20 Watt DC-DC Converters

SR Series

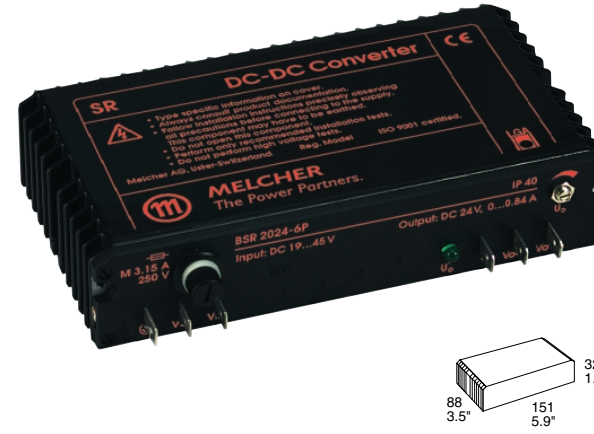
Single output of 5, 12, 15 or 24 V DC
Input voltage up to 180 V DC

- Full input to output isolation 2.5 kV_{rms}
- Wide input voltage range
- High efficiency up to 81%
- Efficient input filter
- Very good dynamic characteristics
- Parallel and series compatible
- Continuous no-load and short circuit proof

Safety according to IEC/EN 60950

LGA

CE



Summary

The DC-DC converters of the SR series are power supply modules for electronic systems. Their major advantages include a high efficiency that remains virtually constant over the entire input voltage range, high reliability, low ripple and excellent dynamic response. The converters are designed for chassis mounting.

Type Survey and Key Data

Table 1: Type survey

Output voltage		Input voltage range and efficiency [2]									Options
$U_{o\,nom}$ [V DC]	$I_{o\,nom}$ [A]	$U_{i\,min}...U_{i\,max}$ **19...45 V DC** [1]	η_{min} [%]	η_{typ} [%]	$U_{i\,min}...U_{i\,max}$ **38...90 V DC** [1]	η_{min} [%]	η_{typ} [%]	$U_{i\,min}...U_{i\,max}$ **76...180 V DC**	η_{min} [%]	η_{typ} [%]	
5	4	BSR 2005-7	70	73	CSR 2005-7	74	77	DSR 2005-7	74	77	-6, R [1], i, P
12	1.67	BSR 2012-7	74	77	CSR 2012-7	75	78	DSR 2012-7	75	78	
15	1.34	BSR 2015-7	74	78	CSR 2015-7	76	79	DSR 2015-7	76	79	
24	0.84	BSR 2024-7	75	79	CSR 2024-7	77	81	DSR 2024-7	77	81	

[1] With option R, shifted input voltage range, for BSR: 16...38 V DC, for CSR: 32...76 V DC. Not available for DSR.
[2] Efficiency at $U_{i\,nom}$ and $I_{o\,nom}$.

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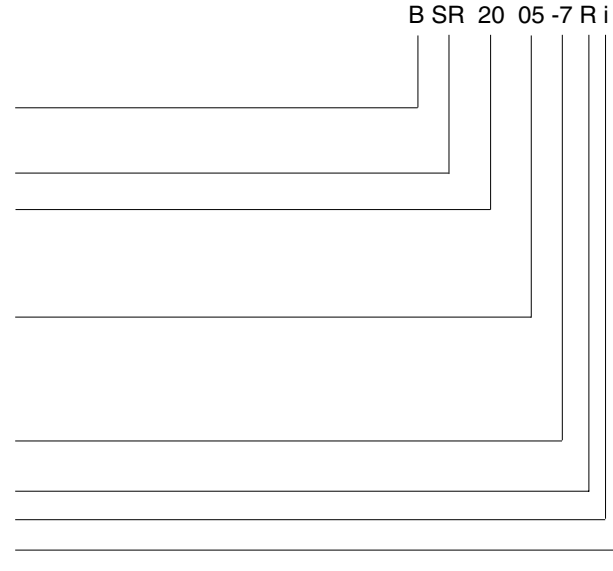
Type Key and Product Marking

Type Key



Input voltage range U_i
- 19...45 V DC ..... B
- 38...90 V DC C
- 76...180 V DC ..... D

Series ..... SR

Nominal output power in watt 20

Nominal output voltage in volt
- 5 V 05
- 12 V 12
- 15 V 15
- 24 V 24

Ambient temperature range T_A = –25...71 °C:
- Plastic semi-conductors ..... -7
- Hermetic semi-conductors (option) ..... -6

Options:
- Shifted input voltage range ..... R
- Inhibit input i
- Potentiometer ..... P

Example: BSR 2005-7RiP = 20 Watt DC-DC converter with a 5 V output, ambient temperature range of –25...71 °C, shifted input range of U_i = 16...38 V DC, inhibit, and potentiometer.

Produkt Marking

Basic type designation, applicable safety approval and recognition marks, CE mark, warnings and Melcher company logo.

