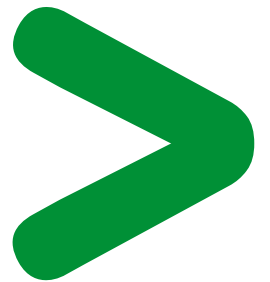




Technical collection

Coordination and protection of busbar distribution

Low voltage
expert guides n° 1



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Design and production of a busbar distribution installation for industrial and commercial buildings must meet 3 main requirements: progressive upgradeability of the installation, simplicity and dependability. Busbar distribution ensures these requirements are fully met.

1.1. Performance criteria of a LV Busbar distribution

Three performance criteria for a busbar distribution installation:

- upgradeability
- simplicity
- dependability

1. Progressive upgradeability of the installation

“**Flexibility**” and “**Adaptability**” have become the key words in all commercial and industrial activities which need to quickly adapt to the market in order to:

- meet their customers’ needs,
- cope with rapid changes and fluctuations in demand.

These performance criteria are expressed in terms of:

- **quantity** of goods to be produced or of services to be provided...
- continually decreasing manufacturing **lead time**,
- **quality**: the level of quality of the products and associated services must be equivalent whatever the decisive parameters (short lead time, large quantity to be produced,...).

This implies permanent adaptation of production means as production rates are stepped up after initial commissioning, and the process is completed by new machines.

Busbar distribution, with its highly flexible design, fully covers these requirements.

2. Simplicity of the busbar distribution

- Easy to design: the study is feasible regardless of energy distribution and load layout. Choice of equipment is predetermined and optimized.
- Easy to install thanks to the factory-built concept.

3. Dependability

Dependable electrical distribution is optimized as a means of guaranteeing:

- safety of persons and equipment
- continuity of service (choice of grounding system, implementation of discrimination techniques, breaking not required when making changes to the installation...)
- reliability (reliable switchgear, factory-mounted subassemblies...)
- easy maintenance (simple, rapid modifications).

Dependability also guarantees an economic operating solution.

Busbar distribution fully meets these criteria.

Busbar distribution

Distribution is divided up into 3 separate levels between the transformer and the final applications:

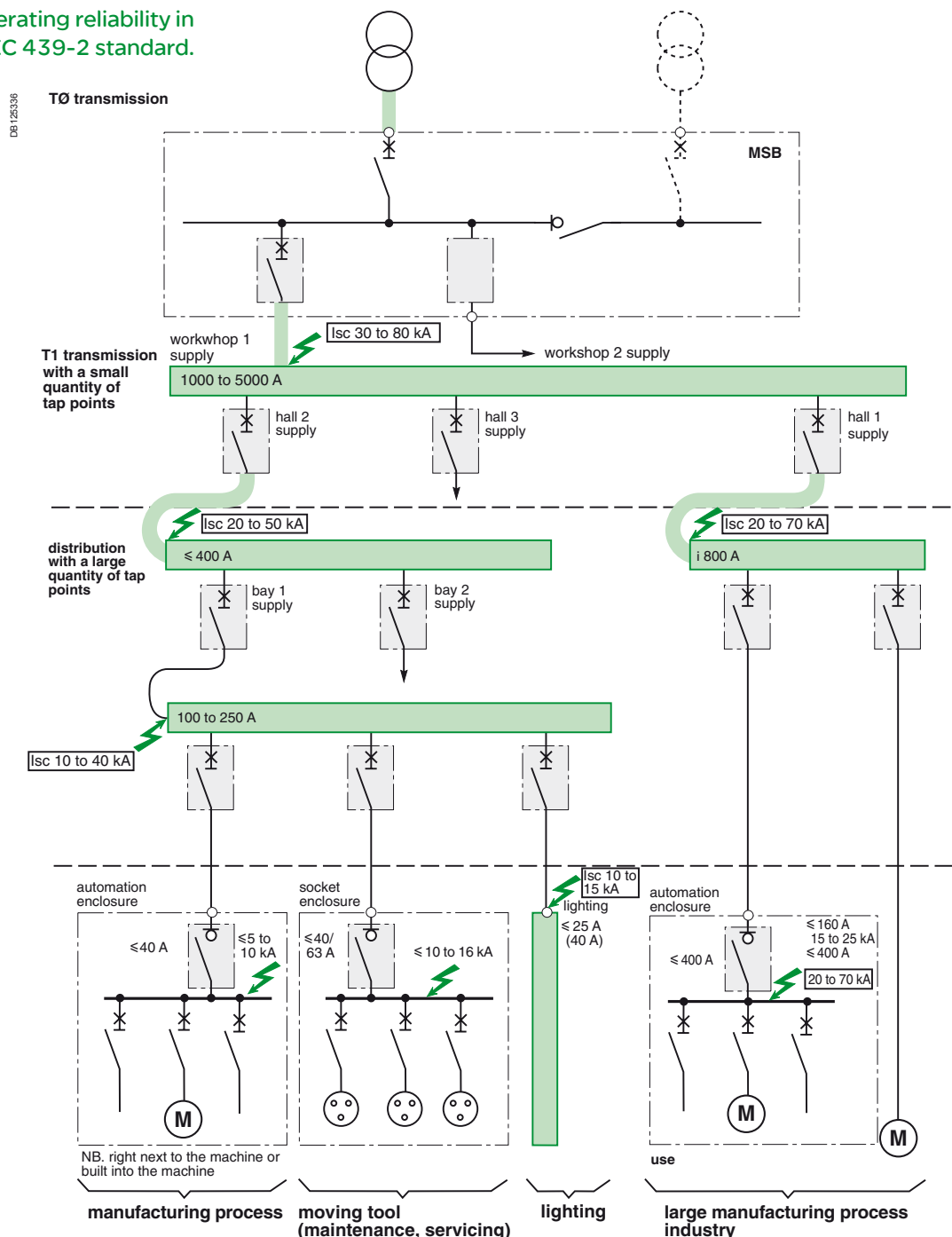
- level A: Transmission and distribution with a small quantity of tap points,
- level B: Distribution with a large quantity of tap points
- level C: the final distribution.

Busbar Trunking (BBT) distribution fully covers the requirements of each level by providing:

- functions that are often specific in nature;
- a high degree of operating reliability in compliance with the IEC 439-2 standard.

In large sites Buildings in excess of 5 000 m²

The following diagrams represent standard installations which cover most cases encountered in practice.



