Installation and Adjustment guide

THE MOTOR PROTECTION

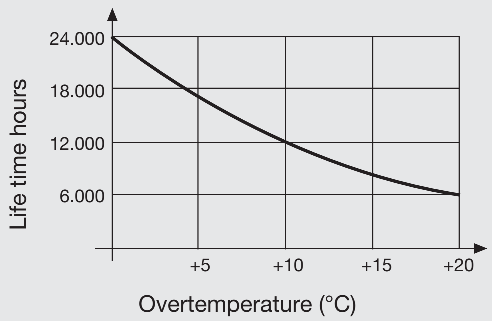
The electric motor is one of the most important operating devices in industry. Many times the shutdown of an industrial process is caused by a simple motor. High-cost production runs and valuable machinery can become paralysed at great cost, even more than the cost of rewinding the motor.

Experience shows that motor protection continues to be a problem, based on the number of breakdowns occuring every day.

Over 60% of failures are caused by overheating of the motor windings. These can be detected, and prevented, by measuring and analysing the current being absorbed by the motor, or by controlling temperature limits of the winding. The major causes are as follows:

- Overloads
- Locked rotor
- Over and undervoltage
- Phase imbalance or phase loss
- Long and heavy start-ups
- Excessive operating cycles
- Heating from non-electrical causes
- Inadequate motor ventilation
- High room temperature
- Insulation failure

The following diagram shows the dramatic decrease suffered in the electric life of a motor due to the excessive heat of the motor windings (Montsinger's rule).



As one can see, a 10ºC increase in temperature reduces the useful life of the motor by half.

The most reliable protection options in common use are:

- Fuses or circuit breakers for short-circuit protection.
- Electronic motor protection relays with thermal memory.
- Contactors for motor control.

FANOX RELAYS

Our R+D Division has allowed FANOX to develop a wide range of easy-to-install and operate electronic relays, at truly competitive prices, which will save downtime and money.

FANOX motor protection relays work with the current measured in real time. The current, which is read by three current transformers built into the relays, is electronically processed and used as a model of the thermal image of the motor, and is continously compared to the values set on the relay.

The three power supply cables to the motor are not directly connected to the relay, but pass through its corresponding CT holes.

This provides motor protection against:

- Overload: The relay creates a model of the thermal image of the motor during its heating and cooling cycles. In this way, in overload conditions, the relay will take into consideration previous operating conditions of the motor, and will trip quicker if the relay has detected previous occasions of overload. This thermal memory is independent of the auxiliary voltage supply of the relay and is stored even when this voltage is cut off or disconnected. The different trip curves available for selection in the relays allow for precise adjustment to any kind of motor start-up or work ing cycle.
- Phase imbalance and phase loss: even if the motor is running below its full load current.
- Incorrect phase sequence detection is highly important when the correct phase sequence is critical as in compressors, pumps, fans and other applications (GL, P, PF).
- Underload by undercurrent: protects the motor against working without load, very important in pumps (P and PS).
- Protection against no-load operation: underload protection by cos φ has been incorporated so that the relay differentiates precisely between very low load and no-load operations, and drops out in the latter case (PF).

In addition, when the relay is connected to thermistor sensors (PTC), it protects the motor against electrical and non-electrical overheating (GL, G).

A visual display of the cause allows maintenance personnel to identify and immediately act on the underlying causes. The use of the OD display makes this operation much easier.

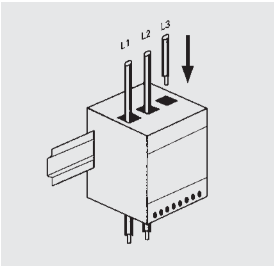
FANOX relays guarantee ideal protection for motors (pumps, compressors, fans, etc).

Installation and Adjustment guide

1 INSTALLATION

General

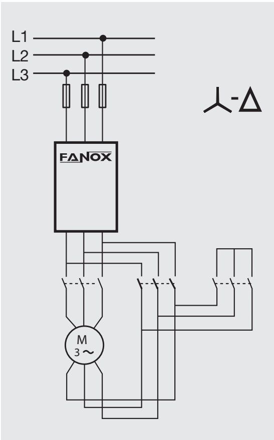
For correct installation and operation of Fanox relays, it is important to consider the following:



- After being fixed to the DIN rail, the cables for the three phases should be passed through the holes in the relay.