Specific type designation, input voltage range, nominal output voltage and current, pin allocation, identification of LED and potentiometer.

Label with batch No., serial No. and data code comprising production site, modification status of the main PCB and date of production.

Functional Description

After passing through a line interference filter, the DC voltage is chopped at a constant frequency of about 30 kHz. After transformer isolation and rectification, an output filter reduces ripple to a minimum without compromising the dynamic behaviour. The output voltage is routed to a control circuit with internal sense lines, where the output voltage is compared with a reference voltage. The voltage is regulated via a control transformer by varying the duty ratio of the forward converter.

The converters have input transient protection by means of a zinc oxide VDR and input reverse polarity protection by means of a protective diode and a fuse.

An internal inhibit signal keeps the output voltage switched off below approx. 0.7...0.9 $U_{i\,min}$.

The outputs are protected against continuous open circuit by means of an internal, electronically switched pre-load and against continuous short circuit by the current limiting circuit.

No output voltage overshoot will occur when plugging in or disconnecting the module, switching the input voltage on/off, inhibiting the unit or after reset.

In the event of a main control circuit failure, the maximum output voltage U_o is restricted to approx. 1.2 $U_{o\,nom}$ by means of an independent second control circuit.

When the converters are located in free, stationary air at a temperature $T_{A\,max}$ = 71 °C and are operated at nominal power, the case temperature $T_{C\,max}$ will reach approx. 85 °C after a certain warm-up time (Case temperature T_C at the measuring point, see: *Mechanical Data*).

Under certain operating conditions the ambient temperature $T_{A\,max}$ may be allowed to exceed 71 °C provided that additional measures are taken to ensure the case temperature $T_{C\,max}$ remains below 85 °C.

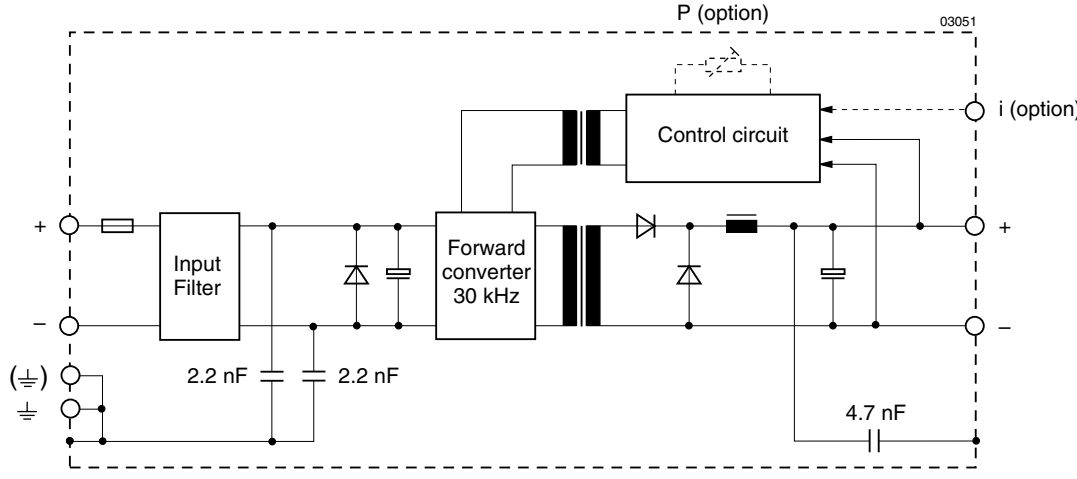


Fig. 1
Block diagram

Electrical Input Data

General Conditions
– T_A = 25 °C, unless T_C is specified
– With option i, pin i is connected with $-U_o$
– With option P, $U_o = U_{o\,nom}$ at $I_{o\,nom}$

Table 2: Input data

Input				BSR			CSR			DSR			Unit
Characteristics			Conditions	min	typ	max	min	typ	max	min	typ	max	
U_i ($U_{i\,nom}$)	Input voltage	Standard	I_o = 0...$I_{o\,nom}$ $T_{C\,min}$...$T_{C\,max}$	19	(30)	45	38	(60)	90	76	(120)	180	V DC
		Option R		16	(24)	38	32	(48)	76		n.a.		
$I_{inr\,p}$	Peak inrush current		$U_{i\,nom}$		28			22			10		A
$t_{inr\,r}$	Rise time				0.2			0.3			0.4		ms
$t_{inr\,h}$	Time to half-value				1			0.7			1		
$u_{i\,RFI}$	RFI level at input 0.01...30 MHz		EN 55022 50 Ω/50 µH $U_i = U_{i\,nom}$			B			B			B	
Si	Primary fuse rating		slow blow		3.15			2			1.6		A
$u_{i\,tr}$	Input transient suppression		1.2/5 µs VDE 0433	0.8			1.5			2.5			kV
$I_{i\,inh}$	Residual input current with converter inhibited		5 min. after start		1...6			1...4			1...4		mA
$I_{i\,uv}$	Input current undervoltage lock-out		after 5 min. $U_i < 0.7\ U_{i\,min}$		1			1			1		

