APPLICATION NOTE

Greenhouses application – lamp starting solution

MS132-...L lamp starters with AF16-...L/AF26-...L lamp contactors

Control cabinets in greenhouses are rarely ventilated, suffer from limited space and the electrical components are exposed to aggressive substances. ABB´s lamp starting solution for assimilation lighting makes sure that plants in greenhouse thrive underneath artificial light without disturbances.

The lamp starting combination was developed especially for control cabinets in greenhouses. The lamp starter combination consists of a MS132-...L lamp starter and an AF16-...L/AF26-...L lamp contactor. It can be mounted on a rail adapter which can be snapped on the busbar energy distribution system typically used in the setup of a greenhouse assimilation cabinet.

Because of the high ambient temperature and aggressive substances in the greenhouses atmosphere it is not common to ventilate the control cabinet. Due to this, the temperature in the control cabinet can be high, which is demanding for the electrical components. The lamp starter combination has a very low heat dissipation, contributing to an acceptable temperature in the cabinet. The temperature compensation of the lamp starter allows suitable overload protection depending on the ambient temperature of the control cabinet in the greenhouse.

10 % less heat generation

The new components guarantee a lower heat generation. The lamp starter generates 10 percent less heat and the contactor even 20 percent less. The lamp starter is able to automatically compensate the temperature up to 60 °C without influencing the characteristics. The MS132-20L is up to 100 kA short-circuit proof at 400V. This is useful as the control panels in a greenhouse complex are placed relatively close to the transformers, which require high short-circuit current protection.

Compact size

The lamp starter combination has a reduced size - the width of the rail adapter was reduced by 17 percent (9 mm) to 54 mm in comparison to the old solution. The lamp starter and the lamp contactor have a width of 45 mm. Because of this, there is an air cap of 4,5 mm on each side with the advantage of an optimized thermal distribution.

2CDC131107M0201 Rev. B 31.08.2017

Contents

Component table

For the design of the electrical system of each individual greenhouse, lamp starting solution and the approbriate control and protection, characteristical parameters are to be identified. Please refer to the questionnaire (2CDC131109D0201) supplied for this purpose. ABB will gladly support you in identifying the necesarry parameters.

Lamp starter

Type	Current range	Order code
MS132-16L	10-16 A	1SAM350100R1011
MS132-20L	16-20 A	1SAM350100R1013
MS132-25L	20-25 A	1SAM350100R1014

Lamp contactor

Type	Rated control circuit voltage	Order code
AF16-40-00L-13	100-250 V 50/60 HZ-DC	1SBL177281R1300
AF16-40-00L-14	250-500 V 50/60 HZ-DC	1SBL177281R1400
AF26-30-00L-13	100-250 V 50/60 HZ-DC	1SBL237081R1300
AF26-30-00L-14	250-500 V 50/60 HZ-DC	1SBL237081R1400

MCCB with residual current device

Type	Order code assembled device	Order coder
T4D 320 + RC222 + spread flags 4 pole	1SDX001755R1	
T4D 320 A switch 4 pole		1SDA054598R1
RC222/4 A RCD trip unit 4 pole		1SDA054954R1
Spread flags 3 pieces included rubber terminal separation		1SDA055004R1
T4D 320 + RC222 4 pole	1SDX002530R1	
T4D 320 A switch 4 pole		1SDA054598R1
RC222/4 A RCD trip unit 4 pole		1SDA054954R1

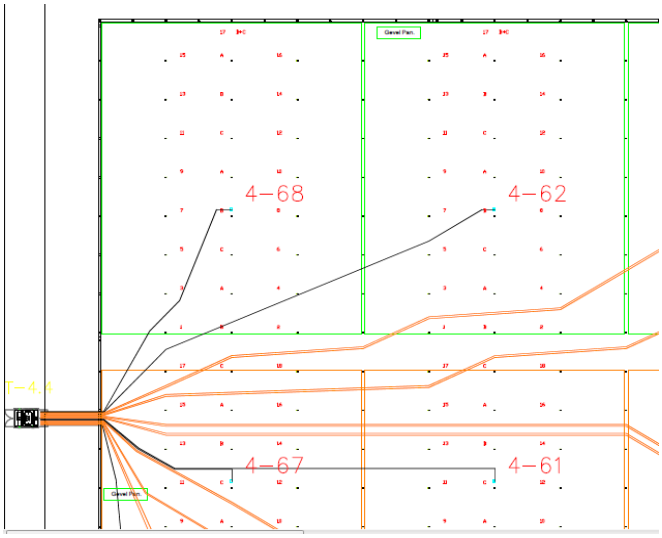
OT disconnect switch

Type	Order code
OT315E03WP	1SCA022809R8650

Loose parts

Type	Order code
Auxiliary contact 1 CO + 1 TRIP cabled 400 V AC	1SDA054912R1
Auxiliary contact 1 CO + 1 TRIP cabled 24 V DC	1SDA066075R1
Pushbutton for remote trip	1SFA619126R1076
Connection set 60 mm Wöhner rail included elevating piece	130193

Structure of greenhouses



Example of a greenhouse layout

Electrical energy is distributed from the transformer on the grid via cables to the panels. The lamps in the greenhouse are then supplied from the panel. The lamps are structured in groups within an individual panel.

