The ABB Guide to

Power Factor Correction and Circuit Breaker Selection

TMAX Moulded-Case Circuit Breakers

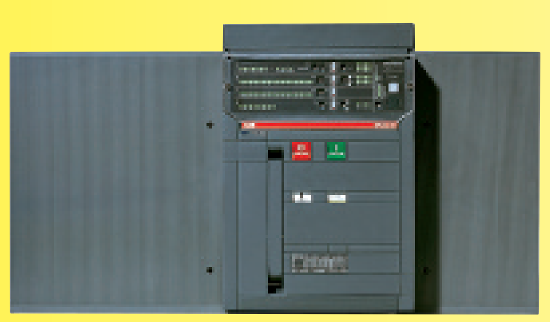
	I_{ncb}	I_{rc}	Q_c [kvar]				N_{mech}	f_{mech}	N_{el}	f_{el}
CB Type	(A)	(A)	400V	440V	500V	690V		[op/h]		[op/h]
T1 B-C-N	160	107	74	81	92	127	25000	240	8000	120
T2 N-S-H-L 160*	160	107	74	81	92	127	25000	240	8000	120
T3 N-S 250*	250	167	115	127	144	199	25000	240	8000	120
T4 N-S-H-L-V 250	250	167	115	127	144	199	20000	240	8000	120
T4 N-S-H-L-V 320	320	213	147	162	184	254	20000	240	6000	120
T5 N-S-H-L-V 400	400	267	185	203	231	319	20000	120	7000	60
T5 N-S-H-L-V 630	630	420	291	320	364	502	20000	120	5000	60

* for plug-in version reduce the maximum power of the capacitor bank by 10%

ISOMAX S Moulded-Case Circuit Breakers

	I_{ncb}	I_{rc}	Q_c [kvar]				N_{mech}	f_{mech}	N_{el}	f_{el}
CB Type	(A)	(A)	400V	440V	500V	690V		[op/h]		[op/h]
S6 N-S-H-L 800	800	533	369	406	462	637	20000	120	5000	60
S7 S-H-L 1250	1250	833	577	635	722	996	10000	120	7000	20
S7 S-H-L 1600	1600	1067	739	813	924	1275	10000	120	5000	20
S8 H-V 2000	2000	1333	924	1016	1155	1593	10000	120	3000	20
S8 H-V 2500	2500	1667	1155	1270	1443	1992	10000	120	2500	20
S8 H-V 3200	3200	2133	1478	1626	1847	2550	10000	120	1500	10

EMAX Air Circuit Breakers



	I_{ncb}	I_{rc}	Q_c [kvar]				N_{mech}	f_{mech}	N_{el}	f_{el}
CB Type	(A)	(A)	400V	440V	500V	690V		[op/h]		[op/h]
E1 B-N	1250	834	578	636	722	997	25000	60	10000	30
E2 B-N	1250	834	578	636	722	997	25000	60	15000	30
E2 B-N	1600	1067	739	813	924	1275	25000	60	12000	30
E2 B-N	2000	1334	924	1017	1155	1594	25000	60	10000	30
E3 N-S-H	1250	834	578	636	722	997	20000	60	12000	20
E3 N-S-H	1600	1067	739	813	924	1275	20000	60	10000	20
E3 N-S-H	2000	1334	924	1017	1155	1594	20000	60	9000	20
E3 N-S-H	2500	1667	1155	1270	1444	1992	20000	60	8000	20
E3 N-S-H	3200	2134	1478	1626	1848	2550	20000	60	6000	20
E4 S-H	3200	2134	1478	1626	1848	2550	15000	60	7000	10
E6 H-V	3200	2134	1478	1626	1848	2550	12000	60	5000	10

Power Factor Correction

Power Factor Correction

- Single

Single or individual power factor correction is carried out by connecting a capacitor of the correct value directly to the terminals of the device, which absorbs reactive power.

Installation is simple and economical; capacitors and load can use the same overload and short-circuit protection, and are connected and disconnected simultaneously.

The adjustment of cos ϕ is systematic and automatic, and benefits both the energy distribution authority and the whole internal distribution system of the user.

