Cascading

What is cascading?

Cascading is the use of the current limiting capacity of circuit breakers at a given point to permit installation of lower-rated and therefore lower-cost circuit breakers downstream.
The upstream circuit breakers acts as a barrier against short-circuit currents. In this way, downstream circuit breakers with lower breaking capacities than the prospective short-circuit (at their point of installation) operate under their normal breaking conditions.
Since the current is limited throughout the circuit controlled by the limiting circuit breaker, cascading applies to all switchgear downstream. It is not restricted to two consecutive devices.

General use of cascading

With cascading, the devices can be installed in different switchboards. Thus, in general, cascading refers to any combination of circuit breakers where a circuit breaker with a breaking capacity less than the prospective Isc at its point of installation can be used. Of course, the breaking capacity of the upstream circuit breaker must be greater than or equal to the prospective short-circuit current at its point of installation.
The combination of two circuit breakers in cascading configuration is covered by the following standards:
- IEC 60947-2 (circuit breaker design and manufacturing)
- IEC 60364, § 434.5.1 (electrical distribution network).

Coordination between circuit breakers

The use of a protective device possessing a breaking capacity less than the prospective short-circuit current at its installation point is permitted as long as another device is installed upstream with at least the necessary breaking capacity. In this case, the characteristics of the two devices must be coordinated in such a way that the energy let through by the upstream device is not more than that which can be withstood by the downstream device and the cables protected by these devices without damage.
Cascading can only be checked by laboratory tests and the possible combinations can be specified only by the circuit breaker manufacturer.

Cascading and protection discrimination

In cascading configurations, due to the Roto-active breaking technique, discrimination is maintained and, in some cases, even enhanced. Where upstream breaker is part of Compact NSX range, consult the enhanced discrimination tables for data on discrimination limits

Cascading tables

Schneider Electric cascading tables are:
- drawn up on the basis of electronical simulations (comparison between the energy limited by the upstream device and the maximum permissible thermal stress for the downstream device)
- verified experimentally in accordance with IEC standard 60947-2.

For distribution systems with 220/240 V, 400/415 V and 440 V between phases, the tables of the following pages indicate cascading possibilities between upstream Compact and downstream Multi 9 and Compact circuit breakers as well as between upstream Masterpact and downstream Compact circuit breakers.

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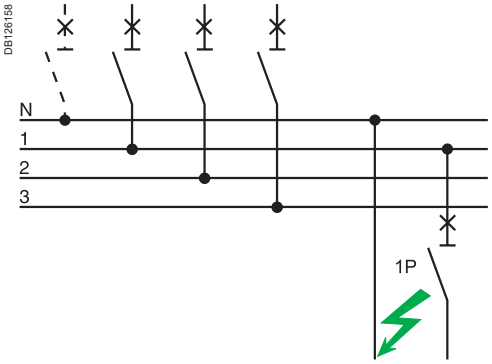
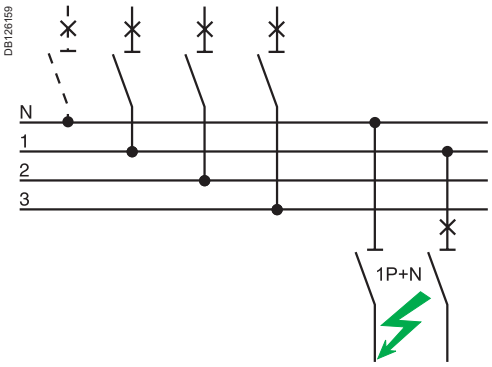
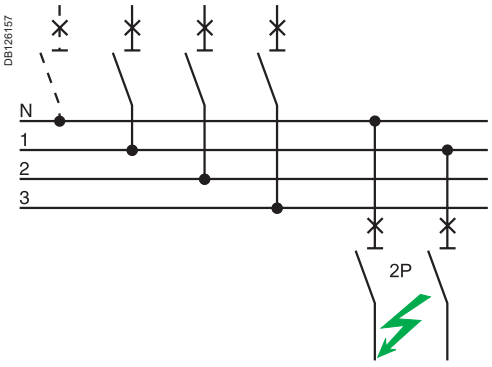
Protection of single-phase circuits in a three-phase network system

■ the breaking capacities enhanced by cascading indicated in the 380/415 V rated voltage tables are valid when the downstream device is type 1P, 1P+N, 3P or 4P





■ in the case of 2P type downstream devices (2P or 4P upstream device), refer to the 220/240 V rated voltage tables.