The maximum section of 700V insulated wires that can pass through the holes are:

C	16 mm^2
GL, P, PF, G, GEN	35 mm^2
GL 200	70 mm^2



- Assembly attached to other components: it is recommended to separate the relays of other units or items that could cause strong magnetic fields, such as power or control transformers, contactors, frequency variators or high current busbars.

- In star-delta starting, the relay or the current transformers must be installed between the fuses or circuit breaker and the contactor.

- Relays used in combination with frequency inverters:

a) Not to be used with frequency inverters and fuel generators:

- GL relays if the protection against phase sequence selector is in the “ON” position.
- P and PF relays.

b) The following can be used with frequency inverters and fuel generators:

- GL relays if the protection against phase sequence selector is in the “OFF” position.
- C, G and PS16-R.

Never connect the relay or current transformers of the auxiliary power supply to the inverter output.

- Connection between the PTC sensors and the relay (GL and G). For PTC connection lengths over 100 m or when the influence of high frequency transient voltages is expected, it is adviseable to use screened cable and connect the screen to terminal T1.

Note: every relay comes with an instruction manual providing information on its correct installation and setup. Please follow this for guidance.

2 SETUP PROCEDURE

Correct order of steps during installation:

	C	GL	G	PS	P	PF	GEN
2.1 Select the trip class / tripping time	1st	1st	1st		1st	1st	1st
2.2 Adjust the I_B current of the relay	2nd	2nd	2nd	1st	2nd	2nd	2nd
2.3 Adjust the cos φ value (underload)						3rd	
2.3 Adjust the cos φ trip delay						4th	
2.4 Adjust the undercurrent level $I<$ (underload)				2nd	3rd		
2.5 Select ON /OFF incorrect phase sequence		3rd					
2.6 Reset	3rd	4th	3rd	3rd	4th	5th	3rd

After installation and setup and before starting up the motor, make sure the motor is in a cold state. This will ensure that both the relay and motor, will operate with the same thermal memory (cold condition).

2.1 Trip class / tripping time (IEC 947-4-1). Relays C, GL, P, PF, G and GEN

The different trip classes / tripping times enable the user to select the overload protection according to the various motor applications in either short or long start-ups and for different generator uses.

The class number or the tripping time refers to the maximum approximate time in seconds allowed for the direct start of the motor from a cold condition.

To select the trip class or tripping time ($t_{6 \times I_B}$) use the corresponding dip switches. The recommended values are listed in the following tables.

Motor with direct start-up

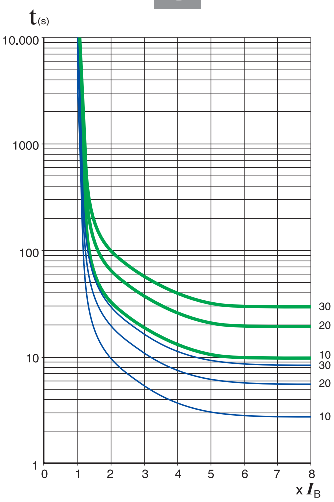
Start time (s) t_s	Trip classes												Trip time
	Models												Model
	C9	C21	C45	GL16	GL40	GL90	GL200	P19	P44	P90	PF16-R	PF47-R	G17
1	10	10	10	10	10	10	10	5	5	5	10	10	4
2	10	10	10	10	10	10	10	10	10	10	10	10	6
3	10	20	20	15	15	15	15	10	10	10	20	20	10
4	20	20	20	20	20	20	20	15	15	15	20	20	12
5	20	30	30	20	20	25	25	15	15	15	20	20	16
6	20	30	30	25	25	25	25				30	30	18
7	30	30	30	30	30	30	30				30	30	22
8	30	30	30	30	30	35	35				30	30	24
9	30	30	30	35	35	35	35				30	30	28
10	30	30	30	35	35	35	35				30	30	30

