A control circuit for a differential switch.

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References cited:
- DE-A-2 015 415
- DE-A-2 036 497
- DE-A-2 424 205
- US-A-3 852 642
- US-A-4 077 055
- US-A-4 316 229

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Description

This invention relates to a control circuit for a differential switch, particularly for protecting single users against possible fault or leakage currents, which circuit is comprised of passive, inexpensive components, and is capable of responding to unidirectional (dc-components) and chopped (pulsating) leakage currents.

As is known, differential switches are utilized to protect one or more users against possible leakage currents, by acting directly upon the power network supplying the circuit of the user(s) to be protected.

The differential switches commercially available may be divided into two basic types: the electro-mechanical type, and the type utilizing electronic circuits.

The electro-mechanical type of differential switches makes use of a toroidal transformer to sense the occurrence of a leakage current to earth and to directly operate an electro-mechanical relay that is capable of causing a network switch to open through a servomechanism. A disadvantage with this type of switch is that it requires a toroidal transformer that must be of a rather large size to be able to transfer an adequate operating power to the relay.

It also requires use to be made of a sophisticated relay and a servomechanism capable of increasing the operating power for opening the main switch, as well as a resetting system for said relay.

All of the above, apart from a consideration of the reliability of the circuit, will inevitably have a consequential effect on the cost of this latter.

The other type of differential switch known, utilizes a toroidal transformer to sense the occurrence of a leakage current, and an electronic circuit that operates a semiconductor element effective for closing the circuit of a trip coil operating a switch. Both the electronic circuit and the trip coil require to be fed from individual power supplies that may be fed from the network or an auxiliary source.

In this case, there is no need for a largely dimensioned core, because the electronic circuit downstream of the transformer enables the signal to be amplified up to the desired levels for operation of the switch through said coil.

However, as already said, two additional power supplies are needed: one power supply for maintaining an adequate voltage on the operating coil, and the other one for providing adequate current to bias the electronic circuits.

In general, the electronic circuits known are of an active type and utilize integrated circuits in order to attain the desired functional results, which increase the complexity and, thus, the cost of the device, while reducing its reliability, due to the multiplicity of functions these circuits are to perform. Reliability is also reduced in that said electronic circuits, being fed from their own power supply, obviously tend to get hot, giving lower performance than do practically cold circuits.

Moreover, said power supplied electronic circuits require a rise-to-working-level time of their supply voltage and this may cause delay in operation, in the event of closure of the differential switch on a pre-existing fault.

A drawback that is frequently experienced with this type of circuits utilizing a solids state switch upstream of the trip coil, is that the operating power supplied to said switch may be in a pulsating form with periodicity of 20 ms, if the network frequency is 50 Hz. As is known, a solid state switch will close upon receiving a triggering signal and open when current flowing therein is brought to zero.

Should a phase difference exist between the leakage current to earth and the network voltage such that the solid state switch closes a few milliseconds before the network voltage goes through zero, then the time during which the current is flowing in the trip coil would be insufficient for the contacts to open, and this would cyclically occur at each period of the network voltage, thereby causing operation of the differential switch to fail.

DE—A—2.015.415 discloses a control circuit for a differential switch as specified in the first part of the independent claim, in particular comprising a matching capacitor and a full-wave rectifier between the secondary winding of a toroidal transformer and a solid state switch, the matching capacitor and the secondary winding of the transformer constituting a resonant circuit at the network frequency.

The arrangement according to DE—A—2015415 does not obviate the drawbacks indicated above and the circuit is not protected against overvoltages and electromagnetic disturbances.

US—A—4.316.229 describes a low sensitivity electric current detector circuit designed to sense an earth-fault current greater than a threshold value of 0.5 amps, needing at least a current limiting resistor for limiting the current flowing in the circuit which comprises a diode bridge rectifier and a complex passive network arranged between the secondary winding of a transformer and a solid state switch.


The differential switch control circuit according to this invention obviates to the drawbacks described above, it is a low-cost, highly reliable device, and allows use of a rather small core for its earth-fault responsive toroidal transformer, without requiring, otherwise, the use of an active electronic circuit.

