

Power Factor Controllers

Application

The main part of central and group power factor correction in systems with variable load is the power factor controller. Appropriate power factor controller and design of correction system are able to reduce effectively reactive power cost. Nowadays, when four-quadrant energy meters are used, the right power factor controller is essential to define the quality of power factor correction system and effectiveness of reduction inductive and capacitive power cost.

Power factor controllers BMR are fully four-quadrant controllers suitable for standard or fast and hybrid power factor correction systems.

Regulation method description

Device digitalizes measured phase voltage and phase current in one or three phases. From those values device calculates power factor, effective values of voltage and current, apparent power, reactive power. On the basis of allowed reactive power, which is set as a requested power factor value in the controller, device counts requested compensation power. In accordance with its size and sign, controller connects or disconnects appropriate capacitor stages.

Within the particular power levels controller uses advanced method of circular switching. Capacitor stage which has been disconnected for the the longest period of time is the next one to be switched on by the controller. The procedure of switching on is the same for every following step as well. Optimal regulation process is achieved due to one regulation loop with minimum number of switched stages.

Controller is equipped with an alarm output. Alarm can be activated by different parameters such as undervoltage, overvoltage, undercurrent, overcurrent, power factor level, harmonics level, temperature and by number of contactor operations.

APFR

APFR system is the technology, developed by BMR, for precise and effective power factor correction. BMR power factor controllers quantify power factor in the same way as energy meter. This method assures that power factor controller reacts smartly on load changes taking into account the value of load and cosφ. Thanks to APFR system, power factor controller reduces number of switching operations, together with precisely kept requested average power factor.

Ranges of power factor controllers

Type	Total number of outputs	Fast transistor outputs	Measuring and supply voltage 400 VAC*	Measuring and supply voltage 230 VAC	Auxiliary supply 230V AC measurement 100 - 690V	Multifunction graphic OLED display	MV application ready	2 nd tariff input	Independent alarm output	Last stage alarm output	Current measurement in every phase	PF correction according energy meter impulses	DIN rail variant	RS485 Interface**
Standard LV and MV compensation	FCR 05	6	○	●						●			○	○
	FCR 07	7	○	●						●			○	○
	FCR 06	6		●	○		●	●	●		○			○
	FCR 12	12		●	○		●	●	●		○			○
	GCR 06	6		●	○	●	●	●	●					○
	GCR 12	12		●	○	●	●	●	●					○
	ICR 06	6		●	○	●	●	●	●			●		○
	ICR 12	12		●	○	●	●	●	●			●		○
Fast and hybrid compensation	FCR 06_xx	6	1 - 6	●	○			●	●		○			○
	FCR 12_xx	12	1 - 12	●	○			●	●		○			○
	GCR 06_xx	6	1 - 6	●	○	●		●	●					○
	GCR 12_xx	12	1 - 12	●	○	●		●	●					○
	FCR 123	12	12	●				●	●		●			○

● default feature ○ optional feature

* Other voltages on request, except controllers FCR05 and FCR07.

** RS485 interface is not recommended for fast and hybrid controllers due to switching speed limitation.

Controller GCR06 and GCR12

Description

New and innovative power factor controller GCR is opening another page of power factor correction. It combines features and experiences of FCR controller and multifunction monitoring device features. Thanks to fully graphic OLED (organic light emitting diode) display there is all information shown on it at the same time.

GCR controllers are ideal for LV and MV application and thanks to its design also for fast and hybrid thyristor power factor compensations.

Main characteristics

- monitoring of U, I, f, P, Q, S, cosφ, THDU, THDI, odd harmonics from 1st - 19th of voltage and current, temperature
- APFR regulation method
- automatic or manual configuration of measuring circuit connection
- automatic or manual detection of connected capacitor stages
- current transformer input ..1A and ..5A
- thyristor switcher control speed of 25 operations per second
- second tariff activation by external input or current direction
- built-in temperature sensor for ventilator and cabinet control
- adjustable temperature for ventilator control and cabinet disconnection
- four preset half-periods of APFR regulation 15, 30, 45, 60 minutes
- ready for fast and hybrid thyristor dynamic compensation
- ready for applications with decompensation reactors
- multifunction graphic OLED display
- monitoring of switching operation number
- memory for minimums and maximums of measured parameters
- independent setting of discharging and min. operation time for each stage
- programmable alarms and alarm output

Adjustable APFR

For better adaptation of regulation method to wide range of applications and local power utility specification there is possibility to change half period of average power factor summation.

