

DESCRIPTION

HEAVY-CURRENT FUSE AND AN ELECTRICAL POWER DISTRIBUTION
NETWORK

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Technical field

The invention relates to a heavy-current fuse according to the precharacterizing clause of Claim 1. Fuses such as this are primarily used as line-protection fuses in low-voltage networks, and are normally arranged in transformer stations, substations and building terminal boxes. They can interrupt overcurrents in the order of magnitude of several hundred amperes. Furthermore, the invention relates to an electrical power distribution network according to the precharacterizing clause of Claim 13.

Prior art

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Heavy-current fuses of this generic type are commercially available in various sizes and configurations. Thus, for example, the prospectus 'NH-Sicherungseinsätze' [lvhrc fuse links] from Rockwell Automation describes various such fuses whose dimensions correspond to the various sizes in the Standards DIN 43620 and IEC 269-2-1. In practice, fuses such as these have a very low impedance at all the frequencies that occur in the network. Their function is limited entirely to disconnection of an overcurrent.

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However, it is known that radio-frequency voltages and currents occur in electrical power distribution networks due to switching processes and other influences, which propagate quickly through the network and, in some circumstances, cause interference to specific sensitive consumers. The load on the network from radio-frequency interference is particularly

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disadvantageously noticeable when messages are also transmitted by means of radio-frequency signals via specific parts of said network, for example within a building.

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Description of the invention

The invention is now based on the idea of designing known heavy-current fuses of this generic type such
10 that they can also largely suppress interference signals of the described type. Since, owing to its conventional function, such a heavy-current fuse normally connects a relatively small network area, in particular an area which is limited to an individual
15 building or a building complex, to the rest of the network, and the transmission of messages via the network is normally likewise limited to areas such as these, it is very advantageously positioned in order to allow it to be used to compartmentalize the said areas
20 off from the rest of the network, with regard to radio-frequency interference, as well.

The heavy-current fuse according to the invention is now designed such that, in addition to interrupting
25 overcurrents, it also largely suppresses radio-frequency signals, in particular in a frequency band between 1 MHz and 40 MHz, as is used in particular for message transmission. In this case, the fuse in each case be designed such that, with regard to its
30 electrical design and with regard to its dimensions, it corresponds to a known, standard heavy-current fuse, at least to the extent that it can replace such a standard fuse without any changes to the plug-in location or to the rest of the environment.

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The advantages achieved by the invention are, in particular, that better impedance relationships for message transmission are produced in a reasonably

simple and cost-effective manner, even in already existing systems, by these impedance relationships being set at the coupling points of individual paths such that large-area propagation of radio-frequency signals via the electrical power distribution network is largely suppressed.

In particular, the ingress of radio-frequency interference signals into a path of an electrical power distribution network in which messages are also transmitted is greatly reduced in this way, and a better signal-to-noise ratio is produced for message transmission. Conversely, this also largely suppresses message signals flowing out in an undesirable manner from this path. In consequence, interference influences are prevented or are at least heavily attenuated and, furthermore, undesirable electromagnetic radiated emissions are reduced. The mutual decoupling between different paths in the frequency band used for message transmission allows multiple use of these frequencies in the network, and thus an increase in the overall message capacity of said network. At the same time, the quality of message transmission within the individual paths is improved.

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Brief description of the drawings

The invention will be explained in more detail in the following text with reference to figures, which illustrate only one exemplary embodiment, and in which:

Figure 1 shows a longitudinal section through a first embodiment of a heavy-current fuse according to the invention, with the inductor shown not cut away,

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Figure 2 shows a longitudinal section corresponding to that in Figure 1 along II-II,

Figure 3 shows a cross section along III-III in Figure 1,

5 Figure 4 shows a longitudinal section through a second embodiment of a heavy-current fuse according to the invention, with the inductor shown partially not cut away,

10 Figure 5 shows a cross section along V-V in Figure 4,

Figure 6 shows a longitudinal section through a third embodiment of a heavy-current fuse according to the invention, with the inductor shown not cut away,

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Figure 7 shows a longitudinal section corresponding to that in Figure 6, along VII-VII,

20 Figure 8 shows a cross section along VIII-VIII in Figure 6,

Figure 9 shows a longitudinal section through a fourth embodiment of a heavy-current fuse according to the invention, with the inductor shown not cut away,