This type of power factor correction is advisable in the case of large users with constant load and power factor, and long connection times.

Individual power factor correction is usually applied to motors and fluorescent lamps. The capacitor units or small lighting capacitors are connected directly to loads.

- In groups

Local power factor correction is achieved by installing a dedicated capacitor bank for groups of loads with similar function characteristics. This method achieves a compromise between the best value solution and the correct operation of the installation, since only the line downstream of the installation point of the capacitor bank is not correctly exploited.

Centralised

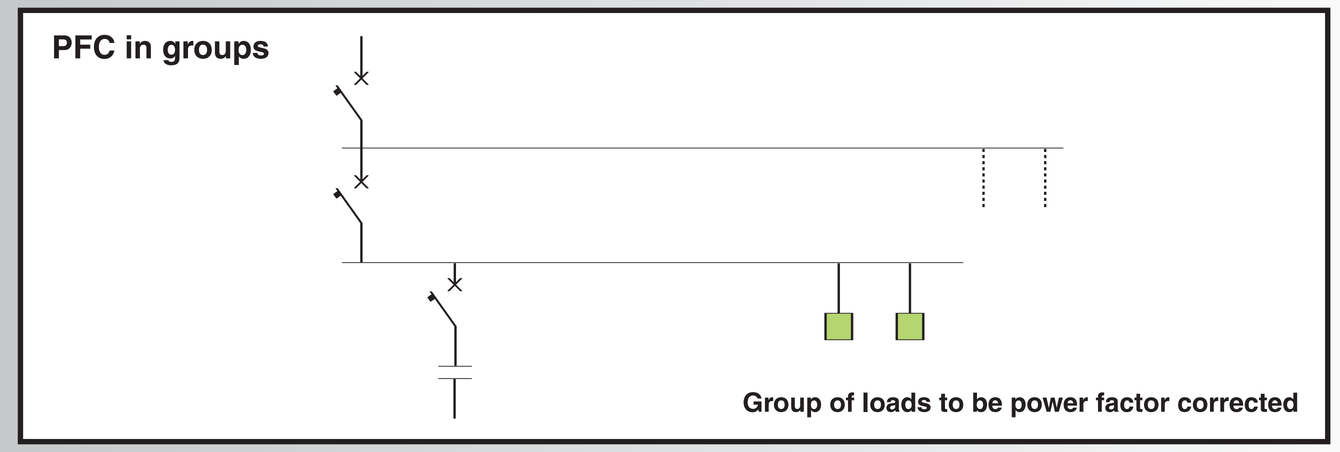
The daily load profile is of fundamental importance for the choice of the most suitable and best value power factor correction.

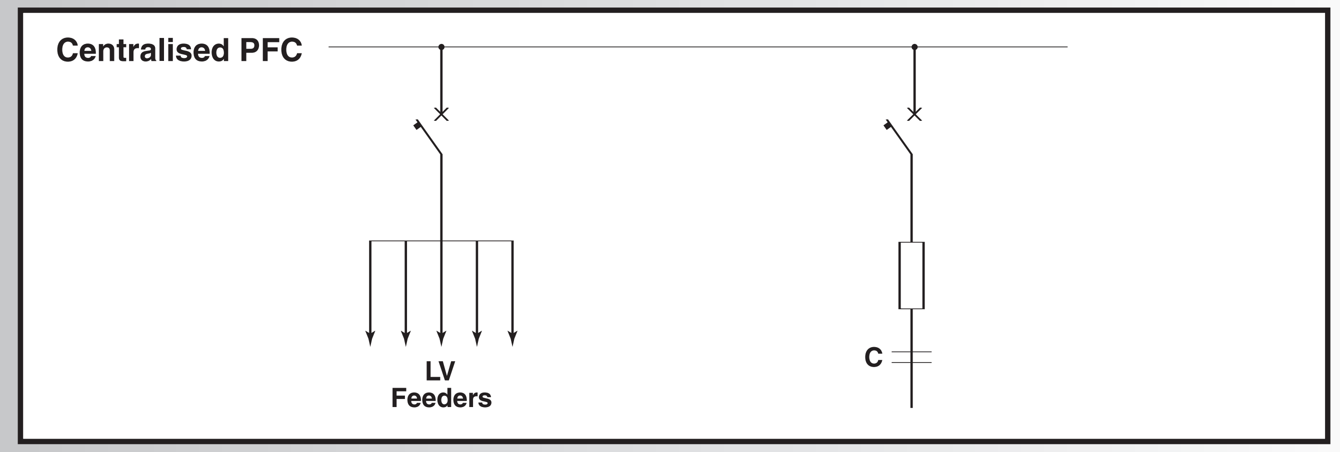
In installations where not all loads function simultaneously and/or in which some loads are connected for only a few hours a day, the single PFC solution may be unsuitable as many of the capacitors installed could stay idle for long periods.

