NHP Technical NEWS

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Circuit breakers working together

written by William Mairs - Technical Manager, NHP Electrical Engineering Products Pty. Ltd.

Electrical installations are required to have both overcurrent and short circuit protection to prevent conductor damage. As the typical installation has a stepping down of conductor sizes from the transformer to final circuits, there must also be a stepping down of the protection provided at each change of conductor size. During a fault, there may be multiple circuit breakers all detecting the same current. From a convenience point of view, it is desirable that only the breaker nearest the fault trips so that healthy circuits are not interrupted. In achieving this, there are other factors at play and these could cause problems worse than unwanted tripping.

An understanding of circuit breaker operation and what happens during a fault can be helpful in specifying and selecting devices for a particular installation.

1.0 Circuit Breaker Design

There are two types of circuit breaker basic operation. There are those breakers designed to make and withstand high fault currents and those designed to trip as quickly as possible. Generally these are distinguished by Air Circuit Breakers (ACBs) and Moulded Case Circuit Breakers (MCCBs). The contact system of the ACB is arranged in a way to use the high electromagnetic forces produced by fault currents to push the contacts together. In MCCBs, the forces are used to drive the contacts open even before the trip mechanism can respond to the fault. For the typical designs, this has meant that an ACB will have a minimum 30 msec to respond to a fault while in an MCCB, the contacts will start to lift when the current

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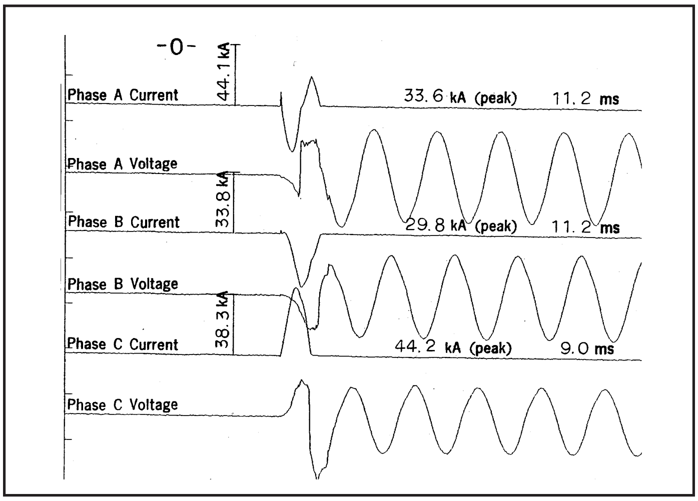
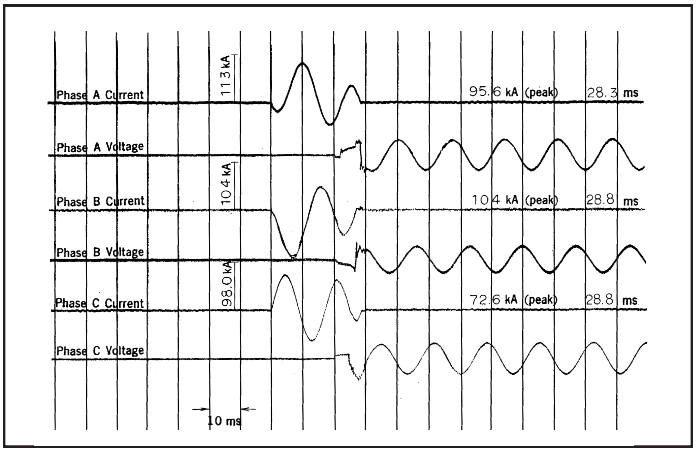


Typical MCCB breaking 50 kA. Breaker starts to open very quickly and limits peak current.



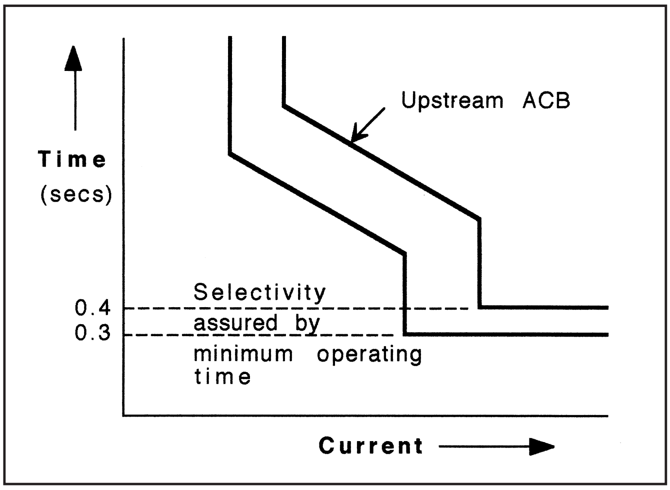
Typical ACB breaking 50 kA. Breaker remains closed for 20 ms. (see delay in appearance of arc voltage)

reaches a value of say 10 kA. If the fault prospective is 50 kA, this value is reached in only a few milliseconds and the opening contacts start to modify the magnitude of the fault current very quickly. The mechanism of the MCCB may not be tripped at this point so it is possible for contact lift to occur but the MCCB not trip if the fault current is interrupted by a down stream device. In general an ACB will not limit the first peak of a fault current but an MCCB can.

