



TECHNICAL GUIDE



COORDINATION

BETWEEN PROTECTION DEVICES

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LEGRAND SUPPORTS YOU ON ALL YOUR PROJECTS

Coordination between protection devices against overcurrents consists of coordinating the characteristics of several protection devices installed in series, with two different objectives:

Selectivity, which prevents the entire installation being put out of service when a fault occurs on one part of the installation.

Back-up (or more generally back-up protection, if the protection devices are not circuit breakers), which increases the breaking capacity Icu of the downstream protection.

LEGAL INFORMATION

Presentation photos do not always include Personal Protective Equipment (PPE), but this is a legal and regulatory obligation that must be scrupulously respected.

In accordance with its continuous improvement policy, Legrand reserves the right to change the specifications and illustrations without notice. All illustrations, descriptions and technical information included in this document are provided as indications and cannot be held against Legrand.



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SAFETY INSTRUCTIONS



Strict adherence to procedures and compliance with these recommendations are essential to ensure the safety of people and property. Any deviation from these requirements may result in accidents of varying severity, including burns, electric shocks, personal injury, and other injuries or property damage.

General information

- Use only the products and accessories recommended by the Legrand Group in the catalogue, instructions, technical data sheets and all other documents provided by Legrand (hereinafter referred to as “the Documentation”) in compliance with the installation rules.

Improper installation or use may result in the risk of arcing in the enclosure, overheating or fire. The enclosures must be used under normal conditions, they must not be subjected to Voltage / Current / Temperature values other than those specified in the Documentation.

- Legrand declines all responsibility for any modification or repair of the equipment making up the enclosure that is not authorized by the Legrand Group, as well as any failure to comply with the rules and recommendations specified by Legrand in the Documentation. In addition, in the cases mentioned above, the warranty granted by Legrand will not be applicable.
- It is necessary to check that the characteristics of the products are appropriate for their environment and use during maintenance operations, and to refer to the Documentation.
- If you have any questions or require clarification, please contact Legrand Group.

Protection/security

- The installation, use and maintenance of the enclosures and their components must be carried out by qualified, trained and authorized personnel, in accordance with the regulations in force in each country.
- People working on the installation must have the appropriate electrical authorizations for the work to be carried out.
- Wear the PPE (Personal Protective Equipment) necessary to work on live products.



- Respect the safety rules related to electrical work.
- Improper electrical and mechanical use of equipment can be dangerous and may result in personal injury or damage to property.

Maintenance

- Depending on the maintenance operations to be carried out, partial or total power cuts of the enclosure concerned should be planned before any work.
- When performing operations that involve access to the inside of the enclosure, be aware of the risk of burns before touching any.
- Before turning the power back on, make sure that there are no foreign bodies and that all physical protections have been put back in place (e.g.: screens, covers, faceplates).

Risk of electric shock, burns and explosion.

The rules and recommendations in this document are based on our knowledge of the typical conditions of use of our products in the fields of application usually encountered. However, it is always the customer’s responsibility to verify and validate that Legrand products are suitable for its installation and use.

The customer must ensure proper installation, maintenance and operation of the equipment to avoid any risk of injury to personnel or damage to property in the event of product failure, especially for applications that require a very high level of safety (e.g., those in which the failure of a component may endanger human life or health).

The rules for storage, handling, installation and maintenance and the appropriate precautions and warnings must be strictly observed and applied.

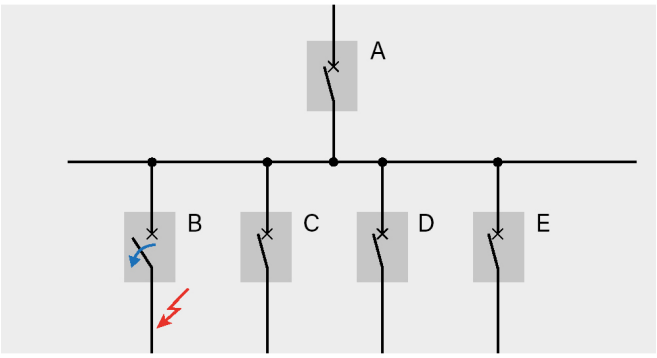
THE SELECTIVITY



DEFINITIONS

Selectivity means that, when a fault occurs, only the part of the installation concerned by this fault is isolated.

It is required when several protection devices are installed in series and when it is justified by safety or operating requirements. Selectivity is based on coordinating the operating characteristics of protection devices so that the intended device operates when overcurrents occur within the given limits, whereas the other devices, located upstream, do not operate.



EXAMPLE

As a result of the selectivity between protection devices A and B, the fault which occurs downstream of B does not affect the other parts of the installation.

Selectivity improves the continuity of service and safety of the installation.

There are two types of selectivity:

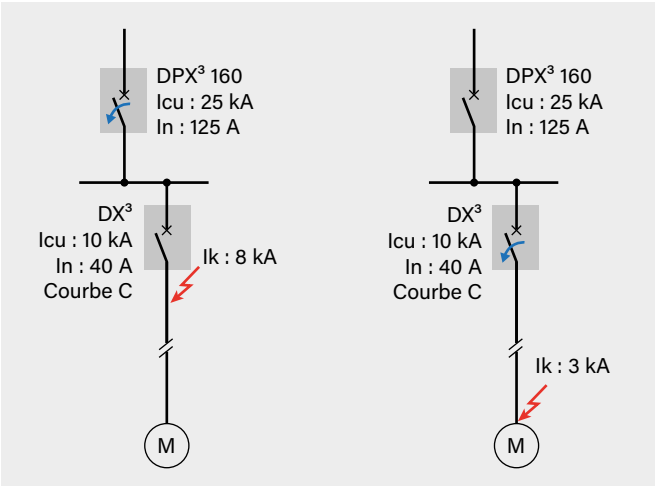
- **Partial selectivity**
- **Total selectivity**

Partial selectivity

Protection up to a given overcurrent level without triggering operation of the upstream protection device. Above this overcurrent level, the upstream device will provide the protection.

