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Study of Sensitivity and Selectivity of Protection Coordination Settings for 110kV Network in Western Region of Saudi Arabia

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Abstract

The large number of protection devices which spread on the network makes the protection systems study and review it difficult especially manually because it needs long time and much effort, because these settings must be coordinated among a lot of protection devices on the entire network. The major issue is the contribution of the whole system to the faulty point, which is called Infeed Problem.

The goal of this paper is to review the existing protection and coordination, evaluate the sensitivity and selectivity of the protection system across the network and implement new coordination with the proper setting by using Computer Aided Protection Engineering (CAPE) program.

INTRODUCTION

With expanding on the transmission network, reroute the transmission lines and expansion due to the growing in the demand which makes building new substations necessary. Also, this expanding will affect the protection systems and their devices significantly and makes protection engineers in a big challenge. Thus, the protection engineers must focus on two major points: selectivity and sensitivity. Selectivity of relays to work in a correct time and a correct order without any overlapping coordination. Sensitivity of the relay is to detect any fault and work properly to avoid any mal-operation or restrains.

It is not enough there are reliable relays because it was a known when the fault occurred many relays will catch it. So, it is reliable. But not the important thing is just catching a fault, the importance it is capable of deciding is this fault in its border or outside it? Hence, one of the essential requirements for the relays is the selectivity, and that is mean the relay can decide to open the breaker or not. In the Fig. 1 almost all relays will sense the fault F1, but the problem is if the relay 9 worked before relay 15.

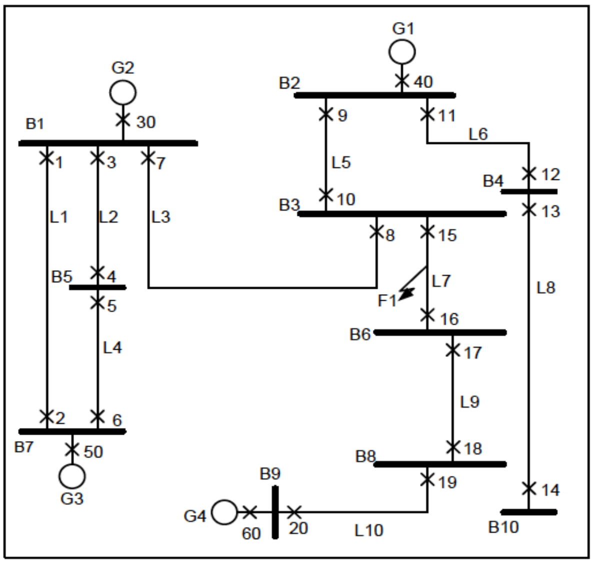

Figure 1

With the growing of the expansion, the protection engineers face a difficult to undertake the coordination and settings relays manually. In fact, this option is impractical and the probability of errors will increase and the protection engineers will remain in fear of relay mal-operation or restrains. However, with the existence of network simulation and protection devices performance analysis software, relay setting and coordination become more accurate and easy. Therefore, the protection engineers have a confidence in doing coordination on the entire network.

STATEMENT OF THE PROBLEM

The growing-up, expansion of transmission network, interconnections and line rerouting make protection system more complicated. So, most of the settings that implemented on reality inside protective relays may be impractical, and may even cause mal-operation or no-operation for protection devices due to the difference on the network diagram.

The large number of protective devices which spread on the network makes the protection systems study and review it difficult especially manually because it needs long time and much effort, because these settings must be coordinated among a lot of protection devices on the entire network. The calculated setting can't be done for relay in complicated network. The major issue is the contribution of the whole system to the faulty point, which is called Infeed Problem.

DEFINITION OF THE GOAL

The goal of this paper is to review the existing protection and coordination, evaluate the sensitivity and selectivity of the protection system across the network and implement new coordination with the proper setting.

