WEB OF SCIENTIST: INTERNATIONAL SCIENTIFIC RESEARCH JOURNAL
ISSN: 2776-0979, Volume 4, Issue 5, May, 2023

INVESTIGATION OF SINGLE-PHASE SHORT CIRCUIT IN NETWORKS WHEN THE TRANSFORMER IS CONNECTED WITH THE NEUTRAL GROUND

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Annotation:
The article deals with the resonant connection of the neutral to the ground. In these experiments, it was considered that the change of the single-phase ground current, the change of the phase voltages depends on the change of the values of active and inductive resistance in cases where the neutral of the transformer is connected in different ways.

Keywords: Transformer, neutral resonantly grounded, neutral, inductive resistance, active resistance, short circuit current, voltage deviation, single phase to ground.

Today, large-scale modernization works are being carried out in physically and emotionally outdated parts of electric power networks. This process is directly related to the working conditions of Neutrals. In this work, it is established that in the case of single-phase grounding currents in networks isolated from the neutral ground, they should be connected to the ground using an arc extinguishing coil. Taking into account the dangerous consequences of single-phase damage and their dependence on the current, the power of the capacity token is standardized according to the rules for the construction of electrical equipment (Chapter 11 EUTQ) [1].
Single-phase capacity current in 35 kV networks with reinforced concrete and metal-supported lines should not exceed 10 A[1]
In generator-transformer block schemes, the capacity current at the generator voltage should not exceed 5 A.

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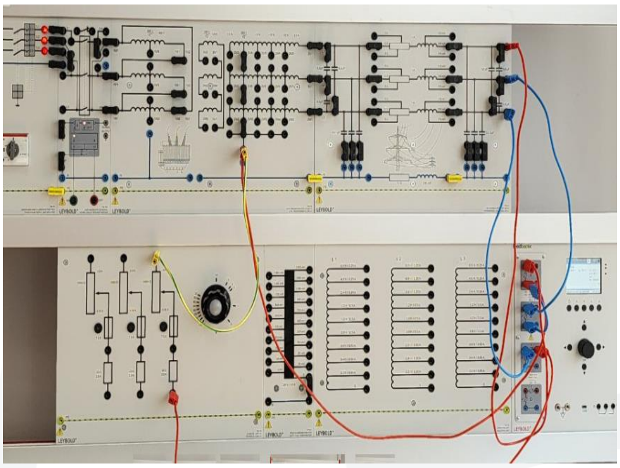
The mathematical determination of the required inductance for neutralization can be re-implemented using only the method of symmetrical components.

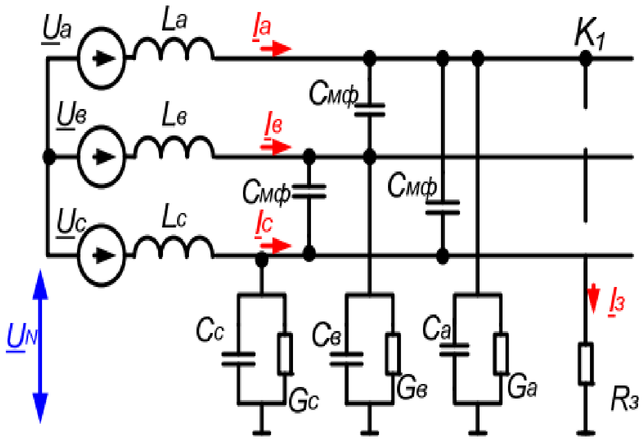
The following condition applies to the reactive resistance of the earth-fault neutraliser:

$$X_E = \frac{1}{3\omega C_E} \qquad (1)$$

A short circuit cannot be fully compensated because the line resistance also has an active component due to the constant presence of the line resistance. The active component is approximately 10% of the short-circuit current and is described as the unbalanced residual earth fault current.[4]

In order to reduce the grounding current of three-phase networks with neutrals resonantly connected to the ground, the neutrals are connected to the ground through an arc extinguishing coil in the 3-35 kV networks of our continent (Fig. 2) [5].





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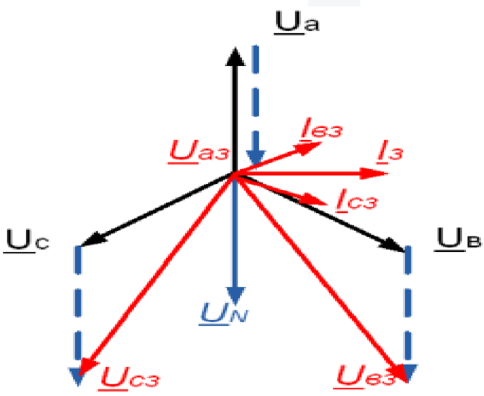

c)

Figure-2. Three-phase networks with neutrals resonantly connected to the ground a) connection diagram of the laboratory stand b) calculation diagram of the network c) voltage vector diagram

