DEVELOPMENT OF ALGORITHM AND SOFTWARE "MVES-GS 2012" FOR SELECTION OF NEUTRAL GROUNDING TYPE IN MEDIUM VOLTAGE NETWORKS

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Abstract. The method of neutral grounding is perhaps more difficult to select than any other feature of power system. It is because of the large number of factors that must be considered. In the paper medium voltage distribution system neutral grounding methods are analysed and compared. The paper presents an algorithm for selection of a neutral grounding type (isolated neutral system, compensated neutral system, system with low resistance neutral earthing). The proposed algorithm takes into account the power line type (overhead line, underground cable line or both of them together), medium line voltage (6kV, 10kV, 20kV), earth fault current, etc. Based on this algorithm, new software "MVES-GS 2012" (Medium Voltage Electrical System Grounding Selection) is developed by the authors of this paper. This software can be useful for distribution network exploiting engineers when trying to find the network optimal neutral grounding system.

Keywords: grounding system, power systems, neutral, medium voltage.

Introduction

The grounding system, its components and bonding conductors shall be capable of distributing and discharging the fault current without exceeding the thermal and mechanical design limits. The grounding system shall maintain its integrity for its expected lifetime with due allowance for corrosion and mechanical constraints.

The grounding system performance shall avoid damage to equipment due to excessive potential rise, potential differences within the grounding system and due to excessive currents flowing in auxiliary paths not intended for carrying parts of the fault current. The grounding system, in combination with appropriate measures, shall maintain step, touch and transferred potentials within the voltage limits [1].

Short-circuit current

Installations shall be designed, constructed and erected to safely withstand the mechanical and thermal effects resulting from short-circuit currents. There are four types of short-circuit: three-phase, phase-to-phase, phase-to-earth, double phase-to-earth. Installations shall be protected with automatic devices to disconnect three-phase and phase-to-phase short-circuits. Installations shall be protected either with automatic devices to disconnect earth faults or to indicate the earth fault condition. The selection of the device is dependent upon the method of neutral grounding [1].

Neutral grounding types

Neutral grounding systems are used to limit the potential of current-carrying conductors with respect to the general mass of earth and to provide a current return path for earth faults in order to allow protective devices to operate [2].

The neutral grounding type significantly affects the power, technical and economical parameters: level of insulation, reliability of network, etc. [3]. There are several neutral grounding types of power systems- isolated neutral system, compensated neutral system, system with low resistance neutral grounding.

Isolated neutral system is a system where all transformer neutrals are ungrounded. The only intentional connection between an ungrounded neutral and earth is via high impedance equipment for protection or measurement purposes such as surge arresters or voltage transformers. In a power system there are however always capacitive connections between the phases and earth. The strength of the capacitive connection depends on the type and length of the power system circuit. When an earth fault occurs in the system, the capacitance to earth of the faulty phase is bypassed. Isolated neutral system is shown in Fig. 1 [4].

Compensated neutral system is a system in which at least one of the neutrals is connected to earth via an inductive reactance, a Petersen coil, and the current generated by the reactance during an earth fault approximately compensates the capacitive component of the single phase earth fault current. Compensated neutral system is shown in Fig. 2 [4].

The system is hardly ever exactly tuned, i.e., the reactive current does not exactly equal the capacitive earth fault current of the system. A system in which the inductive current is slightly larger than the capacitive earth fault current is over compensated. A system in which the induced earth fault current is slightly smaller than the capacitive earth fault current is under compensated.

The neutral point reactor is often combined with a neutral point resistor. In a compensated grounded system the resulting reactive part of the earth fault current is too small for the relay protection to measure. In addition to this, there will always be active losses in the neutral point generator, which contributes to the active part of the earth fault current. Typical examples of power systems with strong capacitive connection to earth, suitable for resonant grounding, are systems consisting of an extensive amount of cables. If the high capacitive earth fault current of such systems is not compensated, the risk of dangerously high potential rise of exposed parts of the power system is evident [4].

System with low resistance neutral grounding. System with low resistance neutral grounding is a system where at least one of the neutral points is connected to earth via a low resistance resistor. System with low resistance neutral grounding is shown in Fig. 3 [4].

The purpose of the neutral point resistor is to increase the resistive part of the earth fault current and hence improve the earth fault detection [4].

The system with low resistance neutral grounding immediately disposes of two defects of the isolated system: it permits ready relaying of ground faults and it minimizes the hazard of arcing grounds. In general the grounding resistances used to have limited the ground-fault current to a magnitude much less than the three-phase short-circuit current.

