

DC/DC CONVERTER

- EN 50155 Railway Compliant
- Conformal Coated PC-boards
- Quick-connect Spring-clamp Terminals
- 77-154Vdc Wide-range Input
- Width only 40mm
- Efficiency up to 91.1%
- Excellent Partial Load Efficiency
- Minimal Inrush Current Surge
- Full Power Between -25°C and +70°C
- DC-OK Relay Contact
- Reverse Input Polarity Protected
- 3 Year Warranty

GENERAL DESCRIPTION

The QS5.241-60 DC/DC converter is designed specifically for railway & transportation applications. It is approved according to the EN 50155 standard, which is an international standard covering electronic equipment used on rolling stock for railway applications. The standard covers aspects such as temperature, humidity, shock, vibration, EMI and other parameters. Because of these requirements, the unit is equipped with conformal coated pc-boards.

The unit features a DC-OK signal contact for remote monitoring, and quick-connect spring-clamp terminals for a reliable connection even when mechanical vibration and shock are involved. The unit also covers an extreme wide temperature range from -25°C up to +70°C with full output current.

This DC/DC converter comes in a very compact housing and requires only 40mm space on the DIN-rail due to the high efficiency and low power losses. The high efficiency is achieved by utilizing cutting edge technology and other unique design techniques.

SHORT-FORM DATA

Output voltage	DC 24V	
Adjustment range	24 - 28V	
Output current	4.2 – 3.6A	continuous
	6.3 – 5.4A	for typ. 4s
Output power	100W	continuous
	150W	for typ. 4s
Output ripple	max. 50mVpp	20Hz to 20MHz
AC Input voltage	-	-
DC Input voltage	DC 110V	- 30%/ +40%
DC Input current	1.0A	at 110Vdc
Inrush current	typ. 10A peak	at 110Vdc
Efficiency	91.1%	at 110Vdc
Losses	9.8W	at 110Vdc
Temperature range	-25°C to +70°C	operational
Derating	-	not required
Hold-up time	typ. 42ms	at 110Vdc
Dimensions	40x124x117mm	WxHxD
Weight	640g / 1.41lb	

ORDER NUMBERS

DC/DC converter **QS5.241-60**

Accessory	ZM12.SIDE	Side mount bracket
	YR2.DIODE	Redundancy module
	UF20.241	Buffer module

MARKINGS



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TERMINOLOGY AND ABBREVIATIONS

PE and \oplus symbol	PE is the abbreviation for Protective Earth and has the same meaning as the symbol \oplus .
Earth, Ground	This document uses the term "earth" which is the same as the U.S. term "ground".
T.b.d.	To be defined, value or description will follow later.
DC 110V	A figure displayed with the AC or DC before the value represents a nominal voltage with standard tolerances (usually $\pm 15\%$) included. E.g.: DC 12V describes a 12V battery disregarding whether it is full (13.7V) or flat (10V)
110Vdc	A figure with the unit (Vdc) at the end is a momentary figure without any additional tolerances included.
may	A key word indicating flexibility of choice with no implied preference.
shall	A key word indicating a mandatory requirement.
should	A key word indicating flexibility of choice with a strongly preferred implementation.

1. INTENDED USE

This device is designed for installation in an enclosure and is intended for the general professional use such as in rolling stock for railway applications or in industrial control, office, communication, and instrumentation equipment. Do not use this DC/DC converter in equipment, where malfunction may cause severe personal injury or threaten human life.

2. INSTALLATION REQUIREMENTS

This device may only be installed and put into operation by qualified personnel.

This device does not contain serviceable parts. The tripping of an internal fuse is caused by an internal defect.

If damage or malfunction should occur during installation or operation, immediately turn power off and send unit to the factory for inspection.

Mount the unit on a DIN-rail so that the input terminals are located on the bottom of the unit. For other mounting orientations see de-rating requirements in this document. See chapter 23.11.

This device is designed for convection cooling and does not require an external fan. Do not obstruct airflow and do not cover ventilation grid (e.g. cable conduits) by more than 15%!

Keep the following installation clearances: 40mm on top, 20mm on the bottom, 5mm on the left and right sides are recommended when the device is loaded permanently with more than 50% of the rated power. Increase this clearance to 15mm in case the adjacent device is a heat source (e.g. another power supply).

⚠ WARNING Risk of electrical shock, fire, personal injury or death.

- Do not use the DC/DC converter without proper grounding (Protective Earth). Use the terminal on the input block for earth connection and not one of the screws on the housing.
- Turn power off before working on the device. Protect against inadvertent re-powering.
- Make sure that the wiring is correct by following all local and national codes.
- Do not modify or repair the unit.
- Do not open the unit as high voltages are present inside.
- Use caution to prevent any foreign objects from entering the housing.
- Do not use in wet locations or in areas where moisture or condensation can be expected.
- Do not touch during power-on, and immediately after power-off. Hot surfaces may cause burns.

3. AC-INPUT

Do not operate this DC/DC converter with an AC-input voltage. Use the QS10.241 or QS10.241-C1 unit instead.

4. DC-INPUT

Use a battery or a similar DC source. A supply from the intermediate DC-bus of a frequency converter is not recommended and can cause a malfunction or damage the unit.

Input voltage	nom.	DC 110V	-30%/+40%
Input voltage range		77-154Vdc 66-77Vdc	short term for 100ms
Input current	typ.	1.0A	at 8.3A and 110Vdc input voltage, see Fig. 4-3
Allowed voltage between input to earth (ground)	max.	375Vdc	continuous, IEC 62103
		± 600V	peak value, allowed for transients
Slew rate for voltage between input to earth (ground)	max.	1000V/μs	
Allowed input ripple voltage	max.	15Vpp 3Vpp	50Hz – 10kHz 10kHz – 50kHz
Turn-on voltage	typ.	73Vdc	steady-state value, at ambient temperatures between -20°C and +70°C, see Fig. 4-1
Shut-down voltage	typ.	63Vdc	steady-state value, see Fig. 4-1
Start-up delay	typ.	120ms	see Fig. 4-2
Rise time	typ.	18ms	at 4.2A constant current load, 0mF load capacitance, see Fig. 4-2
	typ.	38ms	at 4.2A constant current load, 5mF load capacitance, see Fig. 4-2
Turn-on overshoot	max.	100mV	see Fig. 4-2
External input protection	See recommendations in chapter 23.4.		

Fig. 4-1 Input voltage range

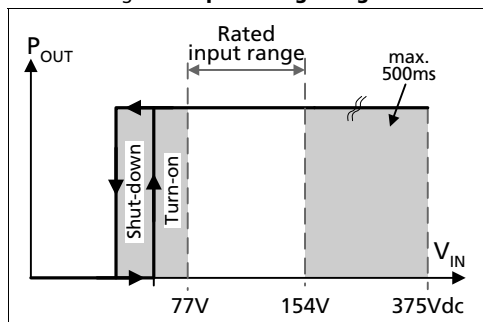


Fig. 4-2 Turn-on behavior, definitions

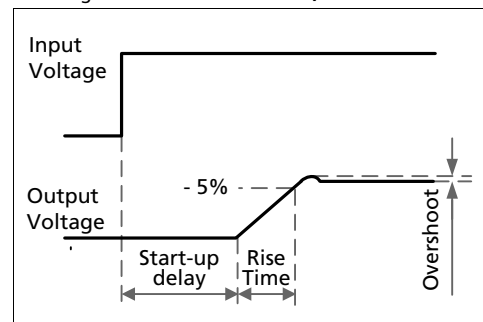
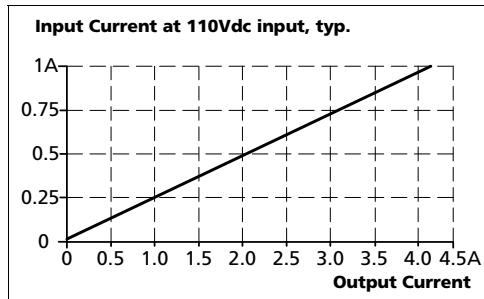


