100 W DC-DC Converters

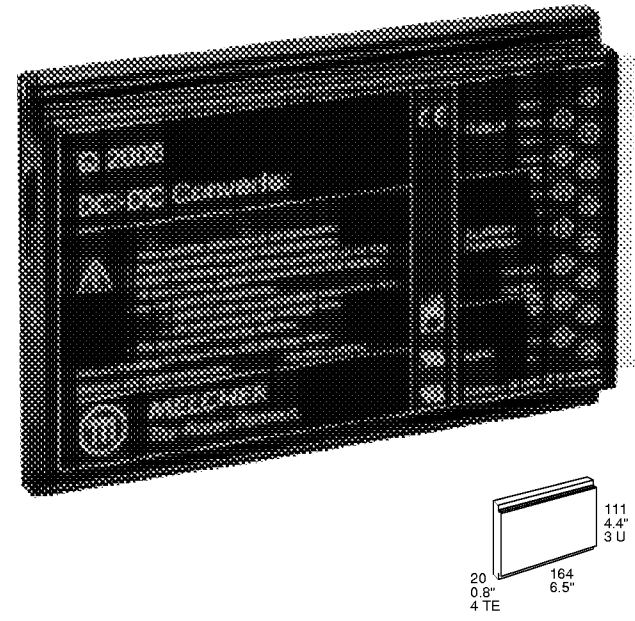
Q-Family

Input to output isolation
Single output: Series 24Q...48Q1000
Double output: Series 24Q...48Q2000

- Very high efficiency of up to 86%
- Flexible output power
- Excellent surge and transient protection
- Input to output electric strength test 2800 V DC
- Redundant operation (n+1), current sharing
- Extremely low inrush current, hot plug-in
- Externally adjustable output voltage and inhibit
- Very compact and fully functional unit (20 mm wide)
- Telecoms compatible input voltage range of 48Q units according to prETS 300132-2 (38...75 V DC)

Safety in accordance to
IEC/EN 60950, UL 1950, EN 41003

LGA



Summary

These extremely compact DC-DC converters incorporate all necessary input and output filtering, signalling and protection features which are required in the majority of industrial applications. The converters provide important advantages such as flexible output power through primary current limitation, very high efficiency, excellent reliability, very low ripple and RFI noise levels, full input to output isolation, negligible inrush current and input over-/undervoltage lockout. The outputs are continuously open-/short-circuit proof. An isolated output power good signal and an output OK LED at the front panel indicate the operation status.

Full system flexibility and n+1 redundant operating mode are possible due to virtually unrestricted series or parallel connection capabilities of all outputs. In parallel connection of several units, automatic current sharing is provided by a single wire interconnection.

As a modular power supply module or as part of a distributed power supply system, the low profile design significantly reduces the necessary power supply volume without sacrificing high reliability. The fully enclosed, black coated aluminium case acts as heat sink and RFI shield. The 19" cassette occupies 3U/4TE only, but can also be chassis-mounted by means of four M 3 screws.

Table of Contents

Type Survey and Key Data

Table 1: Type survey

Output 1		Output 2		Output power	Input Voltage Range and Efficiency [2]				Option
$U_{o\,nom}$ [V DC]	I_o [A]	$U_{o\,nom}$ [V DC]	I_o [A]	T_A = 50 °C $P_{o\,tot}$ [W] [1]	$U_{i\,min}$...$U_{i\,max}$ **16...36 V DC**	η_{min} [%]	$U_{i\,min}$...$U_{i\,max}$ **38...75 V DC**	η_{min} [%]	
5.1	0...16.0	-	-	82	24Q1001-2R	83	48Q1001-2R	83	P
12.0 [3]	0...8.0	-	-	96	24Q2320-2R	85	48Q2320-2R	85	
15.0 [3]	0...6.6	-	-	99	24Q2540-2R	85	48Q2540-2R	85	
24.0 [3]	0...4.4	-	-	106	24Q2660-2R	86	48Q2660-2R	86	
24.0 [4]	0.8...4.0	-	-	96	24Q2320-2R	85	48Q2320-2R	85	
30.0 [4]	0.6...3.3	-	-	99	24Q2540-2R	85	48Q2540-2R	85	
48.0 [4]	0.4...2.2	-	-	106	24Q2660-2R	86	48Q2660-2R	86	
12.0	0.8...7.2	12.0 [5]	0.8...7.2	96	24Q2320-2R	85	48Q2320-2R	85	
15.0	0.6...6.0	15.0 [5]	0.6...6.0	99	24Q2540-2R	85	48Q2540-2R	85	
24.0	0.4...4.0	24.0 [5]	0.4...4.0	106	24Q2660-2R	86	48Q2660-2R	86	

[1] The cumulated power of both outputs may not exceed the total power for the specified ambient temperature.
[2] Efficiency at $U_{i\,nom}$, $I_{o\,nom}$ and T_A = 25 °C.
[3] Output 1 and 2, in parallel configuration.
[4] Output 1 and 2, in series configuration.
[5] Symetrical configuration with second output semi-regulated (±5% $U_{o\,nom}$).

