



Description

The RCM500 and RCM1000 Series converters are reliable power supplies for railway and transportation systems. They are optimized for 110 V railway batteries. The output delivers 24 V with 500 or 1000 W. The converters are designed for chassis mounting and exhibit a closed housing with cooling slots.

Many options are available, such as an output ORing FET for redundant operation, output voltage adjustment, interruption time of 10 ms (class ST2), shutdown input, and a monitoring relay (change-over contact).

Features

- RoHS lead-free-solder product
- Optimized for 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 overload protection
- Many options available
- Compliant to EN 50155, EN 50121-3-2
- Protected against fire and smoke according to EN 45545

Safety-approved to EN 60950-1/A12:2011 and UL/CSA 60950-1 2nd Ed +A2



¹ pending



Preliminary

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Model Selection

Table 1: Model Selection

$V_{i\min}^1$ [V]	Input voltage			$V_{i\max}^1$ [W]	Output		Power P_{onom}	Efficiency ²		Model [V]	Options [V]
	$V_{i\text{cont}}$ [V]		[A]		V_{onom} [%]	I_{onom} [%]		η_{\min}	η_{typ}		
66	77	(110)	137.5	154	24	21	504		96	110RCM500-24	D, M, Q, F
					24	42	1008		96	110RCM1000-24	

¹ Short time; see table 2 for details

² Efficiency at $T_A = 25\text{ }^\circ\text{C}$, $V_{i\text{nom}}$, I_{onom} , V_{onom} , option D fitted.

Part Number Description

Operating input voltage $V_{i\text{cont}}$ (continuously):
 77 – 137.5 VDC 110

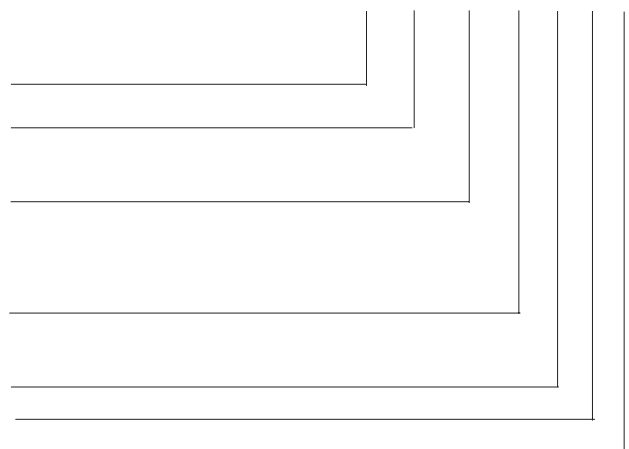
Series RCM

Output power:
 500 W 500
 1000 W 1000

Nominal output voltage:
 24 V -24

Auxiliary functions and options:
 Out OK, output voltage adjust, shutdown¹ D
 Interruption time M
 ORing FET Q
 Fuse F

110 RCM 500 -24 D M Q



¹ Opt. D requires an additional signal connector.

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

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

Example: 110RCM500-24DMQ: DC-DC converter, input voltage range 77 to 137.5 V continuously, output providing 24 V / 21 A, monitoring relay, output voltage adjust, shutdown input, active current sharing, interruption time 10 ms, integrated ORing FET, RoHS-compliant for all six substances.

Available combinations of options:

110RCMxxx-24	No option
110RCMxxx-24D	Basic model (railway)
110RCMxxx-24DF	Basic model (industrial)
110RCMxxx-24DMQ	Full model (railway)
110RCMxxx-24DMQF	Full model (industrial)

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 input voltage is fed via a high-efficient input filter and a step-up converter to the high efficient DC-DC converter with a switching frequency of approximately 135 kHz. The built-in overvoltage limiter protects against input voltage surges.

The inrush current is limited by an electronic circuitry. A VDR resistor protects against external surges.

If there is no external circuit breaker, it is possible to order the converter with built-in fuse (opt. F). Because this fuse is not accessible, a reverse polarity protection is incorporated (only with options F and M).

The circuitry to provide the interruption time (opt. M) is located after the input filter together with the reverse polarity protection formed by a FET.

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 switches the FETs of the DC-DC converter via isolated drivers.