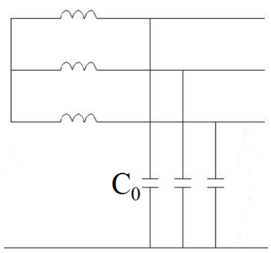

Fig. 1. **Isolated neutral system [4]**

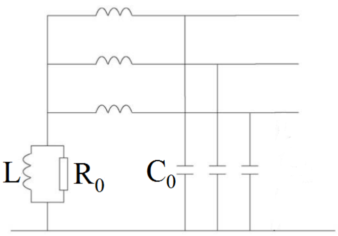

Fig. 2. **Compensated neutral system [4]**

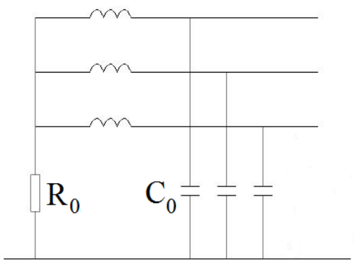

Fig. 3. **System with low resistance neutral grounding [4]**

The broad objective in selecting a type of the system grounding is to secure the best compromise of the conflicting advantages and disadvantages of the various methods. Comparison of different types of grounding neutral system is shown in Table 1 [5].

Table 1

Comparison of different types of grounding neutral system [6]

Arrangement of neutral point	**Isolated neutral system**	**Compensated neutral system**	**System with low resistance neutral grounding**
Examples of use	Networks of limited extent, power plant auxiliaries	Overhead-line networks 10…110 kV	Cable networks 10…110 kV system e.g. in towns
Between system and earth are:	Capacitances (inst. transformer inductances)	Capacitances suppression coils	Capacitances neutral reactor
Voltage rise in whole network	yes	yes	no
Duration of fault	10 to 60 min Possible short-time grounding with subsequent selective disconnection by neutral current (< 1 s)		< 1 s
Earth-fault arc	Self-quenching up to several amperes	Self-quenching	Partly self-quenching usually sustained

Table 1 (continued)

Arrangement of neutral point	Isolated neutral system	Compensated neutral system	System with low resistance neutral grounding
Detection	Location by disconnection, earth-fault wiping-contact relay, wattmeter relay. (With short-time grounding: disconnection by neutral current)		Selective disconnection by neutral current (or short-circuit protection)
Risk of double earth fault	yes	yes	slight
Means of grounding (LVS EN 50522)	Earth electrode voltage $U_E \leq 125$ V Touch voltage ≤ 80 V		Earth electrode voltage $U_E \leq 125$ V Touch voltage

Algorithm for selection of neutral grounding type

Selection of a neutral grounding type depends on line type, mains voltage value and also on bias voltage value. These data are used in the algorithm for selection of a neutral grounding type (see Fig. 4).