Output Configuration

The Q unit design allows high flexibility in output configuration to cover almost every individual requirement, by simply wiring the outputs in parallel, series or symmetrical configurations as per following figures. For further information and for parallel and series operation of several modules refer to *Electrical Output Data*.

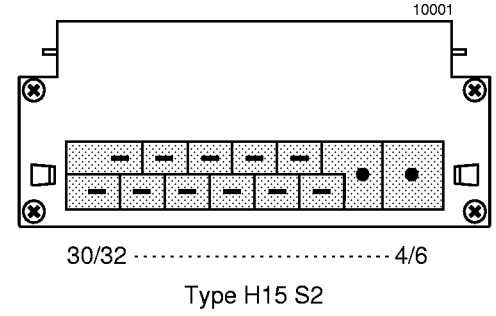


Fig. 1
Single output configuration

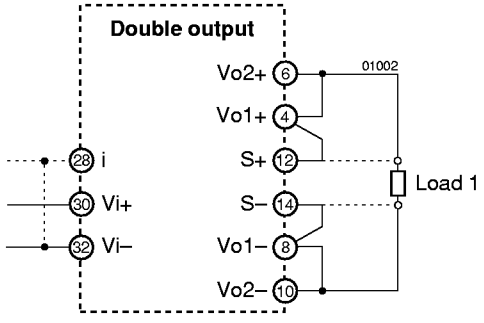


Fig. 2
Parallel output configuration

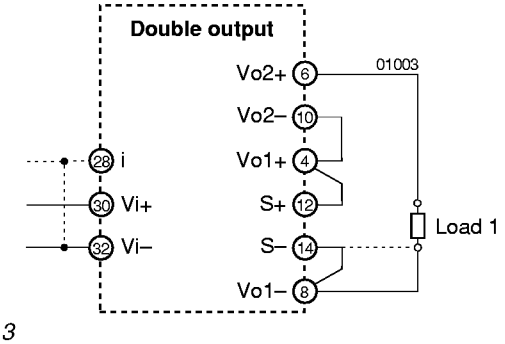


Fig. 3
Series output configuration (negative sense at load only)

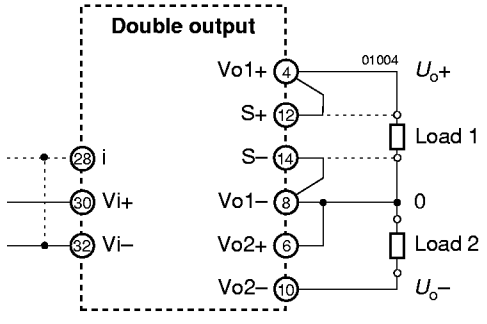


Fig. 4
Symmetrical common ground output configuration

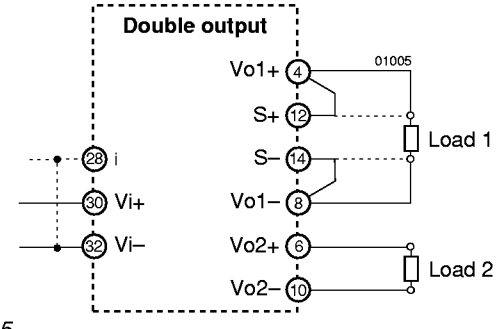
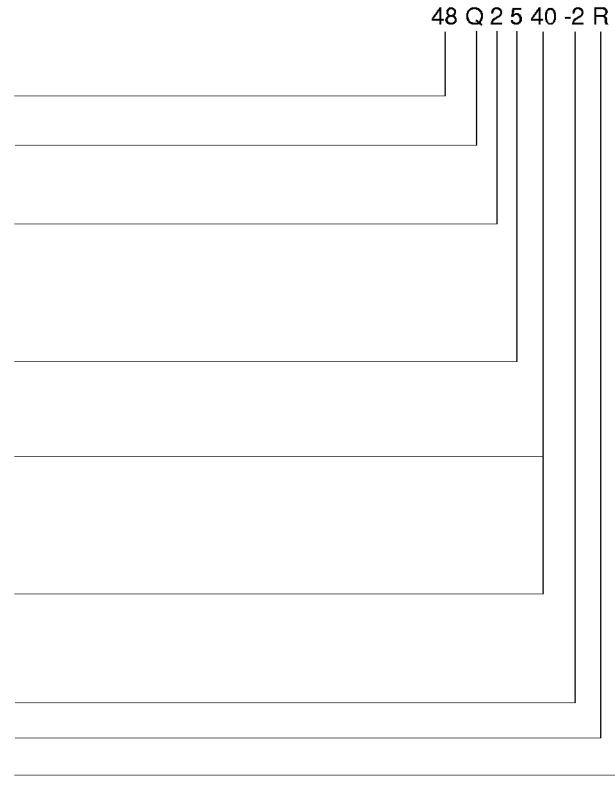


Fig. 5
Independent symmetrical output configuration

Type Key and Product Marking

Type Key



Input voltage range U_I:
- 16...36 V DC 24
- 38...75 V DC 48

Family ..... Q

Number of outputs:
- Single output 1
- Double output 2

Nominal voltage output 1 (main output), $U_{o1\ nom}$
- 5.1 V 0
- 12 V 3
- 15 V 4, 5
- 24 V 6
- other voltages 1, 2, 7, 8

