RCM500E Series

500 W DC-DC Converter

The RCM500E Series converters are reliable power supplies for railway and transportation systems.

They are optimized for 72 or 110 V railway batteries, delivering output power 500 W at 24 V. The converters are designed for chassis mounting and exhibit a closed housing with cooling openings.

Many options are available, such as an output ORing FET for redundant operation, interruption time of 10 ms, shutdown input, and a output voltage monitoring (solid-state relay).

FEATURES

- Unbeatable small form factor (830 cm^3 only)
- Optimized for 72 V or 110 V railway batteries
- Output voltage 24 V
- Closed housing for chassis mounting
- Extremely high efficiency and high power density
- Low inrush current
- 3 connectors: Input, output, auxiliary (option)
- Overtemperature, overvoltage, overcurrent and short-circuit protection
- Multiple options available
- Compliant to EN 50155, EN 50121-3-2, AREMA
- RoHS-compatible for all 6 substances
- Fire and smoke: compliant to EN 45545 and NFPA 130
- 5-year warranty
- Safety-approved to the latest edition of IEC/EN 62368-1 and UL/CSA 62368-1 (Pending approvals)

[1] pending

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RCM500E Series
500 W DC-DC Converter

MODEL SELECTION

Table 1: Standard models

Input voltage					Output		Power	Efficiency [2]	Model	Options
$V_{i\,min}$ [1] [V]	$V_{i\,cont}$ [V]			$V_{i\,max}$ [1] [V]	$V_{o\,nom}$ [V]	$I_{o\,nom}$ [A]	$P_{o\,nom}$ [W]	η_{typ} [%]		
43.2	50.4	(72)	90	110	24	21	500	95	72RCM500E-24	D, M, Q, F, K
66	77	(110)	137.5	154	24	21	500	95	110RCM500E-24	

[1] Short time; see table 2 for details.
[2] Efficiency at T_A = 25 °C, $V_{i\,nom}$, $I_{o\,nom}$.

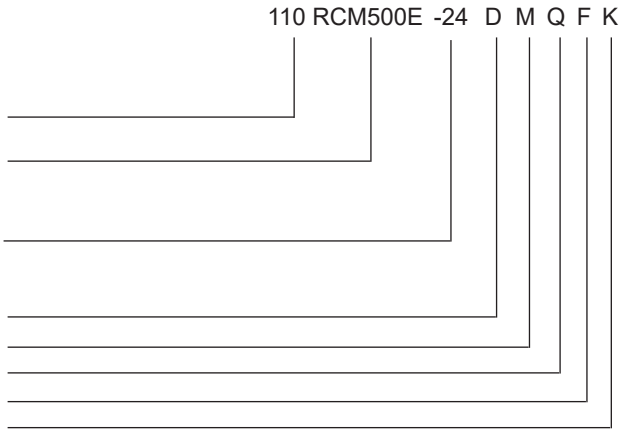
Part Number Description

Operating input voltage $V_{i\,cont}$ (continuously):
- 50.4 – 90 VDC 72
- 77 – 137.5 VDC 110

Series RCM500E

Nominal output voltage:
- 24 V ..... -24

Auxiliary functions and options:
- Out OK, shutdown [1] ..... D
- Interruption time ..... M
- ORing FET ..... Q
- Fuse built-in ..... F
- Pluggable Connectors ..... K



[1] Opt. D requires the auxiliary connector.

Note: The sequence of options must follow the order above.

Note: All models are RoHS-compliant for all six substances.

Available combinations of options:

72/110RCM500E-24 (K)
72/110RCM500E-24D (K)
72/110RCM500E-24DF (K)
72/110RCM500E-24DMQ (K)
72/110RCM500E-24DMQF (K)

Example: 110RCM500E-24DMQ: DC-DC converter, input voltage range 77 to 137.5 V continuously, output providing 24 V / 21 A, monitoring relay, shutdown input, interruption time 10 ms, integrated ORing FET, RoHS-compliant for all six substances.

Product Marking

Type designation, applicable safety approval and recognition marks, CE mark, pin allocation, and product logo.

Input voltage range and input current, nominal output voltage and current, degree of protection, batch no., serial no., and data code including production site, version (modification status) and date of production.

FUNCTIONAL DESCRIPTION

The converters are designed as active clamp forward converters with a switching frequency of approximately 140 kHz. The built-in high-efficient input filter together with a small input capacitance generates very low inrush current of short duration. An anti-parallel diode acts as reverse polarity protection together with the external circuit breaker or fuse.

The circuitry providing the interruption time (opt. M) is located after the input filter. The rectification on the secondary side is provided by synchronous rectifiers, in order to keep the losses as low as possible. The output voltage control logic is located on the secondary side and influences the primary logic and PWM control circuit.