By switching dedicated lighting groups, the light output in the greenhouse can be controlled to have 25, 50, 75 or 100 percent of the light intensity. Alternatively, if sufficient natural light is available in the greenhouse the lighting can be switched off. The nominal voltage of the system is typically 400 V AC, 3-phase without neutral.

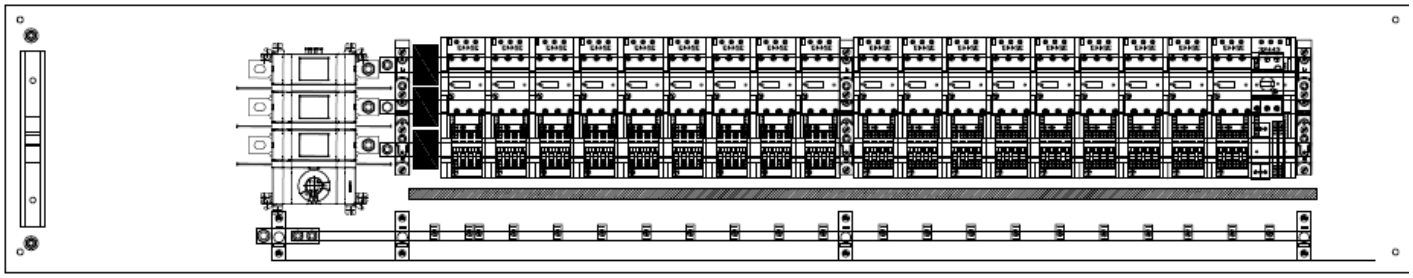
Panel for lamp starters

Example for green house panel location

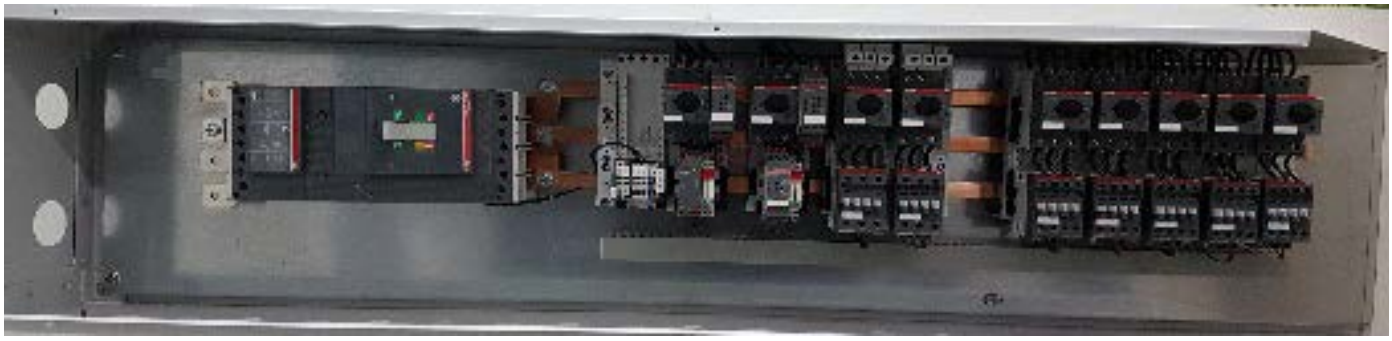
The typical dimensions of a standard panel are (L*W*H) 2000*380*210 mm, but they depend on the panel manufacturers and type of agricultural crop. The panels are designed and placed specifically to create as little shade over the crops in the greenhouse as possible.

The panels are min. IP44 protected due to the environmental conditions and airborne particles inside the greenhouses which could affect the electrical components. Another issue is potentially high levels of humidity. If the boards are not sealed airtight the insurance company will not provide coverage for the electrical installation. A typical arrangement of the components inside the panel is shown in figures three and four.

Actually, the European standard EN/IEC 60364-7-705 requires the use of residual current devices (RCDs) with 300 mA. This may be mandatory in certain countries and has to be implemented in a suitable design. For example, in the Netherlands the standard NEN1010:2015 art 705.411.1 requires the use of RCDs in the segment agriculture, horticulture and livestock farming.



A typical arrangement of the components with a disconnector



A typical arrangement of the components with SACE T4D 320 and RCD 222/4

The panel typically consists of:

- Enclosure, min. IP44
- Busbar system
- MCCB (T4D 320) with RCD (optional if required)
- Busbar adapters for protected lamp starter combinations, e.g. Wöhner
- Protected lamp starter combination, e.g. MS132-...L and AF...-L
- OT disconnect switch
- Control interface to management system to upstream assimilation lighting (management) system
- Lockable handle

Lamp starter combination description

The lamp starter combination controls the lamp loads and provide protection for the lamps and installations against short-circuit and overload.

