Simulation of Power Transformer for study of Inrush and Fault Current

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Abstract **– Power Transformer is important electrical equipment in power generating station which is used to change the voltage level as per the requirement without any change in power and frequency. Transformer is important device it need at all types of generating and distribution substation. Any discrepancy on transformer can lead to power failure so it needs to protection transformer from these types of faults. For protection of Transformer Buchholz relay was used it senses the internal fault. But it is only for oil immersed Transformer. This relay is used only for low voltage rating of Transformer. The limitation of this relay is that used in only oil immersed Transformer and it is gas actuated relay. At present for the protection of large power Transformer the differential relay is used. The main advantage of this relay is used is that it is used in all types of Transformer. It is widely used and most reliable method for all types of internal fault of Power Transformer.**

IndexTerms **– inrush current, fault current, differential relay.**

I. INTRODUCTION

Transformer are the most important part of electrical power system, which transfer the energy from one circuit to another circuit and changes the voltage level as per required. Its very costly device so proper care should be taken. It step up the voltage from generating station to overcome the losses and step down to the distribution substation to meet the industrial demands at the transmission to feed the high end consumers and then again step down to safety limits for the domestic used at distribution end. So protection of Transformer from faults that occur is inside and outside the Transformer protection zone is necessary [1].

II. SIMULATION OF TRANSFORMER

There are various different condition of Transformer. So to simulate all these condition of Transformer a software package is used is called PSCAD i.e. Power System Computer Aided Design which is developed by Manitoba HVDC research center[2]. PSCAD is tool provides to make transformer design as per requirement and simulate. To perform the simulation we need a Transformer data which can be taken from any electricity Board. Three phase transformer is used for simulating all operating condition and ratings of transformer are 315 MVA, 105 MVA each.

III. OPERATING CONDITION OF TRANSFORMER

There are various operating condition of Transformer which are detailed below:-

A. Normal Operating Condition:- In normal operating condition of Transformer rated or less current flow through the winding current flow through primary side of transformer will be equal to the current flowing through secondary side of transformer. So the differential current will be zero. Hence the differential relay will not operate.

$$I_d = I_1 - I_2$$

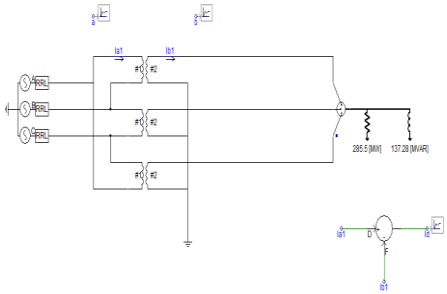

Figure: - 1. Simulation model of Normal Operating Condition

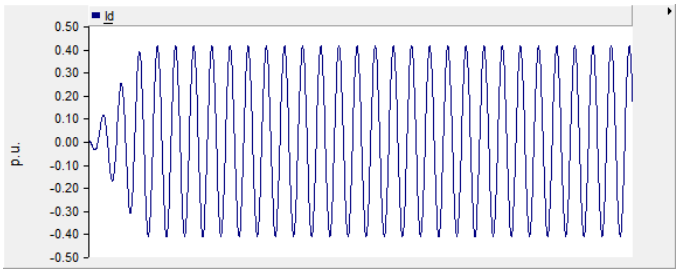

Figure: - 2. Waveform of differential current

B. Over excitation :- It can occur when the transformer is lightly loaded and line capacitance are more prevailing that can result in increased voltage on the transformer. As we know that Transformer operates at the slightly lower than the saturation to achieve the max flux density required, a little change in the flux can push to the transformer in saturation, thus as flux is proportional to the voltage/frequency ratio any increase in v/f ratio will increase in flux. This condition occurs when the rated V/F ratio exceeds 1.1.

Hence certain conditions are to be maintained to restrict over excitation

1. Applied voltage should not exceed the rated voltage by more than 110%

2. The frequency should not be lower than 95% of the rated frequency

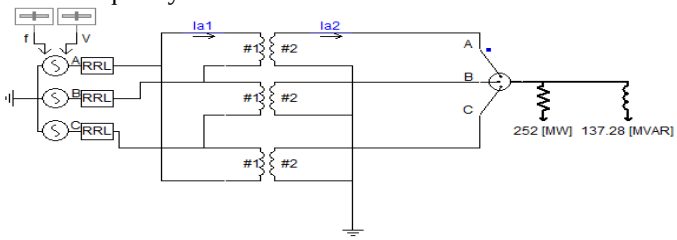

Figure: - 3. Simulation model of Over excitation

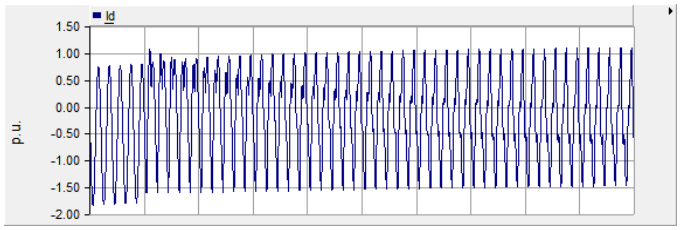

Figure :- 4 Differential current waveform

C. *Magnetizing and Sympathetic inrush:* - In this condition whenever transformer is energies from the fault recovery or at the time of commissioning, very high current flows in the primary winding that current is inrush current. Inrush current flows at the time of switching of the transformer due to the residual magnetism present in the core of the transformer, due to the remanence flux, at no load, transformer core at the time has not been completely magnetized hence it requires a large current to magnetized the core thus it goes to the saturation region .Inrush current can be as large as 5-10 times the normal rated current and flows for a 8-10 cycle[4].Sympathetic inrush current exist when a transformer placed in already energised transformer in parallel then the inrush current flows in the previously energised transformer[7]. When the transformer is energised by closing CB inrush produces which has a dc component the DC component can also saturate already energised transformer resulting in an sympathetic inrush sympathetic inrush flows due to closed path with low impedance between the two transformers.