An auxiliary converter supplies all circuits with a stable bias voltage. An output ORing FET is available (option Q) and allows for a redundant power supply system. If there are no external circuit breakers, it is possible to order the converter with incorporated fuse (opt. F). Because this fuse is not accessible, a serial FET provides reverse polarity protection (only with option F or M). Opt. D encompasses an additional auxiliary connector and allows for output voltage monitor and a primary shutdown.

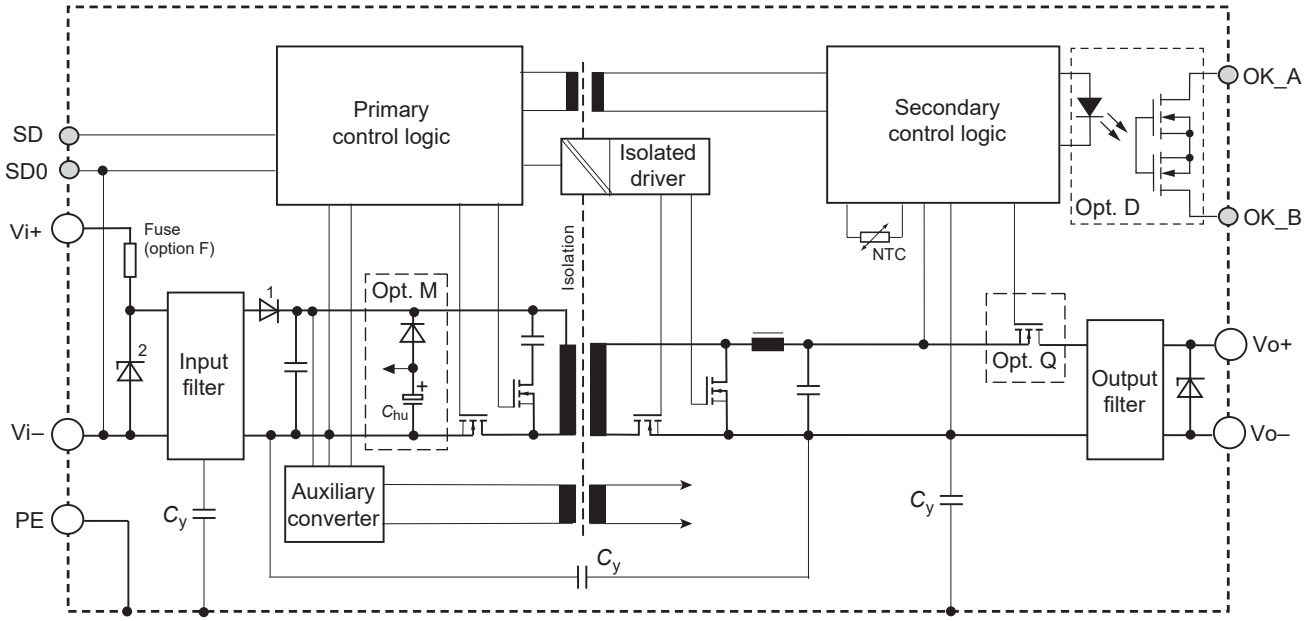


Fig. 1
Block diagram

ELECTRICAL INPUT DATA

General conditions:
- T_A = 25 °C, unless specified.

Table 2: Input data of RCM500E models

Model / Characteristics		Conditions	72RCM500E-24 min	72RCM500E-24 typ	72RCM500E-24 max	110RCM500E-24 min	110RCM500E-24 typ	110RCM500E-24 max	Unit
V_i	Operating input voltage	I_o = 0 – $I_{o\,max}$ $T_{A\,min}$ – $T_{A\,max}$	50.4	(72)	90	77	(110)	137.5	V
$V_{i\,2s}$	for ≤ 2 s	without shutdown	43.2		100.8	66		154	
$V_{i\,nom}$	Nominal input voltage			72			110		
$V_{i\,abs}$	Input voltage limits	3 s without damage	0		105	0		160	
I_i	Typical input current	$V_{i\,nom}$, $I_{o\,nom}$		7.3			4.8		A
$P_{i\,0}$	No-load input power	$V_{i\,min}$ – $V_{i\,max}$, I_o = 0		3	5		3	5	W
$P_{i\,SD}$	Idle input power	$V_{i\,min}$ – $V_{i\,max}$, V_{SD} = 0 V			1			1	
C_i	Input capacitance [1]			65			65		µF
R_i	Input resistance			14			14		mΩ
$I_{inr\,p}$	Peak inrush current [2]	V_i = $V_{i\,max}$, $P_{o\,nom}$			25			40	A
$t_{inr\,d}$	Duration of inrush current				3			5	ms
t_{on}	Start-up time	0 → $V_{i\,min}$, $P_{o\,nom}$			1000			1000	
	Start-up time after removal of shutdown	$V_{i\,min}$, $P_{o\,nom}$ V_{SD} = 0 → 5 V		300	500		300	500	

[1] Not smoothed by the inrush current limiter at start-up (for inrush current calculation)

[2] Initial peak current caused by charging EMI suppression capacitors is disregarded from inrush current considerations.