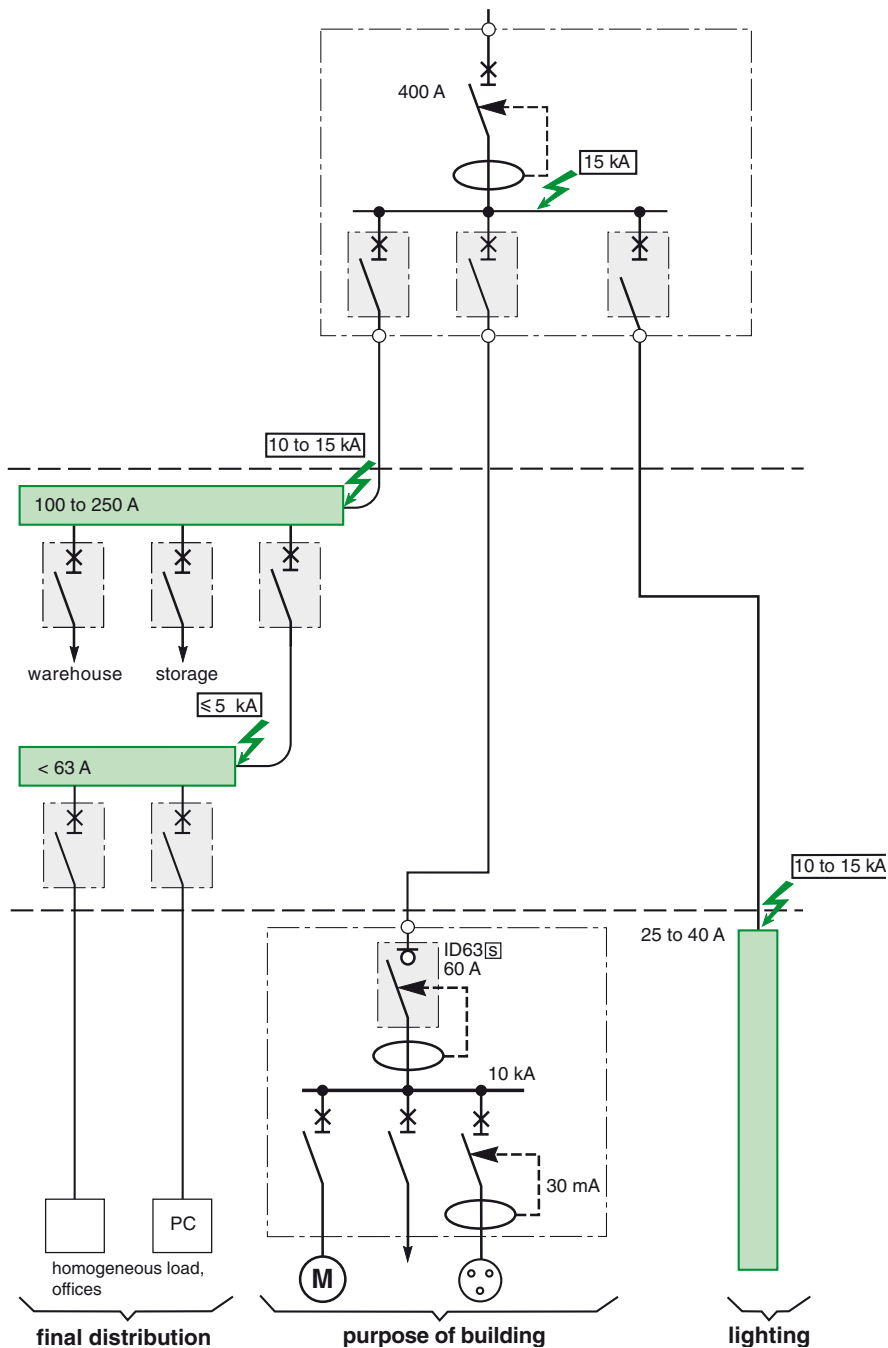
Busbar distribution

**In medium-sized and small sites
Buildings smaller than 5 000 m²**

Level A
Transmission and distribution with a small quantity of tap points.
Note : does not concern "medium-sized and small sites".

Level B
Distribution with a large quantity of tap points.

Level C
Energy utilisation.



Busbar distribution

1.2. Functions

BBT in transmission and distribution with a small quantity of tap points

- High current ratings from 1000 A to 5000 A
- High short-circuit withstand up to 150 kA
- Technological continuity
- Flexibility

BBT in Distribution with a large quantity of tap points:

- numerous tap off sockets
- box positioning flexibility
- safe, easy handling

Final distribution:

- on-load opening (emergency breaking)
- local disconnection.

Level A: transmission and distribution with a small quantity of tap points

Requirements

This level corresponds to Transformer/Main Switchboard (MSB) supply and main distribution downstream from the Main Switchboard (MSB).

The requirements of this level as far as performance criteria are concerned (see p. 3) are summarized in the table below:

Performance criteria	Requirement	Comments
Upgradeability	■ ■	modifications at this level of the installation although rare are important; new layouts do not affect main distribution
Simplicity	■ ■ ■	Power is available at all points of the installation as from the design stage. Implementation simplified by the factory-built BBT concept.
Dependability		
<ul style="list-style-type: none"> ■ continuity of service 	■ ■ ■	Distribution is entirely placed downstream. Maintenance is performed with power on.
<ul style="list-style-type: none"> ■ safety 	■ ■	Safety of persons must be guaranteed. Maintenance is rare and is carried out by qualified staff. A high degree of reliability in the event of an electrical fault is required.

■ minor requirement ■ ■ average requirement ■ ■ ■ major requirement

Busbar Trunking (BBT) with a small quantity of tap points for transmission and distribution

The T0 busbar trunkings convey energy from the MV/LV transformer directly to the Main Switchboard (MSB). The T1 busbar trunkings, downstream from the Main Switchboard (MSB), convey and distribute energy to BBTs with a large quantity of tap points which supply the various workshops. Use transmission and distribution BBTs with a small quantity of tap points ensures a simple, suitable solution:

- the characteristics of the transmission BBTs authorize current ratings ranging from 1000 A to 5000 A and short-circuit withstand levels up to 150 kA.
- use of a flexible link to level B BBTs ensures technological continuity and flexibility of the installation.
- BBTs have a small quantity of tap points, as the number of feeders to be supplied (workshops, halls) is small.
- tap off boxes are of the power on fixed or withdrawable type.

Level B: distribution with a large quantity of tap points

Requirements

Two types of loads must be supplied downstream from the distribution BBTs:

- workshops and large machines (automation cubicle). In this case the short-circuit and current levels may still be high (20 to 70 kA respectively and up to 800 A) (see large sites on page 4).
 - bays and small machines (switchboard, automation enclosure, lighting circuit...).
- Short-circuit and power levels are lower, 10 to 40 kA respectively and up to 400 A.

Busbar distribution

Performance criteria are summarized in the table below.

Performance criteria	Requirement	Comments
Upgradeability	■ ■ ■	Major modifications are possible. The tap off points (loads) evolve physically and electrically, thus calling for: <ul style="list-style-type: none"> – distribution with high density tap off sockets, – upgradeability without interruption of service continuity.
Simplicity	■ ■ ■	On design and installation. It must be possible to place the tap off boxes anywhere on the busbar trunking whatever the Isc level.
Dependability		
<ul style="list-style-type: none"> ■ continuity of service 	■ ■ ■	Modifications are made without breaking. The tap off boxes can be connected and disconnected with power on.
<ul style="list-style-type: none"> ■ safety 	■ ■ ■	Modifications made with power on must be 100% safe: <ul style="list-style-type: none"> – direct contact protection – polarization for proper installation of the tap off boxes – performances of the tap off box equipped with its circuit breaker automatically compatible with the Isc at the considered point.

■ minor requirement ■ ■ average requirement ■ ■ ■ major requirement

Busbar Trunking (BBT) with a large quantity of tap points for distribution

BBT distribution meets the operator's needs:

- a large quantity of tap off sockets
- 100% safe connection of tap off boxes with power on
- boxes can be placed anywhere on the BBT
- easy, fully safe disassembling/reassembling/addition of tap off boxes
- protection device placed near to the user, thereby ensuring easy handling.

Busbar Trunkings comply with the IEC 439-2 standard (see page 9) which guarantees their quality and reliability whatever changes are made to the installation.

Level C : the final distribution

Requirements

Downstream final distribution is often linked to the load. The performance criteria requirements are:

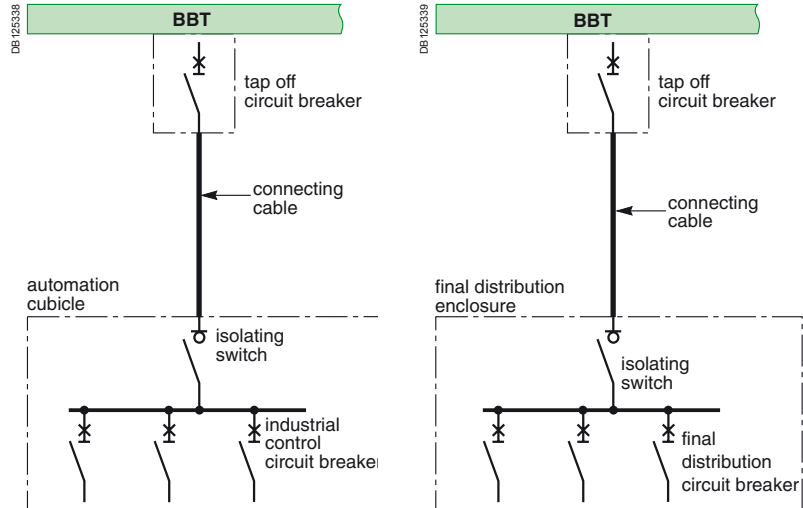
Performance criteria	Requirement	Comments
Upgradeability	■ ■ ■	The BBT tap off boxes must be standard. Protection devices must have a wide setting range.
Simplicity	■ ■	
Dependability		
<ul style="list-style-type: none"> ■ continuity of service 	■ ■ ■	It is vital that protection of the load(s) in the automation cubicle be fully coordinated with the upstream protection devices.
<ul style="list-style-type: none"> ■ safety 	■ ■ ■	Of persons and equipment.

■ minor requirement ■ ■ average requirement ■ ■ ■ major requirement

Busbar distribution

The final distribution

It must meet a number of characteristics in order to ensure system performance, in particular as concerns continuity of service and safety. On-load opening, necessary for emergency breaking, and disconnection are requirements to be built into the enclosure incoming switch. Moreover, the control and protection switchgear are easily accessible to the user, thus making them easy to handle.



1.3. IEC 60439.2 standard

IEC 60439-1

LV switchgear assemblies

IEC 60439-2

Second part : specific busbar trunking rules.

General

Area of application: busbar trunkings for power and lighting distribution.

Factory quality

Manufacturer's guarantee characterizing the product.

