(19) DANMARK

(10) **DK/EP 3035514 T3**

Patent- og Varemærkestyrelsen

(12) Oversættelse af europæisk patentskrift

(51) Int.Cl.: ***H 02 M 1/36 (2007.01)*** ***H 02 H 9/00 (2006.01)***

(45) Oversættelsen bekendtgjort den: **2018-09-03**

(80) Dato for Den Europæiske Patentmyndigheds bekendtgørelse om meddelelse af patentet: **2018-06-06**

(86) Europæisk ansøgning nr.: **14199342.8**

(86) Europæisk indleveringsdag: **2014-12-19**

(87) Den europæiske ansøgnings publiceringsdag: **2016-06-22**

(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: **For-opladningsindretning af en omformer**

(56) Fremdragne publikationer:
DE-A1-102009 037 723
DE-U1- 9 216 662
JP-A- S 637 101
KR-A- 20130 072 951

Description

The invention relates to a pre-charging device for a current converter. The invention also relates to a current converter system having a current converter and a pre-charging device and to a method for pre-charging a current converter.

Current converters are used in order to supply electrical machines, in particular motors, or electrical networks with electrical energy. The machine can be controlled and regulated using the current converter. Furthermore, current converters are used for low-loss transmission of energy by means of high-voltage direct current transmission (HVDCT). A further field of application for current converters is compensators. Using compensators, reactive powers and/or harmonic currents may be compensated, in other words, eliminated, or purposefully fed into a network.

The object of the current converter is to convert electrical power in respect of its voltage level, current level, frequency and phase position.

To connect a current converter with an intermediate circuit capacitor to a power supply network, in particular to a three-phase supply or alternating voltage network, measures have to be taken to avoid loading the network with a high network current during switching on. Pre-charging circuits are used for this purpose, as described for example in documents DE9216662U, KR20130072951 and DE102009037723 in which the intermediate circuit capacitor are charged from the power supply network by resistors. Only when the voltage of the intermediate circuit capacitor has reached a particular value is the current converter directly connected to the power supply network.

Three parallel resistors are conventionally used for the pre-charging circuits, by way of which resistors the intermediate circuit capacitor of the current converter is charged. This charging is also called pre-charging. The alternating connections of the current converter are connected to the power supply network by the resistors. Once pre-charging is complete, the resistors are each short-circuited by means of a switch, so the current converter can replace energy using the power supply network without electrical losses at the resistors.

Pre-charging can be extended in conjunction with wiring of the current converter, for example with a network filter. The resistors are heated more and this requires larger dimensioning of the components of the pre-charging circuit. Depending on the dimensioning of the components of the network filter and the pre-charging circuit, the situation can occur where the minimum voltage of the intermediate circuit capacitor, which is required for connection to the electrical power supply network, is not achieved.

In order to protect against overcurrents, document JPS637101, which is regarded as the closest state of the art, proposes connecting a thyristor and a diode parallel to the pre-charging resistor.

The invention is based on the object of disclosing a pre-charging device with which pre-charging of a current converter can be carried out quickly and with low losses.

This object is achieved by the features of device claim 1 and method claim 8.

Advantageous embodiments of the invention are disclosed in the dependent claims.