An auxiliary converter supplies all circuits with a stable bias voltage.

An output ORing FET is available (opt. Q) and allows for a redundant power supply system.

Opt. D encompasses an additional signal connector to allow for output voltage adjust, active current sharing, primary shut-down, and an output voltage monitor activating a relay with a change-over contact.

The converter is mounted onto a base plate which acts as heat sink. A heatsink for air cooling is available as accessory. A thermal protection on the input and output side prevents from overheating.

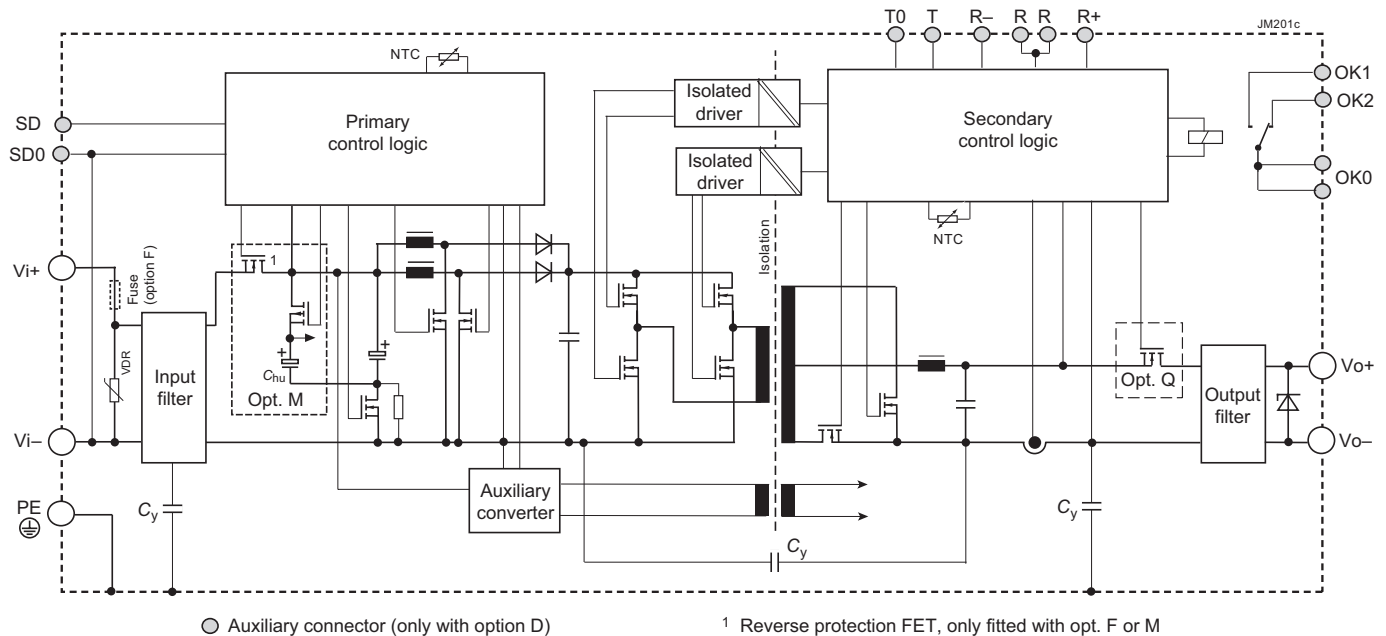


Fig. 1
Block diagram

Electrical Input Data

General Conditions:

- $T_A = 25\text{ }^\circ\text{C}$, unless T_C is specified.
- R input not connected