Fig. 4-3 **Input current vs. output load at 24V output voltage**

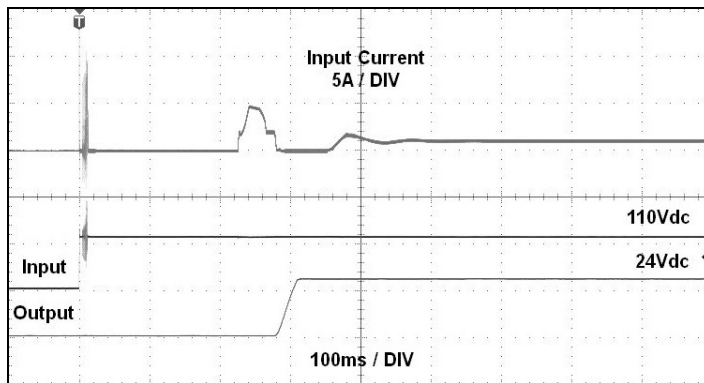


5. INPUT INRUSH CURRENT

An active inrush limitation circuit limits the input inrush current after turn-on of the input voltage. The charging current into EMI suppression capacitors is disregarded in the first microseconds after switch-on.

Inrush current	max.	20A _{peak}	at 110Vdc, temperature independent
	typ.	10A _{peak}	at 110Vdc, temperature independent
Inrush energy	max.	1A ² s	at 110Vdc, temperature independent

Fig. 5-1 **Typical input inrush current behaviour at nominal load and 25°C ambient**



6. OUTPUT

Output voltage	nom.	24V	
Adjustment range	min.	24-28V	guaranteed
	max.	30V ***)	at clockwise end position of potentiometer
Factory setting	typ.	24.1V	±0.2%, at full load, cold unit
Line regulation	max.	20mV	77-154Vdc
Load regulation	max.	100mV	static value, 0A → 4.2A
Ripple and noise voltage	max.	50mVpp	20Hz to 20MHz, 50Ohm
Output current	nom.	4.2A	continuously available at 24V, see Fig. 6-1
	nom.	3.6A	continuously available at 28V, see Fig. 6-1
	nom.	6.3A *)	short term available BonusPower® *) at 24V, for typical 4s, see Fig. 6-1
	nom.	5.4A *)	short term available BonusPower® *) at 28V, for typical 4s, see Fig. 6-1
Output power	nom.	100W	continuously available
	nom.	150W *)	short term available BonusPower® *)
BonusPower® time	typ.	4s	duration until the output voltage dips, see Fig. 6-2
	min.	3s	
	max.	5s	
BonusPower® recovery time	typ.	7s	overload free time to reset power manager, see Fig. 6-3
Overload behaviour	cont. current		
Short-circuit current	min.	4A **)	continuous, load impedance 100mOhm, see Fig. 6-1
	max.	7A **)	continuous, load impedance 100mOhm, see Fig. 6-1
	min.	8A **)	during BonusPower® *)
	max.	13A **)	during BonusPower® *)
	max.	7A **)	continuous, load impedance <10mOhm, see Fig. 6-1
Output capacitance	typ.	3 500µF	included inside the power supply

*) BonusPower®, short term power capability (up to typ. 4s)
The power supply is designed to support loads with a higher short-term power requirement without damage or shutdown. The short-term duration is hardware controlled by an output power manager. This BonusPower® is repeatedly available. Detailed information can be found in chapter 23.1. If the power supply is loaded longer with the BonusPower® than shown in the Bonus-time diagram (see Fig. 6-2), the max. output power is automatically reduced to 100W.

***) Discharge current of output capacitors is not included.

**) This is the maximum output voltage which can occur at the clockwise end position of the potentiometer due to tolerances. It is not a guaranteed value, which can be achieved. The typical value is about 28.6V.

Fig. 6-1 Output voltage vs. output current, typ.

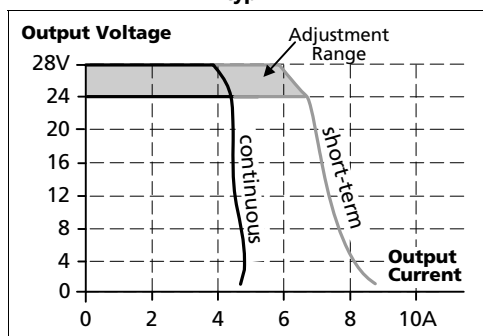


Fig. 6-2 Bonus time vs. output power

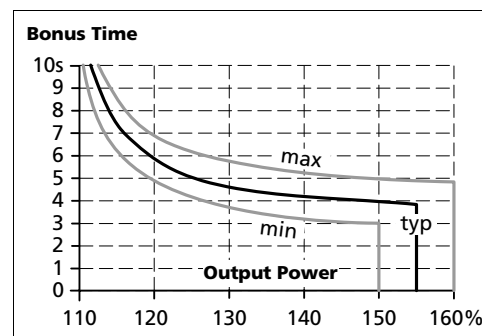
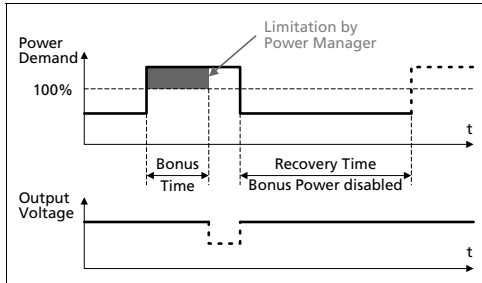


Fig. 6-3 **BonusPower® recovery time**



The BonusPower® is available as soon as power comes on and immediately after the end of an output short circuit or output overload.

Fig. 6-4 **BonusPower® after input turn-on**

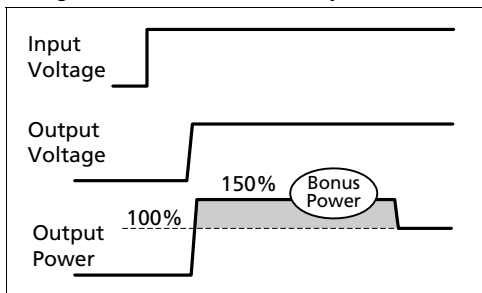
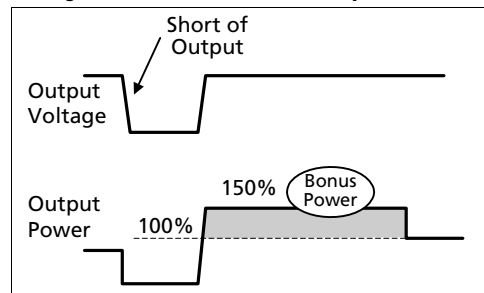


Fig. 6-5 **BonusPower® after output short**



7. HOLD-UP TIME

The internal capacitor, which supplies the energy for the hold-up time is isolated by a diode to the input voltage. A short on the input line does not discharge the internal hold-up capacitor.