The main functions are:

- Overload protection
- Short-circuit protection
- Phase loss sensitivity
- Disconnect function
- Switching lamp loads
- Adjustable current setting for overload protection
- Temperature compensation: -25 to +60 °C

Lamp starter combination

Lamp starter combination on a Wöhner busbar adapter

The typical lamp starter combination is designed with a MS132-…L protected lamp starter and an AF16-…L or AF26-…L lamp contactor for the control and protection of the lamps.

The three-pole protected starter MS132-…L has thermal tripping elements for overload protection and electromagnetic tripping elements for short-circuit protection. Furthermore, it is suitable for isolation of the installation from the supply. This is important e.g. for maintenance work. The protected starter has a setting scale in amperes, which allows the direct adjusting of the device to adapt to the individual lamp load structures.

The lamp starter with MS132-…L and the lamp contactor AF16-…L/AF26-…L are typically mounted on a Wöhner adapter and snapped on a busbar system. This combination is type-tested by ABB for use in lightening applications, especially greenhouses. Typically 16, 18 or 20 of these lamp starters are placed in one panel and each starter is connected with nine lamps of 1000 W / 400 V. The most common

number however is 18 starters. The Lamps are protected per lighting group. When a lamp error occurs in one lighting group, only this group will switch off.

The lamps are mounted in a checkerboard patterns to have an evenly light distribution even when 25, 50 or 75 percent of the lamps are switched on. By switching dedicated lighting groups, the light output in the greenhouse can be controlled to have 25, 50, 75 or 100 percent of the light intensity. Alternatively, if sufficient natural light is available in the greenhouse the lighting can be switched off. Typically, nine lamps are connected between the phases per lamp starter. They are in delta connection L1-L2 L2-L3 L1-L3. With actual lamp technology for nine lamps the current is 13.6 A.

Lamp load types

- 600 W - HPS
- 1000 W - HPS

Examples for heat dissipation for typical combinations

Lamp starter	Connection	Lamp contactor	Busbar adapter	Combination heat dissipation
MS132-20L	cable	AF16…-L		< 3 W per pole
MS132-20L	cable	AF26…-L		< 4 W per pole
MS132-20L	cable	AF16…-L	adapter	< 5.5 W per pole
MS132-20L	cable	AF26…-L	adapter	< 6 W per pole

Example calculation of maximum quantity of lamps

Data

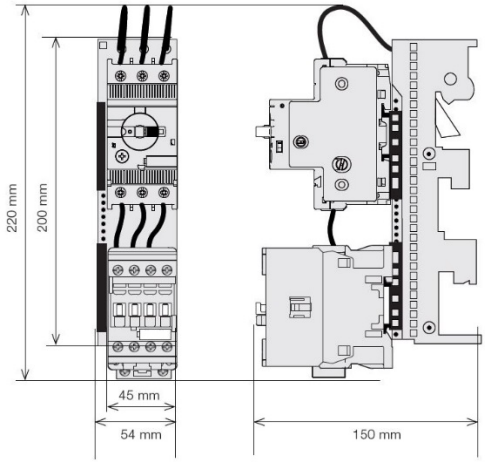
- Lamp 1000 W / 400 V – 2.61 A connected to phases
- Lamp starter load not above 16 A
- Lamps always equal to three

Formula

2.61 A: √3 = 1.51 A x 9 lamps = 13.6 A

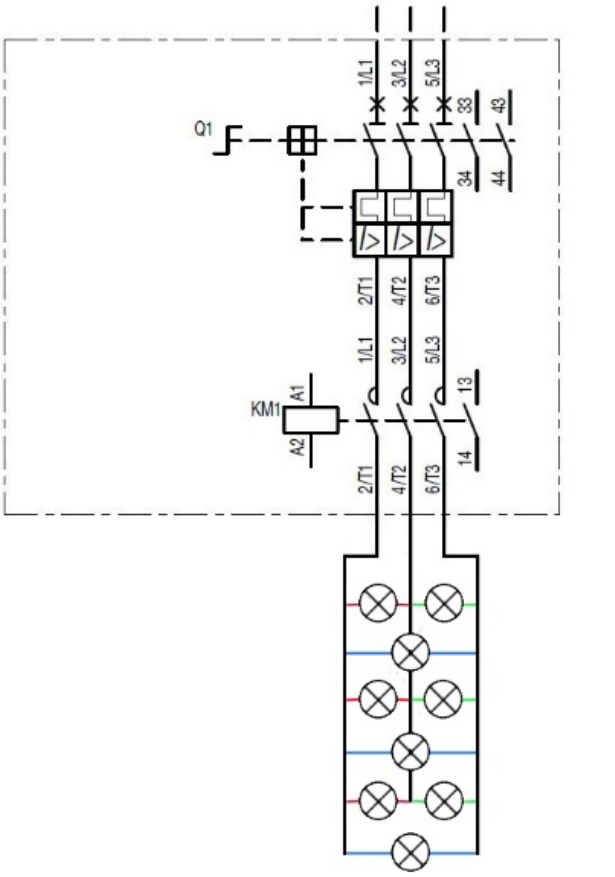
Depending on technical parameters of lamp loads, nine lamps is the maximum amount per combination. This value is based on experience levels in proven-in-use installations and should not be exceeded.

