claims.