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TECHNICAL NEWS

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NHP

Electrical design considerations for commercial buildings

When designing the electrical reticulation system for a commercial building the designer needs to take into consideration numerous details. The focus of this Technical Newsletter is the selection of circuit breakers for overload and short circuit protection. In the early days, fuses and electromechanical induction relays provided such protection. Advancements in technology have produced circuit breakers today with precise circuit protection capability and a high degree of adjustability. Sometimes the features and functionality of today's devices such as communication and power monitoring overshadow the basic fundamentals which need to be considered. This article concentrates on the core function of the circuit breaker and how it is selected.

The fundamental purpose of the Short Circuit Protective Device (SCPD) is to protect the cable (and consequently, the entire installation, its operators and users) from damage. We also live in an age when nuisance tripping is not tolerated due to the high reliance on electricity in almost every aspect of our lives. Although fuses and relays are considered "older" technology compared with circuit breakers, they still have a part to play. The challenge for today's electrical system designer is to ensure the SCPDs of a system work together to ensure system safety and minimise user interruptions under fault conditions as well as integrating with existing devices.

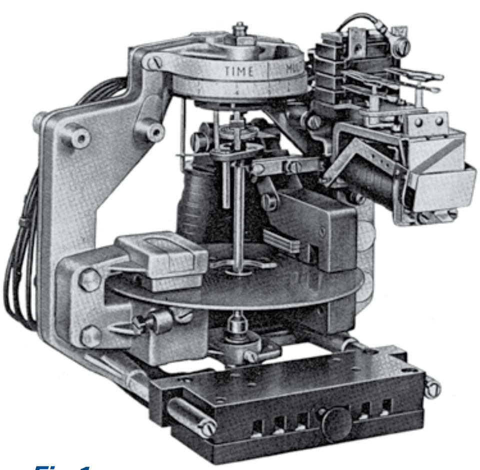

Fig 1
Electromechanical Induction Relay

FEATURING

Explanation of Cascading and Selectivity

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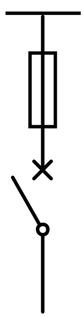
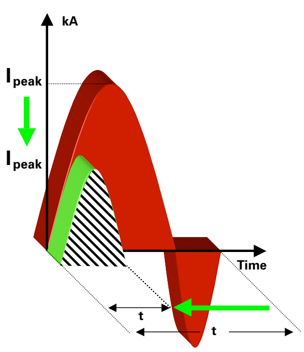
PLEASE CIRCULATE TO:

Device fault rating



Illustrating 'old style' back-up protection

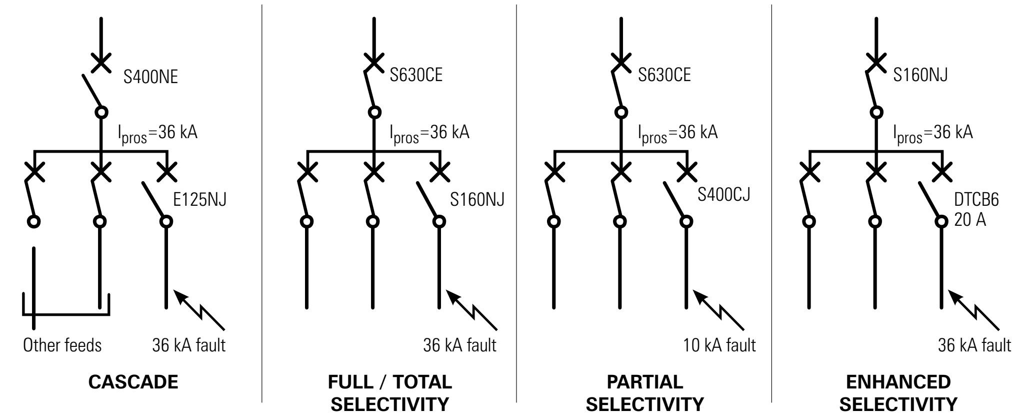


Current limiting Illustrated

One of the first SCPD selection considerations is the device's fault rating (see left). With the increased electrical demand, supply transformer/generator sizes and numbers have been increasing resulting in larger prospective fault currents. Interestingly, the nominated fault level of a switchboard is often larger than the system's actual capability. This makes allowance for future supply increases but often results in significantly oversized protection devices (*Technical News 7* discusses fault level calculations). The SCPD is chosen on its ability to make, carry for a specified time and break the prospective fault current at its point in the installation. Although the fault current depends on the type of fault, a selectivity analysis always assumes the worst case scenario of a 3 phase bolted short circuit. When it comes to an electrical reticulation system, the designer has two operating philosophies to consider, viz.: cascading or selectivity. The choice of which is determined by the application, budget and the relevant standard however both are referred to in the industry as a selectivity study.