Table 2: Input data

Input			110RCM500-24			110RCM1000-24			Unit
Characteristics	Conditions		min	typ	max	min	typ	max	
V_i	Operating input voltage	$I_o = 0 - I_{o\text{max}}$ $T_{C\text{min}} - T_{C\text{max}}$	77	(110)	137.5	77	(110)	137.5	V
V_{i2s}	for $\leq 2\text{ s}$	without shutdown	66		154	66		154	
$V_{i\text{nom}}$	Nominal input voltage			110			110		
$V_{i\text{abs}}$	Input voltage limits	3 s without damage	0		165	0		165	
I_i	Typical input current	$V_{i\text{nom}}, I_{o\text{nom}}$		4.8			9.5		A
P_{i0}	No-load input power	$V_{i\text{min}} - V_{i\text{max}}, I_o = 0$		2.5	4		3	4	W
$P_{i\text{SD}}$	Idle input power	$V_{i\text{min}} - V_{i\text{max}}, V_{\text{SD}} = 0\text{ V}$		2.5	4		3	4	
C_i	Input capacitance ¹						10		μF
R_i	Input resistance								$\text{m}\Omega$
I_{inrp}	Peak inrush current	$V_i = 137.5\text{ V}, I_{o\text{nom}}$			20			40	A
t_{inrd}	Duration of inrush current								
t_{on}	Start-up time at switch on	$0 \rightarrow V_{i\text{min}}, I_{o\text{nom}}$			1000			1000	ms
	Start-up time after removal of shutdown	$V_{i\text{min}} \geq 77\text{ V}, I_{o\text{nom}}$ $V_{\text{SD}} = 0 \rightarrow 5\text{ V}$			300			300	

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

Input Transient and Reverse Polarity Protection

A VDR resistor 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 external input circuit breaker or fuse will trip. If the fuse is incorporated (options F and M), 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.

Efficiency

See fig. 2.

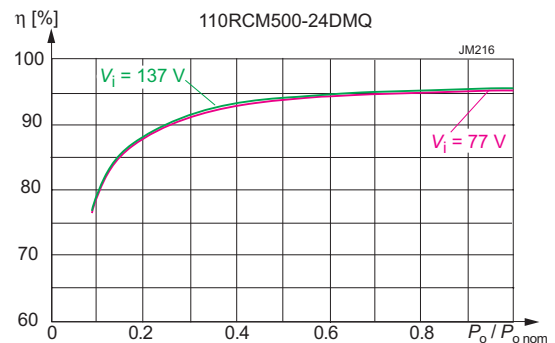


Fig. 2a
Efficiency versus V_i and P_o (110RCM500-24DMQ)

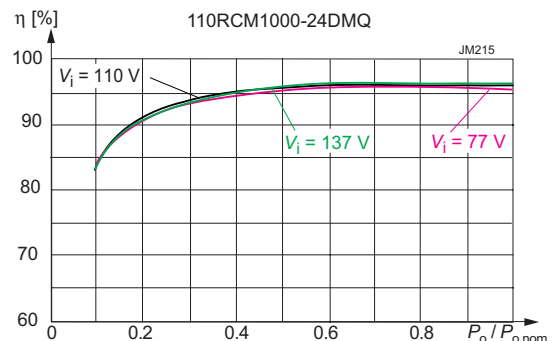


Fig. 2b
Efficiency versus V_i and P_o (110RCM1000-24DMQ)

Electrical Output Data

General Conditions:

- $T_A = 25^\circ\text{C}$, unless T_C is specified.
- R input not connected

Table 4: Output data

Output			110RCM500-24			110RCM1000-24			Unit
Characteristics		Conditions	min	typ	max	min	typ	max	
V_o	Output voltage ¹	$V_{i\text{nom}}, 0.5 I_{o\text{nom}}$	23.76	24	24.24	23.76	24	24.24	V
V_{ow}	Worst case output voltage	$V_{i\text{min}} - V_{i\text{max}}$ $T_{C\text{min}} - T_{C\text{max}}, 0 - I_{o\text{nom}}$	23.28		24.72	23.28		24.72	
V_{odroop}	Voltage droop			-10			-5		mV/A
V_{oP}	Overvoltage protection ²		28.5	30	31.5	28.5	30	31.5	V
V_{oL}	Overvoltage shutdown ⁶			28			28		V
$I_{o\text{nom}}$	Nominal output current			21			42		A
I_{oL}	Output current limit	$T_{C\text{min}} - T_{C\text{max}}$	23			45			
V_o	Output noise ³	Switch. frequ.			240		240		mV _{pp}
		Total incl.spikes	$V_{i\text{nom}}, I_{o\text{nom}}$ BW = 20 MHz		480		480		
V_{od}	Dynamic load regulation	Voltage deviation ⁵							
t_d ⁴		Recovery time							ms
α_{V_o}	Temp. coefficient of V_o (NTC)	$0 - I_{o\text{nom}}, T_{C\text{min}} - T_{C\text{max}}$	-0.02		0	-0.02		0	%/K