Motor with star-delta start

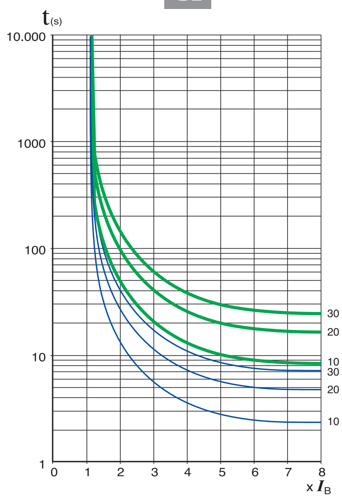
⅄-Δ Start time (s) t_s	Trip classes												Trip time
	Models												Model
	C9	C21	C45	GL16	GL40	GL90	GL200	P19	P44	P90	PF16-R	PF47-R	G17
5	10	10	10	10	10	10	10	5	5	5	10	10	4
10	10	10	10	10	10	10	10	10	10	10	10	10	6
15	20	20	20	10	15	15	15	10	10	10	10	20	8
20	20	20	30	20	20	20	20	15	15	15	20	20	10
25	30	30	30	20	20	25	25	15	15	15	20	20	14
30	30	30	30	20	25	30	30				20	30	16
35	30	30	30	20	30	35	35				20	30	18
40	30	30	30	25	30	35	35				30	30	20

Average trip curves (IEC 947-4-1)

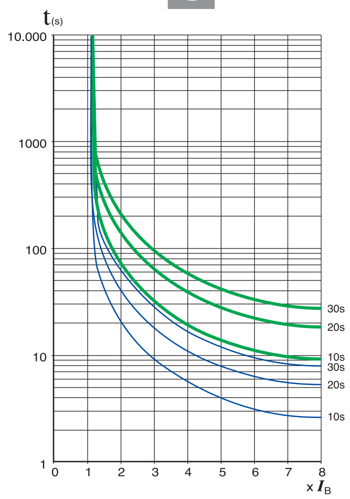
C



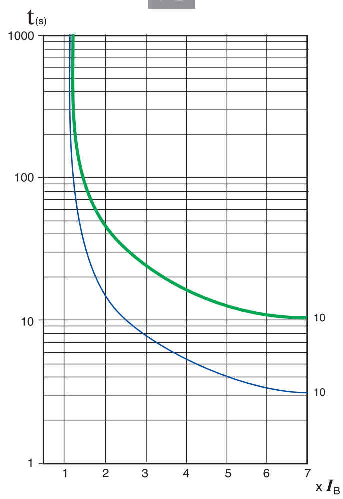
GL



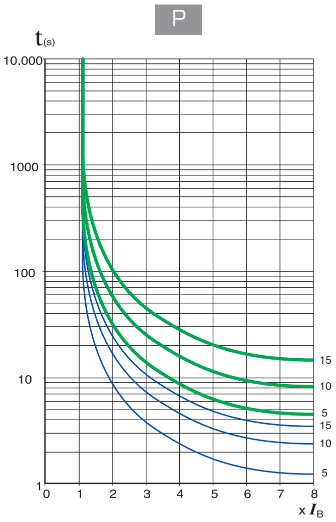
G



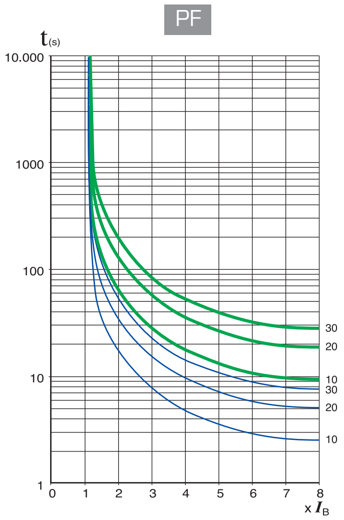
PS



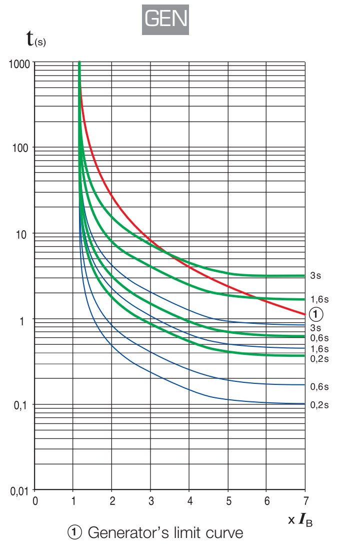
P



PF



GEN



① Generator's limit curve

Cold curve: represents the performance of the relay without any previous current flow, first start.

