APPLICATION OF SERIES REACTORS

Air core series reactors have the advantages that they cannot saturate under fault conditions, have low losses, have a long life and are virtually maintenance free.

Series reactors are mainly used to

1. Reduce fault currents and
2. Match impedance of parallel feeders.

Series reactors require integration into the electricity network. This requires consideration of aspects such as physical layout, protection coordination, and voltage control.

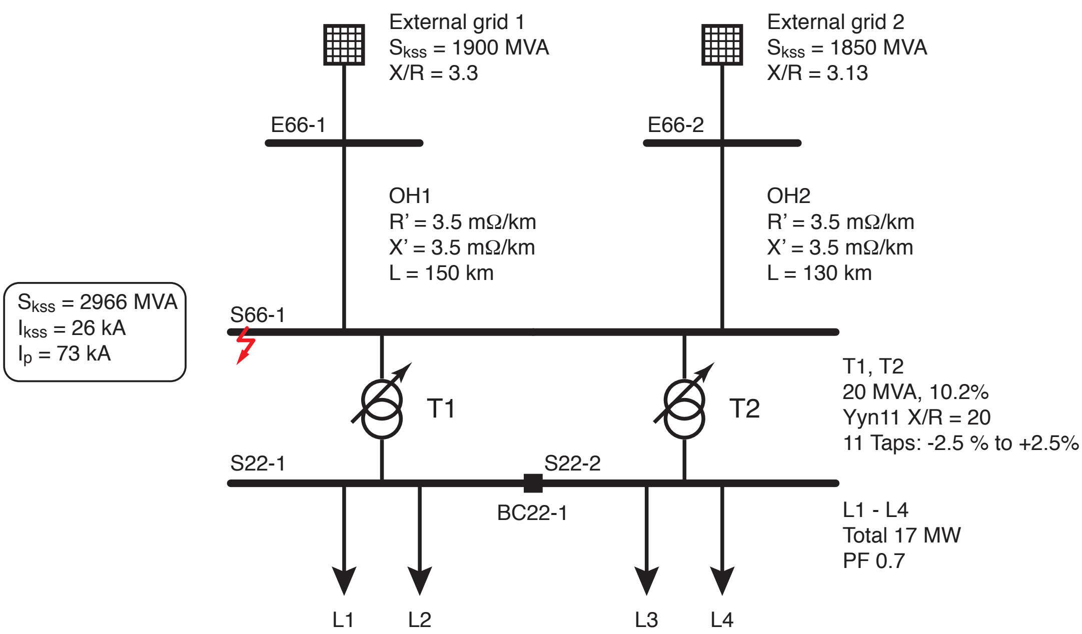
This note describes some aspects of voltage control in applications where series reactors are installed.

1 System augmentation

Series reactors are used extensively in transmission and distribution networks to ensure that fault ratings are not exceeded. For example, when generation capacity is expanded or when feeders are added to a substation, the resulting fault current may exceed the rating of existing equipment.

The effect and implications of series connected current limiting reactors can best be described in the light of a specific example.

A simplified representation of a section of network is shown in the figure below. The network has been augmented by means of an additional feeder (OH2) from a transmission substation to a distribution zone substation. The additional feeder is required to cope with load growth in the distribution network. The fault rating of cables and switchgear on the primary side of the zone substation is stated as 16 kA at 66 kV.



