TRANSIENT ELECTROMAGNETIC COMPATIBILITY ANALYSIS OF PRESSURE SENSOR- COAXIAL CABLE CONNECTED TO THE CIRCUIT BREAKER

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Abstract

The electrical substations are usually are of interconnected with the high voltage protective and controlling devices along with low voltage electronic monitoring devices for the proper operations of the substations. The interconnection of electronic devices like temperature sensor, pressure senor and humidity sensor to the gas insulated switchgear system will be through the low voltage coaxial cable. The genuine measurement of the temperature, pressure and humidity depends on the sensor module and its connected cables to the switchgear system. The electromagnetic interference (EMI) that exists during the switching operation of switchgear system affects the interconnected electronic monitoring system through the low voltage cables. The low voltage coaxial cables are first to receive the transient electromagnetic interference. In this paper Electrical characteristics of transient interference are inspected and simulated based on the analytical model to measure the interference currents and current diffusion impedance during the switching operation of gas insulated switchgear system.

Introduction

The Electromagnetic interference conduction and radiation effect exists during the operation of equipment. These interference signal certainly affect the performance operation of the equipment. The quality of the equipment is checked by the Electromagnetic complicity (EMC) standards before installing it for the operation. The frequency of the EMI will vary based on the equipment operating conditions. In Electrical system the influence of EMI power level more and frequency range is less when compared to communication system. In the gas insulated (GI) substations interference signal exits during the switching process of the GI switchgears components such as circuit breaker and disconnectors.

The higher transient interference current and voltage will exist during the switching process of the switching devices is through the passive components. The secondary side equipment will undergo the EMI effect due to the circuit breakers and disconnectors. These protective devices will give rise the sudden interference voltage and current across the contacts. The higher voltage and current caused by the circuit breaker and disconnector will lead to the malfunctioning of equipment which is connected to the secondary side[1]. The main EMC characteristic of the substations is knowing the source of interference and interference destination. The analysis of EMC in the substation is to identify the propagation path and its intensity through the transmission line and the destination device. During switchgear steady state and transient operation, the noise generated and Electromagnetic fields at power frequency are to be considered for EMC analysis[2].

The connectors, cable assemblies and coaxial cables design has to be carried out, based on the radio frequency and microwave coupling in the system and in subsystem. The characteristic of the coaxial cable is based on the radio frequency coupling and shielding effectiveness when it connected to the different equipment's or devices[3]. The exact simulation of transient electromagnetic signals is based on the component model and its proper frequency range of DC to megahertz[4]. The interference signal frequency are higher in GI substations compared to normal substations during the switching operations[1].The convenient circuit model is consider for the simulation of switching transient current and diffusion current impedance through the coaxial cable which is connected to the sensor for the 63kV/20kV GI substations. The simulation is carried using PYHTON for the coaxial line parameters and the physical dimension of cable.

Analytical model and Simulation Result for the switching transient current through low voltage coaxial cable:

V_1 = Cable input voltage; V_2 = Cable output voltage; I_1 = Input cable current; I_2 = Output cable current; Z_0 = Characteristic impedance of the cable, α= propagation constant through the cable; R= Resistance of the cable; G= Conductance of the cable; L= inductance of the cable; C= capacitance of the cable; l= Length of the cable.

The output current equation is given by[1]

$$I_2 = \frac{V_1 - V_2 \cosh(\alpha l)}{Z_0 sinh(\alpha l)} \qquad (1)$$

$$Z_o = \sqrt{\frac{R+j\omega L}{G+j\omega C}} \qquad (2)$$

$$\alpha = \sqrt{(R+j\omega L)(G+j\omega C)} \qquad (3)$$

The input current at low voltage cable during the switching of circuit breaker

$$I_1 = \frac{V_2}{Z_o} sinh(\alpha l) + \left(\frac{V_1 - V_2 \cosh(\alpha l)}{Z_0 sinh(\alpha l)}\right) \cosh(\alpha l) \qquad (4)$$

The simulation is carried for the coaxial cable which used for the harsh environment pressure sensor[5] and the results were compared with the[1]. The cable parameters are based on[6]. The figure-1 shows frequency response of the transient current that occur at the input terminal of the cable during switching operation the GI circuit breaker. Form the result it is evident that the transient peak current in terms of kA appears at the low frequency range during the switch operation of the circuit breaker. However, the frequency range depends on the switching voltage of the circuit breaker.