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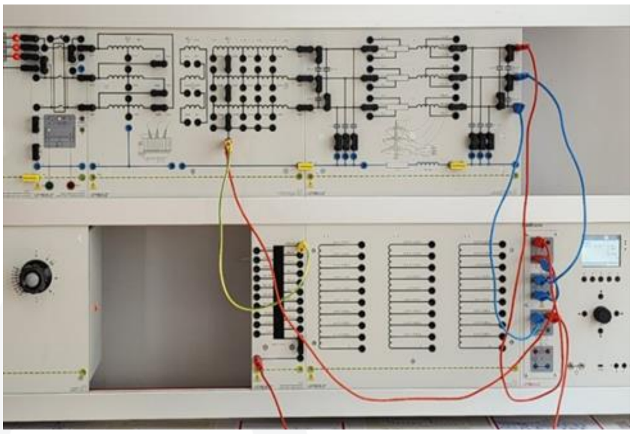
In normal operation, practically no current flows through the coil. When it is fully connected to the phase, the coil of the arc quencher is in phase voltage, and the inductance current JL of the coil passes along with the capacitive current Js from the place of connection to the ground.

Since the inductance and capacitance currents are out of phase relative to each other by 180°, they compensate each other at the ground connection. If IS = IL (resonance), no current flows through the ground. Due to this, an arc does not form in the damaged area and the dangerous consequences associated with it are eliminated.

In our country, three-phase networks connected by a coil compensating the capacitance current of the neutral to the ground network are used in 220 and 380 V networks. At this time, the neutrals of all sources are grounded.



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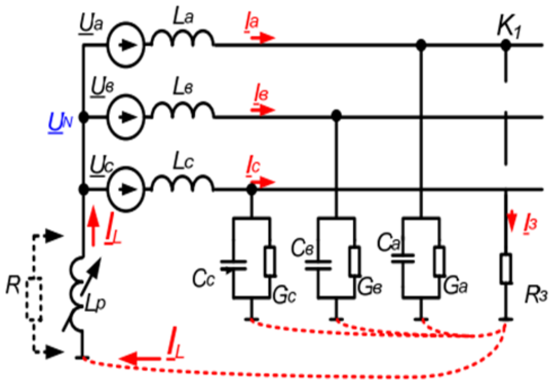

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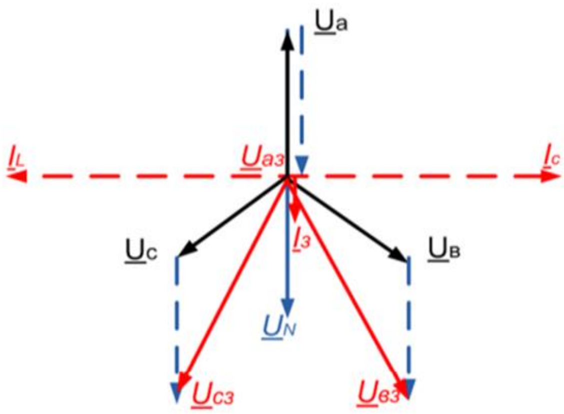

c)

Figure-3. Three-phase networks connected to the neutral ground through a network capacitance current compensating coil a) laboratory stand connection diagram b) network calculation diagram c) voltage vector diagram

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In systems with a voltage of 110 kV and higher, the insulation value is a decisive factor in choosing the method of connecting the neutral to the ground. Here, effective neutral grounding is used, in which the voltage between the undamaged phases in a single-phase short circuit is approximately 0.8 of the phase-to-phase voltage in normal operation. This is the main advantage of the neutral grounding method.

Based on the above studies, in the experiments carried out in the LD-DIDACTIC LEYBOLD physical model, the phase voltage of a single-phase short circuit in the network and the effect of this phase on the phase angle were tested in three different cases. During the initial experiment, the oscillogram of network parameters change when a single-phase short-circuit condition is created when the neutral of the transformer is connected to the ground through an active resistance is presented in Figure 4. During the same experiment, the short-circuit mode was connected with the single-phase ground through an active resistance by changing the active resistance in the range from 200 to 1000, and in this case, the oscillogram of the network voltage change can be seen a significant change compared to the case where the transformer neutral is firmly connected to the ground. The value of the short-circuit current in the Uc phase, where the neutral of the transformer is connected to the ground through an active resistance, was 30% lower than the value of the short-circuit current in the case where the neutral is solidly connected to the ground. In the experiment, the network parameters change, when the neutral of the transformer is connected through a resistance of 1000 Ohm, the value of the voltage in the short circuit phase is 239 kV, and the value of the short circuit current is 248 A. As the value of the resistance gradually decreased, the value of the short circuit current increased. At the smallest level of resistance, i.e. at 200 Ohm resistance, the value of the short-circuit current was 916 A, and the value of the voltage was 203.8 kV.