CASCADING or backup protection is when the protective device immediately upstream of the device at which the fault has occurred trips while it assists the downstream device to safely clear the fault. The result is that both devices trip. The downstream device has a lower fault rating than the prospective fault current. The disadvantage with this method is that power to all other feeds from the upstream device is no longer available. Although this can be annoying, it is suitable on non-essential supplies. Further, the maximum prospective fault current will occur at the switchboard, in which case, tripping the incomer will possibly limit damage to the switchboard. It is also an economically attractive operating philosophy as the downstream SCPD is smaller than it would have been under a full selectivity operating philosophy. Historically, backup protection was employed to compensate for possible SCPD failure i.e. if one device didn't clear the fault, the other would. Accordingly, the series devices were different e.g. fuse with a circuit breaker.

Fig 2: Breakers shown after fault occurs



Cascading today makes use of a development that is applicable to most moulded case and miniature circuit breakers called *current limiting*. MCCBs and MCBs are designed to operate extremely quickly such that the current peak that is let through to the downstream device and the corresponding energy (I^2t) is limited. These devices will typically begin to operate in 2 - 4 ms and will have cleared the fault in 10 - 20 ms. The operating time of the circuit breaker is dependent on the moment of inertia of the mechanical operating parts within the device, hence smaller circuit breakers will operate quicker. The basis of current limiting is the application of Ohm's Law where high impedance is injected into the circuit by the arc inside the circuit breaker thus significantly reducing the current (*Technical News 30* provides more details on current limiting). This is in contrast to the methodology typically used in air circuit breakers called zero quenching. This is where the SCPD clears the fault at the zero crossing point.

The other methodology is **SELECTIVITY** which was previously called discrimination. Selectivity is when the device closest to the fault and only that device trips to safely clear the fault. There are various types of selectivity as follows (refer fig 2).

Full or Total Selectivity: Downstream device only trips up to its short circuit rating. Therefore, the device is chosen so that its fault rating is equal to or larger than the prospective fault current at that point in the installation.

Example 1:
Upstream circuit breaker: 630 A, 50 kA (p/n: S630CE)
Downstream circuit breaker: 160 A, 36 kA (p/n: S160NJ)
Prospective fault current at downstream circuit breaker: 36 kA

If a fault of 36 kA occurs downstream of the S160NJ only it will trip and the upstream device will stay closed.

Partial Selectivity: Downstream device only trips, at a short circuit rating less than its full short circuit rating. This often occurs when similar sized breakers are used in series because the upstream device will operate in a similar amount of time as the downstream device.

Example 2:
Upstream circuit breaker: 630 A, 50 kA (p/n: S630CE)
Downstream circuit breaker: 400 A, 36 kA (p/n: S400CJ)
Prospective fault current at downstream circuit breaker: 36 kA

If a fault of 10 kA occurs downstream of the S400CJ only it will trip and the upstream device will stay closed. For a fault between 10 kA and the maximum prospective fault current, 36 kA, both devices will trip.

Enhanced Selectivity: Downstream device only trips, at a short circuit rating in excess of its short circuit rating due to the assistance of the upstream device. This is often the case in MCCB/MCB combinations.

Example 3:
Upstream circuit breaker: 160 A, 36 kA (p/n: S160NJ)
Downstream circuit breaker: 20 A, 6 kA (p/n: DTCB6320C)
Prospective fault current at downstream circuit breaker: 36 kA

If a fault of 36 kA occurs downstream of the DTCB6320C only it will trip and the upstream device will stay closed.

Zone Selectivity: Downstream device only trips based on communication signals between the circuit breakers.

Most manufacturers produce selectivity tables based on tested SCPD combinations. NHP's selectivity data (refer extract image, below) is available in the NHP Part C catalogue and NHP Circuit Breaker Products Price List (CPB).