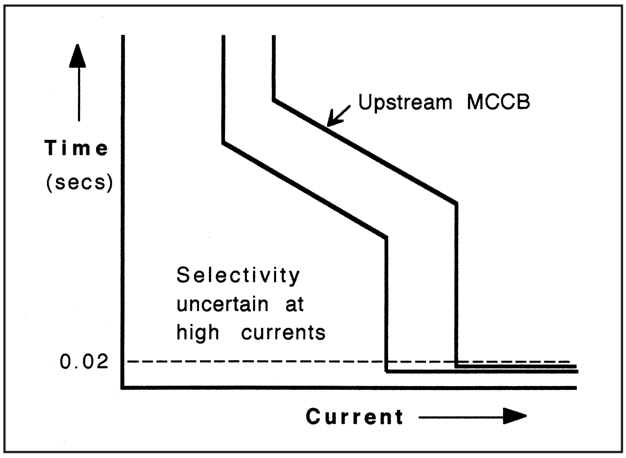
2.0 Selectivity

In the case of the ACB, it is possible to use simple time grading to ensure that only the breaker closest to the fault trips. ACBs are rated to withstand through fault currents without damage so it is possible to allow delay times of up to one or three seconds. If the incoming circuit breaker in an installation is set to clear a short circuit in 0.5 seconds, ACBs downstream could be set at times of say 0.4, 0.3 and 0.2 seconds. This positive time separation ensures selectivity can be achieved but has the disadvantage of very slow clearance times if the fault is just downstream of the incoming breaker. Various electronic means have been available to eliminate this delay by effectively providing communication between the breakers. If the downstream breaker does not detect a fault current, then the upstream breaker trip is not delayed. There has been little market acceptance of this type of protection in industrial or commercial installations.

For MCCBs, a high fault level will require rapid tripping to protect the breaker itself but as the frame size increases, a small delay is possible without causing excessive contact damage. This delay is often introduced by mechanical means and is usually no more than one current loop or 10 milliseconds. As the contacts of the breaker have opened in this short time, the fault current is modified by both the breaker next to the fault and the upstream breaker. This can produce a greater current limiting effect than a breaker operating on its own. Because of the short time delays and the combined effect on the fault current, selectivity



ACBs can withstand high currents.



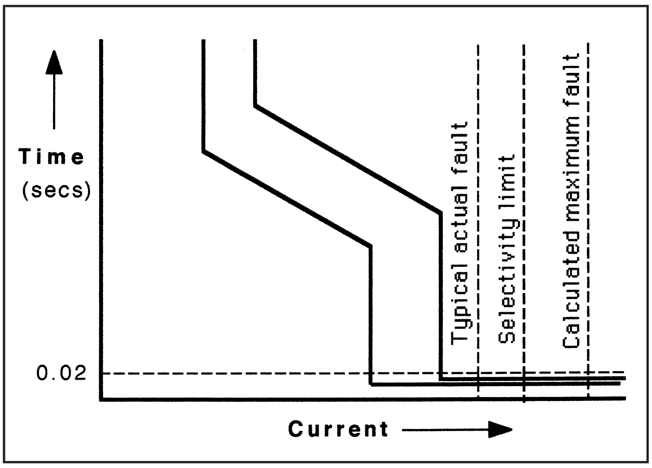
MCCBs must trip quickly at high current levels.

between MCCBs is usually established by test and manufacturers provide tables of suitable combinations. Selectivity can be full with only the first breaker tripping or partial with only high fault currents tripping both breakers.

2.1 Partial selectivity

In most cases, the likely maximum short circuit level is much lower than the theoretical level. Quite often the supply source impedance is ignored and assumptions made in calculating the conductor impedance result in the actual fault prospective being overstated. This may not be a bad thing when selecting the short circuit ratings of the circuit breakers but for selectivity, a conservative approach is not required. From a circuit breaker operation point of view, it is better for two breakers to clear the fault rather than just one. This can ensure the smaller breaker is in a better condition for continued service as the internal damage or wear is less.