- 1 If the output voltage is increased above $V_{o\text{nom}}$ through R-input control, the output power should be reduced accordingly, so that $P_{o\text{max}}$ and $T_{C\text{max}}$ are not exceeded.
- 2 Breakdown voltage of the incorporated suppressor diode at 1 mA . Exceeding this value might damage the suppressor diode.
- 3 Measured according to IEC/EN 61204 with a probe described in annex A
- 4 Recovery time until V_o returns to $\pm 1\%$ of V_o ; see fig. 3.
- 5 No overshoot at switch on.
- 6 Output overvoltage protection by an electronic circuitry.

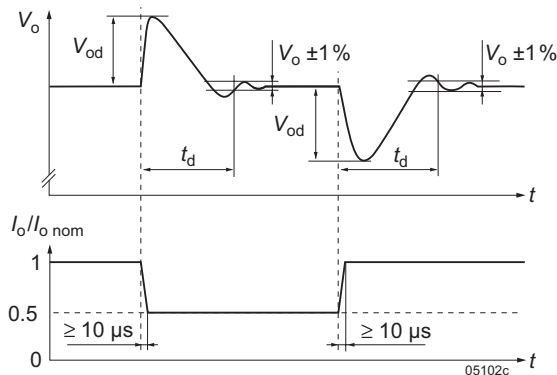


Fig.3
Typical dynamic load regulation of output voltage

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.

Parallel and Series Connection and Redundancy

The outputs of max. 5 RCM Series converters may be connected in series without restrictions.

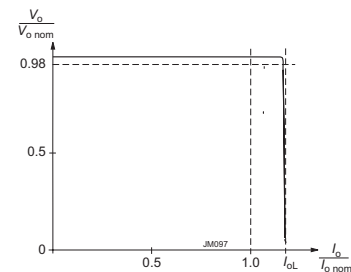


Fig. 4
Rectangular current limitation of single-output models

Converters with option D exhibit an additional pin T to provide active current sharing by simply interconnecting these pins. To ensure proper current sharing, the load lines should have equal length and section. For redundant systems, we recommend option Q.

The output voltage tends to be lowered with increasing temperature.

LED Indicator

The converters exhibit a green LED "Out OK", signaling that the output voltage is within the specified range.

Description of Options

Option D: Output Monitor, Output Adjust, Shutdown

Option D consists of several auxiliary functions and encompasses an additional auxiliary connector.

Output Voltage Adjust (R)

Note: With open R-input, $V_o = V_{o\ nom}$.

The converter allows for adjusting the output voltage in the range of 80 to 105% of $V_{o\ nom}$. The adjust is accomplished by an external resistor R_{ext1} or R_{ext2} , connected to the R-input; see fig. 5.

Depending on the value of the required output voltage, the resistor shall be connected:

either: Between the R-pin and R- to adjust the output voltage to a value below $V_{o\ nom}$:

$$R_{ext1} \approx 4\ \text{k}\Omega \cdot \frac{V_o}{V_{o\ nom} - V_o} - 15.8\ \text{k}\Omega$$

Note: $R_{ext1} = 0\ \Omega$ reduces V_o to 80%.

or: Between the R-pin and R+ to adjust the output voltage to a value greater than $V_{o\ nom}$:

$$R_{ext2} \approx 4\ \text{k}\Omega \cdot \frac{(V_o - 2.5\ \text{V})}{2.5\ \text{V} \cdot (V_o/V_{o\ nom} - 1)} - 682\ \text{k}\Omega$$

Note: $R_{ext2} = 0\ \Omega$ increases V_o to 105%.