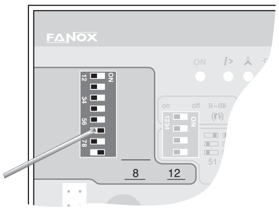
Warm curve: the tripping times decrease as the current flows, and is adapted to the motor heating condition based on the thermal memory. The warm condition (IEC-255) is reached after a current of 0.9 x I_N (motor rated current) flows during approximately 2 hours.

Installation and Adjustment guide

2.2 Current setting I_B.

Relays C, GL, P, PF, G, BG and GEN

Adjust the current I_B on the corresponding dipswitches (full load current). When setting the current take into account that the base current of the relay always remains added to the current selected with the dipswitches in "ON" position (to the right). The total addition is the set current I_B.
Overload tripping current from 1,1 x I_B



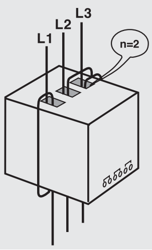
e.g.: relay GL16

I_B=8+4 =12 A

a) For motor or generator rated currents (I_N) within the range of the relay, the setting I_B must be equal to the I_N of the motor or generator.

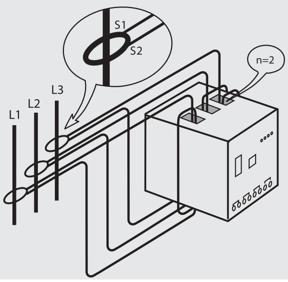
$$I_B = I_N$$

b) For motor rated currents below the range of the relay, the setting I_B must be equal to the rated current of the motor I_N multiplied by the number of times that the conductors have been passed through the relay holes.



$$I_B = I_N \times n$$

c) For motor or generator rated currents (I_N) above the range of the relay, use three current transformers .../5 in combination with the C9, GL16, P19, PF16-R, G17, BG17 or GEN10 according to application.



$$I_B = \frac{I_N \text{ motor}}{I_N \text{ trafo}} \times 5 \times n$$

always n ≥ 2

With current transformers it is always a must to pass the conductors 2 times or more through the holes of the relay.

PS relay

This adjustment is to be made according to the nominal current of the motor I_N indicated in its characteristics plate. The value to be set I_B is the same as I_N. The relay trips with overloads above 1,1 x IB I_B.

$$I_B = I_N$$

2.3 Underload by cos φ. PF.

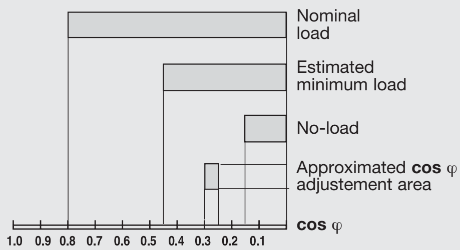
The cos φ underload trip level is set by means of a potentiometer with settings from 0,15 to 1,0.

Select this value taking into consideration the no-load motor cos φ and that corresponding to the estimated minimum operating load. Choose an intermediate value between these two cos φ levels and set it in the relay.

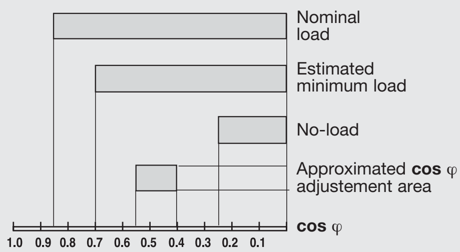
Select the underload trip delay from 5 to 45 seconds using the 3 corresponding dipswitches (trip delay).

For your guidance you can find two practical examples below.

a) A very oversized motor for its application. The cos φ of the motor is 0,15 when working without load.



b) A slightly oversized motor for its application. The cos φ of the motor is 0,25 when working without load.