Other specifications for main output ..... 01...99

Symmetrical double output units:
Nominal voltage output 1/output 2, $U_{o1/2\ nom}$
- 12 V/12 V (24 V series connected) 20
- 15 V/15 V (30 V series connected) 40
- 24 V/24 V (48 V series connected) 60
- other symmetrical voltages ..... 70...99

Operational ambient temperature range T_A:
- –10...50 °C ..... -2

Output voltage control input (Auxiliary function) ..... R [1]

Potentiometer (Option) ..... P [1]

[1] Feature R excludes option P and vice versa

Example: 48Q2540-2P: DC-DC converter, input voltage range 38...75 V, double output, each providing 15 V/3.3 A, equipped with potentiometer and operating ambient temperature of -10...50 °C.

Note: All units feature the following auxiliary functions which are not shown in the type designation: Input and output filters, inhibit, sense lines, current sharing, out OK signal and LED indicator.

Product Marking

Main face: Basic type designation, applicable safety approval and recognition marks, CE mark, warnings, pin allocation of input, output and auxiliary functions, Melcher patents and company logo.

Front plate: Identification of LED and potentiometer.

Back plate: Specific type designation, input voltage range, nominal output voltage and output current and degree of protection.

Rear face: Label with batch no., serial no. and data code including production site, modification status and date of production. Confirmation of successfully passed final test.

Functional Description

The units are designed as forward converters using primary and secondary control circuits in hybrid technology. The switching frequency is approximately 200 kHz under nominal operating conditions. The built-in input filter together with a minimum input capacitance generate very low inrush currents with short duration. After transformer isolation and rectification, the output filter reduces ripple and noise to a minimum without compromise to the dynamic ability. The output voltage is fed back to the secondary control circuit via the sense lines. The resultant error signal is sent to the primary control circuit via a signal transformer.

Double output modules have their voltage regulation of output 2 relying on the close magnetic coupling of the transformer and the output inductor together with the circuits symmetry. The current limitation is located at the primary side, thus limiting the total output current in overload conditions. This allows flex power operation of each output for unsymmetrical loads in the range from 10...90% of the total output power. In applications with large dynamic load changes it is recommended to connect such load to output 1 only. Output 1 and output 2 can either be series- or parallel-connected (see *Electrical Output Data*).