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Figure 10 shows a cross section along X-X in Figure 9,

30 Figure 11 shows a longitudinal section corresponding to that in Figure 9, but with the inductor cut away,

Figure 12 shows a longitudinal section through a fifth embodiment of a heavy-current fuse according to the invention, immediately behind the front wall,

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Figure 13 shows a cross section along XIII-XIII in Figure 12,

5 Figure 14 shows a longitudinal section along XIV-XIV in Figure 13,

10 Figure 15 shows a longitudinal section through a sixth embodiment of a heavy-current fuse according to the invention, immediately behind the front wall,

Figure 16 shows a cross section along XVI-XVI in Figure 15,

15 Figure 17 shows a longitudinal section along XVII-XVII in Figure 16,

20 Figure 18 shows a longitudinal section through a seventh embodiment of a heavy-current fuse according to the invention, whose basic design corresponds to that of the fifth embodiment,

25 Figure 19 shows a side view corresponding to the arrow XIX in Figure 18,

Figure 20 shows a side view corresponding to the arrow XX in Figure 18,

30 Figure 21 shows a longitudinal section through an eighth embodiment of a heavy-current fuse according to the invention, whose basic design corresponds to that of the sixth embodiment,

35 Figure 22 shows a side view corresponding to the arrow XXII in Figure 21,

Figure 23 shows a side view corresponding to the arrow XXIII in Figure 18, and

5 Figure 24 shows, schematically, an electrical power distribution network in which heavy-current fuses according to the invention are used.

Ways to implement the invention

10 A first embodiment of a heavy-current fuse according to the invention (Figures 1-3) has an approximately cuboid housing 1 composed of electrically insulating material, preferably ceramic, which has a first electrical connection at the opposite ends in the longitudinal
15 direction, having a first closure plate 2 which is fitted with a contact blade 3 on the outside, and has a second electrical connection having a second closure plate 4, which is fitted with a contact blade 5 on the outside. The closure plates 2, 4 which close the
20 housing 1 are composed, for example, of aluminum while the contact plates 3, 5 are composed of a copper alloy and are silver-plated.

The housing interior is subdivided into two sections,
25 which follow one another in the longitudinal direction, by means of a separating plate 6 composed of an electrically conductive material, for example aluminum. The somewhat longer first section, which is located between the closure plate 2 of the first electrical
30 connection and the separating plate 6, contains a fusible element which electrically conductively connects the closure plate 2 to the separating plate 6. This fusible element comprises three parallel-connected silver hoops 7 which are arranged one behind the other
35 in a row, and is designed in a known manner such that, in the event of an overcurrent, it melts through in accordance with a standardized characteristic after a

response time that is dependent on the current density, and interrupts the current.

5 An inductor is arranged in the section of the housing interior located between the separating plate 6 and the closure plate 4 of the second electrical connection. This inductor comprises a cylindrical winding 8 which electrically conductively connects the separating plate 6 to the closure plate 4, and a continuous core
10 composed of a ferromagnetic, preferably electrically insulating material, in particular ferrite, which is in the form of a solid round bar 9 located on the axis of the winding 8 and surrounded by said winding 8. The inductance of the inductor is chosen such that its
15 impedance is negligibly small at frequencies in the order of magnitude of the network frequency, that is to say about 50 MHz, but, on the other hand, is very large at radio frequencies from 1 MHz to 40 MHz.

20 The dimensions of the heavy-current fuse can comply with Size 1-3 in Standard DIN 432620, and it can be designed, for example, for 400 V and 400 A. It can be used at any time in place of conventional fuses which comply with this Standard.

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A second embodiment (Figures 4, 5) of the heavy-current fuse according to the invention differs from the first only in that the winding 8 is somewhat smaller and, in addition to a bar 9 arranged on the axis of the core,
30 the core also has a shell which surrounds the winding 8 on the outside and is composed of two half-shells 10a, b which are connected to the head ends of the bar 9 and are separated by a centrally running air gap 11. The shell has two mutually diametrically opposite
35 openings 12a, b, which extend over its entire length and are in the form of sectors, through which the winding 8 is electrically conductively connected to the separating plate 6 and to the closure plate 4.

