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Human safety ensuring in power supply systems with dead-earthed and insulated neutral wire

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Human safety ensuring in power supply systems with dead-earthed and insulated neutral wire

V Markelov and K Vostrov*

Peter the Great St.Petersburg Polytechnic University, Saint-Petersburg, Russia

E-mail: vostrov1@gmail.com

Abstract. In the current paper, the human safety issues in different power supply systems are considered. The conditions for residual-current device utilization and protective characteristics in grounded-neutral and insulated-neutral power supply systems are reviewed. Also, the endangerment factors and accident statistics are analyzed. Based on the given data, the judgment on the safety of different power supply system is given and a novel approach in the residual-current device setting up is proposed. Finally, the topology for IT system performing from TNC system is shown.

1. Introduction

The main energy-intensive consumers in everyday life electrical appliances are represented by heating devices, mainly having as a heating element the tubular-electric heater. This heater may be dry-air with a heating temperature of up to 500 degrees Celsius, or water-based. Such devices are electric cookers, electric kettles, electric boilers, washing machines, etc [1-4]. The normal operating insulation resistance of the heater to 50 M Ω , but in practice this value supposed to be much lower. There are frequent cases of breakdown of insulation on the case and depending on the point of contact between the heating wire and the wall of the heater tube, a potential difference may occur between the metal wall of the heater and heated water that can reach 220V [5-6]. Such a voltage is dangerous and represents an emergency situation.

2. The endangering factors

The protective devices based on the principle of differential circuit breaker used for effective user's protection, if used in Russia, where the power supply system with a low-grounded neutral TNC is utilized, (Figure 1), has a minimum fault current limit of 30mA. From the literature, it is known that the minimal human detectable current is 1mA, whereas the hazardous current limit is 100mA. If we assume that the resistance of the human body is about 20 k Ω , then if it goes under a voltage of 220V, a current of 11mA will flow. T. Briffo [7, p. 161] believes that the lethal current for a human is 50mA, and the upper limit of the dangerous current is 25mA.

In addition, accident statistics for electric shock show [8, p. 164] that 15% lethal accidents happen at a current less than or equal to 5mA, 24% at 5-15 mA, 30% at 11-20 mA and 26% at current greater than or equal to 20mA.



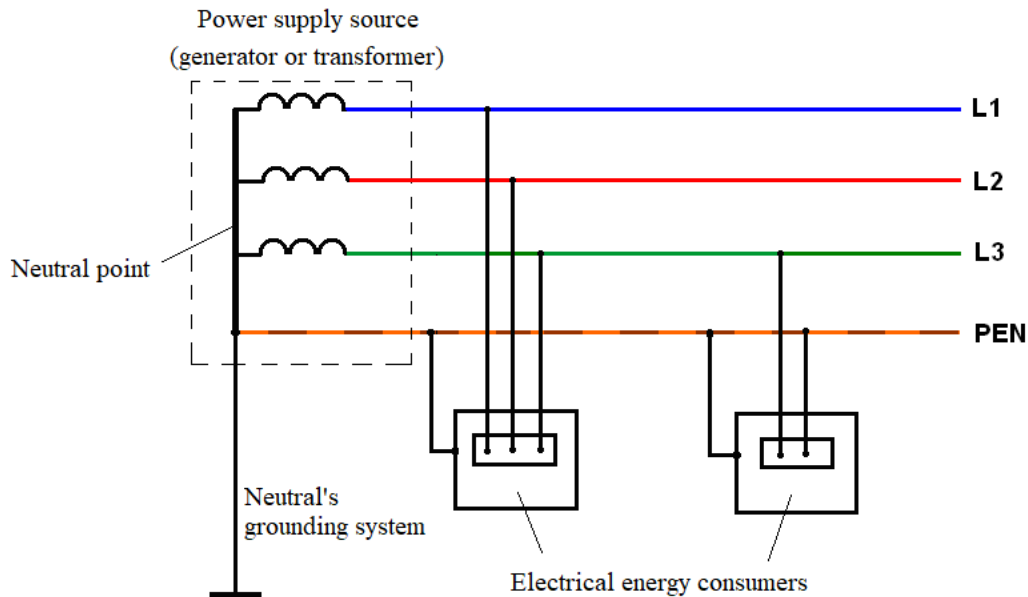


Figure 1. Neutral grounded power supply system (“TN-C” system).

3. Safety of grounded-neutral and insulated-neutral power systems

Power supply systems in European countries and the Russian Federation are fundamentally different. Thus, in Europe, an IT power supply system with an insulated neutral is used (Figure 2), while in the Russian Federation an electrical power supply system with a deaf-grounded neutral is used (Figure 1).