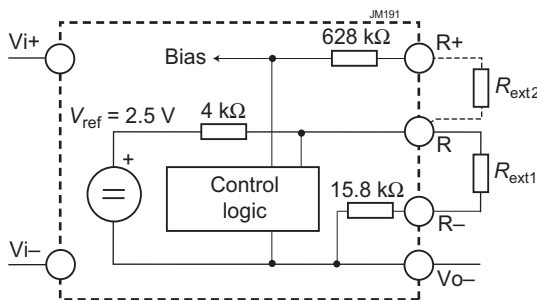


Fig. 5
Output voltage control via R-input

Output Voltage Monitor (D)

The output voltage V_o is monitored. When V_o is in range, a relay with a changeover contact connected to the auxiliary connector is activated.

Note: The trigger levels are typ. $\pm 5\%$ of $V_{o\ nom}$ (with open R-input).

Data of relay contacts: 0.4 A / 150 VDC or 10 A / 250 VAC.

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:	10 to 154 V 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.

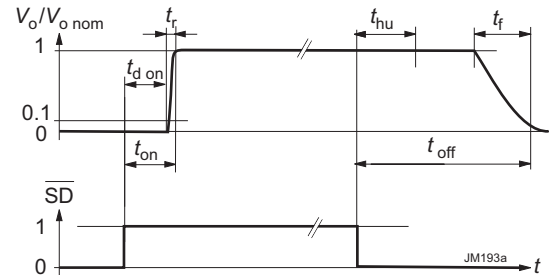


Fig. 6
Typical output response to the SD-signal. If option M is not fitted, $t_{hu} = 0$.

Option M: Interruption Time

The interruption time t_{hu} is specified in the railway standard EN 50155 clause 5.1.1.3: 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. 6 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.

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 and a negative temperature coefficient are helpful as well.

To keep the losses as small as possible, the ORing diode is replaced by a FET. The voltage drop is approx. 22 mV (not dependent on I_o).

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

The railway standard EN 50155 bans fuses in the converters. Consequently, the installer must preview an external fuse or circuit breaker.

However, when this is not possible, we offer an incorporated fuse together with a reverse polarity protection formed by a

FET device. The fuse is not accessible and will not trip, unless the converter is really defect. The type of fuses are specified in table 5.

Table 5: Recommended for external fuses (also opt. F)

Converter	Fuse specification	Ordering number
110RCM500-24	12 A, fast acting	Littlefuse 0505012.MX52LEP
110RCM1000-24	25 A fast acting	Littlefuse 0505025.MX52LEP

Electromagnetic Compatibility (EMC)

Electromagnetic Immunity

Table 6: Electromagnetic immunity (type tests)

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 ³	contact discharge	6000 V _p	1/50 ns	330 Ω	10 positive and 10 negative discharges	yes	A
			air discharge	8000 V _p					
Electromagnetic field	IEC/EN 61000-4-3	x ⁴	antenna	20 V/m	AM 80% /1 kHz	n.a.	80 – 800 MHz	yes	A
		5	antenna	20 V/m	AM 80% /1 kHz	n.a.	800 – 1000 MHz	yes	A
				10 V/m			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 ⁶	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 ⁹	i/c	±2000 V _p	1.2/50 μs	42 Ω 0.5 μF	5 pos. and 5 neg. surges per coupling mode	yes	A
			+i/-i	±1000 V _p					
Conducted disturbances	IEC/EN 61000-4-6	3 ¹⁰	i, o, signal wires	10 VAC (140 dBμV)	AM 80% 1 kHz	150 Ω	0.15 – 80 MHz	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 Exceeds EN 50121-3-2:2015 table 6.3

⁴ Corresponds to EN 50121-3-2:2015 table 6.1

⁵ Corresponds to EN 50121-3-2:2015 table 6.2 (compliance with digital mobile phones).

⁶ Corresponds to EN 50121-3-2:2015 table 5.2

⁹ Covers or exceeds EN 50121-3-2:2015 table 4.3

¹⁰ Corresponds to EN 50121-3-2:2015 table 5.1(radio frequency common mode).

Electromagnetic Emissions

The conducted emissions (fig. 9) have been tested according to EN 55011 (similar to EN 55022, much better values than requested by EN 50121-3-2:2015, table 1.1). The limits in fig. 8 and 9 apply to quasipeak values, which are always lower than peak values.

