B5 – Protection and Automation

PS 2 / APPLICATIONS OF EMERGING TECHNOLOGY FOR PROTECTION, AUTOMATION AND CONTROL

10491_2022

STUDY OF IMPACT OF EXCLUSION OF LINE REACTOR CURRENT ON DISTANCE PROTECTION FUNCTION AND FAULT LOCATOR FOR AN IEC 61850 PROCESS BUS COMPLIANT IED USING HIL SIMULATION

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Motivation

- In a conventional distance protection scheme for a substation with one and a half breaker configuration, the distance protection relay receives the line current over copper cables with external summation done using different CT cores
- For a Line feeder having reactor for compensation, the reactor current is also taken in consideration for processing the protection function and for inbuilt fault location function.
- in a process bus based digital substation, the external summation of currents is not possible and the Sampled values emanating from the Merging Units are subscribed by the protection relays individually and are summated inside the application.
- Due to limitation in number of Sampled Values that can be processed by a distance protection function, certain make IEDs are not able use Line reactor current for protecting line having reactors.
- This paper presents a study of the impact of exclusion of line reactor current on the Distance Protection function and the inbuilt fault location function of the IED.

Approach

- In a Conventional distance protection scheme, for a substation with one and a half breaker configuration the distance protection relay receives externally summated currents of Main CT, Tie CT and Reactor CT as shown in Figure 1

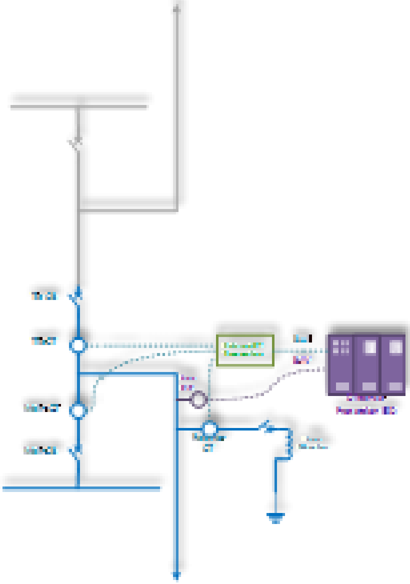

Figure 1 : Conventional Current Summation Scheme (CCSS)

- In case of limitation in number of Sampled Values that can be processed by a distance protection function, Only Tie CT and Main CT currents are fed to the IED as shown in Figure 2

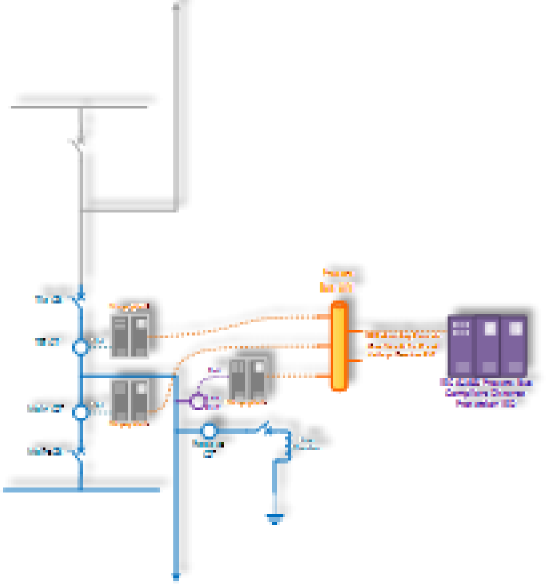

Figure 2 : Modified Current Summation Scheme (MCSS)

Discussion

- For a fixed degree of compensation, depending upon location of fault three different conditions emerge (refer Figure 3) :
  1. Fault exactly is at the same distance on the line length as the degree of compensation, i.e. during fault $I_{XL} = I_{XC}$
  2. Fault towards remote end, i.e. during fault $I_{XL} < I_{XC}$
  3. Fault near to the Source A, i.e. during fault $I_{XL} > I_{XC}$

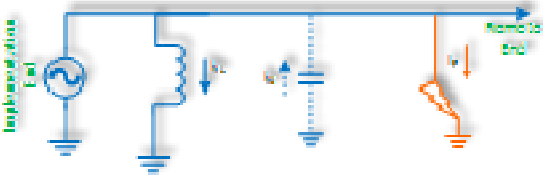

Figure 3 : Fault Scenario

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continued

Discussion (Continued)