Dimensions in mm



Lamp starter combination on a Wöhner busbar adapter

Wiring diagram



Lamp starter combination power circuit with lamp loads

Technical data

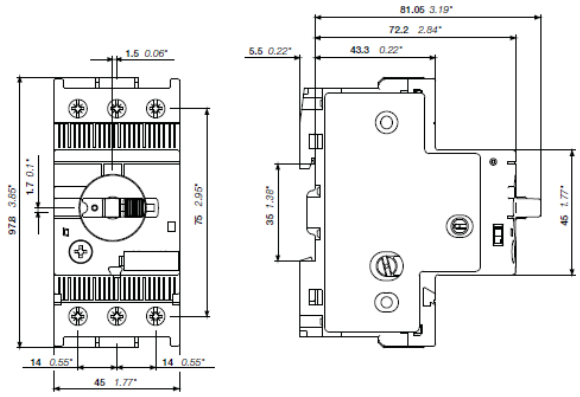
Lamp starters

- For other characteristics, please consult your ABB sales representative
- Accessory fitting details : same as standard MS132 manual motor starters

Type			MS132-16L	MS132-20L	MS132-25L
Standards			IEC/EN 60947–2, IEC/EN 60947-4-1, IEC/EN 60947-1		
Rated operational voltage U_e			690 V AC		
Rated frequency			50/60 Hz		
Rated impulse withstand voltage U_{imp}			6 kV		
Rated insulation voltage U_i			690 V		
Setting range	lower range		10.0 A	16.0 A	20.0 A
	upper value		16.0 A	20.0 A	25.0 A
Rated instantaneous short-circuit current setting I_i			240 A	300 A	375 A
Resistance per pole			0.011 Ω	0.0057 Ω	0.0045 Ω
Power loss per pole	at lower value		1.1 W	1.5 W	1.8 W
	at upper value		1.8 W	2.3 W	2.8 W
Max. cable loop impedance			1.0476 Ω	0.8411 Ω	0.6729 Ω
Pollution category			3		
Overvoltage category acc. to IEC/EN 60664			up to III		
Protective separation acc. to IEC/EN 61140 between the conducting paths of the main circuit			No		
Ambient air temperature					
Operation	open compensated		-25...+60 °C		
Storage			-50...+80 °C		
Ambient air temperature compensation			Acc. to IEC/EN 60947-4-1		
Maximum operating altitude permissible			2000 m		
Mounting position			Position 1-6 (optional for single mounting)		
Degree of protection	housing		IP20		
	main circuit terminals		IP20		
Connecting Capacity, min. / max.					
	rigid	1 or 2x	1...2.5 mm² 2.5...6 mm²		
	flexible with ferrule	1 or 2x	0.75...6 mm²		
	flexible with insulated ferrule	1 or 2x	0.75...6 mm²		
	flexible	1 or 2x	1.5...2.5 mm² 2.5...6 mm²		
Stripping length			10 mm		
Tightening torque			2.0 Nm		
Connection screw			M4		
Recommended screw driver			Pozidriv 2 / 6.5 mm		
Minimum distance to other units same type					
	horizontal		0 mm		
	vertical		150 mm		
Minimum distance to electrical conductive board					
	horizontal, up to 400 V		0 mm		
	horizontal, up to 690 V		> 1.5 mm		
	vertical		75 mm		

Type MS132	400 V AC	
	I_{cs} [kA]	I_{cu} [kA]
16	100	100
20	100	100
25	50	50

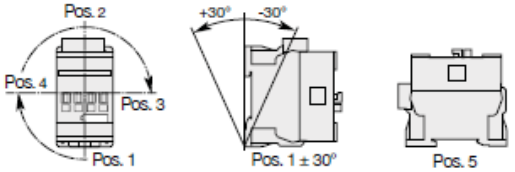
Dimensions in mm, inches



MS132...-L

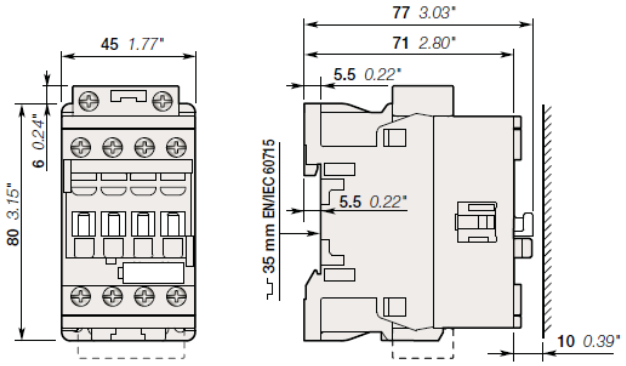
Lamp contactors

For other characteristics, please consult your ABB sales representative.

