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Study Over Current Relay (MCGG53) Response using Matlab Model

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Abstract - *Proper coordination of protective relays at substation renders a significant part in the safe operation of power system. The principal aim of coordinating protective relays in a power system network is to obtain selectivity without sacrificing sensitivity and fast fault clearance time. In order to minimize outages, proper coordination of protective relays must be ensured. As a result of increased urbanization, a substantial increase in electric power demand has been recorded in recent years. But, owing to ineffective coordination of relay operation, there has been limited expansion in the system. This paper presents the design of a MATLAB Graphical User Interface (GUI) model of overcurrent relay (extremely inverse, standard inverse, and very inverse) using various characteristic equations in order to determine the parameters of the different relay. This paper further presents the relay coordination and setting for a over current relay type (MCGG53). The time multiplier setting (TMS), plug setting (PS) and actual operating time of the different relay was ascertained.*

Key Words: Over-current relays, Time multiplier setting (TMS), Plug setting (PS), Relay coordination, MATLAB.

1. INTRODUCTION

Conventionally Over Current (OC) relay settings are provided based on full load current of power system components. Time Dial Setting (TDS) and Type of curve are chosen to ensure that the coordination with the downstream relays.

This conventional procedure for setting the relays went well for a long time. However introduction of Embedded Renewable Generation, Cogenerate on in plants in process industries and islanding from the grids, Change in the Grid Topology etc. results in the drastic change in the fault current. This leads to problems like nuisance tripping of relays, improper coordination or longer time taken to operate the relays for a fault. Situation got worse in the continuous addition of renewable generation, most sophisticated grid islanding schemes, Energy efficient motors which draws high starting current, technological advancements in controlled switching for transformer and reactor to reduce the inrush current etc. made the conventional of relay setting obsolete. These technological advancements along with new feature in the modern numerical relays provide a better platform to coordinate the relays to reduce the operating time of relay, prevent the nuisance tripping and ensure the coordination between the relays in all the grid topologies[1].

Overcurrent Relays utilized in power systems protection as economical protective devices. Overcurrent relays are used as main protection devices in Low Voltage Radial systems and as backup relays to distance and differential in High voltage interconnected transmission and sub-transmission system.

2. SYSTEM DESCRIPTION

Figure 1 shows a simplified model of the system under review. The generator supplies active power P and reactive power Q to the network. A fault between all three phases and ground (that is, ABC-G) shall be explored. The multiple-run component is used to activate the fault at different points on the voltage waveform.

During a three phase-to-ground fault, the entire system is unbalanced. While this type of fault does not occur frequently, its results are used for protective device selection, because this fault type generally yields the maximum short circuit current values.

Firstly load flow analysis is performed on the system to check its load – generation balance.

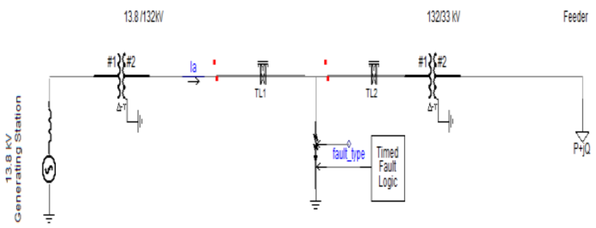

Fig -1: System description

3. OVERCURRENT RELAYS COORDINATION

The protection relays have to operate in a way that should provide adequate selectively by isolating the fault through opening the circuit breakers. This requires coordination of protection functions between the protective relays. Time grading, current grading or unit protection methods are commonly used to provide the required coordination between the relays.

In the time grading method, the protection relays in successive zones are arranged in time so that only the relays near to the fault operate first. For this purpose, definite time relays are used and it is independent of the level of fault current. However, as a disadvantage, the relay near to the source (with highest fault level) clears the fault with longer time delay.

To overcome the limitations of current based and time-based grading, the inverse time overcurrent relay characteristic was developed. The inverse time characteristics are defined by standard curves. In Table 1.

Table -1: IEC 60255 Standard Characteristics [6]

Relay Characteristics	Equations (IEC 60255)
Standard Inverse (SI)	$t = \text{TMS} \times \frac{0.14}{I_r^{0.02} - 1}$
Very Inverse (VI)	$t = \text{TMS} \times \frac{0.13.5}{I_r - 1}$
Extremely Inverse (EI)	$t = \text{TMS} \times \frac{80}{I_r^2 - 1}$
Long Time Standby Earth Fault	$t = \text{TMS} \times \frac{120}{I_r - 1}$

Where: Ir = I/Is, Is is the relay setting current, I is the measured current, TMS is the Time Multiplier Setting. High-set instantaneous element is used to reduce the tripping time and improve the system grading at high fault currents. This becomes very effective when the source impedance is not large enough when compared to the protected circuit impedance [6].