Input Transient and Reverse Polarity Protection

A suppressor diode and a symmetrical input filter form an effective protection against input transients, which typically occur in many installations, but especially in battery-driven mobile applications.

If the input voltage has the wrong polarity, the incorporated anti-parallel diode will cause the external input circuit breaker or fuse to trip. With option M or F (incorporated fuse), an active reverse-polarity protection circuit prevents from any damage.

Input Under-/Overvoltage Lockout

If the input voltage is out of range, an internally generated signal disables the converter to avoid any damage.

Asia-Pacific
+86 755 298 85888
EMEA
+353 61 531 820
North America
+1 866 513 2839
powersupport@belf.com
belfuse.com

ELECTRICAL OUTPUT DATA

General conditions:

- T_A = 25 °C, unless T_C is specified

Table 3: Output data

Model / Characteristics			Conditions	72/110RCM500E-24 min	typ	max	Unit
V_o	Output voltage		$V_{i\,nom}$, 0.5 $I_{o\,nom}$	23.76	24	24.24	V
V_{ow}	Worst case output voltage		$V_{i\,min} - V_{i\,max}$ $T_{C\,min} - T_{C\,max}$, 0 - $I_{o\,nom}$	23.28		24.72	V
$V_{o\,droop}$	Output voltage droop				- 25		mV/A
$V_{o\,L}$	Overvoltage shutdown [5]					28	V
$V_{o\,P}$	Overvoltage protection [1]			28.5	30	41.5	V
$I_{o\,nom}$	Nominal output current		$T_{C\,min} - T_{C\,max}$		21		A
$I_{o\,L}$	Output current limit			21.5		26	A
v_o	Output noise [2]	Switching frequency	$V_{i\,nom}$, $I_{o\,nom}$ BW = 20 MHz			120	mV_{pp}
		Total incl. spikes				240	mV_{pp}
v_{od}	Dynamic load regulation	Voltage deviation [4]	$V_{i\,nom}$, 0.1↔0.9 $I_{o\,nom}$			1000	mV_{pp}
t_d [3]		Recovery time				5	ms

[1] Breakdown voltage of the incorporated suppressor diode at 1 mA . Exceeding this value might damage the suppressor diode.
[2] Measured according to IEC/EN 61204 with a probe described in annex A
[3] Recovery time until V_o returns to ±1% of V_o; see fig. 2.
[4] No overshoot at switch on.
[5] Output overvoltage shutdown by an electronic circuitry, with automatic recovery.

Output Voltage Regulation

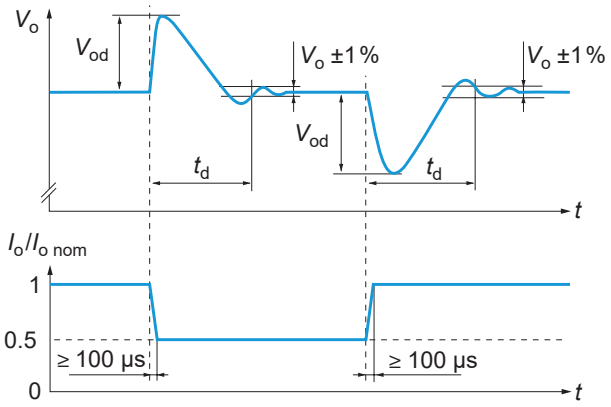


Fig. 2
Typical dynamic load regulation of output voltage

Output Current Limitation

The output is continuously protected against open-circuit (no load) and short-circuit by an electronic current limitation with rectangular characteristic; see Fig. 3.

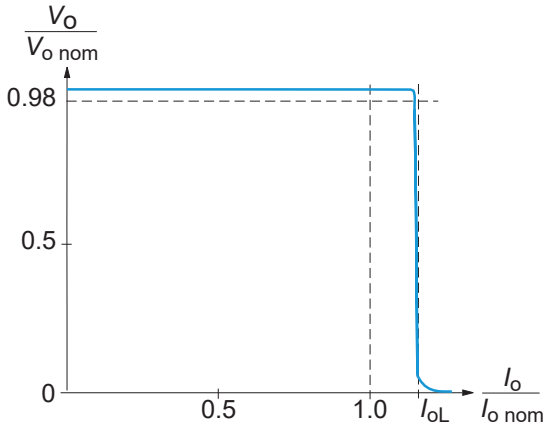


Fig. 3
Rectangular current limitation

Series, Parallel Connection, Redundancy

The outputs of several RCM Series converters may be connected in series.

Note: If the sum of the output voltages is greater than 60 V, it cannot be considered being ES1 (Safety Extra Low Voltage) according to the safety standards.

