OVERCURRENT RELAY COORDINATION FOR PHASE AND EARTH FAULTS USING ETAP

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Abstract- Power system protection and control has always been a subject of concern during emergency conditions in a power system like a zero power condition or blackout. Therefore in order to prevent such conditions, protection system needs to be strong and reliable. Relays form the basis of any power system protection system whose operation settings should be in such a way that it provide correct discrimination and prevent any power blackout. In this paper, coordination of over current relays for a66KVindustrialsystem is done using ETAP (Electrical Transient Analysis Program) software for phase and ground faults. The star view of ETAP software is its unique feature which is helpful in coordinating the overcurrent relays correctly. The load flow results for the system are also shown in the paper.

Index Terms- Overcurrent Relay, Relay Coordination, Radial System, ETAP software

I. INTRODUCTION

Overcurrent Relays are the simplest type of protective devices available. It is easy to set the pick up values of individual relays but the problem arises when each relay has to be coordinated with every other relay in the system. This problem is further aggravated when there are large interconnected systems. The unique feature of ETAP software i.e. the star view is very useful in case of large interconnected power systems. Thus, this paper shows the overcurrent relay coordination of a given system using ETAP's star view. The important characteristics of an overcurrent relay are: selectivity, reliability and discrimination. For any kind of fault be it symmetrical or unsymmetrical, the overcurrent relay has to operate efficiently and provide correct discrimination. The overcurrent relay settings must be set such that it operates for only the faults nearby it or the primary faults.Also these relays should operate after a certain time lag and act as back up protection for other relays.

II. SYSTEM DESCRIPTION

A system is delivering 7.7 MW to its loads of which 5.2 MW is fed from the grid and 2.5 MW is fed from one generator. There are three generators in the plant, of which one is under maintenance, one in cold standby and one is running. The system is shown in Fig.1. All the three generators have same ratings i.e. 7.8 MW, 18% steady state reactance, connected to the 6.6 KV bus. The two transformers present in the system also have same ratings of 25 MVA, 66/6.6 KV, %Z = 15.63%.The loads which are connected to the system, mainly consist of motor loads. Here these are assumed to be lumped loads of 5.4 MVA and 4.5 MVA respectively.Two capacitors of 4 MVar ratings are present on the two sides of sectionalizing circuit breaker. Firstly load flow analysis is performed on the system to check its load – generation balance.

III. LOAD FLOW REPORT

Results of the load flow are shown in appendix 1.

IV. RELAY COORDINATION CONCEPT

The basic rules for correct relay co-ordination can generally be stated as follows [1]:

a. whenever possible, use relays with the same operating characteristic in series with each other

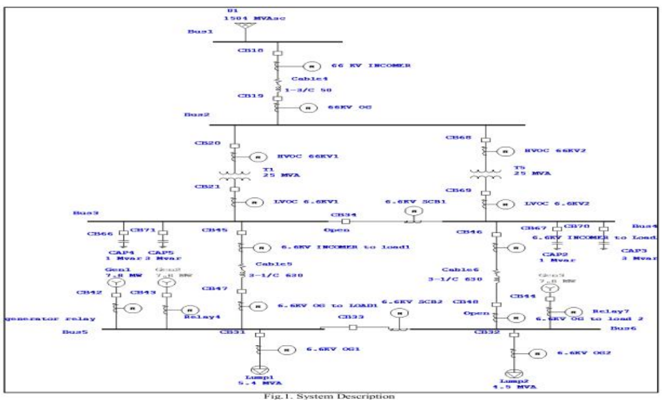

Fig.1. System Description

b. make sure that the relay farthest from the source has current settings equal to or less than the relays behind it, that is, that the primary current required to operate the relay in front is always equal to or less than the primary current required to operate the relay behind it.

Also following parameters for the various devices connected to the system must be considered [2]:

1.a.The overcurrent relay coordination curve for the feeder must lie below the feeder overload and feeder short circuit damage curve on the time – current characteristics graph.

1.b. Also the overcurrent relay coordination curve for the feeder must lie above the ampacity curve of the feeder.