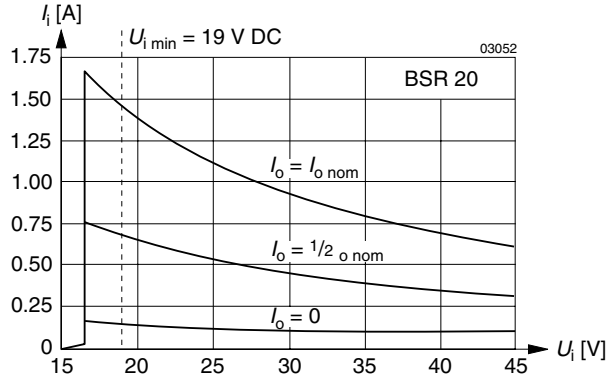


Fig. 2
Input current I_i versus input voltage U_i

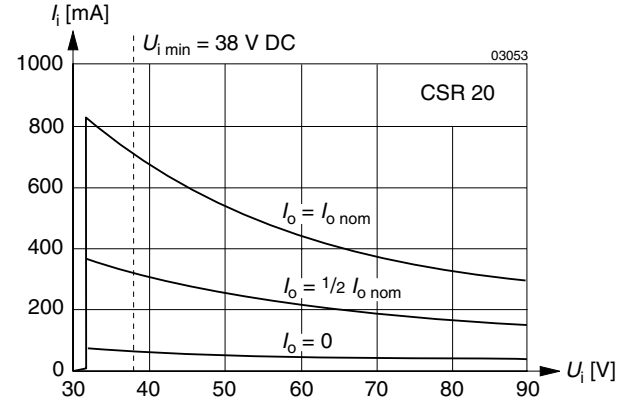


Fig. 3
Input current I_i versus input voltage U_i

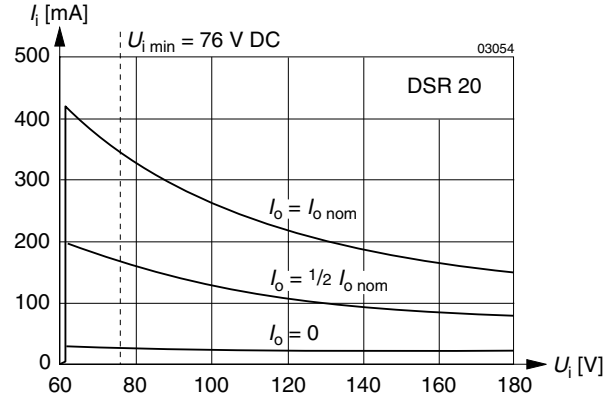
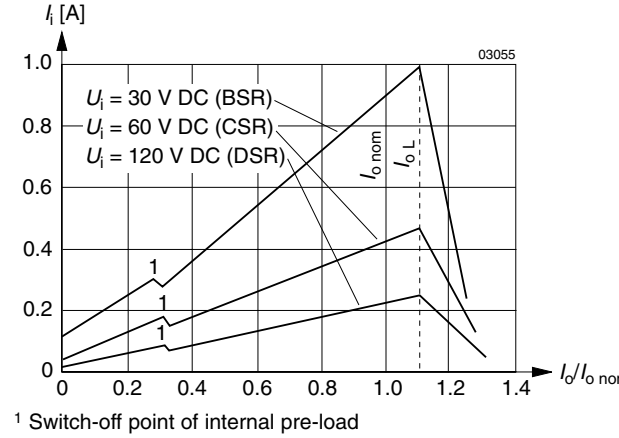


Fig. 4
Input current I_i versus input voltage U_i



[1] Switch-off point of internal pre-load

Fig. 5
Input current I_i versus input voltage U_i

Electrical Output Data

General Conditions
– T_A = 25 °C, unless T_C is specified
– With option i, pin i is connected with $-U_o$
– With option P, $U_o = U_{o\,nom}$ at $I_{o\,nom}$