Hold-up Time	typ.	83ms	at 2.1A, see Fig. 7-1
	min.	59ms	at 2.1A, see Fig. 7-1
	typ.	42ms	at 4.2A, see Fig. 7-1
	min.	30ms	at 4.2A, see Fig. 7-1

Fig. 7-1 Hold-up time vs. input voltage

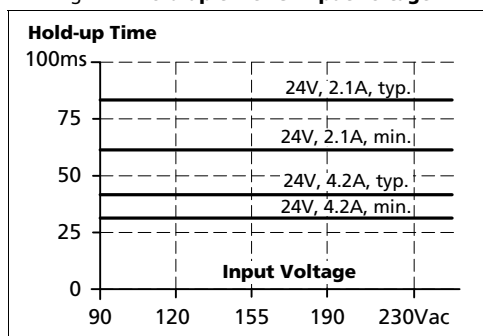
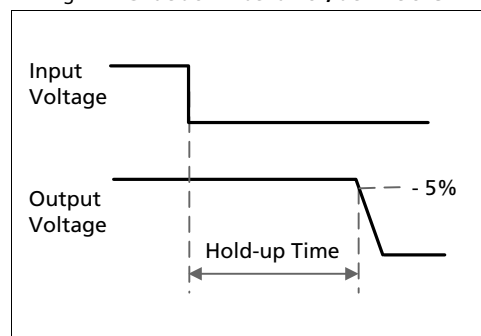


Fig. 7-2 Shut-down behavior, definitions

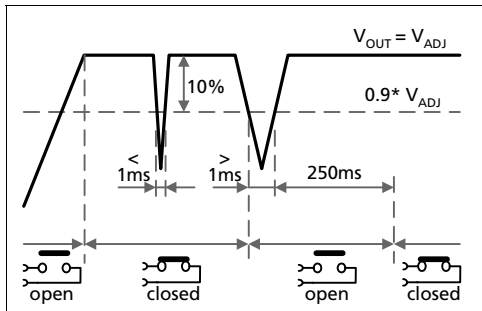


8. DC-OK RELAY CONTACT

This feature monitors the output voltage, which is produced by the DC/DC converter itself. It is independent of a backed voltage from a unit connected in parallel to the DC/DC converter output.

Contact closes	As soon as the output voltage reaches the adjusted output voltage level.		
Contact opens	As soon as the output voltage dips more than 10% below the adjusted output voltage. Short dips will be extended to a signal length of 250ms. Dips shorter than 1ms will be ignored.		
Contact re-closes	As soon as the output voltage exceeds 90% of the adjusted voltage.		
Contact ratings	max	60Vdc 0.3A, 30Vdc 1A, 30Vac 0.5A	resistive load
	min	1mA at 5Vdc	min. permissible load
Isolation voltage	See dielectric strength table in section 18.		

Fig. 8-1 DC-ok relay contact behavior



Note:

The DC-ok feature requires that the output voltage reaches the nominal (=adjusted) level after turn-on in order to function according to specification. If this level cannot be achieved, the overload lamp will be on and the DC-ok contact will be open. The overload signal will only shut off as soon as the adjusted voltage is reached. This is an important condition to consider particularly, if the load is a battery, the power supply is used in parallel or the power supply is used for N+1 redundant systems.

9. EFFICIENCY AND POWER LOSSES

Efficiency	typ.	91.1%	at 110Vdc input and 24V, 4.2A
Average efficiency ^{*)}	typ.	88.9%	25% at 1.05A, 25% at 2.1A, 25% at 3.15A, 25% at 4.2A
Power losses	typ.	4.0W	at 110Vdc input and 24V, 0A
	typ.	6.5W	at 110Vdc input and 24V, 2.1A (= 50% load)
	typ.	9.8W	at 110Vdc input and 24V, 4.2A

*) The average efficiency is an assumption for a typical application where the DC/DC converter is loaded with 25% of the nominal load for 25% of the time, 50% of the nominal load for another 25% of the time, 75% of the nominal load for another 25% of the time and with 100% of the nominal load for the rest of the time.

Fig. 9-1 Efficiency vs. output current, at 24V, typ.

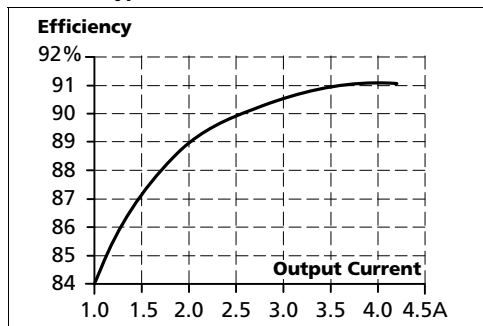
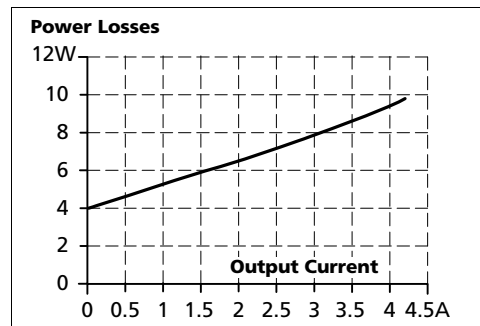


Fig. 9-2 Losses vs. output current, at 24V, typ.



10. LIFETIME EXPECTANCY AND MTBF

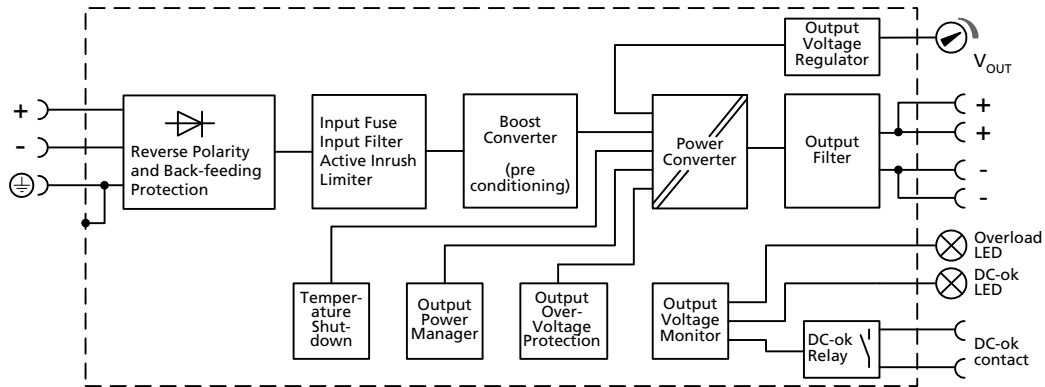
Lifetime expectancy ^{*)}	196 000h ^{*)}	at 24V, 2.1A and 40°C
	535 000h ^{*)}	at 24V, 2.1A and 25°C
	127 000h ^{*)}	at 24V, 4.2A and 40°C
	360 000h ^{*)}	at 24V, 4.2A and 25°C
MTBF ^{**) SN 29500, IEC 61709}	956 000h	at 24V, 4.2A and 40°C
	1 619 000h	at 24V, 4.2A and 25°C
MTBF ^{**) MIL HDBK 217F}	382 000h	at 24V, 4.2A and 40°C, Ground Benign GB40
	515 000h	at 24V, 4.2A and 25°C, Ground Benign GB25
	87 000h	at 24V, 4.2A and 40°C, Ground Fixed GF40
	115 000h	at 24V, 4.2A and 25°C, Ground Fixed GF25

*) The **Lifetime expectancy** shown in the table indicates the minimum operating hours (service life) and is determined by the lifetime expectancy of the built-in electrolytic capacitors. Lifetime expectancy is specified in operational hours and is calculated according to the capacitor's manufacturer specification. The manufacturer of the electrolytic capacitors only guarantees a maximum life of up to 15 years (131 400h). Any number exceeding this value is a calculated theoretical lifetime which can be used to compare devices.