For the (MCGG53) coordination of the case study, the protection arrangement shown in Figure 1 has to be referred. The Standard Inverse (SI) characteristic curve is chosen for the inverse time protection relay. Firstly, the operating time and time multiplier setting (TMS) for the furthest relay from the source has to be determined. The flowchart for the relay coordination procedure is shown in figure 2.

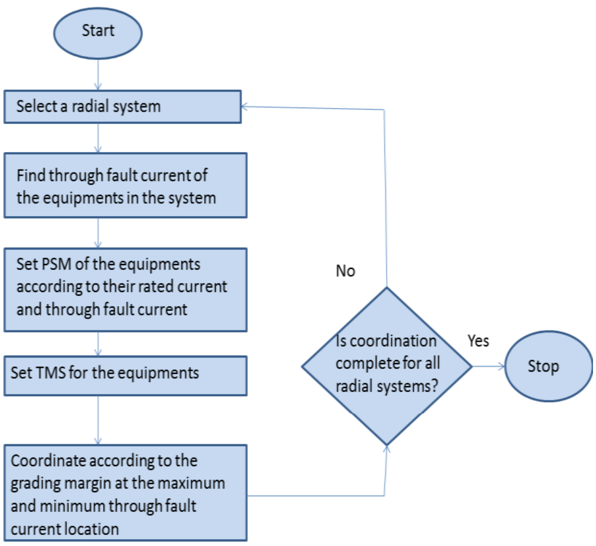

Fig-2: The flowchart for the relay coordination procedure

The smallest available TMS in the relay has to be selected if there are many relays to be coordinated in series (e.g. for MCCG53 relay, TMS=0.05 can be used from the characteristic curve figure 3. Then, if the t_n, TM'n, In, I_{pn} are downstream relay's operating time, time multiplier setting, maximum fault current and peak up current respectively, the operating time of the of this relay can be calculated as:

Table- 2: Typical Relay Timing Errors – Standard Relay

Times	Relay Technology			
	Electro-Mechanical	Static	Digital	Numerical
Typical basic timing error (%)	7.5	5	5	5
Overshoot time(s)	0.05	0.03	0.02	0.02
Safety margin(s)	0.10	0.05	0.03	0.03
Typical overall grading	0.40	0.35	0.30	0.30

Where: In is the fault current for the downstream relay; In+1 is the fault current for the upstream relay. Ip_n+1 the pickup current for the upstream relay; TMSn+1 is the time multiplier setting for the upstream relay.

Table- 3: Setting Results for Protection Relay

Feeders	Function	Pickup Current	TMS	Curve (IEC)	Time (s)	In
33kV	51	0.6 x In	0.3	Normal	-	400/1
	50	4.9 x In	-	Definite	0.05	

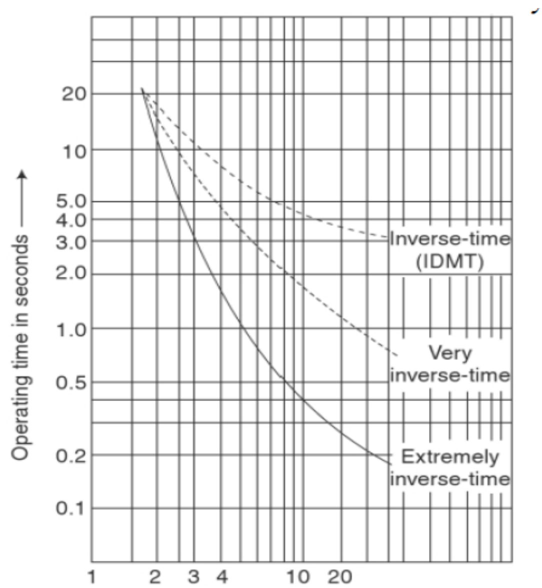

Fig-3: The characteristic curve for relay MCGG 53.

4. System fault study

Figure 4 shows a simplified model of the system under review. The generator supplies active power P and reactive power Q to the network. A fault between all three phases and ground (that is, ABC-G) shall be explored. The multiple-run component is used to activate the fault at different points on the voltage waveform.