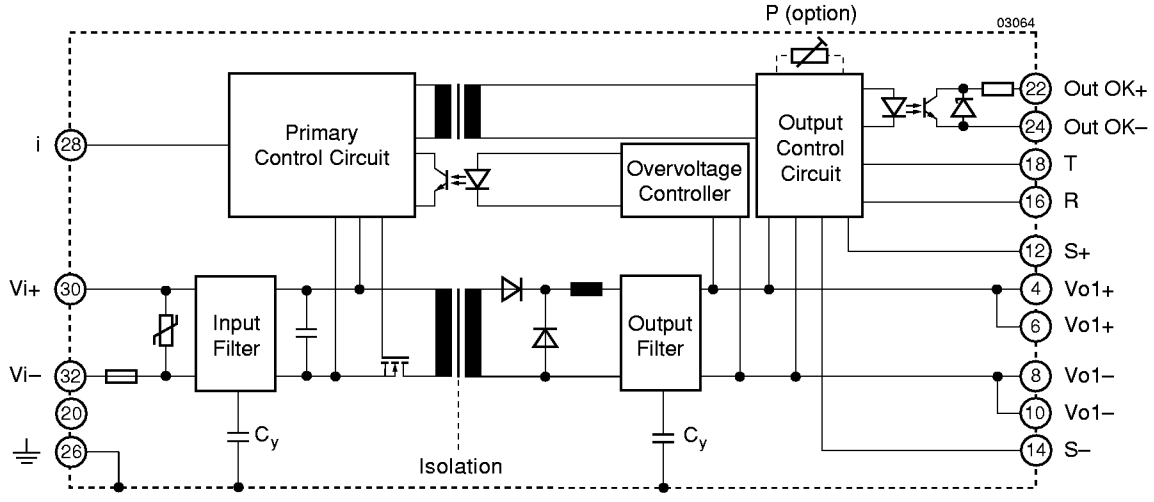


Fig. 6
Block diagram of a single output converter

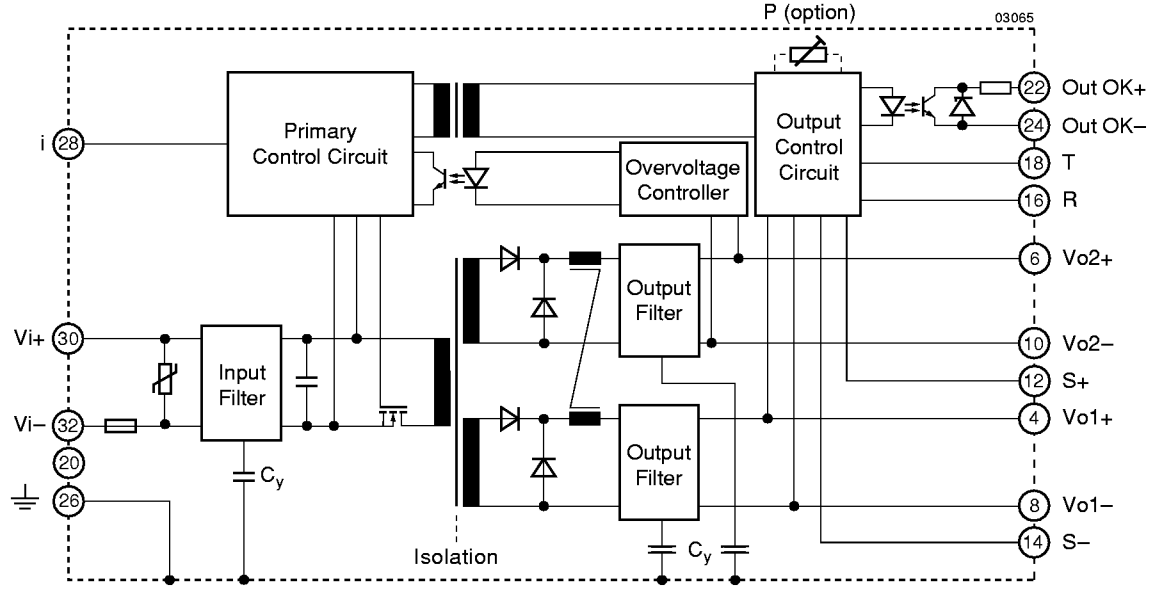


Fig. 7
Block diagram of a double output converter

Electrical Input Data

General Conditions
– T_A = 25 °C, unless T_C is specified.
– Sense lines connected directly at the connector, inhibit (28) connected to Vi– (32).
– R input not connected; with option P, U_o set to $U_{o\,nom}$ at $U_{i\,nom}$.

Table 2: Input data

Input			24Q			48Q			
Characteristics		Conditions	min	typ	max	min	typ	max	Unit
U_i	Operating input voltage	I_o = 0...$I_{o\,nom}$ $T_{C\,min}$...$T_{C\,max}$	16		36	38		75	V DC
$U_{i\,nom}$	Input voltage nominal			24			48		
$U_{i\,abs}$	Input voltage limits	without damage	0		50	0		100	
I_i	Typical input current [1]	$U_{i\,nom}$, $I_{o\,nom}$		4.5			2.2		A
$P_{i\,0}$	No-load input power	$U_{i\,min}$...$U_{i\,max}$ I_o = 0			2.5			2.5	W
$P_{i\,inh}$	Idle input power	unit inhibited			1.0			1.5	
$I_{inr\,p}$	Peak inrush current [2]	$U_{i\,nom}$, $I_{o\,nom}$		55			35		A
$t_{inr\,r}$	Rise time			50			35		µs
$t_{inr\,h}$	Trailing edge half-life			130			80		

[1] Typical input current depends on individual module
[2] According to prETS 300132-2 (Ver. 3.1)

Input Fuse

A fuse mounted inside the converter protects the module in case of failure against severe defects. The fuse can not be made externally accessible. Reverse polarity at the input will cause the fuse to blow.

Table 3: Fuse specification

Module	Fuse type	Fuse rating
24Q	fast-blow	Littelfuse 275 2 × 7 A, 125 V
48Q	fast-blow	Littelfuse 275 10 A, 125 V

Input Transient Protection

A metal oxide VDR (Voltage Dependent Resistor) together with the input fuse and a symmetrical input filter from an effective protection against high input transient voltages which typically occur in most installations, but espacially in battery driven applications.

Input Under-/Overvoltage Lock-Out

If the input voltage remains below approx. 0.9 $U_{i\,min}$ or exceeds approx. 1.1 $U_{i\,max}$ an internally generated inhibit signal disables the output(s). When checking this function the absolute maximum input voltage $U_{i\,abs}$ should be considered!

Inrush Current Limitation

The inherent inrush current value is lower than specified in the prETS 300132-2 (ver. 3.1) standard. The units operate with relatively small input capacitance resulting in low inrush current of short duration. As a direct consequence in a power-bus system the units can be hot plugged-in or disconnected causing negligible disturbance at the input side.

Electrical Output Data

General Conditions:
– T_A = 25°C, unless T_C is specified.
– R input not connected; with option P, U_o set to $U_{o\,nom}$ at $U_{i\,nom}$.
– Sense lines connected directly at the connector, inhibit (28) connected to Vi– (32).