The invention is based on the knowledge that the duration of pre-charging may be reduced by inserting a power semiconductor, such as, for example a diode or a thyristor, into the current path in order to pre-charge the intermediate circuit capacitor of the current converter. According to the invention, the power semiconductor is arranged together with a resistor in order to limit the current in the pre-charging device. The resistor can also be a series connection of individual resistors. The power semiconductor causes the capacitor or the capacitors of a network filter present on the current converter to no longer be recharged since, due to the power semiconductor, only one current flows in one direction between alternating voltage network and current converter in one phase. The alternating voltage network can be for example a three-phase supply or a one-phase alternating current network. A recharging current, which was responsible for recharging the capacitor of the network filter in applications from the prior art, is avoided thereby. As a result, losses during pre-charging can be reduced since the recharging current is no longer present, or can at least be reduced, when a pre-charging device according to the invention is used. Depending on the dimensioning of network filter and pre-charging resistor, with a current converter arrangement from the prior art, the recharging current can assume such high values that the intermediate circuit capacitor of the current converter could not be pre-charged to a particular voltage. By inserting the power semiconductor into the current path for the purpose of pre-charging, the capacitor or capacitors of the network filter, or at least some of these capacitors, is/are no longer recharged. Only one polarity of the corresponding mains voltage is used in the case of the phase of the alternating voltage network, which is connected to the power semiconductor of the pre-charging device. Since the intermediate circuit capacitor of the current converter is charged by the same valves of the current converter, the capacitor of the network filter, which is connected to the phases involved in pre-charging, is electrically parallel to the intermediate circuit capacitor. The pre-charging device can be used for three-phase and for one-phase (where N-conductors are present) current converters for the purpose of pre-charging. The pre-charging device can have one, two, three or even more phase(s). One-phase, two-phase and three-phase pre-charging devices have proven to be particularly advantageous in the case of a pre-charging device for a three-phase current converter. If the three-phase current converter is also connected to an N-conductor of the alternating voltage network, a four-phase pre-charging device can also be expediently used for pre-charging. One-phase and two-phase pre-charging devices have proven to be particularly advantageous in the case of a one-phase current converter (with a connection to an N-conductor of the alternating voltage network). With a one-phase pre-charging device the current flows in one direction through the pre-charging device between alternating voltage network and current converter. The reverse current in the opposite direction flows over one or more electrical connection(s) between current converter and alternating voltage network. The reverse current, which is the same as the current in terms of value and flows in the opposite direction in relation to the current, can be distributed among different phases. The direction in which the current and the reverse current flow depends on the forward direction, also called polarity, of the power semiconductor. It has proven to be particularly advantageous in this connection to provide a phase or an N-conductor for the reverse current and to interrupt the remaining connections of the phases or N-conductors between alternating voltage network and current converter by means of a switch. A pre-charging device can have one or more power semiconductor(s) here. The polarity of the power semiconductor is immaterial here. It is important for operation of the pre-charging device that a current can form between alternating voltage network and current converter and that at the same time there is a reverse current path between current converter and alternating voltage network, either by way of the electrical connection between current converter and alternating voltage network or a further phase of the pre-charging device.

A particularly advantageous embodiment of the invention consists in modifying an existing pre-charging circuit from the prior art having two or three resistors to the extent that an embodiment of the pre-charging device can be inexpensively and easily implemented by replacing a resistor with a power semiconductor. If the pre-charging device from the prior art has resistors in different phases, these can also be arranged in a series connection in such a way that the number of phases of the pre-charging device is reduced.

It has proven to be particularly advantageous if the phases of the alternating voltage network involved in pre-charging only guide a current in one direction. Recharging of the capacitors of the network filter is thereby reliably avoided for all capacitors of the network filter. With pre-charging, in which two phases of the alternating voltage network are involved, or when the alternating voltage network is a one-phase alternating voltage network with N-conductors, a change of sign of the current can be avoided during pre-charging if the pre-charging device has a power semiconductor. With pre-charging by means of three phases of a three-phase alternating voltage network, at least two power semiconductors are required to prevent a change of sign of a current. However, pre-charging can also occur by means of a three-phase alternating voltage network and using a power semiconductor. In this case the recharging current is not eliminated but merely reduced since a capacitor of the network filter has to be at least partially recharged. Fast pre-charging with reduced losses can be achieved particularly easily and inexpensively by way of this exemplary embodiment, however.

In an advantageous embodiment of the invention the resistor and the power semiconductor are arranged in a series connection. Only one pre-charging device with one phase is required for implementing the series connection. The power semiconductor ensures that current only flows in one direction through the resistor. The intermediate circuit capacitor of the current converter is charged with this current. The reverse current does not flow through the pre-charging device but flows directly in the electrical connection between current converter and alternating voltage network. It is easily ensured that only one current in one direction through the pre-charging device is used for charging. Even if power semiconductor and resistor are in different phases of the pre-charging device, this can still be called a series connection if the one current flows through the one phase of the pre-charging device and the reverse current flows through the other phase of the pre-charging device, with the two currents being equal in value and only differing in direction. Components, through which the same current flows, are deemed to be arranged in a series connection. In other words, power semiconductor and resistor are arranged in a series connection if a current flows through the resistor and the corresponding reverse current flows through the power semiconductor with the same value and opposite sign. The direction of current and reverse current is defined by the forward direction of the power semiconductor.