The outputs RCM Series converters may be connected in parallel. In order to ensures proper current sharing, the load lines should have equal length and section. The output voltage exhibits a slight droop characteristic, which facilitates current sharing.

For redundant systems, it is recommended to use option Q, which exhibits ORing diodes built by FETs, in order to keep the losses to a minimum.

Thermal Considerations and Protection

A temperature protection is incorporated in the secondary control logic. It generates an internal inhibit signal, which disables the converter in case of overtemperature. The converter automatically recovers, when the temperature drops below the limit; see Fig. 4. The relationship between T_A and T_C depends heavily upon the conditions of operation and the integration into a system.

Caution: The installer must ensure that under all operating conditions T_c remains within the limits stated in table 7. For installation without external heatsink it is recommended to use forced air or reduced output power.

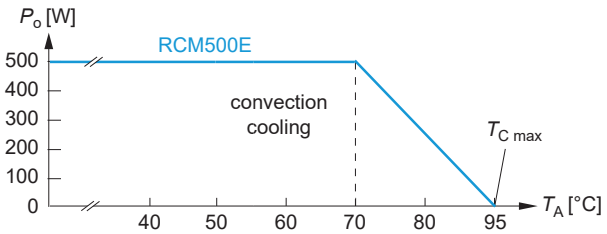


Fig. 4
Typical output power derating versus temperature; horizontal mounting position, free convection cooling.

LED Indicator

Each converter exhibits a green LED “Out OK”, signaling that the output voltage is present.

DESCRIPTION OF OPTIONS

Option D: Output Monitor, Shutdown

Option D consists of several auxiliary functions (OK, SD) and encompasses an additional auxiliary connector.

Output Voltage Monitor (OK)

The output voltage V_o is monitored.

Option D encompasses an output voltage monitor by a solid state relay. When Vo is in range, a solid state relay is activated (connecting OK_A with OK_B). Max. data of relay contacts: 0.14 A /154 VDC.

When selecting load current for OK1/OK2 signals, please consider derating curve, shown below.

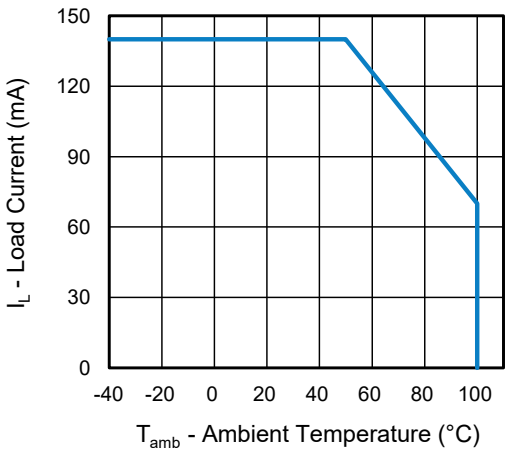


Fig. 5
Maximum Load Current vs. Ambient Temperature

Primary Shutdown (SD)

The output of the converter may be enabled or disabled by a logic signal (e.g. CMOS) applied between the shutdown pin SD and SD0 (= Vi–). If the shutdown function is not required, pin SD can be left open-circuit. Voltage on pin SD:

Converter operating:	12 V to $V_{i\,max}$ or open-circuit
Converter disabled:	–2 to +2 V

The output response is shown in Fig. 6.

Note: In systems consisting of several converters, this feature may be used to control the activation sequence by logic signals or to enable the power source to start up, before full load is applied.

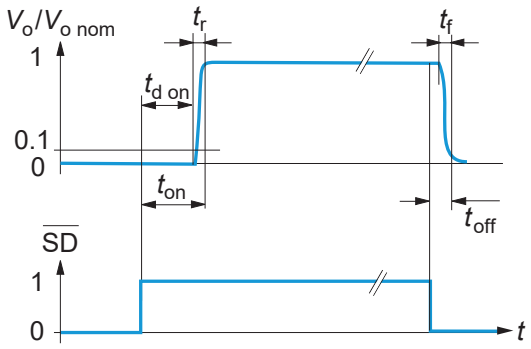


Fig. 6
Typical output response to the SD-signal.

Asia-Pacific
+86 755 298 85888
EMEA
+353 61 531 820
North America
+1 866 513 2839
powersupport@belf.com
belfuse.com

Option M: Interruption Time

The interruption time t_{hu} is specified in the railway standard EN 50155:2021 clause 5.2.4: Class S2 is 10 ms. It is measured at $V_{B\ nom}$ (nominal battery voltage) for interruption and short-circuit of the input. After such an event, the system is ready for the next event after 10 s.

Fig. 7 shows the output voltage V_o, if option M is fitted. Option M encompasses a backrush protection formed by a FET device. For less critical applications, option M is not required (class S1). Such units have a slightly better efficiency.

