# Mitigation of Ferroresonance Effect on High Voltage Transformer Configuration in Power System

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*Abstract*-.**The ferroresonance is a non-linear resonance phenomenon that can affect power networks. The abnormal rates of harmonics and transients or steady state overvoltages and overcurrents that it causes are often dangerous for electrical equipment. The ferroresonance may take place when the core of an inductive device becomes saturated and its currents-flux characteristic becomes non-linear. This paper presents the mitigation of ferroresonance effect on different types of transformer configuration. Three different types of configuration are analyzed by placing the resistance at the low voltage side and the high voltage side. The simulation is done by using MATLAB Simulink 7.10.0.**

**Keywords-Ferroresonance, Transformer, MATLAB, Overvoltage, Configuration Connection**

## I.INTRODUCTION

Ferroresonance is a nonlinear electrical phenomenon which can occur if an inductance with iron core is fed by alternating current voltage source through a capacitive component [1]. Nowadays, ferroresonance is a widely studied phenomenon in power systems involving capacitors, saturable inductors and low losses.

The ferroresonance phenomenon appears after transient disturbances (transient overvoltages, lightning, or temporary fault) or switching operations (transformer energizing or fault clearing). Its effects are characterized by high sustained overvoltages and overcurrents with maintained levels of current and voltage waveform distortion, producing extremely dangerous consequences [2].

Studies have shown that certain power system configuration will increase a network's susceptibility to ferroresonance. Protection and switching equipment that operates on a single-phase basis may leave sections of a network open circuited, effectively creating a series LC circuit that is excited by the remaining phases [3].

Ferroresonance can happen at any voltage level with the appropriate combination of capacitance, non-linear inductance and low losses. Studies and field experience have shown that certain power system configurations are more susceptible to ferroresonance than others. The most frequent cases are listed below [4]:

- Voltage Transformer energized through grading capacitors of open circuit breakers.
- Voltage Transformers connected to an isolated or resonant neutral system.
- Power Transformers energized in only one or two phases.
- Lightly loaded Power Transformers connected to a cable network with low short circuit power.
- Single phase switching (fuse blowing) in distribution networks.

For ferroresonance overvoltage to cause the early demise of the lightning arrester, three conditions need to be meets. First, the right amount of shunt capacitance needs to be connected to the transformer. Second, the transformer needs to be lightly loaded. Finally, a single phase faults needs to occur on the system. The first condition dependents on the configuration of the system. The other two will be determined through the operation of the system [5].

The objective of this paper is to mitigate the ferroresonance effect on high voltage transformer in power system. Three different types of transformer configuration are studied with different position of resistance is located at low voltage side and high voltage side.

## II. METHODOLOGY

In order to investigate the ferroresonance phenomenon in power system. The network in figure 1 is built using MATLAB Simulink 7.10.0. Enlargement of the circuit is provided in appendix.

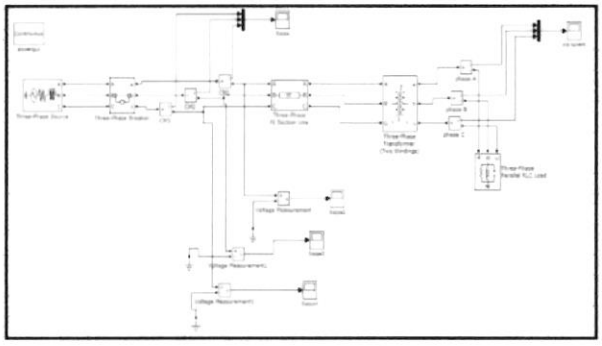

Figure 1: Simulated circuit on MATLAB

A three phase 250 MVA, 400 kV/230 kV transformer is connected to the end of 100km transmission line. A three-phase RLC load is connected to low voltage side of transformer. Single phase switching is applied to the circuit to create ferroresonance effect in the transformer. Resistance is used to mitigate the ferroresonance effect. Resistance is placed at two different position, low voltage side and high voltage side. Three different types of transformer configuration are studied. The flowchart of the methodology is shown in figure 2.

