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(54) SYSTEM AND METHOD FOR ADDRESSING DISTANT ACTUATED SAFETY DEVICES

(57) The present invention concerns a method and a system for monitoring a state of a bi-state distant actuated safety device (hereafter called "DAS") (3), the system comprising:
- a central system (hereafter called "CS") (1) connected to a plurality of electrical modules (2);
- a plurality of DAS (3), each DAS comprising at least one electrical contact (31), wherein each electrical contact (31) is characterized by two states;
- said plurality of electrical modules (2), wherein each electrical module (2) is connected to at least one electrical contacts (31);
the system according to the invention being characterized in that:
- each electrical contact (31) is connected in parallel with an associated impedance element (21) of the electrical module (2) and is further connected to an associated switching circuit (22) of the electrical module (2), wherein the associated switching circuit (22) is characterized by two states, respectively a closed circuit state wherein electrical continuity through the associated switching circuit is maintained, and an open circuit state wherein electrical continuity through the associated switching circuit is broken;
- a loop circuit connects the associated impedance elements (21) in series to the CS (1), wherein the loop circuit has predefined values of impedance in function of the states of the electrical contacts (31),
- the CS (1) is configured for controlling each associated switching circuit (22) so that N associated switching circuits (22) are in a state which is opposite to the state of M other associated switching circuits (22) during a measurement of a value of impedance of the loop circuit, the CS (1) being further configured for monitoring the DAS state by measuring the impedance value of the loop circuit while switching the state of the switching circuits (22) and determining from said measurement the state of each electrical con-tact (31) of the DAS (3).

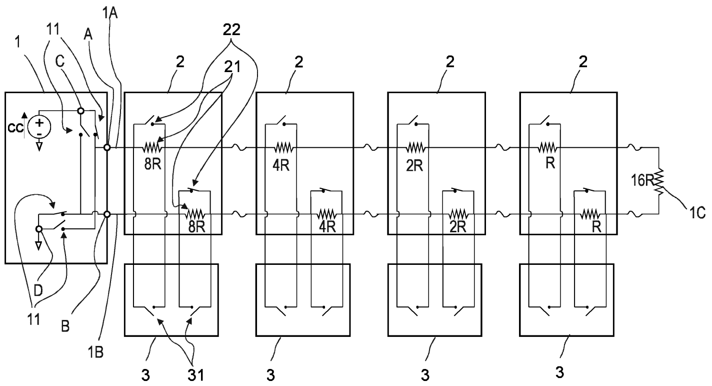

FIG 3

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Description

[0001] The present invention concerns the field of building safety and presents a method and system for monitoring distant actuated safety devices (hereafter called "DAS"). More precisely, the present invention proposes a new manner of addressing DAS contacts by means of impedance measurement.

[0002] DAS are devices that might be automatically or manually actuated for triggering an action within a building or a vehicle (e.g. plane, ship, etc.) in case of safety problems. In the following, we will take the example of DAS installed within a building, but the present invention is not limited to the building use of DAS.

[0003] Typical DAS systems are notification appliances, fireproof doors, devices of locking-unlocking for emergency exits, etc. The DAS is usually a controlled device, whose change of state directly contributes to the safety of a building, for instance in case of fire. A DAS comprises typically two states and is therefore usually a bi-state device, which provides one or two contacts, wherein its binary states are a closed circuit state and an open circuit state which are related to the DAS being "active" (or being in an active state wherein its active state corresponds for instance to the detection of a fire by the DAS system) or "inactive" (or being in an inactive state, wherein its inactive state corresponds for instance to no fire being detected).

[0004] Usually, a central system (hereafter called "CS") is connected to one or several DAS and centralizes information coming from the connected DAS. The latter are usually remotely located compared to the CS location. For instance, the DAS might be installed at different locations within a building in order to ensure the safety of one, several, or all areas of the building, and the CS might be located either in the building itself or in a control center remotely located from the building. Typically, the CS is configured for monitoring and/or detecting a change of a state of at least one DAS among the connected DAS. This state of the DAS is notably determined by the CS from one or two DAS electrical contacts which are powered and controlled by the CS. It is therefore possible for the latter to determine if at least one of the connected DAS changes its state from inactive to active or inversely by verifying the state of the DAS electrical contacts.

[0005] According to the state of the art, there are two different ways or modes for monitoring the connected DAS by means of the CS. These two modes are presented in Figures 1 and 2 respectively and correspond to the single mode (see Figure 1A and 1B) and the collective mode (see Figure 3). According to the single mode monitoring, each DAS is individually monitored by the CS. In this case, the CS knows exactly the state of each connected DAS and is aware of each change of state of the connected DAS. For this purpose, each DAS is connected to the CS by a different pair of wires, so that the number of pairs of wires equals the number of monitored DAS. According to the collective mode, several DAS are connected to the CS by means of a same pair of wires, forming therefore a group of monitored DAS. The collective mode allows a global knowledge of the DAS states for said group: indeed, if one DAS among said group has a failure or changes its state or is in default, then the CS is only able to conclude that at least one DAS among said group has a failure or changed its state or is in default, but it is neither able to determine exactly which one(s) nor how many DAS of said group have the failure or changed their states or are in default. Each mode has its advantages and disadvantages: for instance, the installation cost of DAS according to the single mode is higher, notably because it requires more wires: one pair of wires per DAS. Advantageously, its maintenance cost is optimized, because the CS is able to determine which DAS is in default. At the opposite, the installation cost of DAS according to the collective mode is lower than the single mode, because it requires only one pair of wires per group of DAS. Unfortunately the maintenance cost is then higher, because the CS does not know which DAS among a group of DAS changes its state. Additionally, the collective mode requires that each DAS that has to be supervised is in an identical nominal state (i.e. either active or inactive in its nominal state): indeed a mixture of DAS nominal states (i.e. some DAS having a nominal state corresponding to an active state and some DAS having a nominal state corresponding to an inactive state) is not possible according to the collective mode configuration.

[0006] The state of the DAS is determined by the CS by supervising and/or monitoring the electrical contact(s) comprised within the DAS. Usually, a measure of the electrical resistance of the electrical circuit comprising the electrical contact(s) enables the CS to determine the state of the electrical contact and therefore of the DAS.

[0007] It is an objective of the present invention to provide a system and a method for monitoring distant DAS by means of a CS that comprises the advantages of both the single mode and the collective mode monitoring, i.e. being able to determine the state of each DAS while keeping a low number of connection wires.

[0008] This objective is achieved according to the present invention by a method and a system for monitoring a state of a distant DAS according to the object of the independent claims. Dependent claims present further advantages of the invention.