Table 3: Output data

Output				..SR 2005..			SR 2012 ..			SR 2015 ..			SR 2024			Unit
Characteristics			Conditions	min	typ	max	min	typ	max	min	typ	max	min	typ	max	
U_o	Output voltage		$U_{i\,nom}$, $I_{o\,nom}$	4.97		5.03	11.92		12.07	14.91		15.09	23.85		24.14	V DC
I_o	Output current		$U_{i\,min}$...$U_{i\,max}$	0		4	0		1.67	0		1.34	0		0.84	A
$I_{o\,L}$	Output current limitation		$U_{i\,min}$...$U_{i\,max}$ $T_{C\,min}$...$T_{C\,max}$		4.8			1.84			1.47			0.92		
$U_{o\,L}$	Overvoltage limit with second control loop		Failure of main control circuit	5.3		6.8	13.5		16.0	16.5		19.0	27.0		31.0	V DC
u_o	Total output voltage noise (BW = 20 MHz) [1]		$U_{i\,min}$...$U_{i\,max}$ $I_{o\,nom}$		30	40		10	20		10	20		10	20	mV_{pp}
$\Delta U_{o\,U}$	Static line regulation				±12	±24		±10	±20		±10	±20		±12	±25	mV
$\Delta U_{o\,I}$	Static load regulation		$U_{i\,nom}$ $I_o = 0...I_{o\,nom}$		12	25		20	40		25	50		30	60	
$u_{o\,d}$	Dynamic load regulation	Voltage deviat.	$U_{i\,nom}$ $1 \leftrightarrow {}^1/_5\ I_{o\,nom}$ IEC/EN 61204		±70			±25			±25			±25		
t_d		Recovery time			70			150			200			300		µs
α_{Uo}	Temperature coefficient $\Delta U_o/\Delta T_C$		$U_{i\,min}$...$U_{i\,max}$ $I_o = 0...I_{o\,nom}$			±1			±2			±3			±5	mV/K
						±0.02			±0.02			±0.02			±0.02	%/K

[1] According to IEC/EN 61204. See: *Technical Information: Measuring and Testing.*
[2] See: *Dynamic Characteristics.*

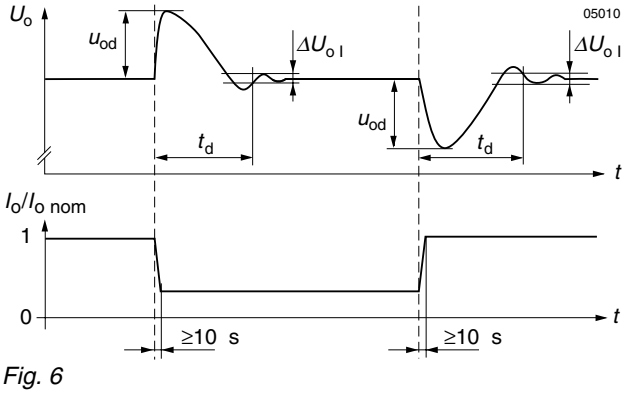
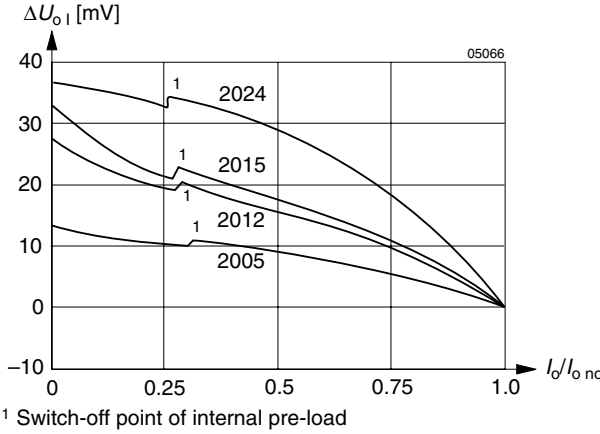


Fig. 6
Dynamic load regulation.



[1] Switch-off point of internal pre-load

Fig. 7
Static load regulation.
Output voltage U_o versus output current I_o.

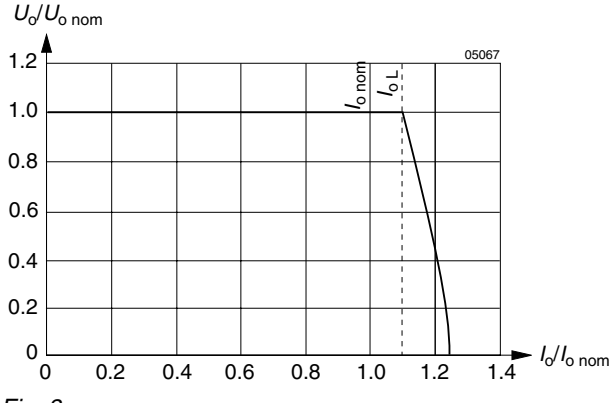


Fig. 8
Short-circuit behaviour.
Output voltage U_o versus output current I_o.

Thermal Considerations

If a converter is located in free, quasi-stationary air (convection cooling) at the indicated maximum ambient temperature $T_{A\,max}$ (see table: *Temperature specifications)* and is operated at its nominal input voltage and output current, the temperature measured at the *Measuring point of case temperature* T_C (see: *Mechanical Data*) will approach the indicated value $T_{C\,max}$ after the warm-up phase. However, the relationship between T_A and T_C depends heavily on the conditions of operation and integration into a system. The thermal conditions are influenced by input voltage, output current, airflow and temperature of surrounding components and surfaces. $T_{A\,max}$ is therefore, contrary to $T_{C\,max}$, an indicative value only.

