ELECTRONIC DEVICE FOR DETECTING AND SIGNALLING THE EARTH FAULTS IN DIRECT CURRENT CIRCUITS OF POWER STATIONS

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1. ABSTRACT

The paper presents a new device for detecting and signalling the earth faults in direct current circuits of the power stations. The d.c. operative voltage is, most frequently, 220 VDC and it is applied by a controlled rectifier, backed up with a rechargeable battery. Both polarities of the supply are insulated from the earth.

Any insulating resistance fault from earth (of one polarity) has to be pointed out, to remove it rapidly. Till now, this function was performed by a device called ASPP.

The main deficiency of this is the very small input impedance of the signalling circuit (between 1 and 10kΩ). In the case of an earth fault, it is created a circulation way for the current and the intermediate relay can work, corresponding to the earth connection localisation.

The paper suggests a new measure scheme, providing a very high input impedance (between 800 and 1000kΩ) avoiding thus the appearance of such undesirable events. The suggested scheme is extremely simple; the principle is based on the voltage measuring, using a Wheatstone bridge. Two arms of the bridge in formed by the insulating resistance of the two polarities, and the power is supplied by the means of one diagonal using the 220Vd.c. source.

2. INTRODUCTION

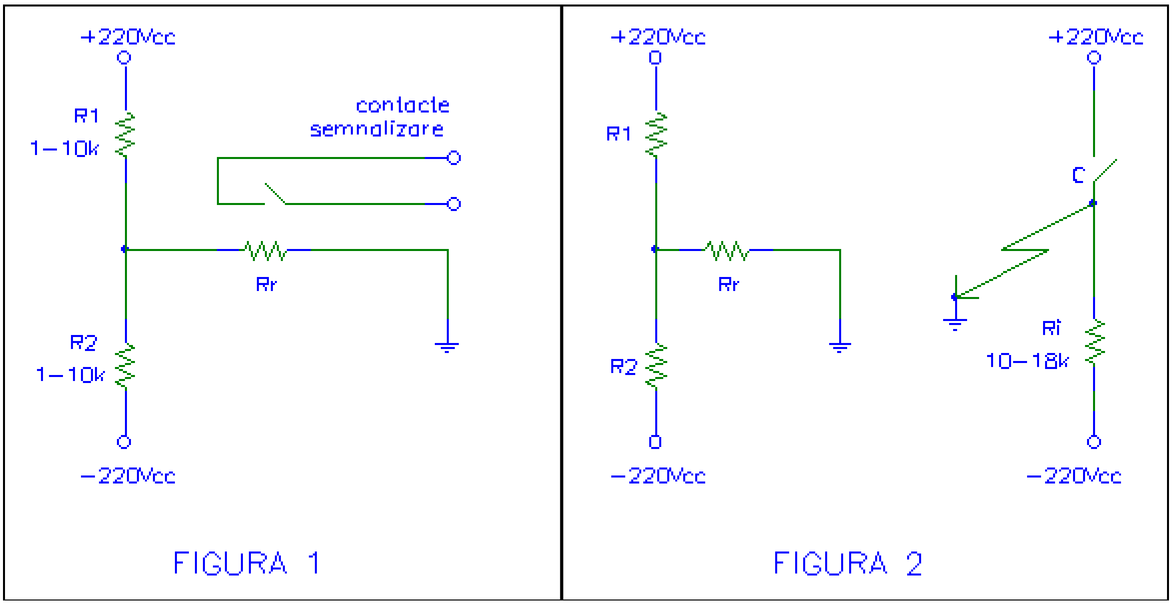
All power stations, no matter the working voltage, the number of power lines or importance in the NES (National Electrical System), require a 220Vd.c. voltage to supply the secondary circuits installations, because the majority of the protection devices fitting out these stations works with this voltage (by reason of security).

As the protection purpose is to provide the line disconnecting at any fault appearance, these can't be supplied only using an direct current voltage (the fault voltage has not a predictable value and it is not stable).

Therefore, the single solution consists in using a controlled rectifier backed up with a rechargeable battery. By reason of security, the both polarities of the direct voltage are insulated from earth, the insulating resistance value - for each polarity - must be over 30 - 50kΩ (the pattern value is situated between 100 and 200kΩ). The value of this insulating resistance must be permanently checked, because a diminution of it on one or both polarities becomes an alarming event and the maintenance staff has to remove the cause.

3. THE OLD SOLUTION

The electric scheme of the old solution is presented in Figure 1. It can be noticed that, for simplifying the scheme, it was drastically reduced the input impedance of the measuring circuit.



The R_1 and R_2 resistor have values between 1 and 10 kΩ, depending on the relay type (this is an ordinary telephone relay with an operating voltage between 24 and 48V). Figure 2 presents a circuit section where the main element is an intermediate relay R_i. This has a terminal connected to the negative voltage polarity and the other terminal is connected to the positive polarity by the mean of a relay contact C (it can be an intermediate or another type of relay).

In the case of an earth connection at the point indicated in the figure, it is created a current way through the relay, between the positive and the negative power supply terminals (+220V/R_1/R_r/R_i/-220V) enough to trip the relay.

$$I_{Ri} = \frac{220V}{R_1 + R_r + R_i}; U_{Ri} = I_{Ri} . R_i = \frac{R_i}{R_1 + R_r + R_i} .220V \approx 135V \qquad (1)$$

This voltage is big enough to trip the intermediate relay R_i, its minimum activating voltage being 125Vdc (in accordance with the norms).