2.a.The overcurrent relay coordination curve for the transformer must lie below the transformer through fault mechanical and thermal damage curve.

2.b. Also the overcurrent relay coordination curve for the transformer must lie above the ampacity curve and the magnetizing inrush points of the transformer.

3.a.The overcurrent relay coordination curve for the generator must lie above the generator full load ampere curve of the generator.

3.b. Also the overcurrent relay coordination curve for the generator must lie below the decrement curve and the overload curve.

The flowchart for the relay coordination procedure is shown in figure 2 below.

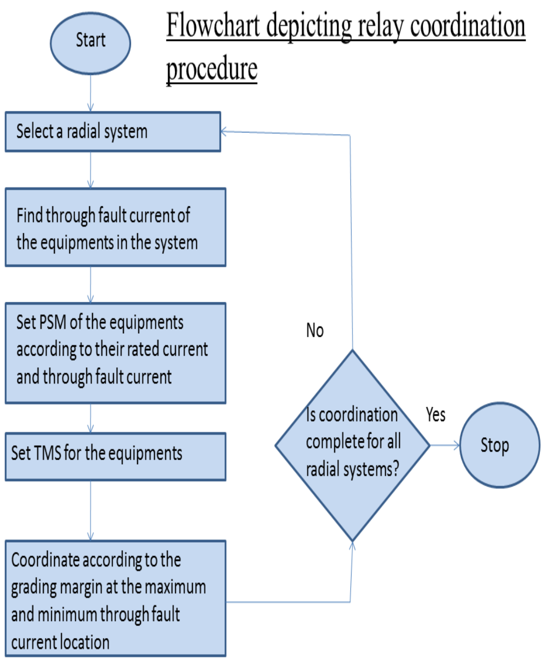

Figure 2. Relay Coordination Procedure.

V. RELAY COORDINATION SETTINGS

The relay current setting is given by Plug Setting Multiplier (PSM) and the time settings are given by the Time Dial Settings.

The formula for finding the PSM is given by:
PSM = (Through Fault Current)/(CT Ratio)*(Relay current setting)

For example the overcurrent relay (51 & 51G) settings are shown below for 66KV Incomer relay:
66KV Incomer Relay
GROUP -51
Relay type used = 7SJ80
CT ratio Primary = 800 A
Secondary = 1 A

Backup Calculation :

Ampacity of the cable = 705 A
Current seen by the CT = 705/800 = 0.88125
O/C PSM with margin at 110% = 0.96
Time Setting = 0.13
Curve type= Inverse

GROUP -51G

Relay type used = 7SJ80
CT ratio Primary = 800 A
Secondary = 1 A

Backup Calculation:

Ampacity of the cable = 705 A
Current seen by the CT = 705/800 = 0.88125
O/C PSM with margin at 120% = 1.05
TMS = 0.14
Curve type = Inverse

The relay current and time settingsfor all other relays in the system are shown in the table in Figure.3. The earth fault settings for the relays is generally 20 -30% of the rated current of the system.

The time interval that must be allowed between the operation of two adjacent relays in order to achieve correct discrimination between them is called the grading margin. If a grading margin is not provided, or is insufficient, more than one relay will operate for a fault, leading to difficulties in determining the location of the fault and unnecessary loss of supply to some consumers.The grading margin depends on a number of factors [1]:

i. the fault current interrupting time of the circuit breaker (40 ms)
ii. relay timing errors (10 ms)
iii. the overshoot time of the relay (20 ms)
iv. CT errors (100 ms)
v. final margin on completion of operation (30 ms)

Here for this system, the grading margin is chosen as 200 ms = 0.2 seconds by taking the summation of the above factors.

