Co-ordination of electrical devices and auxiliary circuits

Two new areas of possible development within European and International standards are Section 570 requirements for the co-ordination of electrical devices and Section 557 requirements for auxiliary circuits.

By Geoff Cronshaw

SECTION 570 - INTRODUCTION

Section 570, which is still at a very early stage of development in CENELEC, gives the rules for the selection and erection of electrical devices within an electrical installation with respect to coordination. The draft standard provides requirements for the selection of electrical devices to ensure electrical coordination between them in case of a fault including overcurrent protective devices such as fuses and circuit breakers and residual current devices.

This is a completely new section. The current requirements for coordination in BS 7671 are given in a small number of regulations contained in section 536. Regulation 536.1 sets out the requirements for coordination and requires discrimination to be considered to prevent danger and where required for proper functioning of the installation. Chapter 36 of BS 7671 uses life support systems as an example where continuity of service is required.

Co-ordination

Regulation 536.1 states that where co-ordination of series protective devices is necessary to prevent danger and where required for proper functioning of the installation, consideration shall be given to selectivity and/or any necessary back-up protection

The term “Co-ordination” generally relates to two subjects:

- Selectivity (also known as discrimination)

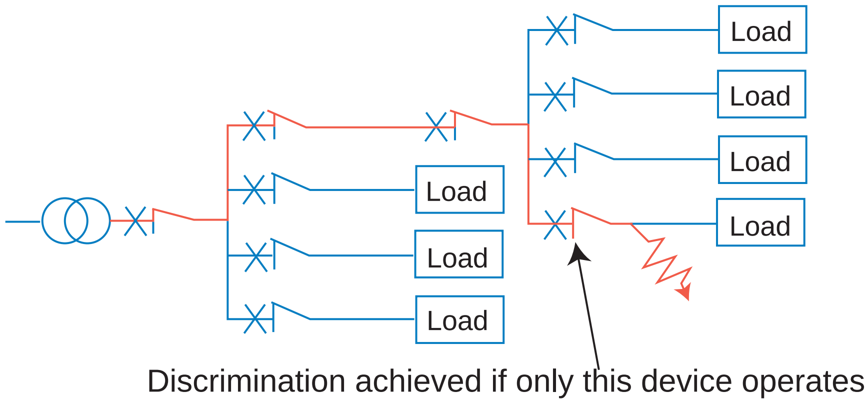
- Back-up protection (also known as cascading).

Some fundamentals of each subject are briefly covered below however; it must be appreciated that more complex engineering principles will apply and that the manufacturer’s data and instructions should be taken into account.

Selectivity

Selectivity is the ability of a protective device to operate in preference to another protective device in series. (see figure 1.)

Figure 1



Regulation 536.2 states that: "Where selectivity between overcurrent protective devices is necessary to prevent danger and where required for proper functioning of the installation, the manufacturer's instructions shall be taken into account".

Selectivity can be by current or time. Time discrimination utilises in-built time delays in the upstream devices, though current discrimination is the more common method used. This form can be divided into either overload discrimination or fault current discrimination. Time/current characteristic graphs for the protective devices can be overlaid to check for overload discrimination.

Back-up protection

Regulation 536.4 states: "Where necessary to prevent danger and where required for proper functioning of the installation, back-up protection shall be provided according to the manufacturer's information". Also, Regulation 536.5.1 states: "A switching device without integral overcurrent protection shall be co-ordinated with an appropriate overcurrent protective device.

The principle of back-up protection is embodied in Regulation 434.5.1 e.g. the characteristics of the devices shall be co-ordinated so that the energy let-through of these devices does not exceed that which can be withstood, without damage, by the lower breaking capacity device(s)

It is very important to note that technical data for the selection of protective devices for the purpose of back-up protection is published by the manufacturer and should be followed.

OVERCURRENT PROTECTIVE DEVICES

Every circuit must be provided with a means of overload and fault current protection although some circuits may be protected against overload by the nature of the load (exceptions are permitted where unexpected disconnection could cause danger, and the designer should consult Sections 433 and 434 of BS 7671 for details). The devices may either be fuses or circuit breakers. The choice of device will depend on a number of factors, including overall installation and maintenance costs. When designing a distribution system it is necessary to consider effective discrimination.

Protective devices in an installation should be graded so that when a fault occurs the device nearest to the fault operates and leaves the other devices intact.