Ventilator temperature setting

Optional alarm for ventilator control by independent alarm output can be enabled. Moreover the temperature for ventilator activation is adjustable in the range 35 - 50°C.

RS485 interface

Power factor controllers GCR 06 and GCR 12 can be optionally equipped with RS485 communication interface with communication protocol Modbus RTU.

Optional 2nd tariff activation

Second tariff of requested cosφ can be activated by external signal or by current direction for application where consumption and distribution is present while distribution has defined different level of cosφ.

Technical features

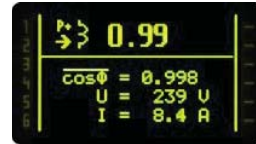
Power supply and measuring voltage	400 VAC (+10%,-15%)
System frequency	50 Hz / 60 Hz
Power consumption	max. 10 VA
Number of outputs	6 (GCR06) or 12 (GCR12)
Current range	10 mA ... 5,3 A
Accuracy	±1 mA (class 2)
Switching power of relay output	250 VAC / 5A
Switching power of transistor output	24 VDC or 230 VAC / 100 mA
APFR alternation setting	15, 30, 45, 60 min.
Range of requested power factor	0,8 inductive ... 0,8 capacitive

Stage reconnection delay	0 ... 900 s
Stage disconnection delay	0 ... 900 s
Stage power setting	0 ... 999,9 kVAr
Communication interface	RS485 (Modbus RTU)
Working temperature	-25°C ... +70°C
Dimensions	144 x 144 x 55 mm
Site depth	55 mm
Panel cutout	138 x 138 mm
Weight	1 kg
Protection degree	IP20 rear, IP54 front panel



OLED graphic display

Bright and fully graphic OLED display gives next dimension to power factor controller. It provides power monitoring functions so there is no need for additional monitoring instrument or analogue meter.



Variants of GCR06 and GCR12

Controllers are available in several variants like for example supply or measuring voltage, communication interface and three-phase current measurement.

Example of variant code: GCR06V230RS

GCR 06 controller with 230VAC supply voltage, 100 - 690V measuring voltage and RS485 interface.

Variant	Description
V100	Supply and measuring voltage 100 VAC
V230	Supply voltage 230 VAC, measuring voltage 100 - 690VAC
RS	Communication interface RS485

Controller FCR06 and FCR12

Device description

Power factor controllers FCR 06 and FCR 12 are well proved controllers for LV and MV application as well as for fast and hybrid thyristor power factor correction systems. In the new generation they are bringing advanced functionality, improved automatic detection of measuring circuits connection and communication interface for including the controller into energy management system.

New FCR 06 and FCR 12 are also faster now by switching the thyristor modules in fast compensation with speed of 25 operation per second.

Main characteristics

- monitoring of U, I, f, P, Q, S, cosφ, THDU, THDI, odd harmonics from 1st - 19th of voltage and current, temperature
- APFR regulation method
- automatic or manual configuration of measuring circuit connection
- automatic or manual detection of connected capacitor stages
- current transformer input ..1A and ../5A
- thyristor switcher controll speed of 25 operations per second
- second tariff activation by external input
- builtin temperature sensor for ventilator and cabinet control
- adjustable temperature for cabinet disconnection
- ready for fast and hybrid thyristor compensation
- ready for applications with decompensation reactors
- monitoring of switching operation number
- memory for minimums and maximums of measured parameters
- independent setting of discharging and min. operation time for each stage
- programmable alarms and alarm output

Symbol menu

Every parameter in monitoring and service menu is introduced by three or four character symbol. Symbols are logic and assure user friendly and easy understanding of all parameters and measured values shown on the segment display.

Three-phase current measurement

In unbalanced systems it is necessary to measure current in each phase and calculate needed compensation power from real three-phase measurement. FCR 06 and FCR 12 controllers are available in the variant T - three-phase with three independent current inputs.