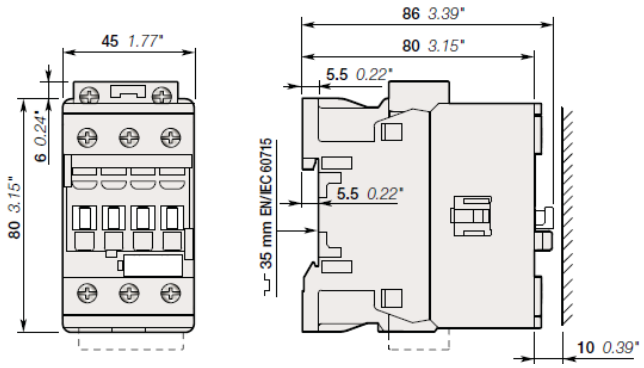
Type			AF16-40-00L	AF26-30-00L
Standards			IEC 60947-1 / 60947-4-1 and EN 60947-1 / 60947-4-1	
Rated operational voltage U_e			690 V AC	
Rated frequency			50/60 Hz	
Conventional free-air thermal current I_{th}				
acc. to IEC 60947-4-1, open contactors, θ ≤ 40 °C			35 A	50 A
with conductor cross-sectional area			6 mm²	10 mm²
Max. electrical switching frequency			6 mm²	10 mm²
Rated insulation voltage U_i acc. to IEC 60947-4-1			690 V	
Rated impulse withstand voltage U_{imp}			6 kV	
Power loss per pole			0.35 W	0.6 W
Electromagnetic compatibility			Devices complying with IEC 60947-1 / EN 60947-1 - Environment A and B	
Ambient air temperature close to contactor				
Operation	fitted with thermal overload relay		-25...+60 °C	
	without thermal overload relay		-40...+70 °C	
Storage			-60...+80 °C	
Climatic withstand			Category B according to IEC 60947-1 Annex Q	
Maximum operating altitude (without derating)			3000 m	
Coil operating limits acc. to IEC 60947-4-1				
AC supply			At θ ≤ 60 °C 0.85 x U_c min...1.1 x U_c max. At θ ≤ 70 °C 0.85 x U_c min...U_c max.	
DC supply			At θ ≤ 60 °C 0.85 x U_c min...1.1 x U_c max. At θ ≤ 70 °C (AF) 0.85 x U_c min...U_c max.	
AC control voltage 50/60 Hz				
Rated control circuit voltage U_c			100...500 V AC/DC	
Coil consumption		**average pull-in value**	50 VA	
		average holding value	2.2 VA / 2 W	
Drop-out voltage			≤ 60 % of U_c min.	
Operating time				
Between coil energization and:		**N.O. contact closing**	40...95 ms	
		N.C. contact opening	38...90 ms	
Between coil de-energization and:		**N.O. contact opening**	11...95 ms	
		N.C. contact closing	13...98 ms	
Mounting position				
			Max. N.C. built-in and add-on N.C. auxiliary contacts: see accessory fitting details for	
			4-pole contactor AF16	3-pole contactor AF26

Type				AF16-40-00L	AF26-30-00L
Connection capacity (min. ... max.) Main conductors (poles)					
	rigid	Solid (≤ 4 mm²)	1 x	1...6 mm²	2.5...10 mm²
		Stranded (≥ 6 mm²)	2 x	1...6 mm²	2.5...10 mm²
	flexible with non-insulated ferrule		1 x	0.75...6 mm²	1.5...10 mm²
			2 x	0.75...6 mm²	1.5...10 mm²
	flexible with insulated ferrule		1 x	0.75...4 mm²	1.5...10 mm²
			2 x	0.75...2.5 mm²	1.5...4 mm²
Stripping length				10 mm	14 mm
Tightening torque	main circuit terminals			1.5 Nm	2.5 Nm
	coil terminals			1.2 Nm	
Degree of protection	main and coil terminals			IP20	
Screw terminals	main circuit terminals			M3.5	M4
	coil terminals			M3.5	
Recommended screwdriver	main circuit terminals			Flat Ø 5.5 / Pozidriv 2	Flat Ø 6.5 / Pozidriv 2
	coil terminals			Flat Ø 5.5 / Pozidriv 2	

Dimensions in mm, inches



AF16-40-00L



AF26-30-00L

OT disconnect switch

Three-pole, front-operated, base-mounted switch-disconnector with black IP65 handle and shaft, wide phase distance and a terminal bolt kit included. Type OT315E03WP.