In installations with many loads occasionally functioning, which have a high installed power and a quite low average power absorption by the loads in simultaneous operation, the use of a single PFC system at the installation origin ensures a significant decrease in the total power of the capacitors required.

Centralised PFC normally uses automatic units with capacitor banks divided into several steps, directly installed in the main distribution switchboards.
The use of a permanently connected capacitor bank is only possible if the absorption of reactive energy is fairly regular throughout the day.

The main disadvantage of centralised PFC is that the distribution lines downstream of the PFC device must be dimensioned to accommodate the full reactive power required by the loads.





Circuit Breakers

Circuit Breakers for protection and switching of Capacitor Banks

The circuit breakers for the protection and switching of capacitor banks in LV should:

1. Withstand the transient currents that occur when connecting and disconnecting the banks. In particular, the instantaneous magnetic and electronic releases should not trip due to these peak currents
2. Withstand the periodic or permanent overcurrents due to the voltage harmonics and to the tolerance (+ 15%) of the rated capacity value
3. Perform a high number of no-load and on-load operations, also with high frequency
4. Be coordinated with any external device (contactors)

Furthermore, the making and breaking capacity of the circuit breaker must be adequate to the short-circuit current values of the installation.

Standards IEC 60831-1 and 60931-1 state that:

· The capacitors shall normally function with an effective current value up to 130% of their rated current Irc (due to the possible presence of voltage harmonics in the network)

· A tolerance of +15% on the value of the capacity is allowed. The maximum current which can be absorbed by the capacitor bank Icmax is

$$I_{cmax} = 1.3 \cdot 1.15 \cdot \frac{Q_c}{\sqrt{3} \cdot U_r} \approx 1.5 \cdot I_{rc}$$

Therefore:

· The rated current of the circuit-breaker shall be greater than $1.5 \cdot I_{rc}$
· The overload protection setting shall be equal to $1.5 \cdot I_{rc}$
· The connection of a capacitor bank, similar to a closing operation under short-circuit conditions, is associated with transient currents with high frequency (1 to 15kHz), of short duration (1 to 3 ms) and with high peak (25-200Irc)

Therefore:

1) The circuit-breaker shall have adequate making capacity
2) The setting of the instantaneous short-circuit protection must not cause unwanted trips

For the second condition, it is generally given that:

· For thermo-magnetic releases, the magnetic protection shall be set at a value not less than $10.I_{cmax}$
· For electronic releases, the instantaneous short-circuit protection shall be deactivated

$$I_3 \geq 10 \cdot I_{cmax} = 15 \cdot I_{rc} = 15 \cdot \frac{Q_r}{\sqrt{3} \cdot U_r}$$

Key to Table + Equations

I_{nCB}	rated current of the protection release (A)
I_{rc}	rated current of the connected capacitor bank (A)
Q_C	power of the capacitor bank which can be connected (kvar) with reference to the indicated voltage and 50 Hz frequency
N_{mech}	rated current of the connected capacitor bank (A)
f_{mech}	frequency of mechanical operations (op/h)
N_{el}	number of electrical operations with reference to a voltage of 415V for Tmax and Isomax moulded-case circuit breakers and to a voltage of 440 V for Emax air circuit-breakers.
f_{el}	frequency of mechanical operations (op/h)
U_r	rated voltage
I_{cmax}	max current absorbed by capacitor bank

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