Preset temperature control

Controller has preset temperature alarm to behave in two levels. First level starts fan for cabinet ventilation at 35°C with hysteresis 5°C. Second level disconnects all compensation stages and gives alarm event on display at 50°C with hysteresis 10°C.

Technical features

Power supply and measuring voltage	400 VAC (+10%,-15%)
System frequency	50 Hz / 60 Hz
Power consumption	max. 10 VA
Number of outputs	6 (FCR06) or 12 (FCR12)
Current range	10 mA ... 5,3 A
Accuracy	±1 mA (class 2)
Switching power of relay output	250 VAC / 5A
Switching power of transistor output	24 VDC or 230 VAC / 100 mA
Range of requested cosφ	0,8 _{inductive} ... 0,8 _{capacitive}
Switching speed of fast outputs	25 operations / 1 second



RS485 interface

Power factor controllers FCR 06 and FCR 12 can be optionally equipped by RS485 communication interface with communication protocol Modbus RTU.

Dichromatic LED indication

Every controller stage operation status is indicated by dichromatic LED. Different colour and logic signalization identify the operation and setting of every stage.

Second tariff of cosφ

Power factor controller has an input for second tariff of cosφ. Value of second tariff cosφ can be defined in the controller service menu. Applying the signal on input activates second tariff of cosφ.

Variants of FCR06 and FCR12

Controllers are available in several variants like for example supply or measuring voltage, communication interface and three-phase current measurement.

Example of variant code: FCR06TRS

FCR 06 controller with three-phase current measurement and RS485 interface.

Variant	Description
V100	Supply and measuring voltage 100 VAC
V230	Supply voltage 230 VAC, measuring voltage 100 - 690VAC
RS	Communication interface RS485
T	Current measurement phases L1, L2, L3

Stage reconnection delay	0 ... 900 s
Stage disconnection delay	0 ... 900 s
Stage power setting	0 ... 999,9 kVAR
Communication interface	RS485 (Modbus RTU)
Working temperature	-40°C ... +80°C
Front panel / cutout dimensions	144 x 144 / 138 x 138 mm
Site depth	55 mm
Panel cutout	138 x 138 mm
Weight	1 kg
Protection degree	IP20 rear, IP54 front panel

Controller FCR05 and FCR07

Device description

Power factor controllers FCR 05 (6 outputs) and FCR 07 (7 outputs) are designed for usage at standard and basic LV power factor correction applications operated by mechanical contactors. Although they are called basic range, those power factor controllers offer four quadrant measurement and regulation, APFR algorithm, high sensitivity, perfect accuracy and monitoring features.

New version of FCR 05 and FCR 07 controllers brings improved automatic detection of measuring circuits and detection of connected capacitors stages.

Range of FCR 05 and FCR 07 controllers was enlarged by version with 400 VAC power supply and measuring voltage for applications without neutral wire.



Main characteristics

- monitoring of U, I, P, Q, S, cosφ, THDU, THDI, odd harmonics from 1st - 19th of voltage and current
- APFR regulation method
- small design 97 x 97 mm for pannel mounting
- special type for DIN rail mounting
- variant for power supply phase voltage 230V or phase-phase voltage 400V
- automatic or manual configuration of measuring circuit connection
- automatic or manual detection of connected capacitor stages
- current transformer input ../1A and ../5A
- monitoring of switching operation number
- independent setting of discharging and min. operation time for each stage
- last stage output programmable for alarm purposes



DIN rail mounting type

Both types of basic power factor controllers FCR 05 and FCR 07 are available also in DIN rail mounting design. Displayed parameters, operation and technical features are the same as for panel mounting type. Dimension of controller in DIN rail design is 5 standard DIN modules.

RS485 interface

Power factor controllers FCR 05 and FCR 07 can be on request delivered with RS485 communication interface and communication protocol Modbus RTU.

Last stage alarm output

Last stage of power factor controller is normally working as standard stage but it can be removed from regulation algorithm and enabled for alarm purposes. Configuration of last stage to behave as an alarm output is easy done in setup menu.

Harmonics measurement

Controllers FCR 05 and FCR 07 offer wide range of monitoring features which were enlarged by THDU, THDI and also particular odd harmonics of voltage and current up to 19th harmonics.