Product quality and dependability guaranteed by a series of factory tests.

This standard concerns LV switchgear assemblies.

Busbar trunkings must comply with the rules laid down in publications 60439-1 and 2.

Définitions

Busbar trunking:

Switchgear type tested assembly in the form of a conductive network concerning, in a duct, cableway or similar enclosure, busbars which are supported by insulating materials.

This assembly can be made up of:

- busbar parts with or without tap off points,
- power supply, flexible links,
- branch busbar parts.

Electrical characteristics of the assemblies

The manufacturer must specify the mean values for the various phases:

R: mean ohmic resistance of the busbar trunking per meter

X: mean reactance of the busbar trunking per meter

Zf: impedance per meter of loop length, including the protection circuit (PE) and the phase giving the highest impedance.

Indirect contact protection by automatic power supply breaking using over current protection devices.

Busbar distribution

Construction arrangements

Busbar trunkings must be designed as type tested LV switchgear assemblies (TTA). According to the manufacturer's instructions, BBTs are designed to withstand mechanical loads.

For safety reasons, an BBT equipped with tap off points must be designed in such a way as to prevent incorrect connection of the tap off parts.

If three-phase ac is used, phase order must be constant throughout the BBT. Temperature rise limits are defined on the enclosures and connection terminals.

Test specifications

Type tests are designed to check compliance with the specifications laid down for a given BBT type.

Type tests are carried out on a copy of an BBT or on an BBT type produced using the same or similar drawings.

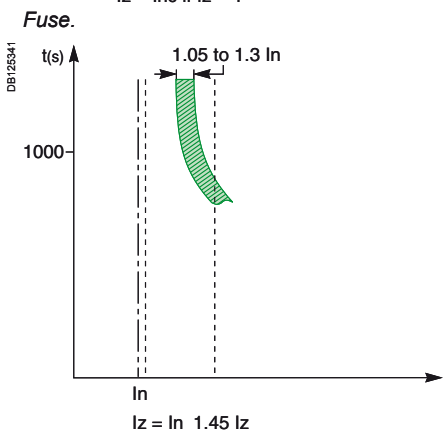
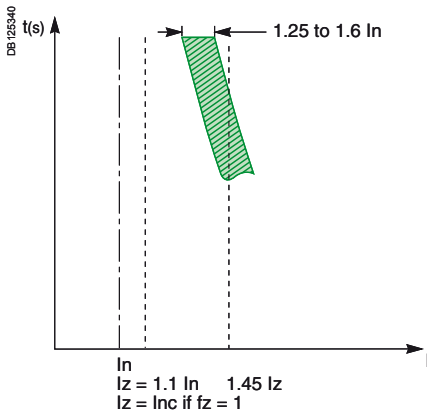
Type tests consist of:

- checking temperature rise limits, dielectric properties, short-circuit withstand, electrical continuity of the protection circuit, clearances and creepage distances, mechanical operation, degree of protection, resistance, reactance and impedance, and sturdiness of the construction.

The standard describes all the conditions and provisions of the tests laid down and, if necessary, the results to be obtained.

1.4. BBT protection

A 20% shift of the opening currents results in a minimum overcalibration of 10% of the busbar trunking if fuse protection is used.



This must be provided in accordance with installation standards.

Overload protection

The busbar trunking supplies loads: the total load current is I_r .

Sizing characteristics for choice of BBT and overload protection are:

- current rating $I_b = k_1 \times I_T$ (k_1 is the concentration factor)
- rated busbar trunking current $I_{nc} > I_b$
- permissible current as a function of temperature $I_z = f_1 \times I_{nc}$ (f_1 is the temperature factor)

derating factor k_2 linked to the type of switchgear:

- fuse $k_2 = 1.1$
- circuit breaker $k_2 = 1$

For extension purposes, busbar trunking is normally protected for its rated current I_{nc} (or for their permissible current I_z if the temperature factor f_1 is applied).

In order to take account of busbar trunking thermal overload protection, the various protection switchgear technologies and the maximum opening currents for protection devices in overload conditions must be considered.

■ Calibration of thermal asymptotes:

- the distribution fuse is calibrated to trip on overloads of between 1.25 and 1.6 times its rated current (fuse I_n)
- the circuit breaker is calibrated to trip on overloads of between 1.05 and 1.3 (1.2 for circuit breakers with electronic protection) times its setting current (I_r as a function of circuit breaker I_n)

■ Maximum opening current:

- this current is set at most by the installation standards (IEC 60364, NFC 15-100,...) to 1.45 times the current permissible to the busbar trunking.

Busbar distribution

Example for a current $I_b = 400\text{ A}$ in an ambient temperature of 35°C :

□ fuse protection:

$$I_{nc} = I_b \times f_1 \times k_2 = 400 \times 1 \times 1.1 = 440\text{ A}$$

The busbar trunking chosen is KSA50 ($I_{nc} = 500\text{ A}$)

□ circuit breaker protection:

$$I_{nc} = I_b \times f_1 \times k_2 = 400 \times 1 \times 1 = 440\text{ A}$$

The busbar trunking chosen is KSA40 ($I_{nc} = 400\text{ A}$)

If operating conditions are different from rated conditions of use, the circuit breaker offers enhanced optimization of busbar trunking protection (e.g. operation at high ambient temperatures of $45^\circ/50^\circ\text{C}$).

Setting circuit breakers equipped with electronic trip units:

- thermal protection I_r adjustable from $0.4 I_n$ to I_n
- short-circuit protection from $2 I_r$ to $10 I_r$
- increased flexibility and upgradeability.

Fineness of the thermal setting

■ The fuse is given a fixed rating. Current changes in the device to be protected require fuse replacement.

The difference between 2 fuse ratings is approximately 25 %. Standard ratings are given according to the series of characteristic numbers of the "Renard" series. For example: 40 - 50 - 63 - 80 - 100 - 125 - 160 - 200 - etc.

■ The circuit breaker offers a setting fineness of:

- 5 % for circuit breakers equipped with conventional thermal-magnetic trip units,
- 3 % for circuit breakers equipped with electronic trip units.

For example: a circuit breaker with a nominal rating of 100 A can easily be set to values of $I_r = 100\text{ A}, 95\text{ A}, 90\text{ A}, 85\text{ A}, 80\text{ A}$.

For example: a circuit breaker with a nominal rating of 100 A set at 90 A will be used to protect a KSA10 busbar trunking ($I_{nc} = 100\text{ A}$) which is used for an ambient temperature of 50°C (see table of maximum permissible temperatures as a function of operating temperature).

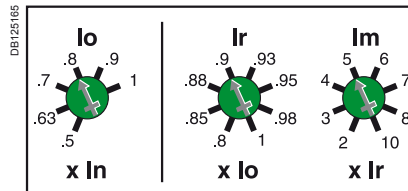
Extensive setting range of circuit breakers equipped with electronic trip units

Circuit breakers equipped with electronic trip units or setting dynamics in:

- thermal protection I_r adjustable from $0.4 I_n$ to I_n
- short-circuit protection from $2 I_r$ to $10 I_r$

For example: a 250 A circuit breaker (NSX250N equipped with a Micrologic 2.2) can easily be set in:

- thermal protection of 100 to 250 A
- short-circuit protection of 200 to 2500 A



Example of setting possibilities.

This ensures a high degree of flexibility with respect to:

- modifications (flexibility), extensions (upgradeability): protection devices are easily adapted to the application requiring protection and to the grounding system used (protection of persons and equipment)
- maintenance: use of this type of device considerably reduces maintenance component stocks.

Busbar distribution

BBT sizing is determined by 3 types of characteristics:

- the maximum peak current, peak I
- the maximum short-term rms current, I_{cw}
- the thermal stress (in A^2s).

Short-circuit protection by circuit breaker

Inherent BBT characteristics

BBT short-circuit sizing is determined by the following characteristics:

- **the maximum peak current, peak I:**
this characteristic expresses the instantaneous electrodynamic withstand limits of the busbar trunking. Peak current value is often the most restrictive instantaneous characteristic for the protection device.
- **maximum short-term rms current I_{cw} :**
this characteristic expresses the permissible temperature rise limit of conductors for a given period of time (0.1 to 1 s).
- **the thermal stress in A^2s :**
this characteristic expresses the instantaneous thermal stress withstand of the BBT. Normally, if the short-circuit generates fault conditions that are compatible with the first two characteristics, this constraint is "naturally satisfied". The assumed short-circuit current to be considered for BBT protection is the one found at supply box level.

Circuit breaker characteristics

Circuit breaker D must meet the requirements of product construction standards (IEC 60947-2,...) and installation standards (IEC 60364 or relevant country standards), i.e. its breaking capacity $I_{cu}^{(1)}$ must be greater than short-circuit current I_{sc} at the point where it is installed.