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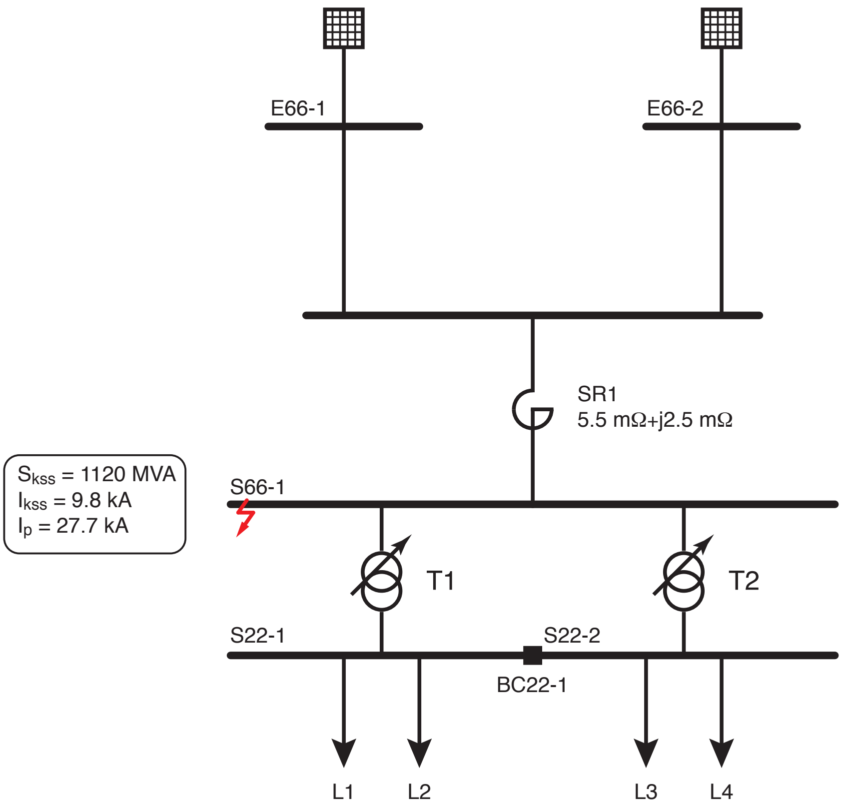
Before the overhead line OH2 was installed, the fault level at the 66 kV side of the zone substation was 12.0 kA. This is substantially less than the rated fault withstand level of 16 kA.

When the second 66 kV feeder is connected as shown, the fault level at S66-1 increases to 26 kA, well over the rated value. Upgrading switchgear, cabling, busbars and other primary equipment to the higher fault level is time consuming and expensive.

2 Fault limiting reactors

A simple and reliable solution is to install fault current limiting reactors in series with both lines. Such a solution is shown in the figure below.

The reactor impedance has been selected such that the highest fault level is less than 10 kA, without consideration of the contribution of rotating loads in the network.

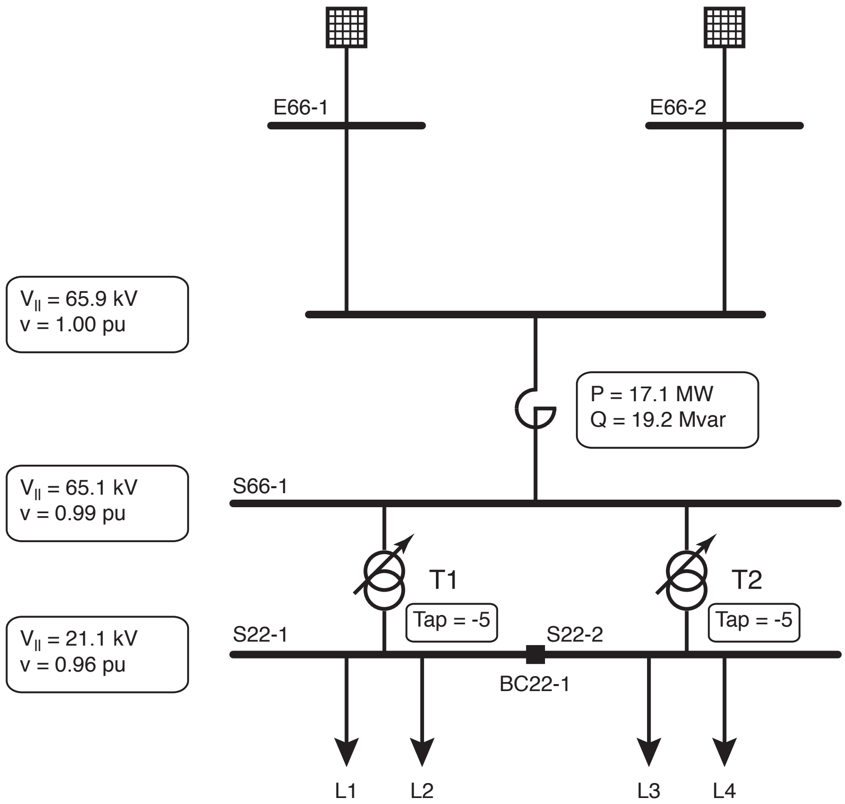


Placing a 2.5 Ω reactance in series with both feeders results in fault current of 9.8 kA, well within limits.