The key components of the study are:

1. Building a network on a platform
2. Insert the entire protection system of the network
3. Review relay settings coordination on the network
4. Evaluate the sensitivity of protective relay settings in the network
5. Evaluate the selectivity of protective relay settings in the network.
6. Place the appropriate values of protective relays after the completion of the analysis and coordination

METHODOLOGY

The study involves the following steps:

- Data Collection: collect all required data which will be implemented on the platform, whether the data for transmission network (e.g. substations, transmission lines, transformers, etc.) or the data related to protective devices (e.g. settings, CT, VT, etc.). These data are important to undertake the study in a proper way and knowing where the roots of mistakes.
- Build and Simulate the Network: the platform that used in this paper is Computer-Aided Protection Engineering (CAPE), the protection software platform is the protection analysis software combined with a model of the utility's power system, including the protection system. CAPE software has a high efficiency to undertake protection analysis and it is available with protection engineering department (PED) in National Grid (NG). The transmission network will build on CAPE which make the study easy and accurate in reasonable time.
- Review and Assessment: after build the transmission network and implement the data for protective devices, run the CAPE software and assess the system by study the curves of protective relays and review settings for each relay in the network.
- Implement the Settings: check all settings of the relays that must be changed to achieve relays correct settings. Also, ensure that the curves of protective relays are acceptable and relays will not work in the mode of mal-operation or non-operation.

ZONES OF PROTECTION

Theoretically, should divide the distance among the substations to several Zones. So that they become Zone 1 represent the entire distance between substation A and substation B as shown in Fig. 2. Then, Z2 represent the entire the distance between substation B and C. Thereafter, Z3 represent the entire the distance between substation C and D.

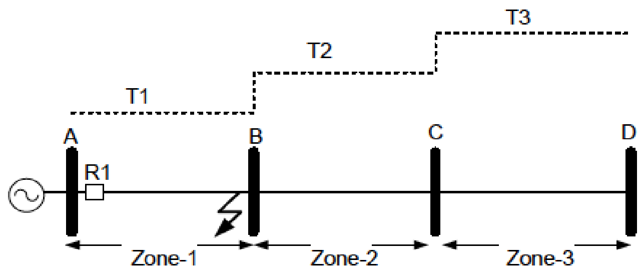

Figure 2

However, practicality, this is impossible due to the error of the CT and VT. Assuming the error is + or – 10% on these devices, hence the relays are exposed to the same percent of error. Subsequently, if the fault occurred in 95% of the line between substation A and B, there is a prospect to sense the fault at 85% of the line that the relay protects, and in this case, no problem because it is still in the same Zone. However, the real issue is when the relay senses the fault between substation B and C due to + 10% error. Because the time now changed from T1 to T2. Thus, must take into account this issue and putting the setting for each Zone as shown in Fig. 3 and the details below.

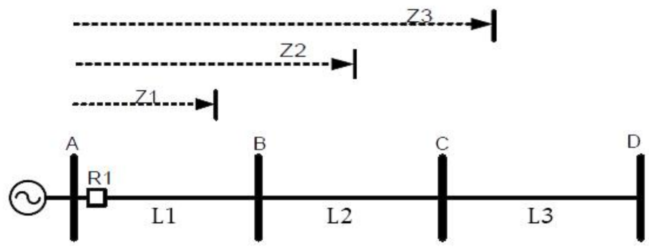

Figure 3

In this paper was used this philosophy:

Z1 = 80% of protected line (L1)

Z2 = 100% of protected line (L1) + 50% of the shortest line from remote bus (L2)

Z3 = 100% of protected line (L1) + 100% of shortest line - second level- (L2) + 25% of shortest line -third level- (L3)

RESULTS

After the study of the network, it was observed that there were several major problems that would make each Zones not work properly. First of them is the inaccurate and non-actual data of the transmission line during the prepared the settings. Also, wrongly choosing of the CT and VT ratio would make the relays not work properly. These two problem are common for all Zones. And there is a problem for all Zones except Zone 1, this problem is putting the settings with not take in account the contribution of the network on the faulty point from other ways.

Zone 1

As shown in Fig. 4, 44.32% of the total number of lines on this study will work outside the boundary of Zone 1. 22.73% will not cover the required zone. 32.95% will work properly.