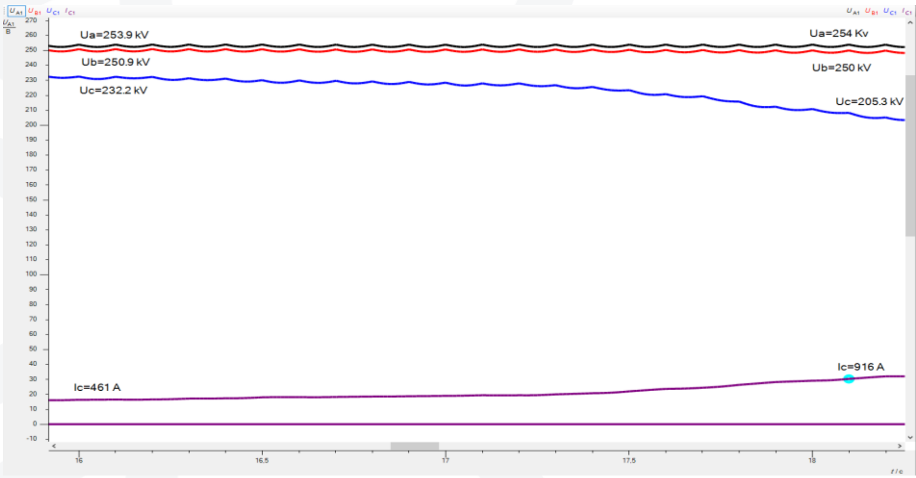

Figure 4. Oscillogram of a transformer neutral with a single-phase ground through an active resistance short circuit

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Then, in laboratory conditions, a short-circuit experiment with a single-phase ground was conducted in the case where the transformer neutral was connected to the ground through an inductive resistance in figure-5. When the neutral of the transformer is connected through an inductive resistance, it can be seen that the value of the voltage on the short-circuited line decreases by 30%, while the value of the short-circuit current decreases as the value of the inductive resistance increases. 1601 A, and the short-circuit phase voltage was 120.7 Kv, the largest inductance was 293 A when connected with 2000 mHn, and the short-circuit phase voltage was 211.7 Kv. During this period, the power flowing from the short-circuited phase to the ground varied between 7 and 20 kW.

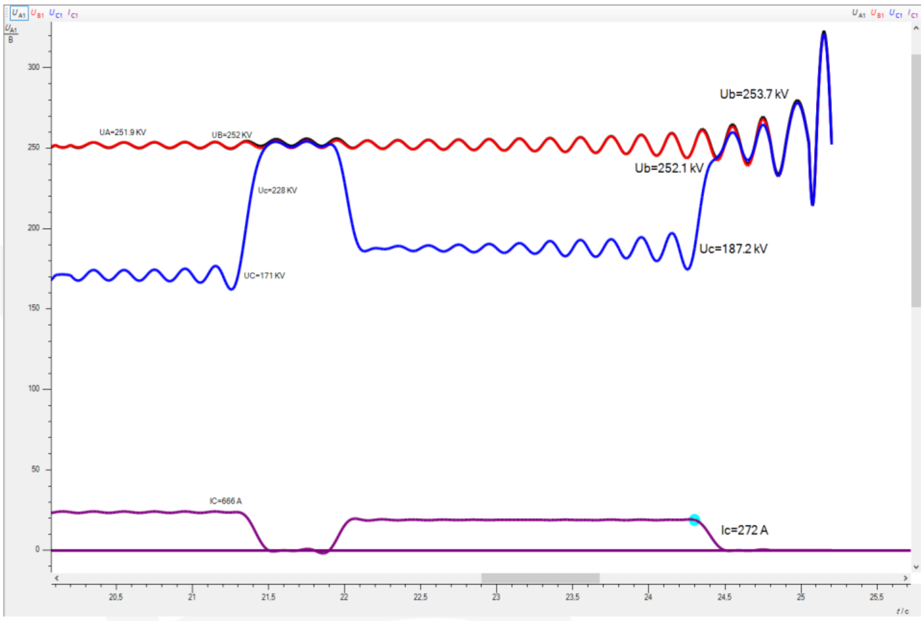

Figure 5. Oscillogram of short circuit through inductive resistance with transformer neutral single-phase ground

Conclusion

It can be seen from the conducted experiments that the change of the short-circuit current in the short-circuit phase of the power line during the short-circuit in different connection states of the transformer neutral was considered. As a result, when the transformer neutral is firmly connected to the ground, the short-circuit phase voltage becomes zero, and the value of the short-circuit current increases to 2282 A, when the transformer neutral is connected through an active resistance, the value of the short-circuit phase voltage decreases by a maximum of 20%, and the value of the short-circuit current is the smallest active resistance. In this case, we have seen that the short-circuit current is 60% less compared to the network with the neutral firmly connected to the ground. In the last experiment, the value of the short-circuit current flowing in the network was the smallest value, i.e. 330A, when the neutral of the transformer was connected to the ground through inductive resistance.

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