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(54) Title: METHOD OF IMPROVEMENT OF EARTH-FAULT PROTECTION RELIABILITY AND APPLICABLE WIRING DIAGRAM

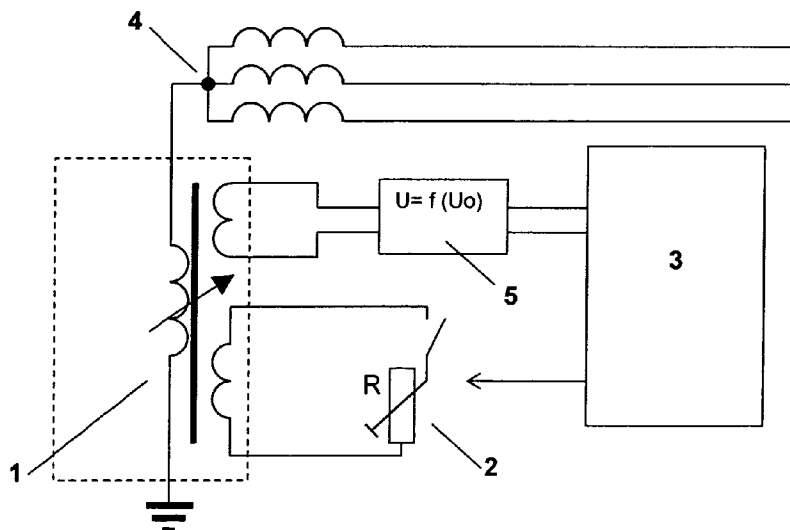


FIG.1

(57) Abstract: The wiring diagram facilitates under earth-fault condition to achieve optimal rise of the fault current watt component, which does not induce a zero voltage component drop below the set limit. The principle is based on automatic switching of fitting resistance value to the secondary winding of an arc-suppression coil, with respect to the earth-fault resistance value. The system allows substantial rise of earth-fault protection sensitivity in networks with considerable earth-fault resistances. This method of resistor wiring and switching allows choosing their sequencing from series up to parallel connection. The way of switching devices configuration offers more steps with different total resistance and eliminates short circuit occurrence in case that one of the switching devices fails.

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Method of improvement of earth-fault protection reliability and applicable wiring diagram

Background and summary of the invention

The invention consists in switching a resistance of optimum value to the secondary winding of an arc-suppression coil during earth faults. The optimum value of the resistance is based on the variation of electric network parameters, taking into consideration also the set conditions.

This switching method allows a suitable choice of serial or parallel sequencing of resistor sections and eliminates short circuits due to wrong switching or failure of switching elements.

In networks provided with compensation of capacitive earth currents, an active resistance is during an earth-fault momentarily switched to the secondary winding of one to the network neutral connected arc-suppression coil. In such way a short-time rise of the earth-fault watt fault current happens, which positively affects the reliability of earth-fault protections. The magnitude of the watt fault current depends on the value of the connected resistance. With lower values of this resistance the watt fault current component becomes very significant. This current brings a decrease of the network zero voltage component also due to the voltage drop across the failure point resistance. Nevertheless, the value of the zero voltage component is the crucial criterion identifying the occurrence of a network earth fault. In case of earth faults with considerable failure point resistance the connection of the resistor provokes a fall of the zero voltage component below a threshold value defining an earth fault, which results in locking-out the earth protection function. Consequently the connection of very low resistance values to the secondary winding of an arc-suppression coil limits the capability of earth protections to detect earth faults with considerable failure point resistance. On the other hand, connection of high resistance values to secondary winding of an arc-suppression coil does not allow

improvement of the earth protections reliability due to the only slight rise of the failure current. For the right choice of secondary resistance the network parameters are an important consideration. With great variation of network parameters often an adaptation of the connected secondary resistance is imperative. With respect to the requirements for detection of high resistance earth faults and earth fault protection settings, the determination of the optimum value of the secondary resistance is regarded as a key problem.

The purpose of the invention is to get within networks with earth capacitive current compensation an optimum rise of the fault current watt component during an earth fault, which does not allow the zero voltage component to fall below a set value and does not negatively affect the function of earth fault protections.

This goal can be reached through automatic selection of the resistance connected to the secondary winding of an arc-suppression coil with respect to current network conditions during an earth fault and the applied earth protection variant as well.

During earth-fault a predetermined resistance value is momentarily connected to the arc-suppression coil secondary winding. As a result of the rise of the fault current at the earth fault point we obtain within the network a zero voltage component and phase to earth voltages change too. On the basis of voltage variations caused by the change of the zero current component in consequence of the resistance connection, the value of earth fault point resistance can be determined. The determination of earth fault point resistance is affected also by other factors as the arc-suppression coil tuning accuracy, network watt current component etc. Moreover the earth-fault resistance tends to be current-dependant. On the basis of available readings, such as zero voltage component and the connected resistance value, only an estimation of the earth-fault resistance can be done. In accordance with this estimation an optimum value of the resistance is determined, subsequently connected to the secondary winding of an arc-suppression coil for given period.