) **MTBF stands for **Mean Time Between Failure**, which is calculated according to statistical device failures, and indicates reliability of a device. It is the statistical representation of the likelihood of a unit to fail and does not necessarily represent the life of a product. The MTBF figure is a statistical representation of the likelihood of a device to fail. A MTBF figure of e.g. 1 000 000h means that statistically one unit will fail every 100 hours if 10 000 units are installed in the field. However, it can not be determined if the failed unit has been running for 50 000h or only for 100h.

11. FUNCTIONAL DIAGRAM

Fig. 11-1 Functional diagram



12. TERMINALS AND WIRING

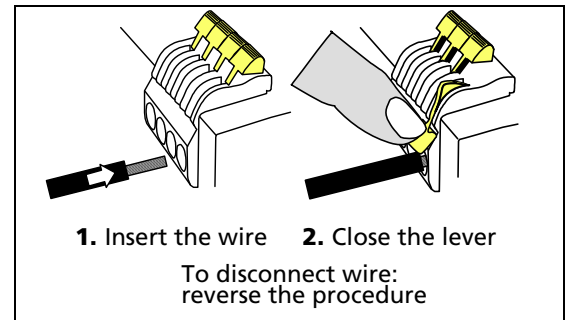
The terminals are IP20 finger safe constructed and suitable for field- and factory wiring. Shipped in open position.

Type	Input	Output	DC-OK-Signal
	Bi-stable, spring-clamp terminals	Bi-stable, spring-clamp terminals	Bi-stable, spring-clamp terminals
Solid wire	max. 6mm ²	max. 4mm ²	max. 4mm ²
Stranded wire	max. 4mm ²	max. 2.5mm ²	max. 2.5mm ²
American Wire Gauge	20-10 AWG	26-12 AWG	26-12 AWG
Wire stripping length	10mm / 0.4inch	6mm / 0.25inch	6mm / 0.25inch
Screwdriver	not applicable	not applicable	not applicable
Recommended tightening torque	not applicable	not applicable	not applicable

Instructions:

- Use appropriate copper cables that are designed for minimum operating temperatures of:
 60°C for ambient up to 45°C and
 75°C for ambient up to 60°C minimum
 90°C for ambient up to 70°C minimum.
- Follow national installation codes and installation regulations!
- Ensure that all strands of a stranded wire enter the terminal connection!
- Do not use the unit without PE connection.
- Ferrules are allowed.

Fig. 12-1 Connecting a wire



Daisy chaining:

Daisy chaining (jumping from one DC/DC converter output to the next) is allowed as long as the average output current through one terminal pin does not exceed 13A. If the current is higher, use a separate distribution terminal block as shown in Fig. 12-3.

Fig. 12-2 Daisy chaining of outputs

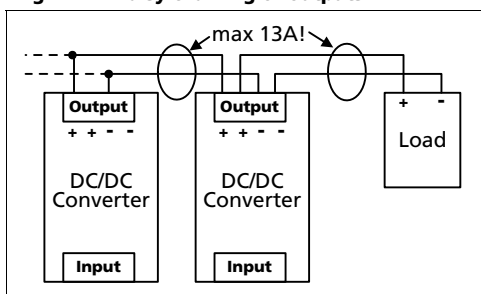
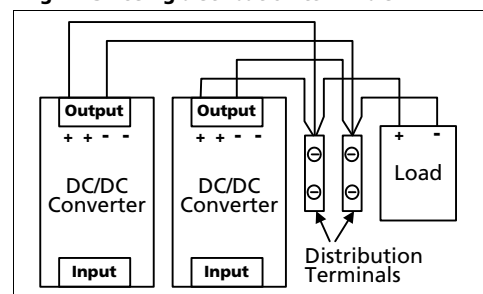


Fig. 12-3 Using distribution terminals



13. FRONT SIDE AND USER ELEMENTS

Fig. 13-1 Front side



- A Input Terminals** (Quick-connect spring-clamp terminals)
 - + Positive input
 - Negative (return) input
 - ⊕ PE (Protective Earth) input
- B Output Terminals** (Quick-connect spring-clamp terminals, two pins per pole)
 - + Positive output
 - Negative (return) output
- C DC-OK Relay Contact** (Quick-connect spring-clamp terminals)
The DC-OK relay contact is synchronized with the DC-OK LED. See chapter 8 for details.
- D Output voltage potentiometer**
Open the flap to adjust the output voltage. Factory set: 24.1V
- E DC-OK LED** (green)
On, when the output voltage is >90% of the adjusted output voltage
- F Overload LED** (red)
On, when the voltage on the output terminals is <90% of the adjusted output voltage, or in case of a short circuit in the output. Input voltage is required
Flashing, when the unit has switched off due to over-temperature.

Indicators, LEDs

	Overload LED	DC-OK LED	DC-OK Contact
Normal mode	OFF	ON	Closed
During BonusPower®	OFF	ON	Closed
Overload ($V_{OUT} < 90\%$)	ON	OFF	Open
Output short circuit	ON	OFF	Open
Temperature Shut-down	Intermitted	OFF	Open
No input power	OFF	OFF	Open

14. EMC

The DC/DC converter is suitable for rolling stock railway applications, for applications in industrial environment as well as in residential commercial and light industry environment without any restrictions.

EMC Immunity	According generic standards: EN 61000-6-1 and EN 61000-6-2 and according to EN 50121-3-2			
Electrostatic discharge	EN 61000-4-2	contact discharge air discharge	8kV 15kV	Criterion A Criterion A
Electromagnetic RF field	EN 61000-4-3	80MHz-2.7GHz	20V/m	Criterion A
Fast transients (Burst)	EN 61000-4-4	input lines output lines DC-OK signal (coupling clamp)	4kV 2kV 2kV	Criterion A Criterion A Criterion A
Surge voltage on input	EN 61000-4-5	+ → - + → PE, - → PE	2kV 4kV	Criterion A Criterion A
Surge voltage on output	EN 61000-4-5	+ → - + / - → PE	0.5kV 1kV	Criterion A Criterion A
Surge voltage on DC-OK	EN 61000-4-5	DC-OK signal → PE	1kV	Criterion A
Conducted disturbance	EN 61000-4-6	0.15-80MHz	10V	Criterion A
Power – Frequency magnetic field	EN 61000-4-8	16.7Hz, 50Hz	100A/m	Criterion A
Power – Frequency magnetic field	EN 61000-4-8	0Hz	300A/m	Criterion A
Pulsed magnetic field	EN 61000-4-9		300A/m	Criterion A

Criteria:

A: DC/DC converter shows normal operation behavior within the defined limits.

EMC Emission	According generic standards: EN 61000-6-3 and EN 61000-6-4 and according to EN 50121-3-2	
Conducted emission input lines	CISPR 16-1-2, CISPR 16-2-1	limits for EN 50121-3-2 fulfilled, limits for DC power port according EN 61000-6-3 fulfilled
Conducted emission output lines	CISPR 16-1-2, CISPR 16-2-1	limits for EN 50121-3-2 fulfilled, limits for DC power port according EN 61000-6-3 fulfilled
Radiated emission	EN 55011, EN 55022, EN 50121-3-2	Class B

This device complies with FCC Part 15 rules.

Operation is subjected to following two conditions: (1) this device may not cause harmful interference, and (2) this device must accept any interference received, including interference that may cause undesired operation.