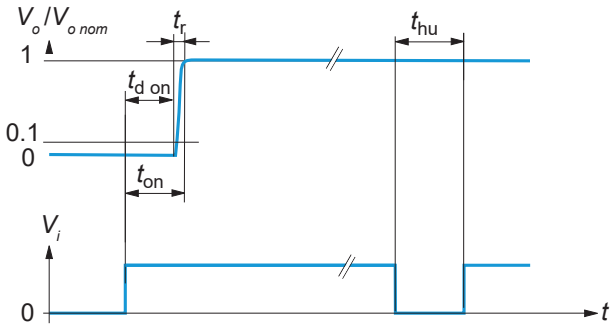


Fig. 7
Typical output response to V_i. If option M is not fitted, t_{hu} = 0 ms.

Option Q: ORing FET for Redundant Systems

Two parallel connected converters are separated with ORing diodes (built by FETs). If one converter fails, the remaining one still delivers the full power to the loads. If more power is needed, the system may be extended to more parallel converters (n+1 redundancy).

Current sharing must be ensured by load lines of equal section and length. In addition, a slight droop characteristic of the outputs helpful as well.

To keep the losses as small as possible, the ORing diode is replaced by a FET.

Note: In the case of a failing converter, the output voltage is maintained by the redundant converters. However, the failing item should be identified and replaced. We recommend the Out OK function (option D).

Option F: Incorporated Fuse

Converters can be supplied either with or without incorporated non-replaceable fuse. When an internal fuse is assembled (option F present in part number), it will not trip at any continuous or transient conditions defined within EN 50155, except if the converter is defective. If an external fusing is to be used, it is recommended to follow the fuse rating specified in the table below:

Table 4: Recommended external fuses

Converter	Specification	Ordering number
72RCM500E-24	20 A, 680 A^2 sec, Fast Blow	Bel Fuse 0ADGC9200
110RCM500E-24	16 A, 410 A^2 sec, Fast Blow	Bel Fuse 0ADGC9160

Option K: Pluggable Connectors

This option allows the use of preassembled pluggable connectors; for details see *Accessories*.

Note: Female connectors must be ordered separately.

ELECTROMAGNETIC COMPATIBILITY (EMC)

Electromagnetic Immunity

Table 5: Electromagnetic immunity (type tests). Corresponds or Exceeds EN50121-3-2:2016 and AREMA.

Phenomenon	Standard	Level	Coupling mode [1]	Value applied	Waveform	Source imped.	Test procedure	In oper.	Perf. crit. [2]
Electrostatic discharge (to case)	IEC/EN 61000-4-2	4	contact discharge	6000 V_p	1/50 ns	330 Ω 150 pF	10 pos. & 10 neg. discharges	yes	A
			air discharge	8000 V_p					
Electromagnetic field	IEC/EN 61000-4-3	x	antenna	20 V/m	AM 80% / 1 kHz	N/A	80 – 800 MHz	yes	A
			antenna	20 V/m	AM 80% / 1 kHz	N/A	800 – 1000 MHz	yes	A
				20 V/m [3]			1400 – 2000 MHz		
				5 V/m			2000 – 2700 MHz		
				3 V/m			5100 – 6000 MHz		
Electrical fast transients/burst	IEC/EN 61000-4-4	3	capacitive, o/c	±2000 V_p	bursts of 5/50 ns; 2.5/5 kHz over 15 ms; burst period: 300 ms	50 Ω	60 s positive 60 s negative transients per coupling mode	yes	A
		3	i/c, +i/–i direct						
Surges	IEC/EN 61000-4-5	3	i/c	±2000 V_p	1.2 / 50 µs	42 Ω 0.5 µF	5 pos. & 5 neg. surges per coupling mode	yes	A
			+i/–i	±1000 V_p					
			i/c, +i/–i	±1000 V_p		12 Ω 9 µF			B
Conducted disturbances	IEC/EN 61000-4-6	3	i, o, signal wires	10 VAC (140 dBµV)	AM 80% / 1 kHz	150 Ω	0.15 – 80 MHz	yes	A
Power frequency magnetic field	IEC/EN 61000-4-8	3		300 A/m			60 s in all 3 axis	yes	A

[1] i = input, o = output, c = case
[2] A = normal operation, no deviation from specs.; B = normal operation, temporary loss of function or deviation from specs possible
[3] Tested value 20 V/m is required by AREMA; 10 V/m is valid for EN50121-3-2

Electromagnetic Emissions

Radiated Emissions

The power supply complies with EN 50121-3-2:2017, Table 3, Section 3.1 & 3.2.

Conducted Emissions

The power supply complies with EN 61204-3, Table H2, Section 3.1.1 and EN 50121-3-2:2017, Table 2, Section 2.1

Radio compatibility of rail vehicles (EMV 06)

The power supply complies with EMV 06 regulation, Annex E, Class S2.

