MITIGATION OF GIC USING SOLID STATE DEVICES

Mrunali Yeole[1], Shubhangi Sonkusale[2], Vickey Bhoyar[3]
[1,2,3] *Department of Electrical Engineering,*
Priyadarshini J.L. College of Engineering, Nagpur, Maharashtra, India
mrunaliy7@gmail.com1, ssonkusale081@gmail.com2, vbhoyar144@gmail.com3

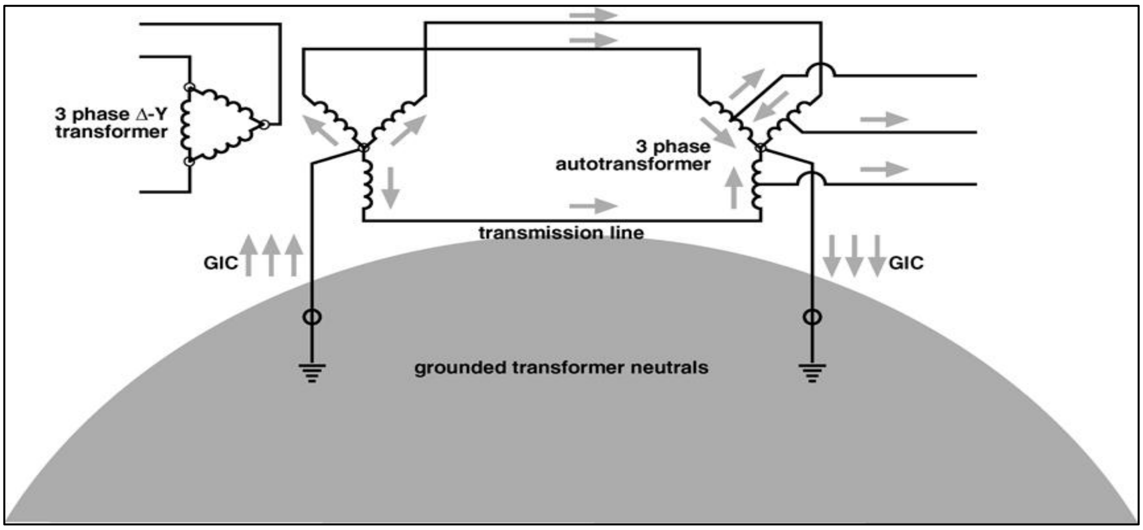
Abstract: The protection of number of equipment connected in a power system happens to be the one of the important aspects taken into consideration while setting up a power distribution station. This is because the equipment used is expensive and their damage may lead to loss of continuity of supply. One of the important equipment used and protected from damage is a transformer, for which differential protection devices are made available in order to prevent the same. But, the transformer still remains unguarded if GIC enter into the system through the transformer neutral. Hence, to safeguard the transformer and further connected devices in the system from the effects of GIC, effective methods have to be found out to prevent the GIC from entering into the system and ultimately protect the system and maintain continuity of power supply.

Thus this paper deals with the effects of GIC on the Power transformer along with comparison between conventional methods used for preventing GIC with their drawbacks and effective methods for GIC detection and mitigation.

KEYWORDS: GIC, Mitigation techniques,Power Transformer, Solid state devices.

INTRODUCTION:Generation and Transmission of Power is a composite process, which needs the working of many components of the power system continuously in synchronism to maximize the output. One of the main components to form a major part is the power transformer in the system.

The interaction between the Earth’s magnetic field and space weather induces current in the surface of the earth called Geo-Magnetically Induced current. This interaction creates due to coronal mass ejection from the solar storm. At the ground level a geo-electric field is induced due to electrojet which is DC current. The current flowing in the direction of this field is called as Geo-Magnetically Induced Current. This current is created by the change in geo-electric field with respect to time. The geo-magnetic changes are ranging around millihertz as compared to 50 Hz frequency used in electrical power system. So when it enters transformer, it affects as a DC current.



