

Fault current circuit breaker

The invention relates to a residual-current circuit breaker according to the preamble of claim 1.

Residual-current circuit breakers for the protection of persons and electric installation arrangements from hazardous residual currents are known which will cut off an electric network after the occurrence of hazardous fault currents.

The disadvantageous aspect is that such a deactivation of an electric network by the user is mostly undesirable or will cause high costs in many cases, e.g. in the supply and control of processes which must not be interrupted such as in the performance of complex technical processes, or in the production of technical glasses where controlled cooling periods in the magnitude of several months is often the case. An interruption of the power supply during such a process causes high costs and is an irresponsible waste of raw materials. A further problem is especially the interruption of the power supply in computer applications which can lead to data loss and even to the endangerment of persons.

It is therefore the object of the invention to provide a residual-current circuit breaker of the kind mentioned above with which the mentioned disadvantages can be avoided and with which unexpected cut-offs of a network to be protected can be reduced.

This is achieved in accordance with the invention by the features of claim 1.

Downtimes of machines can thus be decreased and the incurred costs can be reduced. The users are informed about the momentarily applied fault current level and are optionally able to deactivate or disconnect electric consumers from the network themselves in order to pre-empt a potential deactivation of an electric circuit by the residual-current circuit breaker. It can thus be ensured that the respective residual-current circuit breaker continues to be fully functional as a residual-current circuit breaker even in the case of failure of the signaling means after a short circuit, and the protection of humans and installations is continually assured. In this way, data loss as a result of a cut-off of the network by the residual-current circuit breaker can often be prevented especially in the case of critical computer applications, because data can be

backed up in the case of an impending fault current, or devices potentially causing leakage currents can be deactivated.

The dependent claims, which simultaneously form a part of the description like claim 1, relate to further advantageous embodiments of the invention.

The invention will be described in closer detail by reference to the enclosed drawing which shows a merely preferred embodiment of a residual-current circuit breaker in accordance with the invention by way of example as a schematic block diagram.

The only drawing shows a residual-current circuit breaker 1, comprising at least one summation current transformer 2, through which are guided at least one first conductor 15 and a second conductor 16 of a network to be protected, with at least one secondary winding 17 being arranged on the summation current transformer 2, with the secondary winding 17 being operatively connected at least indirectly with at least one energy storage element 5, with at least one discharge resistor 4 being switched in parallel with the energy storage element 5, with the residual-current circuit breaker 1 having a breaker 7 which is operatively connected with the break contacts in the at least one first conductor 15 and the at least one second conductor 16, with the at least one discharge resistor 4 being formed by a first partial resistor 4a and a second partial resistor 4b which is switched in series to said first partial resistor, and that at least one first electric signaling means 20 is operatively connected at least indirectly with the first partial resistor 4a.

Downtimes of machines can thus be reduced and costs thus incurred can be decreased. The users are informed about the momentarily applied fault current level and are optionally able to deactivate or disconnect electric consumers from the network themselves in order to pre-empt a potential deactivation of an electric circuit by the residual-current circuit breaker 1. It can thus be ensured that the respective residual-current circuit breaker 1 continues to be fully functional as a residual-current circuit breaker 1 even in the case of failure of the signaling means 20 after a short circuit, and the protection of humans and installations is continually assured. In this way, data loss as a result of a cut-off of the network by the residual-current circuit breaker 1 can often be prevented especially in the case of critical computer

applications, because data can be backed up in the case of an impending fault current, or devices potentially causing leakage currents can be deactivated.

The means of the present invention can ensure that in the case of failure of the signaling means 20 or a failure of further modules that are optionally necessary for the operation of the signaling means 20 no low-resistance bridging of the at least one discharge resistor 4 is formed. The discharge resistor 4 directly influences the function of the residual-current circuit breaker 1, in that it influences the tripping characteristics of the residual-current circuit breaker 1, especially the tripping limit values and the frequency-dependent behavior of the tripping limit value, together with the energy storage element 5 that is arranged in parallel with the same. The functioning of the residual-current circuit breaker 1 can be ensured within predeterminable limit values which lie within the statutory requirements by the means of the present invention, even in the case of a total failure of the signaling means 20 in the form of a short circuit.

In the case of the occurrence of a fault current which per se is not large enough or not sufficiently large enough to cause the tripping of the residual-current circuit breaker 1, the signaling means 20 will be activated, e.g. the first electric lighting device 8 will light up and thus signal the presence of a fault current. An operator can thus do something already before the tripping of the residual-current circuit breaker 1, in that devices are disconnected from the network and/or sensitive processes are backed up or ended. Furthermore, the search for faults is considerably simplified by a residual-current circuit breaker 1 in accordance with the invention because it can be recognized immediately after activation of a device whether a fault current occurs, even when the same is (still) too low to cause tripping of the residual-current circuit breaker 1.