Variants of FCR05 and FCR07

Controllers are available in several variants like for example supply and measuring voltage 230VAC or 400 VAC, communication interface and DIN rail mounting.

Example of variant code: FCR05V400DLRS

FCR 05 controller with 400VAC supply measuring voltage, RS485 interface in design for DIN rail mounting.

Variant	Description
V400	Supply and measuring voltage 400VAC
DL	DIN rail mounting
RS	RS485 interface with Modbus RTU communication protocol

Technical features

Power supply and measuring voltage	230 / 400 VAC (+10%, -15%)
System frequency	50 Hz / 60 Hz
Power consumption	max. 3,2 VA
Number of outputs	6 (FCR05) or 7 (FCR07)
Current range	10 mA ... 5,3 A
Accuracy	±10 mA (class 5)
Switching power of relay output	250 VAC / 5A
Range of requested power factor	0,8 _{inductive} ... 0,8 _{capacitive}
Stage reconnection delay	5 ... 900 s
Stage disconnection delay	5 ... 900 s

Stage power setting	0 ... 99,9 kVAr
System connection detection	manual / automatic
Alarm output	programmable last stage
Communication interface	RS485 (Modbus RTU)
Working temperature	-40°C ... +80°C
Front panel dimensions	97 x 97 mm
Cutout dimensions	91 x 91 mm
Site depth	50 mm
Weight	0,5 kg
Protection degree	IP20 rear, IP54 front panel

Controller ICR06 and ICR12

Description

Impulse power factor controller ICR is designed for usage in applications where load variation between working times is too high to be measured by measuring current transformer. ICR controller is also solution for unbalanced systems where there is possibility to take energy impulses directly from utility static energy meter.

Controller ICR is reading, directly or via optical separation unit, pulses from static energy meter. Base on the pulse weight and time distance between particular pulses, controller calculates active and reactive powers. At low signal frequency of measuring pulses, controller corrects power values depending on running time.

ICR controller has full graphic OLED display which provides possibility to show several information at the same moment.



Main characteristics

- monitoring of P, Q, S, $\cos\phi$, temperature
- APFR regulation method
- built-in temperature sensor for ventilator and cabinet control
- adjustable temperature for ventilator control and cabinet disconnection
- four preset half-periods of APFR regulation 15, 30, 45, 60 minutes
- ready for applications with decompensation reactors
- multifunction graphic OLED display
- monitoring of switching operation number
- memory for minimums and maximums of measured parameters
- independent setting of discharging and min. operation time for each stage
- galvanic insulated pulse inputs

RS485 interface

Power factor controllers ICR 06 and ICR 12 can be on request delivered with RS485 communication interface and communication protocol Modbus RTU.

Variants of ICR06 and ICR12

Controller ICR is available in several variants with choices like different number of outputs and communication interface for example.

Example of variant code: ICR06RS

ICR 06 controller with RS485 interface.

Variant	Description
RS	Communication interface RS485

OLED graphic display

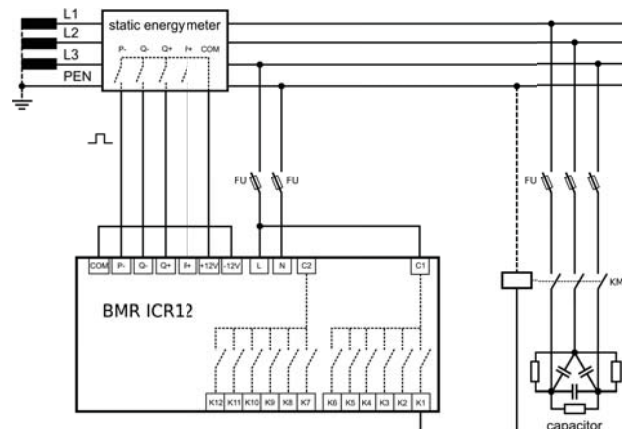
Bright and fully graphic OLED display gives next dimension to power factor controller. It provides power monitoring functions so there is no need for additional monitoring instrument or analogue meter.