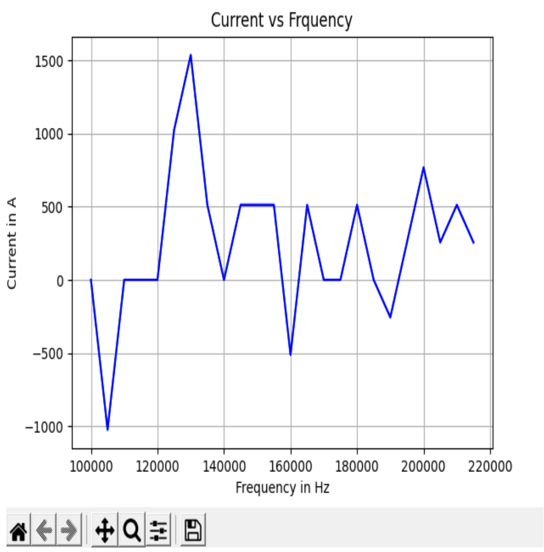

Figure-1 Frequency Response of the

Switching Transient Current.

Analytical model and Simulation Result for the Impedance of the diffusion transient current through low voltage coaxial cable shield:

Z_D = Impedance of the shielded cable during the diffusion transient current.

a = Shield internal radius; b= Shield outer radius; d= Diameter of the braided wire.;

$\sigma =$ Electrical conductivity; $\mu =$ Permeability;

Based on the analytical model derived from[7] and [8].

$$Z_D = r_o \frac{\gamma * d}{sinh(\gamma d)} \quad (5)$$

$$r_o = \frac{1}{2\pi d\sigma(a+b)} \quad (6)$$

$$\gamma = \sqrt{j\omega\mu\sigma} \quad (7)$$

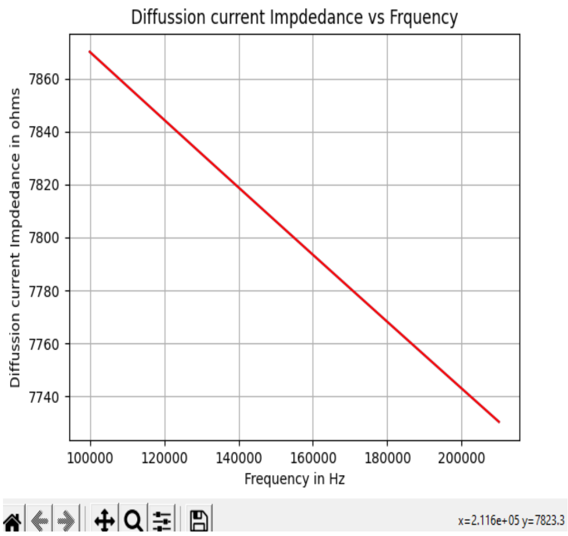

Figure-2 Frequency Response of the Impedance due to the Diffusion Transient current

The impedance of the coaxial cable used for the pressure sensor is analysed and simulated for frequency response of the impedance of the diffusion transient current for the shield coaxial cable. The obtained response is compared with the typical response obtained [8]. The figure-2 shows the simulated frequency response of the impedance due to the diffusion transient current for the shielding cable of pressure sensor [5] and [6]. Form the result is observed the impedance during the diffusion current is high at lower frequency and which the prevent the high transient current entering the cable during the low frequency switching of the GI circuit breaker.

Conclusion

The simple circuit model is analysed and simulated for the analysis of Electromagnetic interference and compatibility of the coaxial cable of the pressure used in the industrial environment. Based on the simple circuit model the more sophisticated model of EMI/EMC can also be analysed using different numerical techniques. before designing the low voltage cables for the secondary equipment of the switchgear systems. The proper selection of the interfacing coaxial cable capable of resistance to the transient electromagnetic interference depends the cable structure and shielding. The proper design of structure and shielding depends on the electrical characteristics of the cable during the switching of circuit breaker is most essential.

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