In a further advantageous embodiment, the pre-charging device has a first input, a second input, a first input and a second output, wherein the first input and the first output of the pre-charging device are electrically interconnected via the power semiconductor and the second input and the second output of the pre-charging device are electrically interconnected via the resistor. The advantage of this embodiment lies in particular in that existing pre-charging circuits with more than one resistor can be particularly easily improved by replacing one resistor with a power semiconductor. Depending on how many phases of the alternating voltage network are used for pre-charging, recharging currents can be avoided or at least significantly reduced hereby. Known built-on structures already known from the prior art can also be used as the basis for a conversion for the construction of this exemplary embodiment. At least one resistor simply has to be replaced by a power semiconductor.

In a further advantageous embodiment, the power semiconductor is a diode or a thyristor. A diode is suitable in particular for use in the pre-charging device. With a diode, a current flow in only one direction is particularly easily possible without particular measures for regulation or control. Furthermore, diodes in the requisite power range are inexpensively available. With the aid of a thyristor the function of a switch can be achieved at the same time as the function of ensuring the one current flow direction. The pre-charging device can be switched on at the desired time by the ignition contact of the thyristor. Furthermore, there is the possibility of further reducing the current, for example by a phase angle control. This allows the use of relatively small resistance values in the resistor of the pre-charging device. Particularly short pre-charging times can be achieved in collaboration with small resistances and by a thyristor-controlled current controller.

In a further advantageous embodiment, the current converter system has a network filter at the AC-side connection of the current converter. Currents through capacitors of a network filter are significantly reduced by the pre-charging device since recharging processes of the capacitors of the network filter are eliminated, or at least significantly reduced, by use of the pre-charging device. The pre-charging device also ensures that, even when a network filter is used, a desired voltage of the intermediate circuit capacitor can be achieved, which leads to conclusion of pre-charging.

In a further advantageous embodiment, the current converter is connected to an alternating voltage network by means of an electrical connection, wherein the electrical connection has a switch, in particular a multipole switch. In this exemplary embodiment, pre-charging can be started if the electrical connection between alternating voltage network and current converter is open, so the current flows via the pre-charging device. After conclusion of pre-charging, the current converter can quickly be prepared for normal operation at the alternating voltage network by closing the switch in the electrical connection. The pre-charging device is then no longer effective. The switch can also be used to safely disconnect the current converter from the alternating voltage network. If the pre-charging device is connected to only one phase of the AC-side connection of the current converter, a current must be able to flow through the electrical connection between current converter and alternating voltage network. At least one phase of the current converter should be connected to the alternating voltage network by way of the switch for this purpose. The remaining phases of the electrical connection remain open, so no re-charging processes occur at the network filter.

The invention will be described and illustrated in more detail below with reference to the exemplary embodiments shown in the Figures, in which:

FIG 1	shows a pre-charging circuit from the prior art and
FIGS 2 to 6	show exemplary embodiments of a pre-charging device of the invention.

FIG 1 shows a three-phase pre-charging circuit 20 from the prior art. In addition to the pre-charging circuit 20 with its inputs 3 and outputs 4, this Figure shows a current converter 2 which is electrically connected to an alternating voltage network 5. Arranged between current converter 2 and alternating voltage network 5 are a network filter 9 and a switch 12 in an electrical connection between current converter 2 and alternating voltage network 5. The pre-charging circuit 20 is electrically parallel to the switch 12. The inputs 3 of the pre-charging circuit 20 are connected to the phases of the alternating voltage network 5. The outputs 4 of the pre-charging device 20 are connected to the AC-side connections of the current converter 2. Arranged between the connections to the outputs 4 of the pre-charging circuit 20 and the current converter 2 is the network filter 9. To start pre-charging, when the switch 12 is open, the switch 8 of the pre-charging circuit 20 is closed. A current now flows between alternating voltage network 5 via the resistors 6 of the pre-charging circuit 2 and current converter 2. The intermediate circuit capacitor (not shown) of the current converter 2 is charged during the pre-charging process. Furthermore, currents are generated through the capacitors of the network filter 9. These currents, which effect recharging of the capacitors of the network filter 9, are also called recharging currents. The pre-charging process is lengthened by the presence of the recharging currents since this current share cannot be used for pre-charging the intermediate circuit capacitor of the current converter 2. Due to the recharging currents, the situation can occur where the entire charging current through the pre-charging circuit 20 is necessary for recharging the capacitors of the network filter. The intermediate circuit capacitor of the current converter 2 is thereby not charged further. This means that even if a stationary current is flowing, the rectified value of the input voltage cannot be achieved in the intermediate circuit. If the intermediate circuit capacitor of the current converter 2 has reached a particular value, the pre-charging circuit 20 can be bridged by means of the switch 12. A current flow via the pre-charging circuit 20 is safely interrupted by opening the switch 8 of the pre-charging circuit 20. The current converter 2 can thereby address the voltage of the alternating voltage network 5 during operation.