Fuses

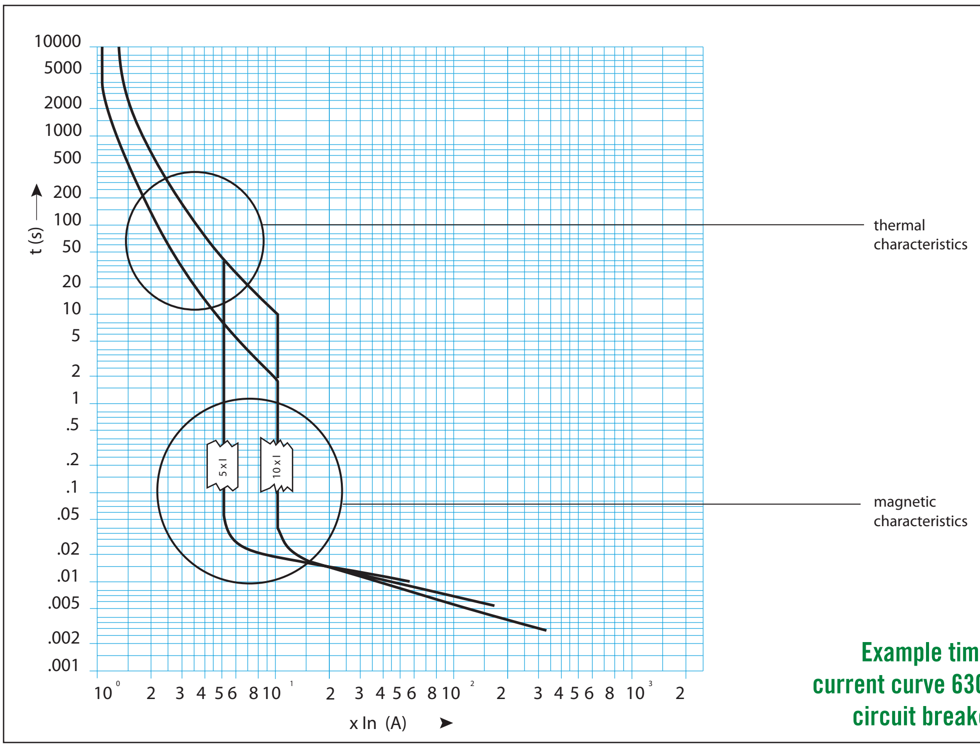
The key requirement for there to be discrimination between fuses is that the total I^2t of the minor fuse must not exceed the pre-arcing I^2t of the major fuse. Pre-arcing I^2t is the energy required to take the fuse element to the point where it starts to melt. Total operating I^2t is the total energy until the arc is quenched. This information is available from the manufacturer. For discrimination between two circuit breakers the fault current should be less than ▶

Electrical excellence

Wiring Matters is a quarterly publication produced by IET Services Limited, a subsidiary of The Institution of Engineering and Technology (IET), for the IET. Michael Faraday House, Six Hills Way, Stevenage, Herts, SG1 2AY, United Kingdom Tel: +44 (0)1438 313311 Fax: +44 (0)1438 313465. The Institution of Engineering and Technology is registered as a Charity in England & Wales (no 211014) and Scotland (no SC038698). The IET is not as a body responsible for the opinions expressed.

Advertising Sales D Thomasson +44 (0)1438 767224 dthomasson@theiet.org | **Editor** G D Cronshaw +44 (0)1438 767384 gcronshaw@theiet.org | **Contributing Editors** M Coles, R Townsend, P Bicheno | **Sub editors** Jim Hannah, Leanne Farnell | **Design** John Rooney, Jon Bonny, Dan Shadrake | **Production controller** Nikki McEllin

Cooperating Organisations The Institution of Engineering & Technology acknowledges the contribution made by the following organisations in the preparation of this publication: British Electrotechnical & Allied Manufacturers Association Ltd – P D Galbraith, M H Mullins | Department for Communities and Local Government – I Drummond | Electrical Contractors Association – City & Guilds of London Institute – H R Lovegrove | Electrical Contractors Association of Scotland SELECT – N McGuiness | Health & Safety Executive – K Morton | Electrical Safety Council | ERA Technology Limited – M Coates, A Finney | Consultant - M. Al-Rufaie | Dept of Health - C Holme | British Cables Association – C Reed | Scottish Building Standards Agency | Department for Business, Enterprise and Regulatory Reform | GAMBICA – M Hadley, A. Sedhev | Lighting Association – L Barling
ISSN 1749-978-X



Example time/ current curve 630A circuit breaker

the instantaneous tripping current of the higher circuit breaker. If the fault current is greater than the instantaneous tripping current of the higher circuit breaker both circuit breakers will trip instantaneously and no discrimination will exist under fault conditions.