S.No.	Relay Name	Relay Type	Phase Fault Settings		Earth Fault Settings	
			Plug Multiplier Settings(PSM)	Time Dial Settings (seconds)	Plug Multiplier Settings(PSM)	Time Dial Settings (seconds)
1.	66KV Incomer	Inverse	0.96	0.13	1.05	0.14
2.	HVOC	Inverse	0.874	0.4	0.874	0.34
3.	LVOC	Inverse	1.04	0.33	0.962	0.3
4.	6.6KV Incomer to load1	Inverse	3.26	0.13	3.55	0.16
5.	6.6KV OG1	Inverse	1.03	0.14	1.13	0.2
6.	6.6KV OG2	Inverse	1.08	0.05	1.18	0.08

Figure 3. Relay Settings for the system.

VI. RELAY COORDINATION CURVES

The relay coordination curves for phase and earth faults in the system are shown in figure 4 & 5 respectively.

Firstly the relay current settings (PSM) as calculated are fed for each relay along with initial time settings. Then the minimum and maximum through fault current of the system is calculated as shown by the points (13999, 1.21s) and (15062, 1.1s) approximately in figure 4 & 5 respectively. For this band of maximum and minimum fault currents the relay curves are adjusted according to the grading margin (0.2 seconds). This way the relays are coordinated using the star view of ETAP software.

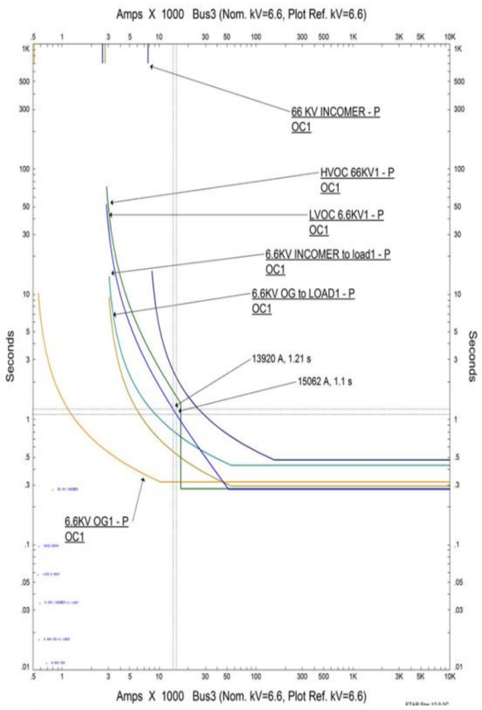

Figure 4. Overcurrent Relay Coordination curves for phase faults.

CONCLUSION

The overcurrent relays are the most important protection devices in a distribution system. They need to be set properly so that they provide correct discrimination and act as primary as well as back up protection devices.

Hence in this paper the overcurrent relay coordination for earth and phase faults using the star view of ETAP software is clearly depicted. The coordinated curves for phase and earth faults are shown and the settings for each relay is shown in the table. The procedure for overcurrent relays using the unique star view of the ETAP software is clearly depicted.

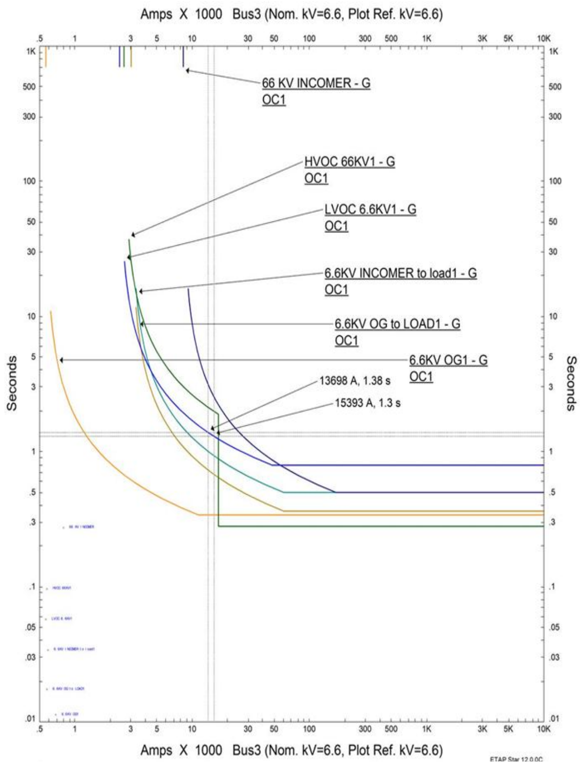

Figure 5. Overcurrent Relay Coordination curves for ground faults.