Note: The product certificate obtained from accredited laboratory is available on request.

IMMUNITY TO ENVIRONMENTAL CONDITIONS

Table 6: Mechanical and climatic stress. Air pressure 700 – 1200 hPa

Test method		Standard	Test Conditions		Status
Ad	Low temperature start-up test	EN 50155:2021, clause 13.4.4 IEC/EN 60068-2-1	Temperature, duration: Performance test:	- 40 °C, 2 h +25 °C	Not operating
Be	Dry heat test, cycle B	EN 50155:2021, clause 13.4.5 IEC/EN 60068-2-2	Temperature: Duration:	70 °C 6 h	Operating perf. crit. A
Db 2	Cyclic damp heat test	EN 50155:2021, clause 13.4.8 IEC/EN 60068-2-30	Temperature: Cycles (respiration effect): Duration:	55 °C and 25 °C 2 2x 24 h	Not operating
Ka	Salt mist test sodium chloride (NaCl) solution	EN 50155:2021, clause 13.4.13 IEC/EN 60068-2-11	Temperature: Duration:	35 $^{\pm 2}$ °C 48 h	Converter not operating
	Functional random vibration test	EN 50155:2021 clause 13.4.10.4 EN 61373:2010 clause 8, class B, body mounted [1]	Acceleration amplitude: Frequency band: Test duration:	0.1 g_n = 1.01 m/s^2 5 – 150 Hz 30 min (10 min in each axis)	Operating perf. crit. A
	Simulated long life testing	EN 50155:2021 clause 13.4.10.2 EN 61373:2010 clause 9, class B, body mounted [1]	Acceleration amplitude: Frequency band: Test duration:	0.58 g_n = 5.72 m/s^2 5 – 150 Hz 15 h (5 h in each axis)	Not operating
	Shock test	EN 50155:2021 clause 13.4.10.3 EN 61373:2010 clause 10, class B, body mounted [1]	Acceleration amplitude: Bump duration: Number of bumps:	5.1 g_n 30 ms 18 (3 in each direction)	Operating perf. crit. A
	Vibration sinusoidal	AREMA Part. 11.5.1 class C, D, E, I, J	Displacement amplitude: Acceleration amplitude: Frequency: Test duration:	0.3" (5 – 10 Hz) 0.07" (5 – 20 Hz) 1.5 g_n = 14.7 m/s^2 (10 – 200 Hz) 5 – 200 Hz 12 h (4 h in each axis)	Operating perf. crit. A
	Mechanical shock	AREMA Part. 11.5.1 class C, D, E, I, J	Acceleration amplitude: Bump duration: Number of bumps:	10 g_n = 98 m/s^2 11 ms 18 (3 in each direction)	Operating perf. crit. A

[1] Body mounted = chassis of a railway coach

Temperatures

Table 7: Temperature specifications, valid for an air pressure of 700 – 1200 hPa (700 – 1200 mbar)

Model			RCM500E EN 50155:2021 Class OT4			Unit
Characteristics		Conditions	min	max	10 min	
T_A	Ambient temperature	Converter operating	- 40	70	85	° C
T_C	Case temperature [1]		- 40	95		
T_S	Storage temperature	Not operational	- 55	85		

[1] Measured at the measurement point T_C; see Mechanical Data.

Reliability

Table 8: MTBF

Calculation method	Model	MTBF
According to IEC 61709 / SN-29500	110RCM500E-24DMQF	> 1 000 000 h

MECHANICAL DATA

Dimensions in mm.