Radiated emissions have been tested according to EN 55011 (similar to EN 55022), class A, as requested in EN 50121-3-2:2015, table 3.1. The test is executed with horizontal and vertical polarization. The worse result is shown in fig. 10.



Fig. 7a
110RCM500-24: Typ. conducted disturbances at the input ($V_i=110\text{ V}$, $I_{i\text{ nom}}$, resistive load, quasi peak and average).

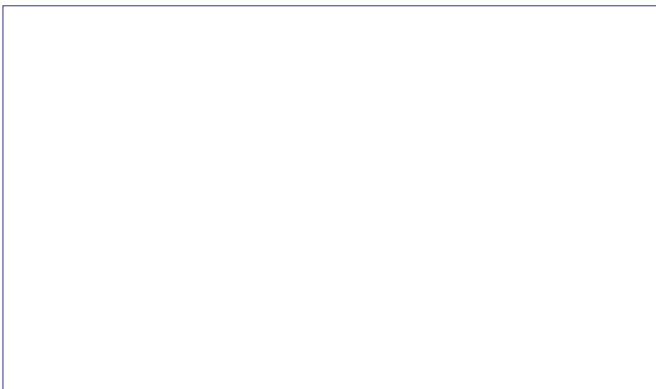


Fig. 7b
110RCM500-24: Typ. radiated disturbances in 10 m distance ($V_i=110\text{ V}$, $I_{i\text{ nom}}$, resistive load, quasi peak).

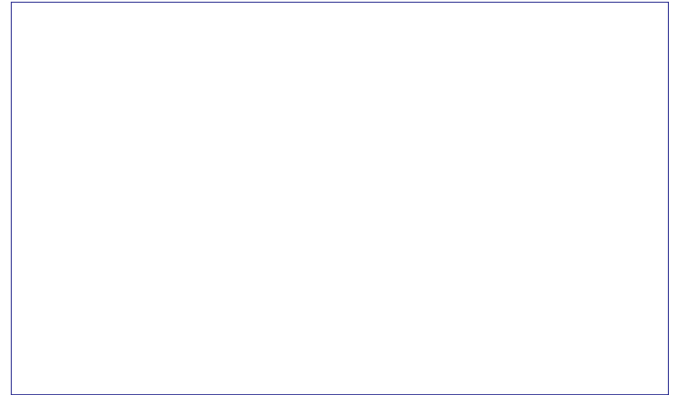


Fig. 8a
110RCM1000-24: Typ. conducted disturbances at the input ($V_i=110\text{ V}$, $I_{i\text{ nom}}$, resistive load, quasi peak and average).

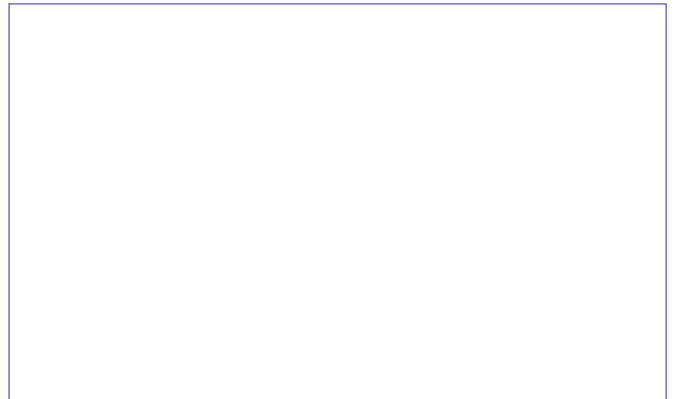


Fig. 8b
110RCM1000-24: Typ. radiated disturbances in 10 m distance ($V_i=110\text{ V}$, $I_{i\text{ nom}}$, resistive load, quasi peak).

