

SHORT CIRCUIT LEVEL REDUCTION OF 220 kV SUBSTATION

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Abstract— *With the inflation of network, there is supplement of new generating station and transmission lines by virtue of which the short circuit levels at some of the substation increases apart from its design limit. The short circuit current induces abusive thermal and mechanical stresses and causes damage to the equipment. Thus, the diminution and adjustment of short circuit current is imperative. For the depletion of short circuit current, one of the solution is to revamp the equipments in order to foresee fault current are inward equipment capacity, Thesees universally recommend the remaking of the substation. But, this solution is lavish. All the protection equipment is to be renewed and certified since revamp of whole substations is totally ambigouisc process. There are techniques reachable for the reduction of short circuit level namely: (1) Application of high impedance transformer, (2) Current Limiting Reactor, (3) Power System Reconfiguration etc. This paper explain some of the techniques in brief and simulation of case study with Application of High Impedance Transformer for the diminution and contraction of short circuit level.*

Keywords— *Short Circuit Current, Fault Level, Bus Splitting, Power System Planning, Reliability*

I. INTRODUCTION

A fault is nothing but an abnormal condition which may occurs due to failure of device, component or the element. The topography of the power system network keeps changing as the economy of a nation grows and its power consumption increases [1]. Due to the supplement of new generating station and transmission line in networks induces trouble of fault current. Moreover, manipulation of computers and power quality sensitive equipment has enforced the utilities to deliver higher and good quality power. As there is a supplement of new generating station, the power interaction increasesas as a consequence of which the fault current also increases at any point in the system. However, previous installed protection equipment turn into downgrade along with the system growth [2].

The three phase fault is humble and extraordinary case, it's rigidity and considerable distructions are high and is used for selecting the rating of protection equipment.

The repellent corollary of increased short circuit fault level are encapsulated as below:

1. There is unseemly electro-dynamic forces and thermal stresses to the equipment;
2. The breaking capability of previous installed circuit breakers is ordinarily limited to 40 kA;
3. To restrict damage to the protection equipment, faster operating circuit breakers are installed;
4. Safety related problem to the personnel due to increased short circuit level.

Due to above mentioned drawback, the fault level reduction has gained a noticeable importance in modern years among various electric utilities.

It is lavish to uprate, restore and redesign the equipment like swtichgear, transformer and bus bar to high fault level [1,2]. And to this problem there is one threat i.e. economics cost.

There are countless techniques for limiting the short circuit current have been introduced in Section II. The various technique namely:

1. Current Limiting Reactor [1,2,3];
2. Fault Current Limiter [1,2,5];
3. Application of High Impedance Transformer;
4. Bus Bar Splitting Technique in the Substations [1,4];

5. Is limiter [1,6];
6. Fuse;
7. Application of neutral reactor;
8. Power System Reconfiguration [1,3];
9. HVDC links;
10. Disconnection of some Transmission Lines from the Critical Substation;
11. Design of higher voltage transmission networks.

Some of these techniques are explained in Section II. The repeated short circuit calculation is also carried out to check their effective outcome.

II. FAULT CURRENT LIMITATION TECHNIQUES

The hitherto suggested some of the fault current limitation techniques are briefly described in this section.

2.1. Current Limiting Reactor (CLR)

For the fault current limitation point of view, CLR is a most recommended technique and is more economical. CLR provides high impedance to the system by series connected reactance. When fault occurs, this high impedance of CLR is used to protect the protection equipment. CLR keeps the short circuit level to the system requirement and stress on protection equipment decreases. There is one disadvantage of CLR that it holds relatively more space in the substation because of the safety purpose.[1,2,3,4].

2.2. Application of High Impedance Transformer

By implementing the high impedance transformers, there is a sustainable contraction in the fault current level. Perhaps there was an unsought issue on stability so this technique requires more surveillance.