FIG 2 shows a first exemplary embodiment of the invention. A current converter 2 is connected to an alternating voltage network 5 in this arrangement as well. The alternating voltage network 5 is designed as a three-phase supply having phases L1, L2 and L3. A network filter 9 is arranged on the AC-side connection of the current converter 2. A switch 12 is arranged in the electrical connection 11 between the alternating voltage network 5 and the current converter 2. The pre-charging device 1 is a one-phase design. The pre-charging device is connected by its input 3 to a phase of the alternating voltage network 5. The output 4 of the pre-charging device 1 is connected to a phase of the electrical connection 11. The pre-charging device is thereby connected to an AC-side connection of the current converter 2. The input 3 of the pre-charging device 1 can be connected to any phase of the alternating voltage network 5. It has proven to be advantageous for the output 4 of the pre-charging device 1 to be connected to the same phase of the alternating voltage network 5 as the input 3 of the pre-charging device 1. The pre-charging device 1 has a series connection of a diode 7 and a resistor 6. Instead of the diode 7, a thyristor or any other power semiconductor 7 can also be used. The diode 7 ensures that for pre-charging only one current can flow in one direction between alternating voltage network 5 and current converter 2. It is immaterial in which direction the current flows here. The direction is predefined by the forward direction of the diode. In other words, the diode can also be arranged in the opposite direction. The switch 12 or a different switch arranged in the alternating voltage network 5 has to separate at least two phases of the electrical connection 11. At least the phase, by which pre-charging occurs by means of the pre-charging device 1, has to be interrupted by the switch 12 in the electrical connection 11. In this example it is the phase L3. As mentioned above, one of the connections to phase L1 or to phase L2 also has to be interrupted by the switch 12 or an additional switch arranged in the alternating voltage network 5 in order to prevent a flow of current through the electrical connection 11 with high currents between phases L1 and L2 of the alternating voltage network 5 and the current converter. This additional switch is not shown for the sake of clarity. In the illustrated embodiment, a current now flows during pre-charging from the phase L3 of the alternating voltage network 5 via the pre-charging device 1 to the current converter 2. This loads the intermediate circuit capacitor of the current converter 2. The reverse current to the alternating voltage network 5 occurs by way of the electrical connection 11 via the phases L1 or L2, depending on which connection is interrupted by means of a switch. Since the current only flows in one direction, in other words does not have a change of sign, the capacitors of the network filter 9 are not recharged but merely charged. As a result, pre-charging can take place quickly and with low losses. Furthermore, an additional switch can be introduced in the current path by way of the pre-charging device, with which switch pre-charging can be purposefully started or ended.