Internal power supply

Controller has built-in 12V DC power supply for supplying the energy meter pulse outputs. Internal power supply is fully metalically separated from the controller.

Schematic connection diagram



Technical features

Supply voltage	230 VAC (+10%, -15%)	Stage power setting	0 ... 999,9 kVAr
System frequency	50 Hz / 60 Hz	Connection and stage setting	manual
Power consumption	max. 10 VA	Internal power supply for pulse inputs	+/- 12 VDC
Number of outputs	6 (ICR06) or 12 (ICR12)	Communication interface	RS485
Switching power of relay output	250 VAC / 5A	Communication protocol	Modbus RTU
Range of requested $\cos\phi$	0,8 _{inductive} ... 0,8 _{capacitive}	Working temperature	-25°C ... +70°C
Stage reconnection delay	0 ... 900 s	Front panel dimensions	144 x 144 mm
Stage disconnection delay	0 ... 900 s	Panel cutout	138 x 138 mm
Pulse inputs S0	+P, -P, +Q, -Q, COM terminal	Site depth	55 mm
Maximum frequency of input pulses	10 Hz	Weight	1 kg
Minimum pulse length	50 ms	Protection degree	IP20 rear, IP54 front panel

Thyristor Switching Modules

Introduction

Contact-less thyristor switching modules CTU are designed for usage in applications where load changes are very fast (welding plants, stamping plants, lifts, cranes, controlled drives, etc.) and therefore the standard contactor operated stages are not possible to compensate reactive power to requested power factor.

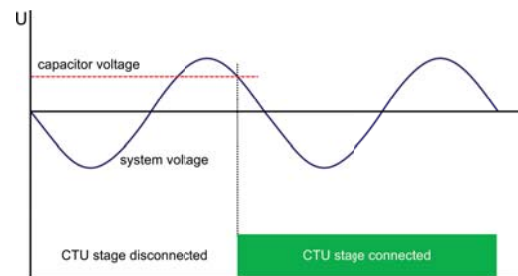
Thyristor switching modules CTU 02 and CTU 03 are designed for switching of capacitor stages in fast dynamic PFC application. Design and construction determine their usage in three-phase systems with needs of fast reaction on the load changes. Together with power factor controllers FCR or GCR range they can operate with the maximum speed of 25 operations per second.

CTU 33 thyristor switching modules are determined for switching of single-phase capacitors in application with outstanding unbalance controlled by FCR 123 controller. CTU 33 allows independent control of single-phase capacitors connected between phases to compensate reactive power and also to balance the system.

Operation principle

Thyristor switching modules CTU are constructed for switching of L-C circuits with prevailing capacitive part (detuned compensation stages).

Advantage of CTU modules comparing to the classic contactor switching of capacitor stages is immediate capacitor connection without its previous discharging. This is possible thanks to special construction which assures that capacitor is ready for another connection immediately after its previous disconnection. Switching of capacitor is realized at the moment when the difference between the capacitor voltage and system voltage before the switching element is equal to zero.



From this feature comes another important advantage and this is significant current surges reduction. Current surges are causing disturbances which can affect proper running of electronic devices and can severely damage and even destroy them. Further more, lifetime of capacitors is increased, because only nominal current flows through the circuit. For the protection of power switching element against current peaks (di/dt) it is necessary to connect in the series with module also inductor 12 μH or higher.

Ranges of thyristor switching modules

Type	Thyristor switchers in all three-phases	Solution for switching of three-phase capacitors	Three-phase capacitor power [kVAR]	3 single-phase capacitors power [kVAR]	Control voltage 230 VAC	Control voltage 24 VDC	System voltage 400 VAC 50 Hz (+10%, -15%)*	Rated phase current [A]	Forced ventilation	Dimensions [mm]	Weight [kg]	
Thyristor switching modules for three-phase fast and hybrid PFC	CTU 02-400-10	•	•	10	○	•	•	15		200x120x155	3,0	
	CTU 02-400-30	•	•	30	○	•	•	42,5		200x120x225	5,0	
	CTU 02-400-50	•	•	50	○	•	•	75	•	238x120x225	5,5	
	CTU 02-400-72	•	•	72	○	•	•	105	•	238x120x225	6,0	
	CTU 03-400-10	•		10	18	○	•	•	15		200x120x155	3,0
	CTU 03-400-30	•		30	51	○	•	•	42,5		200x120x225	5,0
	CTU 03-400-50	•		50	90	○	•	•	75	•	238x120x225	5,5
	CTU 03-400-72	•		72	126	○	•	•	105	•	238x120x225	6,0
Thyristor switching modules for fast phase PFC	CTU 33-400-06	•			18		•	•	15		200x120x155	3,0
	CTU 33-400-17	•			51		•	•	42,5		200x120x225	5,0
	CTU 33-400-30	•			90		•	•	75	•	238x120x225	5,5
	CTU 33-400-42	•			126		•	•	105	•	238x120x225	6,0

