IMPROVEMENT IN PERFORMANCE OF RESTRICTED EARTH FAULT PROTECTION FOR POWER TRANSFORMER

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Abstract—Transformer digital protection system is one of the protection units used as restricted earth Fault protection which initially needs to be operate as fast and reliable protection Scheme for major Equipments. Improvement in performance of REF relay during transients and internal Fault occurs in transformer internal winding, and its need to be improve through proposed Scheme has to be implement in the Transformer Protection, thus Transformer Protection system which typically a fast response and is prone to mal operation of the relay in these paper represent through Simulation in MATLAB.

Index Terms—Current Transformer (CT), High Voltage winding (HV), Low Voltage winding (LV), Earth Fault (EF), Restricted Earth Fault (REF).

I. INTRODUCTION

Phase differential Protection is usually applied for the Protection of Power transformer in many cases it Provides a satisfactory level reliability and Safety.[4] However, Phase differential Protection is not sufficiently sensitive for detecting an internal phase to ground fault. If Fault is located near neutral Point of the transformer, or if the ground fault current is limited [2].

So, the Restricted Earth Fault (REF) Protection is used as an additional protection Method Provided in order to overcome this Problem [1]. As such, from star Connected Primary winding a simple over current earth- fault relay will not Provide proper Protection, especially if the neutral is earthed through neutral grounding impedance [1] .The Situation can be handle more efficiently with the use of restricted earth fault (REF) relay [3].

Thus, these scheme is capable of detecting the fault closer to the neutral end of the winding. The scheme can be equally applied for protection of the transformer with solid grounding of neutral [1]. In this case, because of the absence of neutral grounding impedance, the current is quite large. Since neutral Current is also measured and used as restraining quantity, it is possible to provide Protection Cover to the entire winding [1] .

A high impedance relay can be used to provide high-speed protection for winding faults and stability for outside faults. The REF scheme is quit simpler and is used independently on either side of the transformer for providing high-speed earth-fault Protection. In these paper present the problem of earth fault for Transformer Protection is identified and evaluate, improvement of REF relay in MATLAB Simulation [2] .

II. OPERATION OF REF RELAY PERFORMANCE

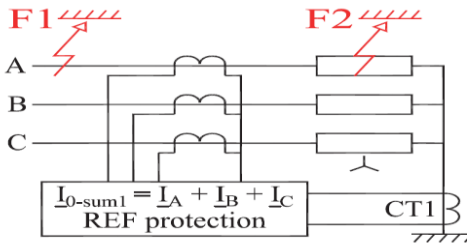


Figure 1: Basic block diagram of REF protection [4]

Operation of a REF relay is based on differential principle. The relay compares transformer neutral current with the sum of the Phase currents and thereby makes a trip decision. The REF relay operates for phase-to-ground faults of a grounded winding and also of the delta winding if a grounding transformer is installed between the delta winding and the CTs[1].

Protection system of a power transformer it is essential to be able to distinguish internal faults from external disturbances capable of causing false tripping. The makers of protective gear speaks of "protecting 80% of the transformer winding" which means that faults in the 20% of the winding near the neutral point can not cause tripping i.e. this portion is unprotected. So, to find out remaining 20% of the winding near the neutral point can be Protection through REF relay.

Various scheme arrangements of REF relay Performance :

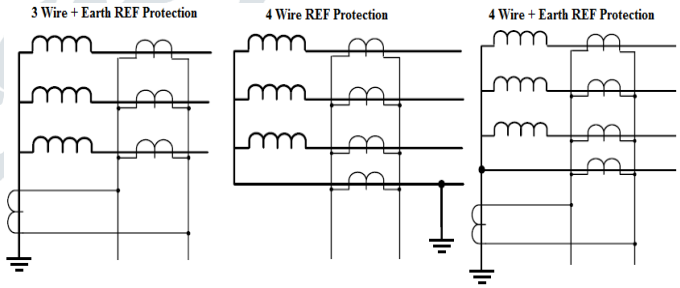


Figure 2: types of REF relay scheme on line diagram [3]

a. AC Connection- Restricted Earth Fault 3 Wire, 3 CTs
b. AC Connection- REF 3 Wire + Earth, 4 CTs
c. AC Connection- REF 4 Wire , 4 CTs
d. AC Connections-REF 4 Wire + Earth , 5 CTs