[0009] According to the present invention, the system for monitoring the state of a distant DAS comprises:

- a CS connected to a plurality of electrical modules;
- a plurality of DAS, each DAS comprising at least one electrical contact, wherein each electrical contact is characterized by two states, respectively a closed circuit state wherein electrical continuity through the electrical contact is maintained, and an open circuit state wherein electrical continuity through the electrical contact is broken;

- said plurality of electrical modules, wherein each electrical module is connected to at least one, preferentially two, of said electrical contacts;

the system according to the invention being characterized in that each electrical contact is connected in parallel with an associated impedance element of the electrical module, each electrical contact being further connected, preferentially also in parallel, to an associated switching circuit of the electrical module, wherein the associated switching circuit is characterized by two states, respectively a closed circuit state wherein electrical continuity through the associated switching circuit is maintained, and an open circuit state wherein electrical continuity through the associated switching circuit is broken, wherein a loop circuit connects the associated impedance elements in series, wherein the loop circuit has predefined values of impedance in function of the states of the electrical contacts of the DAS and optionally in function of the states of the associated switching circuits, wherein the CS is configured for controlling each associated switching circuit in order to switch its state during a measurement of a value of impedance of the loop circuit, therefore obtaining two values of impedance, i.e. a first value corresponding to the measurement of impedance before switching the state of each associated switching circuit by the CS, and a second value corresponding to the measurement of impedance after switching the state of each associated switching circuit by the CS, wherein the CS is configured for controlling the associated switching circuits so that N associated switching circuits (22), for instance half of the associated switching circuits (22), are in a state which is opposite to the state of M other associated switching circuits (22), for instance opposite to the state of the other half of said associated switching circuits, during a measurement of a value of impedance of the loop circuit, i.e. N associated switching circuits and M other associated switching circuits have and are maintained in opposite states during said measurement, wherein M + N equals the total number of associated switching circuits, wherein said measurement by the CS comprises switching the state of the associated switching circuits, for instance the associated switching circuits of a same electrical module have and remain in opposite states during said measurement, the CS being further configured for determining the state of each electrical contact from said measurement, for instance by comparison of the measured value with the predefined impedance values.

[0010] The present invention concerns also a method for monitoring or addressing the state of a distant DAS, the method being implemented by the system previously described and comprising the following chronological steps:

- maintaining N associated switching circuits, for instance half of the associated switching circuits, and M other associated switching circuits, for instance the other half of said associated switching circuits, in opposite states, for instance maintaining the associated switching circuits of each electrical module in opposite states, so that a part of the electrical contacts, for instance one half of the electrical contacts, are short-circuited by their associated switching circuit;
- measuring an impedance value of the loop circuit;
- monitoring the DAS by determining if an electrical contact changes its state by comparing the measured impedance value to a predefined impedance value for the loop circuit;
- changing the state of each associated switching circuits while maintaining in opposite states said N associated switching circuits and said M other associated switching circuits, for instance while maintaining in opposite states half of the associated switching circuits and said other half of said associated switching circuits, preferentially while maintaining in opposite states the associated switching circuits of each electrical module, so that another part, for instance the other half, of the electrical contacts are short-circuited by their associated switching circuit, wherein the union of said part and said other part of the electrical contacts comprises all electrical contacts, and preferentially each electrical contact belongs either to said part or to said other part;
- measuring an impedance value of the loop circuit;
- monitoring the DAS by determining if an electrical contact changes its state by comparing the measured impedance value to the predefined impedance value for the loop circuit.

[0011] For a more complete understanding of the present invention, and the advantages thereof, reference is now made to the following descriptions taken in conjunction with the accompanying drawings, wherein like numbers designate like objects, and in which:

Figure 1 schematically illustrates a circuit diagram of a system for monitoring a single distant DAS according to prior techniques;

Figure 2 schematically illustrates a circuit diagram of a system for monitoring a group of distant DAS according to prior techniques;

Figure 3 schematically illustrates a circuit diagram of a system for monitoring a group of distant DAS according to a first embodiment;

Figure 4 schematically illustrates a circuit diagram of a system for monitoring distant DAS according to a second embodiment.

Figure 5 schematically illustrates a circuit diagram of a system for monitoring distant DAS according to a third embodiment.

[0012] FIGURES 1 through 5, discussed below, and the various embodiments used to describe the principles of the present disclosure in this patent document are by way of illustration only and should not be construed in any way to limit the scope of the disclosure. Those skilled in the art will understand that the principles of the present disclosure may be implemented in any suitably arranged device. The numerous innovative teachings of the present application will be described with reference to exemplary non-limiting embodiments.

[0013] Figures 1 and 2 illustrate respectively the single mode and the collective mode for monitoring distant DAS 3 by means of a CS 1, wherein each DAS 3 is connected to the CS 1 via an electrical module 2. According to Fig. 1A and 1B, the single mode is characterized by a pair of wires 1A, 1B connecting a single DAS 3 to the CS 1. In this case, additional DAS are connected to the CS by additional pair of wires, so that the state of the electrical contacts 31 of each DAS is known by measuring the impedance value of the loop circuits formed by said pair of wires 1A, 1B and connecting the electrical contacts 31 of the DAS to the CS 1. According to Fig. 2, the collective mode is characterized by a single pair of wires 1A, 1B connecting a plurality of DAS 3 to the CS 1 through a plurality of electrical modules 2. In this case, the CS 1 is only able to determine that at least one DAS among the plurality of DAS 3 changed its state, without knowing the exact number of DAS 3 which changed their states and without knowing exactly which one(s) of said DAS 3 changed state.

[0014] These deficiencies are corrected by the present invention, wherein a preferred embodiment is presented in Figure 3, disclosing a system for monitoring the state of a DAS 3, i.e. typically a bi-state distant actuated safety device, the system comprising:

- a CS 1 connected to a plurality of electrical modules 2 by a pair of electrical wires, respectively a first wire 1A and a second wire 1B, wherein the first wire 1A is connected to a first input terminal A of the CS 1 and the second wire 1B is connected to a second input terminal B of the CS 1;
- said plurality of electrical modules 2, wherein each electrical module 2 is connected to two electrical contacts 31, for instance a first electrical contact and a second electrical contact. Preferentially, each electrical module is connected to two and only two electrical contacts 31. Said two electrical contacts 31 may belong to one or two DAS 3;
- a plurality of DAS 3, wherein each DAS comprises at least one electrical contact 31, preferentially two electrical contacts 31. Each electrical contact 31 according to the invention is characterized in particular by two states, respectively a closed circuit state wherein electrical continuity through the electrical contact 31 is maintained, and an open circuit state wherein electrical continuity through the electrical contact 31 is broken. Each electrical contact 31 of the DAS is connected to one and only one electrical module 2, and preferentially all electrical contacts 31 of a same DAS 3 are connected to a same electrical module 2. The total number of electrical contacts 31 is in particular an even number.

[0015] The system according to the invention is further characterized in that:

- each electrical contact 31 is connected in parallel with an associated impedance element 21 of the electrical module 2 and an associated switching circuit 22 of the electrical module 2, wherein the associated switching circuit 22 is characterized by two states, respectively a closed circuit state wherein electrical continuity through the associated switching circuit 22 is maintained, and an open circuit state wherein electrical continuity through the associated switching circuit 22 is broken. The closed circuit state of the electrical contact 31 is configured for short circuiting its associated impedance element 21, while the open circuit state of the electrical contact 31 prevents current flowing through the electrical contact 31, enabling therefore current to flow either through its associated impedance element 21 if the associated switching circuit 22 is in its open circuit state or through its associated switching circuit 22 if the latter is in the closed circuit state;
- a loop circuit is formed by the first wire 1A and the second wire 1B, said loop circuit extending between the first input terminal A and the second input terminal B so as to connect the associated impedance elements 21 in series. The associated impedance elements 21 are therefore preferentially arranged with their corresponding electrical contact 31 with which they are connected in parallel so that irrespective of the state of the electrical contact 31, electrical continuity through the loop circuit is maintained. In particular, the loop circuit has predefined values of impedance across the first and second input terminals in function of the states of the electrical contacts 31. Preferably, the number of predefined impedance values equals the number of electrical modules 2 and are defined by the associated impedance elements 21. According to a preferred embodiment, the first wire 1A and the second wire 1B are connected to each other, for instance by means of an end of line (hereafter "EOL") impedance element 1C, which is preferably an EOL resistor or a Zener diode, so as to form said loop circuit extending through the impedance elements 21 of each electrical modules 2;
- preferentially, half of the associated impedance elements is connected to the first wire 1A and the other half to the second wire 1B (see in particular the configurations presented in Fig. 5 and 6). According to the preferred embodiment of Fig. 3, for each electrical module 2 one of the associated impedance ele-

ments 21 is connected to the first wire 1A and the other one of said associated impedance elements 21 is connected to the second wire 1B. Preferably, each associated impedance element 21 comprises a resistor. The values of the associated impedance elements 21 are notably selected for enabling an identification by the CS of the DAS contact whose electrical contact 31 changed its state from a measurement of an impedance value of the loop circuit;