• Default feature ○ Optional feature

* Other voltages higher than 400 VAC on the request.

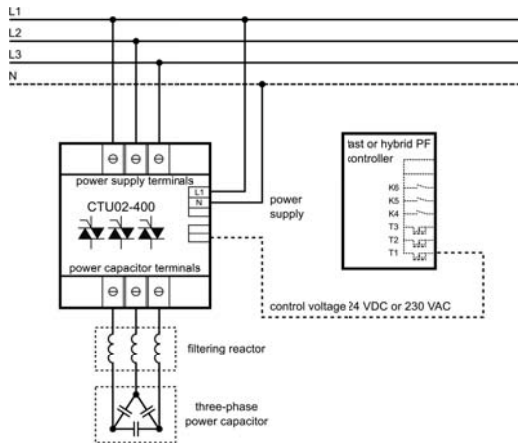
Switching modules CTU02 and CTU03 / 33

CTU02 module for three-phase capacitors

Thyristor switching modules CTU 02 is newly designed for maximum switching speed of three-phase capacitors. Special construction of the module solves voltage discharging problem so the three-phase capacitor can be switched again immediately after disconnection without prior discharging. Switching is realized within 10 ms from receiving the signal from PF controller.

Thanks to this feature and together with controllers FCR range or GCR range is possible to assure operation speed up to 25 operations per 1 second.

Design and construction of PFC cabinet based on thyristor switching module CTU 02 follows the same rules as contactor compensation since the standard three-phase capacitors and reactors are used.

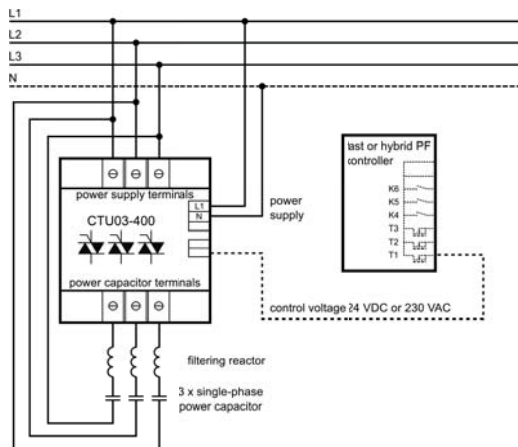


CTU03 / CTU33 module for single-phase capacitors

Range of thyristor switching modules CTU 03 is primarily designed for switching of single-phase capacitors connected to delta. Advantage of CTU 03 modules is higher maximum capacitive power that can operate. The maximum power is 126 kVAr per module CTU 03-400-72.

Variant CTU 33 is equipped with three independent control inputs for operation by controller FCR 123. Construction is the same as CTU 03 module.

Switching is realized within 10 ms from receiving the signal from power factor controller. This feature assures switching speed up to 25 operations per 1 second.



Technical features

System voltage	400 VAC (+10%, -15%)	Power dissipation	max 300 W
System frequency	50 Hz / 60 Hz	Fan power consumption	3 VA
Auxiliary power supply	230 VAC 50 Hz / 2 VA	Working temperature	-25°C ... +45°C
Control voltage	24 VDC or 230 VAC 50 Hz	Conductor size	35 mm ²
Power consumption of control input	0,24 VA	Supply voltage indication	green LED
Reverse blocking voltage	1600 V	Operating status indication	red LED in each phase
Temperature protection	internal +80°C	Mounting position	any
Type of switched load	R, C, RLC	Protection degree	IP00