FIG 3 shows a further exemplary embodiment of the invention. To avoid repetitions, reference will be made to the description relating to Figures 1 and 2 and to the reference characters introduced there. The pre-charging device 1 has a two phase design in this exemplary embodiment. A first input 31 of the pre-charging device 1 is connected to a phase of the alternating voltage network 5. The second input 32 of the pre-charging device 1 is connected to a different phase of the alternating voltage network 5. The electrical connection 11 between current converter 2 and alternating voltage network 5 is interrupted during pre-charging. The switches required for this are arranged in the alternating voltage network 5 in this exemplary embodiment. However, they can also be arranged in the electrical connection between alternating voltage network 5 and current converter 2. Since both the current and the reverse current flow via the pre-charging device 1 in this exemplary embodiment, the three phases in the electrical connection 11 between current converter 2 and alternating voltage network 5 can be separated. The pre-charging device 1 has a diode 7 and a resistor 6 in this exemplary embodiment. The diode 7 can also be replaced by a thyristor or a power semiconductor 7 in this exemplary embodiment. Since the same current flows through the diode 7 and the resistor 6 during pre-charging, these also constitute a series connection. Pre-charging takes place as soon as the switches between the inputs of the pre-charging device 1 and the phases of the alternating voltage network 5 are closed, and the intermediate circuit capacitor of the current convertor 2 is charged. At the same time, the capacitors of the network filter 9 are likewise charged. There is no recharging of one of the capacitors of the network filter 9 due to the current flow in only one direction. This exemplary embodiment is suitable in particular for changing an existing pre-charging circuit from the prior at, which has two or three phases which each have a resistor, in such a way that it becomes an exemplary embodiment of the invention. One of the resistors should be replaced by the diode 7 for this purpose. With a three-phase pre-charging circuit, the remaining resistors should be arranged in a series connection, moreover. If this is carried out, the exemplary embodiment of FIG 3 is achieved.

FIG 4 shows a further exemplary embodiment of the invention, with the pre-charging device 1 having a switch 8 of the pre-charging device 1. To avoid repetitions, reference will be made to the description relating to Figures 1 to 3 and to the reference characters introduced there. In this exemplary embodiment, the electrical connection between current converter 2 and alternating voltage network 5 is interrupted by a switch 12 in the electrical connection 11. Pre-charging then takes place if the switch 12 is open. The switch for connecting the pre-charging device 1 to the phases of the alternating voltage network 5 is also arranged as a switch 8 of the pre-charging device 1 in the pre-charging device 1.

FIG 5 shows a further exemplary embodiment of the invention, with the pre-charging device 1 having a three-phase design. This pre-charging device 1 may also be implemented in that a resistor 6 is replaced by a diode 7 in a pre-charging device 1 known from the prior art. To avoid repetitions, reference will be made to the description relating to Figures 1 to 4 and to the reference characters introduced there. The intermediate circuit capacitor of the current converter 2 is pre-charged via the three phases L1, L2 and l3 with this pre-charging device 1. The current can flow only in one direction due to the diode 7, which is arranged in the current path of L3. The diode 7 can be arranged in the reverse forward direction here too. The diode means that two capacitors of the network filter do not have to be charged. The recharging current is reduced thereby, so a higher current share is available for charging the intermediate circuit capacitor of the current converter 2. The losses in the pre-charging device 1 that result during pre-charging are produced in two resistors 6 in this exemplary embodiment. If one of the resistors 6 is replaced by a further diode 7, which is preferably polarized in the same direction as the existing diode 7, then recharging of all intermediate circuit capacitors of the network filter 9 can be avoided. However, the electrical losses, which are produced during pre-charging of the intermediate circuit capacitor of the current converter 2, are then produced in only one resistor, which has to be configured accordingly for this higher thermal load.

FIG 6 shows a further exemplary embodiment of the invention. To avoid repetitions, reference will be made to the description relating to Figures 1 to 5 and to the reference characters introduced there. This current converter 2 is a one-phase current converter which is connected to a phase L and an N-conductor of an alternating voltage network 5. In this case it has proven to be expedient to also design the pre-charging device to be two-phase. A diode is arranged in one phase of the pre-charging device 1 and a resistor 6 is arranged in the other phase. The illustration of switches has been omitted for reasons of clarity.

Although the invention has been illustrated and described in detail by the preferred exemplary embodiments, it is not limited solely to the disclosed examples and a person skilled in the art can derive other variations therefrom without departing from the scope of the invention, as is defined in the accompanying claims.