Switching Frequencies	The power supply has three converters with three different switching frequencies included. Two are nearly constant. The other one is input voltage and load dependent.	
Switching frequency 1	110kHz	nearly constant
Switching frequency 2	400kHz	nearly constant
Switching frequency 3	55kHz to 500kHz	input voltage and load dependent

15. ENVIRONMENT

Conformal coating	yes	all pc-boards are conformal coated
Operational temperature ^{*)}	-25°C to +70°C (-13°F to 158°F) -40°C +70°C to +85°C (185°F to 185°F)	continuous operation, see Fig. 15-1 start-up tested for maximal 10 minutes every hour
Storage temperature	-40 to +85°C (-40°F to 185°F)	for storage and transportation
Output de-rating	not required	see Fig. 15-1.
Humidity ^{**)}	5 to 95% r.h.	IEC 60068-2-30
Vibration sinusoidal	2-17.8Hz: ±1.6mm; 17.8-500Hz: 2g ^{***)} 2 hours / axis	IEC 60068-2-6; DC/DC converter in operation
Vibration broadband	1.01grms for 10 minutes; 5-150Hz ^{***)}	IEC 60068-2-64, DC/DC converter in operation; Tests limits according to EN 61373
Vibration broadband	5.72grms for 300 minutes; 5-150Hz ^{***)}	IEC 60068-2-64, DC/DC converter not in operation; Tests limits according to EN 61373
Shock	30g 6ms, 20g 11ms, 50g 30ms ^{***)} 3 bumps / direction, 18 bumps in total	IEC 60068-2-27; DC/DC converter in operation
Shock	50g 30ms ^{***)} 3 bumps / direction, 18 bumps in total	IEC 60068-2-27, DC/DC converter not in operation; Tests limits according to EN 61373
Altitude	0 to 2000m (0 to 6 560ft) 2000 to 6000m (6 560 to 20 000ft)	without any restrictions reduce output power or ambient temperature, see Fig. 15-2 IEC 62103, EN 50178, overvoltage category II > 2000m (6500ft), see Fig. 15-2
Altitude de-rating	6W/1000m or 5°C/1000m	
Over-voltage category	III II	IEC 62103, EN 50178, altitudes up to 2000m altitudes from 2000m to 6000m
Degree of pollution	2	IEC 62103, EN 50178, not conductive
LABS compatibility	The unit does not release any silicone or other LABS-critical substances and is suitable for use in paint shops.	

*) Operational temperature is the same as the ambient temperature and is defined as the air temperature 2cm below the unit.
 **) Do not energize while condensation is present
 ***) Tested in combination with DIN-Rails according to EN 60715 with a height of 15mm and a thickness of 1.3mm and standard orientation.

Fig. 15-1 **Output current vs. ambient temp. at 24V output voltage**

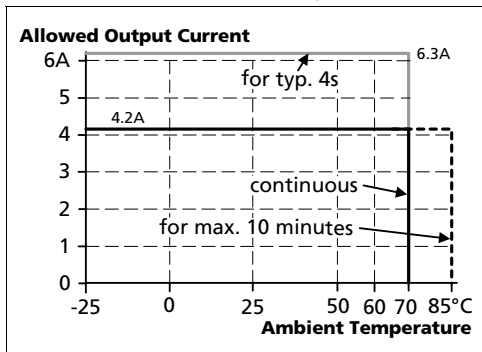
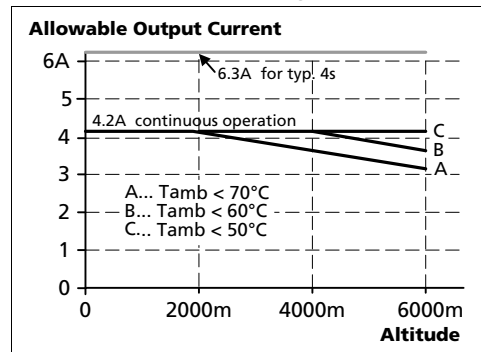


Fig. 15-2 **Output current vs. altitude at 24V output voltage**



16. PROTECTION FEATURES

Output protection	Electronically protected against overload, no-load and short-circuits*)	
Output over-voltage protection	typ. 32Vdc max. 36Vdc	In case of an internal DC/DC converter defect, a redundant circuit limits the maximum output voltage. The output shuts down and automatically attempts to restart.
Degree of protection	IP 20	EN/IEC 60529
Penetration protection	> 3.5mm	e.g. screws, small parts
Over-temperature protection	yes	Output shut-down with automatic restart
Input transient protection	MOV (Metal Oxide Varistor)	
Internal input fuse	DC suitable fuse included	not user replaceable
Reverse input polarity protection	yes	unit does not start, no signalling

*) In case of a protection event, audible noise may occur.

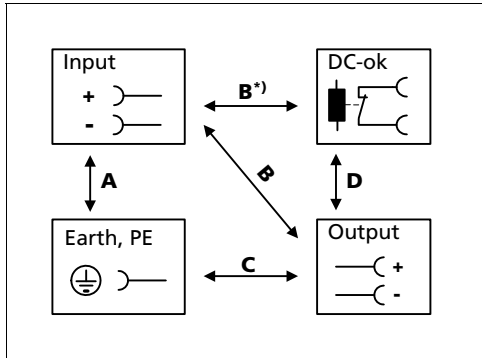
17. SAFETY FEATURES

Classification of output voltage	SELV PELV double or reinforced isolation to the input	IEC/EN 60950-1 IEC/EN 60204-1, EN 50178, IEC 62103, IEC 60364-4-41
Class of protection	I	PE (Protective Earth) connection required
Isolation resistance	> 5MΩ	input to output, 500Vdc
PE resistance	< 0.1Ω	
Touch current (leakage current)	The leakage current which is produced by the DC/DC converter itself depends on the input voltage ripple and need to be investigated in the final application. For a smooth DC input voltage, the produced leakage current is less than 100µA.	

18. DIELECTRIC STRENGTH

The output voltage is floating and has no ohmic connection to the ground. Type and factory tests are conducted by the manufacturer. Field tests may be conducted in the field using the appropriate test equipment which applies the voltage with a slow ramp (2s up and 2s down). Connect all input-terminals together as well as all output poles before conducting the test. When testing, set the cut-off current settings to the value in the table below.

Fig. 18-1 Dielectric strength



B*) When testing input to DC-OK ensure that the max. voltage between DC-OK and the output is not exceeded (column D). We recommend connecting DC-OK pins and the output pins together when performing the test.

		A	B	C	D
Type test	60s	2500Vac	3000Vac	500Vac	500Vac
Factory test	5s	2500Vac	2500Vac	500Vac	500Vac
Field test	5s	2000Vac	2000Vac	500Vac	500Vac
Cut-off current setting		> 10mA	> 10mA	> 20mA	> 1mA

To fulfil the PELV requirements according to EN60204-1 § 6.4.1, we recommend that either the + pole, the - pole or any other part of the output circuit shall be connected to the protective earth system. This helps to avoid situations in which a load starts unexpectedly or can not be switched off when unnoticed earth faults occur.

19. APPROVALS AND DECLARATIONS

EC Declaration of Conformity



The CE mark indicates conformance with the
- EMC directive and the
- Low-voltage directive

Railway applications - Electronic equipment used on rolling stock. EN 50155:2007



The manufacturer's declaration indicate conformance with the following characteristics:

- Altitude category: AX (EN 50125-1 § 4.2.1)
- Environmental category: T3 (EN 50155 § 4.1.2)
- Interruption of voltage supply: S2 (EN 50155 § 5.1.1.2)
- Supply change over: C2 (EN 50155 § 5.1.3)
- Shock and vibration: Category 1, Class A and B (EN 61373)
- EMI: EN 50121-3-2
- Fire Classification: HL3 (EN 45545-2)

20. RoHS, REACH AND OTHER FULFILLED STANDARDS

RoHS Directive



Directive 2011/65/EU of the European Parliament and the Council of June 8th, 2011 on the restriction of the use of certain hazardous substances in electrical and electronic equipment.