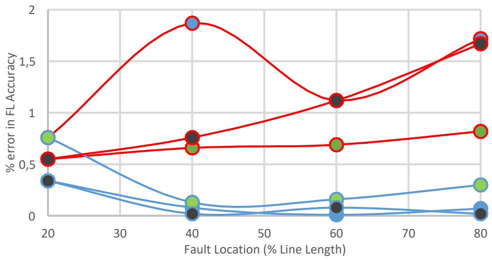
- Table below shows the summary of actual fault current fed by Implementation end source and current read by IED in both configurations

Condition	Actual Fault Current Fed by Source	Current Read by IED in CCSS	Current Read by IED in MCSS
$I_{XL} = I_{XC}$	I_{F1}	$I_{F1} - I_{XC}$	I_{F1}
$I_{XL} < I_{XC}$	I_{F1}	$I_{F1} - I_{XC}$	$I_{F1} + I_{XL} - I_{XC}$
$I_{XL} > I_{XC}$	I_{F1}	$I_{F1} - I_{XC}$	$I_{F1} + I_{XL} - I_{XC}$

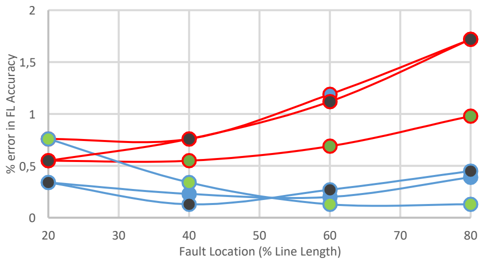
Simulation and Results

- Following scenarios were simulated in order to study the impact of exclusion of reactor current
  1. Base case simulation
  2. Change in degree of compensation from 65% to 50% and 80%
  3. Change in Source impedance ratio to 0.1 and 0.5
- Percentage error calculated for each of the above scenario

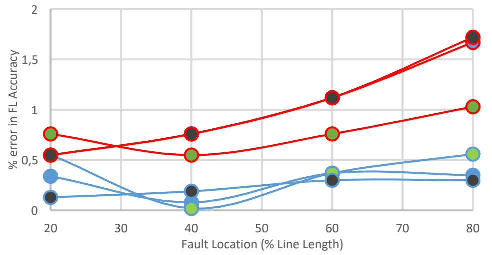
$$\%error = \frac{|Fault\ location\ shown\ by\ IED - Actual\ fault\ location| \times 100}{Actual\ Fault\ Location}$$



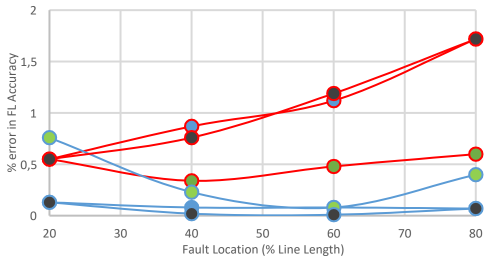
Scenario 1 (base case)



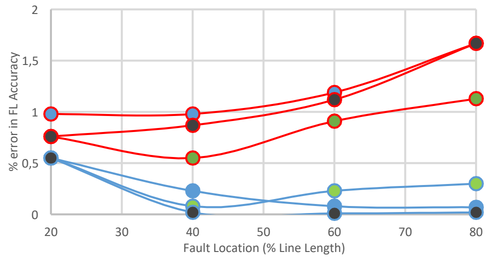
Scenario 2 (50% Line Compensation)



Scenario 2 (80% Line Compensation)



Scenario 3 (0.1 SIR)



Scenario 3 (0.5 SIR)

CCSS — MCSS — LL Fault — LG Fault — 3Ph Fault

Conclusion

- In majority of the fault locations, the MCSS has comparatively better accuracy for the simulated operating conditions.
- The value of line reactor current in comparison with fault current is negligible hence it can be neglected for studied protection function
- if the accuracy is specified, based on the above simulations, the choice of MCSS & CCSS scheme can be made
- Fault locator accuracy of distance IEDs was found to be within the specified limits under the MCSS scheme hence same was adopted.