If the above mentioned cos φ values are unknown, the underload trip setting can be made in the following way:

1. Set the underload trip delay to zero by moving the three dipswitches to the left (trip delay).
2. Using the potentiometer (cos φ setting), set the cos φ value to the minimum: 0,15.
3. Set the reset time to the minimum value using the potentiometer (cos φ reset time).
4. Start up the motor and run it with the minimum estimated load.
5. Slowly turn the cos φ potentiometer clockwise until the relay trips and the cos φ LED lights up.
6. Turn the cos φ potentiometer anticlockwise until the cos φ is set at approximately 30% less than the previous value (point 5).
7. Set the underload trip delay using the 3 corresponding dip switches. Set the reset time using the adequate potentiometer.

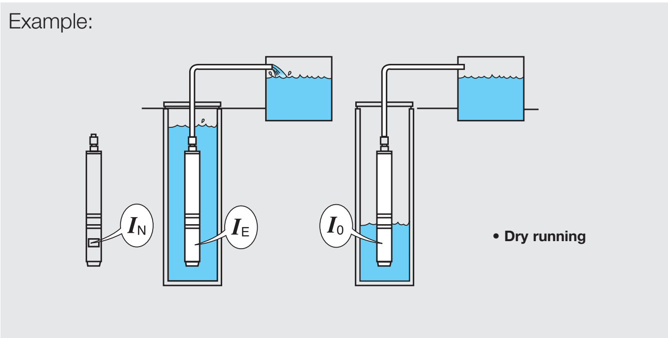
2.4 Undercurrent.

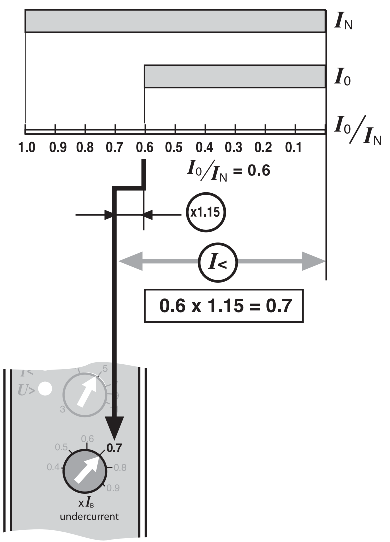
Single phase relay PS

The setting of the underload trip level is made using a potentiometer in wich a factor between 0,4 and 0,9 is to be chosen. By multiplying this factor by the adjusted I_B we obtain a current value under which the relay will trip and disconnect the motor. The trip is delayed by 5 seconds.

a) If the value of the I_B of the motor without load is known:

- To avoid unwanted trips it is recommended to adjust the value 15% above the I_B of the motor without load.



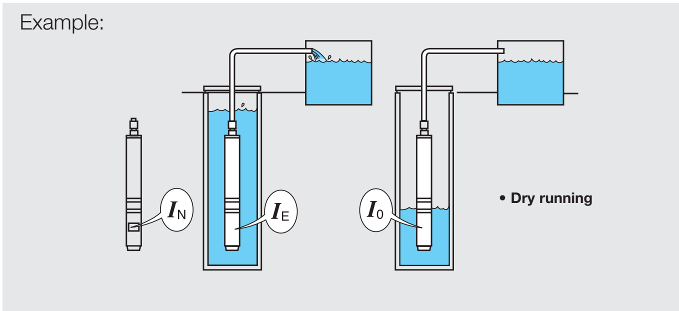


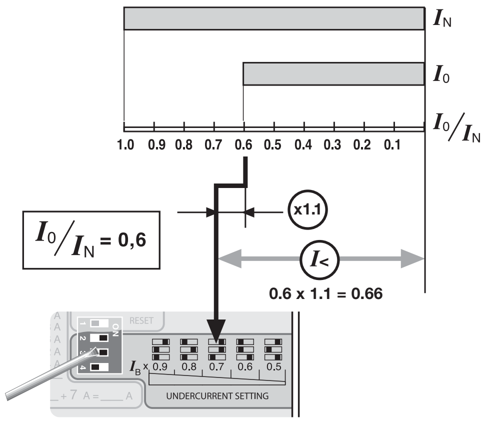
b) If the value of the I_B of the motor without load is unknown:

- If the pump is adequately dimensioned, the recommended value for this factor is 0,7. Adjust the potentiometer "undercurrent" to 0,7.
- If the pump is excessively dimensioned, and during its operation unwanted trips could occur, the underload adjusted factor should be reduced to approximately 0,6.