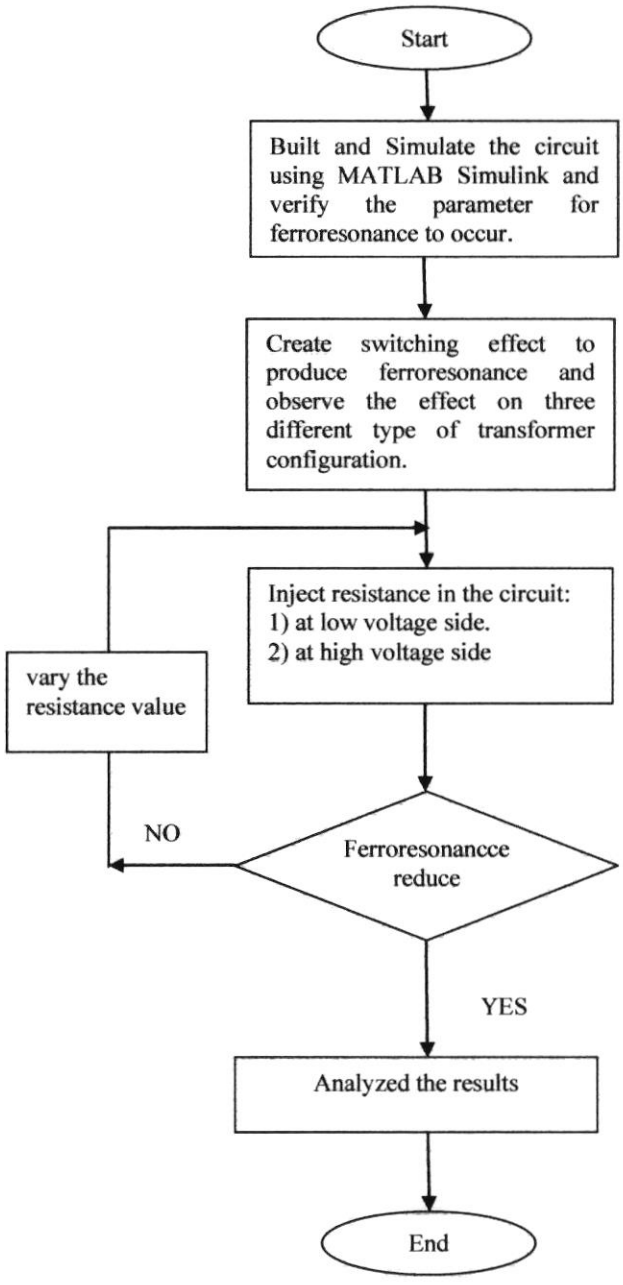


Figure 2: Flow chart of project implementation

## III. RESULTS AND DISCUSSION

### *A. Wye-Wye Configuration*

The result for wye-wye configuration transformer with three different values of resistance 50 kΩ, 500 kΩ and 5 MΩ placed at low voltage side and high voltage side is shown in figure 3 to figure 9.

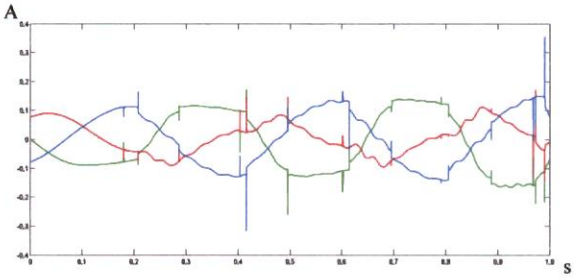


Figure 3: Simulation result for **wye-wye** configuration before inserting the resistor

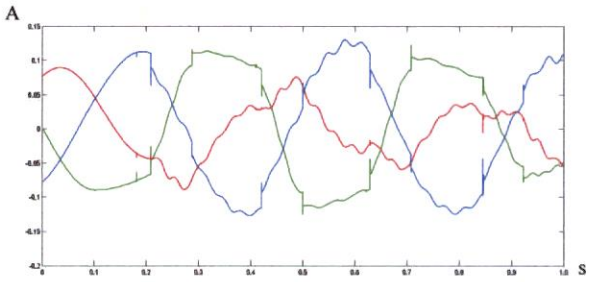


Figure 4: Simulation result for **wye-wye** configuration when resistor *50k*Ω is connected at **low voltage side**