Since almost all faults occur during use, partial selectivity may be adequate if the selectivity limit is higher than the value of the maximum short circuit which may occur at the point of use (or at the end of the trunking). This is referred to as "operating selectivity".

This technique is very often adequate, more economical and less restricting in terms of implementation.



EXAMPLE

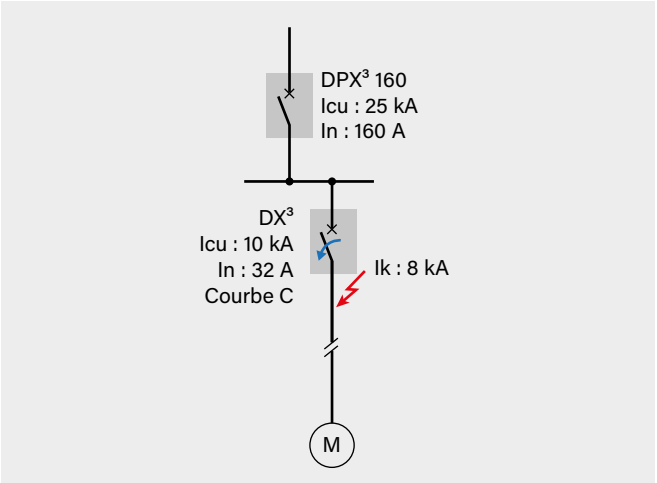
The selectivity limit for coordination of the DPX³ 160 25 kA 125 A with the DX³ 10 kA 40 A C curve is 6 kA.

As the maximum short-circuit level (Ik max) at the installation point is 8 kA, the selectivity is not total.

However, there is total selectivity at the point of use where the prospective short-circuit current is only 3 kA.

Total selectivity

Selectivity between two protection devices installed in series is said to be "total" when the downstream protection device provides protection up to the value of the maximum prospective short circuit at its installation point without triggering operation of the upstream protection device.



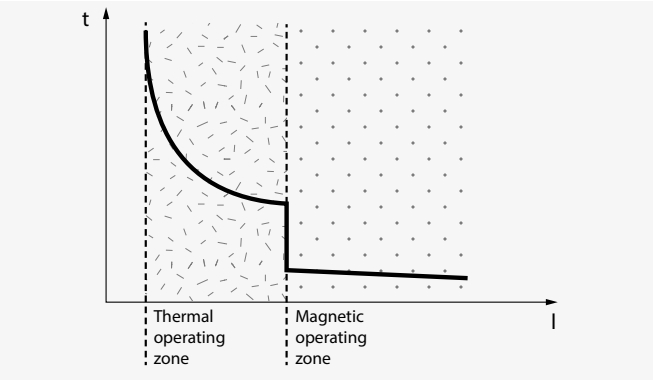
EXAMPLE

The selectivity limit for coordination of the DPX³ 160 25 kA 160 A with the DX³ 10 kA 32 A C curve is 10 kA.

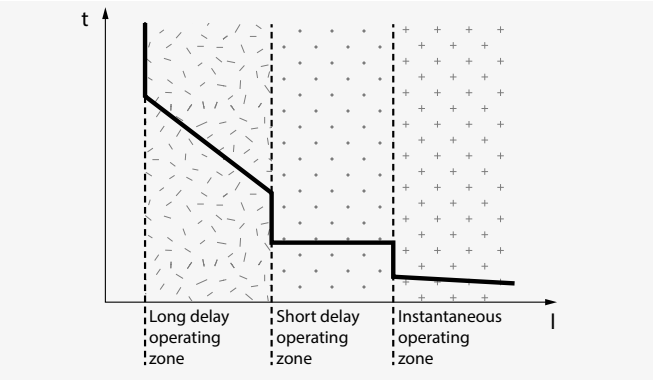
As the maximum short-circuit level (Ik max) at the installation point is 8 kA, the selectivity is total.

METHODS OF CHECKING THE SELECTIVITY LEVEL

To confirm whether the selectivity level for two circuit breakers installed in series is total or partial, **the selectivity must be checked for the various trip zones of the devices.**



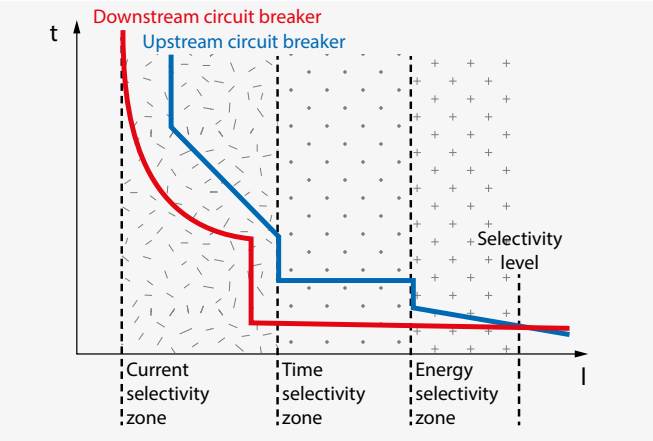
Trip zones of a thermal magnetic circuit breaker



Trip zones of an electronic circuit breaker

Three checking methods must be used in sequence:

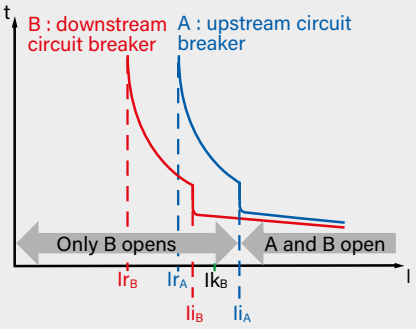
- Current selectivity
- Time selectivity
- Energy selectivity



The check consists of ensuring that that the curves do not intersect before the required selectivity level.

Current sensing selectivity

This technique is based on the difference in the intensity of the tripping curves of the upstream and downstream circuit breakers. It is checked by comparing these curves and ensuring that they do not overlap.



Ik_B : maximum short circuit at the installation point of circuit breaker B

It applies for the overload zone and the short-circuit zone, and the further apart the ratings of the devices, the better the selectivity.

