IEC 61921

Edition 2.0 2017-06
REDLINE VERSION

# INTERNATIONAL STANDARD

colour inside

## Power capacitors – Low-voltage power factor correction banks



IEC 61921:2017-06 RLV(en)

IEC Central Office
3, rue de Varembé
CH-1211 Geneva 20
Switzerland

Tel.: +41 22 919 02 11
Fax: +41 22 919 03 00
info@iec.ch
www.iec.ch

**About the IEC**
The International Electrotechnical Commission (IEC) is the leading global organization that prepares and publishes International Standards for all electrical, electronic and related technologies.

**About IEC publications**
The technical content of IEC publications is kept under constant review by the IEC. Please make sure that you have the latest edition, a corrigenda or an amendment might have been published.

**IEC Catalogue - webstore.iec.ch/catalogue**
The stand-alone application for consulting the entire bibliographical information on IEC International Standards, Technical Specifications, Technical Reports and other documents. Available for PC, Mac OS, Android Tablets and iPad.

**IEC publications search - www.iec.ch/searchpub**
The advanced search enables to find IEC publications by a variety of criteria (reference number, text, technical committee,…). It also gives information on projects, replaced and withdrawn publications.

**IEC Just Published - webstore.iec.ch/justpublished**
Stay up to date on all new IEC publications. Just Published details all new publications released. Available online and also once a month by email.

**Electropedia - www.electropedia.org**
The world's leading online dictionary of electronic and electrical terms containing 20 000 terms and definitions in English and French, with equivalent terms in 16 additional languages. Also known as the International Electrotechnical Vocabulary (IEV) online.

**IEC Glossary - std.iec.ch/glossary**
65 000 electrotechnical terminology entries in English and French extracted from the Terms and Definitions clause of IEC publications issued since 2002. Some entries have been collected from earlier publications of IEC TC 37, 77, 86 and CISPR.

**IEC Customer Service Centre - webstore.iec.ch/csc**
If you wish to give us your feedback on this publication or need further assistance, please contact the Customer Service Centre: csc@iec.ch.

IEC 61921

Edition 2.0 2017-06
REDLINE VERSION

# INTERNATIONAL STANDARD

colour inside

## Power capacitors – Low-voltage power factor correction banks



INTERNATIONAL
ELECTROTECHNICAL
COMMISSION

ICS 31.060.70 ISBN 978-2-8322-4505-7

**Warning! Make sure that you obtained this publication from an authorized distributor.**

CONTENTS

INTERNATIONAL ELECTROTECHNICAL COMMISSION

___________

# POWER CAPACITORS –
# LOW-VOLTAGE POWER FACTOR CORRECTION BANKS

## FOREWORD

1) The International Electrotechnical Commission (IEC) is a worldwide organization for standardization comprising all national electrotechnical committees (IEC National Committees). The object of IEC is to promote international co-operation on all questions concerning standardization in the electrical and electronic fields. To this end and in addition to other activities, IEC publishes International Standards, Technical Specifications, Technical Reports, Publicly Available Specifications (PAS) and Guides (hereafter referred to as "IEC Publication(s)"). Their preparation is entrusted to technical committees; any IEC National Committee interested in the subject dealt with may participate in this preparatory work. International, governmental and non-governmental organizations liaising with the IEC also participate in this preparation. IEC collaborates closely with the International Organization for Standardization (ISO) in accordance with conditions determined by agreement between the two organizations.
2) The formal decisions or agreements of IEC on technical matters express, as nearly as possible, an international consensus of opinion on the relevant subjects since each technical committee has representation from all interested IEC National Committees.
3) IEC Publications have the form of recommendations for international use and are accepted by IEC National Committees in that sense. While all reasonable efforts are made to ensure that the technical content of IEC Publications is accurate, IEC cannot be held responsible for the way in which they are used or for any misinterpretation by any end user.
4) In order to promote international uniformity, IEC National Committees undertake to apply IEC Publications transparently to the maximum extent possible in their national and regional publications. Any divergence between any IEC Publication and the corresponding national or regional publication shall be clearly indicated in the latter.
5) IEC itself does not provide any attestation of conformity. Independent certification bodies provide conformity assessment services and, in some areas, access to IEC marks of conformity. IEC is not responsible for any services carried out by independent certification bodies.
6) All users should ensure that they have the latest edition of this publication.
7) No liability shall attach to IEC or its directors, employees, servants or agents including individual experts and members of its technical committees and IEC National Committees for any personal injury, property damage or other damage of any nature whatsoever, whether direct or indirect, or for costs (including legal fees) and expenses arising out of the publication, use of, or reliance upon, this IEC Publication or any other IEC Publications.
8) Attention is drawn to the Normative references cited in this publication. Use of the referenced publications is indispensable for the correct application of this publication.
9) Attention is drawn to the possibility that some of the elements of this IEC Publication may be the subject of patent rights. IEC shall not be held responsible for identifying any or all such patent rights.