Table 4a: Output data for single output modules and modules in parallel configuration

Output				24Q...48Q1001 5.1 V			24Q...48Q2320 12.0 V			24Q...48Q2540 15.0 V			24Q...48Q2660 24.0 V			
Characteristics			Conditions	min	typ	max	min	typ	max	min	typ	max	min	typ	max	Unit
U_o	Output voltage [1]		$U_{i\,nom}$, $I_{o\,nom}$	5.07		5.13	11.94		12.06	14.93		15.08	23.88		24.12	V
U_{ow}	Worstcase output voltage		$U_{i\,min}$...$U_{i\,max}$ $T_{C\,min}$...$T_{C\,max}$ I_o = 0...$I_{o\,nom}$	5.02		5.18	11.82		12.18	14.78		15.23	23.64		24.36	
$U_{o\,P}$	Overvoltage limitation of second control loop			5.9		6.4	13.5		15.0	17.0		19.0	27.5		30.0	
I_o [2]	Output current		$U_{i\,min}$...$U_{i\,max}$ $T_{C\,min}$...$T_{C\,max}$	0		16.0	0		8.0	0		6.6	0		4.4	A
$I_{o\,nom}$	Nominal output current [7]			16.0			8.0			6.6			4.4			
$I_{o\,L}$	Output current limit [2]			16.8		20.8	8.4		10.4	6.9		8.6	4.6		6.2	
u_o [6]	Output voltage noise	Switch. frequ.	$U_{i\,nom}$, $I_{o\,nom}$ BW = 20 MHz		15	25		15	30		20	30		65	95	mV_{pp}
		Total			20	30		25	45		25	45		75	110	
P_o	Output power [1]		$U_{i\,min}$...$U_{i\,max}$ $T_{C\,min}$...$T_{C\,max}$			90			100			100			110	W
$u_{o\,d}$ [3 6]	Dynamic load regulation	Voltage deviation	$U_{i\,nom}$, I_o = $I_{o\,nom}$ ↔ ½ $I_{o\,nom}$		±500			±500			±500			±700		mV
t_d [3 6]		Recovery time			0.15			0.30			0.30			0.35		ms
$U_{o\,tr}$	Output voltage trimming range [4]		$U_{i\,min}$...$U_{i\,max}$ (0.1...1) $I_{o\,nom}$	4.0 4.6		5.6 5.6	5.5 10.8		13.2 13.2	8.0 13.5		16.5 16.5	14.0 21.6		26.4 26.4	V

Table 4b: Output data for double output modules in series configuration

Output				24Q...48Q2320 24 V (2 × 12 V)			24Q...48Q2540 30 V (2 × 15 V)			24Q...48Q2660 48 V (2 × 24 V)			
Characteristics			Conditions	min	typ	max	min	typ	max	min	typ	max	Unit
U_o	Output voltage [1]		$U_{i\,nom}$, $I_{o\,nom}$	23.76		24.24	29.70		30.30	47.52		48.48	V
U_{ow}	Worstcase output voltage		$U_{i\,min}$...$U_{i\,max}$ $T_{C\,min}$...$T_{C\,max}$	23.52		24.48	29.40		30.60	47.04		48.96	
$U_{o\,P}$	Overvoltage limitation of second control loop		$I_{o\,min}$...$I_{o\,nom}$ [5]	27		30	34		38	55		60	
I_o [2 5]	Output current		$U_{i\,min}$...$U_{i\,max}$ $T_{C\,min}$...$T_{C\,max}$	0.8		4.0	0.6		3.3	0.4		2.2	A
$I_{o\,nom}$	Nominal output current			4.0			3.3			2.2			A
$I_{o\,L}$	Output current limit [2]			4.2		5.2	3.45		4.3	2.3		3.1	
u_o [6]	Output voltage noise	Switch. frequ.	$U_{i\,nom}$, $I_{o\,nom}$ BW = 20 MHz		30	60		40	80		130	190	mV_{pp}
		Total			50	90		50	90		150	220	
P_o	Output power 1		$U_{i\,min}$...$U_{i\,max}$ $T_{C\,min}$...$T_{C\,max}$			100			100			110	W
$u_{o\,d}$ [3 6]	Dynamic load regulation	Voltage deviation	$U_{i\,nom}$, I_o = $I_{o\,nom}$ ↔ ½ $I_{o\,nom}$		±1000			±1000			±1400		mV
t_d [3 6]		Recovery time			0.3			0.3			0.35		ms
$U_{o\,tr}$	Output voltage trimming range [4]		$U_{i\,min}$...$U_{i\,max}$ (0.1...1) $I_{o\,nom}$	11.0 21.6		26.4 26.4	16.0 27.0		33.0 33.0	28.0 43.0		52.8 52.8	V

[1] If the output voltages are increased above $U_{o\,nom}$ through R-input control, option P setting or remote sensing, the output power should be reduced accordingly so that $P_{o\,max}$ and $T_{C\,max}$ are not exceeded.
[2] See *Output Current Limitation*.
[3] Recovery time until U_o remains within 1% of $U_{o\,nom}$, see *Dynamic Load Regulation*.
[4] Upper row represents setting via R-input, lower row option P range.
[5] $I_{o\,min}$ = 10% of $I_{o\,nom}$ for each output necessary (see also *Output Regulation*).
[6] According to IEC/EN 61204.
[7] In parallel configuration $I_{o\,nom} = I_{o1\,nom} + I_{o2\,nom}$.

Parallel or Series Connection of Outputs and/or Units

Single or double output units with equal nominal output voltage can be connected in parallel without any precaution by interconnecting the T-pins for approximate equal current sharing. (See *Auxiliary Functions*.)