APPLICATION RULES

- To obtain selectivity in the overload zone, the ratio of the setting currents (Ir) must be at least 1.6.
- To obtain selectivity in the short- circuit zone, it is generally adequate for the ratio of the magnetic setting currents (Ii) or short delay currents (Isd) for electronic circuit breakers to be at least 1.6. The selectivity limit is then equal to the magnetic tripping current IiA (or short delay current IsdA for an electronic circuit breaker) of the upstream circuit breaker.

The selectivity is therefore total as long as IkB is lower than IiA (IsdA).

Current sensing selectivity is therefore very suitable for final circuits where the short circuits are relatively weak.

Legrand provides tables detailing the three selectivity zones for its circuit breakers. These tables can be accessed in some technical data sheets or in the "XLPro^3 Tool Selectivity and backup/Legrand Selectivity and Backup" application.

The letter "T" (for "Total") indicates that there is selectivity up to the breaking capacity of the downstream device. When a value is given, it must be compared with the prospective short-circuit current at the installation point of the downstream device to check whether the selectivity is total.

(Valeurs en kA)		DPX³ 1600 1250 70kA; Electro S1						DPX³ 1600 1250 70kA; Electro S2; High						DPX³ 1600 1250 70kA; Electro S2; Low Amont					
	In (A) >=	500	630	800	1000	1250	1600	500	630	800	1000	1250	1600	500	630	800	1000	1250	1600
DPX³ 1600 36kA; Electro S1	500	15	15	15	15	15	20	T	T	T	T	T	T	15	15	15	15	15	20
	630		15	15	15	15	20		T	T	T	T	T		15	15	15	15	20
	800			15	15	15	20			T	T	T	T			15	15	15	20
	1000				15	15	20				T	T	T				15	15	20
	1250					15	20					T	T					15	20
	1600						20						T						20
DPX³ 1600 36kA; Electro S2; Low Aval	500	15	15	15	15	15	20	T	T	T	T	T	T	15	15	15	15	15	20
	630		15	15	15	15	20		T	T	T	T	T		15	15	15	15	20
	800			15	15	15	20			T	T	T	T			15	15	15	20
	1000				15	15	20				T	T	T				15	15	20
	1250					15	20					T	T					15	20
	1600						20						T						20
DPX³ 1600 36kA; Electro S2; High Aval	500							4	6,3	8	10	12,5	16						
	630								5	8	10	12,5	16						
	800									6,4	10	12,5	16						
	1000										8	12,5	16						
	1250											10	16						
	1600												12,8						
DPX³ 1600 36kA; MT	500	4	10	15	20	20	20	T	T	T	T	T	T	4	10	15	20	20	20
	630		10	15	20	20	20		T	T	T	T	T		10	15	20	20	20
	800			15	20	20	20			T	T	T	T			15	20	20	20
	1000				20	20	20				T	T	T				20	20	20
	1250					20	20					T	T					20	20
DPX³ 1600 50kA; Electro S10	500																		
	630																		
	800																		
	1000																		
	1250																		
	1600																		
DPX³ 1600 50kA; Electro S1	500	15	15	15	15	15	20	36	36	36	36	36	36	15	15	15	15	15	20
	630		15	15	15	15	20		36	36	36	36	36		15	15	15	15	20
	800			15	15	15	20			36	36	36	36			15	15	15	20
	1000				15	15	20				36	36	36				15	15	20
	1250					15	20					36	36					15	20
	1600						20						36						20

Current sensing selectivity (continued)

CHECKING SELECTIVITY WITH XLPro³ TOOL SELECTIVITY AND BACKUP/LEGRAND SELECTIVITY AND BACKUP

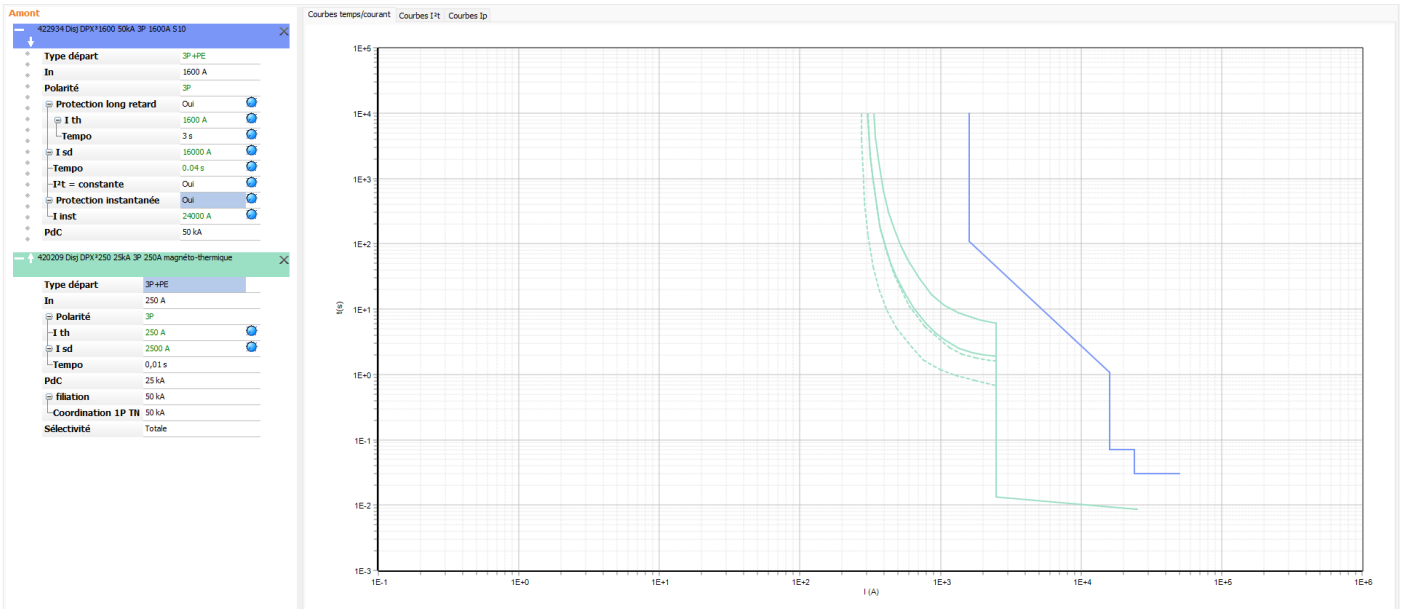
The selectivity is checked using tables or by comparing the tripping curves of the protection devices using the Legrand "XLPro³ Tool Selectivity and backup/Legrand Selectivity and Backup".

