ABB Inc.

Application Note

The Effect of Loop Reconfiguration and Single Phase Tripping on Distribution System Reliability

Introduction

With industry concerns regarding reliability (momentary and sustained interruptions), there is probably no device more underutilized to improve reliability than the recloser. Years of performing reliability studies have shown time and time again that, with the exception of the fuse cutout (taken for granted as a method for protecting laterals), the recloser is by far the simplest and most cost effective method to improve reliability.

Improvements in reliability do not come easily. It is difficult to dramatically improve reliability on the majority distribution systems because their design provides an inherent very high level of reliability. Exposure on distribution systems is the primary factor in determining reliability. Long lines have more exposure and thus lower reliability; hence the need for reclosers.

The purpose of this application note is twofold.

- First it is to quantify the improvements that standard 3 phase reclosing can obtain.
- Second it is to demonstrate the value of loop reconfiguration and single phase operation of three phase reclosers, which the new high tech reclosers are capable of performing.

Distribution Circuit

The distribution circuit, shown in Figure #1, will be used to demonstrate the relative value of reclosing schemes for a suburban/rural system. This system has the following characteristics:

- 10 miles of line
- 8 single phase lateral taps
- Laterals are 3 miles long
- Total of 1800 customers

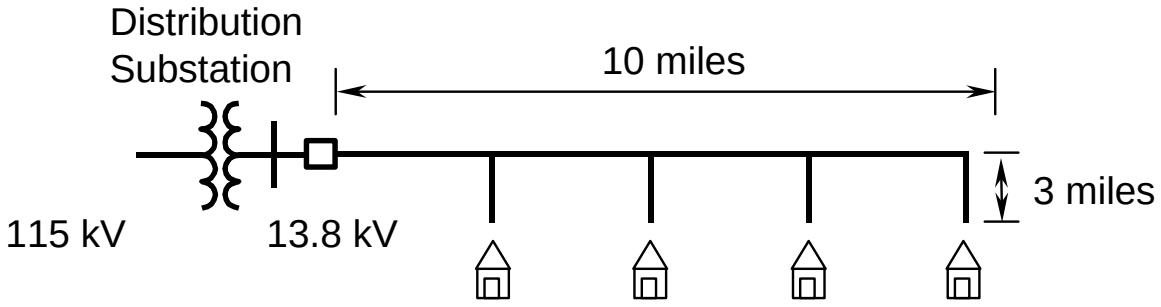


Figure #1 – Model Distribution System

Effect of 3 Phase Reclosing

The purpose of this section is to address the relative value of standard reclosing practices. Figure #2, shown below, demonstrates the value of using reclosing at the substation (which is standard practice with virtually all utilities in the US). As can be seen, the use of a recloser or breaker with a reclosing relay at the substation, significantly reduces the number of sustained interruptions to a customer (SAIFI), the total duration of interruptions to the average customer (SAIDI) and the number of momentary interruptions (MAIFI). This is due to the fact that the majority of faults on this overhead system are temporary.

