(19) DANMARK

(10) DK/EP 2555367 T3

(12) Oversættelse af europæisk patentskrift

Patent- og Varemærkestyrelsen

(51) Int.Cl.: *H 02 H 1/00 (2006.01)* *H 02 H 3/20 (2006.01)*

(45) Oversættelsen bekendtgjort den: **2016-08-15**

(80) Dato for Den Europæiske Patentmyndigheds bekendtgørelse om meddelelse af patentet: **2016-04-27**

(86) Europæisk ansøgning nr.: **12171572.6**

(86) Europæisk indleveringsdag: **2012-06-12**

(87) Den europæiske ansøgnings publiceringsdag: **2013-02-06**

(30) Prioritet: **2011-08-05 DE 102011080523**

(84) Designerede stater: **AL AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO PL PT RO RS SE SI SK SM TR**

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(54) Benævnelse: **Fejllysbueafbryder med overspændingsbeskyttelse**

(56) Fremdragne publikationer:
**EP-A1- 0 349 750**
**WO-A2-2008/005709**
**US-A1- 2008 204 950**

**Description**

The present invention relates to an arc-fault circuit-breaker for protection against arcs in a circuit, for which purpose high-frequency signal components are monitored, with a signal input device to which a line to be monitored can be connected, for the purpose of supplying an input signal from the line, an evaluation device for evaluating the input signal with regard to the presence of an arc fault and a triggering device for interrupting the line to be monitored on the basis of a triggering signal from the evaluation device.

An arc can occur in a circuit when, for example, a light switch is faulty, and the distance between two contacts of the light switch is too small for it to be possible to interrupt the flow of current. An arc then develops between the two contacts. In addition to an arc forming in series in the circuit, the arc can also arise between the live and neutral lines of the circuit. If arcs occur, the temperature of the surrounding components rises, and a fire can start.

It is therefore useful to provide a device with which protection against arcs can be ensured. Arc-fault circuit-breakers (AFDD = Arc Fault Detection Devices) have been developed for this purpose which can detect and dampen serial and parallel arc faults in a low-voltage installation. These devices monitor high-frequency signal components, the line voltage and the load current using complex analogue circuits and/or signal processors.

Since arc-fault circuit-breakers are used to protect branch circuits that are supplied with a voltage of 230 V AC, these devices can be exposed to overvoltages that arise as a result of a fault in a three-phase system or in an upstream distribution transformer. In the event of a fault the line voltage can here be up to 400 V AC.

The electronics of an arc-fault circuit-breaker require a sufficient DC power supply in the range of 10 mA to 50 mA, and a power supply unit that can provide this current at a low DC voltage.

Many of the arc-fault circuit-breaker's sensors, such as the high-frequency transformers for capturing HF components, and current converters for measuring currents or voltages, are connected directly to the live and neutral lines of the branch circuit. They can thus be exposed to the overvoltage. A thyristor, which is usually used to drive a solenoid switch and to trigger a trigger mechanism of the arc-fault circuit-breaker, is also directly connected to parts at which this voltage is present. All of these components can, potentially, be exposed to an overvoltage.

It is expensive, and therefore also unusual, to employ power supply components, sensors and thyristors that can withstand such overvoltages. Components with a higher rated voltage, which on the one hand are more expensive and on the other hand have larger dimensions, would then have to be employed.

WO 2008/005709 A2 discloses a fault-current circuit-breaker that comprises an overvoltage protection circuit.

US 2008/0204950 A1 discloses an arc-fault circuit-breaker that uses high-frequency signal components to detect arcs.

EP 0 349 750 A1 discloses a compensation and overvoltage protection circuit for electronic devices.

Arc-fault circuit breakers (AFCI = Arc Fault Circuit Interrupter) that operate at 120 V AC and which usually can withstand up to 240 V AC, which can be the result of a fault in a two-phase system, are available on the American market. Fault-current circuit-breakers (RCD = Residual Current Device) are confronted with the same problem. Some of them can accept

the overvoltage, and others are fitted with an additional overvoltage protection, which results in additional costs.