Immunity to Environmental Conditions

Table 7: Mechanical and climatic stress. Air pressure 800 – 1200 hPa

Test method	Standard	Test conditions	Status
Db Damp heat test, cyclic	EN 50155:2007, clause 12.2.5 IEC/EN 60068-2-30	Temperature: 55 °C and 25 °C Cycles (respiration effect): 2 Duration: 2× 24 h	Converter not operating
Bd Dry heat test steady state	EN 50155:2007, clause 12.2.4 IEC/EN 60068-2-2	Temperature: 70 °C Duration: 6 h	Converter operating
Ad Cooling test steady state	EN 50155:2007, clause 12.2.3 IEC/EN 60068-2-1	Temperature, duration Performance test –40 °C, 2 h +25 °C	Conv. not operating
-- Low temperature storage test	EN 50155:2007, clause 12.2.14 IEC/EN 60068-2-1	Temperature, duration then start-up –40 °C, 16 h	Conv. not operating
Ka ¹ Salt mist test sodium chloride (NaCl) solution	EN 50155:2007, clause 12.2.10 IEC/EN 60068-2-11 class ST2	Temperature: 35±2°C Duration: 16 h	Converter not operating
-- Shock	EN 50155:2007 clause 12.2.11 EN 61373 sect. 10, class B, body mounted ²	Acceleration amplitude: 5.1 g _n Bump duration: 30 ms Number of bumps: 18 (3 in each direction)	Converter operating
-- Simulated long life testing at increased random vibration levels	EN 50155:2007 clause 12.2.11 EN 61373 sect. 8 and 9, class B, body mounted ²	Acceleration spectral density: 0.02 g _n ² /Hz Frequency band: 5 – 150 Hz Acceleration magnitude: 0.8 g _{n,rms} Test duration: 15 h (5 h in each axis)	Converter operating

¹ This test is not mandatory in EN 50155. It was not yet executed.

² Body mounted = chassis of a railway coach

Temperatures

Table 8: Temperature specifications, valid for an air pressure of 800 – 1200 hPa (800 – 1200 mbar)

Temperature		EN 50155 Class T2			EN 50155 Class TX ¹			Unit
Characteristics	Conditions	min	max	10 min	min	max	10 min	
T _A	Ambient temperature	–40	55	70	–40	70	85	°C
T _C	Case temperature ^{2 3}							
T _S	Storage temperature	–55	85		–55	85	t.b.d. ^{2 3}	

¹ Output power reduced

² Over temperature shutdown

³ Measured at the measurement point T_C; see *Mechanical Data*.

Reliability

Table 9: MTBF and device hours

Ratings at specified case temperature between failures ¹	Model	MTBF	Demonstrated hours
Accord. to IEC 62380	110RCM1000-24		

¹ Statistical values, based upon an average of 4300 working hours per year and in general field use over 5 years; upgrades and customer-induced errors are excluded.

Safety and Installation Instructions

Connectors and Pin Allocation

- Input connector, 3 pins: Wago 745-353: Vi+, Vi-, PE; recommended wire sections:
RCM500: 2 – 6 mm², 14 – 10 AWG;
RCM1000: 3.3 – 6 mm², 12 – 10 AWG;
- Output connector, 2 pins: Wago 745-652/006-000: Vo+, Vo-; recommended wire sections:
RCM500: 3.3 – 13 mm², 12 – 06 AWG;
RCM1000: 5 – 13 mm², 10 – 06 AWG;
- Auxiliary connector: Phoenix Contact 1874043; recommended wire section: 0.2 – 1.5 mm², 24 – 16 AWG;

R+	R-	T	n.c.	OK1	OK2	n.c.	SD
R	R	T0	n.c.	OK0	OK0	n.c.	SD0

Fig. 9:
Auxiliary connector pin allocation

Installation Instructions

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.

Table 11: Isolation

Characteristic		Input to		Output to case	Relay contacts to			Unit
		output ¹	case+output		input	case	output	
Electric strength test	Factory test >1 s	4.2	2.86	1.0	2.86	2.86	2.86	kVDC
	AC test voltage equivalent to actual factory test	3.0	2.0	0.7	2.0	2.0	2.0	kVAC
Insulation resistance		>300 ²	>300 ²	>100	>300	>300	>300	MΩ
Creepage distances		5.0	3.5	1.5	3.5	3.5	3.5	mm

¹ Pretest of subassemblies in accordance with IEC/EN 60950

² Tested at 500 VDC

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 safety standards IEC/EN 60950-1 and UL/CSA 60950-1 2nd Ed.

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 UL standards and with ISO 9001:2008.

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.