Extract of selectivity / cascade table

Downstream MCCBs	Upstream MCCBs kA (RMS)	S250PE 70	H250NE 125	S400NE 50	S400GE 70	H400NE 125	L400NE 200	E630NE 36	S630CE 50
E125NJ	25	25/25	25/65	25/36	25/50	25/65	25/85	25/36	25/25
S125NJ	36	36/36	36/85	36/50	36/65	36/85	36/125	36/36	36/36
S125GJ	65	65/65	65/125	50/50	65/70	65/125	65/150	36/36	50/50
H125NJ	125	70/70	125/125	50/50	70/70	125/125	125/200	36/36	50/50
S160NJ	36	-/65	-/85	36/50	36/65	36/85	36/125	36/36	36/50
S160GJ	65	-/70	-/125	50/50	65/70	65/125	65/150	36/36	50/50

NEW

NHP Electrical Engineering Products Pty Ltd is proud to announce the release of the new **TemCurve 6 Selectivity Analysis Software**.

Other selectivity analyses are conducted based on the published information of how the SCPD behaves in isolation. This information is: time current curves, let through peak current curves and let through energy curves (refer sample characteristic curves, right). These add a degree of subjectivity as a breaker's performance in extreme fault conditions differs depending on whether it is in series with another breaker or on its own. Usually, it will be in series with another breaker. Thus, the published selectivity data based on tested combinations is the final word on selectivity.

To assist in a selectivity analysis, manufacturers provide customers with software. NHP's TemCurve 6 is arguably the most user friendly package available. The user needs only to follow three easy steps to conduct the study. *Newsroom 49* introduced TemCurve 6 to the market and training is available upon request. TemCurve 6 enables the user to draw the single line diagram and select breakers accordingly. Time current selectivity is easily conducted with setting changes made on the fly. An impressive array of reports is also available. The latest version of TemCurve 6 is now available. Contact your sales representative for more information.

During a **time current selectivity** analysis it is common to make changes to the settings of the breaker. The settings change how the circuit breaker performs under fault conditions (*Technical News 5* introduced this topic). Some SCPD e.g. fuses, MCBs have no settings, others are adjustable. Adjustable circuit breakers have two types of trip units: thermal magnetic and electronic. The time current curve is a graphical representation of how quickly the SCPD will trip when subjected to a particular current and it will change depending on the settings of the breaker. It is important then that the factory default settings of the breakers are changed to the required setting during commissioning. TemCurve 6 provides sign-off sheets for this purpose.

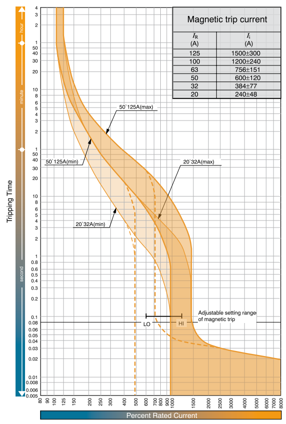
There are several parts to the time current curve. For a thermal magnetic circuit breaker there are two parts, viz.: thermal and magnetic. For electronic circuit breakers there are three parts, viz.: long time delay (LTD), short time delay (STD) and instantaneous (Inst). Refer to the time current curves overleaf. The thermal, magnetic, long time delay, short time delay and instantaneous are the areas under consideration for time current selectivity. This is sometimes referred to as a grading study and the aim is to ensure that the curves do not overlap.

For the t < 30 ms magnetic/instantaneous parts of the curve, it is necessary to refer to the manufacturer's selectivity tables to determine the selectivity status under large fault conditions. If a circuit breaker's time current curve is shown in totality, it is not uncommon to see the curves of series breakers overlap in this area. Some software packages avoid showing this information however this is not a true reflection of the circuit breaker's performance and in the end only misguides the user. Overlapping time current curves in the t < 30 ms area does not mean that there is no selectivity. For the example overleaf, between the upstream 630 A breaker and the downstream 160 A circuit breaker, test results confirm that there is selectivity to 36 kA and cascading to 50 kA.

For the combination of all three circuit breakers in this example, time current selectivity is confirmed because the curves do not overlap in the region of t > 30 ms. For the region t < 30 ms, the selectivity table data is presented and confirms that selectivity is achieved between the downstream and upstream circuit breaker combinations for the nominated prospective fault current at the downstream circuit breaker's switchboard.