Caution: The installer must ensure that under all operating conditions T_C remains within the limits stated in the table: *Temperature specifications.*

Note: Sufficient forced cooling or an additional heat sink allows T_A to be higher than 71°C (e.g. 85°C) as long as $T_{C\,max}$ is not exceeded.

Immunity to Environmental Conditions

Table 4: Mechanical stress

Test Method		Standard	Test Conditions		Status
Ca	Damp heat steady state	IEC/DIN IEC 60068-2-3 MIL-STD-810D section 507.2	Temperature: Relative humidity: Duration:	40 $^{\pm 2}$ °C 93 $^{+2/-3}$ % 56 days	Unit not operating
Ea	Shock (half-sinusoidal)	IEC/EN/DIN EN 60068-2-27 MIL-STD-810D section 516.3	Acceleration amplitude: Bump duration: Number of bumps:	100 g_n = 981 m/s^2 6 ms 18 (3 each direction)	Unit operating
Eb	Bump (half-sinusoidal)	IEC/EN/DIN EN 60068-2-29 MIL-STD-810D section 516.3	Acceleration amplitude: Bump duration: Number of bumps:	40 g_n = 392 m/s^2 6 ms 6000 (1000 each direction)	Unit operating
Fc	Vibration (sinusoidal)	IEC/EN/DIN EN 60068-2-6 MIL-STD-810D section 514.3	Acceleration amplitude: Frequency (1 Oct/min): Test duration:	0.35 mm (10...60 Hz) 5 g_n = 49 m/s^2 (60...2000 Hz) 10...2000 Hz 7.5 h (2.5 h each axis)	Unit operating

Table 5: Temperature specifications, valid for air pressure of 800...1200 hPa (800...1200 mbar)

Temperature			Standard -7 [3]		Option -6 [4]		Unit
Characteristics	Conditions		min	max	min	max	
T_A	Ambient temperature [1]	Operational [2]	–25	71	–25	71	°C
T_C	Case temperature		–25	85	–25	85	
T_S	Storage temperature [1]	Non operational	–40	85	–40	85	

[1] MIL-STD-810D section 501.2 and 502.2
[2] See: *Thermal Considerations*
[3] Plastic semiconductor devices
[4] Hermetic semiconductor devices

Table 6: MTBF and device hours

MTBF	Ground Fixed		Ground Mobile	
MTBF acc. to MIL-HDBK-217D	T_C = 40°C	T_C = 70°C	T_C = 40°C	T_C = 70°C
Standard -7	155'000 h	69'000 h	31'500 h	13'000 h
Option -6	100'000 h	46'000 h	28'000 h	18'000 h

[1]Statistical values, based on an average of 4300 working hours per year and in general field use

Mechanical Data

European Projection

Dimensions in mm. Tolerances ±0.3 mm unless otherwise indicated.

