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A New Algorithms for Faulted Phase Earthing Protection Relays on 20kV Networks

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Abstract: *In This paper present mitigate safety issues during a single phase to ground fault, faulted phase earthing (FPE) is implemented on the 20 kV network. Assessment of the present logic functions in the faulted phase earthing (FPE) relays on the 20 kV network. It also outlines the process used to determine if a newly proposed logic algorithm will be sufficient to increase the sensitivity of the relay to pick up high resistance faults without increasing spurious operations.*

Key words: *distribution network; fault current; safety; unbalanced loads.*

INTRODUCTION

The 20 kV distribution network of Ireland is run as an isolated neutral network. Protection is critical issue in power system and the issue lies in the accurate and rapid discrimination of inrush current from fault current. Transformers are essential and important elements of power systems. Due to their sizes and varieties, protection approaches of power transformers dier depending on the situation. When the network is in a sustained single line to ground fault condition, the three phases remain in service, continuing to provide electricity to customers. The faulted phase earthing (FPE) protection relay triggers the FPE switch in the substation which earths the faulted phase to the substation earthgrid. The majority of the fault current will flow into the substation earthgrid which in turn improves the fault site safety, allowing the system to be operated without disconnecting customers who are fed from the faulted section of network.
In order to maintain security of supply the faulted phase is not tripped, however in order to improve fault site safety the faulted phase is earthed back at the feeding substation. This FPE system is used across the The 20 kV distribution network in Ireland. The existing method has two logic requirements to determine if a single phase is faulted, which will lead to the FPE earthing that phase in the substation.
Fault level reduction is an ongoing task on a growing electrical network. With increasing generation and network capacity added to the system, the fault levels in various locations of a distribution network will approach their maximum allowable design level. For electrical power distribution companies, there are a number of business drivers that result in the implementation of fault level reduction schemes. These business drivers are [4]:

- Maintain the existing equipment within design ratings to avoid expensive upgrades
- Bushfire risk mitigation.
- Quality of Supply Improvement.
- Safety and reliability.

This paper describes a mitigate safety issues during a single phase to ground fault, faulted phase earthing (FPE) is implemented on the 20 kV network.

II. Review

The present 66/22kV systems under studied are solidly earthed, which results in higher earth fault currents under fault condition (is shown in Fig 1). With the expanding network, the situation is quickly worsened because the existing switchgear and other equipment are not rated for the higher fault level. These are shown graphically and mathematically as follows. Without the NER, it can be seen that the Ifault will be naturally high [4].

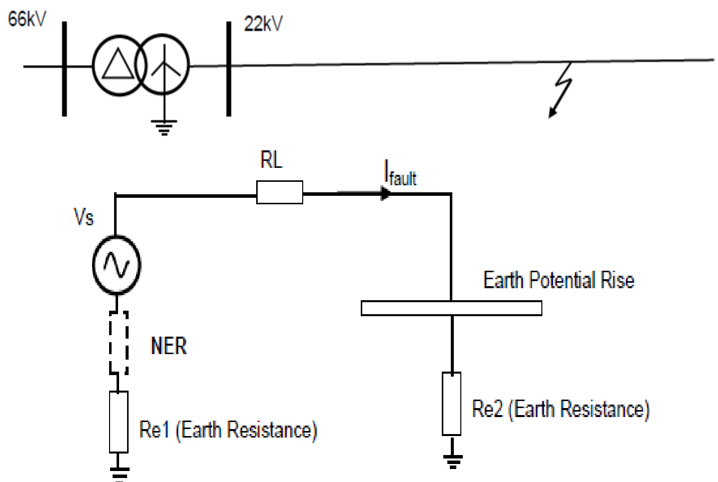

Fig 1. Systems under studied

I fault $= \frac{vs}{Re1+RL+Re2+NER}$

A commonly accepted and cost efficient approach to reduce the single phase to ground fault level is to install a neutral earthing resistor on the transformer neutral (as shown in Fig 2).

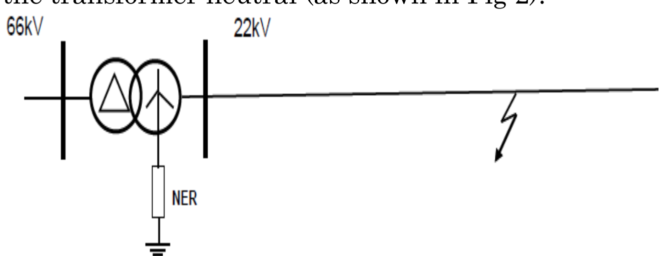

Fig 2. Install a neutral earthing resistor

During the fault, the NER will form part of the positive, negative and zero sequence circuits, providing a mean to control the I fault, consequently a higher NER value will result in a lower fault current (is shown in Fig 3).. The simplified sequence circuits for the symmetrical components to represent the unbalance condition under single phase to ground fault are demonstrated graphically as follows:

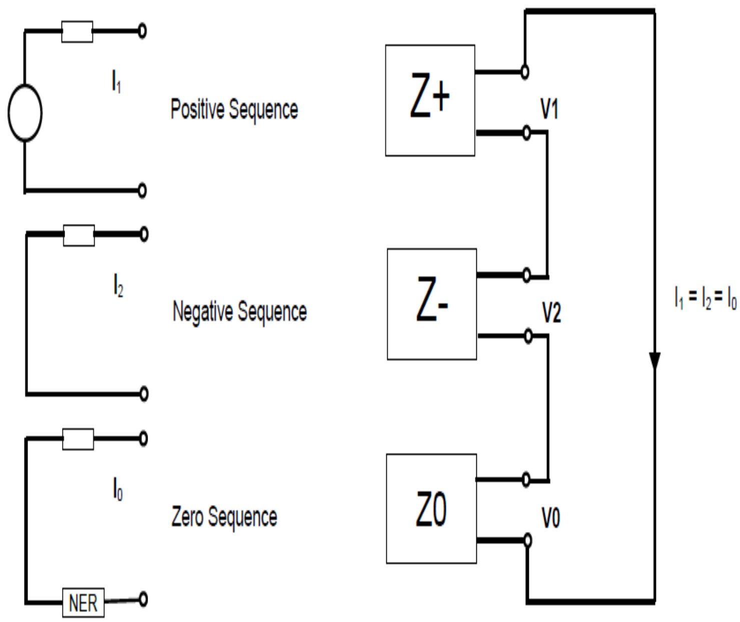

Fig 3. Sequence network

For sequence currents:

$$I1 = I2 = I0 = \frac{E}{Z1+Z2+Z0}$$

For phase currents.

$$Ia = I0 + I1 + I2 = \frac{3E}{Z1+Z2+Z0}$$

Where:

$Z0 = 3\times Z_{NER}$

$Ib = 0$

$Ic = 0$

While the general operation of Neutral Earthing Resistors for fault level reduction is well understood, optimization of the design under various network configurations to yield maximum benefit requires detailed study. The studies involved assessing the impact of Neutral Earthing Impedances of varying sizes for phase-ground faults on a "generic" network with three different configurations:

- Delta-Star Transformer configuration;
- Star-Star Transformer configuration; and
- Bus Tie CB Open (Delta-star Transformer configuration)

Simulation and Application

A system with a generator, a three phase transformer and a load has been simulated. A typical 750MVA, 27/420KV, Power transformer is connected between 25KV source at sending end 400 KV transmission line three phase connection diagram are shown in Fig 4. Iad Ibd Icd refer to a,b,c three phase differential current through CT secondary side: n1, n2 are the number turn on the low voltage (LV) and high voltage on (HV) the simulation of these power transformer is carried out using PSCAD software which is Shown in Figure 2. In each simulation of the system parameter are varied including the fault type fault position , fault inception angle , remnant flux in power transformer core. and also the effect of

CT saturation is also studied. In an isolated neutral system, when there is a single line to earth fault, the voltage on the faulted phase (reference phase) will reduce in proportion to the fault resistance.

The leading and lagging phase voltages will increase in relation to the voltage drop on the faulted phase as a result of the shift in the neutral voltage. The phase leading the faulted phase will have the higher of the two healthy phase voltages. It is important to define the leading and lagging phases, as they will be referenced separately in the logic algorithm of the relay. The leading and lagging phases for each of the references voltages are as follows:

Table 1 Reference (Faulted) Phase and Associated Leading and Lagging Phases

Reference Voltage	Leading Phase	Lagging Phase
R	T	S
S	R	T
T	S	R

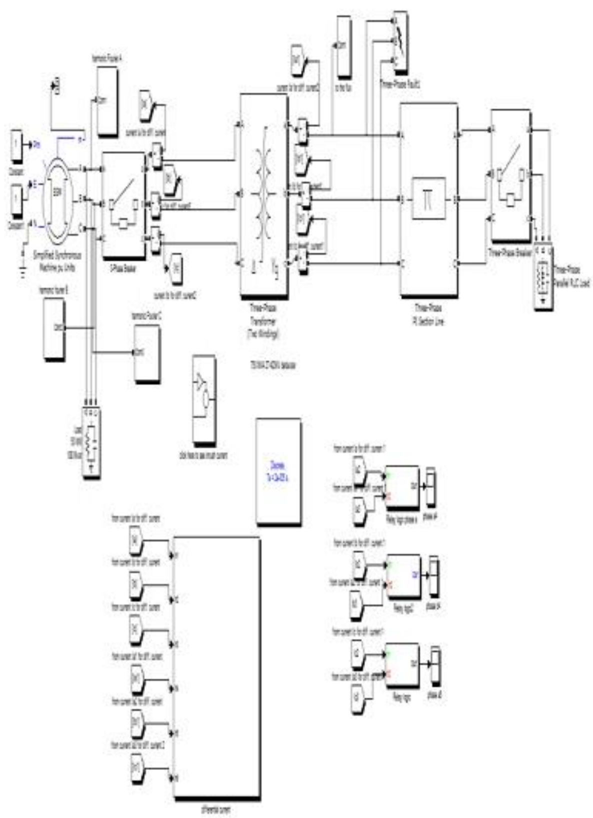

Fig 4. Model

A single phase to earth fault was simulated for different scenarios and the resultant value of the voltage for each phase, as seen at the substation was recorded. In order to get a comprehensive view of how the FPE relay would function under different fault conditions, the fault resistances were varied from small values (1Ω) to large values (200 Ω), where a graph of the resulting voltages against fault current was plotted.