(1) installation standard IEC 364 and the construction standards specify that the breaking capacity of a circuit breaker is:

- the ultimate breaking capacity, I_{cu} , if it is not coordinated with an upstream protection device
- the breaking capacity enhanced by cascading, if there is coordination with the upstream protection device.

Applications

- **Two cases must be considered :**
 - **directly protected busbar trunking**
circuit breaker $I_{cu} \geq$ assumed I_{sc} at point A
BBT peak I \geq asymmetrical assumed or limited I_{sc} at point A
BBT thermal withstand in $I_{cw} \geq$ thermal stress passing through the BBT
 - **busbar trunking protected downstream from a cable**
circuit breaker $I_{cu} \geq$ assumed I_{sc} at point A
BBT peak I \geq asymmetrical assumed or limited I_{sc} at point B
BBT thermal withstand in $I_{cw} \geq$ thermal stress passing through the BBT.

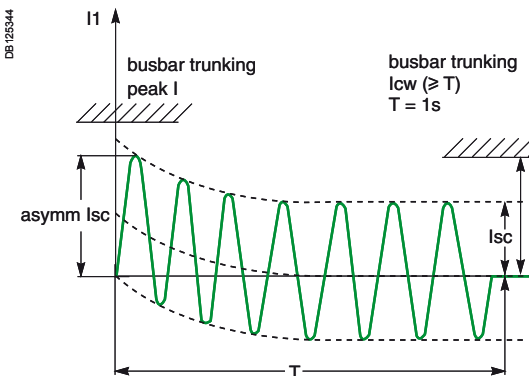
Circuit breaker/busbar trunking coordination

This coordination depends on the type of circuit breaker protecting the busbar trunking.

Non-limiting or time-delayed circuit breaker

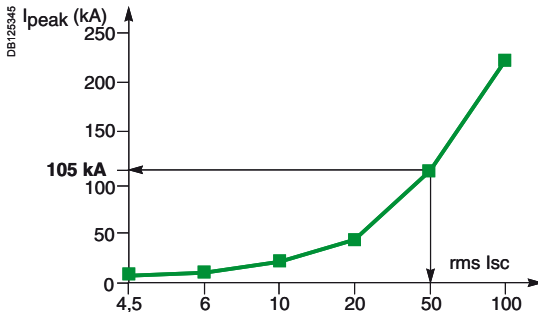
These are non-limiting (instantaneous or time-delayed) circuit breakers and time-delayed limiting circuit breakers, mainly of the air power (> 800 A) type. The busbar trunking must be able to withstand the fault peak current to which it may be submitted as well as thermal withstand during any time delay:

- the permissible peak current, peak I, of the BBT must be greater than the peak value of the assumed asymmetrical short-circuit current, I_{sc} , at point A. The value of the asymmetrical short-circuit current is obtained from the value of the symmetrical short-circuit current, I_{sc} , multiplied by a standardized asymmetry factor (k). The first value of the 1st short-circuit asymmetry peak in the transient state is the one that is taken into account.



Current value of the 1st peak as a function of rms I_{sc} .

Busbar distribution



Transient and steady states of a short-term short-circuit.

Standardized table for calculating the asymmetrical short-circuit

Isc: assumed symmetrical short-circuit kA (rms value)	Assymetric factor k
$4.5 \leq I \leq 6$	1.5
$6 < I \leq 10$	1.7
$10 < I \leq 20$	2.0
$20 < I \leq 50$	2.1
$50 < I$	2.2

For example: for a circuit with a assumed short-circuit current of 50 kA rms, the first peak reaches 105 kA ($50 \text{ kA} \times 2.1$): see figure opposite.

- The short-term short-circuit current, I_{cw} , of the BBT, must be greater than the current flowing through the installation for the duration of the short-circuit I_{sc} (duration T - total breaking time - including the time delay if any -).
- For example: a KTA16 BBT has an I_{cw} characteristic of 60 kA for $T = 1$ second, i.e. a thermal stress withstand expressed in A^2s equal to $3.6 \times 10^9 A^2s$.

If one of these relationships is not verified, a suitable higher rating must be chosen for the BBT.

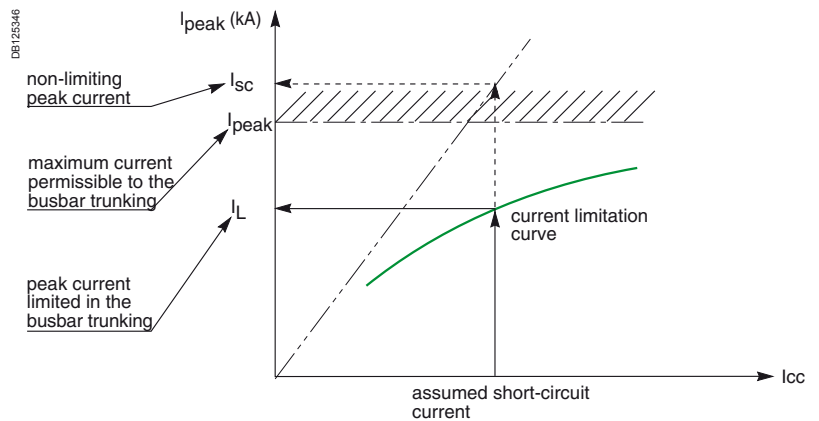
Limiting circuit breaker

This mainly concerns protection of BBTs by moulded case type circuit-breakers ($\geq 1250 \text{ A}$).

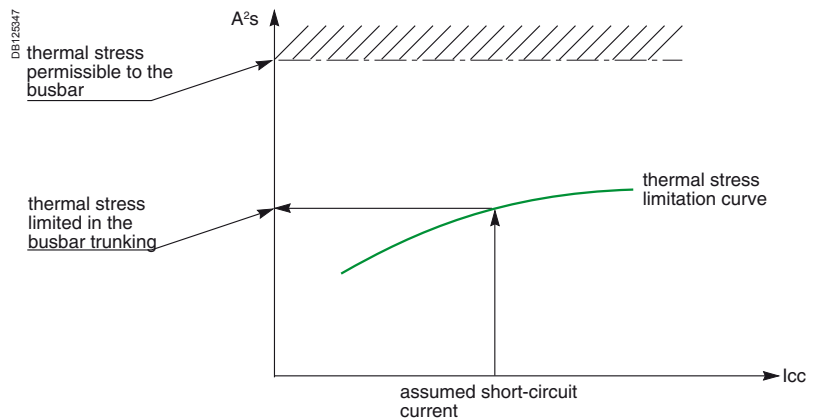
In this case it is ensured that the BBT withstands the peak current limited by the protection device and the corresponding thermal stress.

- The current limited (peak I) by the circuit-breaker is \leq the peak current permissible to the BBT.
- The thermal stress limited by the circuit-breaker is \leq the thermal stress permissible to the BBT.

Checking BBT withstand in peak I



Checking BBT withstand in A^2S



If either of these conditions is not met, oversizing of the BBT will be required.

Busbar distribution

BBT protection summarizing table

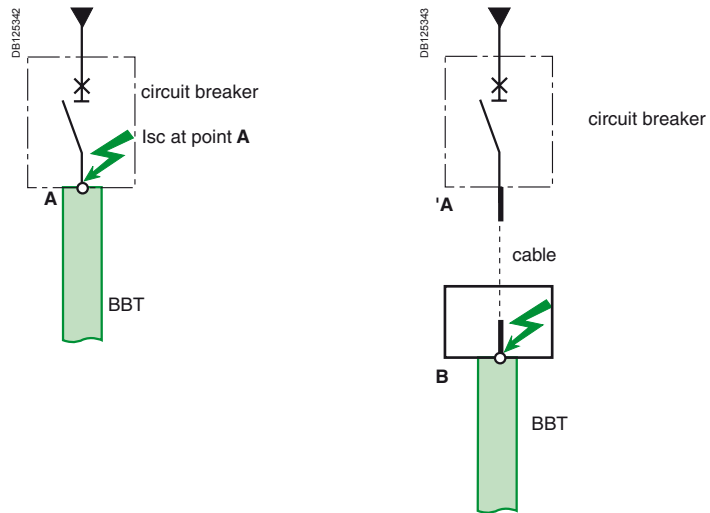
Network characteristics		
Isc		
Circuit breaker characteristics / Short-circuit constraints		
Icu ≥ Isc at point A		
BBT characteristics / Short-circuit constraints ⁽¹⁾		
Peak I	Icw for T ⁽³⁾	A ² s
BBT withstand at peak current	Permissible short-term current	Instantaneous thermal withstand
kÂ	kA rms x f(T)	kA ² s
Time-delayed non-limiting circuit breaker	Peak I ≥ Isc x k ⁽²⁾	Icw ≥ Isc
Limiting circuit breaker	Peak I ≥ I _L limited by the circuit breaker	kA ² s (BBT) ≥ kA ² s limited by the circuit breaker

Characteristics that are not applicable or that are naturally verified

(1) the Isc of the network under consideration is that at the BBT connection point (at point A)

(2) asymmetry factor (see page 13)

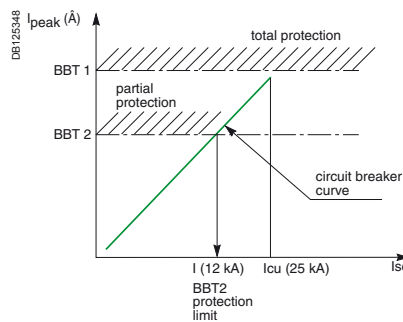
(3) T: total breaking time including any time delays.