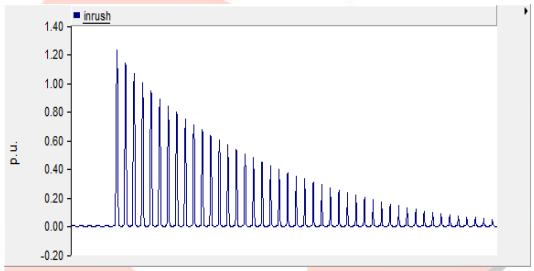

Figure :- 4 Differential current waveform

D. Types of Faults

1. External Fault: - The fault which occurs beyond the protected zone is called the external fault, like fault occur in the bus bar short-circuits on the transmission lines are examples of external fault. The overvoltage on the transformer can cause the external fault.

For this type of fault case the differential current relay should not operate because in this case different current is still look alike same as the normal current. We need require to not tripping the transformer in this condition.

There are four types of external fault

a. Line to ground fault
b. Line to line fault
c. Double line to ground fault
d. Three phase fault

2. Internal Fault: - The fault occurs inside the Protected zone of the Transformer is called Internal Fault.

1. Phase to Phase Fault: - The fault which occurs from one of the winding to other is called Phase to phase fault.

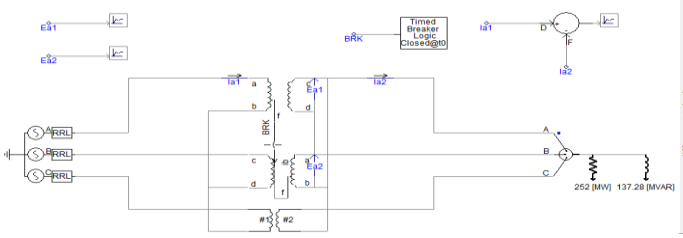

Figure: - 6.Simulation model of internal Fault

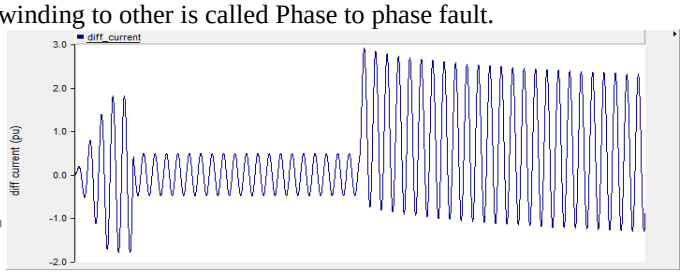

Figure :- 7 Phase to Phase Fault at 25% Fault

2. Phase to Ground Fault: - The fault which occurs from one of the winding to ground is called Phase to ground fault.

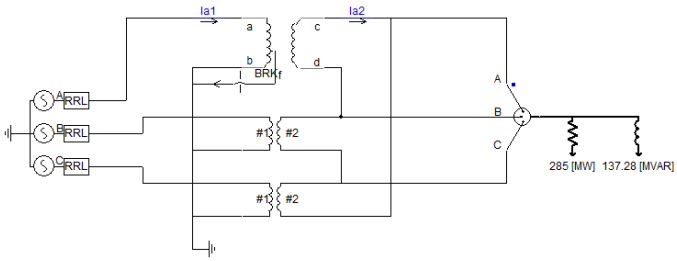

Figure: -8 Simulation Model of Phase to Ground Fault

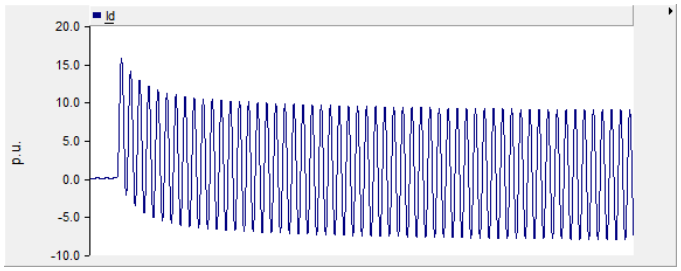

Figure :- 9 Phase to Ground Fault at 25 % Fault

IV. RESULTS

In various operating condition of Transformer there are various analyses has been seen here:-

1. For Normal Operating condition the primary and secondary current is equal so Differential current will be zero. Hence Differential relay will not operate in this condition.
2. For Over excitation condition there are two analyses has been seen here those are respectively Variable Voltage Constant Frequency (VVCF) and Constant Voltage Variable frequency (CCVF).

In VVCF when increasing the operating voltage with keeping Constant frequency it is observed that the differential current increases with respect to voltage.

In CCVF increasing the frequency while keeping the Constant Voltage it is observed that the Differential current decreases.

3. In Sympathetic inrush at normal the nature of inrush current behave like decaying nature. But after increasing switching angle inrush current shows decreasing in nature. When increasing the L/R ratio differential current increases slightly.
4. In Internal fault the phase to ground fault when fault location increases the differential current decreases.

V. CONCLUSION

Internal faults are very severe and dangerous there is always risk of fire it can damage the whole transformer and can cause instability to the system hence we need to concern about this fault and differential current relay should operate for this type of fault. So to discriminate the inrush current and fault current various techniques can be used like threshold technique and waveform identification technique. So for the correct classification of Inrush and internal fault current ANN technique is used. In which it provides the correct classification by using MATLAB. So the data is taken from PSCAD of various operating condition of transformer and it is sent to MATLAB. Then by using algorithm it provides correct classification between inrush current and internal fault current.

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