REACH Directive



Directive 1907/2006/EU of the European Parliament and the Council of June 1st, 2007 regarding the Registration, Evaluation, Authorisation and Restriction of Chemicals (REACH)

21. PHYSICAL DIMENSIONS AND WEIGHT

Width	40mm 1.57"
Height	124mm 4.88"
Depth	117mm 4.61" The DIN-rail height must be added to the unit depth to calculate the total required installation depth.
Weight	640g / 1.41lb
DIN-Rail	Use 35mm DIN-rails according to EN 60715 or EN 50022 with a height of 7.5 or 15mm.
Housing material	Body: Aluminium alloy Cover: zinc-plated steel
Installation clearances	See chapter 2

Fig. 21-1 Front view

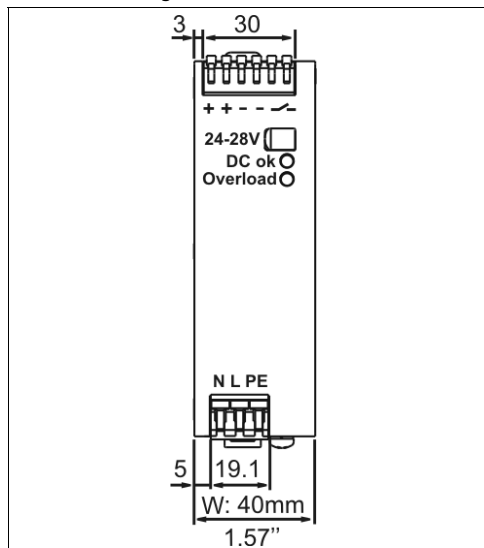
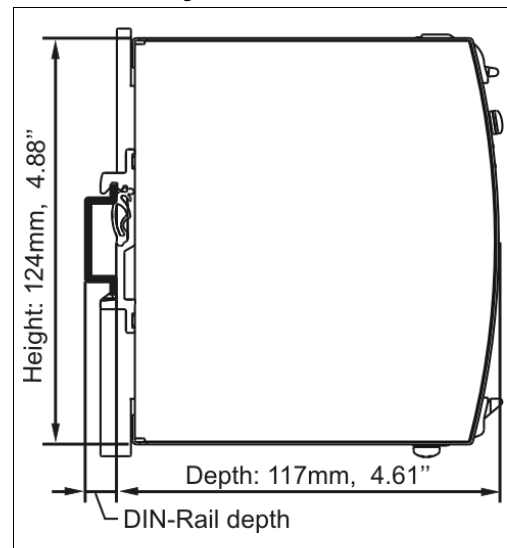


Fig. 21-2 Side view

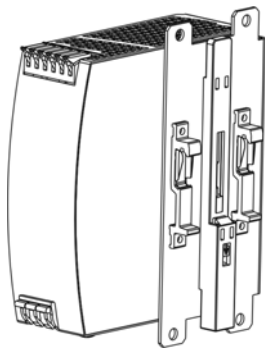


22. ACCESSORIES

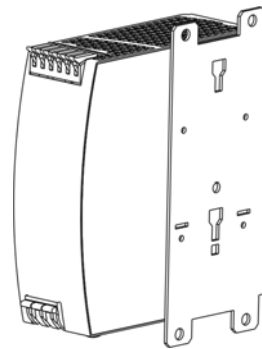
22.1. ZM12.SIDE - SIDE MOUNTING BRACKET

This bracket is used to mount the DC/DC converter sideways with or without utilizing a DIN-Rail. The two aluminum brackets and the black plastic slider of the unit have to be detached, so that the steel brackets can be mounted.

For sideways DIN-rail mounting, the removed aluminum brackets and the black plastic slider need to be mounted on the steel bracket.



Side mounting with DIN-rail brackets

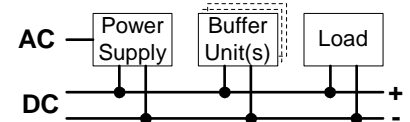


Side mounting without DIN-rail brackets

22.2. UF20.241 BUFFER MODULE

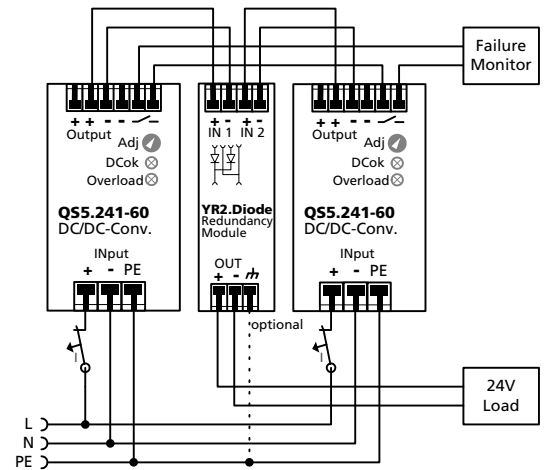
This buffer unit is a supplementary device for DC 24V power supplies. It delivers power to bridge typical mains failures or extends the hold-up time after turn-off of the input power. In times when the power supply provides sufficient voltages, the buffer unit stores energy in integrated electrolytic capacitors. In case of input voltage fault, this energy is released again in a regulated process. One buffer module can deliver 20A additional current.

The buffer unit does not require any control wiring. It can be added in parallel to the load circuit at any given point. Buffer units can be added in parallel to increase the output ampacity or the hold-up time.



22.3. YR2.DIODE REDUNDANCY MODULE

The YR2.DIODE is a dual redundancy module, which has two diodes as decoupling devices included. It can be used for various purposes. The most popular application is to configure highly reliable and true redundant power supply systems. Another interesting application is the separation of sensitive loads from non-sensitive loads. This avoids the distortion of the power quality for the sensitive loads which can cause controller failures.



23. APPLICATION NOTES

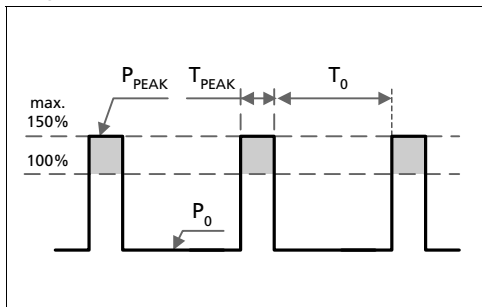
23.1. REPETITIVE PULSE LOADING

Typically, a load current is not constant and varies over time. This power supply is designed to support loads with a higher short-term power demand (=BonusPower®). The short-term duration is hardware controlled by an output power manager and is available on a repeated basis. If the BonusPower® load lasts longer than the hardware controller allows it, the output voltage will dip and the next BonusPower® is available after the BonusPower® recovery time (see chapter 6) has elapsed.

To avoid this, the following rules must be met:

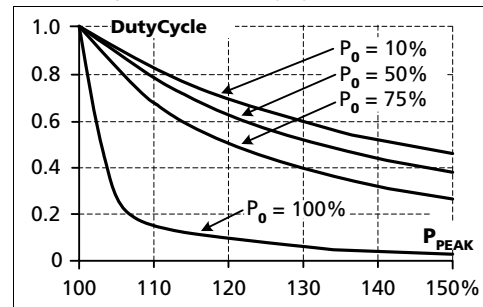
- The power demand of the pulse must be below 150% of the nominal output power.
- The duration of the pulse power must be shorter than the allowed BonusPower® time. (see output section)
- The average (R.M.S.) output current must be below the specified continuous output current. If the R.M.S. current is higher, the unit will respond with a thermal shut-down after a period of time. Use the maximum duty cycle curve (Fig. 23-2) to check if the average output current is below the nominal current.