Please contact your subsidiary to download it for free.

It is an additional option for XLPro Calcul which makes it easy for users to obtain the required level of selectivity.

Product benefits:

- Can be used to adjust values to match customer requirements as closely as possible.
- Automatic updating of the software and the selectivity tables.



The current settings of the circuit breakers given in the tables are assumed to be their maximum values. If the settings are different, it is advisable to check the selectivity in the current and time zones, while the values given remain true in the energy zone.

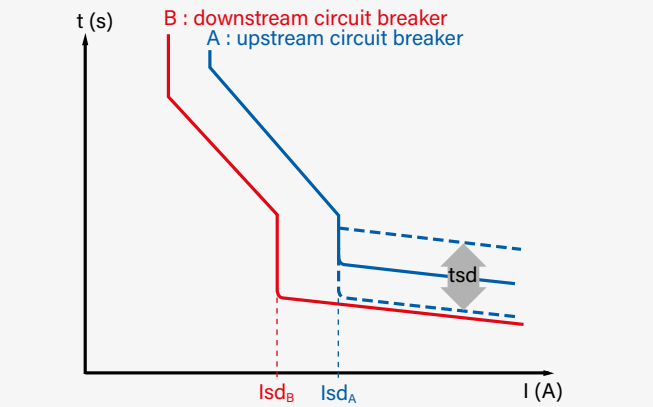
If it is not possible to obtain the required selectivity level using conventional methods, there are two additional techniques with Legrand electronic circuit breakers:

- **Dynamic selectivity (only for S2/Sg electronic trip units)**
- **Logical selectivity**

Time selectivity

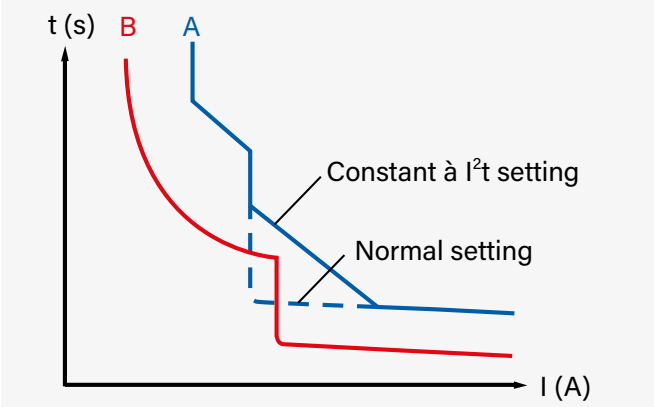
This technique is based on the difference in the times of the tripping curves of the circuit breakers in series. It is checked by comparing the curves and is used for selectivity in the short- circuit zone.

It is used for selectivity in the medium intensity short-circuit zone.



It is used in addition to current selectivity in order to obtain selectivity beyond the magnetic setting (or short delay) current of the upstream circuit breaker (IiA or IsdA).

Using circuit breakers with electronic releases set at constant I^2t improves the selectivity.



Removal of the short delay section of the tripping curve avoids overlapping of the tripping curves.

This option is available on electronic DPX and DPX^3, and on DMX^3.

APPLICATION RULES

The non-tripping time of the upstream device must be longer than the breaking time (including any time delay) of the downstream device.

The following conditions must be met for this:

- It must be possible to set a time delay on the upstream circuit breaker
- The upstream circuit breaker must be able to withstand the short-circuit current and its effects for the whole period of the time delay
- The conductors through which this current passes must be able to withstand the thermal stresses (I^2t).



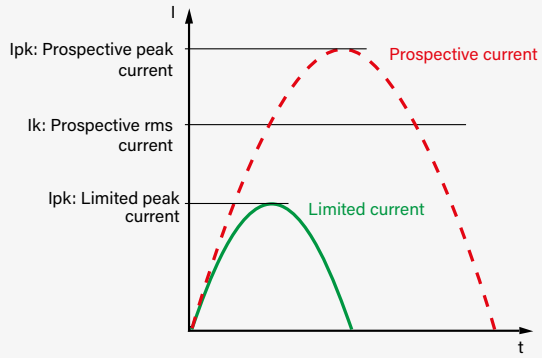
DPX, DPX^3 and DMX^3 circuit breakers have a number of time delay setting positions for implementing selectivity with a number of stages.

METHODS OF CHECKING THE SELECTIVITY LEVEL

Energy selectivity

This is based on the capacity of the downstream protection device to limit the energy flowing through it to a value lower than that required to cause tripping of the upstream device.

It is checked by reading the manufacturers' selectivity tables.



If there is a short circuit, without any protection, the current that would flow through the installation is the prospective short-circuit current. When a short-circuit current crosses a circuit breaker, the circuit breaker has the capacity, to a greater or lesser extent, to allow only part of this current to flow. The short circuit is then limited in amplitude and duration.

When the downstream circuit breaker B is a limiting device, the short-circuit current is limited in terms of both time and amplitude. The selectivity is therefore total if the limited current (IkB) which device B allows to pass is lower than the tripping current of device A.

Energy selectivity is used in the high intensity short-circuit zone.
The selectivity tables give the short-circuit current limit value for total selectivity between two circuit breakers. When this value is at least equal to the breaking capacity Icu of the downstream circuit breaker, it is simply marked "T".

ADDITIONAL SELECTIVITY TECHNIQUES

Dynamic selectivity

Dynamic selectivity is a particular type of selectivity developed by Legrand. It is based on making maximum use of the limitation characteristics of moulded case circuit breakers and extends the concept of time coordination to the highest short-circuit currents.