- the CS 1 is configured for controlling each associated switching circuit 22 so that half of the associated switching circuits are in a state which is opposite to the state of the other half of said associated switching circuits during a measurement of a value of impedance of the loop circuit. In particular, the CS 1 is configured for reversing a direction of a flow of current at the first input terminal A (resulting also in an inversion of the direction of flow of current through the second input terminal B) during the measurement of said impedance value, wherein said inversion of direction automatically triggers a switching of the state of the associated switching circuits, while maintaining half of the associated switching circuits and the other half in opposite state. Preferentially, said half of the associated switching circuits comprises the associated switching circuits that are connected in parallel with the associated impedance elements of said half of the associated impedance elements connected to the first wire 1A, and said other half of the associated switching circuits comprises the associated switching circuits that are connected in parallel with the associated impedance elements of said other half of the associated impedance elements connected to the second wire 1B. According to a preferred embodiment, the associated switching circuits 22 of a same electrical module 2 have opposite states during the measurement of a value of impedance of the loop circuit. The CS 1 is indeed capable of switching the state of each associated switching circuit 22 by controlling the latter during a measurement of a value of impedance of the loop circuit. The CS 1 according to the invention is configured for monitoring any DAS state by measuring the impedance value of the loop circuit and determining from said impedance value measurement the state of each electrical contact 31 of any DAS 3 connected through the loop circuit. The present invention realizes thus the monitoring of DAS through a measurement of the value of impedance of the loop circuit for both states of the associated switching circuits 22 of all electrical modules 2, wherein during said measurement, the state of the associated switching circuits 22 of all electrical modules 2 are preferentially changed at the same time while keeping opposite states between the associated switching circuits 22 of a same electrical module 2.

[0016] According to the present invention, the loop circuit comprises notably two legs, respectively an outgoing leg and a return leg, wherein one end of the outgoing leg is connected to the first input terminal A and its other end to the EOL impedance element 1C, and one end of the return leg is connected to the second input terminal B and its other end to the EOL impedance element 1C. The CS is in particular configured for reversing the direction of a flow of current at the first input terminal A, so that electrical current may circulate during a period of time T1 from the first input terminal A through the loop circuit, for instance through its outgoing leg, then through the EOL impedance element 1C, then through the return leg, until reaching the second input terminal B, and then during a period of time T2 from the second input terminal B through the loop circuit, for instance through its return leg, then through the EOL impedance element 1C, then through the outgoing leg, until reaching the first input terminal A. Preferentially, said inversion of the flow of current automatically switches the state of each associated switching circuit 22 of all electrical modules 2 of the loop circuit. The advantage of this inversion of flow is that during the period of time T1, one half of the electrical contacts 31 are short-circuited by their associated switching circuit 22 by maintaining in opposite states the associated switching circuits 22 of each electrical module 2, enabling therefore a first measurement of the impedance value of the loop circuit, and during the period of time T2, the other half of the electrical contacts 31 are short-circuited by their associated switching circuit 22 by maintaining in opposite states the associated switching circuits 22 of each electrical module 2, enabling therefore a second measurement of the impedance value of the loop circuit, while keeping the number of wires of the system according to the invention low compared to the number of connected DAS. Then, the identification of the electrical contact 31 whose state changed is performed by the CS through the knowledge of the impedance values of each associated impedance element 21 which have been selected for predefining impedance values of the loop circuit in function of the states of the electrical contacts 31. For instance, the associated impedance elements 21, typically resistors, have identical electrical resistance within a same electrical module 2, wherein said electrical resistance is greater than or at least equal to $2^{N-1} \cdot R$, wherein N represents the ranking of the associated impedance element 21 within the series and counted from the EOL impedance element 1C in direction of the first input terminal 1A or in direction of the second input terminal 1B, and R an electrical resistance value. N = 1 corresponds to the first associated impedance element of the first or second wire when counting the associated impedance elements starting from the EOL impedance element, and N = M corresponds to the last one, with M being the number of associated impedance elements connected in series by the first wire 1A or the second wire 1B. For instance, starting from the EOL impedance element 1C, the first associated impedance element 21 of the first wire 1A connected to the EOL impedance element 1C corresponds to N = 1 and is characterized by an electrical resistance equal to R. Then, the second associated impedance element 21 of the series of associated impedance elements 21 counted on the first wire A from the EOL impedance element 1C in direction of the first input terminal A correspond to N = 2 and is therefore characterized by an electrical resistance equal to 2R. The next associated impedance element will therefore be characterized by an electrical resistance equal to 4R. Of course, those skilled in the art will recognize that the order of the impedance elements might be different while not departing from the spirit and scope of the present invention. As shown by Fig. 3, wherein the system according to the invention comprises 4 electrical modules 2 and 4 associated impedance elements 21, the last impedance element of the first wire 1A before reaching the first input terminal A is characterized by an electrical resistance equal to 8R. Finally, the EOL impedance element 1C is preferentially characterized by an electrical resistance equal to $2^M \cdot R$, wherein M is the total number of electrical modules 2, or, in other words, the total number of associated impedance elements 21 connected in series by the first wire 1A or alternatively by the second wire 1B as previously explained.

[0017] Figures 3 and 4 further present a preferred embodiment of the CS 1 which enables a change of the direction of the flow of current, for instance in function of the time (i.e. during the period of time T1, current flowing in a first direction, and during the period of time T2, the current flowing in a second direction opposite to the first one), through the first input terminal A or through the second input terminal B. For this purpose, the CS 1 comprises notably two pairs of switching elements 11, respectively a first pair of switching elements 11A, 11C (see Fig. 4) and a second pair of switching elements (11B, 11D), wherein said two pairs are connected in parallel between a first electrical node C and a second electrical node D, wherein each pair of switching elements 11 comprises a first switching element 11A, 11B, that is connected to the first electrical node C with the first switching element of the other pair, wherein the first switching element 11A of the first pair is then connected, together with the second switching element 11C of the first pair, to the second input terminal B, wherein the first switching element 11B of the second pair is then connected, together with the second switching element 11D of the second pair, to the first input terminal A, wherein the second switching element 11C, 11D of each pair are connected together to the second electrical node D, wherein the two switching elements 11 of each pair, respectively (11A, 11C) and (11B, 11D), are connected in series, wherein each switching element 11 has a closed circuit state wherein electrical continuity through the switching element 11 is maintained, and an open circuit state wherein electrical continuity through the switching element is broken. According to the present invention, the switching elements 11, the electrical contacts 31 and the associated switching circuits 22 are typically switches, or any device capable of breaking or maintaining electrical continuity through an electrical path.