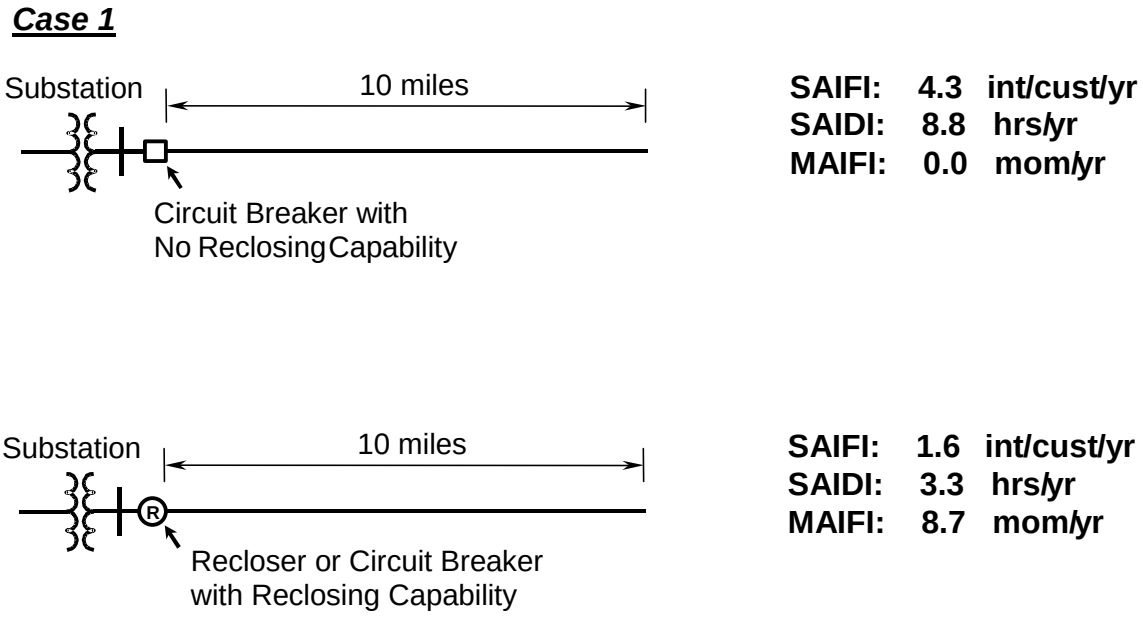
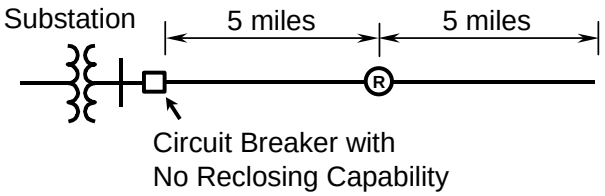


Figure #2 – Radial Distribution System

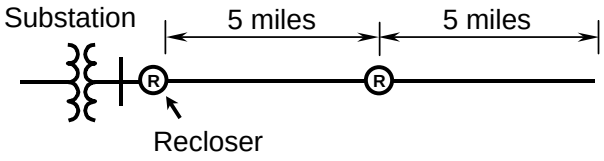
Figure # 3, shown below, illustrates the value of the line recloser. As can be seen, the use of the line recloser (comparing cases 2 and 4) reduces all the indicies approximately 25%.

Case 3



SAIFI: 2.6 int/cust/yr
SAIDI: 5.4 hrs/yr
MAIFI: 2.1 mom/yr

Case 4

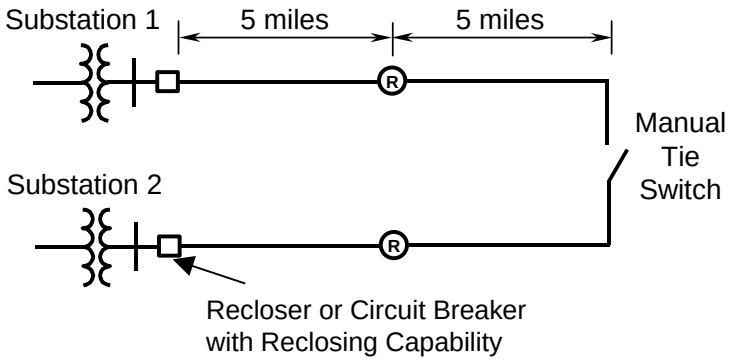


SAIFI: 1.2 int/cust/yr
SAIDI: 2.6 hrs/yr
MAIFI: 6.5 mom/yr

Figure #3 – Use of Line Reclosers

Figure # 4 (Case 5) shows the effect of using a manual tie and figure # 5 (Case 6) shows the value of replacing the manual tie with a recloser and implementing a Loop Scheme restoration system. Adding this automatic tie point and implementing a loop scheme as indicated in this manual provides improvement in the SAIFI and SAIDI.