An arc protection module for the European IEC technology is known from document DE 10 2008 004 869 A1. The module comprises means for detecting whether an arc has occurred in the circuit. The module, furthermore, does not have its own isolating contacts, but instead has means for initiating the opening of the isolating contacts of a circuit-breaker that is in any case already arranged in the circuit.

The object of the present invention is to protect an arc-fault circuit-breaker and the circuit that it monitors against overvoltages in a simple manner.

- According to the invention this object is achieved by an arc-fault circuit-breaker according to Claim 1.

The arc-fault circuit-breaker is thus supplemented in an advantageous manner by a voltage converter that reduces the voltage in a line to be monitored so that it can be evaluated by the conventionally designed electronics of an arc-fault circuit-breaker. The evaluation device of the arc-fault circuit-breaker can then also be used in the event of an overvoltage to trigger the triggering device.

Preferably the voltage converter is implemented by a voltage divider. A voltage divider can be manufactured very economically, so that the costs for the arc-fault circuit-breaker can be kept low.

The voltage divider can, in particular, comprise ohmic resistors. Ohmic resistors are particularly economical to manufacture.

The output voltage of the voltage converter can be less than 5%, in particular for example 0.5%, of the input voltage of the voltage converter. The output voltages then usually lie in the

low, single-figure voltage range which can easily be sampled by conventional electronics.

The evaluation device can have an input with A/D converter, to which the output signal of the voltage converter is taken. Digital processors, which commonly are in any case present in arc-fault circuit breakers, can thus be used for the evaluation.

In addition, the evaluation device can sample the output signal of the voltage converter a number of times and form an average value from the plurality of samples. In this way it can be ensured that short measuring peaks do not result in triggering the arc-fault circuit-breaker on the basis of an overvoltage.

The signal input device can, furthermore, comprise a power supply unit with rectifier. This power supply unit can, in particular, be employed to supply power to the evaluation device.

According to one special form of embodiment, the evaluation device evaluates the output signal with regard to voltage and time, and drives the triggering device for disconnecting the line if the measured voltage lies above a predefined threshold value for a predetermined time. This allows for the situation in which the components of the arc-fault circuit-breaker can be exposed to an overvoltage for a certain period of time without being damaged.

It is particularly advantageous here if the predetermined time depends on the predetermined threshold value. A time-dependent function for triggering the arc-fault circuit-breaker in response to an overvoltage is therefore important.

The present invention will now be explained in more detail with reference to the attached drawing which shows a schematic

diagram of an arc-fault circuit-breaker with overvoltage protection according to the invention.

The exemplary embodiments subsequently described represent preferred forms of embodiment of the present invention.

An arc-fault circuit-breaker 1 is represented schematically in the figure. It is used to disconnect a live line L and a neutral line N. The lines L and N can in some circumstances also be part of a three-phase system. The disconnection of the two lines L and N is made through a common switch 2 that is integrated into the arc-fault circuit-breaker 1. The switch 2 is driven by a triggering device (A) 3. The triggering device 3 is driven in the usual manner by a controller (C) or by an evaluation device 4.

The evaluation device 4 is connected to the lines L and N in order to evaluate corresponding voltages or currents. In particular, for example, high-frequency components in the signals are evaluated, in order to be able to detect arc faults.

The arc-fault circuit-breaker 1 moreover contains a power supply unit (N) 5, which is also connected to the lines L and N. The power supply unit 5 rectifies the alternating current in the line L, and supplies the evaluation device 4 with direct current.

In order to now provide overvoltage protection, the arc-fault circuit-breaker is additionally provided with an appropriate protection component. Since the arc-fault circuit-breaker already usually contains a processor or similar components in the evaluation device 4 with which a signal analysis can be carried out and an arc detected, only a few additional means are necessary to be able to measure the line voltage and to actuate the triggering device 3 of the arc-fault circuit-breaker when the line voltage exceeds a predetermined threshold

value. A complete, additional analysis unit is therefore not necessary in order to detect overvoltages in addition to arc faults.

