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FERRORESONANCE DAMPING SIMULATION ON THE VT IN GIS SUBSTATION

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Abstract- Ferroresonance is one of the rare and destructive phenomena in power network that figured as a nonlinear resonance that happen between the capacitor of the network and the nonlinear inductance of voltage transformer at the saturation instant. The effective elements in causing resonance and ferroresonance in power systems are, harmonic warming of transformers, increasing of heat, temperature increasing and damaging voltage transformers, high noise due to evolution due to magnet and bad working of protective instruments. Therefore some limitations should be applied to parameters of systems to avoid occurrence of undesirable phenomena like these. In this paper the effect of damping resistor and self nonlinear in secondary winding (thirty) in single and 3 phase with applying the EMTP-RV software for damping ferroresonance investigated and finally the simulation results have been presented.

Keywords: Ferroresonance, GIS Substation, VT.

I. INTRODUCTION

The word of ferroresonance, that arrived to the books and papers from the end of the second decade of 20th century use for all the oscillation phenomena in electrical circuits that consist of at least nonlinear self, capacitor, voltage source(generally sinusoidal). The main feature of ferroresonance phenomena is over voltage charge and discharge of power transformer, or switching defective and so on that can cause ferroresonance in specific condition. Regarding to this point that urban and industries areas with increasing load and insufficient area and needing high voltages are regarded, in recent years the use of GIS substation (Gas Insulated Substation) have increased.

In this paper we study The Karoon 4 GIS substation that is a 400 kV substation with double busbar and disconnector switch, this substation is fed by 16 single phase 100 MW transformers. The outputs of these transformers are connected to the 400 kV network with 4 over headlines [1, 2]. Despite the advantages of this gas insulated substations, it has fundamental problems.

One of the main ingredients of destruction of the instruments in GIS substations is ferroresonance that influenced the insulation of network at different point. Ferroresonance is one of the rare and destructive phenomena in power network that figured as a nonlinear resonance that happen between the capacitor of the network and the nonlinear inductance of voltage transformer at the saturation instant.

The effective elements in causing resonance and ferroresonance in power systems are, harmonic, core saturating, changing inductance of wiring, cutting of 1 or 2 phases of system, unsymmetrical load, inappropriate use of circuit breakers and fuses, using cables with high capacitance. The ferroresonance has other destructive effects such as oscillation of high voltages, intricacy in wave forms of voltage and current, warming of transformers, damaging voltage transformers (VT), for example in Karoon-4 400 kV GIS substation, loud noise due of evolution due to magnet, malfunction protective instruments. Numerous cases of ferroresonance in power system have been reported in years.

In recent years the number of ferroresonance because of the intricacy of system and operating modern instrument has increased. [3], [4] outbreak of ferroresonance has some signs like permanent over voltage with vast amplitude as phase to phase or phase to ground, permanent over current with vast amplitude, shifting voltage zero point, increasing temperature of voltage transformer, continual increasing of the noise altitude of transformators and reactors, damaging electrical equipment's such as capacitor banks and CVT because of increasing the thermal effect or breakage of dampers of the protective equipment's. Therefore some limitations should be applied to parameters of systems to avoid occurrence of undesirable phenomena like these. [5, 6]

II. SIMULATION AND CASE STUDY

The purpose of this paper is to study the ferroresonance on voltage transformers (VT) in Karoon-4 power plant GIS 400 kV substation as an example of GIS substation with busbar and long line that have been effected by this phenomenon by increasing the voltage and damaging isolation and heating, destruction and damaging of VT. These simulations are done by EMTP-RV Software and finally propose the practical method to resist it (Figures 1 and 2).

The conductive wires of A and C phases of damping reactor have been burnt by the high current at secondary circuit because of the single phase with VT ferroresonance. One of the reasons of this phenomenon is that the VT Company adequately doesn't consider the capacity of the damping reactor to absorb the resonance energy in VT in some cases of GIS switching conditions during first energizing at site.

III. FERRORESONANCE ANALYSIS USING RESISTANCE CIRCUIT AND NONLINEAR REACTANCE

The conditions of standard analysis that can be used in done simulation are as below:

1. CB Capacitance = 4000 pF/phase,
2. Unit Earth Capacitance for GIS = 52.4 pF/m,
3. Internal Earth Capacitance of main transformer = 13366 pF/phase,
4. Internal Earth Capacitance of in Shunt Reactor = 3382 pF/phase.