The goal of additional power capacity and restricted fault current is therefore achieved with the combination of a new feeder and a series reactor.

3 Voltage regulation

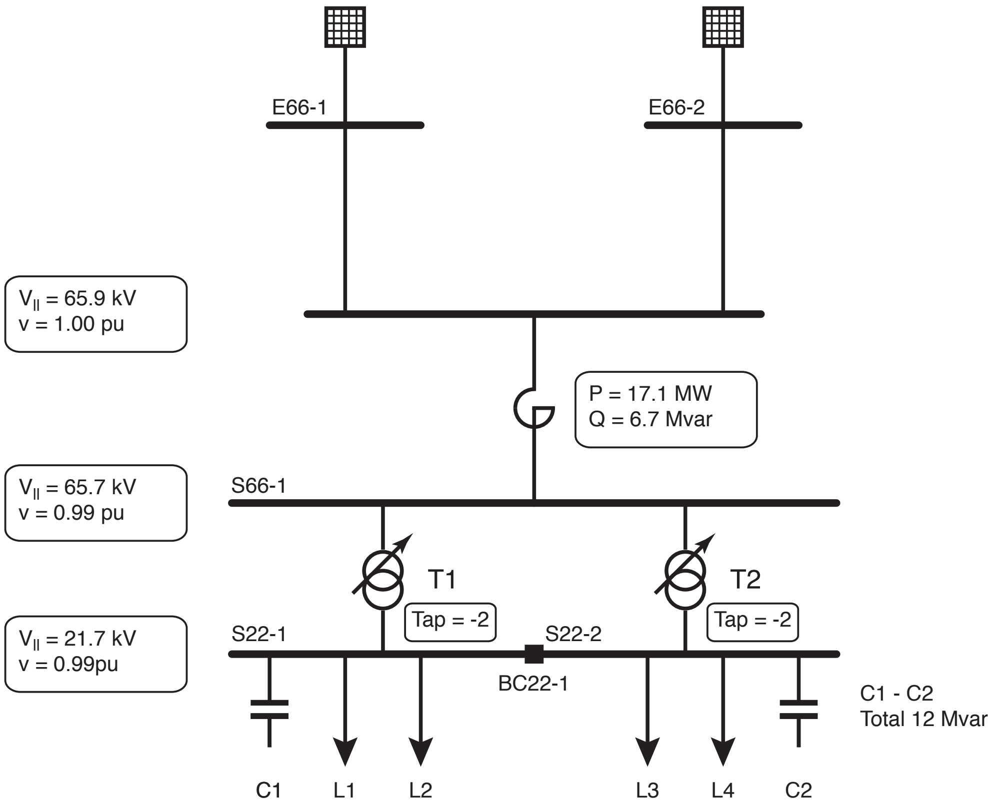
The series reactor will result in a voltage drop related to the impedance of the reactor. In most cases, this voltage drop is small compared to the normal system voltage fluctuations and no additional action is required. The voltage drop across the reactor for a combined zone substation loading of 17 MW at a power factor of 0.7 is approximately 1%, as shown below.



The two zone substation transformers have on-load tap changers configured to maintain the voltage of the 22 kV busbar within a narrow range.

In this case, the tap changers have reached the tap limit of -5, and the voltage of the 22 kV buses has dropped to 0.96 p.u. This may be unacceptable, since the tap changers will not be able to cope with any additional voltage reduction.

A solution is shown in the single line diagram below.



Improving the power factor of the zone substation load to 0.93 or better results in excellent voltage regulation and allows the system to operate with the tapping range of the transformer. The 22 kV busbar voltage is improved to 0.99 p.u. and the transformer taps are at position -2.

4 Conclusion

This application note describes in simple terms the benefits of installing series-connected current limiting reactors. It is shown that additional network capacity can be made available without the need for costly upgrades of existing primary plant.

There is some concern about the resulting voltage drop across the reactor, and how voltage regulation can be maintained when series reactors are connected. The reality is that these voltage drops are in most cases quite small. In cases where such voltage drop is excessive, shunt capacitor banks can be used to improve the power factor of the load and to improve voltage regulation.

Determining the appropriate impedance for a fault current limiting reactor is a relatively simple exercise. To ensure a successful installation, care must be taken to consider all aspects of the application.

ONE can assist you in selecting the correct series reactor for your application, and provide advice on the best way to integrate the reactors into your network.