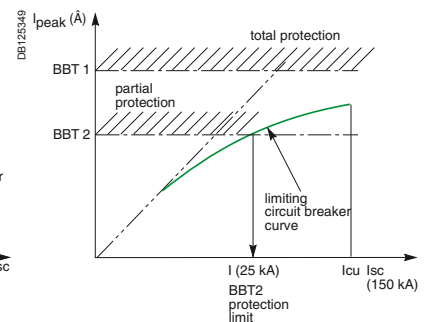
■ The busbar trunking short-circuit protection level can be either **total** or **partial**:

□ **total protection**: the busbar trunking is protected up to the ultimate breaking capacity of the circuit breaker

□ **partial protection**: the busbar trunking is protected up to a high short-circuit current level (e.g. 55 kA) but less than circuit breaker ultimate breaking capacity (Icu) (e.g. Icu = 70 kA).



Non-limiting circuit breaker.



Limiting circuit breaker.

Busbar distribution

1.5. Busbar distribution coordination

Protection device coordination:

System performance is guaranteed by standardization of circuit breaker protection and BBT busbar distribution.

The performance of a busbar distribution system depends on the specific characteristics of each of its component parts.

This performance will be optimized by providing proper coordination, obtained by a system type design.

Continuity of service and discrimination

The previous chapters dealt with BBT overload and short-circuit protection. An installation is always made up of a number of distribution levels. Continuity of service must be guaranteed by ascending coordination of protection devices from the load to the source. This coordination relies on discrimination techniques.

Discrimination of protection devices consists of coordinating automatic protection devices so that a fault occurring at any point of the network is eliminated by the circuit breaker **immediately upstream from it and by this circuit breaker alone**. The performance of an electrical distribution system is guaranteed by standardization of circuit breaker protection and BBT busbar distribution.

1.6. Summarizing busbar distribution characteristics

The performance criteria of a distributed electrical distribution installation in industrial and commercial buildings call for functions whose characteristics are summarized in the table below.

Criteria	Relevant functions	Level A transmission and distribution with a small quantity of tap points	Level B distribution with a large quantity of tap points	Level C final distribution
Upgradeability	numerous tap off points	□	■	
Simplicity	easy study and installation	■	■	□
	easy site modification	□	■	□
Continuity of service	discrimination of protection devices	■	■	■
	modification with power on	□	■	
	protection device easily reset	□	□	■
Safety	controlled fault parameters ⁽¹⁾	■	■	■
	on-load braeking and disconnection	■	■	■

- vital maximum performance
- normal performance

(1) System global control
 - Circuit breaker protection device coordination
 - Inherent BBT performance
 - Protection of persons and equipment
 - Compliance with standards
 - etc...

The Schneider Electric busbar distribution System

Busbar distribution fully satisfies requirements for upgradeability, simplicity, continuity of service and safety.

Schneider Electric recommends a System type approach to perform the above functions.

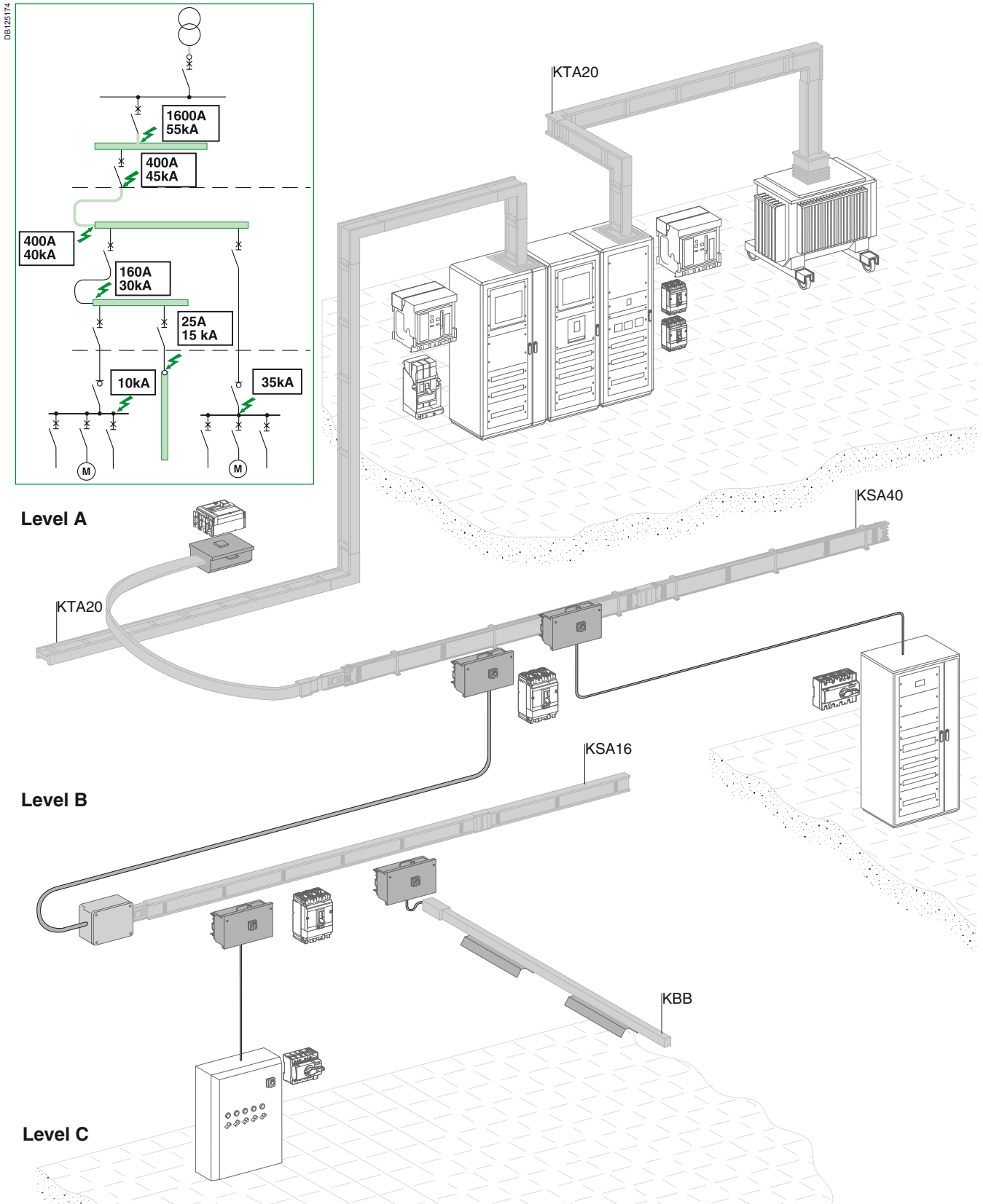
These solutions are based on a BBT busbar distribution system, protected by circuit breakers, and provide:

- simplicity of choice
- homogeneity of solutions
- rationalization of components
- a manufacturer's guarantee of System coordination.

The two block diagrams on the following pages give some examples of the Schneider Electric circuit breaker protected busbar distribution system.