Example of three level cascading

Consider three circuit breakers A, B and C connected in series. The criteria for cascading are fulfilled in the following two cases:

■ the upstream device A is coordinated for cascading with both devices B and C (even if the cascading criteria are not fulfilled between B and C). It is simply necessary to check that the combinations A + B and A + C have the required breaking capacity

■ each pair of successive devices is coordinated, i.e. A with B and B with C (even if the cascading criteria are not fulfilled between A and C). It is simply necessary to check that the combinations A + B and B + C have the required breaking capacity.

The upstream breaker A is a NSX250L (breaking capacity 150 kA) for a prospective Isc of 80 kA across its output terminals.

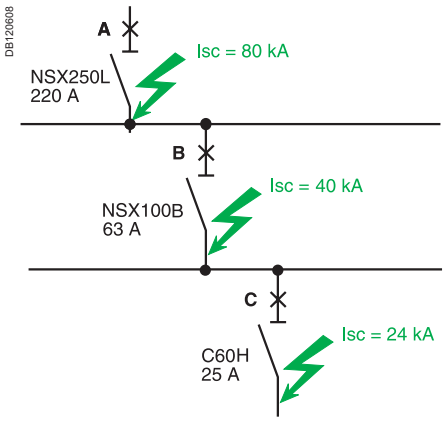
A NSX100B (breaking capacity 25 kA) can be used for circuit breaker B for a prospective Isc of 40 kA across its output terminals, since the "reinforced" breaking capacity provided by cascading with the upstream NSX250L is 50 kA.

A C60H (breaking capacity 15 kA) can be used for circuit breaker C for a prospective Isc of 24 kA across its output terminals since the "reinforced" breaking capacity provided by cascading with the upstream NSX250L is 25 kA.

Note that the "reinforced" breaking capacity of the C60H with the NSX100B upstream is only 20 kA, but:

■ A + B = 50 kA

■ A + C = 25 kA.



Cascading, network 380/415 V

Upstream: iDPN, iC60, C120, NG125
Downstream: iDPN, iC60, C120, NG125

Upstream	iC60N iDPNN 10	iC60H 15	iC60L ⩽ 25 A 25	 32/40 A 20	 50/63 A 15	C120N 10	C120H 15	NG125N 25	NG125H 36	NG125L 50
Downstream	**Breaking capacity (kA rms)**									
iDPN	10	10	20	15	10	10	10	10	15	20
iDPNN		15	25	20	15		15	15	20	25
iC60N ⩽ 25 A		15	25	20	15		15	25	25	25
iC60N 32 A and 40 A		15		20	15		15	25	25	25
iC60N 50 A and 63 A		15			15			25	25	25
iC60H ⩽ 25 A			25					25	36	36
iC60H 32 A and 40 A								25	36	36
iC60H 50 A and 63 A								25	36	36
iC60L ⩽ 25 A								25	36	40
iC60L 32 A and 40 A								25	36	40
iC60L 50 A and 63 A								25	36	36
C120N							15	25	25	36
C120H							15	25	25	36
NG125N									36	36
NG125H										50

Cascading, network 380/415 V

Upstream: NG160, NSC100N, Compact NSX100-160
Downstream: iDPN, iC60, C120, NG125, NSC100N, Compact NSX100-160

Upstream Breaking capacity (kA rms)	NG160E 16	NG160N 25	NG160H 36	NSC100N 18	NSX100B 25	NSX100F 36	NSX100N 50	NSX100H 70	NSX100S 100	NSX100L 150
Downstream	**Reinforced breaking capacity (kA rms)**									
iDPN	10	10	10	10	10	10	10	10	10	10
iDPNN	15	15	15	15	15	15	15	15	15	15
iC60N	16	25	25	18	20	25	30	30	30	30
iC60H ⩽ 40 A	16	25	25	18	25	36	40	40	40	40
iC60H 50 A et 63 A	16	25	25	18	25	36	36	36	36	36
iC60L ⩽ 25 A		25	25	18		36	40	40	40	40
iC60L 32 A et 40 A		25	25	18	25	36	40	40	40	40
iC60L 50 A et 63 A		25	25	18	25	36	36	36	36	36
C120N		25	25	18	25	25	25	25	25	25
C120H		25	25	18	25	25	25	25	25	25
NG125N						36	36	36	50	70
NG125H							40	50	70	100
NG125L								70	100	150
NSC100N					25	36	50	50	50	50
NSX100B						36	36	50	50	50
NSX100F							50	70	100	150
NSX100N								70	100	150
NSX100H									100	150
NSX100S										150
NSX100S										150