2.3. Fault Current Limiter (FCL)

In FCL, a short circuit current briskly limited by a volatile charge. This volatile charge opens a conductor and turns the current to a parallel fuse to squash the short circuit current. During normal condition, FCL offers lower impedance and during faulty condition, their impedance increases instantly thus the fault current is within the limit. If FCL is exposed to high current, it has property of shifting from a superconducting state to the normal state. Because of the characteristic of superconducting, they can be helpful for limiting the fault current. The FCL is too much extravagant. [2,3,5,7].

2.4. Fuse

The fastest short circuit break off device is fuse. The fuse is simple in construction, cost effective. It is normally confined to beneath 40 kV. After every break off it can be replaced. The disadvantage of fuse is that it can not be used where the high speed auto reclosing is required.

2.5. Is Limiter

The updated model of fuse is Is Limiter. Most of the current passed through a pavement parallel to fuse in normal operation. During fault condition, the parallel pavement is unlatched using electro-dynamic force of fault current. Hence, the fault current is restored to the fuse and the trouble of limiting the normal current of fuse is cleared up. The interrupting capacity of Is Limiter is up to 5 kA. And it is still limited to 40 kV rated voltage [3].

2.6. Bus Bar Splitting Technique in the Substations

To shrink fault current level, the bus section is opened. From the short circuit reduction point of view this method is more effective than CLR technique. The bus bar splitting is equivalent to CLR with infinite reactance. Perhaps there was an unsought issue on stability so this technique requires more surveillance [3,4].

2.7. Disconnection of Some Transmission Lines from the Critical Substation

For the depletion of short circuit level at bus bar, some of the transmission lines are disconnected from the bus bar. These disconnected transmission lines are reconnected to other the substation where the short circuit level is low. This

technique is not acceptable from the power system operation point of view. The main issue related to this technique is that there is unsought issue on stability of system so this technique requires more surveillance.

2.8. Power System Reconfiguration

Power system reconfiguration technique is some what more practical method. The power system reconfiguration is case dependent and there is no definite rule. It mainly depends on vision and intimacy of the engineer with the system. This technique results in considerable reduction of fault current level and may improve stability of the system [1,3].

III. CASE STUDY

According to the data provided, the whole network is designed in MiPower software. The details of related line and related transformer with 220 kV Side of 400 kV Substation is as shown in Fig. 2.

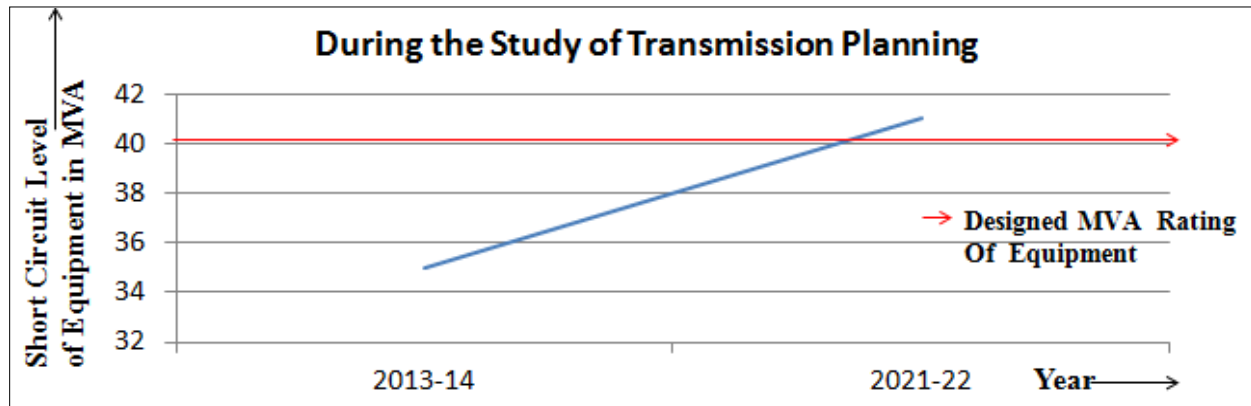


Fig. 1 During the Study of Ttransmission Planning, Short Circit Level at 220 kV side Increases Beyond it's Designed limit

