

The Application and Analysis on Iterative Earthing in TN-S System

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Abstract: Iterative earthing is a important measure in low-voltage distribution system, and necessary in industrial power distribution system or civil power supply system. This paper introduces the definition, effects and specific technical requirements of iterative earthing, and illustrates its significance through the analysis on iterative earthing of TN-S system.

1. Introduction

1.1 Producing hardcopy using MS-Word

Iterative earthing is that one or more points of PEN line is earthed again. Neutral line is earthed many times repeatedly in order to ensure security, that means different several points of PEN line are metallic earthing with ground. It is aimed at ensuring that earthing protection is effective when PEN line disconnection occurs, reducing voltage to ground of PEN line so that decreasing accidents. If only one neutral line is earthed, and is broken, it will lose the effect of zero line connection protection, further lead to the voltage of enclosure is highly similar to phase voltage, it will be very dangerous.

According to the stipulation of IEC, there are several earthing forms in low-voltage distribution system: TN system, TT system and IT system, it is divided into TN-C, TN-S, and TN-C-S among TN system. This paper will analyze principally the iterative earthing of TN system because of TN system is used widely in construction site.

2. The discussion about the iterative earthing of TN system is N-line iterative earthing or PE-line iterative earthing

In low-voltage distribution system, the issue on iterative earthing is N-line iterative earthing or PE-line iterative earthing, it is ambiguous in the previous design or construction.

As shown in Figure 1, it is a distribution system from distribution transformer, transmission line, buildings power supply service to load.

In Figure 1, on the assumption that the system was not earthed before service, the system is unprotected when PEN line disconnection occurs. If PEN line installs iterative earthing device at the power supply service, it will provide reliable earthing protection for latter TN-S system due to

installing earthing device, but the system have changed from TN-S system to TT system^[1].

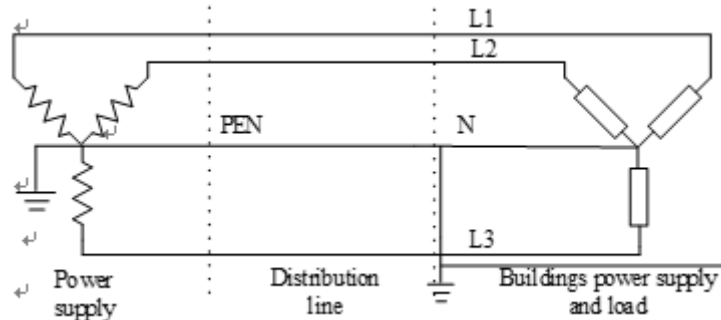


Figure 1 Power supply and distribution system

In distribution system, if earthing fault of short circuit to ground occurs in the one phase line, short circuit current will pass short circuit earthing point, ground, power supply earthing point and power supply finally, so that form circuit. At the moment, with the change of short-circuit earthing current and short-circuit-point resistance, the potential of earthing point that power supply works will change, and the potential of PEN line will rise. If PEN line installs iterative earthing device at the power supply service, equivalent resistance of parallel will be much less than the earthing resistance that power supply works because of parallel between the earthing resistance at iterative earthing of PEN line and the earthing resistance that power supply works, therefore, under the circumstance of same short-circuit earthing current, make the potential at short circuit point increase, so that reduce the voltage of PEN line effectively.

In the TN-S system, PE line and N line are divided, and enclosures of electric equipment connect with PE line, not N line. So the potential of PE line is concerned mainly by us, therefore, iterative earthing in the TN-S system is iterative earthing of PE line^[2]. In the TN-S system, if N line is used iterative earthing, the front will not be used earth leakage protection. Because three-phase load cannot reach complete balance when system runs normally, unbalanced will current pass N line and return the neutral point of power supply when grid is running. It will lead to wrong action earth leakage protector occur when N line is used iterative earthing, so N line should not be used iterative earthing except the neutral point of power supply.

3. Effects of iterative earthing

In the TN system, it is pivotal that how reduce expectant touch-voltage adding on body when earthing fault occurs. When there is earthing fault, if without earthing device, the touch-voltage is voltage drop of fault current between PEN line and PE line; if there is earthing device, the touch-voltage is sum of voltage drop that PE line and the resistance of iterative earthing^[3]. But the voltage drop of the resistance of iterative earthing is divider of the voltage drop of PE line, therefore, iterative earthing can reduce expectant touch-voltage when fault occurs relative to the case of without any measure. The main effect of iterative earthing is preventing potential driftage caused by working PEN line disconnection, the electric equipment of different phases can form circuit mutually and become series circuit when PEN line disconnection occurs. The low-power equipment because of larger resistance, gets the voltage relatively high so that is burned out. The high-power equipment because of smaller resistance, gets the relatively high voltage so that cannot work. In the zero line connection protection system, if PEN line disconnection occurs, it will make the enclosures all equipment of zero connection electrification, but iterative earthing can reduce the rate of electric shock. Iterative earthing can shorten the lasting time of fault, reduce the voltage-drop wastage of PEN line, and mitigate the risk of reverse connection between phase and PEN line.

The effect of equal potential connection is to reduce the touch voltage of indirect touch electric

shock between construction and the potential difference of between different metallic parts, and eliminate the hazard of dangerous fault voltage brought from construction external to electric circuit and various metallic pipeline. Iterative earthing make the potential of N line, PE line or PEN line approximate ground's, and prevent mainly circuit disconnection.

Take TN-S system as example, introducing the effect of iterative earthing.