The only drawing shows a merely especially preferred embodiment of a residual-current circuit breaker 1 in accordance with the invention for fault current tripping in a manner preferably independent of mains voltage as a schematic illustration of the functional modules and their circuit connections. The discharge resistor 4 which is formed in the present invention by the first and second partial resistor 4a, 4b is shown in the only drawing as a dot-dash compensating resistor. Such a residual-current circuit breaker 1 is provided for the

protection of installations and persons, with the consumers connected to the residual-current circuit breaker 1 being disconnected from a supply network comprising a first conductor 15 and a second conductor 16 in the case that a hazardous fault current occurs. The residual-current circuit breaker 1 comprises terminals, especially screw-type terminals, for the connection of at least one first and one second conductor 15, 16 of an electric supply network. The illustrated schematic circuit diagram shows an embodiment with merely one first and one second conductor 15, 16. It is possible to provide embodiments with any pre-determinable number of lines or conductors of an electric power supply network, especially embodiments with three or four conductors, e.g. for the protection of a three-phase current consumer connected to a three-phase network. The further description relates to the illustrated embodiment with a first and the second conductor 15, 16, with this accordingly including embodiments with several conductors in an equivalent manner. The first and the second conductors 15, 16 comprised so-called break contacts (not shown), which are therefore switching contacts and which are provided and arranged for disconnecting and interrupting the first and second conductors 15, 16 and subsequent closing of the same. The components and modules described and/or illustrated in the drawing are jointly arranged in a housing which is made of insulating material and which comprises breakthroughs at least for the terminals and a manual switching lever which can be actuated manually and which is provided for the manual opening and closing of the break contacts. It can further be provided that a residual-current circuit breaker 1 in accordance with the invention comprises further modules or components that are not shown or described, e.g. a switching position indicating device, a tripping display and the like.

As already mentioned, a residual-current circuit breaker 1 in accordance with the invention is preferably arranged as a residual-current circuit breaker 1 which is independent of mains voltage. The modules arranged in such a residual-current circuit breaker 1 which is independent of mains voltage for the detection of a fault current and tripping of the residual-current circuit breaker 1, therefore the disconnection of the break contacts, obtain their energy required for tripping completely from the fault current or from the fault current signal proportional to the same in the secondary winding 17.

A residual-current circuit breaker 1 in accordance with the invention comprises in the known manner at least one summation current transformer 2 with a transformer core comprising a magnetic material, through which the first and second conductor 15, 16 are guided as the primary winding. It can be provided that the first and second conductor 15, 16 are guided neatly through a substantially central opening of the summation current transformer 2, or to wind the same about the transformer core. A secondary winding 17 for the detection of a fault current signal is further arranged on the summation current transformer 2, with the secondary winding 17 being connected at least indirectly by means of circuitry with at least one energy storage element 5, and the energy storage element 5 is connected at least indirectly with a breaker 7, or cooperates with such a breaker, which is preferably arranged as permanent-magnetic trip relay, through which an especially secure and rapid response of the residual-current circuit breaker 1 can be achieved. The breaker 7 acts mechanically, preferably by way of a breaker mechanism (not shown), on the break contacts. A respective fault current signal is generated in the secondary winding 17 after the occurrence of the hazardous fault current, and the breaker 7 acts on the break contacts which are opened and disconnect the first and second conductor 15, 16.

It is provided according to the especially preferred embodiment of a residual-current circuit breaker 1 in accordance with the invention as shown in the only drawing that a rectifier circuit 3 is connected to the secondary winding 17, which rectifier circuit is preferably arranged as a full-wave rectifier, preferably as a bridge rectifier, and that the rectifier circuit 3 is connected by means of circuitry with the energy storage element 5 which is arranged according to the illustrated preferred embodiment as a capacitor 19, through which a simple configuration and a rapid response of the energy storage element 5 can be achieved.

In accordance with the invention, at least one discharge resistor 4 is switched in parallel to the energy storage element 5, which discharge resistor is formed by a first partial resistor 4a and at least one second partial resistor 4b, with the first and second partial resistors 4a, 4b being switched in series with respect to one another, as is also shown in the only drawing. The discharge resistor 4 ensures both the discharge of the energy storage element 5 after the occurrence of a fault current and also influences and predetermines the residual-current tripping characteristics of the residual-current circuit breaker 1. A tripping limit value can