Dynamic selectivity operates between an electronic DPX/DPX^3 S2/Sg circuit breaker installed upstream and an electronic or thermal magnetic DPX/DPX^3 circuit breaker installed downstream.

Electronic DPX and DPX^3 have a 2-position setting:

- "High" for a higher selectivity level
- "Low" for a normal selectivity level

Electronic circuit breakers set to "High" have a slight tripping delay which enables a high selectivity level to be obtained even for the highest short-circuit currents.

APPLICATION RULES

Before considering dynamic selectivity, the time selectivity must be checked for medium intensity short- circuit currents by comparing the tripping curves.

When this has been checked, the following rules can be applied:

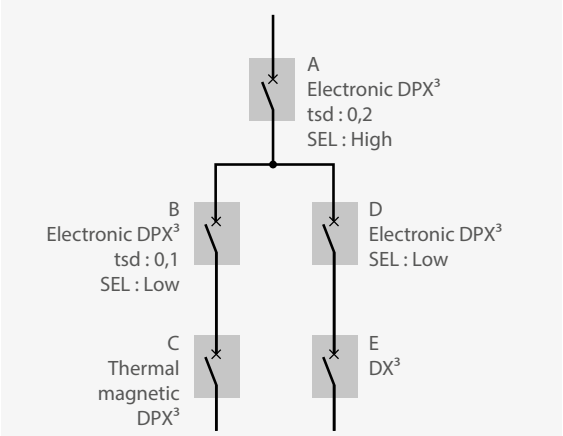
- The upstream circuit breaker must be set to "High"
- The downstream circuit breaker can be an electronic DPX or DPX^3 S2/Sg set to "Low", or a thermal magnetic DPX^3

Dynamic selectivity is applied only to S2/Sg electronic trip units, is NOT available on S1 and S10 electronic trip units.

On DPX^3 dynamic selectivity is set on the LCD screen in the same way as the other settings.

EXAMPLE

Dynamic selectivity between 2 levels:



Dynamic selectivity is particularly useful for installations characterised by a high intensity short-circuit current, when the circuit breakers concerned are in the same distribution board.

Dynamic selectivity enables:

- The selectivity limit for high intensity short-circuit currents to be increased in comparison with conventional energy selectivity
- The continuity of service and safety to be increased simply and economically

When there is no specific requirement for selectivity or the device is protecting a final circuit, it is not suggested to activate this function to reduce the electrodynamic effects.

In case of different electronic trip units (S10, S2/Sg, S1) the selectivity is anyway garanteed with S10 as upstream breaker and S2/Sg set in LOW or S1 as downstream breaker.

UPSTREAM

A: electronic DPX or DPX³ with “S2 or Sg” release and the SEL selector switch set to High (tsd = 0.2, considered to be the result of the previous time selectivity study on medium intensity short circuits).

DOWNSTREAM

B: electronic DPX or DPX³ with “S2 or Sg” release and the SEL selector switch set to Low (tm = 0.1, considered to be the result of the previous time selectivity study on medium intensity short circuits).

D: electronic DPX with SEL selector switch set to Low.

It is possible to install other circuit breakers downstream of the two dynamic selectivity levels:

C (thermal-magnetic DPX or DPX³) and E (DX³).

For high intensity short-circuit currents downstream of C or downstream of E, the selectivity with the upstream devices is no longer dynamic but current selectivity.



Setting dynamic selectivity on a DPX³

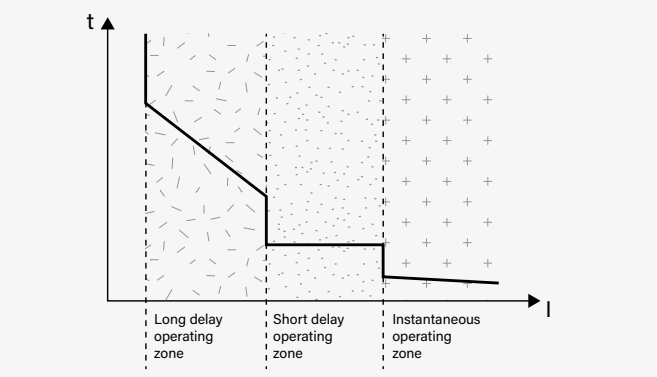
Logic selectivity

Logic selectivity is an “intelligent” type of selectivity performed by exchanging data between electronic DPX/DPX³/DMX³ linked by an external connection.

Logical selectivity is used on the short delay zone of the tripping curve t=k (time constant).

It concerns medium and high intensity short circuits (energy part).

It does not operate on the long delay part of the curve (current selectivity) dealing with overloads.



The operating principle of logical selectivity is as follows:

- the circuit breakers which detect the short-circuit current or a high starting current send a signal, via the connecting cable, to the circuit breaker(s) at the next level up, and at the same time they check the presence of a signal coming from one or more circuit breakers located at the level immediately below them;
- the circuit breaker within the logical selectivity chain that detects the short-circuit and receives no signal from downstream circuit breakers operates instantaneously;
- the circuit breaker which detects the short circuit and confirms the presence of a signal from a downstream circuit breaker remains closed, ensuring total selectivity.

In this way, if there is a short circuit, only the part of the installation affected by the fault is isolated by the circuit breaker immediately upstream.

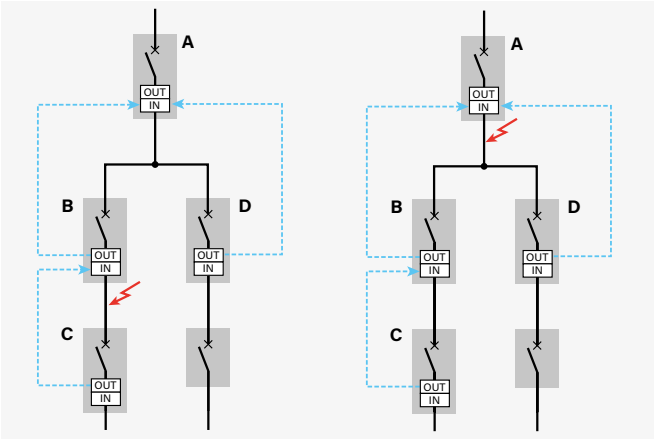
This ensures that good selectivity is obtained on several levels, in addition to the various time delays even if the tsd setting is the same.