Fig. 23-1 Repetitive pulse loads, definitions



- P_0 Base load (W)
- P_{PEAK} Pulse load (above 100%)
- T_0 Duration between pulses (s)
- T_{PEAK} Pulse duration (s)

Fig. 23-2 Max. duty cycle curve



$$\text{DutyCycle} = \frac{T_{\text{peak}}}{T_{\text{peak}} + T_0}$$

$$T_0 = \frac{T_{\text{peak}} - (\text{DutyCycle} \times T_{\text{peak}})}{\text{DutyCycle}}$$

Example: A load is powered continuously with 100W (= 50% of the rated output load). From time to time a peak power of 300W (= 150% of the rated output load) is needed for 1 second.

The question is: How often can this pulse be supplied without overloading the power supply?

- Make a vertical line at $P_{PEAK} = 150\%$ and a horizontal line where the vertical line crosses the $P_0 = 50\%$ curve. Read the max. duty cycle from the duty cycle-axis (= 0.37)
- Calculate the required pause (base load) length T_0 :
- Result: The required pause length = 1.7s
- Max. repetition rate = pulse +pause length = **2.7s**

$$T_0 = \frac{T_{\text{peak}} - (\text{DutyCycle} \times T_{\text{peak}})}{\text{DutyCycle}} = \frac{1\text{s} - (0.37 \times 1\text{s})}{0.37} = \underline{\underline{1.7\text{s}}}$$

More examples for pulse load compatibility:

P_{PEAK}	P_0	T_{PEAK}	T_0	P_{PEAK}	P_0	T_{PEAK}	T_0
150W	100W	1s	>25s	150W	50W	0.1s	>0.16s
150W	0W	1s	>1.3s	150W	50W	1s	>1.6s
120W	50W	1s	> 0.75s	150W	50W	3s	>4.9s

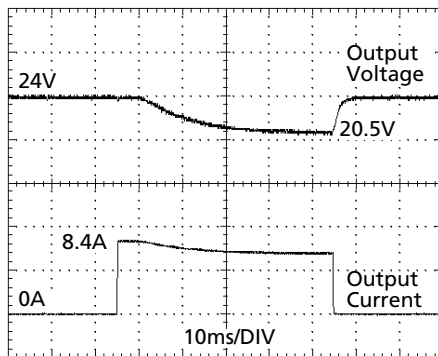
23.2. PEAK CURRENT CAPABILITY

The DC/DC converter can deliver peak currents (up to several milliseconds) which are higher than the specified short term currents. This helps to start current demanding loads. Solenoids, contactors and pneumatic modules often have a steady state coil and a pick-up coil. The inrush current demand of the pick-up coil is several times higher than the steady-state current and usually exceeds the nominal output current. The same situation applies when starting a capacitive load.

The peak current capability also ensures the safe operation of subsequent circuit breakers of load circuits. The load branches are often individually protected with circuit breakers or fuses. In case of a short or an overload in one branch circuit, the fuse or circuit breaker need a certain amount of over-current to open in a timely manner. This avoids voltage loss in adjacent circuits.

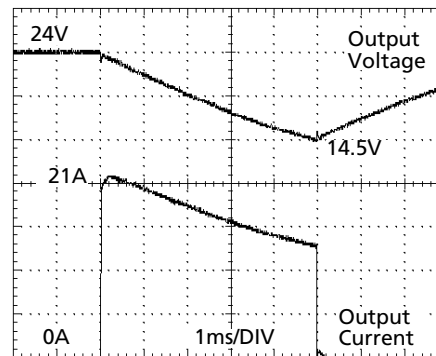
The extra current (peak current) is supplied by the built-in large sized output capacitors of the DC/DC converter. The capacitors get discharged during such an event, which causes a voltage dip on the output. The following two examples show typical voltage dips:

Fig. 23-3 Peak load with 2x the nominal current for 50ms, typ.



8.4A Peak load (resistive) for 50ms
Output voltage dips from 24V to 20.5V.

Fig. 23-4 Peak load with 5x the nominal current for 5ms, typ.



21A Peak load (resistive) for 5ms
Output voltage dips from 24V to 14.5V.

Peak current voltage dips	typ.	from 24V to 20.5V	at 8.4A for 50ms, resistive load
	typ.	from 24V to 19.5V	at 21A for 2ms, resistive load
	typ.	from 24.5V to 14.5V	at 21A for 5ms, resistive load

23.3. INDUCTIVE AND CAPACITIVE LOADS

The unit is designed to supply any kind of loads, including unlimited capacitive and inductive loads.

23.4. EXTERNAL INPUT PROTECTION

The unit is tested and approved for branch circuits up to 30A (UL) and 32A (IEC). An external protection is only required if the supplying branch has an ampacity greater than this. Check also local codes and local requirements. In some countries local regulations might apply.

If an external fuse is necessary or utilized, minimum requirements need to be considered to avoid nuisance tripping of the circuit breaker. A minimum value of 6A B- or 3A C-Characteristic breaker should be used.

23.5. CHARGING OF BATTERIES

The DC/DC converter can be used to charge lead-acid or maintenance free batteries. (Two 12V batteries in series)

Instructions for charging batteries:

- a) Set output voltage (measured at no load and at the battery end of the cable) very precisely to the end-of-charge voltage.

End-of-charge voltage	27.8V	27.5V	27.15V	26.8V
Battery temperature	10°C	20°C	30°C	40°C

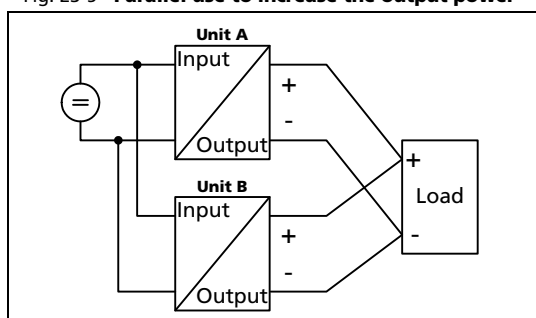
- b) Use a 10A circuit breaker (or blocking diode) between the DC/DC converter and the battery.
- c) Ensure that the output current of the DC/DC converter is below the allowed charging current of the battery.
- d) Use only matched batteries when putting 12V types in series.
- e) The return current to the power supply (battery discharge current) is typ. 2.5mA when the power supply is switched off (except in case a blocking diode is utilized).

23.6. PARALLEL USE TO INCREASE OUTPUT POWER

QS5.241-60 DC/DC converters can be paralleled to increase the output power. The output voltage shall be adjusted to the same value ($\pm 100\text{mV}$) with the same load conditions on all units, or the units can be left with the factory settings. The ambient temperature is not allowed to exceed $+60^\circ\text{C}$.

If more than three units are connected in parallel, a fuse or circuit breaker with a rating of 8A or 10A is required on each output. Alternatively, a diode or redundancy module can also be utilized.

Fig. 23-5 Parallel use to increase the output power



Instructions for parallel use:

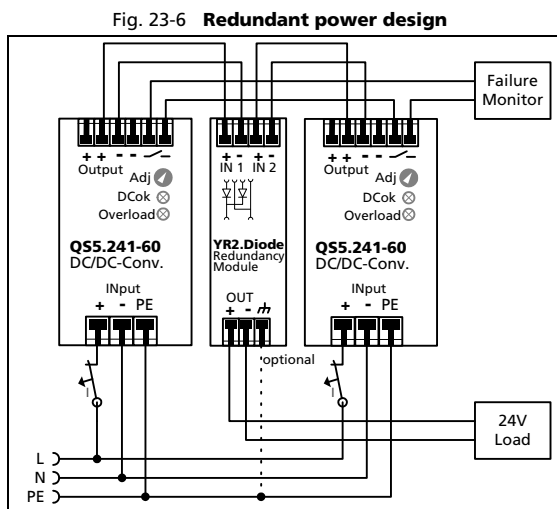
- Keep an installation clearance of 15mm (left / right) between two DC/DC converters and avoid installing the DC/DC converters on top of each other.
- Do not parallel DC/DC converters in orientations other than the standard mounting orientation (terminals on bottom of the unit) or in any other condition where a derating of the output current is required (e.g. altitude, temperature, input voltages).
- Pay attention that EMI and inrush current will increase when using multiple DC/DC converters.