In above analysis, the Karoon-4 GIS substation, that is a 400 kV substation with double busbar with bypass disconnector switch, is studied and equivalent circuit of GIS substation is analyzed. The model consists of main parameters like, source and resistance series with it, and CB. It also includes the capacitor C_1 which is parallel with GIS circuit breaker had two 2000 pF capacitor parallel with contacts of circuit breaker and equivalent capacitance is 4000 pf. The simulation is done on the basis of these values.

Above simulated circuit consist of equivalent capacitor of GIS substation in different studied conditions that are as a result of summation of existing parameters which is studied in bellow waveforms. Also in this circuit, one VT with prime voltage of 400 kV is used for simulation and equivalent circuit substation form of single phase (Figure 1) and three phase (Figure 2) diagrams with damping circuit (damping resistor and nonlinear inductor) for damping probability of ferroresonance due to 4000 pf capacitor parallel with CB [9, 10].

C_1 = 4000 pF and C_2 = 3820 pF (for VT of bus 1)

C_2 = (53.2 + 5.6 + 5.6 + 2 + 6.5) × 52.4 = 3820 pF

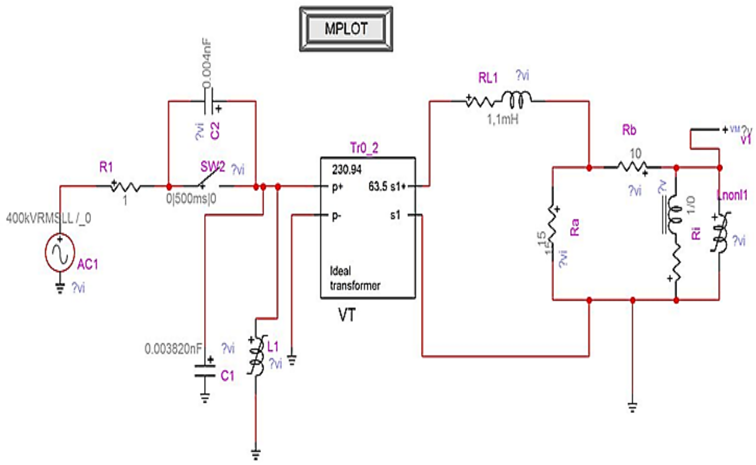


Figure 1. Single phase EMTP model for ferroresonance survey with damping circuit (Case 1)