Patentkrav

1. Omformersystem (10), omfattende en omformer (2) og en for-opladnings-indretning (1), hvor for-opladningsindretningen (1) har mindst en indgang (3,31,32) og mindst en udgang (4,41,42), hvor indgangen (3,31,32) af for-opladningsindretningen (1) kan forbindes med et vekselspændingsnet (5), hvor udgangen (4,41,42) for-opladningsindretningen (1) er forbundet med omformeren (2), hvor for-opladningsindretningen (1) har mindst en modstand (6) og en effekthalvleder (7), hvor den mindst ene udgang (4,41,42) af for-opladningsindretningen er forbundet elektrisk med en tilslutning af omformeren (2) på vekselspændingssiden, hvor omformersystemet på omformerens (2) tilslutning på vekselspændingen har et netværksfilter (9), hvor effekthalvlederen (7) er placeret på en sådan måde, at der gennem effekthalvlederen (7) i en fase kun foregår en strømning af strøm mellem vekselspændingsnet (5) og omformer (2) i en retning.

2. Omformersystem ifølge krav 1, hvor effekthalvlederen (7) er placeret på en sådan måde, at de faser af vekselspændingsnettet (5), der er involverede i for-opladningen, kun fører en strøm i en retning.

3. Omformersystem ifølge et af kravene 1 eller 2, hvor modstanden (6) og effekthalvlederen (7) er placeret i en seriekobling.

4. Omformersystem ifølge et af kravene 1 til 3, hvor for-opladningsindretningen (1) har en første indgang (31), en anden indgang (32), en første udgang (41) og en anden udgang (42), hvor den første indgang (31) og den første udgang (41) af for-opladningsindretningen (1) er forbundet elektrisk med hinanden via effekthalvlederen (7), og den anden indgang (32) og den anden udgang (42) af for-opladningsindretningen (1) er forbundet elektrisk med hinanden via modstanden (6).

5. Omformersystem ifølge et af kravene 1 til 4, hvor effekthalvlederen (7) er en diode eller en tyristor.

6. Omformersystem (10) ifølge et af kravene 1 til 5, hvor omformeren (2) er forbundet med et vekselspændingsnet (5) ved hjælp af en elektrisk forbindelse

(11), hvor den elektriske forbindelse (11) har en omskifter (12), især en omskifter (12) med flere poler.

7. Fremgangsmåde til for-opladning af en omformer (2) af et omformersystem ifølge et af kravene 1 til 6, hvor der kun anvendes en polaritet af mindst en spænding af et vekselspændingsnet (5), der er forbundet med omformeren (2) på vekselspændingssiden, til for-opladningen af omformeren (2).