3.1 Reduce the earthing voltage of fault point

If TN-S system is used the power supply system of electric equipment enclosure using PE line protection, when electric parts touch enclosure, it will form short current through phase line, PE line and equipment enclosure. At the same time, the ground voltage of equipment is much higher than safety voltage. For improving the case, equipment PE earthing line will be added a earthing device again, that is iterative earthing. In this way, the fault-point ground voltage must lower than before ground voltage.

As shown in Figure 2, it is a circuit figure that one phase is ground short circuit. When without iterative earthing, short current will form circuit through fault point, ground and earthing point of power supply, at the moment, the voltage U_0 of work earthing point of power supply is

$$U_0 = U_{p0} \times R_A / (R_A + R_D) \quad (1)$$

In the last formula, R_A is power supply earthing resistance, R_D is the resistance between fault point and ground, U_{p0} is the voltage between fault point and work earthing point O of power supply. When R_D is smaller, U_0 will exceed safety voltage (50V), and reach to all electric equipment enclosure along PE line, even endanger personal safety.

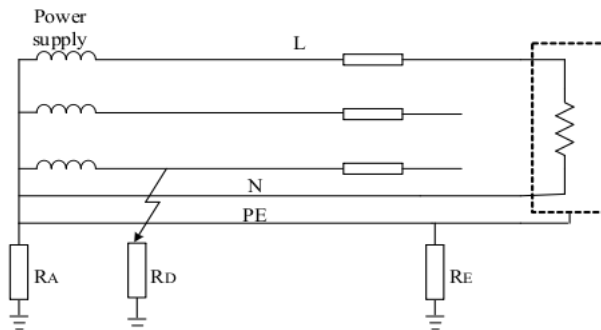


Figure 2 circuit of one phase ground short circuit

If PE line install the iterative earthing device, then U_0 is

$$U_0 = U_{p0} \times R / (R + R_D) \quad (2)$$

In the last formula, R is parallel equivalent resistance by R_A and iterative earthing resistance R_E of PE line, much less than R_A , that makes U_0 reduce greatly, so that reduce ground voltage of PE line effectively and decrease electric shock danger.

3.2 Mitigate the disconnection risk of PE line

In the case of protection line disconnection, iterative earthing device is benefit to lower touch voltage when touch enclosure short fault of electric equipment occurs, but touch voltage lowered still is within the scope of dangerous, meanwhile, should make the voltage value of PEN line disconnection ends approach to 220V. So PE line disconnection should be avoided, and managers should improve maintenance when equipment is running normally.

3.3. Shorten fault lasting time

If there are several iterative earthing devices in the system, in general, every iterative earthing resistance is required to less than 10Ω , in that way, lower the earthing resistance value of whole system. Thus, when one phase is electric leakage or disconnection in low-voltage grid, it can constitute circuit nearby through different iterative earthing, form multi-point short circuit, then make fault current increase immensely, and insurance device act quickly, so shorten fault lasting greatly. More important, the longer the lines, the more obvious the effect, so that accelerate the action of distribution line protection device.

3.4. Improve anti-thunder performance of grid

In a region or season with thunder and lightning, when the lines of low-voltage grid have been struck by lightning or induction lightning have been introduced, the high-voltage and heavy-current of thunder and lightning have great dangerous to electric equipment and personnel. However, the voltage and current can enter into ground nearby through different iterative earthing, so decrease the dangerous of thunder and lightning.

4. The specific technical requirements of iterative earthing

The end of low-voltage overland line, the branch of branch-line exceeding 200m and coastal every 1km PEN line should install iterative earthing; (2) When high-voltage and low-voltage use the same tower laying, low-voltage PEN line should install iterative earthing at the common laying; (3) The low-voltage cable of metallic enclosure as PEN line should install iterative earthing; (4) Workshop inside should use annular iterative earthing; (5) <Earthing of AC Electric Device> (GB50065)NO.7.2.2 stipulate ” when distribution transformer set in the outside of construction, PE line or PEN line should install iterative earthing and earthing resistance should not exceed 10Ω at the low-voltage enter into construction^[4]”; (6) If iterative earthing points is no less than three points in grid, every earthing resistance cannot exceed 30Ω ; (7) N line of low-voltage distribution TT system cannot use iterative earthing.

<Civil Architectural Electrical Design Code> (JGJ16-2008) NO.22.8.9 stipulate” The neutral conductor of output end of UPS uninterrupted power supply device should install iterative earthing^[5]” NO.12.4.9 stipulate ”The earthing of overland line and cable line should accord with following stipulations: In the low-voltage TN system, PEN conductor or PE conductor of end of overland-line trunk line and branch line should install iterative earthing. Cable line and overland line should install iterative earthing at the every construction lead-in line according to NO.12.2.2stipulate of this code. PEN conductors with residual current device are not allowed to install iterative earthing. Neutral conductor (N) should not install iterative earthing excepting power supply neutral point; Earthing resistance of every iterative earthing grid of low-voltage line should not be greater than 10Ω . In the grid that earthing resistance of electric equipment is allowed to reach to 10Ω , earthing resistance value of every iterative earthing should not exceed 30Ω , and iterative earthing points should not be less than three points^[6].”

5. Conclusion

Take TN system as example, this paper illustrates the definition, main effects and specific technical requirements of iterative earthing and analyzes in detail on the effects and meaning of iterative earthing safety protection. Owing to the limit of knowledge and ability of writers, there must be many improper explanation with the article, so hope every expert and reader to give us

precious suggestion. Writers hope heartily the article to be helpful to spot construction, and effective in the aspect of safety.

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