The Schneider Electric busbar distribution System

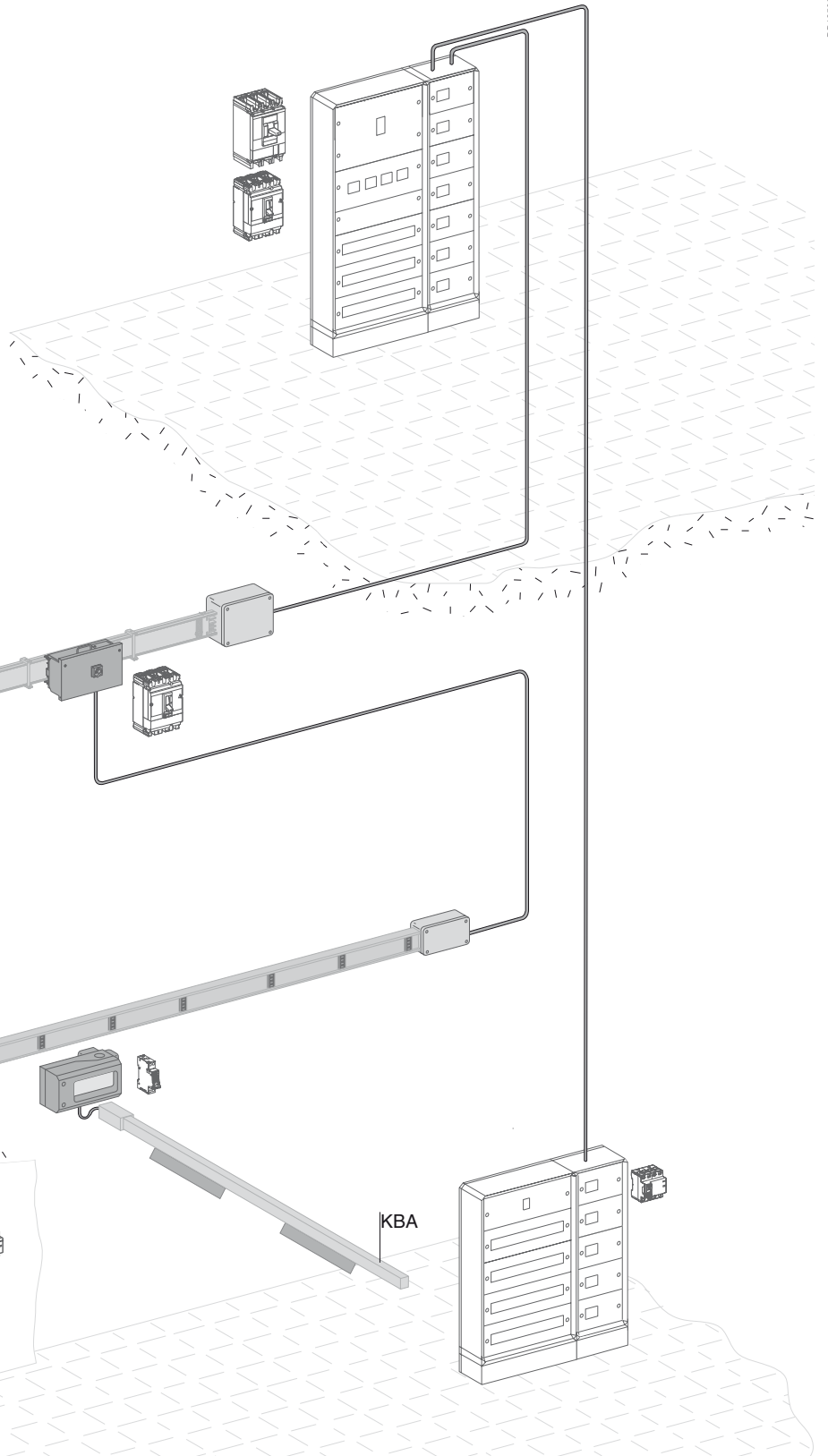
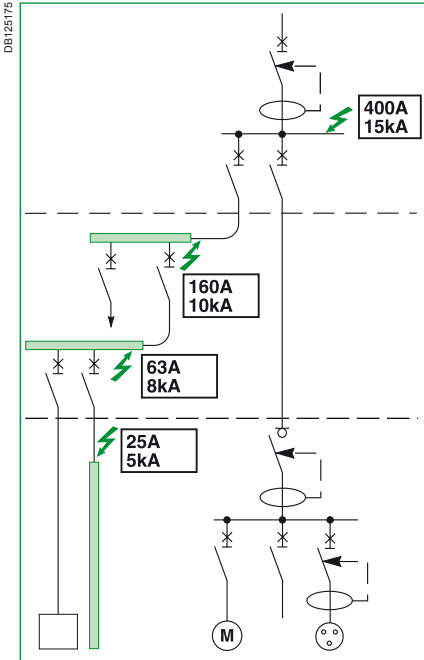
In large sites
Buildings in excess of 5 000 m²



Example of an industrial site.

The Schneider Electric busbar distribution System

In medium-sized and small sites
Building smaller than 5 000 m²



Level B

Level C

Example: of a supermarket.

The Schneider Electric busbar distribution System

2.1. BBT/circuit breaker coordination

In order to simplify choice, Schneider Electric presents the results of each circuit breaker/ BBT combination directly in table form (see Technical complementary data).

The approach used in the study examined earlier, applied to Schneider Electric products, enhances the Schneider Electric system.

Protection of a transmission or distribution BBT downstream from the Main Switchboard (MSB)

The diagram opposite shows a T1 transmission BBT and a KTA16 distribution BBT (1600 A) protected by a Masterpact M16 circuit-breaker with a 0.5 s time delay.

■ At point A, at the supply end of the KTA16 distribution BBT, the I_{sc} is 55 kA.

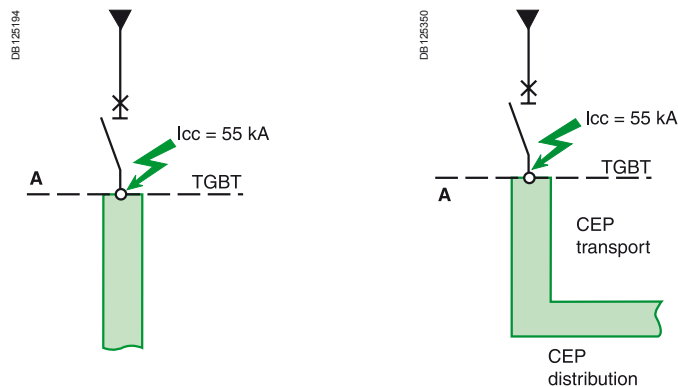
The conditions laid down on page 15 are carefully verified:

- for the Masterpact I_{sc} (65 kA) > I_{sc} (55 kA) at point A of the installation
- for the busbar trunking:
 - the withstand current I_{cw} (66 kA) for 1 s is greater than the short-circuit current I_{sc} (55 kA) for $T = 0.5$ s
 - the peak withstand, peak I (130 kA) of the busbar trunking is greater than the maximum asymmetrical peak current.

The following table lists the various constraints and characteristics of the circuit breaker and busbar trunking.

Network characteristics at point A		
$I_{sc} = 55 \text{ kA in A}$		
Circuit breaker characteristics / short-circuit constraints		
$I_{cu} = 65 \text{ kA} \geq 55 \text{ kA in A}$		
BTT characteristics / short-circuit constraints		
Peak $I = 130 \text{ kA}$	$I_{cw} = 66 \text{ kA for 1s}$	A^2s
BBT withstand at peak current kA	Permissible short-term current $\text{kA rms} \times f(T)$	Instantaneous thermal withstand kA^2s
Non-limiting circuit breaker	$130 \text{ kA} \geq 55 \text{ kA} \times 2,2$	$66 \text{ kA} \geq 55 \text{ kA for 1s}$

Naturally verified characteristics.



Protection of an BBT by an NSX400N limiting circuit breaker

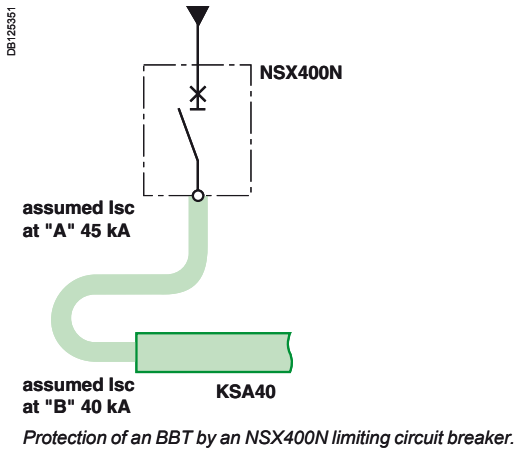
Limiting capacity

The circuit breakers in the Compact NSX range are limiting circuit breakers with a high limiting capacity.

A circuit breaker's limiting capacity expresses its ability only to let a limited current I_L lower than the assumed I_{sc} asymmetrical peak short-circuit current, through on a short-circuit.

The consequence is a considerable reduction in electrodynamic and thermal stresses in the installation requiring protection.