**This redline version of the official IEC Standard allows the user to identify the changes made to the previous edition. A vertical bar appears in the margin wherever a change has been made. Additions are in green text, deletions are in strikethrough red text.**

International Standard IEC 61921 has been prepared by IEC technical committee 33: Power capacitors and their applications.

This second edition cancels and replaces the first edition published in 2003. It constitutes a technical revision.

This edition includes the following significant technical changes with respect to the previous edition:

- numerous changes regarding verification methods to align with IEC 61439-1;
- modification of marking;
- add routine verification of rated output;
- new Annex D with guidance on methods for temperature rise verification;
- update of normative references;
- general editorial review.

The text of this International Standard is based on the following documents:

| FDIS | Report on voting |
|---|---|
| 33/607/FDIS | 33/611/RVD |



Full information on the voting for the approval of this International Standard can be found in the report on voting indicated in the above table.



This document has been drafted in accordance with the ISO/IEC Directives, Part 2.



The committee has decided that the contents of this document will remain unchanged until the stability date indicated on the IEC website under "http://webstore.iec.ch" in the data related to the specific document. At this date, the document will be



- reconfirmed,
- withdrawn,
- replaced by a revised edition, or
- amended.

**IMPORTANT – The "colour inside" logo on the cover page of this publication indicates that it contains colours which are considered to be useful for the correct understanding of its contents. Users should therefore print this publication using a colour printer.**

# POWER CAPACITORS – LOW-VOLTAGE POWER FACTOR CORRECTION BANKS

## 1 Scope

This International Standard is applicable to low-voltage AC shunt capacitor banks intended to be used for power factor correction purposes, possibly equipped with a built-in switchgear and controlgear apparatus capable of connecting to or disconnecting from the mains part(s) of the bank with the aim to correct its power factor.

Low-voltage power factor correction banks if not otherwise indicated hereinafter and where applicable ~~shall~~ comply with the requirements of ~~IEC 60439-1 and those of IEC 60439-3~~ IEC 61439-1 and IEC 61439-2.

## 2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.



~~IEC 60439-1:1999, *Low-voltage switchgear and controlgear assemblies – Part 1: Type-tested and partially type-tested assemblies*~~

~~IEC 60439-3:1990, *Low-voltage switchgear and controlgear assemblies – Part 3: Particular requirements for low-voltage switchgear and controlgear assemblies intended to be installed in places where unskilled persons have access for their use – Distribution boards*~~

IEC 60831-1:~~1996~~ 2014, *Shunt power capacitors of the self-healing type for AC systems having a rated voltage up to and including 1 000 V – Part 1: General – Performance, testing and rating – Safety requirements – Guide for installation and operation*

IEC 60931-1:1996, *Shunt power capacitors of the non-self-healing type for AC systems having a rated voltage up to and including 1000 V – Part 1: General – Performance, testing and rating – Safety requirements – Guide for installation and operation*

IEC 61439-1:2011, *Low-voltage switchgear and controlgear assemblies – Part 1: General rules*

IEC 61439-2:2011, *Low-voltage switchgear and controlgear assemblies – Part 2: Power switchgear and controlgear assemblies*

IEC 61642:1997, *Industrial AC networks affected by harmonics – Application of filters and shunt capacitors*

## 3 Terms and definitions

For the purposes of this document, the terms and definitions given in ~~IEC 60439-1,~~ IEC 61439-1, IEC 61439-2, IEC 60831-1 and IEC 60931-1 and the following apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

- IEC Electropedia: available at http://www.electropedia.org/
- ISO Online browsing platform: available at http://www.iso.org/obp

**3.1**
**Low-voltage AC capacitor bank or power factor correction bank**
Combination of one or more low-voltage capacitor units together with associated switching devices and control, measuring, signalling, protective, regulating equipment, etc., completely assembled under the responsibility of the assembly manufacturer with all the internal electrical and mechanical interconnections and structural parts

~~Note 1 to entry: Throughout this standard, the abbreviations "automatic bank" and "assembly" are used for a low-voltage a.c capacitors automatic or non-automatic bank.~~

Note 1 to entry: The capacitor bank can be fixed, manually switched or automatically controlled through the use of a power factor controller.