III. EARTH FAULT ON A TRANSFORMER WINDING:

Under balanced conditions the phase currents have equal magnitude and are displaced in phase from each other by $2\pi/3$ rad. So, currents which are fed to primary windings of the current transformers sum to zero. If a relay set to operate at 0.3A were used and this Protected 80% of the winding, then reducing the setting to 0.2A would provide protection for faults on 90% of the turns such as increase in sensitivity would, however increase the difficulty of maintaining stability during external faults.

IV. SIMULATION ON REF RELAY RESPONSE UNDER POWER TRANSFORMER INTERNAL FAULTS :

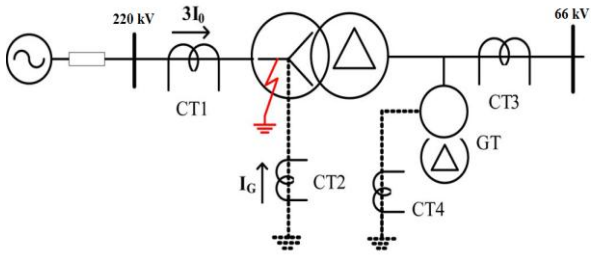


Figure 3: Single line diagram on study system [1].

The Power transformer protection is developed in MATLAB Simulation to evaluate the impact of internal faults at star with grounded neutral side or a HV winding side. If LV winding is delta connected transformer So [1] , Grounding transformer (GT) is used as with the vector group of YNd is connected to the power transformer LV side and its zero sequence impedance is determined so that the LV side phase to ground fault Current is limited to the power transformer rated current. The impedance is 63.5Ω [1] .

A. Test Procedures for REF relay Performance:

The Procedure for the REF relay testing, for internal faults only.

Step 1) let us take three winding transformer Tapping provided on three phase transformer in single phase A.

Step 2) internal fault occurs in the transformer winding through various CB Switching states up to 10 Switching states C1 to C10.

Step 3) In various switching states REF relay which is Simulate on MATLAB So it will be measure difference between the ($3I_0$-I_N).

Step 4) operating Condition of the REF relay it makes a trip decision on Relay Setting is 20% so pick up current is 0.2A.

This Simulation studies for internal faults at the transformer HV side is 220kV and LV side is 66kV in HV winding show that earth faults within the lower 10% of the Solid grounded winding, these close to the neutral point, that are not detectable by the differential unit. So, this region it should be protected by REF Relay [1] .

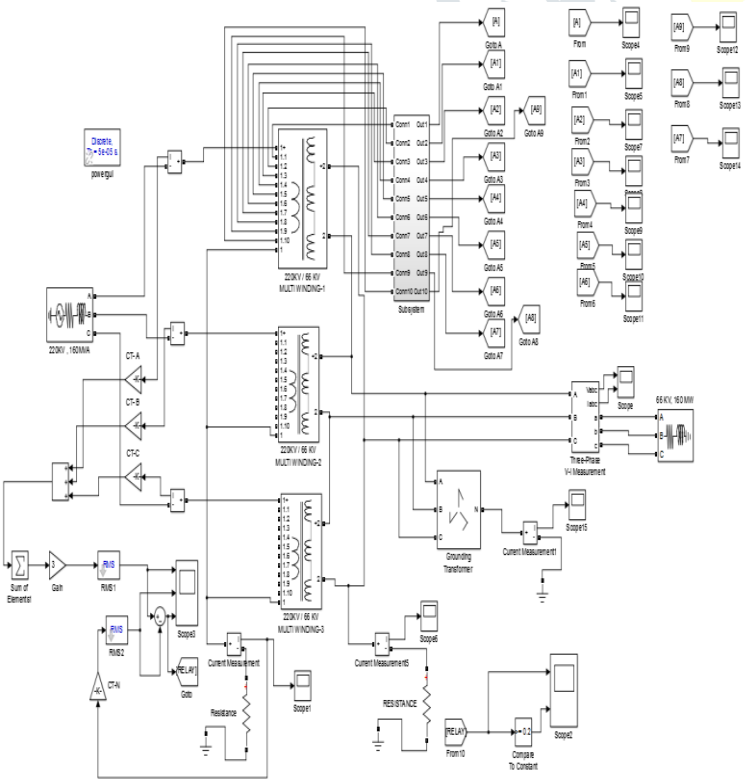
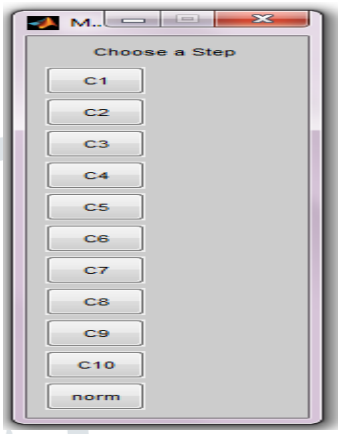