Three phase relay P

The undercurrent trip level in P relays is set using three dipswitches. To avoid nuisance trips, set this level to approximately 10% above the no-load motor current.





2.5 Phase sequence

Monitoring the current. GL and P relays

An incorrect phase sequence is detected by current sensing and it is only operative during the motor start-up. For correct detection the starting time must be longer than 0.2 s.

In GL relays the user can activate or desactivate this protection by means of a dipswitch. Should the right phase sequence be critical, move the dipswitch to the "ON" position. If this protection is not required, always leave it in the "OFF" position.

As this function is not compatible with the use of frequency inverters, where it is necessary to protect phase sequence in these installations, move the dipswitch to "OFF" and install the Fanox "S" model relay.

Monitoring the voltage. PF relays

An incorrect phase sequence is detected by voltage monitoring.
In the event that an incorrect phase sequence has been detected, the motor will not start-up since the relay has tripped because of previously detecting the wrong phase sequence.

2.6 Reset

Relays	manual	remote	autom.
C, GL, G, GEN	•	•	
P, PF	man	man	auto
PS		•	•

Manual reset:

	PS	P	PF	C	GL	G	GEN
I>	NO	<5 m	<7 m	<8 m	<8 m	<8 m	<1 m
I<	NO	2 s	-	-	-	-	-
cos φ	-	-	NO	-	-	-	-
⅄	-	2 s	2 s (*)	2 s	2 s	2 s	2 s
((·))	-	2 s	2 s (*)	2 s	2 s	-	-
U>	NO	-	-	-	-	-	-
+t°	-	-	-	-	1 s (*)	1 s (*)	-

(*) After recovering normal conditions.

Remote reset:

	PS	P	PF	C	GL	G	GEN
I>	<1 m	<1 m	<3 m	<3 m	<3 m	<3 m	<1 m
I<	10 s	10 s	-	-	-	-	-
cos φ	-	-	10 s	-	-	-	-
⅄	-	10 s	10 s	20 s	20 s	10 s	10 s
((·))	-	10 s	10 s	10 s	10 s	-	-
U>	NO	-	-	-	-	-	-
+t°	-	-	-	-	1 s (*)	1 s (*)	-

It is necessary to disconnect the auxiliar voltage more than 3 seconds after having waited the time indicated in the table.

Automatic reset:

	PS	P	PF	C	GL	G	GEN
I>	4 m	15 m	4 m	NO	NO	NO	NO
I< PS11-R	2-70 m	15 m	-	-	-	-	-
I< PS16-R	2-240 m						
cos φ	-	-	2-75m	-		-	
⅄	-	15 m	4 m (*)	NO	NO	NO	NO
((·))	-	15 m	4 m (*)	-	NO	-	-
U>	1 s (*)	-	-	-	-	-	-
+t°	-	-	-	-	NO	NO	-

(*) After recovering normal conditions.

3 OPERATING TEST. C, GL, P, PF, G and GEN

To perform the trip test for phase loss, the current which passes through the relay must be higher than 0.7 of the set current I_B .Under these conditions, push and hold the TEST button for three seconds, the relay will trip due to phase loss and the corresponding LED will light up.

4 APPLICATIONS

Industries

- OEM (Original Equipment Manufacturers)
- Chemical and petrochemical
- Quarries, gravel pits and cement factories
- Steelworks, iron and steel industry
- Automotive
- Utilities and electric generation
- Water treatment and distribution
- Mining
- Food industry, sugar industry
- Marine and shipbuilding
- Timber industry
- Elevation industry
- HVAC (Heat Ventilation Air Condition)

Installations

- Motor Control Centers (MCC)
- EEx e motors in explosive environments
- Submergible pumps, in service stations and water pumping, surface pumps, etc
- Compressors
- Fans, blowers and ventilators
- Industrial refrigeration and air conditioning
- Centrifuges
- Presses
- Cranes, elevators, escalators and lifting machinery
- Machine tool
- Conveyor belts
- Mills and mixers
- Generators and alternators.