Note 2 to entry: The components of switchgear and controlgear of the automatic bank may be electromechanical or electronic.

**3.2**
**step of capacitor bank**
~~**step**~~
combination of one or more capacitor units switched together through a single switch with possible detuned reactors, connecting wires, and associated switchgear and controlgear apparatus



**3.3**
**automatic reactive power ~~regulator~~**
**controller**
~~circuit~~ device designed to calculate the reactive power absorbed by the load connected to the power line and to control the switching on and off of the steps of the automatic bank, in order to compensate for the reactive power



Note 1 to entry: The reactive power is normally calculated at the fundamental frequency.

Note 2 to entry: The controller may be "built-in" or "free-standing"~~ and has usually to be adjusted for each bank before operation~~.

Note 3 to entry: The controller generally performs functions of measurement / monitoring of power, controlling (of capacitor steps) and protection (of capacitor bank).

**3.4**
**transient inrush current $I_t$**
transient overcurrent of high amplitude and frequency that may occur when a capacitor is switched on, the amplitude and frequency being determined by factors such as the short-circuit impedance of the supply, the amount of energized capacitance switched in parallel and the instant of the switching

**3.5**
**rated reactive power $Q_N$ (of ~~an assembly~~ a capacitor bank)**
total reactive power of ~~an assembly~~ a capacitor bank at the rated frequency and voltage, calculated by the total impedance of the bank including reactors, if any

**3.6**
**maximum permissible current**
value of current declared by the manufacturer which can be present continuously in the capacitor bank, used for installation and protection settings

# 4 Marking of a capacitor bank

The following minimum information shall be given by the manufacturer in an instruction sheet or alternatively, on request of the purchaser, on a rating plate to be fixed on the assembly capacitor bank.

1) Manufacturer's name or trademark.
2) Identification number or type designation.
3) Date of manufacture, in clear or code form.
4) Rated reactive power, $Q_N$ in kilovars (kvar).
5) Rated voltage, $U_N$ in volts (V).
6) Rated frequency, $f_N$ in hertz (Hz).
7) Reference to the IEC 61921 standard and its year of publication.

The following information must also be given by the manufacturer, on the rating plate or on instruction sheet.

8) Rating of steps, in kvar.
9) Short-circuit withstand strength, in amperes (A) Value of series reactor if any (or reactance ratio in % or tuning frequency).
10) Minimum and maximum ambient temperatures in degrees Celsius (°C).
11) Degree of protection of enclosure.
12) Location type: indoor or outdoor.
13) Rated short time withstand current ($I_{cw}$).
14) Rated conditional short-circuit current ($I_{cc}$), if applicable.
15) Maximum permissible current.
16) Rated insulation voltage($U_i$).
17) Rated impulse withstand voltage ($U_{imp}$).



# 5 Service conditions

See relevant clauses of IEC 61439-1 and IEC 61439-2.

# 6 Guide for design, installation, operation and safety

## 6.1 General

Unlike most electrical apparatus, shunt capacitors, whenever energized, operate continuously at full load, or at loads that deviate from this value only as a result of voltage and frequency variations.

Overstressing and overheating shorten the life of a capacitor, and therefore the operating conditions (that is temperature, voltage and current) should be strictly controlled.

It should be noted that the introduction of a capacitance in a system might produce unsatisfactory operating conditions (for example amplification of harmonics, self-excitation of machines, overvoltage due to switching, unsatisfactory working of audio-frequency remote-control apparatus, etc.).

Because of the different types of capacitors and the many factors involved, it is not possible to cover, by simple rules, installation and operation in all possible cases. The following information is given with regard to the more important points to be considered. In addition, the instructions of the manufacturer and the power supply authorities shall be followed.

### ~~5.2 Choice of components~~

~~The choice of components of an assembly shall be carried out with careful reference to compliance between their ambient air temperature category and that of the assembly itself.~~

### 6.2 Design

#### ~~5.3.1 Power factor correction system enclosed within a main switchboard~~

~~The equipment needed for the automatic correction of power factor in an installation, including controller, fuses, switching devices, capacitors and reactors (chokes), can be installed as an integral part of the main switchboard.~~

~~This equipment can be also installed in a separate shell of the main board or simply as an added part in the common main switchboard shell.~~

#### ~~5.3.2 Free standing power factor correction system~~

~~The equipment is free standing and usually installed adjacent or close to the main switchboard or relevant sub-board. It generally has a main bus bar arrangement of the required fault level to match the adjacent main switchboard or sub-board or the required fault current of that section of the installation.~~