Dimensions	
Product net width	191 mm
Product net height	185 mm
Product net depth	107 mm
Product net weight	3.38 kg

OT disconnect switch OT315E03WP

Technical information	
Rated operational current AC-21A (I_e)	(380 ... 415 V) 315 A
	(500 V) 315 A
	(690 V) 315 A
	(1000 V) 315 A
Rated operational current AC-22A (I_e)	(380 ... 415 V) 315 A
	(500 V) 315 A
	(690 V) 315 A
Rated operational current AC-23A (I_e)	(500 V) 315 A
	(380 ... 415 V) 315 A
	(690 V) 315 A
Rated operational power AC-23A (P_e)	(380 ... 415 V) 160 kW
	(500 V) 220 kW
	(690 V) 315 kW
Conventional free-air thermal current (I_{th})	q = 40 °C 315 A
Conventional thermal current (I_{the})	fully enclosed 315 A
Rated impulse withstand voltage (U_{imp})	12 kV
Rated insulation voltage (U_i)	1000 V
Rated operational voltage	1000 V
Rated short-circuit making capacity (I_{cm})	(690 V AC) 65 kA
Rated short-time withstand current (I_{cw})	for 1 s 15 kiloampere rms
Power loss	at rated operating conditions per pole 6.5 W
Pollution degree	3
Handle type	handle and shaft included
Switches operating mechanism	mechanism at the end of the switch
Distance between phases	wide phase distance
Position of line terminals	top in - bottom out
Operating mode	front operated
Standards	IEC 60947-3
Special functions	wide phase distance
Mounting type	base mounting
Number of poles	3
Terminal type	lug terminals
Terminal width	25 mm
Tightening torque	30...44 Nm

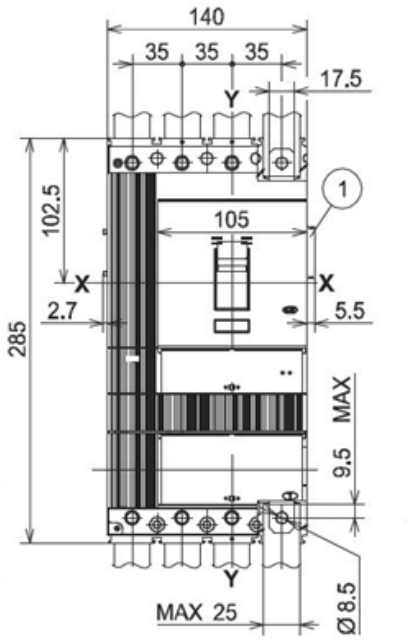
MCCB 320 A with residual current device for assimilation panels

The European standard EN/IEC60364-7-705 requires the use of residual current devices (RCDs) with 300mA. This may be mandatory in certain countries and has to be implemented in a suitable design. For example, in the Netherlands the standard NEN1010:2015 art 705.411.1 requires the use of RCDs in the segment agriculture, horticulture and livestock farming. For this, the Tmax T4D 320 with the residual current device RC222 is used. For assimilation panels it is allowed according to determination 531 that all end groups can be protected by a group protection device as long as the sum of the leakage currents does not exceed 30 percent of the assigned trip current.

Heat dissipation 1SDX002530R1 – T4D 320 + RC222 4 pole = 27.85 W/pole

Technical information			
Conventional thermal current, I_{th}			250/320 A
Rated service current in category AC22, I_e			250/320 A
Rated service current in category AC23, I_e			250 A
Poles		[No.]	3/4
Rated service voltage, U_e	(AC) 50-60 Hz		690 V
	(DC)		750 V
Rated impulse withstand voltage, U_{imp}			8 kV
Rated insulation voltage U_i			800 V
Test voltage at industrial frequency for 1 minute			3000 V
Rated short-circuit making capacity, I_{cm}	(min) switch-disconnector only		5.3 kA
	(max) with circuit-breaker on supply side		440 kA
Rated short-circuit withstand current for 1s, I_{cw}			3.6 kA
Reference Standard			IEC 60947-3
Versions			F – P – W
Terminals			F-FC CuAl-FC Cu-EF-ES-R-MC-HR-VR
Mechanical life			20000 no. operations
			120 no. hourly operations
Basic dimensions, fixed	3 poles	W	105 mm
	4 poles	W	140 mm
		D	103.5 mm
		H	205 mm
Weight	Fixed	3/4 poles	2.35/3.05 kg
	Plug-in	3/4 poles	3.6/4.65 kg
	withdrawable	3/4 poles	3.85/4.9 kg

Dimensions T4D and RC222 in mm



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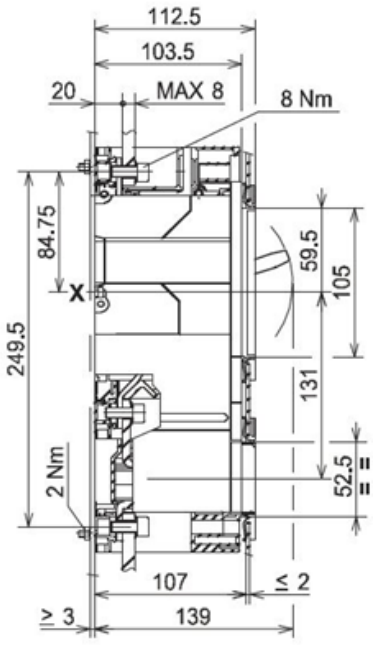