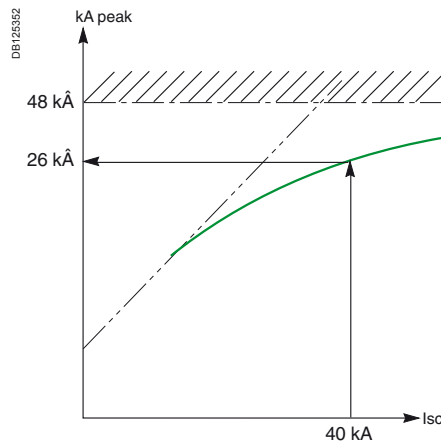
The Schneider Electric busbar distribution System



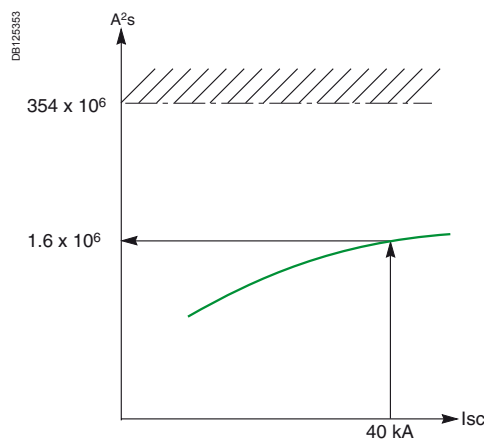
Applying limiting capacity to BBT protection

This fault current limitation means that BBT protection level is extremely high. With Compact NSX circuit breakers, a 10% limitation (I_L /asymmetrical Isc) reduces to less than 1% the fault current flowing through the installation. The diagram opposite shows protection of the KSA40 distribution busbar trunking by an NSX400N limiting circuit breaker. In this diagram:

- the Isc is 45 kA at point A.
- in B, the limited Isc is only 26 kA (instead of nearly 84 kA without limitation)
- the energy limited in A²s is far lower than BBT withstand.



a. current limitation



b. energy limitation

The following table lists the various constraints and characteristics of the circuit breaker and BBT.

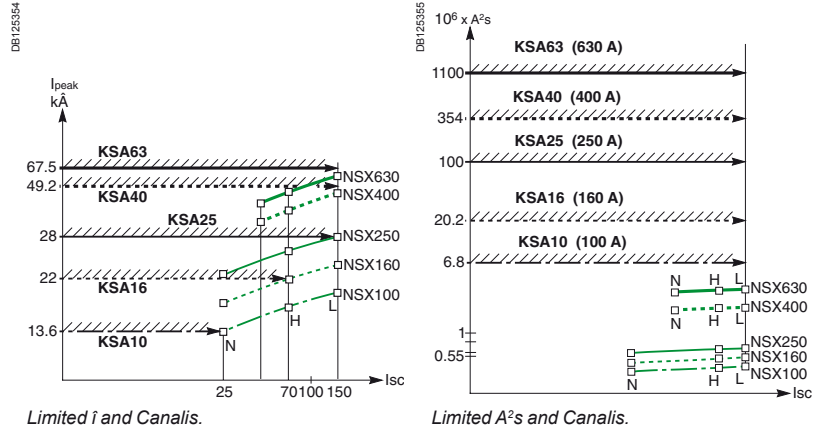
Network characteristics		
Isc = 45 kA at point A	Isc = 40 kA at point B	
Circuit breaker characteristics / Short-circuit constraints		
Icu = 45 kA ≥ 45 kA at point A		
BBT characteristics / Short-circuit constraints (at point B)		
Peak I = 48 kA	I _{cw} = 66 kA for Ts	"A ² s" = 354 x 10 ⁶ A ² s
BBT withstand at peak current	Permissible short-term current	Instantaneous thermal withstand
kA	kA rms x f(T)	kA ² s
Limiting circuit breaker	48 kA ≥ I_L = 28 kA	354 x 10⁶ ≥ 1,6 x 10⁶ A²s

■ Unapplicable characteristics.

This table shows that the limitation performance of the Compact NSX is vital to reduce the stresses to which the busbar trunkings are subjected and in particular the thermal stress.

The Schneider Electric busbar distribution System

The exceptional limitation of the peak current means that monitoring of the BBT thermal stress criterion can be "ignored" (limited $I^2t \ll$ BBT withstand I^2t). The following limitation curves immediately show the coordination characteristics.

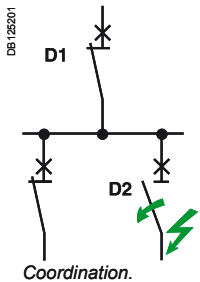


These diagrams show that protection is provided in excess of the maximum I_{sc} encountered on installations.

2.2. Exclusive features of the Schneider Electric system: enhanced busbar distribution coordination

Enhanced coordination has many advantages: exclusive features of the Schneider Electric system

- possibility of installing circuit breakers with standard breaking capacity (anywhere on the tap off BBT) downstream from an BBT protected by a Compact NSX.
 - standard guarantee of total distribution discrimination.
- This results in reduced installation and operating costs.



Coordination between a Compact NSX circuit breaker (D1 placed upstream) and a downstream circuit breaker (D2) protecting an BBT, enhances the I_{sc} withstand performance of this BBT. Enhancement depends on the limitation performances and breaking technique of the Schneider Electric circuit breakers.

Reminder: coordination between 2 protection devices

When 2 circuit breakers are installed in series in an electrical installation, their behavior when a short-circuit occurs downstream is referred to by the term "coordination" (see diagram opposite).

This term covers 2 notions:

- **discrimination:** only the circuit breaker placed immediately upstream from the fault eliminates the fault
- **cascading:** the upstream circuit breaker uses its limiting capacity to help the downstream circuit breaker eliminate the fault on breaking.

Thus, according to the level of short-circuit to be eliminated, D1 and D2 may be:

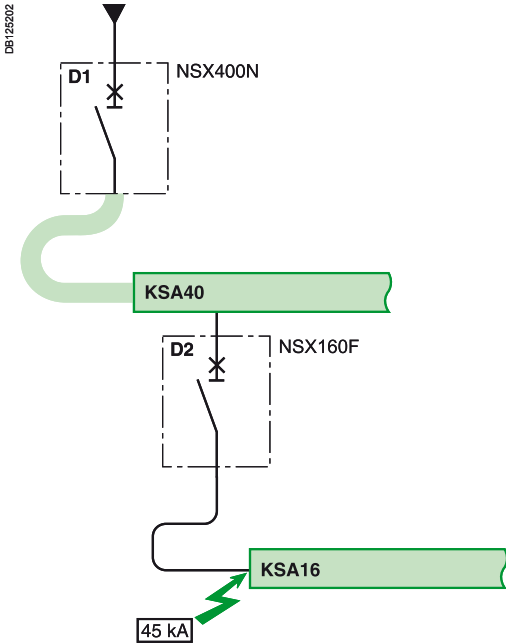
- **discriminating:** only D2 will eliminate downstream faults
- **cascading:** D1 will help D2 eliminate short-circuits. In this case D2's short-circuit capacity will be enhanced.

Implementation of a D1 upstream Compact NSX circuit breaker of the Compact NSX type coordinated with a D2 downstream circuit breaker, simultaneously enhances:

- breaking capacity by cascading of circuit breaker D2,
- as well as the discrimination level up to the enhanced breaking capacity of the combination.

Coordination is defined and recognised by the switchgear standards (IEC 60947) and installation standards (IEC 60364 or relevant country standards), and is guaranteed by manufacturing tests or calculations.

The Schneider Electric busbar distribution System



Enhanced protection of a KSA-16 BBT by an NSX160F circuit breaker coordinated with an NSX400N circuit breaker.

Application: enhanced BBT protection

This cascading technique also considerably enhances BBT withstand characteristics with respect to the assumed short-circuit current.

In the diagram opposite the KSA40 busbar trunking is protected by the NSX400N circuit breaker (D1). A KSA16 tap off protected by an NSX160F (D2) circuit breaker is placed on this busbar trunking.

- Without coordination, the very high limiting capacity of the NSX160F alone already protects the KSA16 up to its ultimate breaking capacity I_{cu} , i.e. 35 kA.
- However coordination performance is enhanced as a result of enhanced coordination with the upstream NSX400N:

- **enhanced breaking capacity** of the NSX160F which rises to 45 kA,
- **enhanced discrimination**: due to the techniques developed in the NSX type ranges, discrimination is total between the 2 protection devices, in other words up to the enhanced breaking capacity of D2, i.e. 45 kA.
- **enhanced busbar trunking withstand**: tested coordination of Canalis KSA16 is enhanced up to the enhanced I_{sc} of the NSX160F, i.e. 45 kA.

This exclusive Schneider Electric system feature increases:

- **reliability**, thanks to the high limitation of short-circuit current thermal and electrodynamic stresses
- **continuity of electrical distribution service** thanks to the increased discrimination level.