Circuit breakers

There are many types of circuit breaker available, the most common being the 'thermal magnetic circuit breaker'. 'Miniature circuit breakers' (MCBs) should comply with BS EN 60898 entitled 'Circuit-breakers for Overcurrent Protection for Household and Similar Installations'. The scope identifies they are designed for use by an uninstructed person. The maximum rated current permitted is 125 A.

'Air Circuit Breakers (ACB)' or 'Moulded Case Circuit Breakers (MCCB)' are for use by instructed persons. These devices should comply with BS EN 60947-2 entitled 'Low Voltage Switchgear and Controlgear – Part 2: Circuit Breakers'. The scope identifies that this standard applies to circuit breakers with a rated voltage not exceeding 1000 V a.c. or 1500 V d.c. and places no restriction on rated current. The minimum size available is 16 A.

The rated current In can be defined as the current which a circuit breaker will carry continuously under specified conditions on which the time / current characteristics are based. In BS EN 60 898 this calibration is always carried out at a reference ambient temperature of 30ºC unless otherwise stated. Devices covered by BS EN 60947-2 are calibrated at 40ºC. The value of In can be fixed by the manufacturer or can be adjusted by the installer. Note: Adjustable releases are not available on BS EN 60898 devices.

Figure 2

Type	Magnetic trip setting	Application
B	3 - 5 I_n	General Domestic Use, resistive loads
C	5 - 10 I_n	Motors, Fluorescent Lighting, inductive loads
D	10 - 20 I_n	Transformers, Sodium Lighting, Highly Inductive Loads

Thermal trip

A thermal bi-metallic trip is used to protect against overload currents. The bi-metallic or thermal sensing element deflects mechanically as current passes through it. The higher the overcurrent, the greater the deflection. At a predetermined point the element will actuate a tripping mechanism, open the contacts and disconnect the circuit. This action is represented by the inverse time characteristic (curved section) of the circuit breaker's tripping

The Standard BS EN 60898 refers to 1.45 In as the conventional tripping current which must open the circuit breaker contacts within the conventional time. This is defined as one or two hours. 1.45 In relates directly to circuit design, in section 433 protection against overload current, regulation 433.1.1 states that:

the operating characteristics of a device protecting a conductor against overload shall satisfy the following conditions:

(i) the rated current or current setting of the protective device (In) is not less than the design current (Ib) of the circuit, and

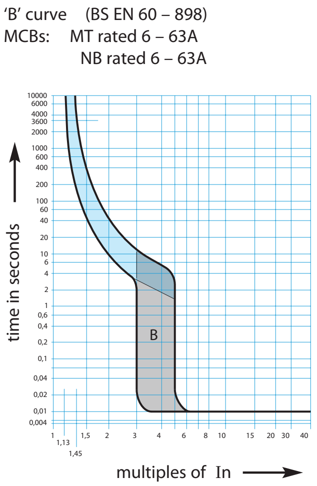
(ii) the rated current or current setting of the protective device (In) does not exceed the lowest of the current-carrying capacities (Iz) of any of the conductors of the circuit, and

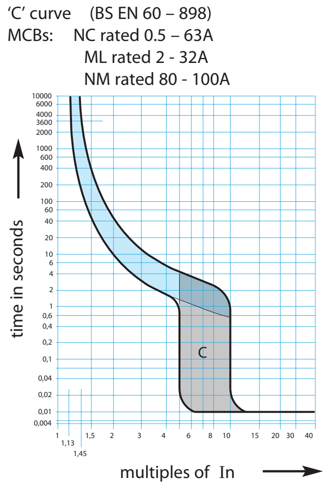
(iii) the current (I2) causing effective operation of the protective device does not exceed 1.45 times the lowest current carrying capacities (Iz) of any of the conductors of the circuit.

Factor of 1.45 ensures that deterioration of cables does not result from small overloads. This is based upon practical studies and experience that has shown when a current of 1.45 times the current carrying capacity of the cable is interrupted within the conventional times, there is no significant deterioration in the working life of the cable.