[0018] The CS is in particular configured for changing the state of one of the switching elements 11 during a measurement of the impedance value of the loop circuit while maintaining the switching elements of a same pair in opposite states, and maintaining the first switching element of both pairs in opposite states. By this way, the direction of flow of current through the first or second input terminal A, B, both being typically electrical nodes, might be inverted. For instance, during the period of time T1, the first switching element 11A of the first pair is in an open circuit state (see Fig. 4) while the first switching element 11B of the second pair is in a closed circuit state, enabling the current to flow through first input terminal A according to a first direction, while during the period of time T2, the first switching element 11A of the first pair is in a closed circuit state (not shown) and the first switching element 11B of the second pair is in an open circuit state, enabling the current to flow through first input terminal A according to a second direction opposite to the first direction.

[0019] Figure 4 illustrates a preferred embodiment of the present invention, wherein the associated switching circuit 22 comprises a transistor 221. As already illustrated in Figure 3, the system according to the invention is provided through an electrical circuit comprising a plurality of electrical modules 2 and a plurality of DAS 3, wherein each DAS has said closed circuit state (at least one of its electrical contacts is closed) and said open circuit state (all electrical contacts 31 are open) implemented by its electrical contact(s), wherein each DAS 3 is connected to at least one electrical module 2 and the plurality of electrical modules 2 are connected in series in said loop circuit extending between the two input terminals A, B of the CS 1, wherein each electrical contact 31 of the DAS has an associated impedance element 21 within the electrical module 2 it is connected to, wherein each electrical module 2 is connected to two electrical contacts 31, wherein the associated impedance element 21 is arranged with its corresponding DAS 3 so that, irrespective of the state of the DAS 3, electrical continuity is maintained through the loop circuit, wherein the loop circuit has predefined values of impedance across the input terminals A,B in function of the states of the DAS 3, wherein the number of predefined impedance values preferentially equals the number of electrical modules 2, wherein each electrical module 2 comprises for each electrical contact 31 said associated switching circuit 22, wherein the associated switching circuit 22 has two states, namely the open circuit state wherein electrical continuity through the switching circuit 22 is broken and the closed circuit state wherein electrical continuity through the switching circuit 22 is maintained, wherein each electrical contact 31 is further connected in parallel with its associated impedance element 21 and its associated switching circuit22. According to the present invention, each electrical module 2 might comprise the same type of components, i.e. an associated impedance element and an associated switching circuit, wherein one electrical module 2 differs from another one of the electrical modules 2 connected to the same loop circuit in that the value of the electrical resistance of its associated impedance elements is different from the value of the electrical resistance of the associated impedance elements of the other electrical module 2.

[0020] According to the preferred embodiment illustrated in Figure 4, there is a first electrical module 2A which comprises the first associated impedance element with regard to the connection in series of the associated impedance elements 21 starting from the first input terminal A until the EOL impedance element 1C and a last electrical module 2M comprising the last associated impedance element with regards to said connection in series of the associated impedance elements from the first input terminal A until the EOL impedance element 1C. Preferably, each electrical module 2 comprises at least four electrical nodes, namely a node I and a node J on the first wire 1A, and, a node K and a node L on the second wire 1B. The node I connects a first terminal of the associated impedance element 21 of the electrical module 2 either to the first input terminal A of the CS 1 if the electrical module 2 is said first electrical module 2A or to a node J of a directly neighboring electrical module 2 (i.e. to a directly neighboring associated impedance element in direction to the first input terminal with respect to the connection in series of the associated impedance elements 21 from the first input terminal A until the EOL impedance element 1C). The node J connects a second terminal of said associated impedance element 21 either to the EOL impedance element 1C or to the node I of a directly neighboring electrical module 2 (i.e. more precisely to the first terminal of the directly neighboring associated impedance element in direction to the EOL impedance element with respect to the connection in series of the associated impedance elements 21 from the first input terminal A until the EOL impedance element 1C). The same applies mutatis mutandis for the nodes K and L on the second wire 1B (see Fig. 4). In the case the associated switching circuit 22 comprises an NMOS transistor 221 comprising as usual a drain, a source and a gate, and being characterized by a gate to source threshold voltage, then the node I further preferentially connects in parallel the first terminal of the associated impedance element 21, the drain and a first terminal of the electrical switch 31, the node J connecting then the second terminal of the associated impedance element, the source of the NMOS transistor, and a second terminal of the electrical switch 21. The same applies mutatis mutandis for the nodes K and L on the second wire 1B. In order to enable an automatic switching of the associated switching circuits when reversing the direction of flow of the current, the present invention further proposes to connect to the node I the gate of the NMOS transistor connected in parallel with the associated impedance element mounted on the second wire 1B, and to connect to the node K the gate of the NMOS transistor connected in parallel with the associated impedance element mounted on the first wire 1A. Preferentially, said connection of the node I or K to the gate of the NMOS transistor is realized through an additional impedance element 222. In other words, according to the above-described configuration, within a same electrical module, the gate of the transistor of one of its associated switching circuits 22 is connected to the drain of the transistor 221 of the other one of its associated circuits 22. The NMOS transistor is therefore advantageously used in parallel with its corresponding electrical contact 31 in order to be able to short circuit the latter: indeed, the NMOS transistor is arranged for breaking the electrical continuity through the associated switching circuit 22 if a gate voltage is lower than the voltage of the source and for maintaining the electrical continuity through the associated switching circuit 22 if the gate voltage is higher than the sum of the voltage of the source and of the gate to source threshold voltage, wherein the EOL impedance element 1C is characterized by a voltage drop higher than the gate to source threshold voltage of the NMOS transistor. By this way, reversing the direction of flow of the current at the first input terminal automatically switches the state of each associated switching circuit comprising said NMOS transistor. According to the preferred embodiment of Fig. 4, all NMOS transistors are preferentially identical. Nevertheless, the skilled man may envisage variations of the presented circuit configuration without departing from the concept of the present invention.

[0021] According to the above-mentioned arrangement, the CS 1 is capable of determining if a DAS from the plurality of DAS connected together via the loop circuit and through the electrical modules changed its state and of identifying which electrical contact of which DAS changed its state from the measurement of the impedance value of the circuit loop realized by the CS when the current is flowing according to the first direction and when the current is flowing according to said second direction which is opposite to the first direction. For instance, and as already explained, the CS is configured for maintaining opposite sates between the switching elements of each pair of switching elements and maintaining opposite states between the first switching element 11A, 11B of each pair of said switching elements. During a first period of time T1, the CS is in particular configured for measuring the impedance value of the loop circuit while maintaining the state of the first switching element 11B of the second pair opposed to the states of all switching circuits of the electrical modules connected to the first wire 1A and identical to the states of all switching circuits of the electrical modules connected to the second wire 1B, obtaining therefore a first impedance value that characterizes the states of half of the electrical contacts. Then, the CS is configured for changing the state of the first switching element of the second pair, following which it proceeds to the measurement, during the period of time T2, of the impedance value of the loop circuit while maintaining the state of the first switching element 11B of the second pair opposed to the states of all switching circuits of the electrical modules connected to the first wire 1A and identical to the states of all switching circuits of the electrical modules connected to the second wire 1B, obtaining therefore a second impedance value that characterizes the states of the other half of the electrical contacts. Therefore, changing the state of the first switching element of one of the pairs of switching elements is configured for automatically switching the state of the switching circuits connected to the first wire 1A and second wire 1B.

[0022] As usual, and therefore not described in details in the present document, the CS is configured for supplying a current between the first and second input terminals of the loop circuit and that flows through the loop circuit, and comprises measuring means for measuring a voltage drop between the first and second input terminals and processing means for determining the impedance value of the loop circuit from the voltage drop value and knowledge of the impedance values of the associated impedance elements of the electrical modules 2. For instance, the CS may comprise a memory for storing the value of the associated impedance elements connected in series by means of the first wire 1A and the second wire 1B, and a correspondence between said value and the electrical contact connected in parallel with the associated impedance element so as to identify from the measurement of impedance value of the loop circuit each of the DAS whose electrical contact changed state.