GIC MITIGATION TECHNIQUES

1. Disconnecting Neutral
2. Resistor at neutral
3. Inductor at neutral
4. Capacitor at neutral
5. Solid state device at neutral

Description:

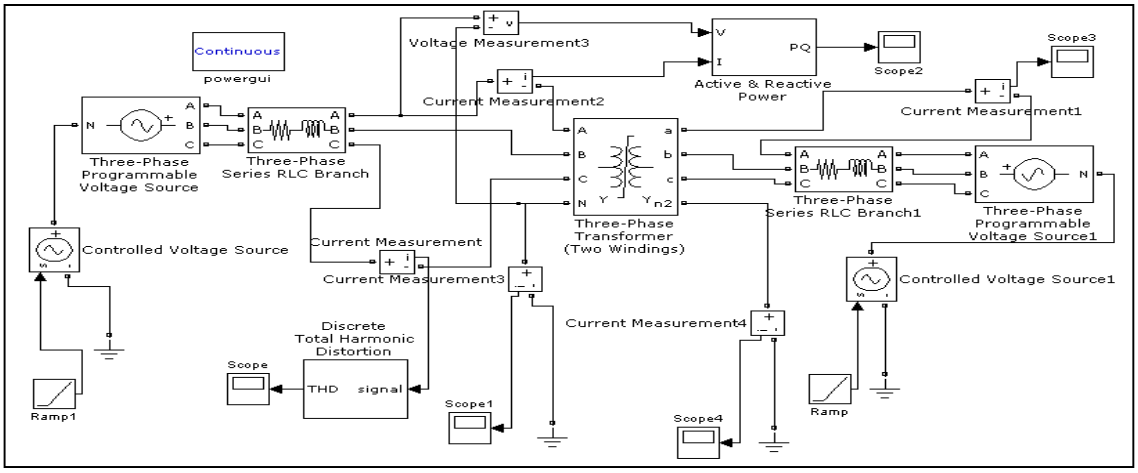
1) Disconnecting Neutral: The ground wire is an additional path for electric current to return safely to the ground without danger to any of its connected devices in the event of short circuit. But if for eliminating GIC, the neutral is disconnected the excessive current during short circuit may damage the system.
2) Resistor at Neutral: Resistance earthing limit the maximum fault current as per ohms law to a value which will not damage the equipment. The Resistor at the neutral for grounding as well as eliminating GIC will always be a reason for the losses in the system and does not eliminate GIC completely.
3) Inductor at Neutral: Addition of Inductor to the neutral causes the high transient over voltages on the system and arcing ground fault condition. For eliminating GIC, if this method is used, Inductor with high impedance will be needed which would increase the size of the choke coil and make the system bulky.
4) Capacitor at Neutral: The addition of capacitor to the transformer neutral can block the GIC completely but due to high cost of capacitor, they are avoided to bring into use.

EFFECTIVE TECHNIQUE OF GIC MITIGATION

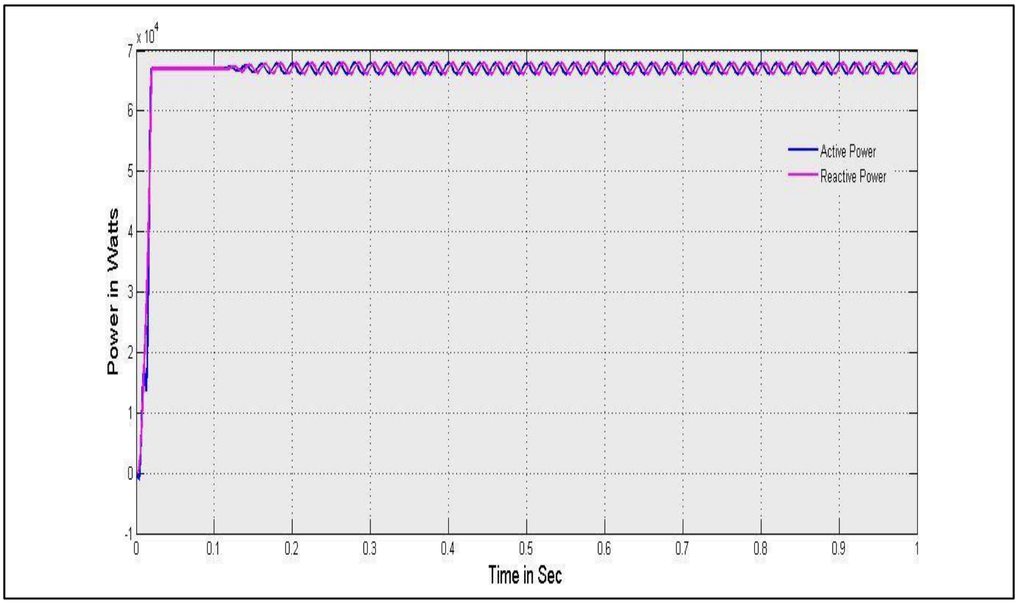
After studying the above four basic techniques of eliminating GIC, the techniques were found to be disadvantageous in some or the other ways as mentioned and described above. Hence in order to find out effective technique with reduced cost and losses, we connected solid state devices at the neutral of the transformer and made the following observations:

MOSFET	**IGBT**
High switching frequency (>100kHz)	**Low switching frequency (<20kHz)**
High Voltage Rating (<1kV)	**Very High Voltage Rating (>1kV)**
Low Current Rating (<200A)	**High Current Rating (>500A)**
Fast Switching Speed	**Medium switching Speed**
Cost is medium	**Cost is high**

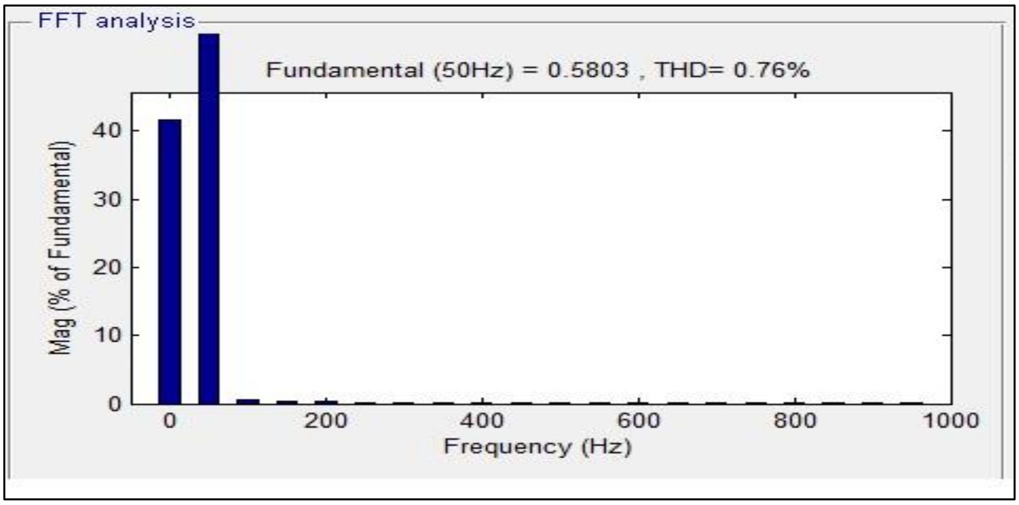
SIMULATION MODEL AND RESULTS:



Simulation model for mitigation of GIC using MATLAB is shown below. The 3 phase transformer is of 200MVA 50Hz pu., which steps down voltage from 400KV/163KV. In this analysis we are particularly focussing on the effects of GIC. The input acting as GIC here is Ramp input controlling Controllable voltage source connected to 3 phase programmable voltage source further connected to Active and Reactive power block through voltage measurement and current measurement block.
The total harmonic distortion block is employed to examine the distortion waveform.
As shown in the graph below plotted active and reactive power against time, the reactive power seems to have created oscillations.



POWER-TIME GRAPH



FFT analysis with GIC

Conclusion

The Resistor, inductor, capacitor used to eliminate GIC were ineffective as well as expensive. Hence, these conventional methods could be replaced by solid state devices as it is found to be mitigating GIC without much losses and larger size of equipment.

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