If this relay is used for turning on/off a circuit breaker the results are surely destructive (turning off a working circuit breaker can cause its destruction and thus, can cause a power failure for the customers).

4. THE NEW SOLUTION

For working out the new solution it were analysed the old solution deficiencies. Thus, for removing the possibilities of erroneous tripping of the primary equipment, it is necessary that the input impedance of the apparatus supervising the 220Vdc source insulation to be big enough that, in the case of an earth connection at any part of the installation, any current circulation way of small impedance can be found. Also, the solution have to be constructively simple, cheap and safe.

Among many analysed and tested alternatives, the scheme presented in Figure 3, carries out all the conditions mentioned before.

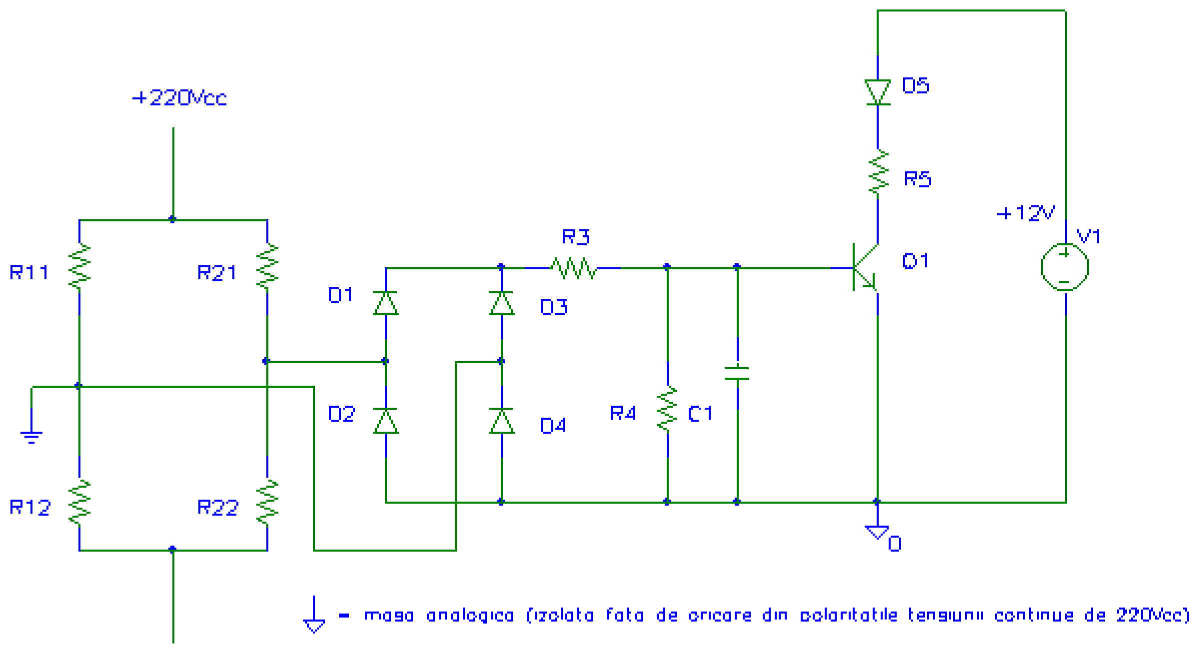


FIGURA 3

A measuring scheme with a Wheatstone bridge was selected. Two arms of the bridge, R_{11} and R_{12} respectively, are formed by the insulating resistance between the two polarities and earth, each of it paralleled with a physical resistor (500 - 1000kΩ). The value of the other resistors in the bridge (R_{21} and R_{22}) are chosen so that all the bridge resistors have approximately the same value at the balance point.

Because of the thermal stability, the R_{21} and the R_{22} resistors have to be well paired. The same condition is also required for the other two resistors, but considering that they aren't physical resistors, this condition is hard to achieve. However, it can be supposed the condition is satisfied because of the circuit symmetry.

So, in the case of a Wheatstone bridge loss of balance, a voltage is produced. This voltage is filtered, then applied to the base-emitter junction of a bipolar npn transistor (Q_1 in the scheme). When the voltage is big enough to open the transistor *be* junction, the earth fault is signalled by a LED (D_5 in the scheme).

As the earth connection can be produced on each of the two polarities (of the 220Vdc source), the voltage obtained from the measuring bridge is rectified by means of D_1 - D_4 diodes. So, the final transistor is properly polarised in both cases.

If the signalling of the polarity (on witch the fault is produced) is required, it is necessary to separate the two unbalanced voltages using two simple rectifying diodes. The signalling part will be doubled in this case, two transistors being necessary, one for each polarity.

A specific feature of the scheme is that the supply voltage has to be insulated from the 220Vdc source and also from the earth. This feature is required for the scheme not to influence the measuring circuit. For this reason it was chosen a classical switching power supply, very simple, with the secondary circuit totally insulated from the primary circuit.

5. CONCLUSIONS

The device usability is obvious and it is not necessary to emphasise it here.

The simple fact that the new solution has a very high input impedance, avoiding thus erroneous tripping of the switching devices at some faults, represents more safety for the equipment in power stations.

Improvements are also possible. By connecting an electronic measuring instrument we can show (directly in kΩ) the value of the insulating resistance on each polarity.

6. REFERENCES

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