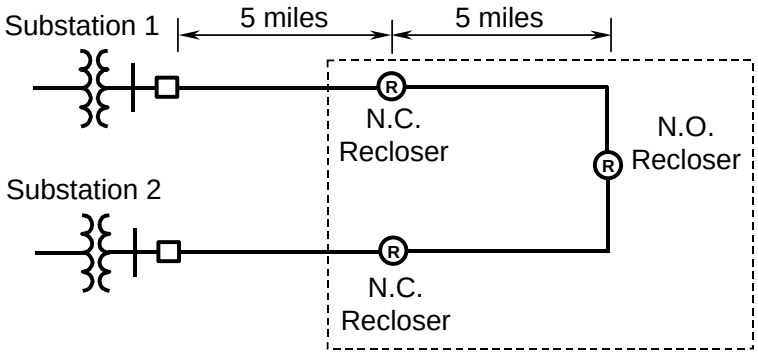
Case 5



SAIFI: 1.2 int/cust/yr
SAIDI: 2.3 hrs/yr
MAIFI: 6.5 mom/yr

Figure #4 – Loop Configuration with Manual Switch

Case 6

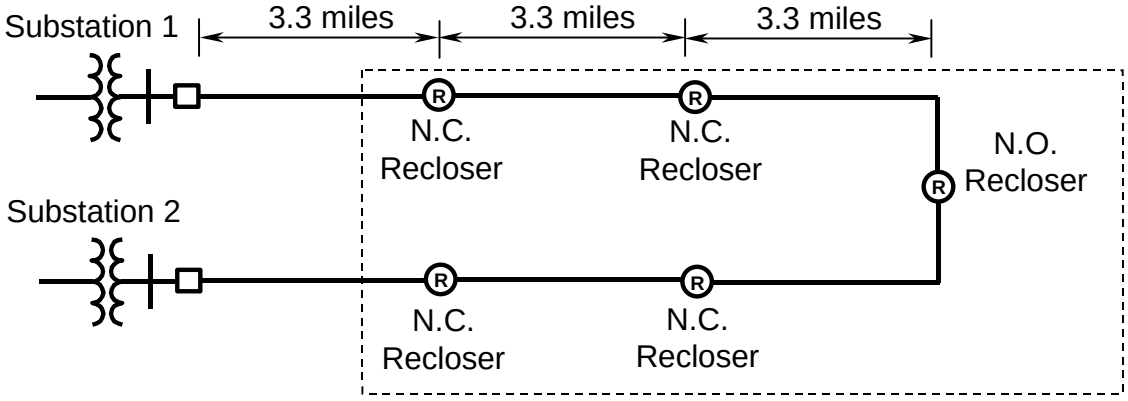


SAIFI: 1.0 int/cust/yr
SAIDI: 2.1 hrs/yr
MAIFI: 6.8 mom/yr

Figure # 5 – Automatic Recloser Loop Scheme

Figure #6 (Case 7), illustrates the value of a 5 recloser automated loop scheme. As can be seen, while the numbers don't change very much from the base case, all the indicies are still improving. Some utilities have very good reliability but seek to improve for various reasons. If a utility has a reliability and system design similar to Case 6 and still desires more, a case can be made that a 14% reduction in SAIDI can be obtained using this scheme.

Case 7



N.C. - Normally-Closed
N.O. - Normally-Open

SAIFI: 0.8 int/cust/yr
SAIDI: 1.7 hrs/yr
MAIFI: 6.5 mom/yr

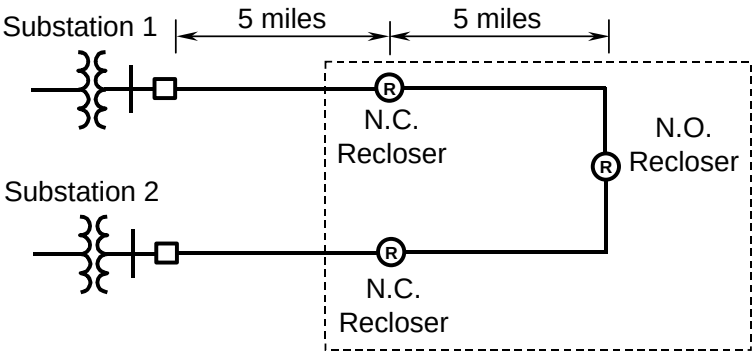
Figure # 6 – 5 Recloser Loop Scheme

A summary of the benefits of reclosing is shown below. As can be seen, protection schemes to improve reliability are clearly a case of diminishing returns but, if a utility requires these different tiers of reliability, reclosers are clearly the way to go.