Front – F, fixing on sheet

Busbar adapter

Wöhner busbar adapter EEC 32 A

Basic information

Part No.: 32 442
EQUES®60Classic
2 adjustable mounting rails
54 x 200, with leads AWG 10 (6 mm²)
for busbars 12, 15, 20, 25, 30 x 5, 10 and section busbars

Standards

IEC 61439-1:2011

Approvals

CSA, UL, DNV GL
for UL feeder circuits > 250 V
Type number: EEC6032-L
UL file: E123577, UL category (for USA): NMTR
UL file: E123577, UL category (for CAN): NMTR7
CSA file: 110285, CSA class: 3211-37
CCC approval: no certification required

Electrical data

Rated current (IEC):	32 A
Rated voltage (IEC) AC:	690 V
Rated current (UL):	30 A
Rated voltage (UL) AC:	600 V

Mechanical data

W x H x D:	54 x 200 x 63 mm
Weight:	38 kg/100
Poles:	3-pole
for busbars:	12, 15, 20, 25, 30 x 5, 10 and section busbars

Power dissipation

The power dissipation at a typical load of 80 percent of the rated current results to 1.5 W. (The power dissipation for operation with rated current would be 2.4 W.)

- rated isolation voltage U_i (AC): 800 V
- rated withstand voltage U_{imp} : 6 kV
- max. permitted voltage (IEC) AC: 800 V
- max. permitted voltage (IEC) DC: 800 V
- short-circuit withstandability: the motor starter gives the protection to the adapter

Material properties

- Body:
  temperature stability 125 °C, self-extinguishing in acc. to UL 94, creepage resistance CTI 600, halogen-free
- DIN rail:
  temperature stability 125 °C, self-extinguishing in acc. to UL 94, creepage resistance CTI 550, halogen-free
- Screws:
  screw +/- (PZ1), galvanized, chromized
- Conductor insulation:
  temperature-resistant up to 105 °C

Information about the busbar system

Tin-plated copper busbars make contact position preparation much easier. Cu busbars are effectively protected against corrosive substances. The current capacities of flat busbars in the diagram below were calculated by testing at an ambient temperature of 35 °C under optimal conditions (IEC and UL).

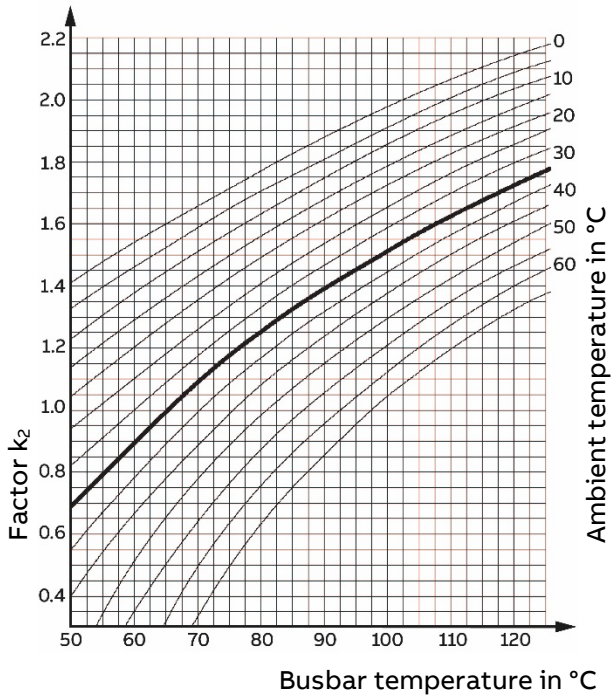
Current carrying capacities higher than those specified in DIN 43 671 were obtained under operating conditions. The busbar temperature is normally positively influenced by mounting components on the busbar and by air circulation within the installation.

A correction factor k_2 as defined in DIN 43 671 can be applied for flat busbars using the diagram below. The factor is dependent on the relevant ambient temperature. This correction factor should be taken into account when conditions change and loading is continuous. Alternatively, a higher load can be applied if the components have a higher thermal endurance level.

A 30 x 10 galvanized busbar can, under normal operating conditions, be loaded with 630 A. A correction factor k_2 of 1.3, for example, is required if a load of 800 A is applied. This diagram demonstrates that the busbar heats up to approx. 85 °C if this correction factor and an air temperature of 35 °C apply.

- Tensile strength: min. 300 N/mm^2
- Permissible tolerance
  Radius R 0.3…0.7
  Width: +0.1 / -0.5
  Thickness: +0.1 / -0.1
- Centre spacing:
  +0.5 / -0.5 (60 mm system)
  +1.0 / -1.0 (100 mm system / 185 mm system)
- Deviation in the contact levels: 0.4

Correction factor diagram according to DIN 43 671



The diagram on the left is taken from DIN 43 671. It shows the correction factor k_2 (used to correct the basic rated current) depending on the busbar temperature and the ambient temperature in °C.