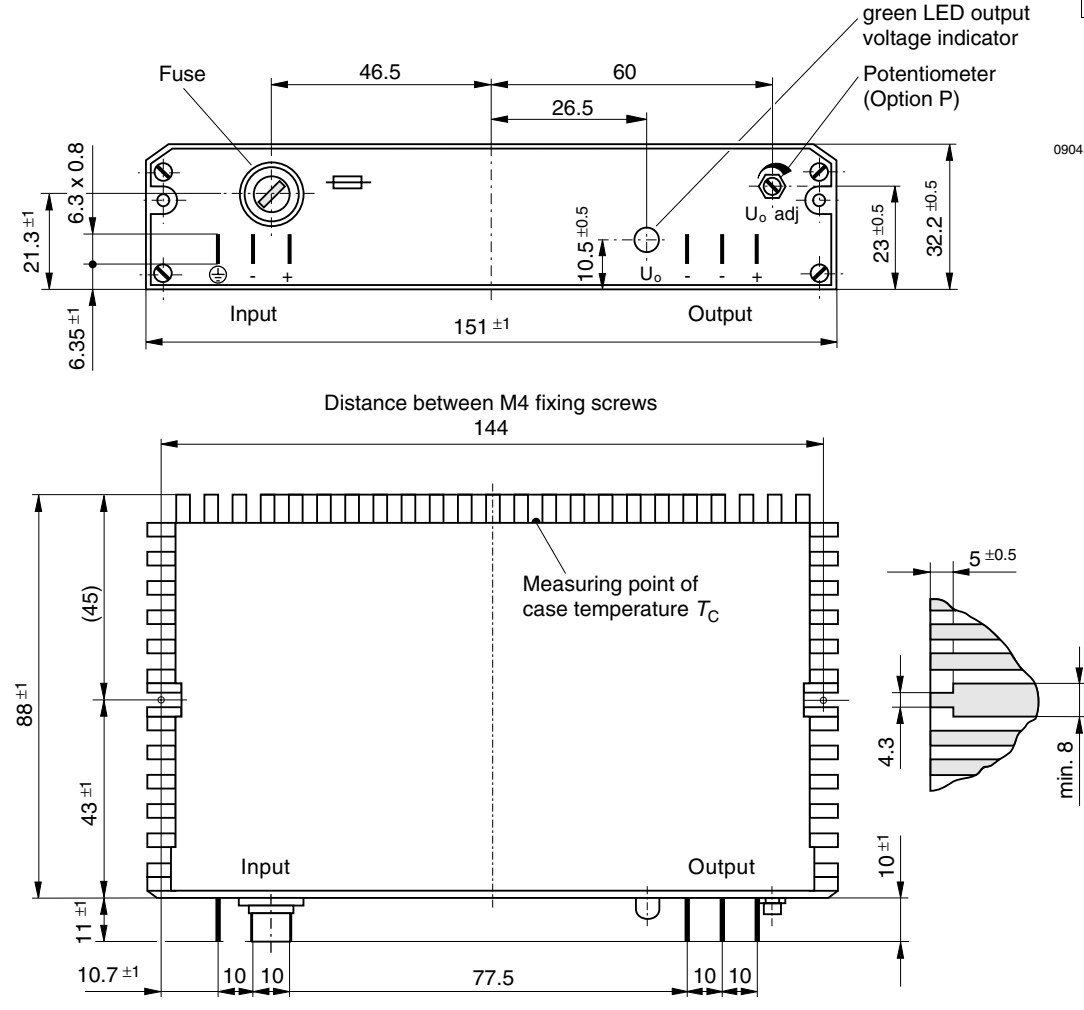


Fig. 9
Case: C01 (weight: BSR 550 g, CSR and DSR 555 g).
Aluminium, black finish, fully enclosed, self cooling.

Safety and Installation Instructions

Installation Instructions

Our DC-DC converters are components, intended exclusively for inclusion within other equipment by an industrial assembly operation or by professional installers. Installation must strictly follow the national safety regulations in compliance with the enclosure, mounting, creepage, clearance, casualty, markings and segregation requirements of the end-use application. See also: *Technical Information: Installation and Application.*

Connection to the system shall be made via the 6.3 × 0.8 mm faston contacts at the cover side of the unit according to *Mechanical Data.*

The DC-DC converters are provided with an earth pin (⏚), which is reliably connected with their case. For safety reasons it is essential to connect this pin with the protective earth of the supply system if required in: *Safety of operator accessible output circuit.*

An input fuse is built-in in the connection from the Vi+ terminal of the unit. Since this fuse is designed to protect the unit in case of an overcurrent and does not necessarily cover all customer needs, an external fuse suitable for the application and in compliance with the local requirements should be installed in the wiring to one or both input pins (Vi+ and/or Vi–).

Important: Whenever the inhibit function is not in use, pin i should be connected to pin Vo1– to enable the output. Do not open the modules, or guarantee will be invalidated.

Make sure that there is sufficient air flow available for convection cooling. This should be verified by measuring the case temperature when the unit is installed and operated in the end-use application. The maximum specified case temperature $T_{C\,max}$ shall not not be exceeded. See also: *Thermal Considerations.*

Cleaning Agents

In order to avoid possible damage, any penetration of cleaning fluids is to be prevented, since the power supplies are not hermetically sealed.

Standards and Approvals

The DC-DC converters correspond to class I equipment. All types are LGA approved to IEC/EN 60950 standards.

The units have been evaluated for:

- Building in,
- Basic insulation between input and case/output, based on 250 V AC and 400 V DC,
- Basic insulation between output and case, based on 250 V AC and 400 V DC,
- The use in a pollution degree 2 environment,
- Connecting the input to a circuit which is subject to a maximum transient rating of 2500 V.

The DC-DC converters are subject to manufacturing surveillance in accordance with EN 60950 and ISO 9001 standards.

Protection Degree

The protection degree of the DC-DC converters is IP 40, exept in the vicinity of the terminals, where it depends on the installation.

Isolation

The electric strength test is performed as factory test in accordance with IEC/EN 60950 and UL 1950 and should not be repeated in the field. Melcher will not honour any guarantee claims resulting from electric strength field tests.

Table 7: Isolation

Characteristic		Input to case	Input to output	Output to case	Unit
Electric strength test voltage	Required according to IEC/EN 60950	2.0	2.5 [1]	1.0	kV_{rms}
	Actual factory test 1 s	2.8	3.5 [1]	1.4	kV DC
Insulation resistance at 500 V DC		>100	>100	>100	MΩ

[1] In accordance with IEC/EN 60950 only subassemblies are tested in factory with this voltage.