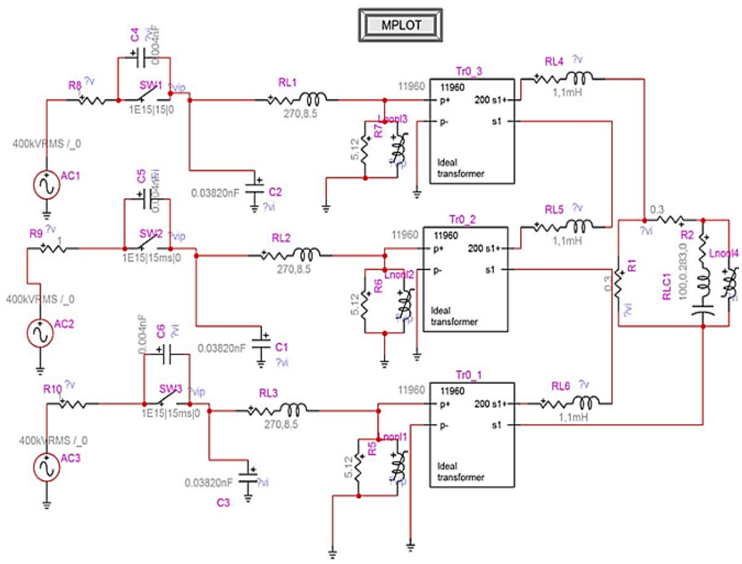
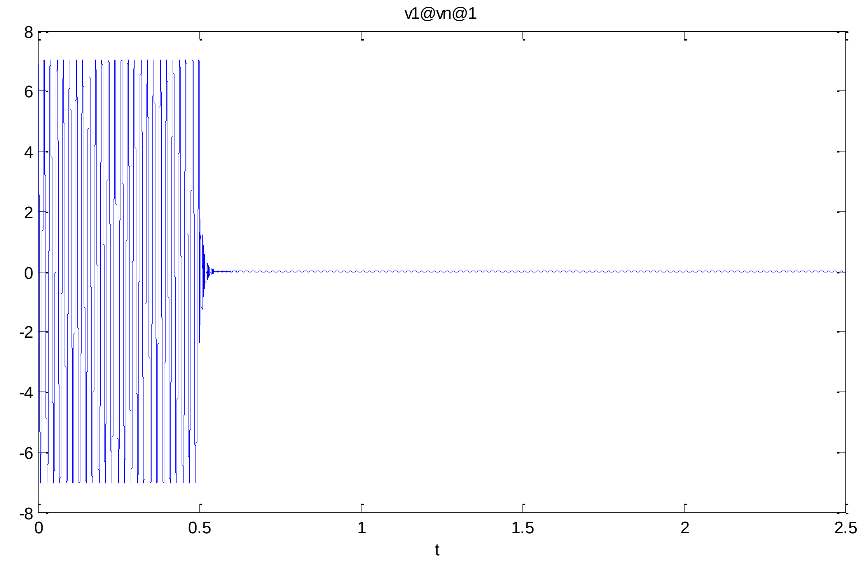
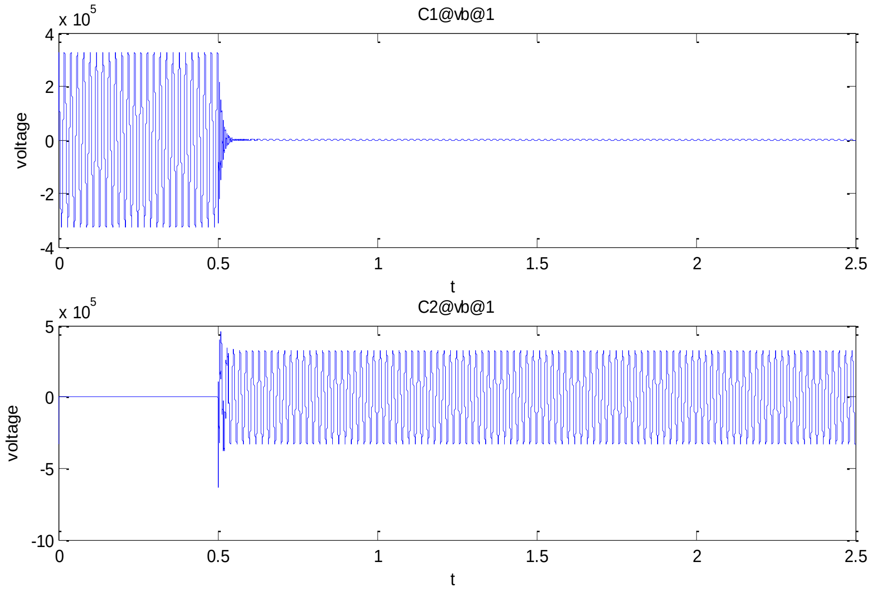


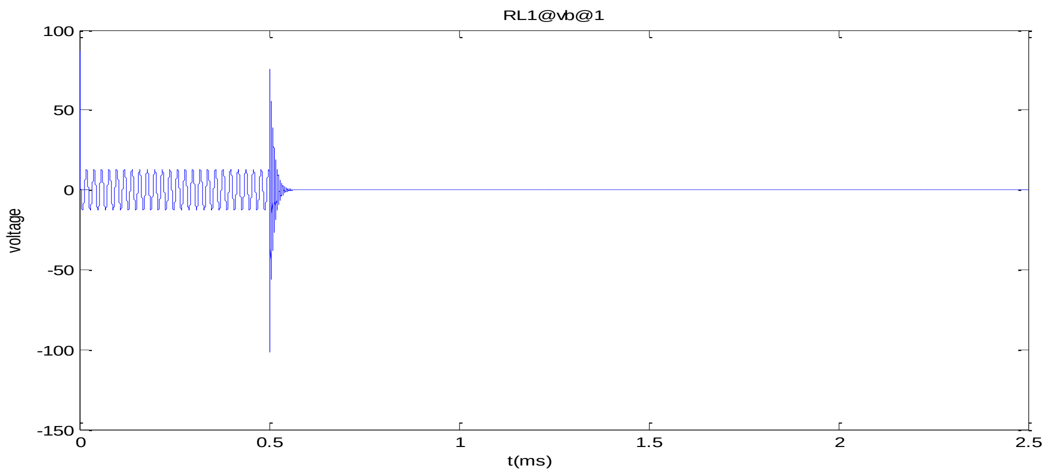
Figure 2. Three phase EMTP model for ferroresonance survey with damping circuit