[0023] Figure 5 discloses finally an additional embodiment of the present invention. The basic idea of the invention remains the same as for the previous embodiments, i.e. only two wires, respectively the first wire 1A and the second wire 1B, are used for monitoring twice the number of electrical contacts 31 that is usually possible to monitor with conventional techniques. As already disclosed in the previous embodiments, the concept is based on an alternation of the direction of the flow of current through the first input terminal 1A during a measurement of the impedance value of the loop circuit, said current flowing in said loop circuit in one direction during a certain period of time T1 of said measurement, automatically short-circuiting half of the associated switching circuits 22 while electrical continuity is ensured in the other half of said associated switching circuits 22, and then, said current flowing in an opposite direction during a period of time T2 of said measurement, automatically short-circuiting the other half of the associated switching circuits 22 while continuity is ensured for said half of the associated switching circuits 22. Advantageously and in particular, the alternation, by means of the CS, of the direction of the flow of current during measurement of the impedance value of the loop circuit together with the use of transistors 221 (like NMOS transistors) for the associated switching circuit 22 and an EOL impedance element 1C whose impedance value is chosen for enabling a switch of the state of the transistor when the direction of current flow is reversed enables an automation of the change of the state of each transistor 221 when said direction of the current flow changes from one direction to the opposite direction, enabling therefore to have, first, half of the electrical contacts 31 being checked when the current is flowing in a first direction, and then, second, the other half of the electrical contacts 31 being checked by the CS when the current is flowing in a second direction opposed to the first direction.

[0024] Compared to Figure 4, the electrical module 2 of Figure 5 comprises an associated switching circuit 22 with two legs, respectively one leg connected to a first node M and the other leg connected to a second node N, wherein the associated impedance elements 21 of the electrical contacts 31 of the DAS 3 are mounted in series between the first node M and the second node N. According to this configuration, the first wire 1A connects in series the associated impedance elements 21 of half of the electrical modules 2 and the second wire 1B connects in series the associated impedance elements of the other half of the electrical modules 2, the first wire 1A and the second wire 1B being connected together through the EOL impedance element 1C in order to form said loop circuit. As previously disclosed, the associated switching circuit 22 preferentially comprises a transistor 221, for instance a NMOS transistor, wherein impedance values of the associated impedance elements 21 and EOL impedance element 1C are suitably chosen for enabling an automatic switching of the state of the switching circuit, e.g. its transistor, when the direction of flow of current is reversed during measurement of the impedance value of the circuit loop. In particular, the drain of the transistor 221 is connected to the second node N, its source to the first node M and its gate to the first wire 1A if the associated impedance elements 21 are connected in series between first node M and second node N through the second wire 1B, or to the second wire 1B if the associated impedance elements 21 are connected in series between the first node M and second node N through the first wire 1A, as illustrated in Fig. 5.

[0025] According to other embodiments, the CS 1 may comprise two sources of current, for instance a first source connected to the first input terminal A and a second source connected to the second input terminal B, wherein a switching system enables to switch from the first source to the second source and vice versa in order to reverse the direction of the flow of current through the first and second input terminals. Of course, the skilled man will understand that other configurations of the CS 1 may enable an inversion of the direction of the flow of current within the loop circuit so as to automatically switch the state of the associated switching circuits 22.

[0026] Although exemplary embodiments of the present disclosure have been described in detail, those skilled in the art will understand that various changes, substitutions, variations, and improvements disclosed herein may be made without departing from the spirit and scope of the disclosure in its broadest form.

Claims

1. System for monitoring a state of a bi-state distant actuated safety device (hereafter called "DAS") (3), the system comprising:

   - a central system (hereafter called "CS") (1) connected to a plurality of electrical modules (2);
   - a plurality of DAS (3), each DAS comprising at least one electrical contact (31), wherein each electrical contact (31) is **characterized by** two states;
   - said plurality of electrical modules (2), wherein each electrical module (2) is connected to at least one electrical contacts (31);

   the system according to the invention being **characterized in that**:

   - each electrical contact (31) is connected in parallel with an associated impedance element (21) of the electrical module (2), each electrical contact (31) is further connected to an associated switching circuit (22) of the electrical module (2), wherein the associated switching circuit (22) is **characterized by** two states, respectively a closed circuit state wherein electrical continuity through the associated switching circuit is maintained, and an open circuit state wherein electrical continuity through the associated switching circuit is broken;
   - a loop circuit connects the associated impedance elements (21) in series to the CS (1), wherein the loop circuit has predefined values of impedance in function of the states of the electrical contacts (31);
   - the CS (1) is configured for controlling each associated switching circuit (22) so that N associated switching circuits (22) are in a state which is opposite to the state of M other associated switching circuits (22) during a measurement of a value of impedance of the loop circuit, wherein M + N equals the total number of associated switching circuits (22), the CS (1) being further configured for monitoring the DAS state by measuring the impedance value of the loop circuit while switching the state of the associated switching circuits (22) and determining from said measurement the state of each electrical contact (31) of the DAS (3).

2. System according to claim 1, wherein each DAS comprises two electrical contacts (31) connected to one and the same electrical module (2).

3. System according to claim 1 or 2, wherein the associated impedance elements (21) are arranged with their corresponding electrical contact (31) so that irrespective of the state of the electrical contact (31), electrical continuity through the loop circuit is maintained.

4. System according to one of the claims 1 to 3, wherein the number of predefined impedance values equals the number of electrical modules (2).

5. System according to one of the claims 1 to 4, wherein the CS (1) is connected to the plurality of electrical modules (2) by a pair of electrical wires forming said loop circuit, respectively a first wire (1A) and a second wire (1B), wherein the first wire (1A) is connected to a first input terminal (A) of the CS (1) and the second wire (1B) is connected to a second input terminal (B) of the CS (1) .

6. System according to one of the claims 1 to 5, wherein the CS (1) is configured for comparing the measured value of impedance of the loop circuit with the predefined impedance values.

7. System according to one of the claims 1 to 6, wherein the associated switching circuit (22) comprises a transistor (221) .

8. System according to claim 7, wherein the transistor (221) of each associated switching circuit (22) of a same electrical module (2) is a NMOS transistor comprising a gate, a drain, and a source, and being **characterized by** a gate to source threshold voltage, the NMOS transistor being arranged for breaking the electrical continuity through the associated switching circuit (22) if a gate voltage is lower than the voltage of the source and for maintaining the electrical continuity through the associated switching circuit (22) if the gate voltage is higher than the sum of the voltage of the source and of the gate to source threshold voltage, wherein an end-of-line impedance element (1C) is **characterized by** a voltage drop higher than the threshold voltage of the NMOS transistor.

9. System according to one of the claims 1 to 8, wherein the CS (1) is configured for reversing a direction of a flow of current within the loop circuit.

10. System according to claim 9, wherein the CS (1) comprises two pair of switching elements, respectively a first pair of switching elements (11) and a second pair of switching elements (11), wherein said two pairs are connected in parallel between a first electrical node (C) and a second electrical node (D), wherein each pair of switching elements (11) comprises a first switching element, wherein the first switching elements are connected together to the first electrical node (C), wherein the first switching element of the first pair is then connected, together with the second switching element of the first pair,

to the second input terminal (B), wherein the first switching element of the second pair is then connected, together with the second switching element of the second pair, to the first input terminal (A), wherein the second switching element of the first and second pair are connected together to the second electrical node (D), wherein the switching elements (11) of a same pair are connected in series, wherein each switching element (11) has a closed circuit state and an open circuit state.