	SAIDI	% IMPRVMT.
Case 1 - No reclosing	8.8	---- (Base)
Case 2 - Substation reclosing	3.3	63%
Case 4 - Line Recloser	2.6	70%
Case 5 - Loop with Manual Switch	2.3	74%
Case 6 - 3- Recloser Automatic Loop Restoration	2.1	76%
Case 7 - 5- Recloser Automatic Loop Restoration	1.7	81%

Single Phase Tripping

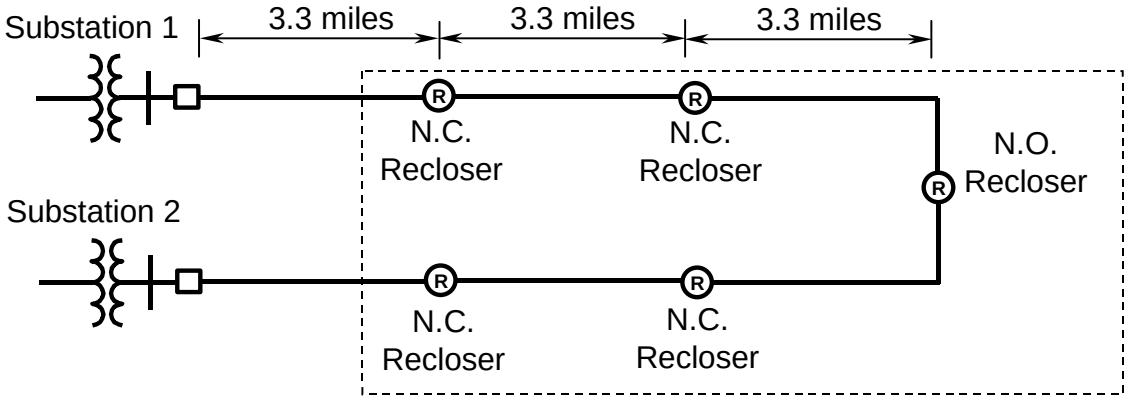
Single phase tripping is an option that utilities can utilize with modern high technology reclosers. Since the vast majority of faults on distribution systems are line to ground, it makes sense to utilize the inherent capability of the recloser to operate in a single phase mode and thus reduce interruptions to customers on the other 2 phases. Figure # 7, shown below, illustrates the value of this concept. As can be seen, single phase reclosing using 3 reclosers compares very favorably with the 5 recloser scheme and dramatically outperforms this scheme for momentary interruptions (MAIFI). The benefit gained is accomplished at a relatively low cost compared to other reliability improvement means.



SAIFI: 0.8 int/cust/yr
SAIDI: 1.8 hrs/yr
MAIFI: 3.1 mom/yr

Figure # 7 – 3 Recloser Loop Scheme with Single Phase Tripping

Finally, the 5 recloser scheme using single phase tripping shows even more improvement for those utilities seeking to be in the top industry quartile for reliability. While the law of "diminishing returns" still applies, the value of single phase tripping is obvious.



N.C. - Normally-Closed
N.O. - Normally-Open

SAIFI: 0.6 int/cust/yr
SAIDI: 1.4 hrs/yr
MAIFI: 2.7 mom/yr

Figure # 8 – 5 Recloser Loop Scheme with Single Phase Tripping

Summary

The analysis provided in this application note is meant to show the reader the value of reclosers. As has been demonstrated, reclosing and the use of reclosers can have a dramatic positive effect on reliability indices. Also illustrated is the value of loop reconfiguration and single phase tripping. The new high-tech reclosers afford the user with the ability to dramatically improve reliability indices with low relative cost and low coordination complexity.