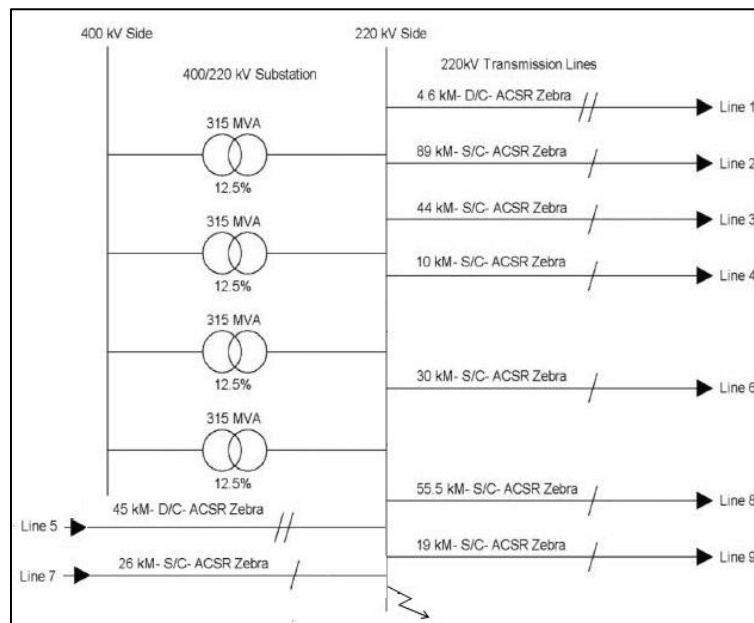


Fig.2 Substation Details

IV. ANALYSIS STUDY

4.1. Short Circuit Analysis

The short circuit analysis is carried out at 220 kV Side of 400 kV Substation in MiPower Software. The simulation results are as per Table I.

Table I: Short Circuit Results of 220 kV Side of 400 kV Substation

Bus Name	TPG Fault		SLG Fault	
	Fault MVA	Fault Current kA	Fault MVA	Fault Current kA
220 kV side of 400 kV Substation	14306.140	37.544	14578.733	38.259

The result shows that Single Line to Ground fault (SLG) at 220 kV Side reaches up to 38.259 kA. And within 2-3 years with expansion of network, it may reach beyond its design limit of 40 kA. Therefore, it is mandatory to either reduce the short circuit level with various techniques or upgrade all the switchgear system. Therefore, we have analysed the several mitigation techniques for reduction of short circuit level of 220 kV Side of 400 kV Substation.

4.2. Techniques applied for the reduction of Short Circuit Level

For the reduction of short circuit current various methods are available as discussed in Section II of this paper. In this paper, Application of High Impedance Transformer are applied for the reduction of short circuit fault current.

4.2.1. Application of High Impedance Transformer

The Short Circuit Current is mainly limited by the Impedance of the system. The equation of Short Circuit kVA is given below:

$$\text{Short Circuit kVA of 3 Phase Circuit} = \frac{\text{Base kVA} \times 100}{\% X} \dots\dots\dots(1)$$

From above equation it is clear that, as the impedance X of transformer increases the short circuit kVA automatically reduces.

In our case study, the short circuit level is mainly contributed by 4x315 MVA transformers. If the impedance of transformer are increased, the short circuit level at 220 kV side of 400 kV substation are reduces significantly. Previously the impedance of transformer is 12.5% and is increased to 15% which is shown in Fig. 3.