11. System according to claim 10, wherein the CS (1) is configured for changing the state of the first switching element of the first pair during a measurement of the impedance value of the loop circuit, wherein the CS (1) is further configured for controlling the switching elements (11) so that the switching elements of a same pair have opposite states, and the first switching element of the first pair and the first switching element of the second pair also have opposite states.

12. System according to one of the claims 1 to 4, wherein for each electrical module (2) one of the associated impedance elements (21) is connected to the first wire (1A) and the other one of said associated impedance elements (21) is connected to the second wire (1B).

13. Method for monitoring a state of a bi-state distant actuated safety device (hereafter called "DAS") (3) by means of a system, the latter comprising:

- a central system (hereafter called "CS") (1) connected to a plurality of electrical modules (2);
- said plurality of electrical modules (2), wherein each electrical module (2) is connected to at least one electrical contact (31) of a DAS (3);
- a plurality of said DAS (3), each DAS comprising at least one of said electrical contacts (31), the latter being connected in parallel with an associated impedance element (21) of the electrical module (2), wherein each electrical contact (31) is **characterized by** two states, respectively a closed circuit state wherein electrical continuity through the electrical contact (31) is maintained and which enables to short circuit its associated impedance element (21), and an open circuit state wherein electrical continuity through the electrical contact (31) is broken, wherein each electrical contact (31) is further connected with an associated switching circuit (22) of the electrical module (2), wherein the associated switching circuit (22) is **characterized by** two states, respectively a closed circuit state wherein electrical continuity through the associated switching circuit is maintained and which enables to short circuit said associated impedance element (21), and an open circuit state wherein electrical continuity through the associated switching circuit is broken;
- a loop circuit formed by the first wire (1A) and the second wire (1B) and extending between the first input terminal (A) and the second input terminal (B), said loop circuit connecting the associated impedance elements (21) in series, wherein the loop circuit has predefined values of impedance across the first and second input terminals in function of the states of the electrical contacts (31);

the method comprising chronologically the following steps:

- maintaining N associated switching circuits (22) and M other the associated switching circuits (22) in opposite states so that a part of the electrical contacts (31) are short-circuited by their associated switching circuit (22), wherein M + N equals the total number of associated switching circuits (22);
- measuring an impedance value of the loop circuit;
- monitoring the DAS (3) by determining if an electrical contact (31) changed its state by comparing the measured impedance value to a predefined impedance value for the loop circuit;
- changing the state of each associated switching circuits (22) so that said N associated switching circuits (22) and said M other associated switching circuits (22) remain in opposite states so that another part of the electrical contacts (31) are short-circuited by their associated switching circuit (22), wherein an union of said part and said other part of the electrical contacts (31) comprises all electrical contacts (31);
- measuring an impedance value of the loop circuit;
- monitoring the DAS (3) by determining if an electrical contact (31) changed its state by comparing the measured impedance value to the predefined impedance value for the loop circuit.

14. Method according to claim 13, wherein changing the state of each associated switching circuit (22) is automatically realized by reversing a direction of a flow of current through the loop circuit by means of the CS (1).

15. Method according to claim 14, comprising changing a state of switching elements of the CS (1) for reversing said direction.