FAULT 1: SHORT CIRCUIT DOWNSTREAM OF B

Circuit breakers A and B detect the fault. Circuit breaker A receives a signal from downstream circuit breaker B and therefore remains closed. As it does not receive any signal from the circuit breakers at the lower levels, circuit breaker B trips.

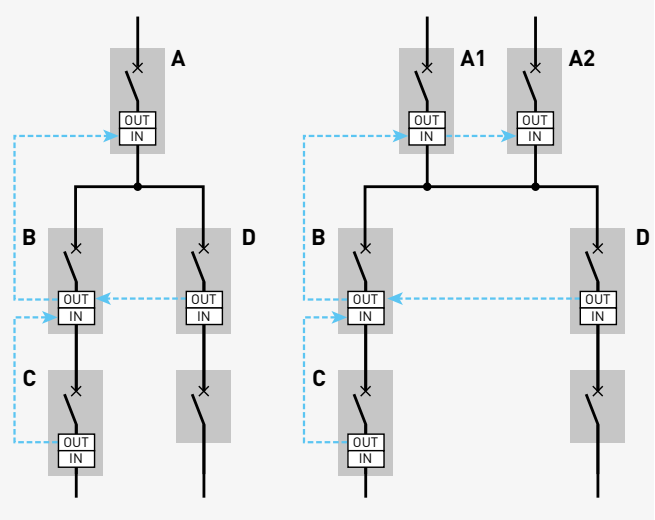
FAULT 2: SHORT CIRCUIT DOWNSTREAM OF A

Only circuit breaker A detects the fault. As it does not receive any signal from the circuit breakers at the lower levels, circuit breaker A trips.



For details about logic selectivity working (for any type of device) see dedicated “Logical selectivity” technical guide.

In both the cases described above, to prevent a double connection to circuit breaker A, it is also possible to use the following wiring:



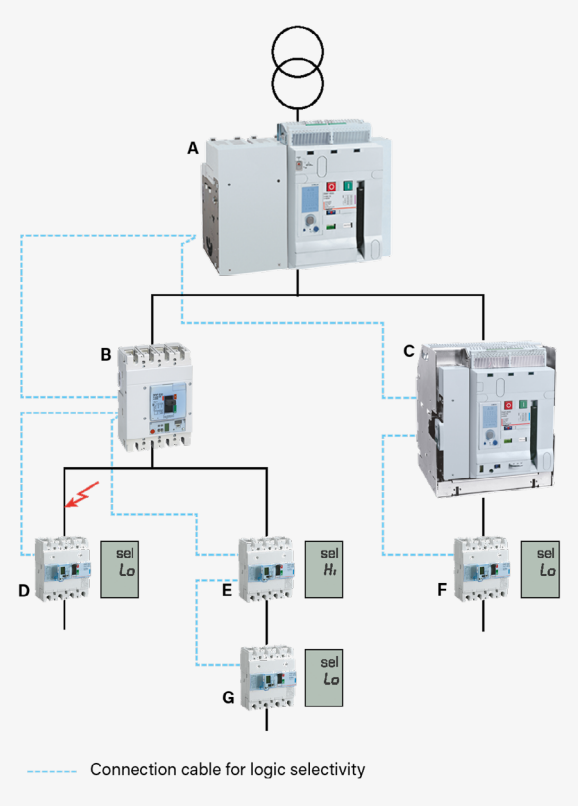
APPLICATION RULES

A permanent external power supply is required to allow the logical selectivity. To ensure correct time selectivity for medium intensity short circuits, the time/current curve with constant time (tsd) is used. Using the time/current curve with constant I^2t prevents correct operation of logical selectivity.

All the circuit breakers occupying the levels of the logical selectivity system must have a minimum tsd setting of 100 ms for S2/Sg or 80 ms for S10.

In case of different electronic trip units (S10, S2/Sg, S1) the selectivity is anyway garanteed with S10 as upstream breaker and S2/Sg set in LOW or S1 as downstream breaker.

EXAMPLE



SELECTIVITY OF RESIDUAL CURRENT DEVICES

The conditions for coordinating residual current protection devices (RCDs) are defined by standard IEC 60364 part 5-53 (ch. 535.2).

Selectivity between several RCDs in series ensures maximum safety and enables the power supply to be maintained to the parts of the installation which are not affected by any fault.

Selectivity between residual current protection devices can be total or partial.

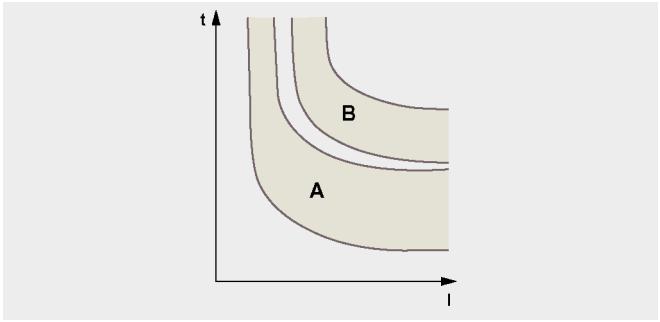
Total selectivity

Total selectivity can be specified for safety or operational reasons.

To obtain total selectivity between two RCDs, the time/current non-tripping characteristic of the upstream device must be greater than that of the downstream device.