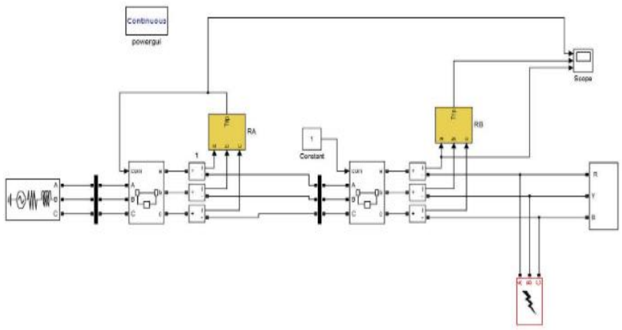

Fig- 4: Simplified model of the system.

From Figures 5, it can be observed the input signal is assigned to the relay.

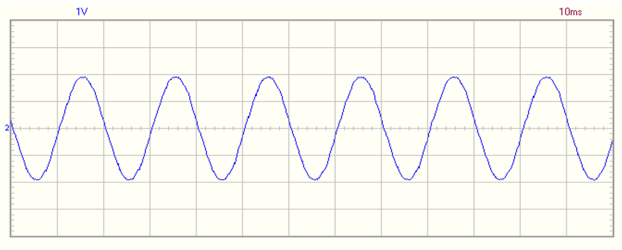

Fig-5: The input signal is assigned to the relay.

In this case, we will connect the output terminals of O / C relay, in case of load (actual state), and draw the response signal (connection) of the O/C relay, as in Figure (6).

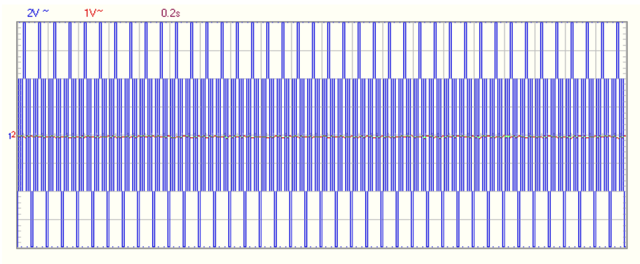

Fig- 6: The response signal of the over current relay

Note that the response signal for the O / C relay is as shown in Figure. 7, where the separation time depends on the relay calibration. The separation time is different whether it is instantaneous (i.e, moment of failure) or after a specific period of time through relay curves, It should be noted that the value of the current is greater than the current rated value as in Figure 8.

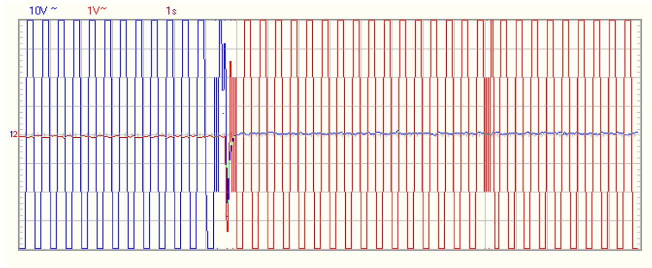

Fig-7: Relay signal in case of separation (excessive current)

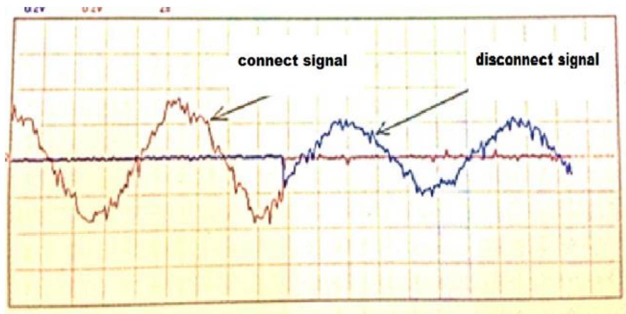

Fig- 8 : Response of both the rated current and the instantaneous current.

5 .RESULTS AND DISCUSSION:

Relay co-ordination settings are generally based on their characteristic curve, which indicates the speed of operation. The characteristics are: (1) Standard Inverse (2) Very Inverse and (3) Extremely Inverse.

The respective values of actual operating time and time multiplier settings recorded from the simulation of the different overcurrent relay characteristics are shown in Figures 7nd 8 and . The time of operation of these relays varies, with the extremely inverse relay the smallest, followed by the very inverse and standard inverse. It would be observed that the three relay characteristics must be considered during the relay setting. The standard inverse characteristic takes care of faults within the utility substation. The very inverse characteristic takes care of fault at the mid-point of the feeder while the extremely inverse characteristic takes care of fault at the far end of the feeder.

6. CONCLUSION:

The relays in the power system are to be coordinated properly so as to provide primary as well as back up protection, and at the same time avoid malfunction and hence avoid the unnecessary outage of healthy part of system. In this paper, the operating time of the relays was determined using a MATLAB model. Thus it can be concluded that the results obtained showed the proper coordination of the different overcurrent relay characteristics.

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