Any double output unit with its outputs in parallel behaves like a single output unit, i.e. is fully regulated. There is no inconvenience or restriction using the R-input and the sense lines .

Single output units and/or main and second outputs of double output units can be connected in series with any other (similar) output. For double output modules consider, that the effect via sense lines, R-input or option P is doubled.

Note:

- Parallel connection of several double output units should always include both, main and second output to maintain good regulation of all outputs.
- Series connection of second outputs without involving their main outputs should be avoided as regulation may be poor.
- The maximum output current is limited by the output with the lowest current limitation if several outputs are connected in series.
- Rated output voltages above 48 V (SELV = Safety Extra Low Voltage) need additional measures in order to comply with international safety requirements.

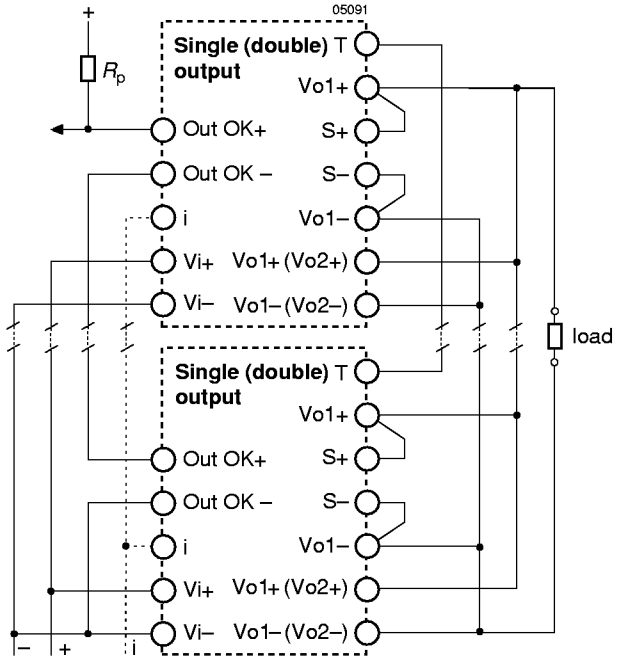


Fig. 8
Parallel connection of outputs and/or several modules, sense lines connected at connector side

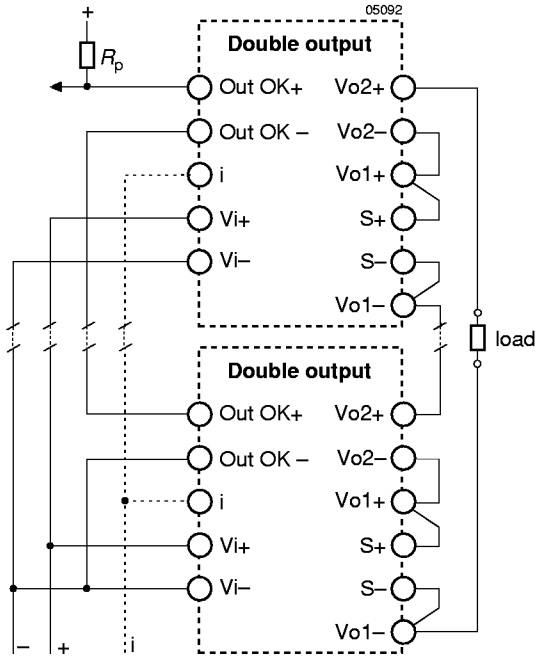


Fig. 9
Series connection of outputs and/or several modules, sense lines connected at connector side only

Dynamic Load Regulation

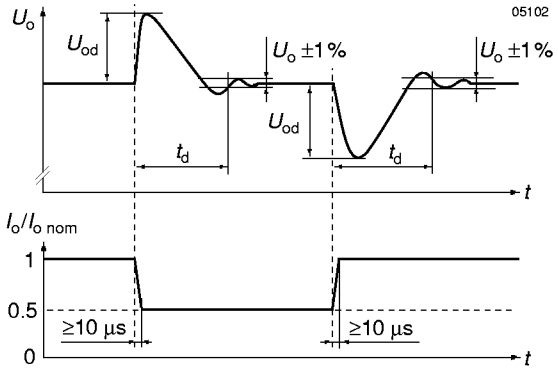


Fig. 10
Control deviation of U_o versus dynamic load change

Hold up Time

The modules provide virtually no hold up time. If hold up time is required, use external output capacitors or decoupling diodes and input capacitors of adequate size.

Formula for additional external input capacitor

$$C_{i\,ext} = \frac{2 \cdot P_o \cdot t_h \cdot 100}{\eta \cdot (U_{ti}^2 - U_{i\,min}^2)}$$

where as:

$C_{i\,ext}$ = external input capacitance [mF]
P_o = output power [W]
η = efficiency [%]
t_h = hold-up time [ms]
$U_{i\,min}$ = minimum input voltage [V]
U_{ti} = threshold level [V]

General Conditions:
– T_A = 25 °C, unless T_C is specified.
– R input not connected; with option P, U_o set to $U_{o\,nom}$ at $U_{i\,nom}$.
– Sense lines connected directly at the connector, inhibit (28) connected to Vi– (32).