A third embodiment (Figures 6-8) also largely corresponds to the first, but the core, which is once again in the form of a solid round bar 9, extends
5 essentially over the entire length of the housing 1, and reaches from the closure plate 2 of the first electrical connection to the closure plate 4 of the second electrical connection. The three silver hoops 7 of the fusible element are arranged around the bar 9.
10 This embodiment is distinguished by particularly good mechanical robustness.

A fourth embodiment (Figures 9-11) of the heavy-current fuse according to the invention has a different design.
15 Here, the core is once again in the form of bar 9 which is surrounded by the winding 8. However, they both have a rectangular cross section, that is to say they are cuboid, and the bar 9 is hollow and has a central bushing which is continuous in the longitudinal
20 direction and in which the fusible element is arranged, which in this case is composed of a single silver hoop 7. The winding 8 is separated from the closure plate 2 of the first electrical connection by an insulation layer 13, and the silver hoop 7 is separated from the
25 closure plate 4 of the second electrical connection by an insulation layer 14.

The silver hoop 7 is connected through an opening in the first insulation layer 13 to the first closure
30 plate 2. Its opposite end is connected via an intermediate plate 15, which rests on the second insulation layer 14, to a return-path line 16, which is, for example, in the form of a return-path wire and runs back in a groove on the outside of the bar 9, in
35 the opposite direction to the silver hoop 7, to that end of the winding 8 which is closest to the first closure plate 2. That end of the winding 8 which is opposite this is, finally, connected through an opening

in the second insulation layer 14 to the closure plate 4. The current path thus runs from the closure plate 2 through the silver hoop 7, the intermediate plate 15, back through the return-path line 16 and, after
5 redirection once again, through the winding 8 to the closure plate 4.

This embodiment is particularly space-saving and, in particular can be very short. It can thus be produced
10 to match the dimensions of Size 00-3 in Standard DIN 43620, and can be used at any time in place of conventional heavy-current fuses which comply with this Standard.

15 A fifth embodiment of the heavy-current fuse according to the invention (Figures 12-14) corresponds in terms of its basic design to the fourth embodiment, but the winding 8 is arranged alongside the fusible element, which is arranged between the contact blade 3 of the
20 first electrical connection and an intermediate plate 15 and is once again composed of three parallel silver hoops 7. The intermediate plate 15 is connected by means of a return-path line 16 to that end of the winding 8 which is closest to the first electrical
25 connection, with its opposite end abutting against the closure plate 4 of the second electrical connection. An insulation layer 14 is located between the latter and the intermediate plate 14. The winding 8 surrounds a core, which is surrounded by an insulation layer. It
30 may once again be in the form of a solid round bar 9, or else may be composed of a number of parallel bars.

The current path runs from the contact blade 3 of the first electrical connection via the silver hoops 7 to
35 the intermediate plate 15, and then via the return-path line 16, through the winding 8 and via the closure plate 4 to the contact blade 5 of the second electrical connection.

According to a sixth embodiment, the heavy-current fuse according to the invention (Figures 15-17) is designed with a winding 8 arranged between the contact blades 3, 5 and with a fusible element, which is arranged
5 alongside and is in the form of a silver hoop 7, in a similar way to the fifth embodiment of the heavy-current fuse according to the invention. The contact blade 3 of the first electrical connection is connected to the closure plate 2 thereof, which is
10 connected via the fusible element to an intermediate plate 15, which is arranged, at a distance, alongside the closure plate 4 of the second electrical connection. The intermediate plate 15 is connected via the return-path line 16 to that end of the winding 8
15 which is closest to the connecting plate 2 of the first electrical connection, with its opposite end abutting against the closure plate 4 of the second electrical connection, which is once again fitted with the contact blade 5 thereof.

20 The winding 8 once again surrounds a core, which is a solid round bar 9 and is surrounded by insulation which at the same time forms an insulation layer 13, which separates the winding 8 and the return-path line 16
25 from the closure plate 2 of the first electrical connection, as well as an insulation layer 14, through which the winding 8 is connected to the closure plate 4 of the second electrical connection.

30 In the two most recently described embodiments, the dimensions of the heavy-current fuse according to the invention are larger than those of known heavy-current fuses of this generic type, but this increase can be limited to just one dimension transversely with respect
35 to the connection between the contact blades, while the other dimensions once again comply with the Standard dimensions for known heavy-current fuses of this generic type, so that, normally, there is nothing to

prevent the heavy-current fuse according to the invention from being used in a standard plug-in location.

