Selectivity basic guide

How to apply selectivity?

Powering Business Worldwide

Safety is the first priority in any electrical installation,

meaning a fault generally needs to be cleared in the shortest possible time no matter what. Yet there are scenarios, particularly in large systems, when this is not the case – otherwise, power would be cut off to critical loads elsewhere in the installation.

Reliability of energy supply is essential

For this reason, it makes sense to fine-tune the circuit protection by isolating the impact of a fault to the section actually affected by it only, so that the rest of the system can continue to function. This is known as **selectivity**. Historically also referred to as discrimination or (selective) coordination, it describes the process by which the circuit protection devices in a system are coordinated to minimise the impact of a fault as much as possible. However, designing a system with the right level of selectivity that also meets the requirements of the respective project can be a challenge. This guide will therefore provide a brief overview of how selectivity can be implemented in practice, including the different types of selectivity available.

Why is selectivity important?

The basic premise of selectivity is simple: whenever a fault occurs in an electrical installation, it should be cleared by the nearest upstream overcurrent protection device (either a fuse or circuit breaker) to prevent unwanted tripping and preserve system availability. In other words, the aim is to limit the number of loads that will be disconnected from the power supply if a fuse or breaker trips.

While not mandatory according to the relevant international standards, selectivity is highly recommended for electrical installations supplying medical devices, marine applications or high-rise buildings, as well as for systems where reliable power is crucial, such as data centres or any type of critical infrastructure.

An example where the tripping of an upstream circuit breaker at the same time or before a downstream device may pose grave dangers is a building's life safety system. In the event of a fire, equipment such as sprinklers, smoke extractors, and fire pumps and lifts need to continue operating, no matter the possible damage due to overcurrent, since saving lives clearly overrides the objective of cable protection in this case.

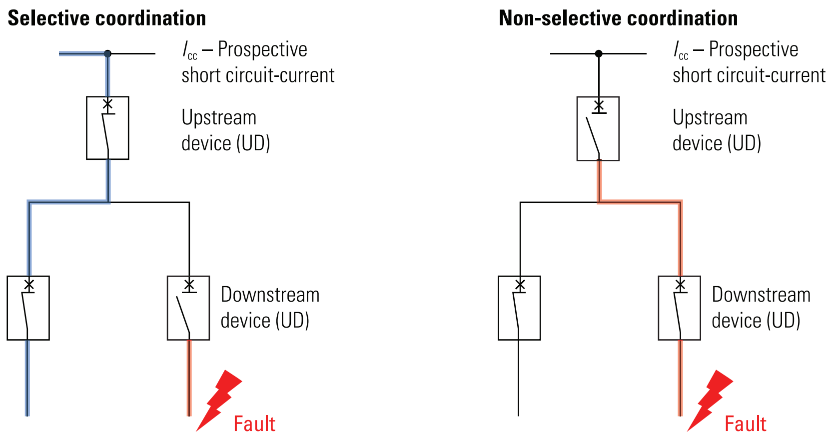
How does selectivity work in practice?

Selectivity between two serially connected circuit breakers in an electrical installation is determined by two factors: the maximum short-circuit current on the load side, and the tripping characteristics of both devices.

For definitions as well as guidance on how to achieve selectivity, see the international standards IEC 60364-5-53 or IEC 60947-1, for example. There are basically three situation in real installations such as total selectivity, partial selectivity or no selectivity. Meaning of total selectivity is that downstream device (DD) is fully selective against upstream devices (UD) up to level of its breaking capacity. Partial selectivity means, that selectivity of serially connected devices is achieved up to certain value, which is named selectivity limit current (I_s).

Accordingly, to achieve selectivity, the maximum short-circuit current at a particular point in the system must not exceed the selectivity limit current value (I_s) of the circuit breakers connected in series to protect that part of the installation. This should be checked for all types of fault current, from overload to short circuits and earth faults.

There are various ways to implement selective coordination, such as current selectivity, time selectivity, energy selectivity and zone selectivity.



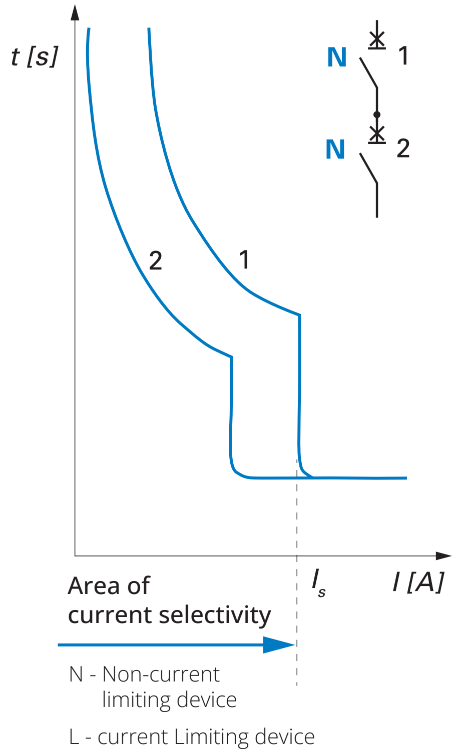
Schematic of selectivity

Current selectivity

This type of selectivity is based on a simple observation: the closer the location of a fault to the power supply terminals, the greater the current; and inversely, the farther removed a circuit protection device is from the power supply, the smaller the fault current will be.