The circuit according to the invention is characterised by the features described in the characterising portion of the independent claim.

The arrangement as claimed enables the circuit to respond to both unidirectional and chop-
ped or pulsating, leakage currents, provides an appropriate operating time for triggering the solid state switch while obviating the drawbacks indicated above and protects the latter against over-voltages and electromagnetic disturbances.

The above and further features of the invention will be best understood when reading the following description in connection with the accompanying drawings which show, as a non-restrictive example, a preferred embodiment of the invention.

In the drawings:

Figure 1 is a block diagram of the differential switch control circuit according to the invention; and

Figure 2 is a wiring diagram of the control circuit in figure 1, showing the different circuit components.

Reference will be made now to the above figures and first to figure 1, where the control circuit of the invention is designated by 1 as a whole.

F and N are the power network conductors. T1 is a toroidal transformer designed to sense the existence of leakage currents to earth and to operate, via a circuit to be described herein below, a trip coil L1 through a solid state switch I1 to cause opening of movable contacts 2 and 3 in the power network. Said circuit that is interconnected between the secondary 4 of transformer T1 and the solid state switch I1, consists of a capacitor C1, a rectifier R1, a passive network P1, and second capacitor C2, the functions of which are explained herein after. The trip coil L1 is provided with its own supply of power A1 that may be drawn out from the power network or an auxiliary source.

A second rectifier R2 is arranged in the circuit section where the trip coil L1 is placed. Provision of rectifier R2 is necessary if the solid state switch I1 is a SCR but not essential when the solid-state switch I1 is a TRIAC.

Provided between the solid state switch I1 and the trip coil, is a second passive network P2 which performs the functions of preventing the circuit from being subjected to electromagnetic disturbances and protecting it against possible over-voltages. It is to be noted that because the circuit 1 is formed by passive components, the circuit is, in itself, little liable to disturbances.

The capacitor C1, that is arranged right downstream of the secondary 4 of transformer T1, is dimensioned so that it will attain a resonance, or near-to-resonance, condition with the inductance of secondary 4. In this way, indeed, a maximum power transfer is obtained downstream of the transformer T1, which gives adequate voltage and current values for triggering the solid state switch I1.

Correct dimensioning of the rectifier R1 and, particularly, the passive network P1, upstream of the solid state switch I1, enables the circuit to respond to both unidirectional (dc-components) and chopped or pulsating leakage currents.

The capacitor C2, when arranged as shown in the diagram, permits achievement of the desired operating time. Clearly, with a rather high capacitance C2, delays of the order of the tens and even hundreds of milliseconds may be obtained for the operating time of the switch. This may be useful when a selectivity in operation is desired, i.e. when it is desired that the differential operations of an entire installation be coordinated.

Moreover, the capacitor C2, provided it is of a proper value relatively to the features of the solid state switch, enables this latter to be at any time maintained in a closed condition, once the triggering condition is reached, thereby overcoming any problem of unfavourable difference of phase between the leakage current to earth and the network voltage, a drawback that is experienced with the electronic circuits mentioned above.

Referring now to the circuit diagram in figure 2 showing the different circuit components, given herein below are the principle values of said components for a correct functioning of the circuit, the commercial symbols for some of them being given too.

In said diagram, the toroidal transformer T1 is a $21.5 \times 8.5$ mm BTicino—28023 with $N_1$ (number of turns of the primary) = 5 and $N_2$ (number of turns the secondary) = 1000.

When such a transformer is used, in order to be able to work under near-to-resonance conditions, i.e. to have a maximum power transfer downstream of said transformer, the capacitor C1 should have a capacitance of $0.22 \mu F$ with 20% tolerance and 50 dcvV (director current working volts).

The rectifier R1 is a 1 N 4148 diode. The passive network P1 is a 50 kΩ potentiometer. C1 is a $0.47 \mu F$ capacitance with 20% tolerance, and 50 dcvV. The solid state switch I1 is a C106M1. The passive network P2 is a RC-series: the resistance of a $22 \Omega$ with 20% tolerance and 0.25 W maximum power dissipation; the capacitor is of 0.1 $\mu F$ with 20% tolerance and 400 dcvV.