Since usual processors only have relatively low input voltages, and voltages in the range up to, for example, 400 V are to be measured with the present arc-fault circuit-breaker, the detection unit for recognizing an overvoltage must comprise a voltage converter that reduces the voltage to be monitored in a suitable manner. A simple voltage divider 6 can be used as a voltage converter according to the example of the figure. The voltage divider 6 can, in particular, be constructed purely out of ohmic resistors. It is favourable for the present application (line voltages up to about 400 V) to reduce the voltage to be measured to about 0.5% of the true value. The voltage divider is to be designed accordingly. The rectified voltage at the output of the power supply unit is used in order to save an additional rectifier. The signal prepared in this way is sent to an input of the evaluation unit 4 (in particular a microcontroller) with an analogue-digital converter for sampling and analysis.

The evaluation device 4 takes a large number of samples, calculates an average value for the voltage, extrapolates the true line voltage value, and then decides whether or not the arc-fault circuit-breaker should be triggered.

A voltage-time characteristic can be stored in the evaluation device 4 as a trigger criterion, as is also used as the trigger criterion in what is known as a "POP" (Permanent Overvoltage Protection). At a higher overvoltage, for example, triggering accordingly takes place earlier than at a lower overvoltage.

In the present case, the arc-fault circuit-breaker thus has an overvoltage protection that also allows it to use components with low values of rated voltage for detecting overvoltages, and thus to offer an additional performance feature to the

user. The components of the power supply system are thus only exposed to the overvoltage for a limited period of time, which means that the robustness of these components in respect of such short-term stresses must be ensured.

Advantageously, no components for increased rated voltage values have to be provided for the solution according to the invention. This saves costs and space. The arc-fault circuit-breaker is thus provided with an additional feature of permanent overvoltage protection. The additional measures required to implement this feature are minimal. That is to say that only additional, economical resistors need to be provided for a voltage divider, and the computing capacities of the arc-fault circuit-breaker can be shared for the overvoltage protection.

## Patentkrav

**1.** Fejllysbueafbryder (1) til beskyttelse mod lysbuer i et strømkredsløb, til hvilket formål højfrekvente signaldele overvåges, med
- en signalindgangsindretning, som en ledning (L, N), der skal overvåges, kan tilsluttes til, til afgivelse af et indgangssignal fra ledningen,
- en analyseindretning (4) til analyse af indgangssignalet med hensyn til forekomst af en fejllysbue og
- en udløserindretning (3) til afbrydelse af ledningen, der skal overvåges, på baggrund af et udløsersignal fra analyseindretningen (4),

**kendetegnet ved, at**
- signalindgangsindretningen omfatter en spændingstransformer (6) til reduktion af spændingen på den ledning, der skal overvåges,
- spændingstransformerens (6) udgangssignal ledes hen til analyseindretningen (4), og
- analyseindretningen (4) analyserer udgangssignalet med hensyn til en overspænding og aktiverer udløserindretningen (3) tilsvarende.

**2.** Fejllysbueafbryder ifølge krav 1, hvor spændingstransformeren (6) er en spændingsdeler.

**3.** Fejllysbueafbryder ifølge krav 2, hvor spændingsdeleren har ohmske modstande.

**4.** Fejllysbueafbryder ifølge et af de foregående krav, hvor spændingstransformerens (6) udgangsspænding er mindre end 1% af spændingstransformerens indgangsspænding.

**5.** Fejllysbueafbryder ifølge et af de foregående krav, hvor analyseindretningen (4) har en indgang med A/D-omformer, som spændingstransformerens udgangssignal er ført hen til.