To exploit this principle, the instantaneous trip settings of the protective devices in different parts of the installation can be set to different current values. Put differently, each downstream circuit breaker on the load side needs to have a lower current setting than the next upstream device on the supply side.

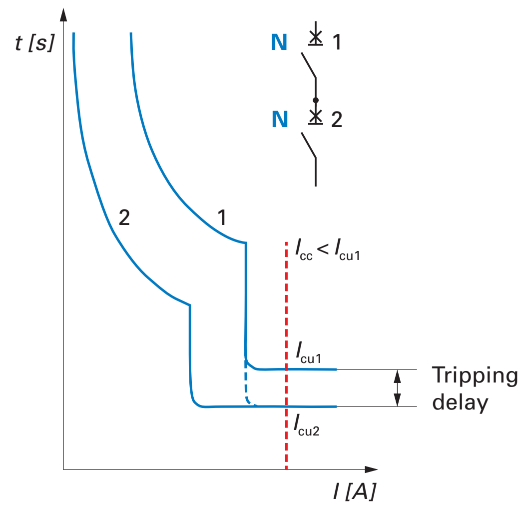
The time-current trip curves of circuit breakers are normally used for this evaluation.



Time selectivity

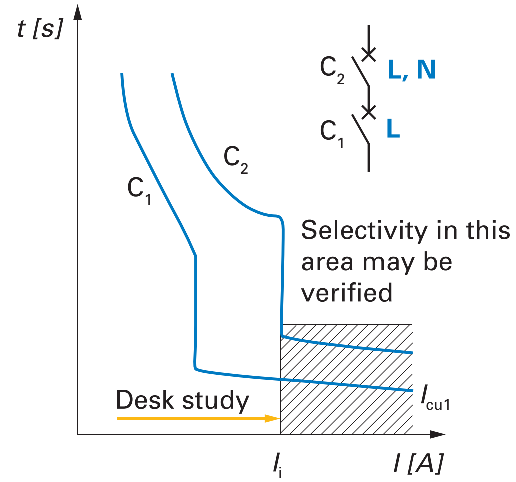
In many instances, however, current selectivity is not an option, for instance if the response time of two fast-acting circuit protection devices is similar or identical. This is where time selectivity comes in. As the name suggests, this type of selectivity depends on differences in the response intervals between upstream and downstream devices, whereby the circuit breakers closer to the power source will take longer to trip than those on the load side.

Time selectivity can be easily implemented through the use of two serial non-current limiting circuit breakers with electronic trip units, (MCCBs above 630 A or ACBs type) which enable a precisely adjustable time delay between the various protective layers of the installation.



Energy selectivity

In case of current limiting circuit breakers, which are mainly MCBs or MCCBs up to 630 A, the switching processes during disconnection of short circuit currents is very dynamic within a few milliseconds only, then it is necessary to work with let-through energy characteristics of both devices. Additionally, serially connected current limiting circuit breakers affect each other. It means a simple comparison of let through energies or time-current tripping characteristics does not provide reliable results in this case. Therefore user cannot determine the energy selectivity, it must be ensured by producers in form of tables or software tools.



Verification of selectivity

Selectivity of two current limiting circuit breakers (MCB, MCCB) is verified by producer. Conditions for evaluation are described by product standards and results are published in form of tables.

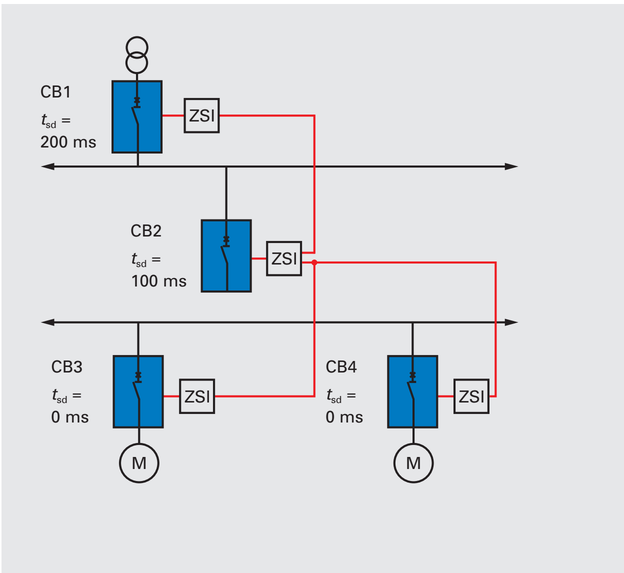
The following example shows how to use available selectivity tables. Information about prospective short circuit current value in the installation is also needed for correct verification of selectivity.