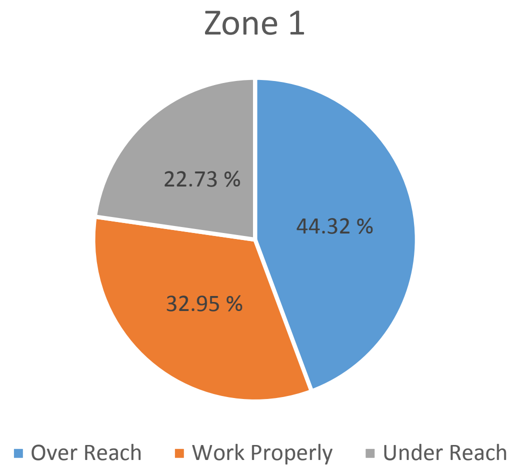

Figure 4

As shown in Fig 5, this is the percentage represent the relays behaviors for Zone 1 after the study.

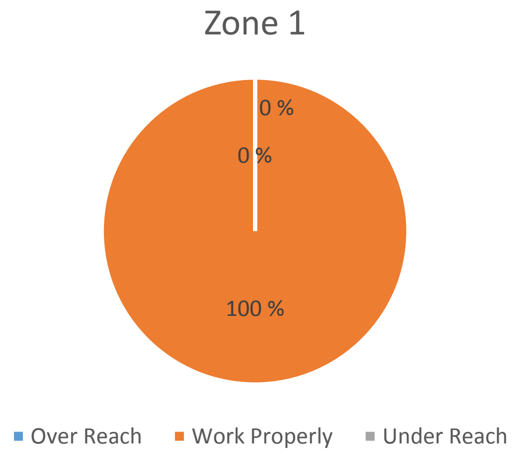

Figure 5

Zone 2

The Zone 2 was divided into five categories; the first one (represent 37% of total number of line in this study) is the relays that can't sense a fault outside the first level (protected line). The second one (31%) is the relays that can reach the entire of Zone 2 without the need for infeed factor. The third one (28%) is the relays that can reach the entire of Zone 2 with infeed factor. The fourth one (2%) is the relays that reach the second level but can't reach required setting. The last one (2%) is the relays that can protect entire of the first level only because the remote bus is ended bus.

As shown in Fig 6, this is the percentage represent the relays behaviors for Zone 2 before the study. Must take in account the categories here above.

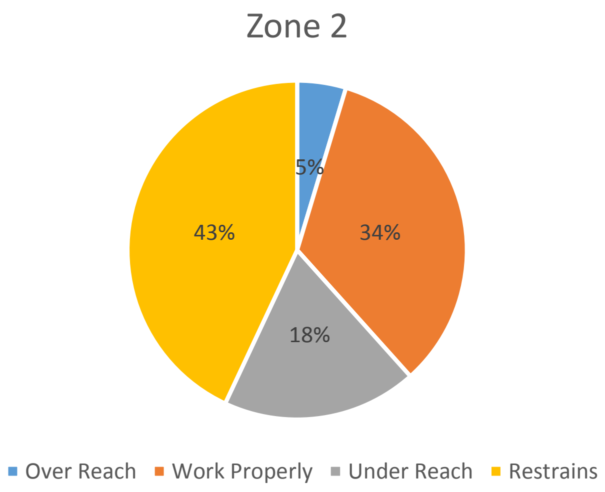

Figure 6

As shown in Fig 7, this is the percentage represent the relays behaviors for Zone 2 after the study.