This requires two conditions to be met:

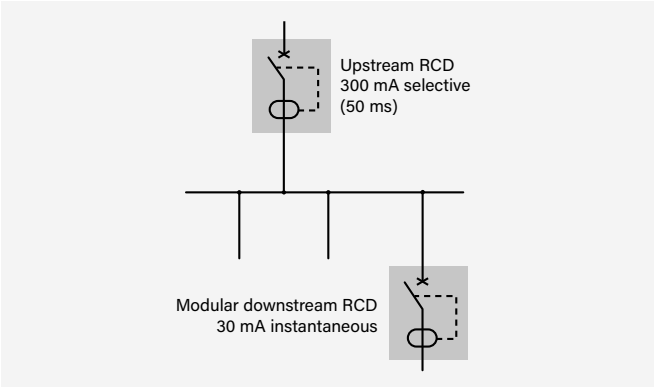
- The residual operating current of the upstream RCD must be higher than that of the downstream RCD
- The operating time of the upstream RCD must be greater than that of the downstream RCD for all currents



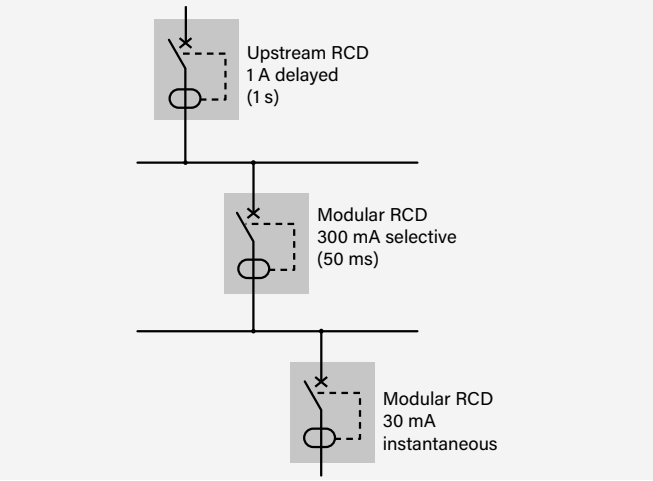
The selectivity between downstream device A and upstream device B is total

In practice, the sensitivity level of the upstream device must be 2 to 3 times higher than that of the downstream device, and must be type S or delayed. The breaking time must be at least 3 times longer than that of the downstream device.

Caution: a check must be carried out to ensure that the maximum breaking time of each device satisfies the protection conditions. A delay of more than 1 s is not usually permitted.



Total selectivity at two levels



Total selectivity at three levels

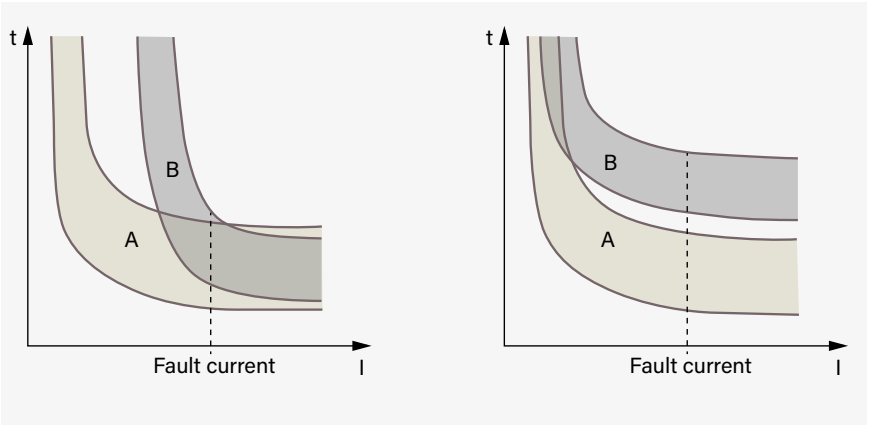
Partial selectivity

When the conditions for total selectivity are not met, the selectivity is partial.

Selectivity between two devices with different sensitivity levels and no time delay is virtually zero. The intensity of the fault current is generally enough to trip the upstream device.

However partial selectivity between two RCDs with similar sensitivity levels (for example, 500 mA and 300 mA) but with a type S or delayed upstream device, is much more efficient. The delay on the upstream device generally allows the downstream device to eliminate the fault.

In practice, uncertainty concerning the values of the fault currents means that this type of selectivity is rarely practicable.

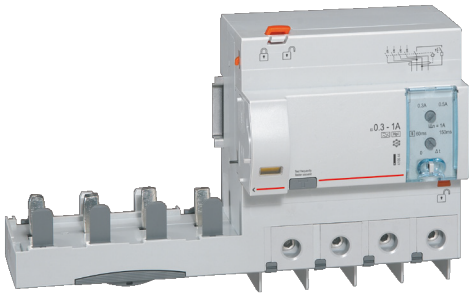


Partial selectivity between two non- delayed RCDs with different sensitivity levels: incorrect selectivity.

Partial selectivity between two RCDs with similar sensitivity levels with device B delayed: better selectivity.



DPX^3 with electronic earth leakage module: tripping adjustable from 0 to 3 s.



DX^3 add-on module: tripping adjustable from 0 to 3 s.

BACK-UP PROTECTION



BACK-UP LEVELS

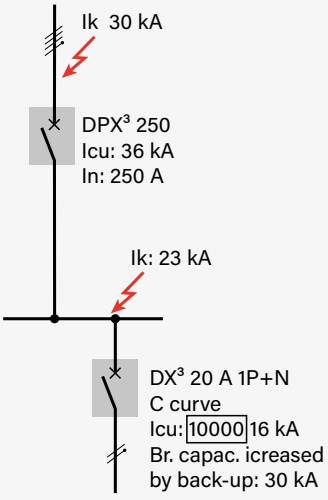
Back-up is the technique by which the breaking capacity of a circuit breaker is increased by coordinating it with another protection device, placed upstream.
This coordination makes it possible to use a protection device with a breaking capacity which is lower than the maximum prospective short-circuit current at its installation point.

It can be used even if the devices are located in different distribution boards.