Upstream Breaking capacity (kA rms)	NSX160B 25	NSX160F 36	NSX160N 50	NSX160H 70	NSX160S 100	NSX160L 150
Downstream						
iDPN	10	10	10	10	10	10
iDPNN	15	15	15	15	15	15
iC60N	20	25	30	30	30	30
iC60H ⩽ 40 A	25	36	40	40	40	40
iC60H 50 A and 63 A	25	30	30	30	30	30
iC60L ⩽ 25 A		36	40	40	40	40
iC60L 32 A and 40 A	25	36	40	40	40	40
iC60L 50 A and 63 A	25	30	36	36	36	36
C120N	25	25	25	25	25	25
C120H	25	25	25	25	25	25
NG125N		36	36	36	50	70
NG125H			40	50	70	100
NG125L			50	70	100	150
NG160E	25	25	30	30	30	30
NG160N		36	36	50	50	50
NG160H			50	50	50	50
NSC100N	25	36	50	50	50	50
NSX100B		36	36	50	50	50
NSX100F			50	70	100	150
NSX100N				70	100	150
NSX100H					100	150
NSX100S						150
NSX160B		36	36	50	50	50
NSX160F			50	70	100	150
NSX160N				70	100	150
NSX160H					100	150
NSX160S						150

Cascading, network 380/415 V

Upstream: Compact NSX250-630
Downstream: iDPN, iC60, C120, NG125-160, NSC100N, Compact NSX100-250

Upstream Breaking capacity (kA rms)	NSX250B 25	NSX250F 36	NSX250N 50	NSX250H 70	NSX250S 100	NSX250L 150
Downstream	**Reinforced breaking capacity (kA rms)**					
iDPN	10	10	10	10	10	10
iDPNN	15	15	15	15	15	15
iC60N ⩽ 40 A	20	25	30	30	30	30
iC60N 50 A and 63 A	20	25	25	25	25	25
iC60H ⩽ 40 A	25	30	30	30	30	30
iC60H 50 A and 63 A	25	25	30	30	30	30
iC60L ⩽ 25 A	25	30	36	36	36	36
iC60L 32 A and 40 A	25	30	30	30	30	30
iC60L 50 A and 63 A	25	25	25	25	25	25
C120N	25	25	25	25	25	25
C120H	25	25	25	25	25	25
NG125N		36	36	36	50	70
NG125H			40	50	70	100
NG125L			50	70	100	150
NG160E	25	25	30	30	30	30
NG160N		36	36	50	50	50
NG160H			50	50	50	50
NSC100N	25	36	50	50	50	50
NSX100B		36	36	50	50	50
NSX100F			50	70	100	150
NSX100N				70	100	150
NSX100H					100	150
NSX100S						150
NSX160B		36	36	50	50	50
NSX160F			50	70	100	150
NSX160N				70	100	150
NSX160H					100	150
NSX160S						150
NSX250B		36	36	50	50	50
NSX250F			50	70	100	150
NSX250N				70	100	150
NSX250H					100	150
NSX250S						150

Upstream Breaking capacity (kA rms)	NSX400F 36	NSX400N 50	NSX400H 70	NSX400S 100	NSX400L 150	NSX630F 36	NSX630N 50	NSX630H 70	NSX630S 100	NSX630L 150
Downstream	**Reinforced breaking capacity (kA rms)**									
NG160E	25	25	30	30	30	25	25	30	30	30
NG160N		36	50	50	50		36	50	50	50
NG160H		50	50	50	50		50	50	50	50
NSC100N		50	50	50	50		50	50	50	50
NSX100B	36	36	50	50	50	36	36	50	50	50
NSX100F		50	70	100	150		50	70	100	150
NSX100N			70	100	150			70	100	150
NSX100H				100	150				100	150
NSX100S					150					150
NSX160B	36	36	50	50	50	36	36	50	50	50
NSX160F		50	70	100	150		50	70	100	150
NSX160N			70	100	150			70	100	150
NSX160H				100	150				100	150
NSX160S					150					150
NSX250B	36	36	50	50	50	36	36	50	50	50
NSX250F		50	70	100	150		50	70	100	150
NSX250N			70	100	150			70	100	150
NSX250H				100	150				100	150
NSX250S					150					150
NSX400F		50	70	100	150		50	70	100	150
NSX400N			70	100	150			70	100	150
NSX400H				100	150				100	150
NSX400S					150					150
NSX630F							50	70	100	150
NSX630N								70	100	150
NSX630H									100	150
NSX630S										150