thus be predetermined and set in a very simple way. In the preferred embodiment of the energy storage element 5 as a capacitor 19 and the preferred embodiment of the first and second partial resistors 4a, 4b as ohmic resistors, they jointly form a high-pass of the first order, by means of which an increase of the tripping limit value in high-frequency fault currents can be achieved. This is advantageous because the effect of the electric current on the human body decreases towards higher frequencies. As a result of a respective dimensioning of this high-pass, the tripping characteristics can be adjusted to the requirements of the protection of persons, and tripping of the residual-current circuit breaker 1 in the case of fault currents which are not hazardous to humans or installations can be prevented. The effect of electric current depending on the frequency is known to the person skilled in the art from the publication of Prof. Biegelmeier: "Wirkung von Wechselströmen höherer Frequenz (Effects of Alternating Currents of Higher Frequency), IEC Report 479, 2nd edition, 1986, part 2, chapter 4" and the subsequent publication in: "Wirkung des elektrischen Stromes auf Menschen und Nutztiere (Effect of Electric Current on Humans and Working Animals), VDE-Verlag 1986, from page 169". The dimensioning of a high-pass whose pass band is sufficient at least for this frequency dependence is known to the person skilled in the art of electrical engineering.

As already explained, the energy storage element 5 acts on the breaker 7. It is preferably provided in this case that the energy storage element 5 is operatively connected via a second threshold circuit 6 with the breaker 7, with the second threshold switch 6 predetermining the voltage threshold for the tripping of the breaker 7. A threshold switch can be realized to comprise a zener diode or be arranged as a simple transistor circuit.

It is preferably further provided that the residual-current circuit breakers 1 further comprise a test circuit for testing the functionality and operational reliability of the residual-current circuit breaker 1. The test circuit comprises a test button and a test resistor, with a fault current being simulated by pressing the test button via the test resistor, which fault current should make the residual-current circuit breaker 1 trip.

Residual-current circuit breakers 1 in accordance with the invention comprise at least one first electric signaling means 20 which is operatively connected at least indirectly with the first

partial resistor 4a. It is preferably provided in an especially simple embodiment of the present invention that the first electric signaling means 20 is switched in parallel by means of circuitry with the first partial resistor 4a which is arranged as an ohmic resistor, and therefore the voltage applied to the first partial resistor 4a and dropping via the same is output or displayed at least qualitatively by the electric signaling means 20. The first and second partial resistors 4a, 4b jointly form a voltage divider. The partial voltage applied to the first partial resistor 4a or dropping via the first partial resistor 4a is therefore proportional to the total voltage dropping via the first and second partial resistors 4a, 4b. By dividing the discharge resistor 4 into a first and at least second partial resistor 4a, 4b and displaying the voltage dropping on the first partial resistor 4a it can be achieved that the bridging of the first partial resistor 4a, as can occur in the case of a defective first signaling means 20, will not lead to a failure of the residual-current circuit breaker 1, but will lead to maintaining the functionality within the scope of the statutory requirements. For this purpose, the first and second partial resistors 4a, 4b are preferably dimensioned in such a way that in the case of a bridging of the first partial resistor 4a the required tripping fault current of 30 mA for example at a frequency of 50 Hz will still not be exceeded. As a result, an increased security of the residual-current circuit breaker 1 can be achieved, because it will still guarantee a minimum amount of protection even in the case of failure of a component that can be given by using the residual-current circuit breaker in rough conditions and/or outside of the specified applications or ambient conditions such as use under high ambient temperatures and/or strong vibrations.

The electric signaling means 20 concern any means of generating and emitting a signal after receipt of a predeterminable electric current and/or voltage signal, e.g. a loudspeaker, a buzzer, a mechanical signal generator such as a flag, an externally arranged relay, a radio interface or the like, with preferably the arrangement of the first electric signaling means being provided as an optical electric signaling means, preferably as a first electric lighting device 8.

A first electric lighting device 8 can be provided as any kind of lighting device 8, e.g. bulbs, gas-discharge lamps, LEDs 18 and/or LCD displays, with the arrangement of the first electric lighting device 8 being provided according to the illustrated especially preferred embodiment as at least one light-emitting diode 18, by means of which it is possible to achieve both a high luminosity and thus a strong signaling effect, and also low power consumption. It can be

provided according to an especially simple embodiment of the present invention that nearly one single lighting device 8 is provided and merely the brightness, the luminosity or the amount of the emitted luminous flux is a measure for the magnitude of the voltage applied to the energy storage element 5 and thus a measure for the magnitude of the fault current. It can also be provided to arrange a predeterminable number of electric lighting devices 8, wherein it can be provided that this predeterminable number of electric lighting devices 8 is triggered in such a way that the number of the lit lighting devices 8 is a measure for the magnitude of the fault current. Linear scaling can be provided in this case, or also the reproduction of a bit pattern, thus providing a very fine reproduction of different values in a very simple manner. It can also be provided to arrange a predeterminable number of electric lighting devices 8 in the form of an alpha-numeric display, with respective means for triggering such a display being provided. In all described embodiments of the arrangement of first electric lighting devices 8, any of the arrangements of the electric lighting device 8 as described above can be provided.