Safety of operator accessible output circuit

If the output circuit of a DC-DC converter is operator accessible, it shall be an SELV circuit according to the IEC/EN 60950 related safety standards

The following table shows some possible installation configurations, compliance with which causes the output circuit of the DC-DC converter to be an SELV circuit according to IEC/EN 60950 up to a configured output voltage (sum of nominal voltages if in series or +/– configuration) of 44 V.

However, it is the sole responsibility of the installer to assure the compliance with the relevant and applicable safety regulations. More information is given in: *Technical Information: Safety*.

Table 8: Insulation concept leading to an SELV output circuit

Conditions	Front end			DC-DC converter	Result
Supply voltage	Minimum required grade of isolation, to be provided by the AC-DC front end, including mains supplied battery charger	Maximum DC output voltage from the front end [1]	Minimum required safety status of the front end output circuit	Measures to achieve the specified safety status of the output circuit	Safety status of the DC-DC converter output circuit
Mains ≤250 V AC	Operational (i.e. there is no need for electrical isolation between the main supply voltage and the DC-DC converter input voltage)	≤180 V [1]	Primary circuit	Basic insulation, based on 250 V AC (provided by the DC-DC converter), input fuses [2], output suppressor diode [3], earthed output circuit and earthed [4] or non user accessible case [5]	Earthed SELV circuit
	Basic	≤60 V [6]	Earthed SELV circuit [4]	Operational insulation (provided by the DC-DC converter)	SELV circuit
	Supplementary		ELV circuit	Basic insulation, based on 250 V AC (provided by the DC-DC converter)	
		>60 V [1]	Unearthed hazardous voltage secondary circuit [5]		
	Double or reinforced	≤60 V [1]	SELV circuit	Operational insulation (provided by the DC-DC converter)	
		≤120 V [6]	TNV-3 circuit	Basic insulation, based on the maximum output voltage from the front end (provided by the DC-DC converter)	
		>60 V [1]	Double or reinforced insulated unearthed hazardous voltage secondary circuit [6]		

[1] The front end output voltage should match the specified input voltage range of the DC-DC converter. The nominal voltage between any input pin and earth can be up to 250 V AC or 400 V DC.
[2] The installer shall provide an approved fuse (type with the lowest rating suitable for the application) in both input lines directly at the input of the DC-DC converter (see fig.: *Schematic safety concept*). For UL's purpose, the fuse needs to be UL-listed.
[3] The suppressor diode should be dimensioned in such a way, that in the case of an insulation fault the diode is able to limit the output voltage to SELV (<60 V) until the input fuse blows (see fig.: *Schematic safety concept*).
[4] The earth connection has to be provided by the installer according to the relevant safety standard, e.g. IEC/EN 60950 (see also fig.: *Schematic safety concept*).
[5] Has to be insulated from earth by at least supplementary insulation according to the relevant safety standard, based on the maximum output voltage from the front end.
[6] The front end output voltage should match the specified input voltage range of the DC-DC converter.
[7] Has to be insulated from earth by at least supplementary insulation according to the relevant safety standard, based on the maximum mains supply voltage.

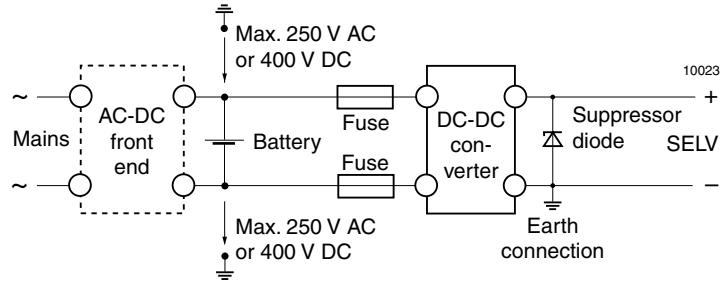


Fig. 10
Schematic safety concept. Use fuse, suppressor diode and earth connection as per table Safety concept leading to an SELV output circuit.

Description of Options

-6 Hermetic semiconductor

The converters are equipped with hermetic semiconductors instead of the standard plastic ones as far as such components are electrically and mechanically compatible.

P Potentiometer

The potentiometer provides an output voltage adjustment range of ±5% from the nominal output voltage $U_{o\,nom}$ and is accessible from the connector side. This option can be used, for example, to compensate for voltage drops in the supply lines.

R Shifted input voltage range

Option R allows the operation of BSR and CSR converter series from either 24 or 48 V input voltages. The input voltage tolerance is –30...25% as required by IEC 571: *Rules for Electronic Equipment used on Rail Vehicles*.