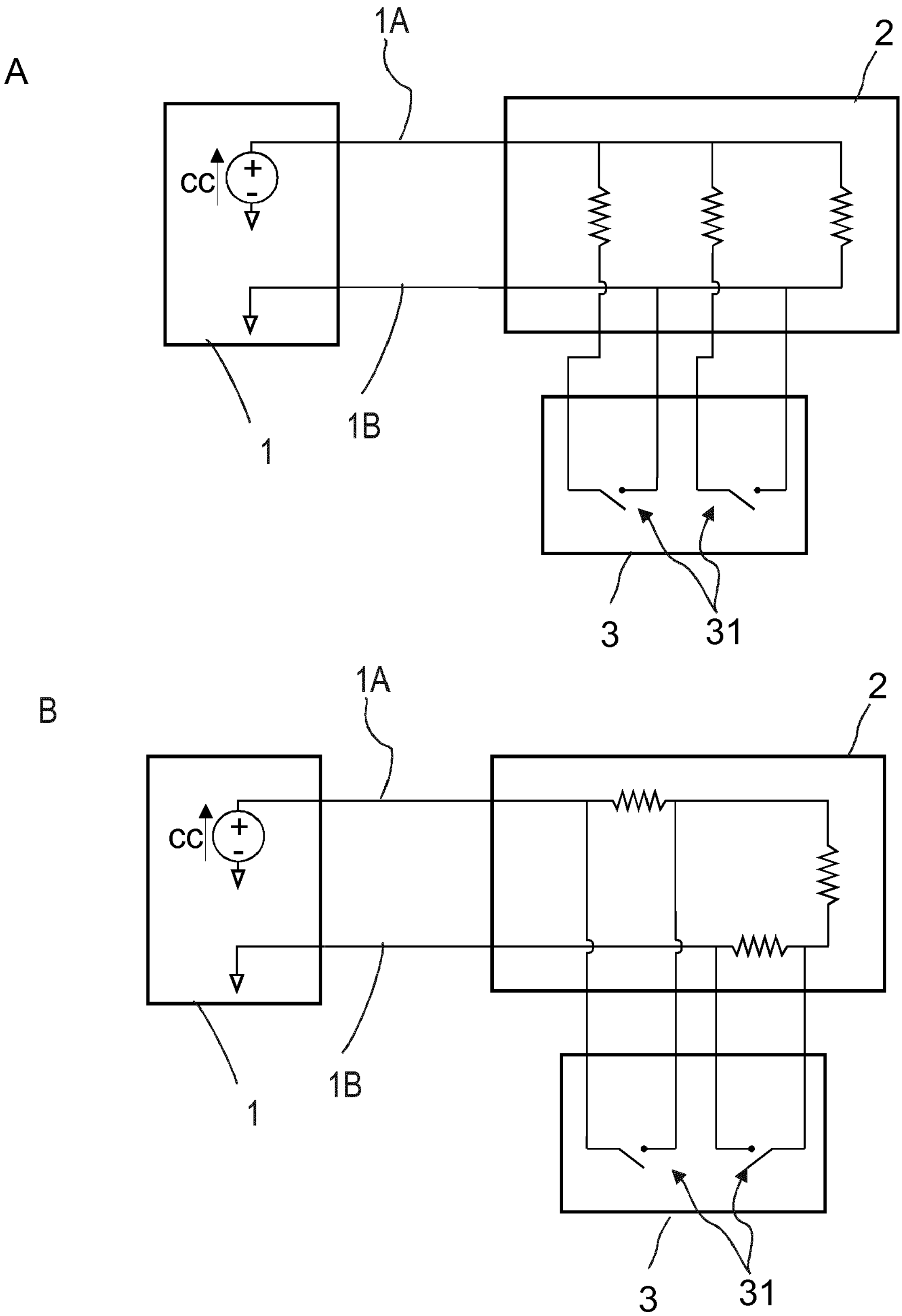


FIG 1

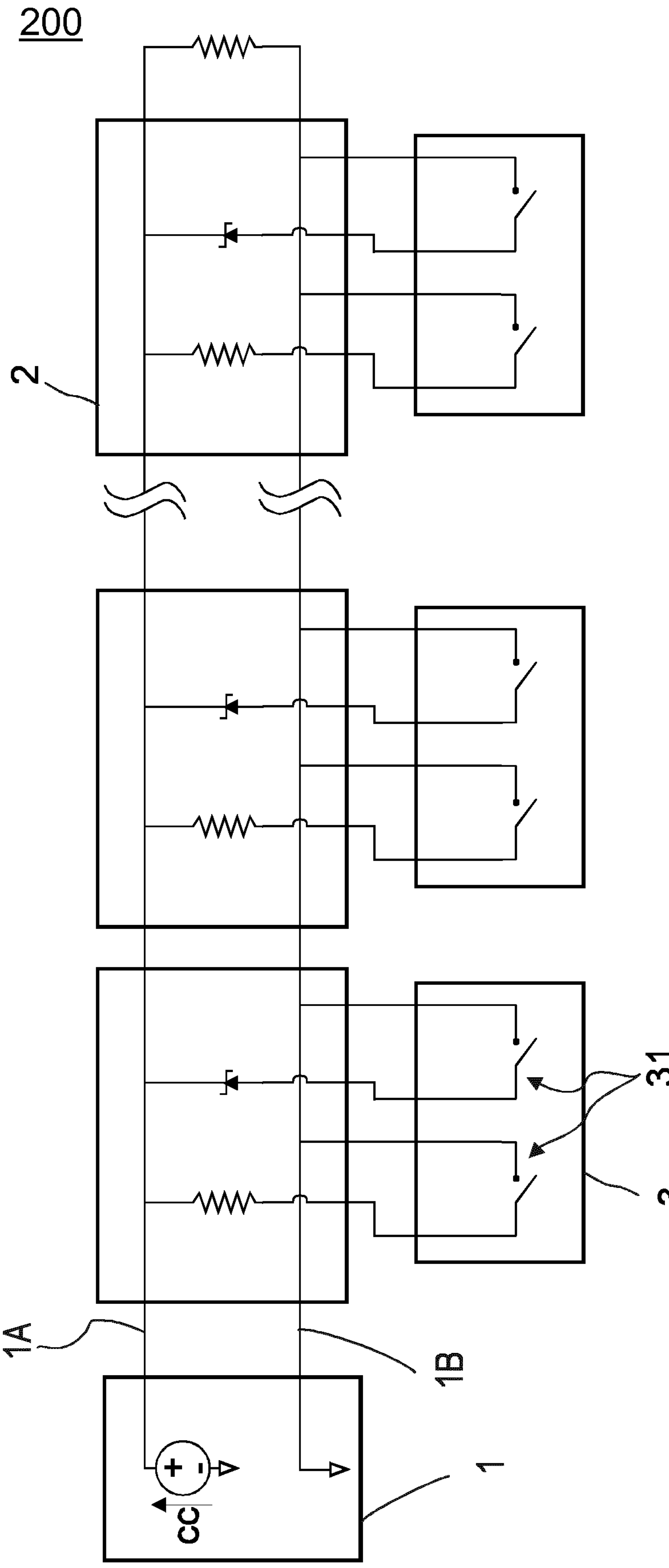


FIG 2

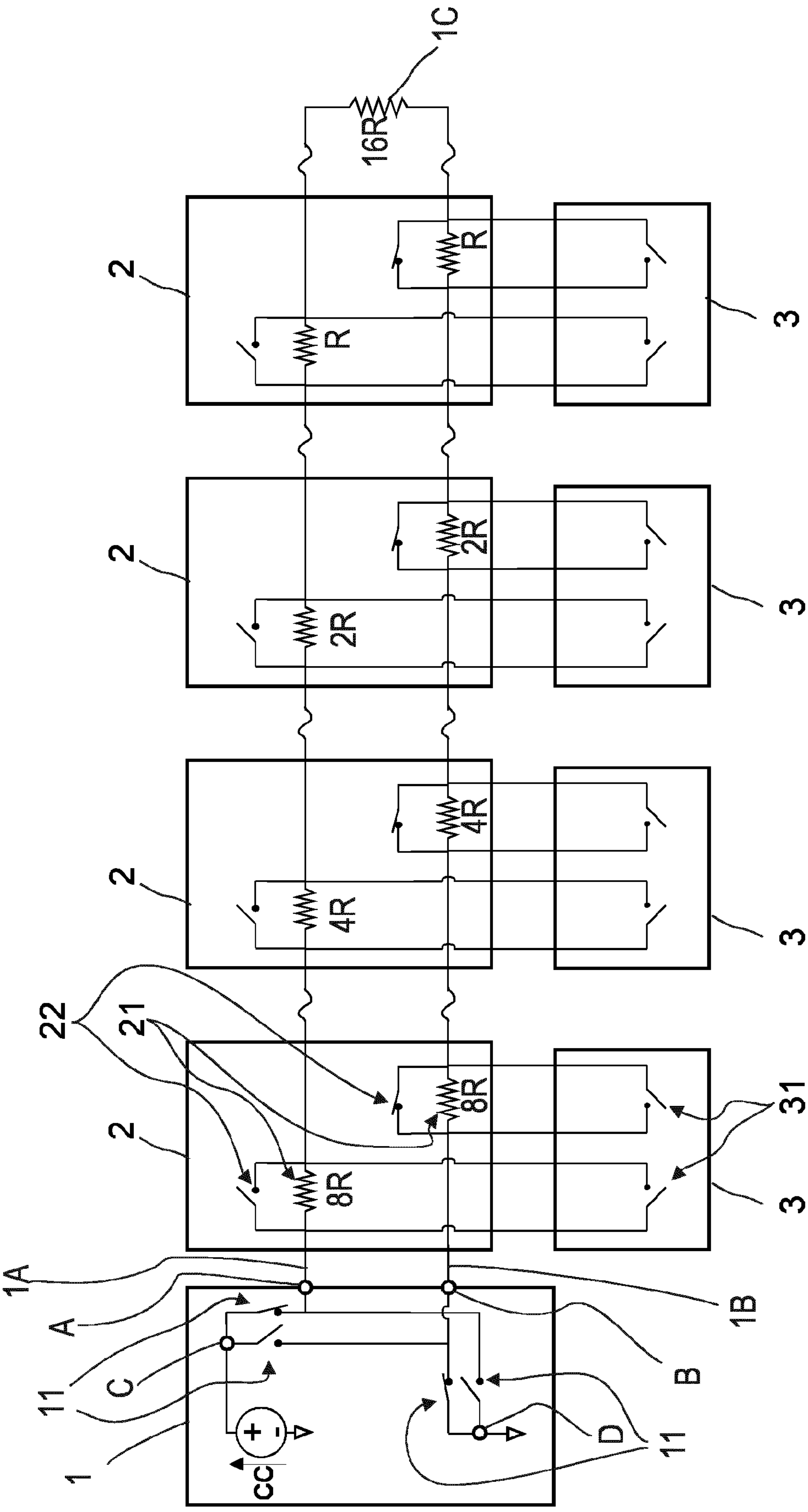
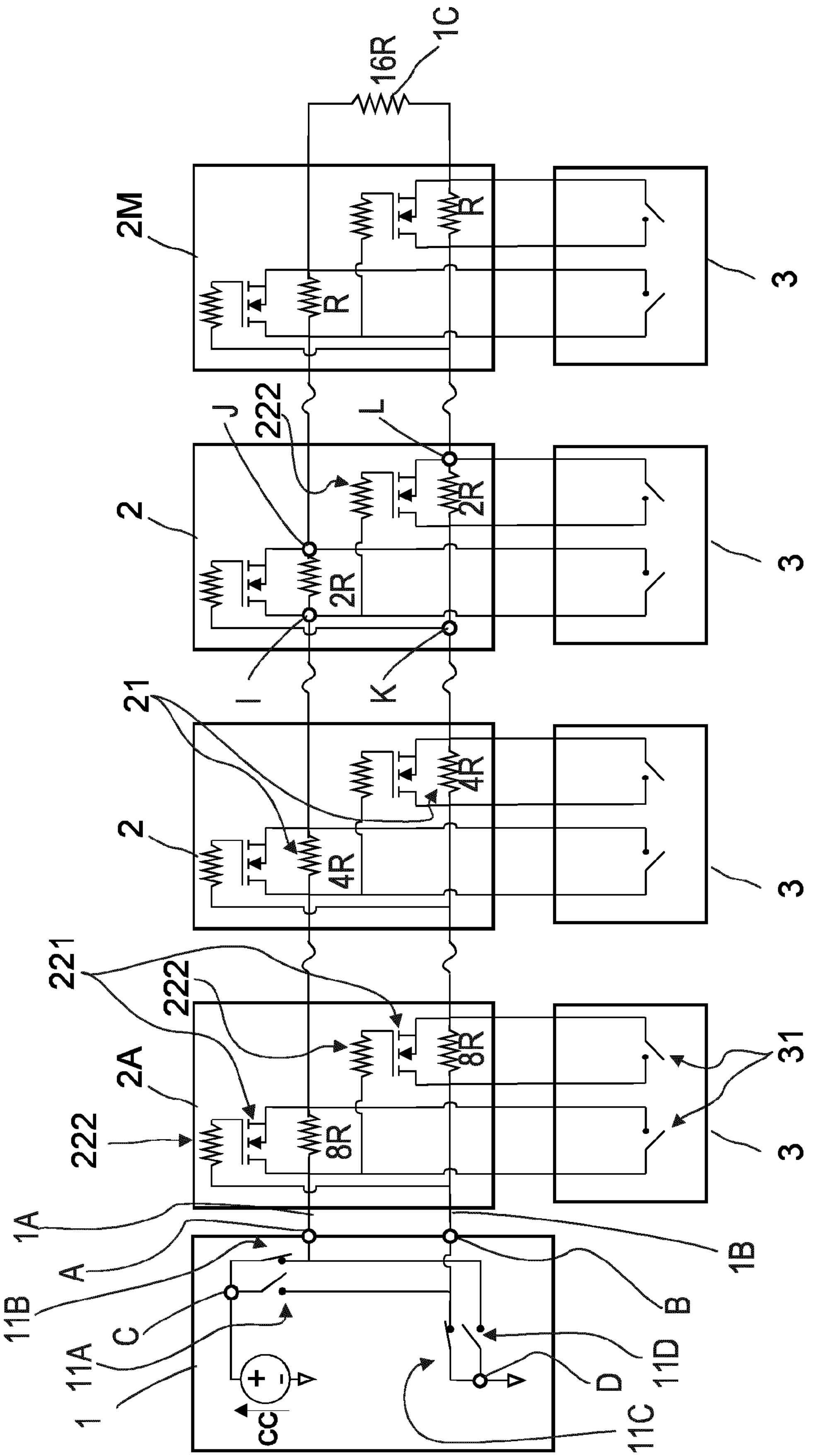