Figure 4: Simulation on REF protection for star-delta connected transformer.

Three phase transformer internal fault occurs in phase A in three winding transformer so multi winding transformer used in MATLAB, here internal fault to generate Circuit Breaker Switching states at 0.04 second in various tapping provide in phase A in which percentage of winding cover through transformer.

Transformer is rated as 160 MVA and 220 kV/66 kV such as fault current passes through CT primary winding and CT ratio as 600/1 A so percentage Relay Bias Setting is 20% such as pick up current for REF relay is 0.2A. therefore operating condition of REF for transformer protection it should be greater than or equal to 0.2A or operating region it should be protect through Relay at HV winding of the transformer as greater than 0.2A and Relay will be protect at various CB switching C1 to C8 (0.04 second) so protection of winding it should be cover through 85% of the winding Protection.

B. Model Properties used as a Switching C1 to C10:



C. STAR-DELTA TRANSFORMER WITH GROUNDED NEUTRAL OF (SUBSYSTEM) WITH SWITCHING 0.04 SECOND:

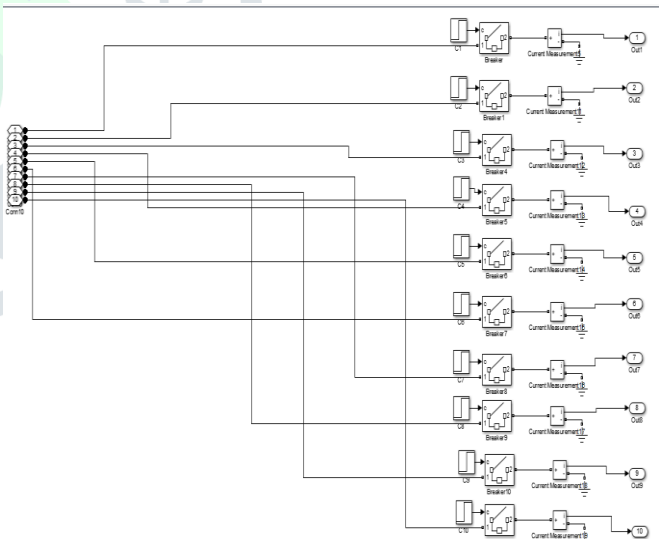
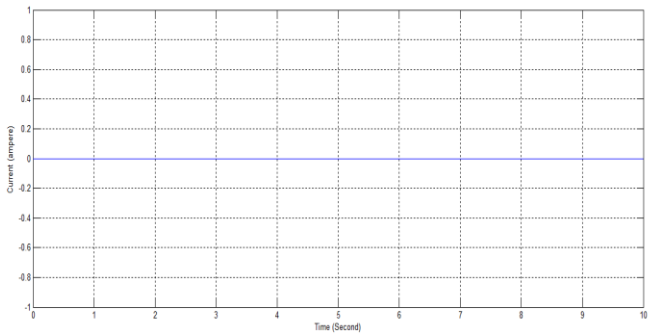


Figure 5: Transformer internal fault occurs through CB Switching.