The rectifier R2 is a WLO8 diode bridge. Finally, the trip coil L1 is a BTicino 25883 trip coil.

Logically, the above values, that are the values for an optimal operation of the circuit, are at least in part related to one another and result from actual tests carried out. Thus, for example, the capacitance C1 is calculated as a function of the size of the core of transformer T1, the type of material from which it is made, and the number of turns in the secondary.

As a matter of fact, even though the values ascribed to the different circuit components are given as optimal values, they may be varied, when necessary, taking into account the mutual relationships.

Claim

A control circuit for a differential switch including a toroidal transformer (T1) for sensing a leakage current to earth, a matching capacitor (C1) connected to the secondary (4) of the toroidal transformer (T1) to provide a resonance or near-
to-resonance condition with the inductance of said secondary (4), a diode rectifier (R1) for rectifying the current provided by said secondary (4) and a solid-state switch (I1) arranged to be triggered when the sensed leakage current is higher than a predetermined threshold value to operate thereby a trip coil (L1) which is supplied with power, and which opens the differential switch by acting upon movable contacts (2, 3), characterised in that it further includes a first passive network between said diode rectifier (R1) and said solid state switch, said first passive network consisting of a potentiometer (P1) and a further capacitor (C2) connected in parallel across the output of the diode rectifier (R1), and a second passive network, consisting of a resistor and a capacitor in series, and arranged in parallel with said solid state switch (I1).

**Patentanspruch**

Ein Steuerkreis für Differentialschalter, der einen Ringkerntransformator (T1) umfasst, der in der Lage ist, einen Kriechstrom zur Erde festzustellen, sowie einen Anpassungskondensator (C1), der verbunden ist mit der Sekundärwicklung (4) des Ringkerntransformators (T1) zur Bestimmung eines Resonanz-Zustandes oder der Resonanz-Nähe durch die Induktivität der Sekundärwicklung (4); eine Gleichrichter-Diode (R1) zum Gleichrichten des von der Sekundärwicklung (4) gelieferten Stroms und einen Festkörperschalter (I1), ausgelegt zur Betätigung, wenn der erhobene Kriechstrom eine vorgewählte Grenze überschreitet, das heisst zur Steuerung einer gespeisten Auslöschspule (L1), die den Differentialschalter öffnet, indem sie auf die beweglichen Kontakte (2, 3) einwirkt; Steuerkreis dadurch gekennzeichnet, dass er ausserdem ein erstes passives Netz zwischen der erwähnten Gleichrichter-Diode (R1) und dem genannten Festkörperschalter umfasst, wobei das erste passive Netz aus einem Potentiometer (P1) besteht und einem weiteren Kondensator (C2) in Parallel- schaltung am Ausgang der Gleichrichter-Diode (R1), sowie ein zweites passives Netz mit einem Widerstand und einem Kondensator in Reihenschluss, parallel angeordnet zu dem genannten Festkörperschalter (I1).

**Revendication**

Un circuit de commande pour interrupteurs différentiels comprenant un transformateur toroïdal (T1) apte à relever un courant de fuite vers la terre, un condensateur d’adaptation (C1) relié au secondaire (4) du transformateur toroidal (T1) pour déterminer une condition de résonance ou proche de la résonance avec l’inductance dudit secondaire (4), une diode de redressement (R1) pour redresser le courant fourni par ledit secondaire (4) et un interrupteur à l’état solide (I1) disposé pour être actionné lorsque le courant de fuite relevé dépasse une valeur de seuil pré- établie et commander de cette façon un bobine de décrochage (L1) alimentée, qui ouvre l’interrupteur différentiel en agissant sur des contacts mobiles (2, 3), caractérisé par le fait qu’il comprend ultérieurement un premier réseau passif entre ladite diode de redressement (R1) et ledit interrupteur à l’état solide, ce réseau passif étant formé d’un potentiomètre (P1) et d’un condensateur ultérieur (C2) relié en parallèle sur la sortie de la diode de redressement (R1), et un deuxième réseau passif comprenant un résistor et un condensateur en série, disposé parallèlement au dit interrupteur à l’état solide (I1).