The determination of the optimum secondary resistance is based on several aspects. One of them is the type of the used network earth protections. When using earth fault protections based on the monitoring of the zero power component, the best way of choosing value of the connected resistance is to ensure, that the network zero voltage component shows after the connection just 50% of the phase to earth voltage. With this voltage value, the faulted feeder is supplied with maximum power of the voltage and current component. When using vector protections, the connected resistance should be selected with respect to the highest rise of the fault current and the principle, that the value of the zero voltage component exceeds the limit for earth fault detection, corresponding to the earth fault protection setting. According to the calculation and with respect to the above mentioned aspects, the optimum value of the connected resistance can be fixed. The resistance value is to be adjusted through serial-parallel sequencing of individual resistor sections. An important advantage consists in the possibility of using feedback signal about the operation of protections, sent to the switching resistor controller. In case of unsuccessful evaluation of an earth- fault feeder, a restart of switching after parameter setting is possible. In the next step the original evaluation of the fault resistance can be made more accurate and the conditions for the earth protection operation are better. With first successful operation of one of all earth protections, further resistor switching is stopped.

Brief description of the Drawings

Technical approach is illustrated by enclosed figures. Figure 1 shows an example of a resistor with variable resistance value connected to the secondary winding of an arc-suppression coil, wired between network neutral and the earth potential point. The figure illustrates also measurement of network neutral voltage on the measuring winding of the corresponding controller. Figure 2 shows general wiring of resistances without any resistor step restrictions. With three resistor elements we

get five real resistance sequencing combinations. With five resistor elements up to twenty real resistance sequencing combinations are possible. Figure 3 shows an example of variable resistance represented by a step resistor with five resistor elements R1 to R5 and relevant system of 5 switching devices S1 to S5. This wiring offers different combinations of resistor elements from full parallel connection with minimum resistance value with switched on devices S1 to S5 even to the serial resistor sequencing, giving the maximum resistance with only device S1 closed.

Detailed description of the preferred embodiments

A device for connection of variable resistance can be realized as a stepped resistor with relevant system of switching devices offering different combination of resistor elements, going from parallel connection with minimum resistance value even to serial resistor sequencing, giving the maximum resistance value. These switching devices are operated by means of a controller fitted with the measurement of zero voltage component as well as zero component of current, passing through the resistor.

With an earth-fault inception the controller with set time operating delay switches momentarily all resistor series-connected elements to the secondary winding of the arc-suppression coil (maximum connected resistance value). The connection of maximum resistance into the secondary winding during an earth-fault generates a zero voltage component variation. Due to this variation the controller evaluates the value of the earth-fault resistance and determines its corresponding optimum value. This resistance is subsequently connected for a set time into the secondary winding of the arc-suppression coil. After this switching step the controller evaluates on the basis of voltage and current variations the earth-fault resistance again, making this choice more accurate, for the event of necessary switching repetition due to unsuccessful earth protection operation. So the earth-fault resistance becomes stepwise more and more accurate, because under real conditions the resistance is current-dependent.

If the controller evaluates a low earth-fault resistance value, a command switches on a small resistance, producing a rise of watt earth fault current component even by tens of amperes. In case of low-resistance earth-faults and sensitive feeder earth-fault protections, setting a current limit is possible. It is the maximum value of the watt current, passing through the earth fault point after the resistance has been switched in.

If the controller evaluates a considerable earth fault resistance, the controller sets a combination of switching devices, achieving with the connected resistance the maximum rise of the watt earth-fault component, ensuring at the same time, that the network zero voltage does not fall below a preset limit. This zero voltage limit may be higher or of equal value as the setting of earth protections, installed within the network for earth fault evaluation.