~~This bus bar section is bus barred or cabled back to the main supply of the installation.~~

~~Feeding off this bus bar section is a group of fuses, circuit-breakers or fused switch which are wired to a switching device and then to the capacitor banks.~~

#### ~~5.3.3 Automatic power factor correction system with remote mounted capacitors~~



~~All components except for the capacitors are mounted in the control cubicle.~~

~~The capacitors and the required reactors, if any, are mounted on a remote mounting rack. This arrangement is generally used if there is a problem with space requirements or to allow further dissipation of heat.~~

~~It is important to note that power factor component equipment such as fuses, capacitors, reactors, etc. generate a significant amount of heat.~~

#### ~~5.3.4 Compartmentalization~~

~~The general arrangement of a power factor correction assembly can be made in sections, which can be arranged in separate compartments or in a single configuration:~~

~~a) bus bar, main connection and/or main isolation;~~

~~b) capacitor bank fuses or circuit-breakers and/or contactors;~~

~~c) reactors for harmonic control purposes;~~

~~d) capacitors;~~

~~e) control fuses, terminals and controller.~~

#### 6.2.1 Choice of rated voltage

The rated voltage of the capacitor bank shall be at least equal to the service voltage of the network to which the capacitor is to be connected, account being taken of the influence of the presence of the capacitor itself. The service voltage is the actual voltage level experienced by the capacitor bank even if it does not respect the normal tolerances on the rated voltage.

In certain networks, a considerable difference may exist between the service and rated voltage of the network, details of which should be furnished by the purchaser, so that due allowance can be made by the manufacturer. This is of importance for capacitor banks, since their performance and life may be adversely affected by an undue increase of the voltage across the capacitor dielectric.

If no information to the contrary is ~~available~~ agreed between the manufacturer and the customer, the service voltage shall be assumed as equal to the rated ~~(or declared)~~ voltage of the network with applicable tolerances.

Where circuit elements are inserted in series with the capacitor to reduce the effects of harmonics, etc., the resultant increase in voltage at the capacitor terminals over and above the service voltage of the network necessitates a corresponding increase in the rated voltage of the capacitor.

When determining the voltage to be expected on the capacitor terminals, the following considerations shall be taken into account:

a) Shunt-connected capacitors may cause a voltage rise from the source to the point where they are located (see Annex B); this voltage rise may be greater due to the presence of harmonics. Capacitors are therefore liable to operate at a higher voltage than that measured before connecting the capacitors.

b) The voltage on the capacitor terminals may be particularly high at times of light load conditions (see Annex B); in such cases, some or all of the capacitors should be switched out of circuit in order to prevent overstressing of the capacitors and undue voltage increase in the network.



Only in case of emergency should capacitors be operated at maximum permissible voltage and maximum ambient temperature simultaneously, and then only for short periods of time. Exception will be during temperature rise test of the design verification.



NOTE 1 An excessive safety margin in the choice of the rated voltage ~~$U_N$~~ of the capacitor units ~~should~~ has to be avoided, because this would result in a decrease of reactive power output when compared with the rated reactive power output.

NOTE 2 See IEC 60831-1 concerning maximum permissible voltage.

~~**5.3.6 Special service conditions**~~

~~Apart from the conditions prevailing at both limits of the temperature category, the most important conditions about which the manufacturer shall be informed are the following:~~

~~a) High relative humidity~~

~~It may be necessary to use insulators of special design. Attention is drawn to the possibility of external fuses being shunted by a deposit of moisture on their surfaces.~~

~~b) Rapid mould growth~~

~~Mould growth does not develop on metals, ceramic materials and certain kinds of paints or lacquers. For other materials, mould growth may develop in humid places, especially where dust, etc. can settle.~~

~~The use of fungicidal products may improve the behaviour of these materials, but such products do not retain their poisoning property for more than a certain period.~~

~~c) Corrosive atmosphere~~

~~Corrosive atmosphere is found in industrial and coastal areas. It should be noted that in climates of higher temperature the effects of such atmosphere might be more severe than in temperate climates. Highly corrosive atmosphere may be present even in indoor installations.~~

~~d) Pollution~~

~~When capacitors are mounted in a location with a high degree of pollution, special precautions shall be taken.~~

~~e) Altitude exceeding 2 000 m~~

~~Capacitors used at altitudes exceeding 2 000 m are subject to special conditions. Choice of type of capacitor should be made by agreement between purchaser and manufacturer.~~

### 6.2.2 Switching and overload protection

Capacitor overload capacities are given in IEC 60831-1 and in IEC 60931-1. These limits are however larger than the ones applicable for the banks. The switching and protective devices and the connections shall be designed to carry continuously a current of at least 1,3 times the current that would be obtained with a sinusoidal voltage of an r.m.s. value equal to the rated voltage at the rated frequency.