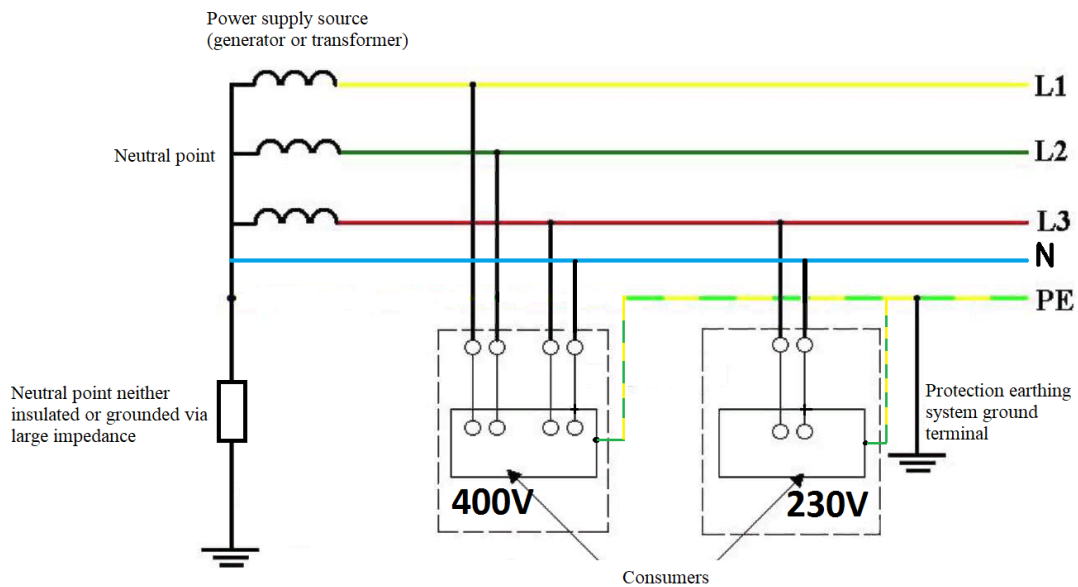


Figure 2. Insulated neutral power supply system (“IT” system).

The advantages and disadvantages of power supply systems are described in detail in the literature [9-11]. However, the transition to a system with an isolated neutral in the Russian Federation is almost impossible because of the great-forks of the “Rules of Electrical equipment Organization” [12] and the different “Sets of Norms and Rules” [13-15]

Therefore, it is necessary to consider the development of residual-current devices with the possibility of differentiated settings at a specific workplace in the interval from 5mA to 30mA in 5mA

increments. Thus, by upgrading the RCD, one can make it wide-range and increase the level of public safety, as well as reduce the degree of fire danger of the premises.

In addition, in special cases, a galvanic isolation transformer can be used (see **Figure 3**). It is also possible to apply the IT power supply system (**Figure 2**), where the neutral point of the transformer is connected to ground through a large resistance. In this case, the current through the person will be minimal and its safety will be guaranteed.

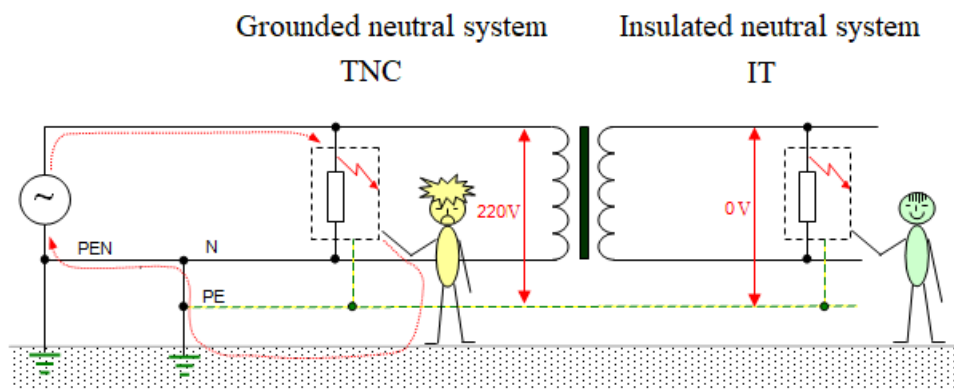


Figure 3. Utilization of insulating transformer for the arrangement of an IT system from TNC system.

4. Conclusions

Based on the analyzed data and statistics, we can find out that IT system provides more operating safety. In case of consumer device malfunction or human touching open live parts, the current flowing through the human will be determined by the sum of the body resistance and the large resistance between the ground and the neutral point. In contrast, in the TNC system, the electric shock current is determined by the human body resistance only.

The IT-systems is a more expensive network type and usually is applied in Russia for applications where extra safety is required. The local IT system may be arranged by the meaning of the insulating transformer (**Figure 3**).

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