Depending on the available output of the provided summation current transformer 2, an amplification of the voltage of the energy storage element 5 can be advantageous. An amplifier circuit for amplifying the voltage of the energy storage element 5 is provided according to an especially preferred embodiment of the invention. The power available for triggering the lighting device 8 can be increased by the amplifier circuit 9. The amplifier circuit 9 comprises active amplifying components such as transistors, FETs and/or bipolar and/or operational amplifiers.

In order to provide the supply voltage for the active components, a power supply unit is provided according to a first preferred embodiment of the amplifier circuit 9, which power supply unit is preferably integrated in the module of the amplifier circuit 9 and which is connected by means of circuitry with the first and second conductor 15, 16 of the network to be protected, and thus draws the power for the operation of the amplifier circuit 9 directly from the network to be protected.

If the amplifier circuit is provided, at least one amplifier input 11 of an amplifier circuit 9 is connected to the energy storage element 5, and at least one amplifier output 12 of the amplifier circuit 9 is operatively connected at least indirectly with the first electric lighting

device 8, and therefore the amplifier output 12 is connected by means of circuitry either directly with the lighting device 8 or via a further interposed module. The term amplifier input 11 and amplifier output 12 designates preferably all contacts or poles necessary for a functional amplifier input 11 and amplifier output 12. In the illustrated preferred embodiment, the amplifier input 11 and amplifier output 12 each comprise two contacts or poles. A larger predeterminable number of contacts and poles can be provided in this case in processing more complex signals.

It is preferably provided according to the illustrated preferred embodiment in order to enable a pre-determinable feedback control of the response of the lighting device 8 that the at least one amplifier output 12 is connected by means of circuitry with at least one threshold circuit input 13 of a first threshold circuit 10, and that at least one threshold circuit output 14 of the first threshold circuit 10 is connected by means of circuitry with the first electric lighting device 8. The first threshold circuit 10 can be arranged in such a way that an adjustability of threshold value by the operator is possible. As a result, a limit value for the activation of the signaling means 20 by an operator can be predetermined.

Further embodiments in accordance with the invention merely have a part of the described features, with any combination of features, which especially also include those of different described embodiments, being provided.

CLAIMS:

1. A residual-current circuit breaker (1), comprising at least one summation current transformer (2), through which are guided at least one first conductor (15) and one second conductor (16) of a network to be protected, with at least one secondary winding (17) being arranged on the summation current transformer (2), with the secondary winding (17) being operatively connected at least indirectly with at least one energy storage element (5), with at least one discharge resistor (4) being switched in parallel with the energy storage element (5), with the residual-current circuit breaker (1) having a breaker (7) which is operatively connected with the break contacts in the at least one first conductor (15) and the at least one second conductor (16), characterized in that the at least one discharge resistor (4) is formed by one first partial resistor (4a) and one second partial resistor (4b) which is switched in series to said first partial resistor, and that at least one first electric signaling means (20) is operatively connected at least indirectly with the first partial resistor (4a).
2. A residual-current circuit breaker (1) according to claim 1, characterized in that the first electric signaling means (20) is switched in parallel at least indirectly with the first partial resistor (4a).
3. A residual-current circuit breaker (1) according to claim 1 or 2, characterized in that the first electric signaling means (20) is arranged as an optical electric signaling means, preferably as a first electric lighting device (8).
4. A residual-current circuit breaker (1) according to claim 3, wherein the first electric signalling means (20) is arranged as a first electric lighting device (8), characterized in that the first electric lighting device (8) is arranged at least as a light-emitting diode (18).
5. A residual-current circuit breaker (1) according to one of the claims 1 to 4, characterized in that at least one amplifier input (11) of an amplifier circuit (9) is connected to the first partial resistor (4a), and that at least one amplifier output (12) of

the amplifier circuit (9) is operatively connected at least indirectly with the first electric signaling means (20).

6. A residual-current circuit breaker (1) according to claim 5, characterized in that the amplifier circuit (9) is connected by means of circuitry with the first conductor (15) and the second conductor (16).
7. A residual-current circuit breaker (1) according to claim 5 or 6, characterized in that the at least one amplifier output (12) is connected by means of circuitry with the at least one threshold circuit input (13) of a first threshold circuit (10), and that at least one threshold circuit output (14) of the first threshold circuit (10) is connected by means of circuitry with the first electric signaling means (20).
8. A residual-current circuit breaker (1) according to one of the claims 1 to 7, characterized in that the energy storage element (5) is arranged as a capacitor (19).
9. A residual-current circuit breaker (1) according to one of the claims 1 to 8, characterized in that a rectifier circuit (3) is connected to the secondary winding (17), and that the rectifier circuit (3) is connected by means of circuitry with the energy storage element (5).
10. A residual-current circuit breaker (1) according to one of the claims 1 to 9, characterized in that the energy storage element (5) is operatively connected with the breaker (7) via a second threshold circuit (6).