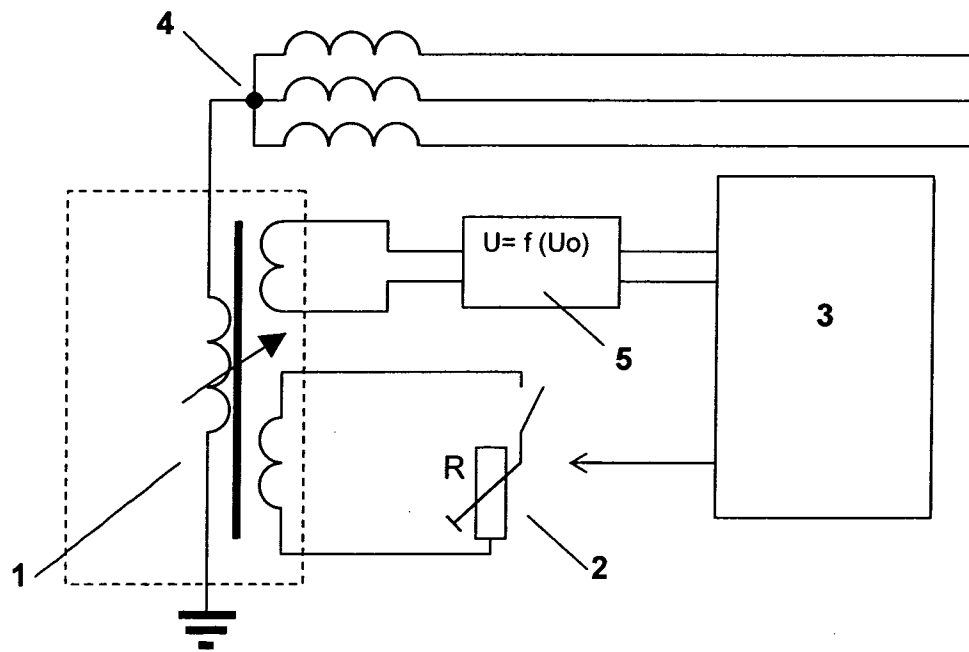
The device is intended for short-time rise of the watt earth-fault current component within networks with capacitive current compensation. Its application contributes to better reliability of earth protections and allows earth faulted feeder detection even for considerable resistance values of a single-phase failure. The improvement of earth protection reliability is ensured even in case of great parameter variations of the protected network.

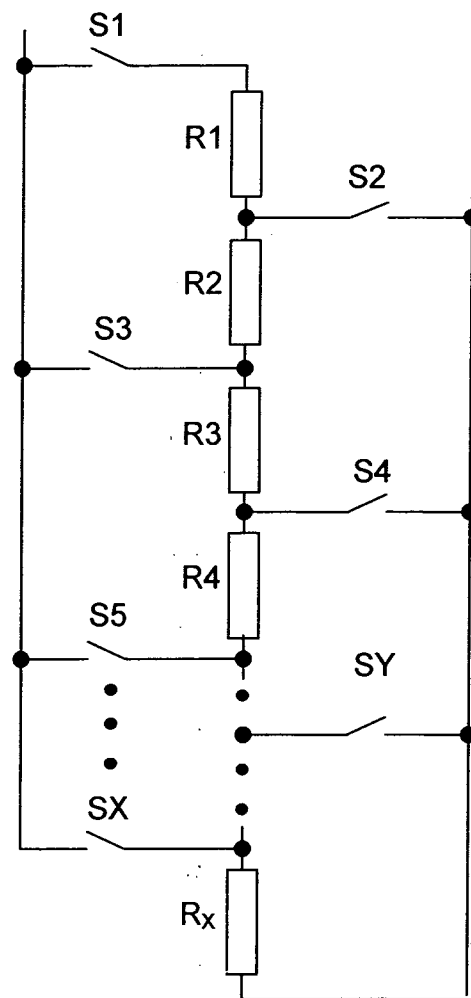
Overview of the positions used in the drawings

- 1 Arc-suppression coil (without/with variable inductance)
- 2 Variable active resistance(resistor with step sequencing of resistances)
- 3 Automatic earth fault resistance evaluation and resistor operation unit
- 4 Network neutral (transformer neutral)
- 5 Block for automatic evaluation of network zero voltage component U_0

CLAIMS

1. Circuit diagram for improvement of earth fault protection reliability within compensated networks with an arc-suppression coil (1), connected between the network neutral (4) and the ground as well as an active resistance (2), connected to the secondary winding of the arc-suppression coil (1), characterized by that the active resistance (2) is variable.
2. Circuit diagram for earth fault protection reliability improvement according to claim 1, characterized by that the active variable resistance (2) is interconnected with the unit (3), providing automatic earth-fault resistance evaluation as well as resistor operation and setting, whereon the input of the unit (3) is connected with the block (5) for network zero voltage component evaluation.
3. Method of improvement of earth-fault protection reliability according to claim 1, characterized by that the unit (3) for automatic earth-fault resistance evaluation, resistor operation and setting, based on the input information about the value of zero voltage component U_0 from the block (5) which evaluates the network zero voltage component U_0 , sets the value of the active variable resistance (2) in order to achieve maximum network active earth fault current without the condition $U_0 > U_{0 \text{ min.}}$ being violated, where U_0 is the minimum required value of the network zero voltage component U_0 , necessary for correct working of earth-fault protections.

**FIG.1**

**FIG. 2**