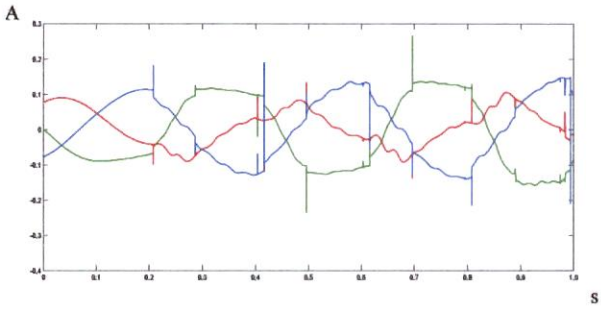


Figure 5: Simulation result for **wye-wye** configuration when resistor *500k*Ω is connected at **low voltage side**

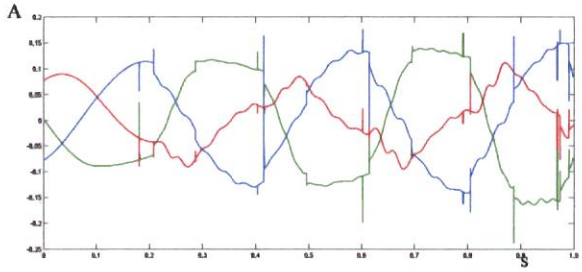


Figure 6: Simulation result for **wye-wye** configuration when resistor *5M*Ω is connected at **low voltage side**

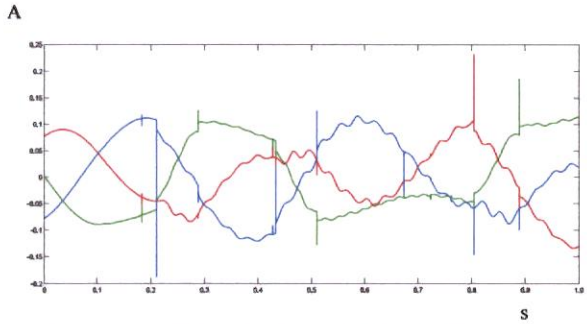


Figure 7: Simulation result for **wye-wye** configuration when resistor *50k*Ω is connected at **high voltage side**

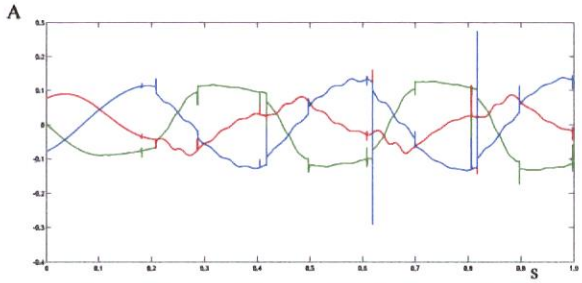


Figure 8: Simulation result for **wye-wye** configuration when resistor *500k*Ω is connected at **high voltage side**

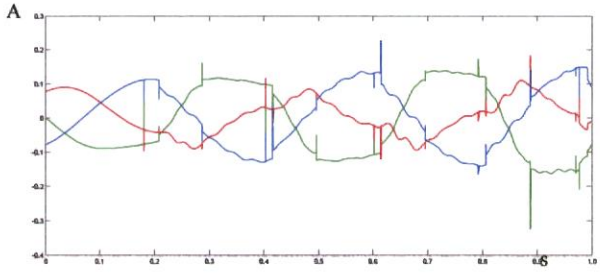


Figure 9: Simulation result for **wye-wye** configuration when resistor *5M*Ω is connected at **high voltage side**

From the results obtained it can be seen that using 50 kΩ resistance placed at low voltage side, the ferroresonance is reduced. The ferroresonance effect also can be reduced when inserting resistance 500 kΩ at high voltage side. From the results obtained, for wye-wye configuration, inserting a 50 kΩ resistance at low voltage side is more effective to reduce the ferroresonance effect.

B. *Delta-Wye Configuration*

The results for delta-wye configuration transformer with three values of resistance 50 kΩ, 500 kΩ and 5 MΩ placed at low voltage side and high voltage side is shown in figure 10 to figure16.