FIG 1

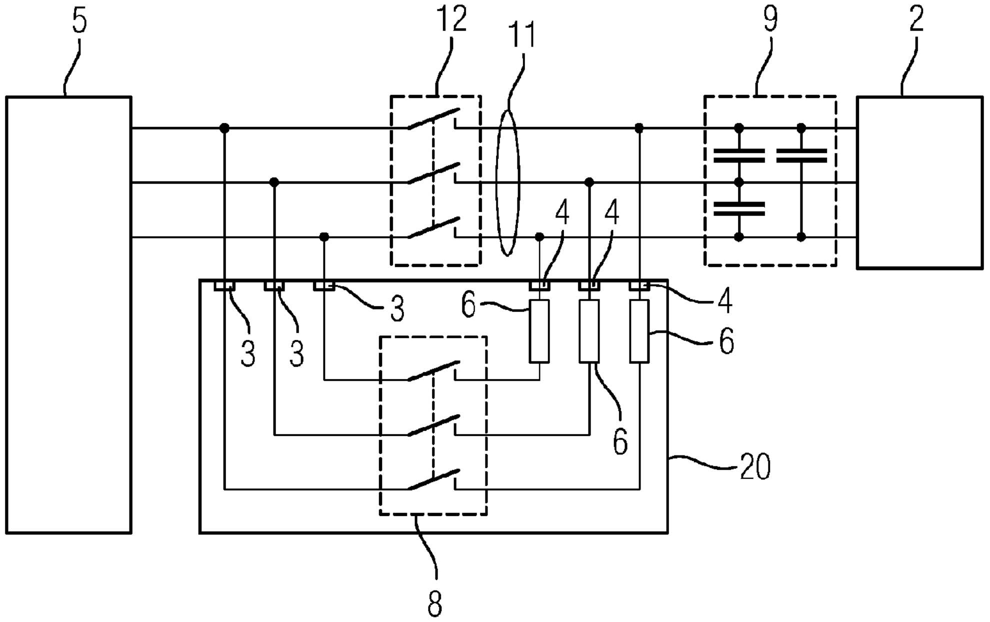

FIG 2

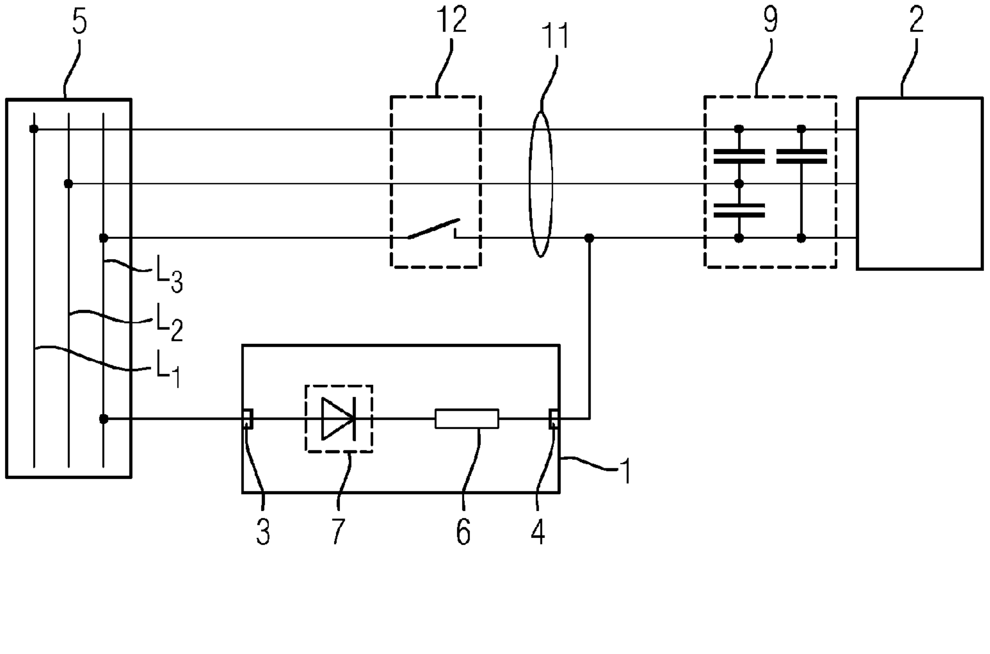

FIG 3