The switching and protective devices and the connections shall also be capable of withstanding the electrodynamic and thermal stresses caused by the transient overcurrents of high amplitude and frequency that may occur when switching on.



Such transients are to be expected when a bank or a step is switched in parallel with others that are already energized. ~~It is common practice to increase the inductance of the connections in order to reduce switching current, although this increases the total losses.~~ Care should be taken not to exceed the maximum permissible switching current of capacitors and switching devices.



Some of the techniques used to reduce the switching transient include use of series reactors, use of capacitor duty contactors with pre-charging resistors or solid state switches. When consideration of electrodynamic and thermal stresses runs the risk of leading to excessive dimensions, special precautions, such as those mentioned in IEC 60831-1 for the purpose of protection against overcurrents, should be taken.

NOTE ~~1~~ In certain cases, for example when the banks are automatically controlled, repeated switching operations may occur at relatively short intervals of time. ~~Switchgear and fuses~~ Switching and protection devices should be selected to withstand these conditions.

~~NOTE 2 Switching devices connected to a busbar which is also connected to a bank, may be subjected to special stress in the event of switching on a short-circuit.~~

~~NOTE 3 Devices for switching parallel steps and their associated protective equipment should be able to withstand the inrush current (amplitude and frequency) resulting when one bank is connected to a busbar to which other bank(s) are already connected.~~

It is recommended that capacitors be protected against overcurrent by means of suitable overcurrent ~~relays, which are adjustable to operate the switching~~ devices when the current exceeds the permissible limit specified in IEC 60831-1 and IEC 60931-1. Fuses do not generally provide suitable overcurrent protection.

~~NOTE 4 Depending on the design of capacitors, their capacitance will vary more or less with the temperature. If iron-core reactors are used, attention should be paid to possible saturation and overheating of the core by harmonics.~~

Any bad contacts in capacitor circuits may give rise to arcing, causing high-frequency oscillations that may overheat and overstress the capacitors. Regular inspection of all capacitor equipment contacts is therefore recommended.

#### ~~5.3.8 International protection designation (IP)~~

~~Most panels are installed in main switch rooms or adjacent to main boards: in these conditions, IP20 may be sufficient. Other IP levels should be agreed between manufacturer and purchaser.~~

~~Degrees of protection (IP rating) for assemblies to be installed outdoor may be increased up to IP54. Careful consideration is to be paid to the design of the ventilation of the cubicle.~~

#### ~~5.3.9 Accessibility of components~~

~~The cubicle and equipment shall be arranged so that in the event of a component failure, components can be easily replaced.~~

~~The arrangement of cabling to the capacitor(s) should allow easy regular maintenance checks.~~

## 6.3 Installation and operation

### 6.3.1 Electrical environment

#### 6.3.1.1 Harmonics

The connection of ~~PFC (power factor correction) equipment~~ a capacitor bank onto a system containing harmonics may reduce ~~the life of the PFC equipment~~ its life time. The damaging effects of harmonics can be mitigated by the use of a suitable detuning reactor in series with each capacitor step.



If iron-core reactors are used, attention should be paid to possible saturation and overheating of the core by harmonics.

More detailed information can be found in IEC 61642.



#### ~~5.4.1.2 Voltage spikes~~

~~Voltage spikes should be avoided. If switching components are selected which are specifically recommended for capacitor applications, the problem should not arise. Nevertheless, equipment does deteriorate with time and worn contacts should be replaced during regular maintenance checks.~~

#### ~~5.4.1.3 Load assessment~~

~~The decision of where to apply the power factor correction is determined by a number of factors, including cost and available space:~~

a) ~~determine where the loads with the low power factor are situated: the PFC can be located at these points;~~
b) ~~generally, it is more practical to locate PFC at the main switchboard, where space is available. In this case, the PFC will correct the power factor of the whole load and maintenance of the PFC is in one location.~~

#### 6.3.1.2 Switching overvoltages

Switching overvoltages internally generated due to the operation of the capacitor bank should be avoided or minimized. Such switching overvoltages if any shall not exceed the limits prescribed in the IEC 60831-1 or IEC 60931-1. If switching components are selected which are specifically recommended for capacitor applications, the problem should not arise. Nevertheless, equipment does deteriorate with time and worn contacts should be replaced during regular maintenance checks.