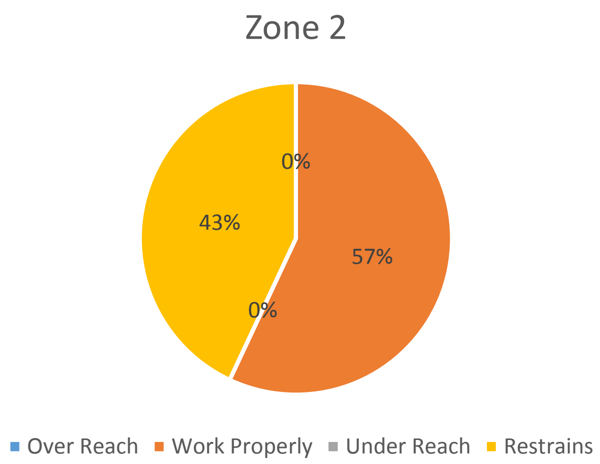

Figure 7

Zone 3

The Zone 3 was divided into six categories; the first one (37%) is the relays that can't sense a fault outside the first level (protected line). The second one (3%) is the relays that can reach the entire of Zone 3 without the need for infeed factor. The third one (17%) is the relays that can reach the entire of Zone 3 with infeed factor. The fourth one (34%) is the relays that can't sense a fault on the second level. The fifth one (4%) is the relays that reach the third level but can't reach required setting. The last one (5%) is the relays that can protect entire of the first level or second level only because the remote bus is ended bus.

As shown in Fig 8, this is the percentage represent the relays behaviors for Zone 3 before the study.

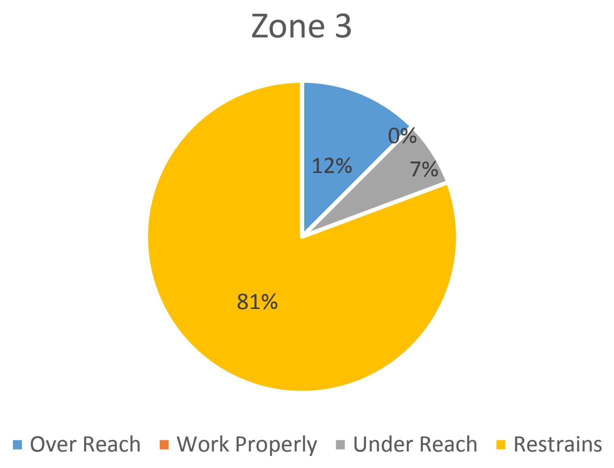

Figure 8

As shown in Fig 9, this is the percentage represent the relays behaviors for Zone 3 after the study.

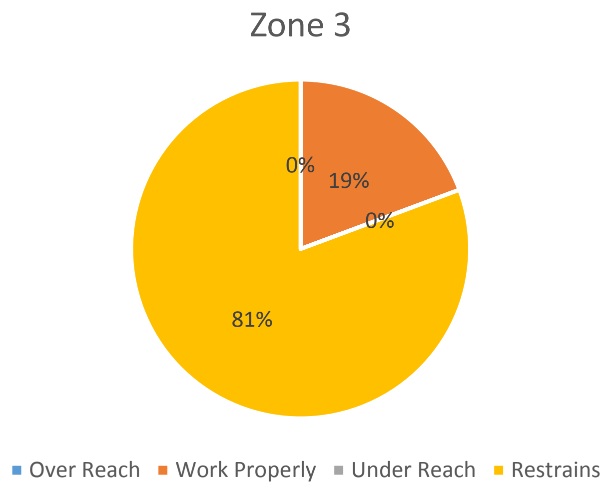

Figure 9

CONCLUSION

After simulating the network on the CAPE platform, several important things became clear and these things mainly affected on the settings when putting the settings by protection engineers, and it is difficult to estimate these things without using one of the simulation software, these things like:

- Knowing the value of the infeed current on the remote buses and that they can affected on the settings for Zone 2 and Zone 3
- It turns out that some of the relay settings of Zone 2 and Zone 3 are barely covering the protected line.
- It turns out that some of the relay settings of Zone 3 are barely covering the adjacent line.
- And each of these things are should take on account during putting the settings.

RECOMMENDATION

After simulating the network on the CAPE platform, several important things became:

- Make zone 1 reach 80% of the protected line
- Multiply Zone 2 by infeed factor ranging from 1.2 till 1.6 depending on the feeding on the remote bus.
- Multiply Zone 3 by infeed factor ranging from 2.5 till 3.0 depending on the feeding on the remote buses.

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