23.7. PARALLEL USE FOR REDUNDANCY

QS5.241-60 DC/DC converters can be paralleled for redundancy to gain higher system availability. Redundant systems require a certain amount of extra power to support the load in case one DC/DC converter unit fails. The simplest way is to put two DC/DC converters in parallel. This is called a 1+1 redundancy. In case one DC/DC converter unit fails, the other one is automatically able to support the load current without any interruption. Redundant systems for a higher power demand are usually built in a N+1 method. E.g. five power supplies, each rated for 4.2A are paralleled to build a 16.8A redundant system.

For N+1 redundancy the same restrictions apply as for increasing the output power, see also section 23.6.

Please note: This simple way to build a redundant system does not cover failures such as an internal short circuit in the secondary side of the power supply. In such a case, the defective unit becomes a load for the other power supplies and the output voltage can not be maintained any more. This can be avoided by utilizing decoupling diodes which are included in the redundancy module YR2.DIODE.



Recommendations for building redundant power systems:

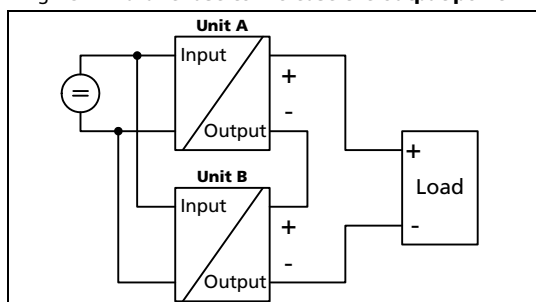
- Use separate input fuses for each DC/DC converter.
- Monitor the individual DC/DC converter units. Use the DC-OK relay contact of the QS5 DC/DC converter.
- It is desirable to set the output voltages of all units to the same value ($\pm 100\text{mV}$) or leave it at the factory setting.

23.8. SERIES OPERATION

DC/DC converters of the same type can be connected in series for higher output voltages. It is possible to connect as many units in series as needed, providing the sum of the output voltage does not exceed 150Vdc. Voltages with a potential above 60Vdc are not SELV any more and can be dangerous. Such voltages must be installed with a protection against touching.

Avoid return voltage (e.g. from a decelerating motor or battery) which is applied to the output terminals.

Fig. 23-7 Parallel use to increase the output power



Instructions for series use:

- Keep an installation clearance of 15mm (left / right) between two DC/DC converters and avoid installing the DC/DC converters on top of each other.
- Do not use DC/DC converters in series in mounting orientations other than the standard mounting orientation (terminals on bottom of the unit).
- Pay attention that EMI and inrush current will increase when using multiple DC/DC converters.

23.9. BACK-FEEDING LOADS

Loads such as decelerating motors and inductors can feed voltage back to the DC/DC converter. This feature is also called return voltage immunity or resistance against Back- E.M.F. (Electro Magnetic Force).

This DC/DC converter is resistant and does not show malfunctioning when a load feeds back voltage to the DC/DC converter. It does not matter whether the DC/DC converter is on or off.

The maximum allowed feed-back-voltage is 35Vdc.

23.10. USE IN A TIGHTLY SEALED ENCLOSURE

When the DC/DC converter is installed in a tightly sealed enclosure, the temperature inside the enclosure will be higher than outside. In such situations, the inside temperature defines the ambient temperature for the DC/DC converter.

The following measurement results can be used as a reference to estimate the temperature rise inside the enclosure.

The DC/DC converter is placed in the middle of the box, no other heat producing items are inside the box

Enclosure:	Rittal Typ IP66 Box PK 9516 100, plastic, 110x180x165mm
Load:	24V, 3.2A; (=80%) load is placed outside the box
Input:	110Vdc
Temperature inside enclosure:	32.8°C (in the middle of the right side of the DC/DC converter with a distance of 2cm)
Temperature outside enclosure:	22.4°C
Temperature rise:	14.4K

23.11. MOUNTING ORIENTATIONS

Mounting orientations other than all terminals on the bottom require a reduction in continuous output power or a limitation in the maximum allowed ambient temperature. The amount of reduction influences the lifetime expectancy of the DC/DC converter. Therefore, two different derating curves for continuous operation can be found below:

Curve A1 Recommended output current.

Curve A2 Max allowed output current (results in approximately half the lifetime expectancy of A1).

Fig. 23-8
Mounting Orientation A
(Standard orientation)

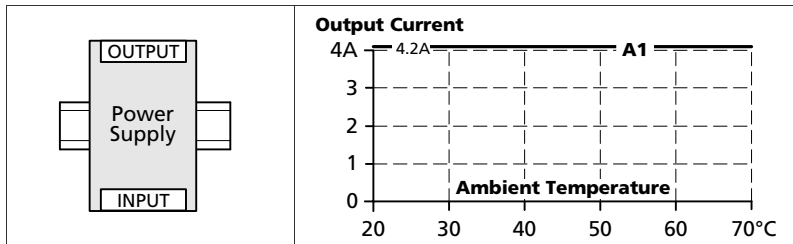


Fig. 23-9
Mounting Orientation B
(Upside down)

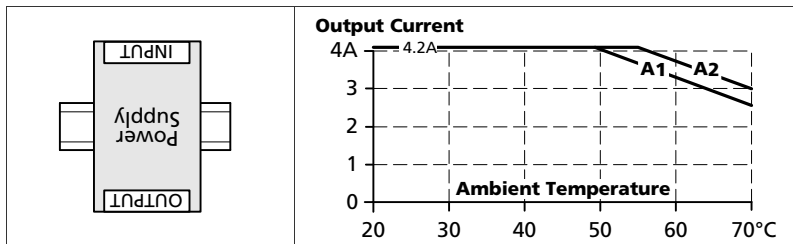


Fig. 23-10
Mounting Orientation C
(Table-top mounting)

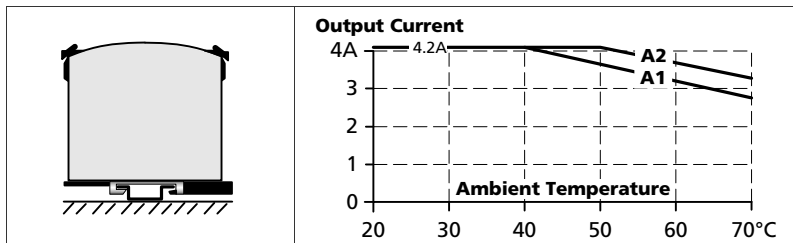


Fig. 23-11
Mounting Orientation D
(Horizontal cw)

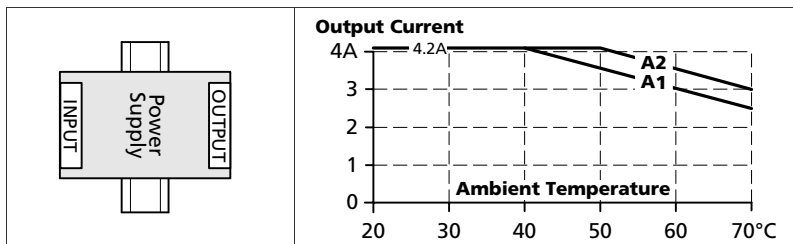


Fig. 23-12
Mounting Orientation E
(Horizontal ccw)