v1@vn@1
t

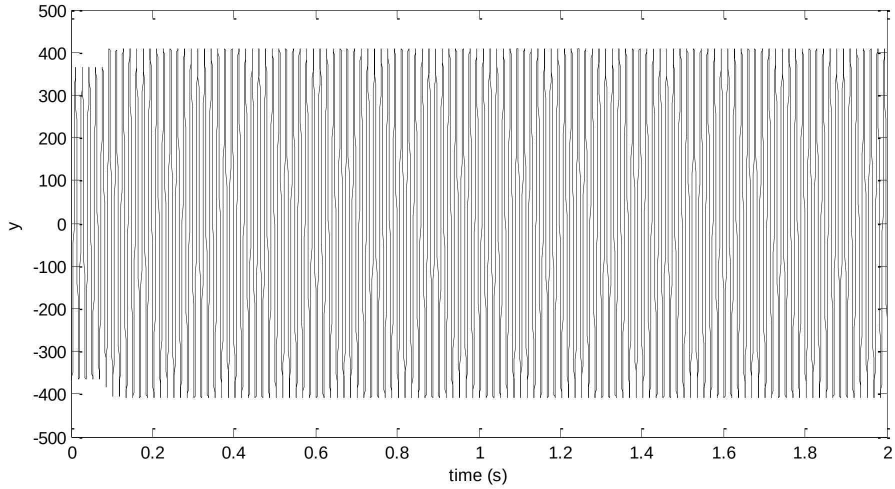
(a)


C1@vb@1
x 10^5
voltage
t
C2@vb@1
x 10^5
voltage
t

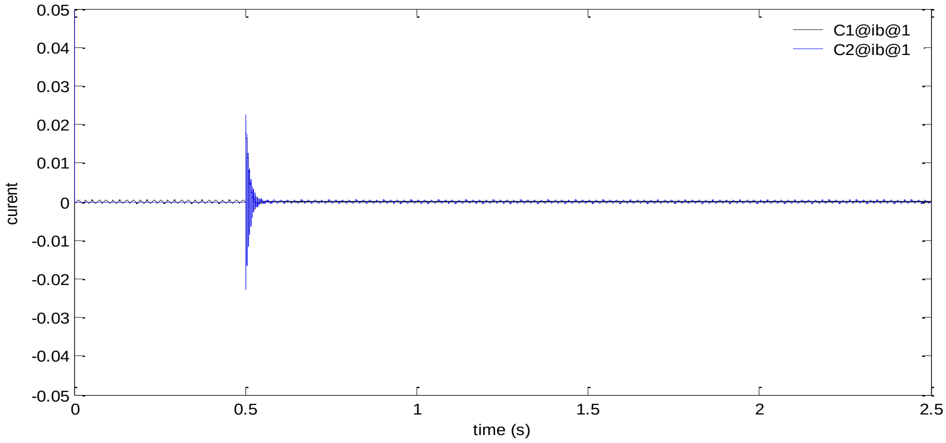
(b)


RL1@vb@1
voltage
t(ms)

(c)



(d)



(e)

Figure 3. The simulation result of Figure 2 for three phase EMTP model for ferroresonance survey with damping circuit

The Figure 3 shows the simulation result of Figure 2 as the following:
(a) The secondary voltage of VT with damping resonance
(b) The secondary voltage from C_1 and C_2 capacitors
(c) The secondary voltage along damper RL_1
(d) The ferroresonace wave without resistance damper
(e) The secondary current from C_1 and C_2

IV. CONCLUSIONS

In this paper the simulation of ferroresonance in 400 kV GIS substation on VT is studied. The effects of damper circuit on damping ferroresonance oscillations have been presented. The EMTP simulation result for Karoon 400 kV GIS substation, shows the risk of ferroresonance will increase by enlarging the capacitance of capacitor parallel with circuit breaker. To eliminate this phenomenon, damper circuit had been designed and added to model, results of simulation showed success damping of these ferroresonance oscillations.

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BIOGRAPHIES

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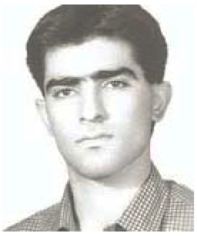

Ahmad Khosravi was born in Khorramabad, Iran, in 1981. He received his B.Sc. degree in Electrical Power Engineering from Yazd Branch, Islamic Azad University, Yazd, Iran in 2010. At the present he is the M.Sc. student in Electrical Power Engineering at South Tehran Branch, Islamic Azad University, Tehran, Iran. His research interest is design and simulation of damping circuit ferroresonance.