Table 5a: Output data for double output modules in symmetrical configuration

Output				**24Q...48Q2320 12 V/12 V**						**24Q...48Q2320 15 V/15 V**						
Characteristics			Conditions	Output 1			Output 2			Output 1			Output 2			Unit
				min	typ	max	min	typ	max	min	typ	max	min	typ	max	
U_o	Output voltage [1]		$U_{i\,nom}$, $I_{o\,nom}$	11.94		12.06	11.82		12.18	14.93		15.08	14.78		15.23	V
U_{ow}	Worstcase output voltage		$U_{i\,min}$...$U_{i\,max}$ $T_{C\,min}$...$T_{C\,max}$ $I_{o\,min}$...$I_{o\,nom}$ [5]	11.82		12.18	see *Output voltage regulation*			14.78		15.23	see *Output voltage regulation*			
$U_{o\,P}$	Overvoltage limitation of second control loop						13.5		15.0				17.0		19.0	
I_o [5]	Output current		$U_{i\,min}$...$U_{i\,max}$ $T_{C\,min}$...$T_{C\,max}$	0.8		7.2	0.8		7.2	0.6		6.0	0.6		6.0	A
$I_{o\,nom}$	Nominal output current [2]			8.0						6.6						
$I_{o\,L}$	Output current limit [2]			8.4		10.4	8.4		10.4	6.9		8.6	6.9		8.6	
u_o [6]	Output voltage noise	Switch. frequ.	$U_{i\,nom}$, $I_{o\,nom}$ BW = 20 MHz		15	25		15	30		20	30		20	30	mV_{pp}
		Total			25	45		25	45		25	45		25	45	
P_o	Output power [1]		$U_{i\,min}$...$U_{i\,max}$ $T_{C\,min}$...$T_{C\,max}$	100						100						W
$u_{o\,d}$ [3 6]	Dynamic load regulation	Voltage deviation	$U_{i\,nom}$, I_{o1} = ½ ↔ ¼ $I_{o\,nom}$ I_{o2} = ½ $I_{o\,nom}$	±500						±500						mV
t_d [3 6]		Recovery time		0.3						0.30						ms
$U_{o\,tr}$	Output voltage trimming range [4]		$U_{i\,min}$...$U_{i\,max}$ (0.1...1) $I_{o\,nom}$	5.5 10.8		13.2 13.2	5.5 10.8		13.2 13.2	8.0 13.5		16.5 16.5	8.0 13.5		16.5 16.5	V

Table 5b: Output data for double output modules in symmetrical configuration

Output				**24Q...48Q2660 24 V/24 V**						
Characteristics			Conditions	Output 1			Output 2			Unit
				min	typ	max	min	typ	max	
U_o	Output voltage [2]		$U_{i\,nom}$, $I_{o\,nom}$	23.85		24.14	23.64		24.36	V
U_{ow}	Worstcase output voltage		$U_{i\,min}$...$U_{i\,max}$ $T_{C\,min}$...$T_{C\,max}$ $I_{o\,min}$...$I_{o\,nom}$ [5]	23.64		24.36	see *Output voltage regulation*			
$U_{o\,P}$	Overvoltage limitation of second control loop						27.5		30.0	
I_o [5]	Output current		$U_{i\,min}$...$U_{i\,max}$ $T_{C\,min}$...$T_{C\,max}$	0.4		4.0	0.4		4.0	A
$I_{o\,nom}$	Nominal output current [2]			4.4						
$I_{o\,L}$	Output current limit [2]			4.6		6.2	4.6		6.2	
u_o [6]	Output voltage noise	Switch. frequ.	$U_{i\,nom}$, $I_{o\,nom}$ BW = 20 MHz		65	95		65	95	mV_{pp}
		Total			75	110		75	110	
P_o	Output power [1]		$U_{i\,min}$...$U_{i\,max}$ $T_{C\,min}$...$T_{C\,max}$	110						W
$u_{o\,d}$ [3 6]	Dynamic load regulation	Voltage deviation	$U_{i\,nom}$, I_{o1} = ½ ↔ ¼ $I_{o\,nom}$ I_{o2} = ½ $I_{o\,nom}$	±700						mV
t_d [3 6]		Recovery time		0.35						ms
$U_{o\,tr}$	Output voltage trimming range [4]		$U_{i\,min}$...$U_{i\,max}$ (0.1...1) $I_{o\,nom}$	14.0 21.6		26.4 26.4	14.0 21.6		26.4 26.4	V

[1] If the output voltages are increased above $U_{o\,nom}$ through R-input control, option P setting or remote sensing, the output power should be reduced accordingly so that $P_{o\,max}$ and $T_{C\,max}$ are not exceeded. Same conditions for both outputs.
[2] Value of total current, I_{o1} + I_{o2}. See *Output Current Limitation*.
[3] Recovery time until U_o remains within 1% of $U_{o\,nom}$, see *Dynamic Load Regulation*.
[4] Upper row represents setting via R-input, lower row option P range.
[5] $I_{o\,min}$ = 10% of $I_{o\,nom}$ for each output necessary (see also *Output Regulation*).
[6] According to IEC/EN 61204.