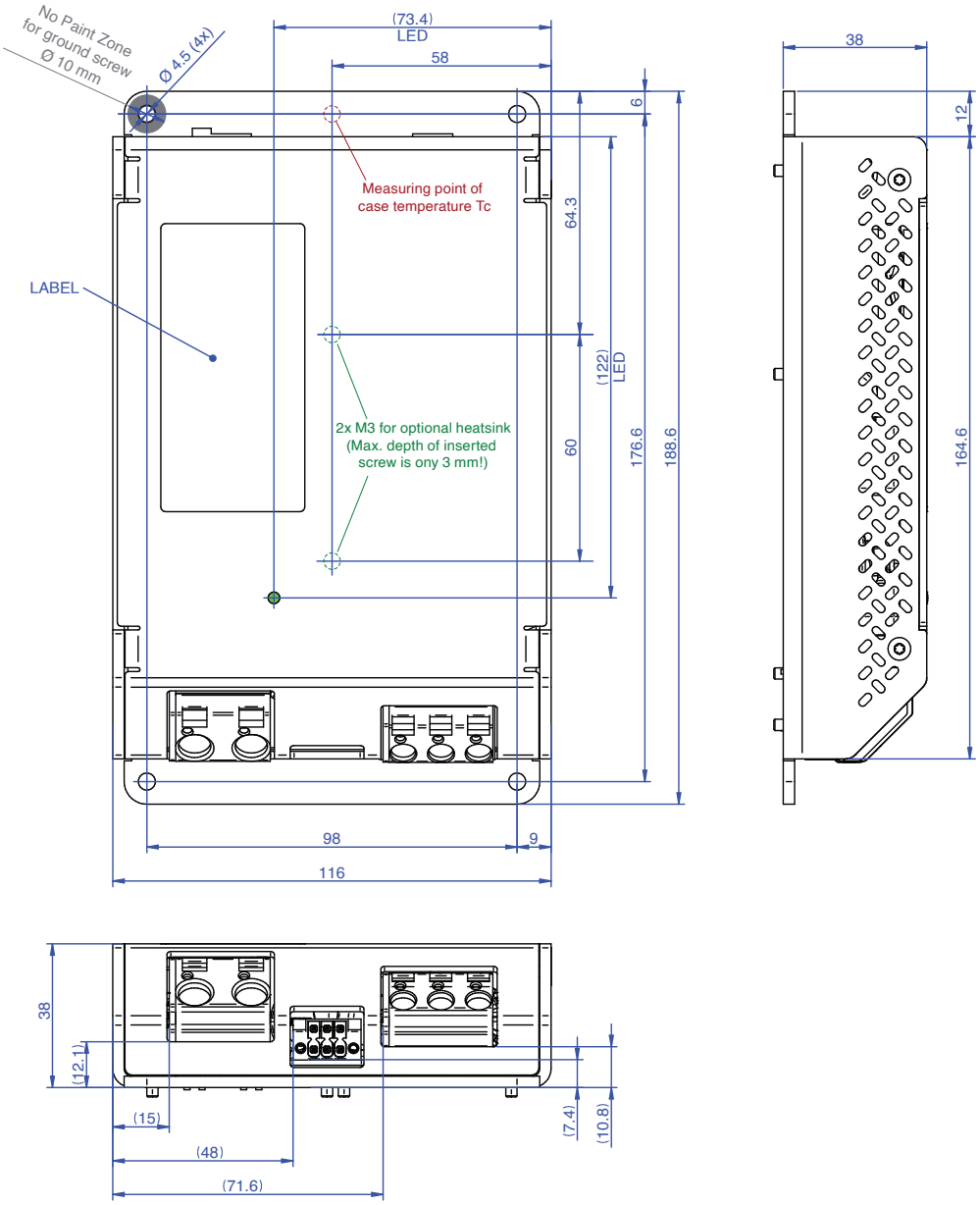


Fig. 8
Case for RCM500E, Standard version, Aluminum, EP black anodized; 750 g.

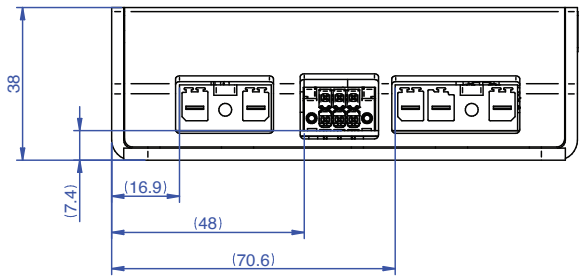


Fig. 9
Mechanical dimensions RCM500E (Version with option K)

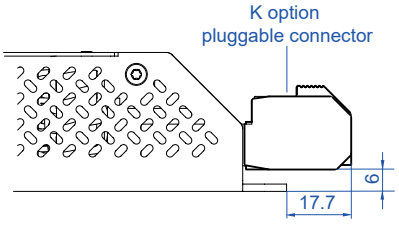


Fig. 10
Case detail (Version with option K)

Asia-Pacific
+86 755 298 85888

EMEA
+353 61 531 820

North America
+1 866 513 2839

powersupport@belf.com
belfuse.com

SAFETY AND INSTALLATION INSTRUCTION

CONNECTORS AND PIN ALLOCATION

- Input connector (Wago 745-353), 3 pins: Vi+, Vi–, PE; wire sections: 0.2 – 6 mm², 24 – 10 AWG;
  Option K connector (Weidmüller 1048500000)
- Output connector (Wago 745-652/006-000), 2 pins: Vo+, Vo; wire sections: 0.2 – 16 mm², 24 – 06 AWG
  Option K connector (Weidmüller 1048390000)
- Auxiliary connector (Phoenix Contact 1874027)