Results

The three phase voltages and calculated neutral voltage were then plotted along with the logic algorithm settings to determine where the limit of the existing algorithm lay with respect to the detection of different fault impedances.

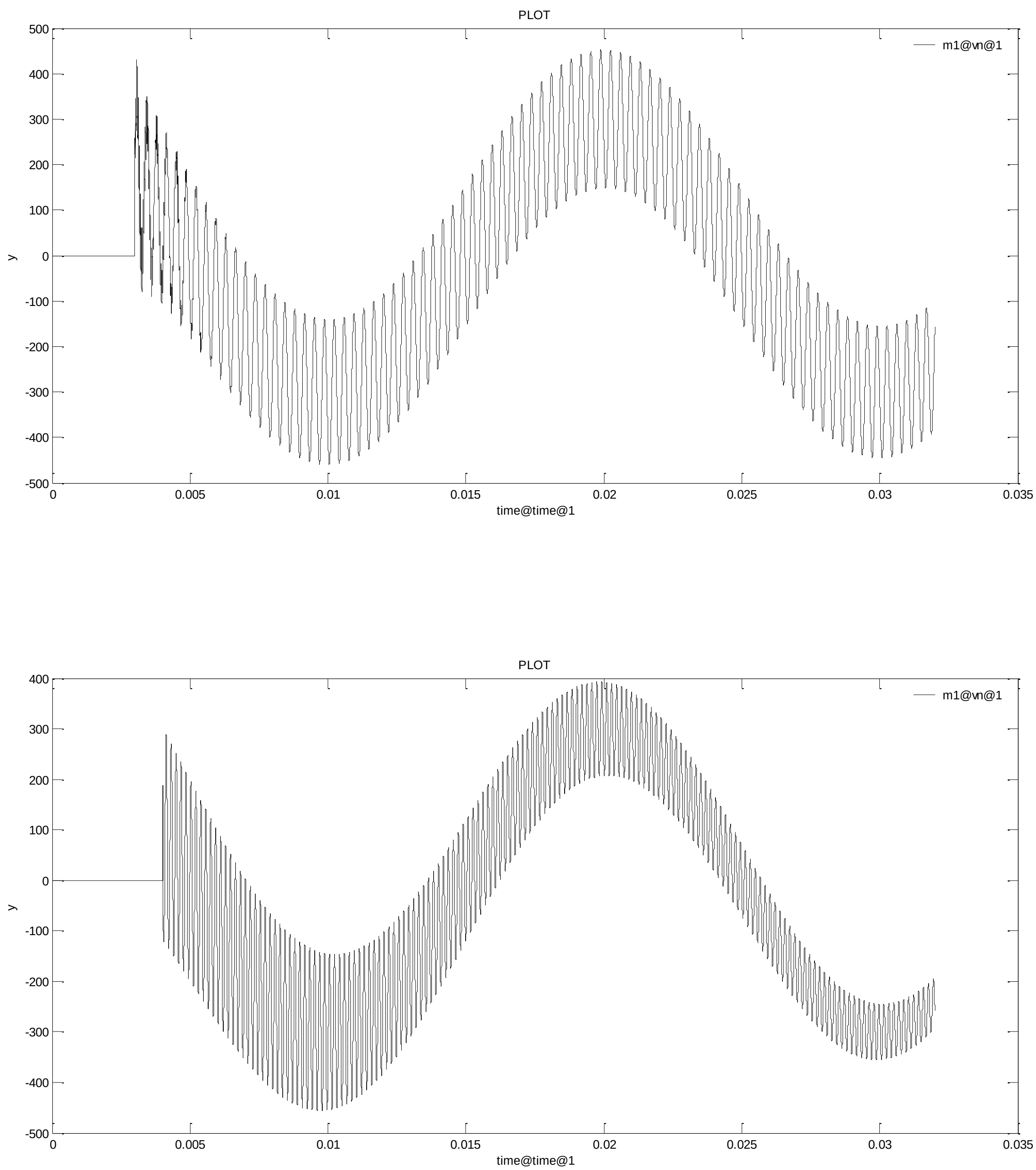

Figure 1 Resultant

Conclusions

In This paper present mitigate safety issues during a single phase to ground fault, faulted phase earthing (FPE) is implemented on the 20 kV network. The results of the study showed that the altered algorithm would increase the detection limit of the existing relays presently installed on the 20 kV network.

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