5 NOMINAL CURRENT RATING OF ASYNCHRONOUS THREE-PHASE MOTORS

The current values listed in the following table correspond to the average ratings given by various manufacturers. In some cases, these may not coincide exactly with the ratings listed on the motor data plates.

kW			0,75	1,1	1,5	2,2	3	3,7	4	5,5	7,5	11	15	18,5	22	30	37	45	55	75	90	110
CV			1	1,5	2	3	4	5	5,5	7,5	10	15	20	25	30	40	50	60	75	100	125	150
I_N (A) Average values	MOTOR 4P	230 V 50Hz	3,5	5	6,5	9,5	11	–	15	22	28	42	54	68	80	104	130	154	192	248	312	360
		400 V 50Hz	2	2,5	3,5	5	6,5	–	8,5	11	15	22	29	35	42	57	69	81	100	131	162	195
		440 V 50Hz	1,7	2,4	3,2	4,5	6	–	8	10,5	14	20	27	33	39	52	64	76	91	120	147	178
		220/240 V 60Hz	3,2	4,4	6,2	8,5	10,5	–	14	20	26	38	50	63	74	98	122	146	180	233	290	345
		440/460 V 60Hz	1,5	2,2	3	4,3	5,5	–	7,5	10	13	19	25	31	37	49	61	73	90	116	144	173
	MOTOR 2P	400 V 50Hz	2,0	2,8	3,8	5,5	7	–	9,5	13	16,5	24	32	40	47	64	79	92	113	149	183	220
		440/460 V 60Hz	1,9	2,5	3,4	4,8	6	7,5	–	11	15	21	27	33	39	53	65	79	95	120	153	183

Selection guide

• Motor management system

MODELS	Adjustment range I_B (A)	MOTOR CHARACTERISTICS 400V		PROTECTION FUNCTIONS						
		HP	kW	$I<$	Phase loss	Phase sequence	Overtemperature	JAM	Locked rotor	I_g / I_o
PBM B1	0,8 - 6	0,33 - 3	0,25 - 2,2	•	•	•	•	•	•	•
PBM B5	4 - 25	3 - 15	2,2 - 11	•	•	•	•	•	•	•

• Protection relays

MODELS	Adjustment range I_B (A)	MOTOR CHARACTERISTICS 400V		PROTECTION FUNCTIONS						
		HP	kW	$I>$	$I<$	cos φ	Phase loss	Phase sequence	Overtemperature	$U>$
C 9	3 - 9,3	2 - 5,5	1,5 - 4	•			•			
C 21	9 - 21,6	7,5 - 12	5,5 - 9	•			•			
C 45	20 - 45,2	15 - 30	11 - 22	•			•			
GL 16	4 - 16,7	3 - 10	2,2 - 7,5	•			•	ON	•	
GL 40	15 - 40,5	10 - 25	7,5 - 18,5	•			•	ON	•	
GL 90	40 - 91	30 - 60	22 - 45	•			•	ON	•	
GL 200	60 - 200	50 - 150	37 - 110	•			•	ON	•	
PS 11-R	3 - 11	0,5 - 2	0,37 - 1,5	•	•					•
PS 16-R	3 - 16	0,5 - 3	0,37 - 2,2	•	•					•
P 19	7 - 19,6	4 - 10	3 - 7,5	•	•		•	•		
P 44	19 - 44,2	12,5 - 27,5	9,2 - 20	•	•		•	•		
P 90	40 - 90,4	27,5 - 55	20 - 40	•	•		•	•		
PF 16-R	4 - 16,6	3 - 10	2,2 - 7,5	•		•	•	•		
PF 47-R	16 - 47,5	10 - 30	7,5 - 22	•		•	•	•		
G 17	5 - 17,7	3 - 10	2,2 - 7,5	•			•		•	
GEN 10	4 - 10,3	-	-	•			•			

$I>$	$I<$	cos φ	(symbol)	(symbol)	$+t°$	$U>$ / $U<$	I_N	(symbol)	JAM	I_g / I_o
Overload	Undercurrent	Underload	Phase loss Phase imbalance	Phase sequence	Overtemperature	Overvoltage / Undervoltage	Loss of neutral	Locked rotor	JAM	Earth leakage: differential/homopolar