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Comprehensive analysis of Single CT in Bus coupler compared to Dual CT for Bus Bar protection scheme

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***Abstract*— In this document, the bus bar protection application using single current transformer over dual current transformer in a bus section or bus coupler arrangement is discussed. The impact of the protection system based on the location of the current transformer is discussed considering various faults in each location.**

I. INTRODUCTION

In this document, the pros & cons of using single CT (current transformer) compared to the conventional dual CT are discussed. Earlier days, in bus bar protection relays, two CTs were used on either side of the bus coupler breaker due to the following reasons

1. CT current direction has to be matched in the relay. It's a common practice to earth the CT towards the protected zone direction. In case of two CTs, one will be earthed towards zone 1 and one towards zone2
2. To provide zone overlap and to prevent the blind spot between the CT and the CB.

In modern relays, the above two concepts can be achieved using the internal logics and flexibility of the relay. Figure 1 shows the single CT arrangement with faults located in various places. The color shows the zone limit. In this example, green color represents zone 1 and blue color represents zone 2. The CT defines the boundary for both the zones.

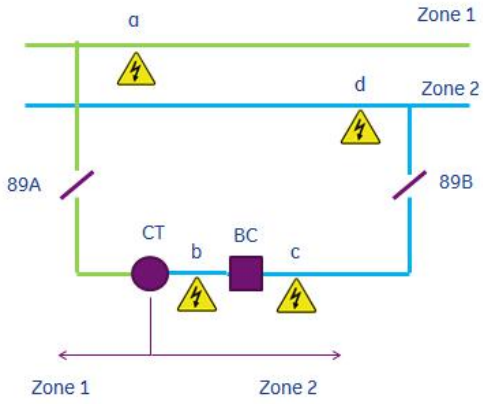

Figure 1: Zone segregation for single CT arrangement

Table 1 shows the trip matrix for various fault locations of Figure 1. It can be observed that the relay trips the faulty zone and there is no blind spot in this scheme. For fault located in b, Zone2 trips and opens the bus coupler circuit breaker. Opening of bus coupler circuit breaker will eliminate the CT from zone 1 which in turn will trip zone 1 thereby clearing the fault.

Table 1: Trip matrix for various fault location in single CT arrangement

Fault Location	Zone 1	Zone 2
a	Trip	No trip
b	Trip (Delayed)	Trip
c	No Trip	Trip
d	No Trip	Trip

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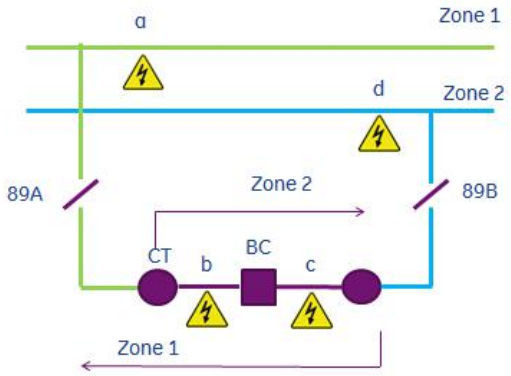

Figure 2: Zone segregation for Dual CT arrangement

Table 2 shows the trip matrix for various fault locations of Figure 2. It can be observed the relay trips the faulty zone and there is no blind spot in this scheme too. For fault located in b and c, both the zones trips and opens the bus coupler circuit breaker. When the fault is located in c, it's a clear zone 2 fault and zone 1 need not trip. This trip did not occur in single CT arrangement as shown in Table 1. Hence an unwanted trip of a healthy zone can be eliminated by using single CT arrangement only.

Table 2: Trip matrix for various fault location in dual CT arrangement

Fault Location	Zone 1	Zone 2
a	Trip	No trip
b	Trip	Trip
c	Trip	Trip
d	No Trip	Trip

II. Analysis:

The use of single CT has reduced the cost and also met all the power system protection principle by the use of advanced logic in numerical relays. More over dual CT has dis advantages compared to single CT as hi-lighted. With the availability of this flexibility in numerical relays, dual CT for Bus coupler and Bus section is no longer a mandatory requirement for low impedance bus bar protection relays. However, In Table 1, we observed that there was a delay in tripping of the bus bar protection, if the fault is located at position b. This delay is the breaker operation time delay which may not be acceptable in some cases. Bus bar protection relays are supposed to trip in 15ms to 25ms as per majority of the specification and hence this delay of CB operation time may act as a dis-advantage. To better analyze the requirement, we have to choose based on the application and identify the number of incoming bays available in the substation. If the substation is close to a generation station and the bus fault can feed a huge amount of fault current, then dual CT would be beneficial as we cannot compromise on timing. However, if the bus does not have major source, and the operation philosophy permits only one bay through the Bus coupler, then there would not be any difference between the fault current of a bus bar and the fault current of a feeder bay. In such scenarios, the specification permits 35ms to 40 ms for a feeder tripping and then why should the user worry about a delay tripping of a bus where the bus itself acts as an extension of a feeder with the same fault current? In such scenarios single CT would be a cost effective solution.