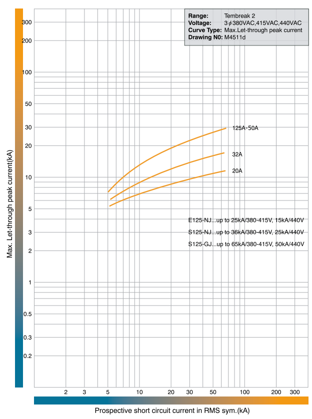
Sample characteristic curves

E125-NJ, S125-NJ, S125-GJ



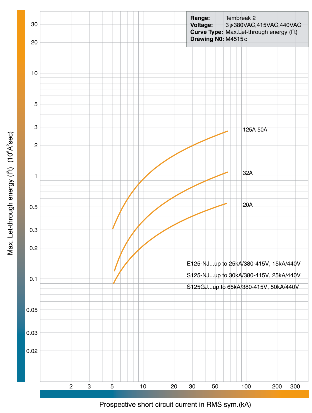
TIME CURRENT

E125-NJ, S125-NJ/GJ 440 V AC

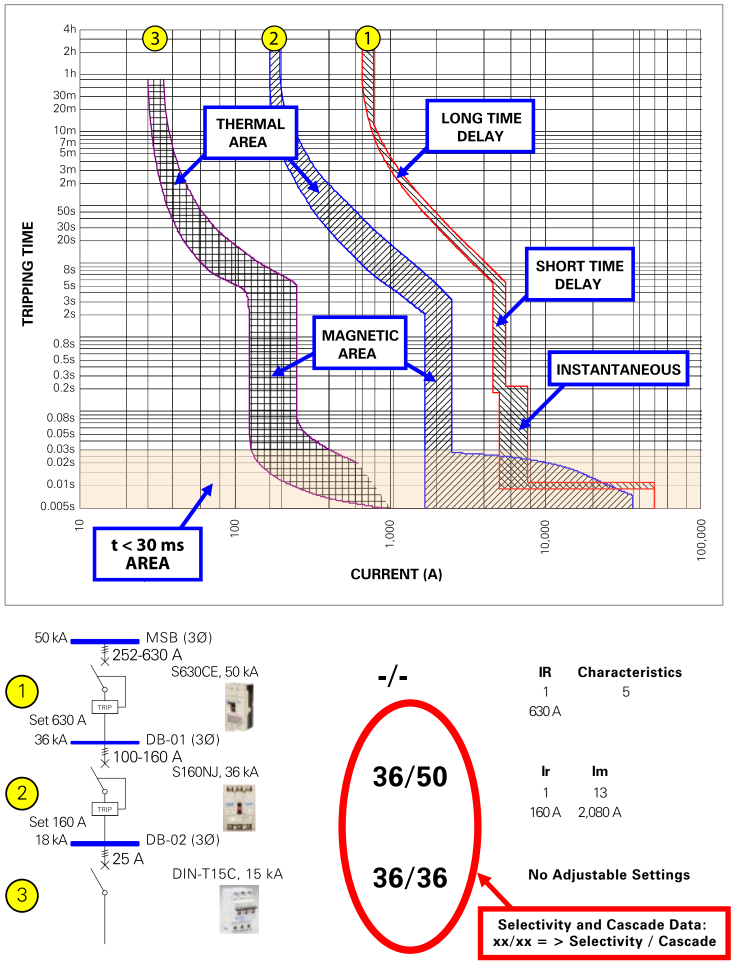


LET THROUGH PEAK CURRENT

E125-NJ, S125-NJ/GJ 440 V AC



LET THROUGH ENERGY



Selectivity study example

Current selectivity makes use of the let through peak current graphs. This method is seldom used and is only applicable when the fault levels are low and the cable runs long. It is important to highlight that the vertical scale is PEAK current and the horizontal scale is RMS current. It should also be noted that large short circuits are generally asymmetrical because they have a large DC component due to the reactance of the cable. Hence, the normal peak to RMS conversion does not apply. Accordingly, AS3439 introduces the n factor to make allowance for this. In short, current selectivity is achieved when the let through peak current of the downstream device is less than √2 times the instantaneous setting of the upstream device.

Energy selectivity compares the let through energy curves. This method of selectivity applies primarily to fuses as they have clearly defined pre-arcing and total clearing characteristics. Energy selectivity is achieved when the total clearing energy of the downstream device is less than the pre-arcing energy of the upstream device. When this methodology is applied to circuit breakers, it is not as clear cut however it can be helpful when selectivity data of circuit breakers in series is not available from the manufacturer.

There are many other considerations to be made when selecting a circuit breaker for an installation but most of those consider the circuit breaker independently of the other SCPDs. Selectivity and cascading however deals with the normal occurrence of circuit breakers in series and their corresponding performance. Software tools such as TemCurve 6 make the designer’s job much easier and NHP is here to assist you and your team in the selection of circuit breakers and protection devices to meet your clients needs.

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