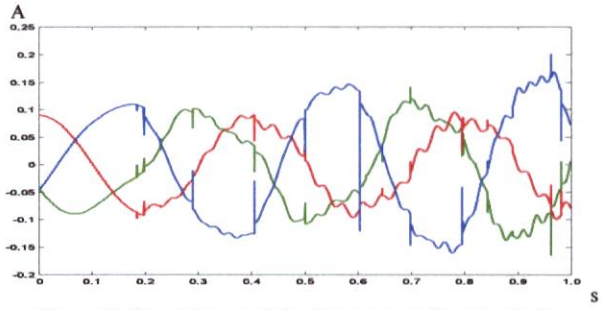


Figure 10: Simulation result for **delta-wye** configuration before inserting the resistor

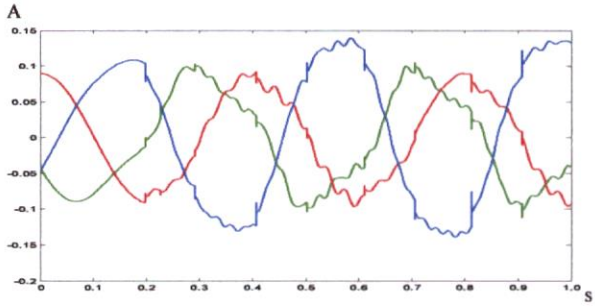


Figure 11: Simulation result for **delta-wye** configuration when resistor *50k*Ω is connected at **low voltage side**

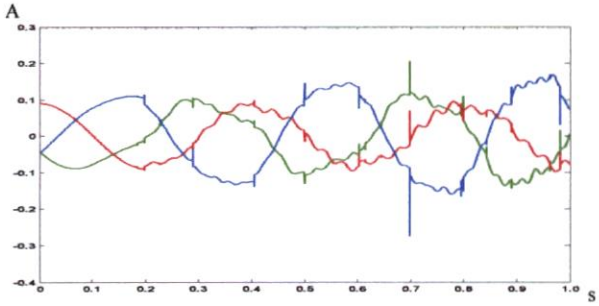


Figure 12: Simulation result for **delta-wye** configuration when resistor *500k*Ω is connected at **low voltage side**

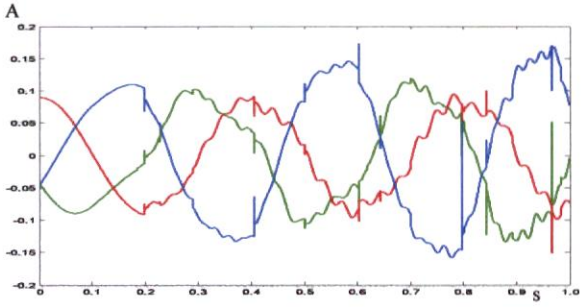


Figure 13: Simulation result for **delta-wye** configuration when resistor *5M*Ω is connected at **low voltage side**

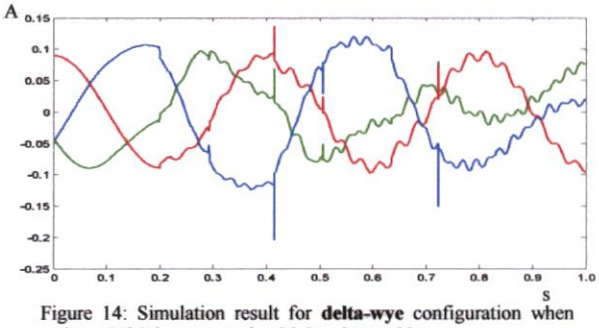


Figure 14: Simulation result for **delta-wye** configuration when resistor *50k*Ω is connected at **high voltage side**

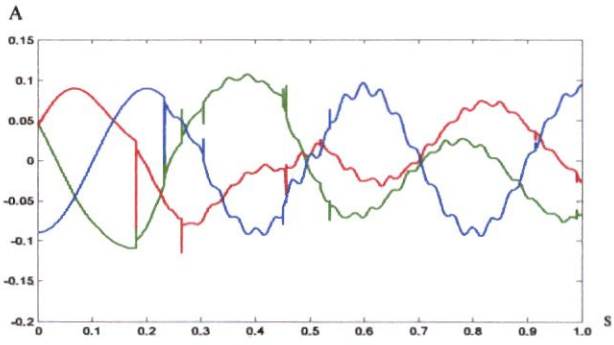


Figure 20: Simulation result for **wye-delta** configuration when resistor *5MΩ* is connected at **low voltage side**