III. Differential blocking during CT trouble and release during a fault:

The CT trouble logic in bus bar protection relay is used to identify the flow of differential current in the relay due to errors in the secondary system and not a bus fault. The relay can discriminate a bus bar fault and a secondary system fault by the comparison of the additional security measures like the directional principle and the bus voltage supervision check. Check zone cannot identify this issue unless it is using a separate CT or a different core from the same CT. Even different core of the same CT may not meet the requirement since open CT conditions affect the CT itself and it

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does not reproduce the primary current properly.

Based on the above verification measures, the CT trouble function detects a failure of a CT and differential is blocked. However in case of a real bus bar fault followed by the CT trouble; the relay will not trip, since the CT trouble functionality is blocking its operation. In busbar relay, this issue is handled by implementing the logic shown in Fig 3. In case of a CT trouble, bus bar relay verifies the healthiness of the bus bar voltage and bus bar protection is blocked only during voltage healthy conditions. When there is a bus fault following a CT trouble, the bus voltage collapses and the blocking command is unblocked dynamically, thereby executing a tripping command successfully as desired.

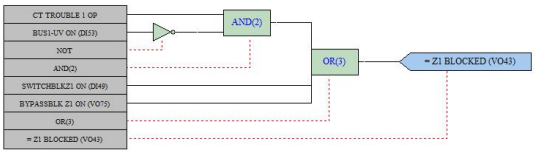

Fig. 3. Block Logic for R phase zone1

The above sections ensure proper tripping and blocking of busbar relay under different scenarios. After proper identification of a bus fault, it is observed in some stations, that the 96 relay [5] does not operate for some of the bays and this issue is explained and handled in the next section.

IV. TRIP LOGIC TO ENSURE PROPER TRIPPING OF CB WHEN TRIPPED USING 96 RELAY:

Tripping of CB is issued from bus bar relay to a latching relay called as 96 relay. This relay will in turn extend tripping to the CB. In some of the cases this relay does not operate if the pulse produced by busbar relay is less than 10ms since these are conventional electromechanical relays and the sensitivity is not as accurate as a numerical relay. To ensure proper operation of the 96 relay, the output contacts of busbar relay is latched for 50ms as shown in Fig4.

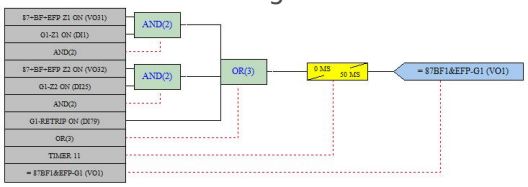

Fig. 4. Trip Logic of busbar relay for Bay1

Blocking and tripping of busbar relay for various scenarios were discussed in the previous sections however during the time of bus changeover, the 89A and 89B isolator of a bay is closed for a short duration. During this period, this path acts as a parallel path to the BC which will result in improper measurement of differential current in busbar relay. This can be handled using bus unification logic where both zones can be treated as a since zone.

V. Conclusion:

Bus Couplers with single & Dual CT application has been described in this paper, and both the types have merits and demerits as hi-lighted. The application depending upon the operation philosophy and the fault current magnitude would be the best input to decide the better option based on which the user is fee to choose the type of CT arrangement for their station.

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K N Dinesh Babu is a professional power system protection engineer in India with extensive experience in HV / EHV sub stations and industries. He is currently working for Megger India and his work background includes experience in working for Alstom, ABB, and GE in various roles like testing; commissioning; design and application engineering. A major portion of this experience has been in the area of protective relaying with a major focus on the application and coordination of protective facilities on electrical power systems. His experience includes the development of protection philosophies, implementation of new technologies in the field; control logic requirements for protective systems; development of specifications for protective relay settings; and analysis of disturbances and faults in electric power systems. He also trains protection engineers, field engineers and O&M engineers on IEDs, SCADA, power system protection and synchrophasors for major utilities and industries in India and Abroad.

He holds a doctorate in electrical engineering and is a DFSS certified six sigma green belt. He is a senior member of IEEE and member of CIGRE. His areas of contribution are electric traction, power system protection and renewable energy utilization and have published several articles in international journals and conferences.

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