Magnetic Characteristic

The magnetic characteristics on BS EN 60898 circuit breakers are fixed. Devices with a common nominal current rating are available in three different types. A letter preceding the nominal current rating i.e. B20 for a 20A type B circuit breaker denotes the type of device. The letters B, C, or D relate to the magnetic trip setting or characteristic curve, see ▶





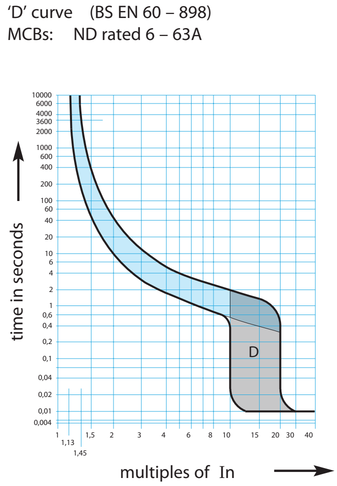


figure 2. This component of the circuit breaker is constructed using a coil or solenoid, which is designed to operate the tripping mechanism when the overcurrent reaches a set magnitude. This magnetic component is specifically designed to deal with fault current.

As can be seen from the above graphs, the letter B, C, or D represents a multiple of In. When the current rises to this multiple value, the magnetic trip operates instantaneously to open the contacts.

RESIDUAL CURRENT DEVICES

An RCD is a protective device used to automatically disconnect the electrical supply when an imbalance is detected between live conductors. In the case of a single-phase circuit, the device monitors the difference in currents between the line and neutral conductors. If a line to earth fault develops, a portion of the line conductor current will not return through the neutral conductor. The device monitors this difference, operates and disconnects the circuit when the residual current reaches a preset limit, the residual operating current (IΔn). An RCD on its own does not provide protection against overcurrents. Overcurrent protection is provided by a fuse or a circuit-breaker. However, combined RCD and circuit breakers are available and are designated RCBOs.

Unwanted tripping of RCDs can occur when a protective conductor current or leakage current causes unnecessary operation of the RCD. An RCD must be so selected and the electrical circuits so subdivided that any protective conductor current that may be expected to occur during normal operation of the connected load(s) will be unlikely to cause unnecessary tripping of the device.

Discrimination: Where two or more RCDs are connected in series, discrimination must be provided, if necessary, to prevent danger. During a fault, discrimination will be achieved when the device electrically nearest to the fault operates and does not affect other upstream devices. Discrimination will be achieved when 'S' (Selective) types are used in conjunction with downstream general type RCDs. The 'S' type has a built-in time delay and provides discrimination by simply ignoring the fault for a set period of time allowing more sensitive downstream devices to operate and remove the fault. For example, when two RCDs are connected in series, to provide discrimination, the first RCD should be an **'S' type. RCDs with built in time delays should not be used to provide personal protection.**

RCBO – residual current circuit breaker with overcurrent protection

SECTION 557 AUXILIARY CIRCUITS

Section 557 applies to auxiliary circuits for low voltage electrical installations. Auxiliary circuits are defined as circuits for transmission of signals intended for detection, supervision or control of the functional status of a main circuit such as circuits for control, signalling and measurement.

Auxiliary circuits in connection with fire and intruder alarms, traffic lights etc (where specific standards exist) are excluded.

This is a completely new section. The current requirements for auxiliary circuits in BS 7671 are given in regulation 537.5.3 (extract below).

537.5.3 A circuit shall be designed, arranged and protected to limit dangers resulting from a fault between the control circuit and other conductive parts liable to cause malfunction (e.g. inadvertent operation) of the controlled equipment.

The draft standard covers issues such as ac or dc auxiliary circuits, power supplies for auxiliary circuits dependent on the main circuit, also, auxiliary circuits supplied by an independent source, protection against overcurrent, and types and sizes of cables for auxiliary circuits. Also special requirements for auxiliary circuits used for measurement. Functional safety and EMC are also covered.

For example, in the situation where the auxiliary circuit is supplied by an independent source, e.g. by batteries or a power supply independent from the mains, in the event of a loss of supply of the main circuit the independent auxiliary circuit shall not create a hazardous situation. Also, in case of the use of batteries as power supply for auxiliary circuits the voltage fluctuation due to charging or discharging shall not exceed certain voltage tolerances.

In situations where the auxiliary circuit is supplied from the main circuit via a transformer or rectifier requirements for the connection of the devices are covered and also protection against overcurrent. Furthermore, detailed requirements are included for circuits used for measurement, such as connection requirements for voltage and current transformers etc.

Conclusion

It is important to point out that this article is only intended as a brief overview of issues that are being considered at a very early stage and therefore may not become European and International standards. Persons involved in this area are recommended to seek specialist advice. ■

Acknowledgements
Special thanks to Hager for some of the images and information contained in this article. Also special thanks to Schneider Electric and MK for some of the images used.