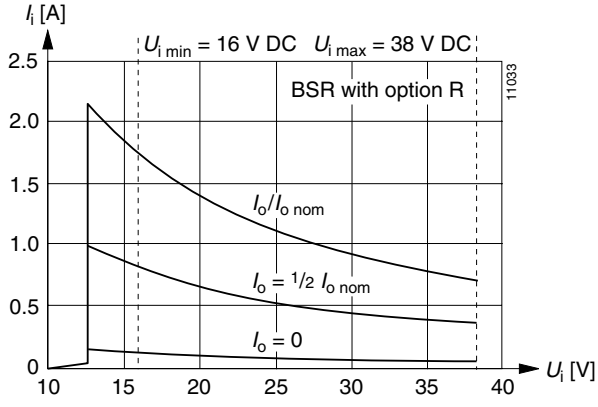


Fig. 11
Input current I_i versus input voltage U_i

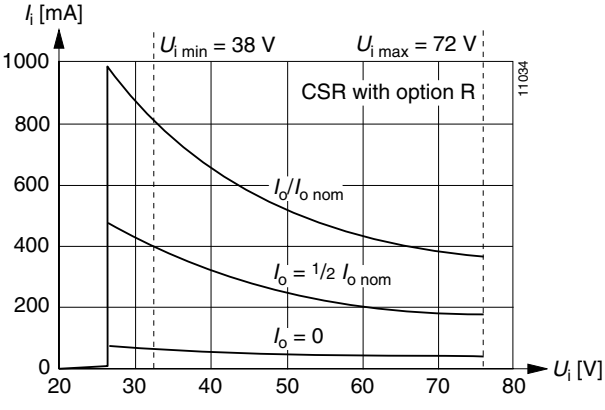


Fig. 12
Input current I_i versus input voltage U_i

i Inhibit

The DC-DC converter can be switched on or off with a control signal via the inhibit input i. In systems with several units, this feature can be used, for example, to control the activation sequence of the units with a logic signal (TTL, C-MOS, etc.).

Note: A non-used inhibit input should be connected to the negative output to enable the unit.

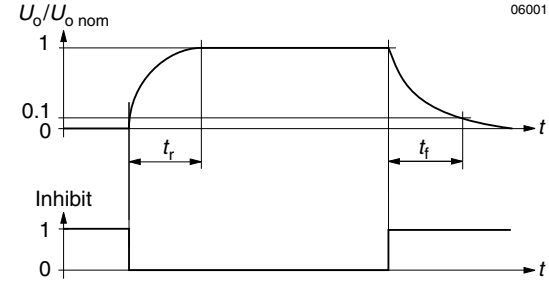


Fig. 13
Output response as a function of inhibit signal

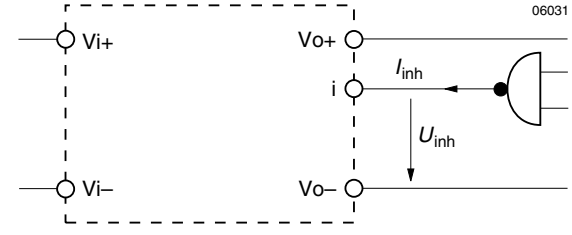


Fig. 14
Definitions of I_{inh} and U_{inh}

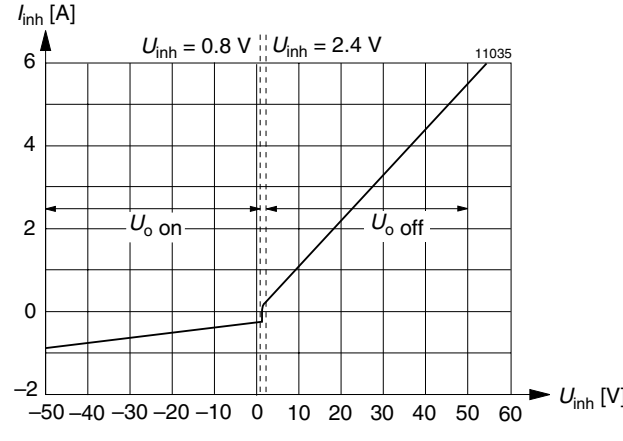


Fig. 15
Inhibit current I_{inh} versus inhibit voltage U_{inh}

Table 9: Inhibit characteristics

Characteristics			Conditions	.. SR 2005			.. SR 2012			.. SR 2015			.. SR 2024			Unit
				min	typ	max	min	typ	max	min	typ	max	min	typ	max	
U_{inh}	Inhibit input voltage to keep output voltage...	U_o = on	$U_{i\,min}$...$U_{i\,max}$ $T_{C\,min}$...$T_{C\,max}$ $R_L = U_{o\,nom}/I_{o\,nom}$ ...∞	–50		+0.8	–50		+0.8	–50		+0.8	–50		+0.8	V DC
		U_o = off		+2.4		+50	+2.4		+50	+2.4		+50	+2.4		+50	
I_{inh}	Inhibit input current at U_{inh} = 0					–400			–400			–400			–400	µA
t_r	Switch-on time after inhibit command		$R_L = U_{o\,nom}/I_{o\,nom}$ $U_{i\,nom}$		40			80			80			110		ms
t_f	Switch-off time after inhibit command				2			75			75			80		