- 5 A seventh embodiment of a heavy-current fuse according to the invention (Figures 18-20) corresponds in terms of its basic design to that of the fifth embodiment. However, the figures illustrate details of the change to the design. The contact blade 3 of the first
10 electrical connection is mechanically and electrically conductively connected to a first end plate 17 which closes one end of a fuse housing 18 composed of electrically insulating material, and is closed on the opposite end by a second end plate 19. The fuse housing
15 18 contains three parallel silver hoops 7, which electrically conductively connect the first end plate 17 and the second end plate 19. In addition to the contact blade 3, the first end plate 17 is fitted with a hinged indicator 20. The second end plate 19 is
20 screwed to an intermediate plate 15, which forms an integral Z-shaped component with a return-path line 16, which runs back alongside the fuse housing 18, and the connecting plate 21 which is arranged alongside the first end plate 17. For mechanical reinforcement of the
25 heavy-current fuse, the first end plate 17 and the connecting plate 21 are screwed to a connecting plate 22, which overlaps both and is composed of electrically insulating material.
- 30 An inner winding 8a and an outer winding 8b, which are electrically connected in parallel, are arranged between the connecting plate 21 and a front plate 23, which is arranged at a distance in front of the second end plate 19, is connected thereto via spacers 24
35 composed of electrically insulating material and is fitted on the outside, facing away from the second end plate 19, with the contact blade 5 of the second electrical connection. The reason for this arrangement

is as follows: the windings 8a, b are composed of varnish-insulated winding wire with an approximately rectangular cross section, with the longer side edge of the rectangle being aligned radially in order to achieve a larger number of turns for a given cross section. The radial extent of the winding wire is, however, limited since, when the wire is being wound, no disturbing twists, compressions or bulges may occur in the winding which would increase the distance between turns. In order to achieve high current carrying capacity despite the restriction in cross section which results from this, the current is distributed between two windings.

15 A ferrite core 9 which is surrounded by an insulating sleeve 25 is arranged within the inner winding 8b and is fixed by a cover 26, which closes an opening in the front plate 23. Instead of the solid ferrite core in the form of a bar, a ferrite tube or a parallel arrangement of relatively thin ferrite bars or tubes may also be provided. Ferrite cores of different lengths may also be used, which are compensated for by covers or inserts of different thickness.

25 The described heavy-current fuse is suitable for high current densities, and is nevertheless compact and mechanically very robust, and can be inserted into a conventional plug-in location. As a rule, it is surrounded by a housing which is not illustrated here, is composed of electrically non-conductive material and leaves free the fronts formed by the first end plate 17, the connecting plate 22 and the connecting plate 21 at one end, and by the front plate 23 at the other end. The connecting plate 21 and the front plate 23 are each provided with a pulling lug 27, to simplify insertion into a plug-in location, and removal from such a location.

An eighth embodiment of a heavy-current fuse according to the invention (Figures 21-23) corresponds in terms of its basic design to that of the sixth embodiment, but the figures once again also show the details of the design. The contact blade 3 of the first electrical connection is in this case screwed to a front plate 23 which, for its part, is screwed to a first end plate 17, to which a fuse housing 18 is connected, as well as silver hoops (not illustrated) which are arranged therein and produce an electrically conductive connection between the first end plate 17 and a second end plate 19, which closes the fuse housing 18 at the opposite end. The first end plate 17 is fitted with a hinged indicator 20.

The second end plate 19 is screwed to a curved connecting lug 28 of the return-path line 16, which is routed back along the fuse housing 18 and is bent into a connecting plate 21 which is parallel to the front plate 23, but is at a distance from it. A winding 8 is located between the connecting plate 21 and the sealing plate 29 which is composed of electrically insulating material and is fitted with a closure plate 4 and the contact blade 5 (screwed thereto) of the second electrical connection, and this winding 8 is electrically conductively connected first to the connecting plate 21 and secondly through the sealing plate 29 and via the closure plate 2 to the contact blade 5. The winding 8 once again runs around a ferrite core 9 which is surrounded by an insulating sleeve 25. For mechanical reinforcement of the heavy-current fuse, the sealing plate 29 is screwed to a connecting lug 30 which projects from the return-path line 16. A certain minimum distance must be maintained between the closure plate 4 and the connecting lug 30 in order that the voltages which can occur owing to the inductance of the network when a heavy-current fuse blows and which in

some circumstances are considerable, do not lead to any flashovers.