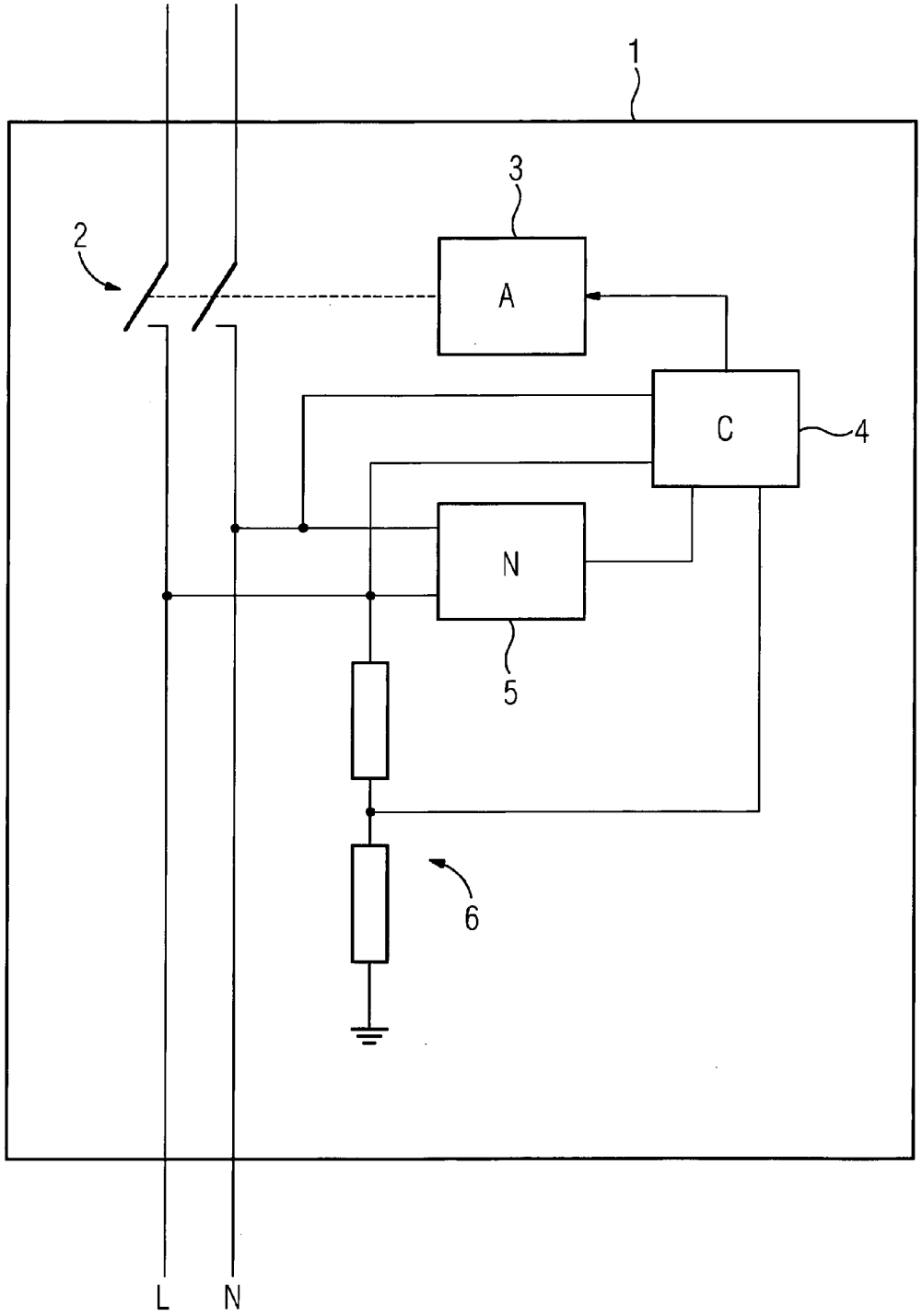
**6.** Fejllysbueafbryder ifølge et af de foregående krav, hvor analyseindretningen (4) aftaster spændingstransformerens (6) udgangssignal flere gange og danner en middelværdi af aftastningsværdierne.

**7.** Fejllysbueafbryder ifølge et af de foregående krav, hvor signalindgangsindretningen omfatter en netdel (5) til tilslutning til et trefaset net.

**8.** Fejllysbueafbryder ifølge krav 7, hvor netdelen (5) forsyner analyseindretningen (4) med strøm.

**9.** Fejllysbueafbryder ifølge et af de foregående krav, hvor analyseindretningen (4) analyserer spændingstransformerens (6) udgangssignal med hensyn til spænding og tid og aktiverer udløserindretningen (3) til separation af ledningen (L, N), når den målte spænding i et forudbestemt tidsrum ligger over en defineret tærskelværdi.

**10.** Fejllysbueafbryder ifølge et af de foregående krav, hvor det forudbestemte tidsrum afhænger af den definerede tærskelværdi.


1
2
3
A
C
4
N
5
6
L
N