Downstream	Upstream		NZM...1-A I_{cu} = 25 (50) kA						NZM...2-A I_{cu} = 25 (50) (100) (150) kA								
	I_n [A]	I_n [A]	40	50	63	80	100	125	40	50	63	80	100	125	160	200	250
			Selectivity-limit current I_S [kA]														
FAZ (15 kA) Characteristic B	16		1	1,2	1,5	2	3	8	1	1,2	1,5	2,5	T	T	T	T	T
	20		0,8	1,2	1,5	1,5	3	8	1	1,2	1,5	2,5	T	T	T	T	T
	25		0,7	1,2	1,5	1,5	3	7	0,8	1	1,5	2	T	T	T	T	T
	32		-	1,2	1	1,5	2	6	-	1	1,5	2	8	8	8	8	T
	40		-	-	-	1,5	2	5	-	-	1,2	1,5	7	7	7	7	T

3 — Partial selectivity up to 3 kA (Selectivity-limit current I_s = 3 kA)

T — Total selectivity = Full selectivity

\- — No selectivity



Zone selectivity

Zone selectivity or Zone Selectivity Interlocking (ZSI) is a more intelligent evolution of **time selectivity** that has been developed to counteract possible issues with time delay. Rather than tripping automatically if a certain current threshold or time delay is reached, **circuit breakers equipped with this function** can communicate with each other to **precisely delimit and isolate the zone of the fault**.

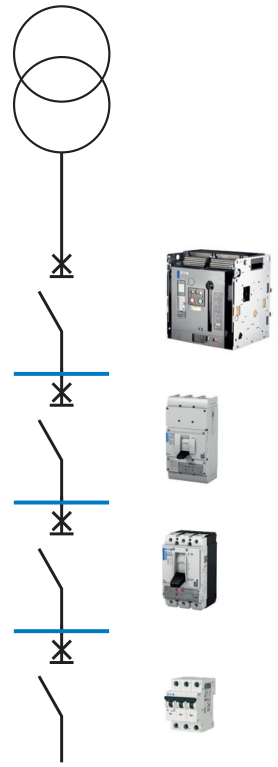
Most of Eaton's electronic trip units, such as those used in our air circuit breakers (IZMX/NRX) and molded case circuit breakers (digital NZM series), offer this smart feature. Zone selectivity interlocking speeds up the time required to eliminate certain faults, without sacrificing the overall coordination or introducing the risk of nuisance tripping.

In the case of ZSI, the circuit protection devices closest to the fault will trip instantaneously by overriding the short-time delay of the electronic trip unit, thereby reducing the response time and minimising the damage to equipment and dangerous for people, who operate electrical equipment in a moment a fault will occure. And should a downstream breaker fail to clear the fault, the next upstream device will take over – much as with time selectivity, though without any delay. Even better, the communication between our devices with ZSI does not require an external power supply or any external modules.

Why is selectivity not standard across the board?

The short answer is usually **time pressure**. Given the added layer of complexity, designing a selective power protection system simply takes a little longer – and as mentioned above, **selectivity is generally only recommended**, rather than **being required**. Moreover, a selective approach could require larger and thus more **costly devices.**

System designers are therefore faced with the choice of merely complying with local and international standards, or exceeding the coordination requirements to achieve additional safety and reliability. At the same time, the advantages of selectivity are obvious, especially when opting for devices with ZSI, which are able to overcome the drawbacks of usually used solutions.



For this reason, it is always advisable to consult a leader in power management and protection such as Eaton to consider all aspects of system design. Like other manufacturers, we also publish selectivity tables for our circuit breakers and provide software that makes it easy to display their tripping characteristics. This removes the need for conducting costly studies or plotting multiple time-current curves, which is often complicated and laborious – making it even easier for you to maximise both system availability and protection.

For more information on selectivity, consult your Eaton team.

Eaton is an intelligent power management company dedicated to improving the quality of life and protecting the environment for people everywhere. We are guided by our commitment to do business right, to operate sustainably and to help our customers manage power —today and well into the future. By capitalizing on the global growth trends of electrification and digitalization, we're accelerating the planet's transition to renewable energy, helping to solve the world's most urgent power management challenges, and doing what's best for our stakeholders and all of society.

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