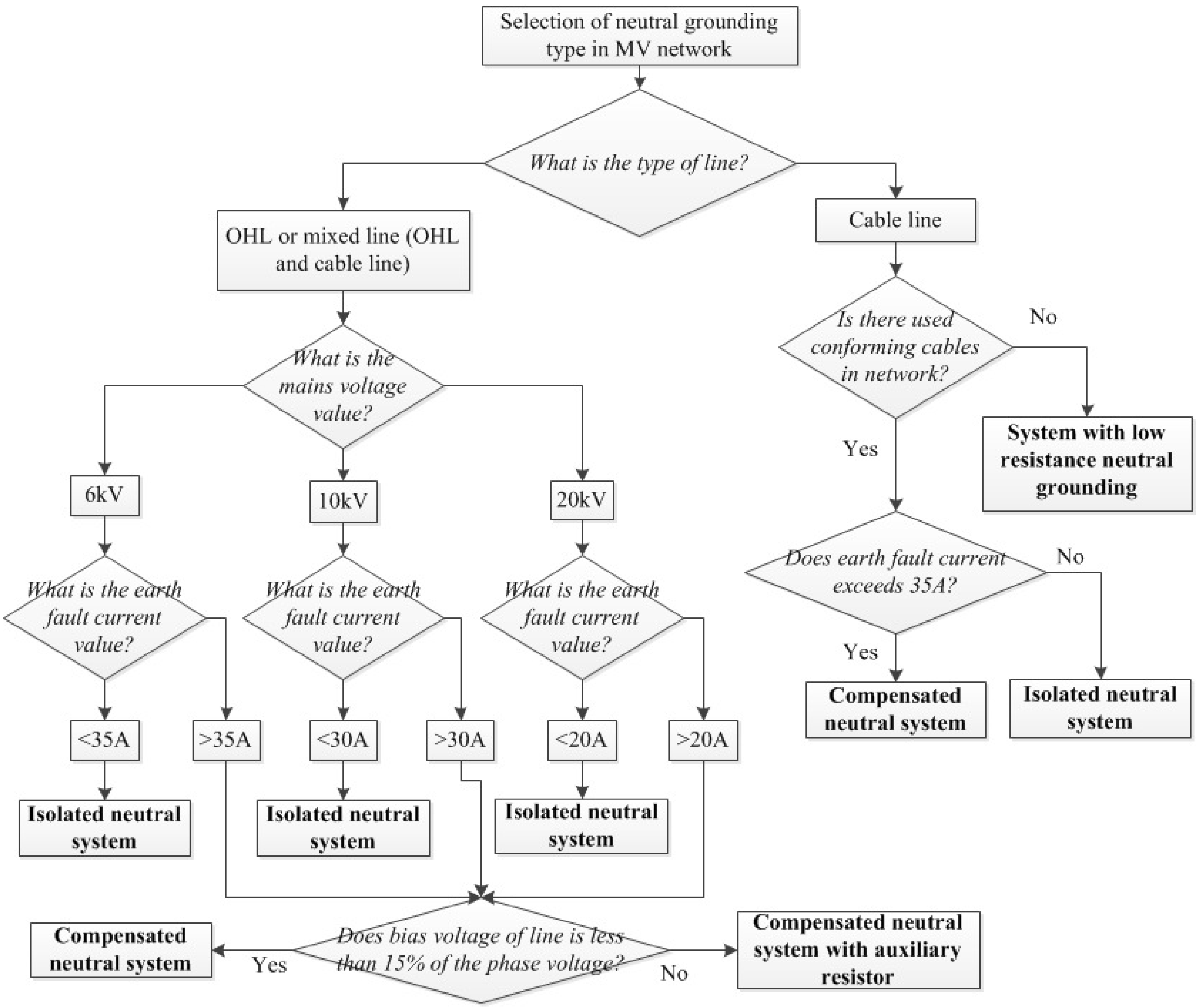

Fig. 4. **Selection of neutral grounding type in MV network**

In the first step it is necessary to clarify what the type of line is. Cable lines and overhead (and also mixed) lines must be assessed differently. In case of cable lines there are two options- in network conforming cables are used or not. If not, than there should be a system selected with low resistance neutral grounding. If conforming cables are used in the network, it is necessary to clarify if the earth fault current exceeds. If it exceeds 35 A than there should be selected a compensated neutral system but if not- than there should be selected an isolated neutral system.

In case of overhead lines or mixed lines it is necessary to clarify the main voltage value and earth fault current value. If the current value is less than 35 A for 6 kV network, 30 A for 10 kV network and 20 A for 20 kV network than there should be an isolated neutral system selected. If the current value is greater than 35 A for 6 kV network, 30 A for 10 kV network and 2 0A for 20 kV network than it is necessary to clarify the bias voltage value. If the bias voltage value is less than 15 % of the phase voltage in that case there should be a compensated neutral system selected. If the bias voltage value is greater than 15 % of the phase voltage, in that case a compensated neutral system with auxiliary resistor should be selected.

Software "MVES-GS 2012" test

Software "MVES-GS 2012" developed by the authors was tested. The results are shown in Fig. 5, Fig. 6 and Fig. 7. In Fig. 5 a case of overhead line is shown. The result is a compensated neutral system because in 10 kV overhead line the earth fault current is greater than 30A and bias voltage of the line is less than 15 % of the phase voltage. In Fig. 6 a case of cable line is shown. The result is an isolated neutral system because in the cable line network there are conforming cables used and the earth fault current does not exceed 35 A. In Fig. 7 a case of cable line is shown. The result is a system with low resistance neutral grounding because in the cable line network there are non-conforming cables used.