	BBT protection	BBT protection in coordination
Canalis KSA 16	Protected by limiting D2 NSX160F I_{cu} = 35 kA	Protected by limiting D2 NSX160F I_{cu} = 35 kA coordinated upstream with D1 NSX400N I_{cu} = 45 kA
Protection limit KSA16	I_{sc} = 35 kA	I_{sc} = 45 kA
Discrimination limit	Up to max. I_{sc} = 35 kA according to upstream	Up to max. I_{sc} = 45 kA guaranteed

KSA16 characteristic	Maximum stresses on BBT if a short-circuit occurs	
Peak I = 22 kA A^2s = 20,2 10 ⁶	I_{sc} = 35 kA I_L = 19 kA A^2s = 0,52 10 ⁶	I_{sc} = 45 kA I_L = 20 kA A^2s = 0,6 10 ⁶

2.3. Final distribution

The following diagrams optimize all the functions required for all industrial and commercial building applications.

Protection

- switchboard overcurrent protection is provided by the protection circuit breaker (DD) installed in the tap off box.
- feeder protection is provided by the circuit-breakers (DCI) installed at each feeder. Continuity of service is optimum at feeder level:
- thanks to enhanced total discrimination between the protection devices
- thanks to easy access and resetting of the protection devices.

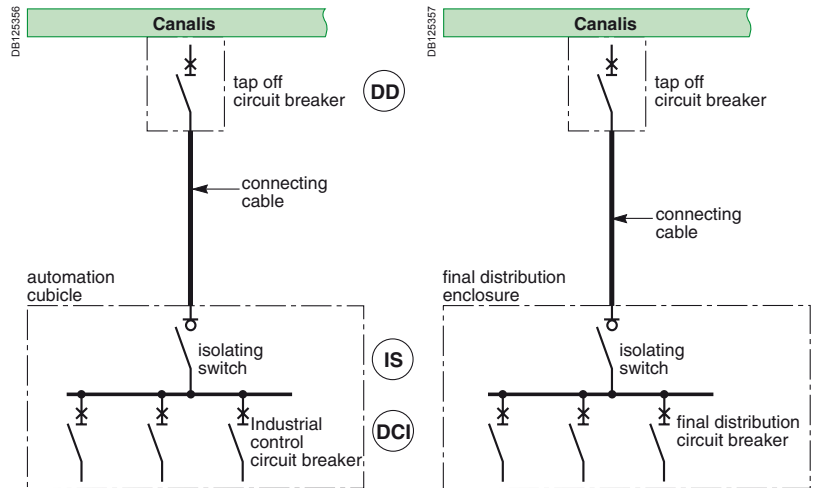
Maintenance

The switchboard incoming switch (IS) guarantees disconnection and thus safety for maintenance, servicing and upgrading of the installation.

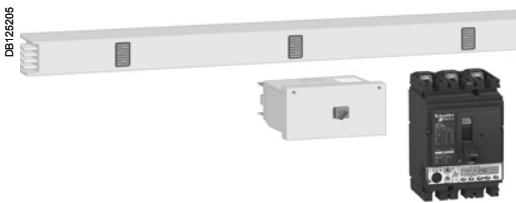
The Schneider Electric busbar distribution System

On-load opening

This function is performed by a switch. The incoming switch places the installation out of operation should a problem arise, either by manual control or automatically using an emergency punch button. This safety function requires a high degree of reliability should a fault occur on the electrical installation.



2.4. Advantages of the Schneider Electric system

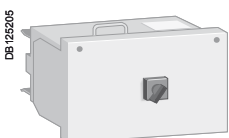


Canalis KSA busbar trunking.

BBT protection

Schneider Electric circuit breakers offer:

- overload and short-circuit protection,
- an extensive setting range and thus protection device standardization,
- coordination between the protection devices and the Telemecanique Canalis BBTs:
 - total discrimination: 1 to 6300 A between all Merlin Gerin circuit breakers
 - cascading:
 - enhancement of low and medium power BBT short-circuit protection devices, thus meeting all the short-circuit levels encountered.
 - tap off protection using standard circuit breakers regardless of where the tap off box is placed on the Canalis BBT.
- use of standard circuit breakers simplifies the study process, while ensuring a high degree of dependability.
- quick, easy fault tracking.
- simple reclosing ("resetting") once the fault has been eliminated by the operator.



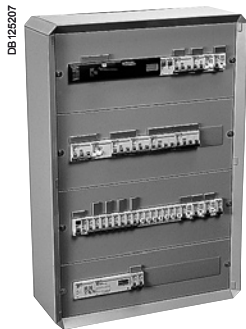
Tap off box.

Tap off boxes

The Schneider Electric Canalis tap off boxes satisfy operators' needs in terms of:

- installation upgradeability without production downtimes
 - continuity of service
 - safety.
- The tap off boxes:
- can be connected and disconnected with power on without risk to the operator
 - are designed for installation at one-meter intervals on the distribution BBTs.

The Schneider Electric busbar distribution System



Prisma enclosure.



Automation enclosure.



Switch.

Final distribution

The protection switchgear optimizes switchboard functions.

■ Coordination of upstream protection devices is provided and guaranteed by Schneider Electric:

- for distribution applications between Masterpact, Compact C, Compact NSX circuit breakers and Multi 9 circuit breakers.
- for industrial control applications between circuit breakers and control (motor circuit breaker, Integral,...).

The coordination tables are available in the relevant product catalogs.

The Schneider Electric switches comply with the IEC 60947-3 standard, and are designed to ensure AC23 on-load breaking and disconnection. Their protection is guaranteed by coordination with the upstream circuit breakers.

2.5. Advantages and exclusive features of the Schneider Electric system

Total coordination of the Schneider Electric system guarantees and enhances safety of persons and equipment, continuity of service and installation upgradeability and simplicity.

Total coordination is materialized by:

Comprehensive coordination choice guide tables

■ Schneider Electric proposes coordination tables for a busbar distribution system from 1 to 5000 A:

- circuit breakers: Multi 9, Compact NSX, Compact CM, Masterpact
- from 1 to 6300 A.
- BBT: lighting BBT, low, medium and high power distribution BBT.

■ Whatever the installation's short-circuit current, 2 table types directly supply the appropriate BBTs and circuit breakers:

- one to ensure coordination
- the other to ensure cascading and enhanced discrimination.

Standard performance circuit breakers for all $I_{sc} \leq 70 \text{ kA}$

The BBT tap off boxes are equipped with standard Compact NS circuit breakers and can be installed at any point of the BBT.

Optimization of the tap off box offer

The extensive setting ranges of the circuit breakers equipped with electronic trip units.

- in thermal protection, I_r is adjustable from 0.4 to I_n ,
- in short-circuit protection, I_m is adjustable from 2 to 10 I_r , allow optimization of the tap off box stocks required for maintenance and extension purposes.

This feature helps enhance the natural flexibility and upgradeability of the BBTs.

The Schneider Electric busbar distribution System

Summarizing table

Criteria	Relevant functions		Level A Transmission and distribution with a small quantity of tap points	Level B Distribution with a large quantity of tap points	Level C Final distribution
Upgradeability	One tap off connection every meter			BBT	
	Extensive setting range of protection devices		CB	CB	
	Easy installation		BBT	BBT	
	Standard performance circuit breakers for all $I_{sc} \leq 70$ kA	●		CB	CB
Simplicity	Comprehensive coordination choice guide tabl	●	BBT, CB	BBT, CB	BBT, CB
	Optimization of the tap off box offer	●	CB	CB	
	Easy, rapid BBT installation		BBT	BBT	
	Easy installation modification		BBT	BBT	
	Extensive protection enclosure range		BBT	BBT	
Continuity of service	Total discrimination of BBT protection devices	●	BBT, CB	BBT, CB	
	Total discrimination of protection devices for all Merlin Gerin and Telemecanique circuit breaker ranges ⁽¹⁾	●			CB
	Modification without production downtimes		BBT	BBT	
	Easily resettable protection device		CB	CB	CB
Safety of persons and equipment	System coordinated from 40 to 5000 A cascading and total coordination of protection devices	●	BBT, CB	BBT, CB	BBT, CB
	On load breaking and disconnected coordinated with upstream protection devices		CB	CB	CB
	Testable protection devices		CB	CB	CB
	Polarized tap off boxes		BBT	BBT	

● : exclusive advantage of the Schneider Electric system.

BBT : performance owed to the Canalis BBTs

CB : performance due to the circuit breakers

BBT, CB : performance due to the coordination between BBTs and circuit breaker

⁽¹⁾ In particular thanks to :

■ a system coordinated from 40 to 5000 A

■ cascading and total coordination of protection device.

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