Cascading, network 380/415 V

Upstream: Compact NS630b-3200N, Masterpact NT NW
Downstream: Compact NSX100-630, Compact NS630b-1600

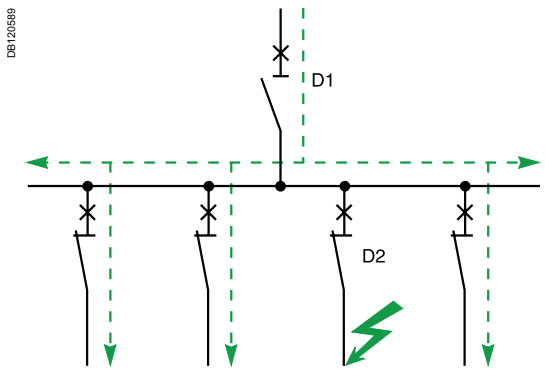
Upstream	NS630bN to NS1600N	NS630b H	NS630b L	NS630b LB	NS800 H	NS800 L	NS800 LB	NS1000 H	NS1000 L	NS1250H NS1600H	NS2000N NS2500N NS3200N	Masterpact NT L1	Masterpact NW L1
Breaking capacity (kA rms)	**50**	**70**	**150**	**200**	**70**	**150**		**70**	**150**	**70**	**70**	**150**	**150**
Downstream	**Reinforced breaking capacity (kA rms)**												
NSX100B	50	50	50	50	50	50	50	50	50	50		50	
NSX100F	50	70	150	150	70	150	150	70	150	70		150	
NSX100N		70	150	150	70	150	150	70	150	70		150	
NSX100H			150	150		150	150		150			150	
NSX100S			150	200		150	200		150			150	
NSX100L				200			200						
NSX160B	50	50	50	50	50	50	50	50	50	50		50	
NSX160F	50	70	150	150	70	150	150	70	150	70		150	
NSX160N		70	150	150	70	150	150	70	150	70		150	
NSX160H			150	150		150	150		150			150	
NSX160S			150	200		150	200		150			150	
NSX160L				200			200						
NSX250B	50	50	50	50	50	50	50	50	50	50		50	
NSX250F	50	70	150	150	70	150	150	70	150	70		150	
NSX250N		70	150	150	70	150	150	70	150	70		150	
NSX250H			150	150		150	150		150			150	
NSX250S			150	200		150	200		150			150	
NSX250L				200			200						
NSX400F	50	70	150	150	70	150	150	70	150	70		150	
NSX400N		70	150	150	70	150	150	70	150	70		150	
NSX400H			150	150		150	150		150			150	
NSX400S			150	200		150	200		150			150	
NSX400L				200			200						
NSX630F	50	70	150	150	70	150	150	70	150	70		150	
NSX630N		70	150	150	70	150	150	70	150	70		150	
NSX630H			150	150		150	150		150			150	
NSX630S			150	200		150	200		150			150	
NSX630L				200			200						
NS630bN		70	150	200	70	150	200	70	150	70	70	150	65
NS630bH			150	200		150	200		150			150	
NS800N					70	150	200	70	150	70	70	150	65
NS800H						150	200		150			150	
NS1000N							200	70	150	70	70	150	65
NS1000H							200		150			150	
NS1250N										70	70		65
NS1600N											70		65

Protection discrimination

Protection discrimination is an essential element that must be taken into account starting at the design stage of a low voltage installation to ensure the highest level of availability for users.

Discrimination is important in all installations for the comfort of users, however it is fundamental in installations requiring a high level of service continuity, e.g. industrial manufacturing processes.

Industrial installations without discrimination run a series of risks of varying importance including:
- production deadline overruns
- interruption in manufacturing, entailing:
  - production or finished-product losses
  - risk of damage to production machines in continuous processes
- restarting of machines, one by one, following a general power outage
- shutdown of vital safety equipment such as lubrification pumps, smoke fans, etc.



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What is discrimination?

Discrimination, also called selectivity, is the coordination of automatic protection devices in such a manner that a fault appearing at a given point in a network is cleared by the protection device installed immediately upstream of the fault, and by that device alone.

Total discrimination

Discrimination is said to be total if, for all fault current values, from overloads up to the non-resistive short-circuit current, circuit breaker D2 opens and D1 remains closed.

Partial discrimination

Discrimination is partial if the above condition is not respected up to the full short-circuit current, but only to a lesser value termed the selectivity limit current (Is).

No discrimination

In the event of a fault, both circuit breakers D1 and D2 open.