Railway Applications

The RCM Series converters have been designed observing the railway standards EN 50155:2007 and EN 50121:2015. All boards are coated with a protective lacquer. The converters comply with the fire & smoke standard EN 45545, HL1 to HL3.

Isolation

The electric strength test is performed in the factory as routine test in accordance with EN 50514 and IEC/EN 60950 and should not be repeated in the field. The Company will not honor warranty claims resulting from incorrectly executed electric strength tests.



Mechanical Data

Dimensions in mm.

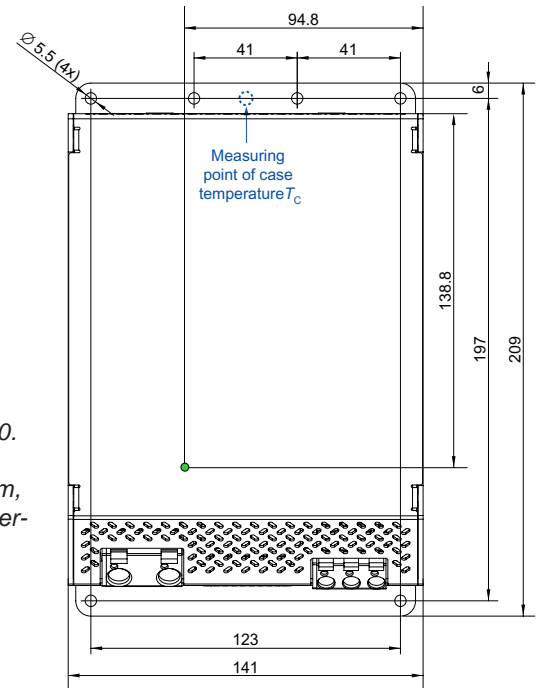
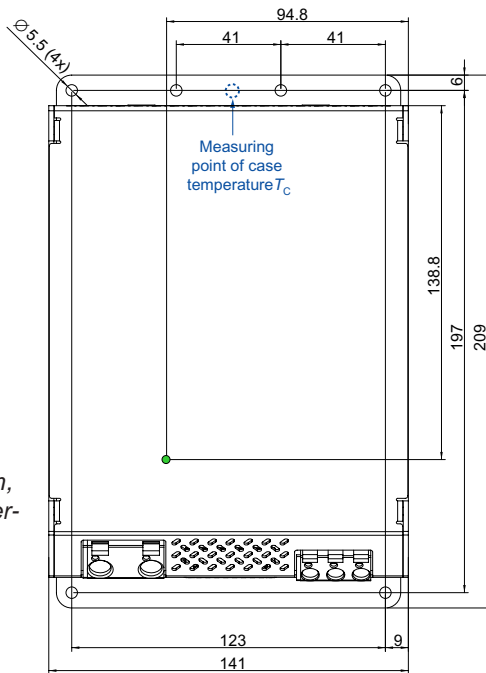
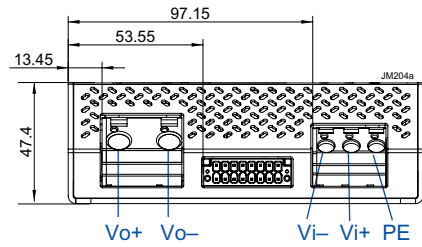
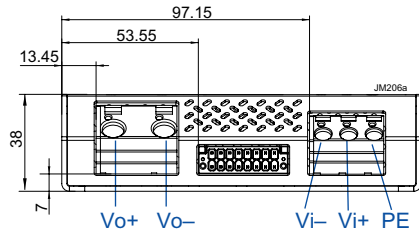


Fig. 10
Case for
RCM500.
RCM03,
Aluminum,
EP powder-
coated.

Fig. 11
Case for
RCM1000.
RCM04,
Aluminum,
EP powder-
coated.

Accessories

Female Connector

A suitable 16 pin female connector (HZZ00146-G). is available.

NUCLEAR AND MEDICAL APPLICATIONS - These products are not designed or intended for use as critical components in life support systems, equipment used in hazardous environments, or nuclear control systems.

TECHNICAL REVISIONS - The appearance of products, including safety agency certifications pictured on labels, may change depending on the date manufactured. Specifications are subject to change without notice.

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