Transformer Internal Fault occurs through model properties of Switching C1 to C10 states and Circuit Breaker Switching is to Generate internal Fault occurs in the transformer Winding in phase A, so fault current which is sense through CTs and phase current are sum of the three phase is $3I_0$.

Fault Current also passes through the neutral CTs and Relay will be measure difference between the Sum of the three phase current $3I_0$ and neutral Current I_N and REF relay takes the trip decision whenever ($3I_0$-I_N) current is above the pick up current passes through the relay and operating condition is to satisfy by Relay setting is 20% of the REF relay [1] .

D. Normal operating Condition of REF relay:



In REF relay performance whenever normal Condition of the relay passes through the difference between the ($3I_0$-I_N) is zero so operating region of the relay condition is below pick up current at that time relay should not be operate [1] .

V. REF RELAY PERFORMANCE IMPROVEMENT

Proposed scheme has to be implemented in REF relay performance evaluation so evaluate the performance a characteristic which is set the relay pick up value.

A. Performance of the REF relay at Switching (0.04sec) C1 :

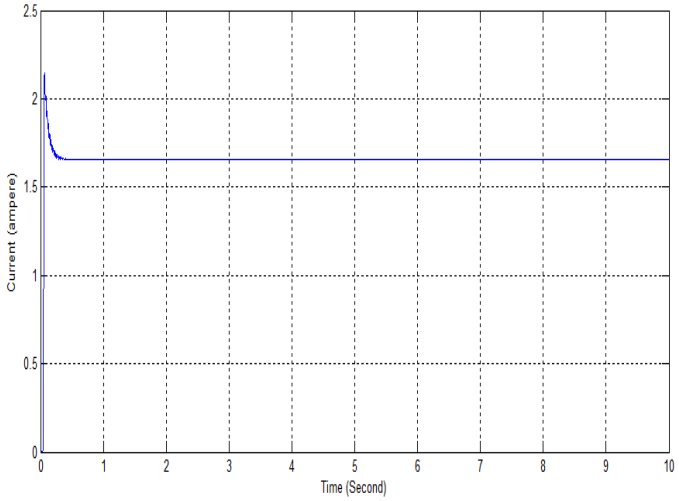


Figure 6: transformer fault occurs at switching C1 (0.04sec) that current passes through sum of three phase current $3I_0$

REF relay performance Enhance the transformer winding fault internally at that time Sum of three phase current will be measured in three phase is $3(I_a+I_b+I_c=I_0)$ it can be measured in simulation study through REF relay performance scheme under abnormal condition of the power system [1] .

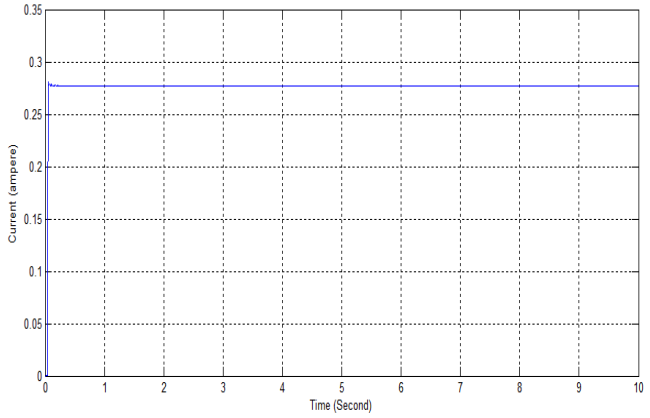


Figure 7 :transformer fault occurs at switching C1 (0.04sec) that current passes through neural current flow I_N

Fault current passes through the neutral CTs so relay will be measured neutral current and it takes the tripping mechanism of the REF evaluation scheme by percentage bias setting is 20% And it perform by ($3I_0$-I_N) value it should be greater than or equal to 0.2A.