Two-level back-up

The breaking capacity of a protection device must be at least equal to the maximum short circuit which may occur at the installation point of this device. For economic reasons, it is however possible to combine a number of protection devices to obtain high operational performance on several levels, as long as:

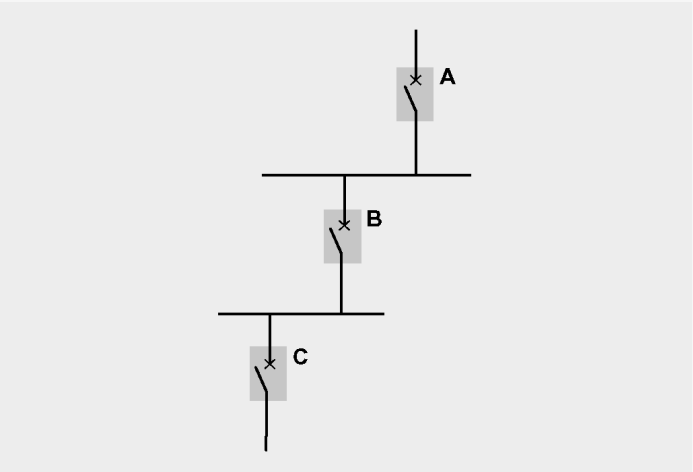
- It is backed up by an upstream device that has the necessary breaking capacity at its own installation point
- The downstream device and the protected trunking can withstand the energy limited by the two devices in series Substantial savings can therefore be made by using back-up protection.



The back-up values given in the tables are based on laboratory tests carried out in accordance with IEC 60947-2.

For single phase circuits (protected by 1P + N or 2P circuit breakers) in a 400/415 supply, supplied upstream by a 3-phase circuit, it is advisable to use the back-up tables for 230 V.

Three-level back-up



Three-level back-up is possible if one of the following conditions is met.

BACK-UP WITH THE MAIN PROTECTION DEVICE

Devices B and C are coordinated with device A. Upstream device A must have an adequate breaking capacity at its installation point. It is then simply a matter of checking that the B + A and C + A back-up values have the necessary breaking capacities. In this case, there is no need to check the back-up between devices B and C.

SUCCESSIVE CASCADING

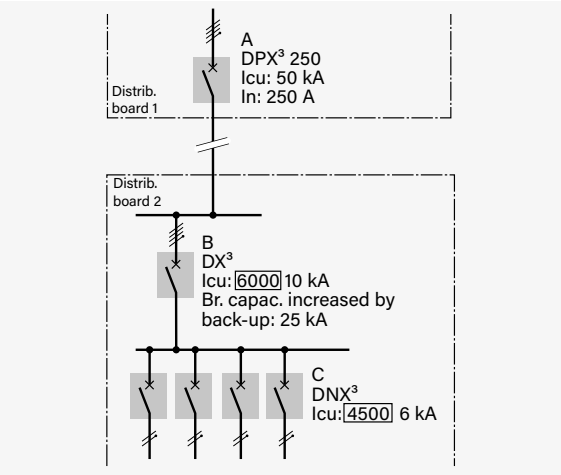
Coordination is implemented between two successive devices. Upstream device A must have an adequate breaking capacity at its installation point. It is then simply a matter of checking that the C + B and B + A back-up values have the necessary breaking capacities.

In this case, there is no need to check the back-up between devices A and C.

BACK-UP BETWEEN DISTRIBUTION BOARDS

Back-up protection can also be obtained when the devices are installed in different distribution boards.

It is therefore generally possible to benefit from the advantages of back-up between devices, for example when one of the devices is located in the maindistribution board and the other in a secondary board.



The upstream device must always have the necessary breaking capacity at its installation point.

It is also possible to have back-up on distribution board 2 between device B and the secondary devices C.

In this example, the DX³ + DNX³ back-up has an increased breaking capacity of 25 kA.



BACK-UP PROTECTION

SWITCH COORDINATION

A switch must be protected against overcurrent conditions such as overloads and short circuits.

1 - OVERLOAD PROTECTION:

Upstream:

The rated current of the switch must be at least equal to the setting of the upstream protection.
If this protection is set to a value lower than the continuous permissible current (Iz) of the upstream cable, it is accepted that the switch must be rated for a current at least equal to Iz.

Downstream:

The switch is protected provided that the sum of the rated currents of the downstream protection devices, distributed per phase, does not exceed the switch's rated current.
If the installation is not permanent, it is advisable to allow for a reserve or to make provision for future expansion by leaving some protection devices unconnected (equipped reserve).

2 - SHORT-CIRCUIT PROTECTION:

Upstream:

CASE 1

SAME BRAND OF SWITCHES AND CIRCUIT BREAKERS
When the switch and its associated upstream protective device are from the same brand, the coordination data provided by the manufacturer shall be taken into account. This is referred to as switch coordination.
The switch coordination rating shall be higher than the prospective short-circuit currents considered at the switch installation point (Ik1, Ik2 or Ik3).

CASE 2

DIFFERENT BRAND OF SWITCHES AND CIRCUIT BREAKERS
Switch coordination tables cannot be used. To verify that the switch can withstand the electrical stresses, the current-limitation curves of the upstream protective device shall be used to determine the limited peak current corresponding to the maximum prospective short-circuit current at the switch installation point.
For a thermal-magnetic circuit breaker, this limited peak current shall be lower than the switch rated making and breaking capacity (Icm).
For an electronic circuit breaker, as a short-time delay may be applied, the clearing time can be longer. In this case, refer to Case 3.

CASE 3

UNKNOWN UPSTREAM PROTECTIVE DEVICE

The upstream protective device is unknown or is an electronic circuit breaker from another manufacturer. The switch rating shall be at least greater than the cable continuous current-carrying capacity (Iz) or the rated current of the upstream protective device.

The switch rated short-time withstand current, Icw (1 s), shall exceed the prospective short-circuit current at the point of installation of the switch (Ik1, Ik2 or Ik3). It is assumed that any protective device will interrupt a short-circuit current in less than 1 s, which is the reference duration for the Icw rating.

Downstream:

Provided that a recognized declaration of conformity is available, a manufacturer may use downstream protection for switches, subject to compliance with the assembly design and verification rules defined in the IEC 61439 series of standards (refer to Legrand selectivity documentation).

Notes

Notes







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