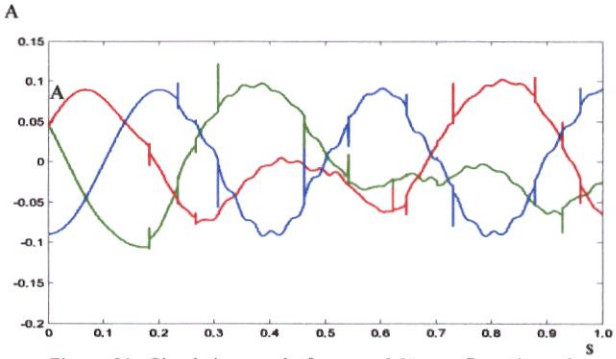


Figure 21: Simulation result for **wye-delta** configuration when resistor *50kΩ* is connected at **high voltage side**

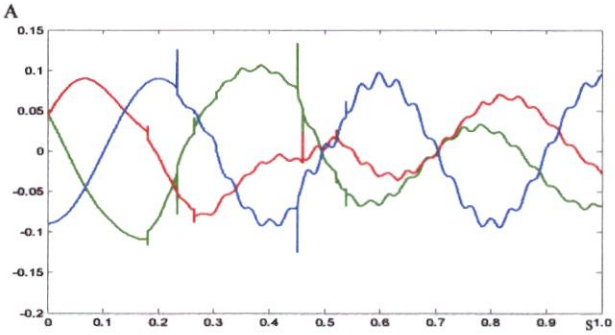


Figure 22: Simulation result for **wye-delta** configuration when resistor *500kΩ* is connected at **high voltage side**

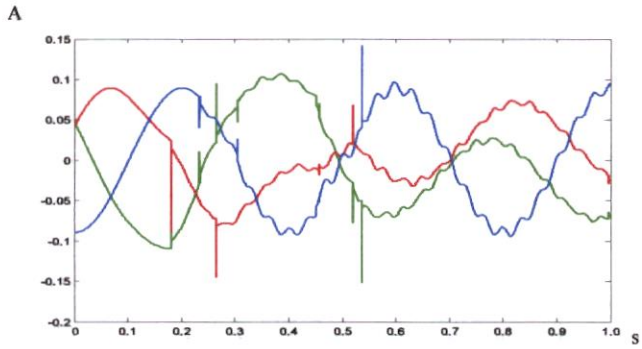


Figure 23: Simulation result for **wye-delta** configuration when resistor *5MΩ* is connected at **high voltage side**

From the results obtained, it can be seen that using 50 kΩ resistance placed at low voltage side, the ferroresonance is reduced. The effect of the ferroresonance also can be reduced by inserting 500 kΩ resistance at high voltage side. From the results of both mitigation options, it can be seen, inserting 50 kΩ resistance at low voltage side is more effective to reduce the ferroresonance effect.

From the results obtained, for three different types of configuration, it can be seen that the wye-delta configuration has a small effect of ferroresonance phenomenon due to switching activity. It can be seen that, by inserting 50 kΩ resistance at low voltage side for the three different type of configuration, is more effective to reduce the ferroresonance effect.

## IV. CONCLUSION AND FUTURE WORK

The simulation results show that the ferroresonance can occur in power system due to switching activity. To mitigate the ferroresonance effect, a resistor could be placed either at low voltage side or high voltage side. For 250 MVA, 400 kV/230 kV wye-delta connection, a damping resistor of 50 kΩ placed at low voltage side give the best result to mitigate the ferroresonance effect.

For the future work, this study can be carried out to a different size of transformer. Other than that, the effect of the ferroresonance due to fault condition in transmission line and due to voltage transformer energized through grading capacitor of open circuit breaker could be studied.

## V. REFERENCE


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