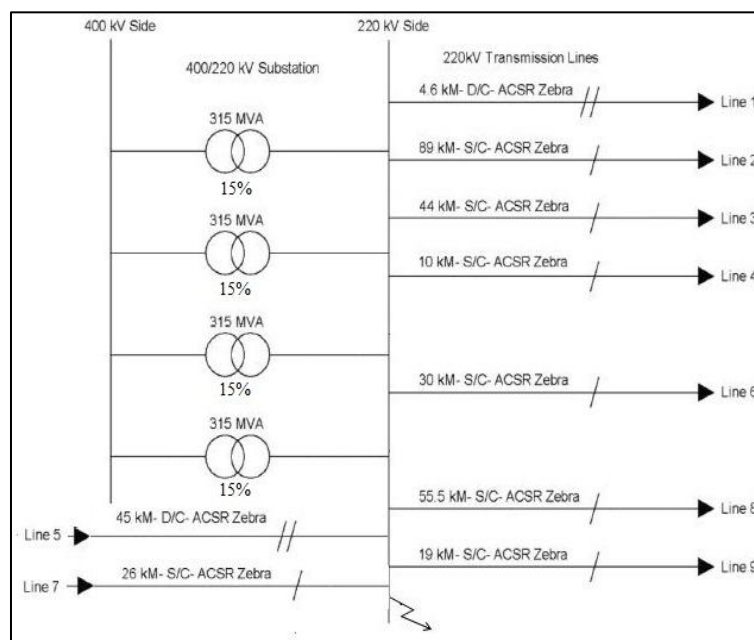


Fig. 3 Application of High Impedance Transformer

The short circuit level result due to High Impedance Transformer are as shown in Table III.

Table II: Short Circuit Results with Application of High Impedance Transformer

Bus Name	TPG Fault		SLG Fault	
	Fault MVA	Fault Current kA	Fault MVA	Fault Current kA
220 kV side of 400 kV Substation	13699.402	35.952	13450.546	35.299

Looking from Table II the short circuit level of 220 kV Side are reduced so this method are used for reduction of short circuit level. The transient stability and voltage stability with the Application of High Impedance Transformer are with in limits.

The comparison of short circuit level in kA, previously and using Application of High Impedance Transformer is shown in Fig. 4.

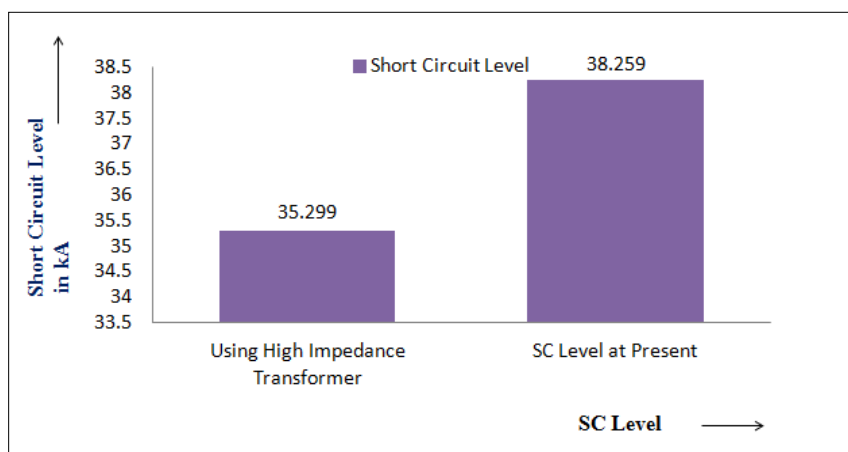


Fig. 4 Comparison of Short Circuit Level

V. CONCLUSION

The numerous mitigation techniques are studied in this paper for the reduction of short circuit level below the design limit of substation. Here, the Application of High Impedance Transformer are applied for reduction of short circuit level. Using this methods, the short circuit level are reduced and hence can be applied for the reduction of short circuit level. In Application of High Impedance Transformer 4 nos. of transformers are replaced with high impedance. While looking to the cost estimate, it is too expensive. Looking to the cost estimate and space constraint in substation, the other techniques must be applied for the reduction of short circuit level. In the next paper, for the reduction of short circuit level we are going to implement the Current Limiting Reactor (CLR) technique and Bus Bar Splitting Technique in the Substations.

VI. REFERENCES

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