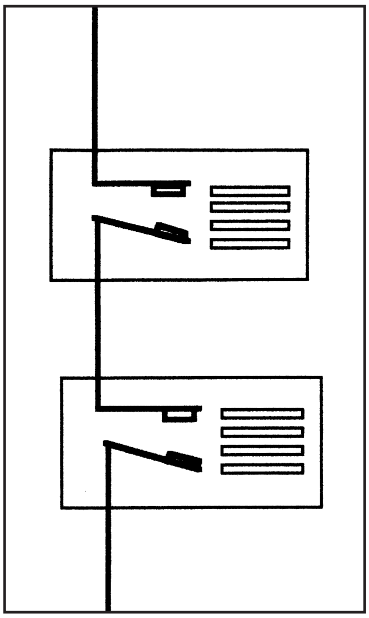
For the protection system to see the maximum fault level, a 'bolted' fault is required across the outgoing terminals. This is very unlikely and most faults will occur at some distance downstream of the breaker and arcing is usually involved. Considering this and allowing for the calculated fault level being on the high side, practical selectivity levels can be limited to say half the calculated full fault prospective.



Typical actual fault levels should be considered when designing for selectivity.

Another issue to consider is that if the actual fault level is near the calculated maximum, the fault must be at or very close to the breaker meaning that the fault may be inside the switchboard. In this case, it is highly desirable that the upstream breaker trips as well.

3.0 Cascade



A fault passing through two CBs can result in a high combined short circuit rating.

As mentioned above, at high fault levels the contacts of an MCCB will open even without the mechanism being tripped. This effect generally means that when a fault current passes through two circuit breakers, the combined operation can result in a higher fault current capability. It is permitted to select a device on the basis of this higher rating. As the circuit breakers are required by the Wiring Rules to be able to interrupt fault current up to the prospective fault level at its point of installation, it is only the breaker downstream of the other that can be considered for this improved or cascade rating.

Cascade performance needs to be proven by testing and manufacturers publish tables showing suitable combinations. Using cascade ratings can allow a more economic solution to the selection of the circuit breakers.

4.0 Conclusion

In some installations, there may be a strong need to provide security of supply, but specifying full selectivity may be introducing unnecessary costs. Under some high fault levels full selectivity may be undesirable. Consideration of the practical selectivity range may result in a better overall protection scheme.

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The Editor - 'NHP Technical News' PO Box 199, Richmond, Victoria, 3121.

NHP Electrical Engineering Products Pty Ltd A.B.N. 84 004 304 812
www.nhp.com.au
AUSTRALIA
VICTORIA
MELBOURNE
43-67 River Street
Richmond VIC 3121
Phone (03) 9429 2999
Fax (03) 9429 1075
NEW SOUTH WALES
SYDNEY
30-34 Day Street North,
Silverwater NSW 2128
Phone (02) 9748 3444
Fax (02) 9648 4353
NEWCASTLE
575 Maitland Road
Mayfield West NSW 2304
Phone (02) 4960 2220
Fax (02) 4960 2203
QUEENSLAND
BRISBANE
16 Riverview Place
Murarrie QLD 4172
Phone (07) 3909 4999
Fax (07) 3399 9712
TOWNSVILLE
62 Leyland Street
Garbutt QLD 4814
Phone (07) 4779 0700
Fax (07) 4775 1457
ROCKHAMPTON
14 Robison Street
Rockhampton North QLD 4701
Phone (07) 4927 2277
Fax (07) 4922 2947
TOOWOOMBA
Cnr Carroll St & Struan Crt
Toowoomba QLD 4350
Phone (07) 4634 4799
Fax (07) 4633 1796
CAIRNS
Unit 2, 1 Bramp Close
Portsmith QLD 4870
Phone (07) 4035 6888
Fax (07) 4035 6999
SOUTH AUSTRALIA
ADELAIDE
36-38 Croydon Road
Keswick SA 5035
Phone (08) 8297 9055
Fax (08) 8371 0962
WESTERN AUSTRALIA
PERTH
38 Belmont Ave
Rivervale WA 6103
Phone (08) 9277 1777
Fax (08) 9277 1700
NORTHERN TERRITORY
DARWIN
3 Steele Street
Winnellie NT 0820
Phone (08) 8947 2666
Fax (08) 8947 2049
TASMANIA
HOBART
2/65 Albert Road
Moonah Tasmania 7009
Phone (03) 6228 9575
Fax (03) 6228 9757
NEW ZEALAND
NHP Electrical Engineering Products (NZ) Limited
7 Lockhart Place
Mt Wellington Auckland NZ
Phone 64 9 276 1967
Fax 64 9 276 1992
85 Gasson Street
Sydenham Christchurch NZ
Phone 64 3 377 4407
Fax 64 3 377 4405

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