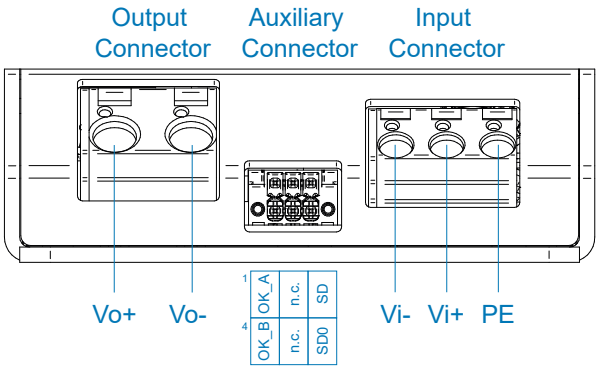


Fig. 11
Connectors and pin allocations

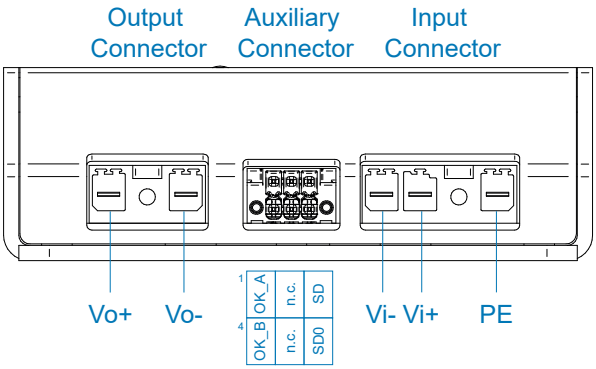


Fig. 12
Connectors and pin allocations (Version with option K)

Installation Instruction

These converters are components, intended exclusively for inclusion by an industrial assembly process or by a professionally competent person. Installation must strictly follow the national safety regulations in respect of the enclosure, mounting, creepage distances, clearances, markings and segregation requirements of the end-use application.

Connection to the system shall only be effected with cables with suitable section (primary and secondary connector in cage clamp technique).

The auxiliary connector shall be connected via the suitable female connector; see *Accessories*.

Other installation methods may not meet the safety requirements. Check that PE is safely connected to protective earth.

No fuse is incorporated in the converter (except for option F). An external circuit breaker or a fuse in the wiring to one or both input pins.

Do not open the converters, or the warranty will be invalidated. Make sure that there is sufficient airflow available for convection cooling and that the temperature of the bottom plate is within the specified range. This should be verified by measuring the case temperature at the specified measuring point, when the converter is operated in the end-use application. $T_{C\,max}$ should not be exceeded. Ensure that a failure of the converter does not result in a hazardous condition.

Standards and Approvals

The RCM Series converters are approved according to the last edition of IEC/EN 62368-1 and UL/CSA 62368-1.

They have been evaluated for:

- Class I equipment
- Building in
- Double or reinforced insulation based on 250 VAC or 240 VDC between input and output, and between input and OK signals (relay contacts)
- Pollution degree 2 environment

The converters are subject to manufacturing surveillance in accordance with the above mentioned safety standards and with ISO 9001:2015, IRIS ISO/TS 22163:2017 certified quality and business management system.

Cleaning Liquids and Protection Degree

The converters are not hermetically sealed. In order to avoid possible damage, any penetration of liquids shall be avoided. The converters correspond to protection degree IP 20.

RCM500E Series
500 W DC-DC Converter

Railway Applications

The RCM Series converters have been designed observing the railway standards EN 50155:2021, EN 50121-3-2:2016, EN 50124-1:2017 and AREMA. All boards are coated with a protective lacquer.

The converters comply with the fire & smoke standard EN 45545:2016, HL1 to HL3.

Insulation Test

The electric strength test is performed in the factory as routine test in accordance with EN 62911, EN 50155:2021 and AREMA. It should not be repeated in the field, and the Company will not honor warranty claims resulting from incorrectly executed electric strength tests.

Table 9: Isolation

Characteristics		Input to		Output to Case	OK contacts to			Unit
		Output [1]	Case + Output		Input	Case	Outputs	
Electric strength test	Factory test 10 s	4.48	2.86	2.86	4.48	2.86	2.86	kVDC
Insulation resistance		>300 [2]	>300 [2]	>300	>300	>300	>300	MΩ
Creepage distances		5.0	3.5	3.5	3.5	3.5	3.5	mm

[1] Pretest of subassemblies in accordance with IEC/EN 62368-1
[2] Tested at 500 VDC

ACCESSORIES

Female Connector

A suitable female auxiliary connector is available

• HZZ02021 (6 pins, Phoenix Contact 1790302)

Wire section: 0.2 – 1.5 mm², 24 – 16 AWG

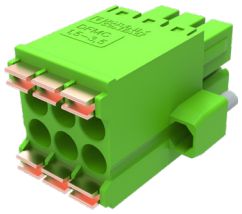


Fig. 13
Female connector 6 pins

For converters with option K, use:

• HZZ00303-G (3 poles, Weidmüller 1060580000)
• HZZ00302-G (2 poles, Weidmüller 1060550000)

Wire section: 0.5 – 10 mm², 24 – 8 AWG

Fig. 14
Female connectors used with option K