FIG 3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2A
8R
8R
222
31
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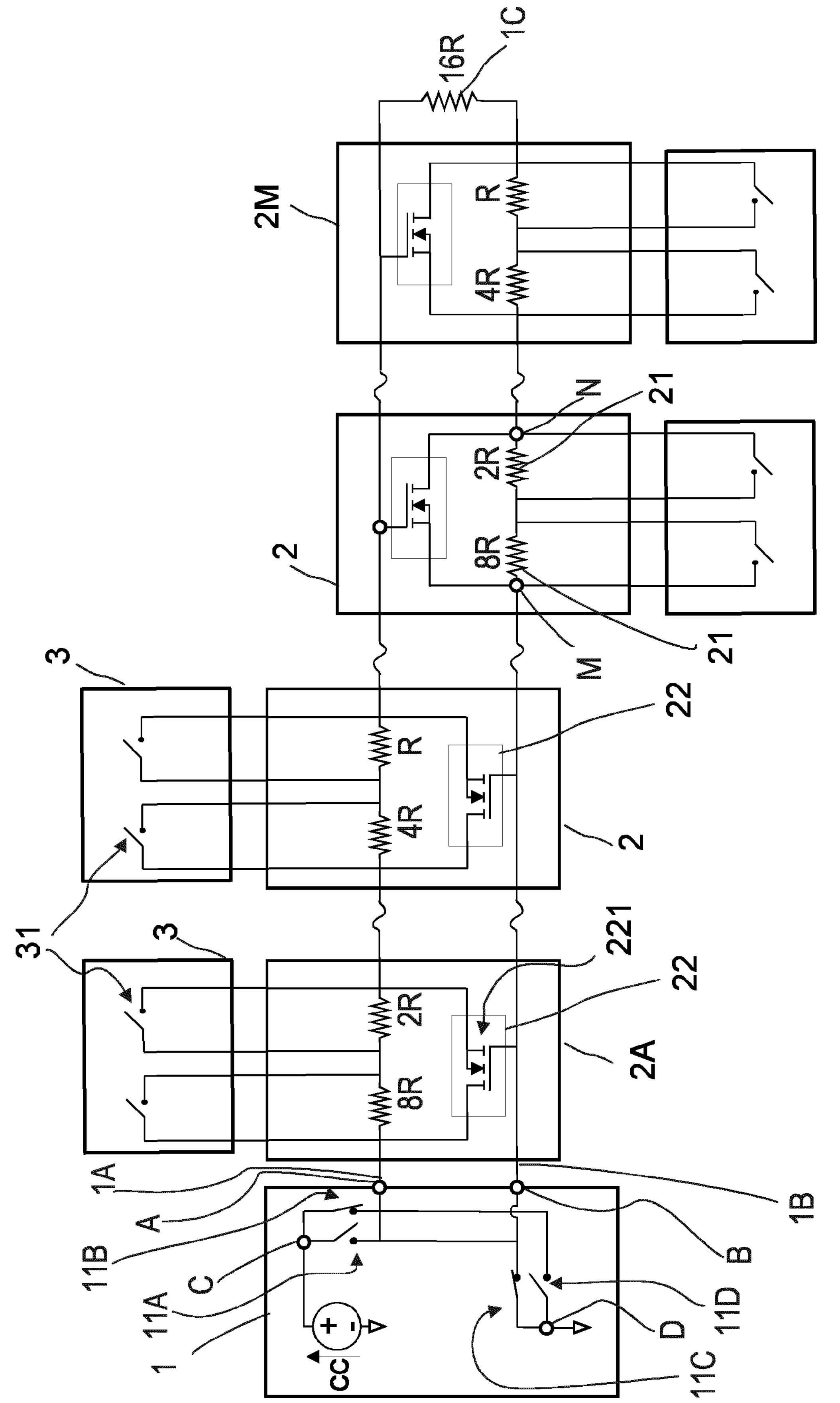
11D
11C

FIG 4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8R
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1A
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11D
D
11C

FIG 5

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EUROPEAN SEARCH REPORT

Application Number
EP 18 16 1770

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The present search report has been drawn up for all claims

1

Place of search	Date of completion of the search	Examiner
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