Continuous currents for busbars according to DIN 43 671

Width x thickness in mm	Cross section in mm²	Weight[1]	Material[2]	Cont. current in A	
				AC current up to 60 Hz	
				Bare bar	Coated bar
12 x 2	23.5	0.209	E-Cu F30	108	123
15 x 2	29.5	0.262		128	148
15 x 3	44.5	0.396		162	187
20 x 2	39.5	0.351		162	189
20 x 3	59.5	0.529		204	237
20 x 5	99.1	0.882		274	319
20 x 10	199.0	1.770		427	497
25 x 3	74.5	0.663		245	287
25 x 5	124.0	1.110		327	384
30 x 3	89.5	0.796		285	337
30 x 5	149.0	1.330		379	447
30 x 10	299.0	2.660		573	676
40 x 3	119.0	1.060		366	435
40 x 5	199.0	1.770		482	573
40 x 10	399.0	3.550		715	850
50 x 5	249.0	2.220		583	697
50 x 10	499.0	4.440		852	1020
60 x 5	299.0	2.660		688	826
60 x 10	599.0	5.330		985	1180
80 x 5	399.0	3.550		885	1070
80 x 10	799.0	7.110		1240	1500
100 x 10	999.0	8.890		1490	1810

[1] Calculated with a density of 8.9 kg/dm^3

[2] Reference basis for the continuous current levels (figures taken from DIN 43 671)

Further Information

The standard DIN 43 671 can be accessed at www.din.de

Current technical datasheets of busbars can be found at www.woehner.com

Please note that all information given about the busbar adapter and the busbar system are subject to change at Wöhner's behalf and ABB AG does not accept any responsibility whatsoever for potential errors or possible lack of information in this section.

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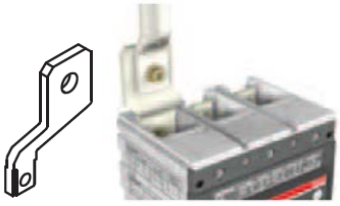
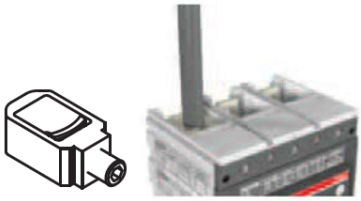
Useful hints

Spread flags for mounting with cable lugs



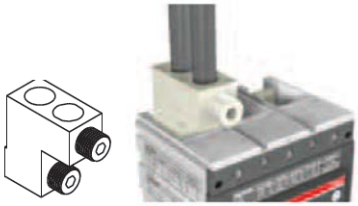
1SDA055004R1 Spread flags 3 pieces included rubber terminal separation

Standard terminals fall into the cage of the switch



1SDA054984R1 Standard terminals CuAl 2,5…50 mm² 3 pieces without terminal cover
1SDA054988R1 Standard terminal CuAl 6…185 mm² 3 pieces without terminal cover

External terminals fall outside the cage of the switch



1SDA054993R1 External terminal CuAl 2 X 35…150 mm² 4 pieces included terminal cover
1SDA064550R1 External terminal CuAl 150…240 mm² T4 4 pieces included terminal cover

Separation and covers

1SDA054970R1 Separation 100 mm
1SDA054972R1 Separation 200 mm
1SDA054967R1 Terminal cover low 4 pole set of 2 pieces
1SDA054959R1 Terminal cover high 4 pole set of 2 pieces

Definitions

- **Clearance**
  shortest distance in air between two conductive parts
- **Creepage distance**
  shortest distance along the surface of a solid insulating material between two conductive parts
- **Electrical breakdown**
  failure of insulation under electric stress when the discharge completely bridges the insulation, thus reducing the voltage between the electrodes almost to zero
- **Overvoltage**
  any voltage having a peak value exceeding the corresponding peak value of maximum steady-state voltage at normal operating conditions
- **r.m.s. withstand voltage**
  highest r.m.s. value of a voltage which does not cause breakdown of insulation under specified conditions
- **Rated impulse withstand voltage (U_{imp})**
  The peak value of an impulse voltage of prescribed form and polarity which the equipment is capable of withstanding without failure under specified conditions of test and to which the values of the clearances are referred.
- **Rated insulation voltage (U_i)**
  The rated insulation voltage of an equipment is the value of voltage to which dielectric tests and creepage distances are referred.
- **Rated operational current (I_e)**
  A rated operational current of an equipment is stated by the manufacturer and takes into account the rated operational voltage, the rated frequency and the utilization category.
- **Rated operational voltage (U_e)**
  A rated operational voltage of an equipment is a value of voltage which, combined with a rated operational current, determines the application of the equipment.
- **Rated output voltage for constant voltage controlgear**
  output voltage, at rated supply voltage, rated frequency and at rated output power, assigned to the controlgear
- **Effective power loss of equipment installed inside the enclosure**
- **Effective power loss of conductors installed inside the enclosure**

References

The following standards and documents are referred to for the application of application note

- IEC 60947-1 (ed5.1)
- IEC 60947-4-1 (ed3)
- IEC 61439-1/2
- IEC 60364-7-705
- IEC 60598
- IEC 60890

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