5 Spacers 24 composed of electrically non-conductive material are arranged alongside the winding 8 and connect the closure plate 2 to the sealing plate 29, so that the heavy-current fuse is mechanically robust and is set to standard dimensions irrespective of the winding 8. Pulling lugs 27 are once again screwed to
10 the end plates 17, 19.

Figure 24 shows, schematically, an electrical power distribution network in which heavy-current fuses according to the invention are used. A low-voltage line
15 32 originates from a transformer 31 - this may also be some other branching point such as a building terminal box - and a number of paths 33 branch off from this line 32, each of which passes via a heavy-current fuse 34 according to the invention, following which it
20 branches further. The individual paths 33 can, for example, each supply one building. Each path is connected to transmitters and receivers 35, for example in each case one PLC master and various units (not shown) which are connected to that path and by means of
25 which it communicates using radio-frequency signals, for example with carrier frequencies in the band between 1 MHz and 40 MHz. The signals are injected conductively or capacitively. Since they are heavily attenuated by the heavy-current fuses 34, the signals
30 in each case remain limited essentially to a single path, so that interference between the various paths does not lead to interference even if the frequency bands overlap or are so closely adjacent that interference interactions would otherwise occur. As a
35 rule, it is in this case assumed that the transmitters and receivers 35 are operating synchronously, that is to say they each transmit and receive at the same time.

PATENT CLAIMS

1. Heavy-current fuse having a housing (1) composed of electrically insulating material and, at mutually opposite ends of said housing (1) in the longitudinal direction, having a first electrical connection and a second electrical connection which are electrically conductively connected via a fusible element arranged in the housing (1), **characterized in that** the electrically conductive connection between the first electrical connection and the second electrical connection is produced via an inductor which is arranged in the housing (1) and is connected in series with the fusible element.
2. Heavy-current fuse according to Claim 1, **characterized in that** the inductor comprises at least one winding (8) and has a core composed of ferromagnetic, in particular electrically insulating material which is magnetically coupled to the winding (8).
3. Heavy-current fuse according to Claim 2, **characterized in that** the core comprises a bar (9) which is surrounded by the winding (8).
4. Heavy-current fuse according to Claim 2 or 3, **characterized in that** the core comprises a shell which at least partially surrounds the winding (8) on the outside.
5. Heavy-current fuse according to Claim 4, **characterized in that** the shell has two mutually opposite openings (12a, 12b) in the form of sectors.



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6. Heavy-current fuse according to Claim 4 or 5, **characterized in that** the shell is subdivided into two half-shells (10a, 10b) by means of a circumferential air gap (11).
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7. Heavy-current fuse according to one of Claims 1 to 6, **characterized in that** the fusible element and the inductor are arranged one after the other in the longitudinal direction in the housing (1).
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8. Heavy-current fuse according to Claim 7, **characterized in that** that part of the housing interior which contains the fusible element and that part of the housing interior which contains the inductor are separated from one another by a transversely running separating plate (6).
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9. Heavy-current fuse according to one of Claims 1 to 6, **characterized in that** the inductor surrounds the fusible element.
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10. Heavy-current fuse according to Claims 3 and 9, **characterized in that** the bar (9) is hollow with a bushing which holds the fusible element, and the winding (8) is connected to the fusible element by means of a return path which is arranged outside the bar (9) and runs in the opposite direction to the fusible element.
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11. Heavy-current fuse according to one of Claims 1 to 6, **characterized in that** the fusible element and the inductor are arranged parallel alongside one another in the longitudinal direction in the housing (1).
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12. Heavy-current fuse according to one of Claims 1 to 11, **characterized in that** the inductor comprises
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at least two coaxially arranged, parallel-connected windings (8a, 8b).

- 5 13. Electrical power distribution network having a number of electrically conductively connected paths (33), **characterized in that** a heavy-current fuse (34) according to one of Claims 1 to 11 is located at the input in each path (33).



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