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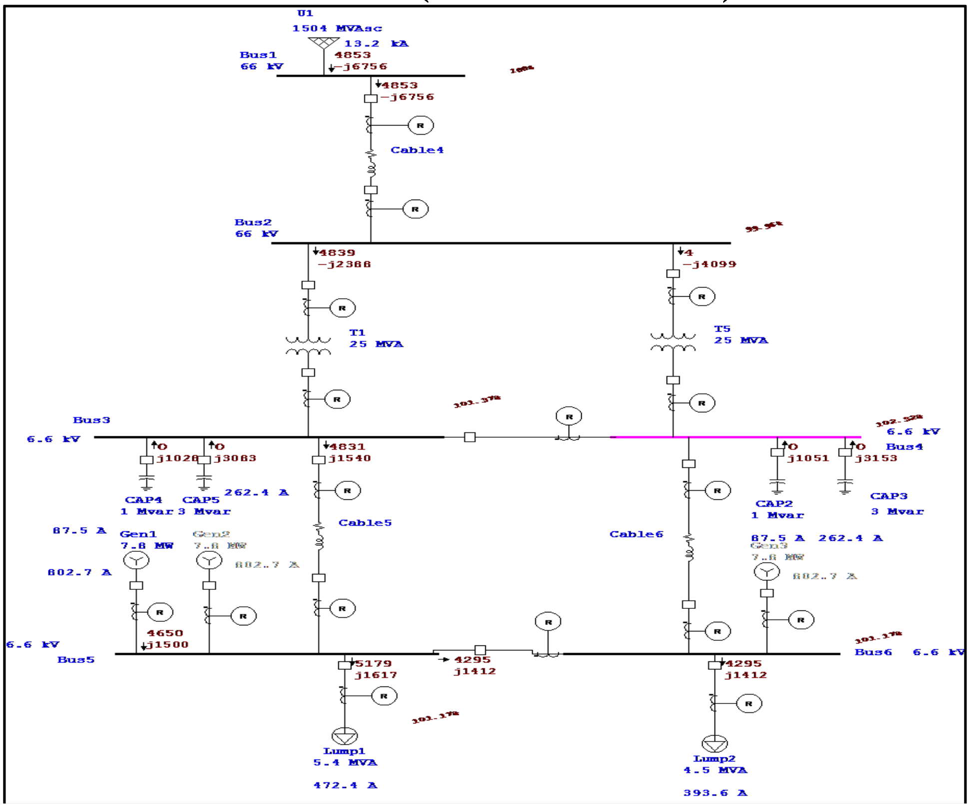
APPENDIX – 1 (LOAD FLOW RESULTS)



Bus			Voltage		Generation		Load			Load Flow					
ID															
		kV	% Mag.	Ang.	MW	Mvar	MW	Mvar		ID	MW	Mvar	Amp	%PF	%PF
Bus1		66	100	0	4.853	-6.756	0	0		Bus2			4.853	-6.756	72.8
Bus2		66	99.957	-0.1	0	0	0	0		Bus1			-4.843	6.487	70.9
										Bus3	4.839	-2.388	47.2	-89.7	
										Bus4	0.004	-4.099	35.9	-0.1	
Bus3		6.6	101.369	-1.8	0	0	0	-4.11		Bus5			4.831	1.54	437.6
										Bus2	-4.831	2.57	472.2	-88.3	
Bus4		6.6	102.519	-0.1	0	0	0	-4.204		Bus2			0	4.204	358.7
Bus5		6.6	101.169	-1.9	4.65	1.5	5.179	1.617		Bus3			-4.824	-1.529	437.6
										Bus6	4.295	1.412	390.9	95	
Bus6		6.6	101.169	-1.9	0	0	4.295	1.412		Bus5			-4.295	-1.412	390.9

★★★