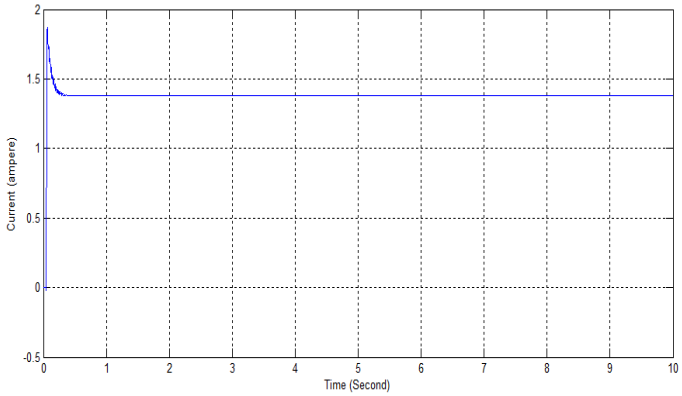
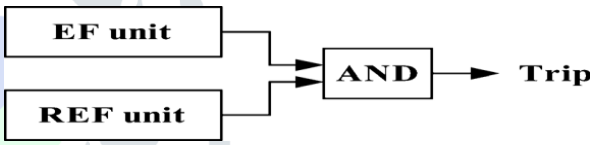


Figure 8: transformer fault occurs at switching C1 (0.04sec) that current passes through difference ($3I_0$-I_N)

REF relay performance Result indicate the value of REF relay current passes through the ($3I_0$-I_N) is equal to 1.40A so its value is greater than or equal to relay setting is 0.2A so Relay should be operate.

Similarly other Switching state result indicate C1, C4 , C7 , C10 operate and result will be identified by C9 and C10 Switching state in these region REF relay cannot trip so it should mainly 85% of the transformer winding cover through REF relay performance.

B. REF RELAY PERFORMANCE RESULT BY VALUATION OF PROPOSED SCHEME [1]:



Setting for the Earth Fault relay is below the REF relay unit so first EF unit is to operate the abnormal condition and there after REF unit [1] .

It should be operate so in between this two unit Time delay put up in Relay setting. For example Proposed Earth Fault unit Setting is 16% and REF relay Setting is 20% it should be set to operate REF relay and it takes the trip decision.

TABLE I: SIMULATION RESULT OF REF RELAY PERFORMANCE FOR TRANSFORMER PROTECTION

Types of fault	Switching instant (0.04sec)	Sum of three phase fault current	Neutral current	Difference between (3I0-In)	Operating condition of relay
A-G	C1	1.68	0.28	1.40	operate
A-G	C4	1.60	0.40	1.20	operate
A-G	C7	1.290	0.55	0.74	operate
A-G	C10	0.268	0.232	0.036	In-operate

In Simulation result of above table indicate the REF relay operation at Switching states C1, C4, C7, in these three case study of the state Relay operate as 20% Relay setting and pick up value of the Relay is 0.2A so operating condition of the Relay is Above 0.2A of the Current and it takes trip decision should be greater than or equal to 0.2A. here C9 and C10 switching state Relay does not operate so 85% of transformer winding will be protect through REF.

VI. CONCLUSION

Power transformer protection method generally used as differential protection in phase to phase fault occurs internal winding fault But phase to earth fault occurs in the transformer so it is less sensitive to protect the transformer winding internally at that time REF relay is used as 85% protection cover through transformer whole winding compare to differential protection which is protect 80% of the whole winding, Thus we have conclude that in our case study REF relay can be use to operate as Switching C1 to C8 (internal fault only) but C9 and C10 switching states relay can not be operate so near the neutral winding relay can not take tripe decision through last two switching so 15% of the winding is not protect through REF relay.

TABLE II
APPENDIX
POWER TRANSFORMER PARAMETERS

Technical Data	Rated Values
Rated Power	160 MVA
Rated Primary Current	600 A
Rated Secondary Current	1 A
HV rated voltage	220kV
LV rated voltage	66kV
Short-circuit Impedance	16%
Total winding reactance over resistance	40

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