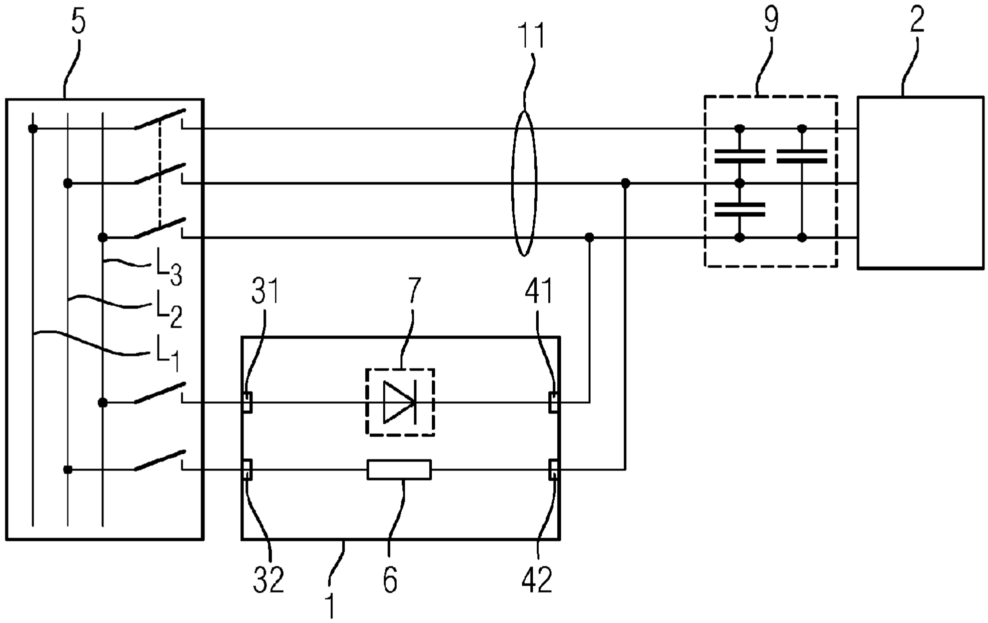

FIG 4

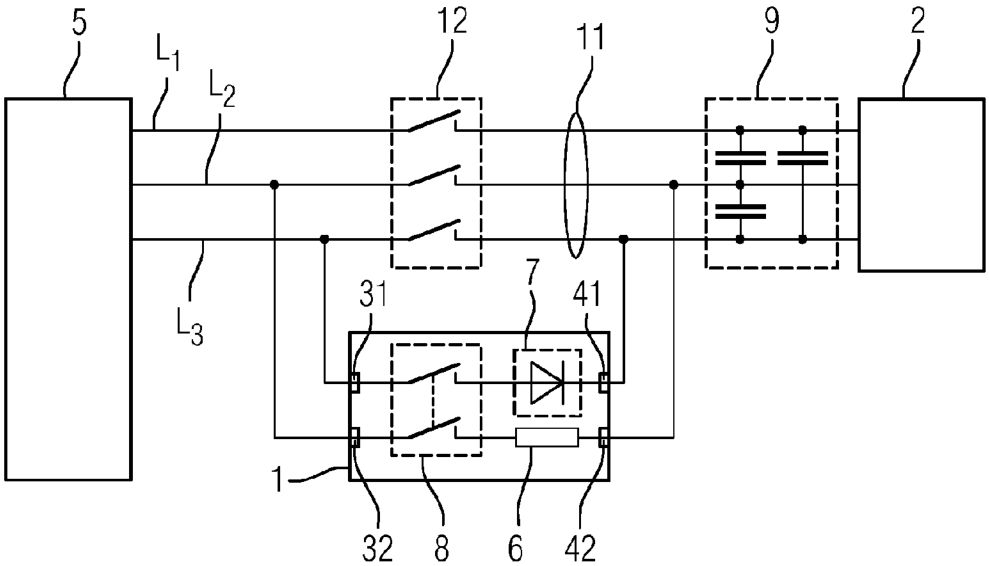

FIG 5

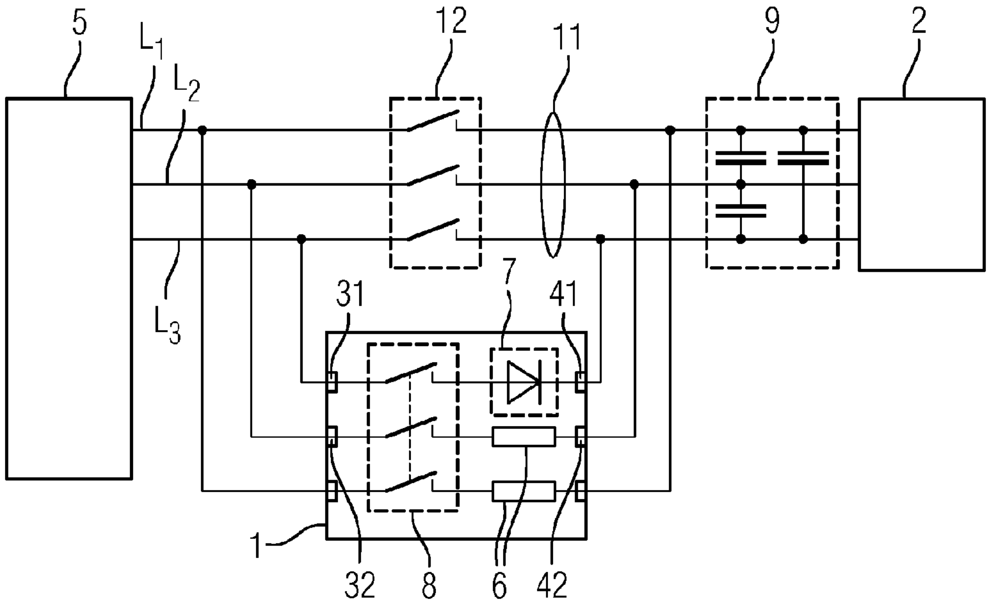

FIG 6