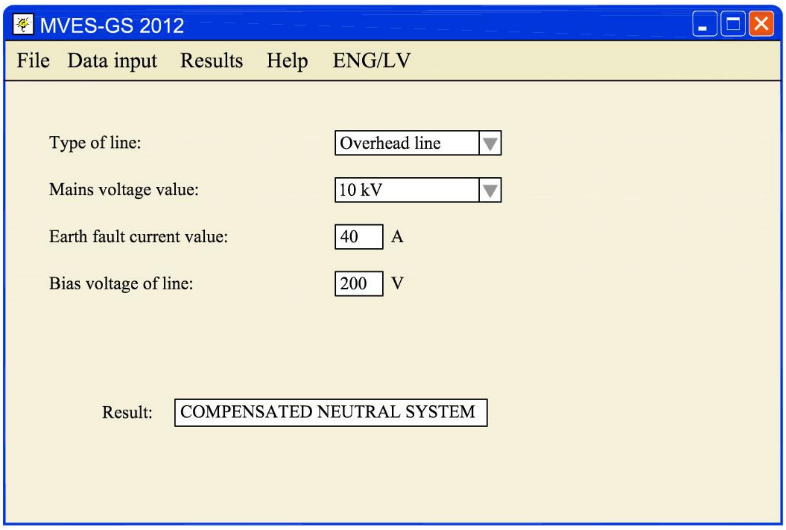

Fig. 5. **Example of selection of neutral grounding type by software "MVES-GS 2012" in case of overhead lines**

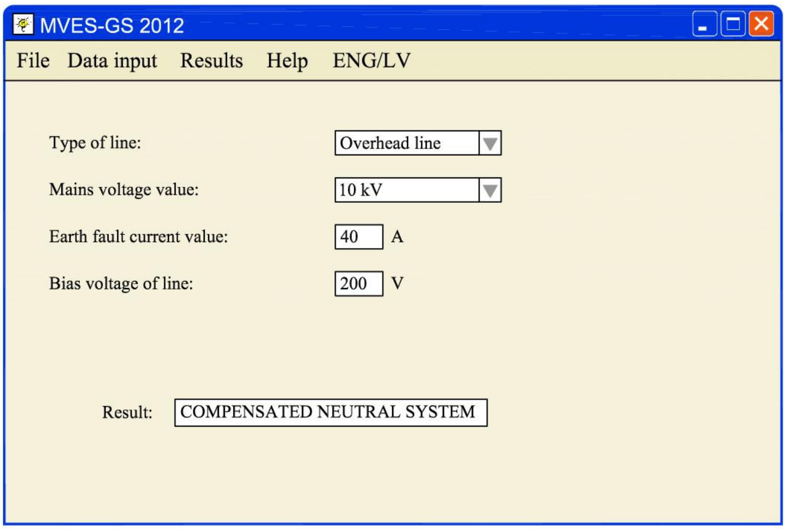

Fig. 6. **Example of selection of neutral grounding type by software "MVES-GS 2012" in case of cable lines**

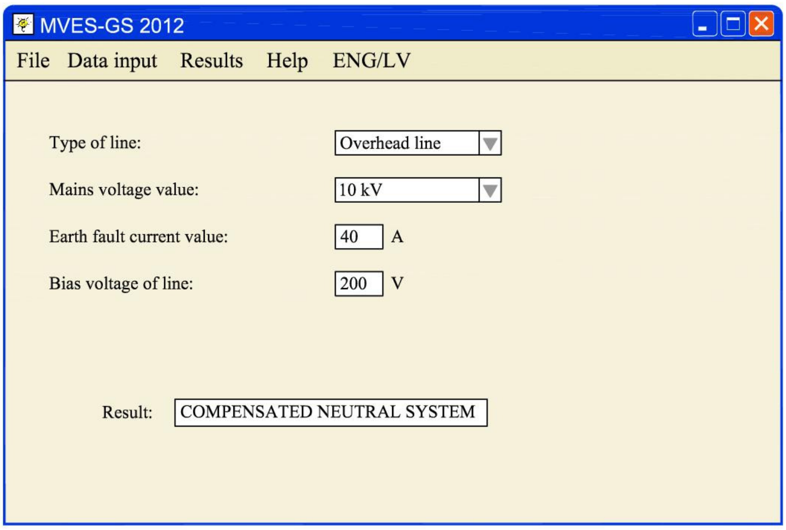

Fig. 7. **Example of selection of neutral grounding type by software "MVES-GS 2012" in case of cable lines**

Results and discussion

Software "MVES-GS 2012" enables engineers to easily select the neutral grounding type in medium voltage networks. Software "MVES-GS 2012" interface is very simple, that is why it is very easy to learn and use it.

Conclusions

In the paper medium voltage distribution system neutral grounding methods are analyzed and compared. An algorithm for selection of the neutral grounding type (isolated neutral system, compensated neutral system, system with low resistance neutral grounding) was made. The proposed algorithm takes into account the power line type (overhead line, underground cable line or both of them together), medium line voltage (6 kV, 10 kV and 20 kV), earth fault current, etc. Based on this algorithm, new software "MVES-GS 2012" (Medium Voltage Electrical System Grounding Selection) was developed by the authors of this paper. This software can be useful for distribution network exploiting engineers when trying to find the optimal neutral grounding system of the network. With this software it will be easy and quickly to select the neutral grounding type in medium voltage networks.

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