Output Voltage Regulation of Double Output Modules

In symmetrical configuration the main output 1 is under normal conditions regulated to $U_{o\,nom}$, independent of the output currents. Note that if the load on output 2 is too small (<0.1 • $I_{o\,nom}$), its voltage will rise, possibly activating the overvoltage protection, which will then reduce the voltage on both outputs.

U_{o2} is dependent upon the load distribution: When each output is loaded with at least 10% of $I_{o\,nom}$, the deviation of U_{o2} remains within ±5% of the value of $U_{o\,nom}$. The following figures explain the regulation with varying load distributions up to the current limit. If $I_{o1} = I_{o2}$ or the two outputs are in series-connection, the deviation of U_{o2} remains within ±1% of the value of $U_{o\,nom}$ provided that the load is more than 10% of $I_{o\,nom}$.

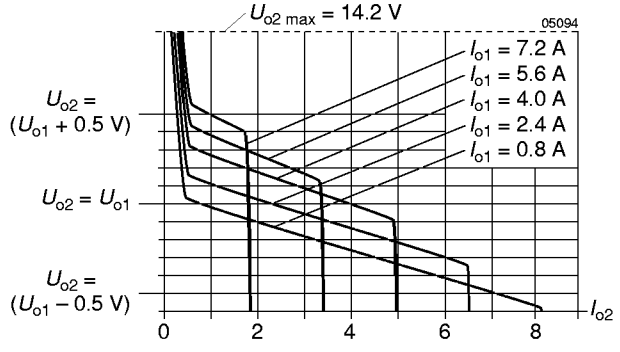


Fig. 11
24/48Q2320 output 2 voltage deviation vs. output 2 current with different currents on output 1

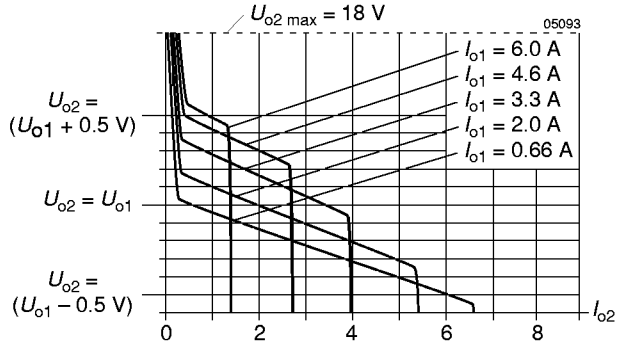


Fig. 12
24/48Q2540 output 2 voltage deviation vs. output 2 current with different currents on output 1

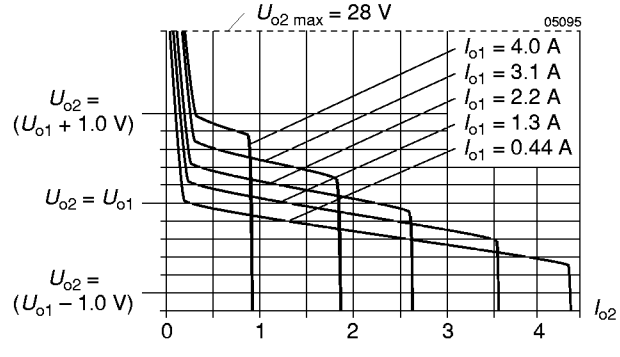


Fig. 13
24/48Q2660 output 2 voltage deviation vs. output 2 current with different currents on output 1

Output Voltage Overshoot Protection

Negligible output voltage overshoot may occur if the module is either hot plugged-in or disconnected, the input voltage is switched on or off, the module is switched with an inhibit signal, or after a reset of a short circuit and power failure.

Second Control Loop

A fully independent second control loop limits the output voltage to approximately 1.25 • $U_{o\,nom}$ (e.g. sense lines wired incorrectly). It further protects the load in the unlikely event of a malfunction of the main control circuit.

In double output modules output 1 is fully regulated with overvoltage protection on output 2, through this second control loop.

There is no specific built-in protection against externally applied overvoltages.

Continuous Open-Circuit and Short-Circuit Proof

All outputs are fully protected against continuous open circuit, e.g. against no load condition (for the 24Q...48Q2000 characteristics refer to *Output Voltage Regulation of Double Output Modules*) and all outputs are fully protected against continuous short circuit condition by means of the electronic current limitation on the primary side (see *Output Current Limitation*).

Output current limitation

Single output units and series- or parallel-connected double output units have a quasi rectangular constant current limitation characteristic.

In double output units, the total current is limited, allowing free choice of load distribution between the two outputs, up to a total $I_{o1} + I_{o2} \leq I_{o\,max}$ (see *Output Voltage Regulation of Double Output*). In overload ($I_{o1} + I_{o2} > I_{o\,max}$) both output voltages are simultaneously reduced.

Independent outputs with symmetrical current loads both have a rectangular current limitation characteristic.

Current distribution in overload is dependent upon the type of overload. A short-circuit in one output will cause the full current flow into that output whereas a resistive overload results in more even distribution and in a reduced output voltage.

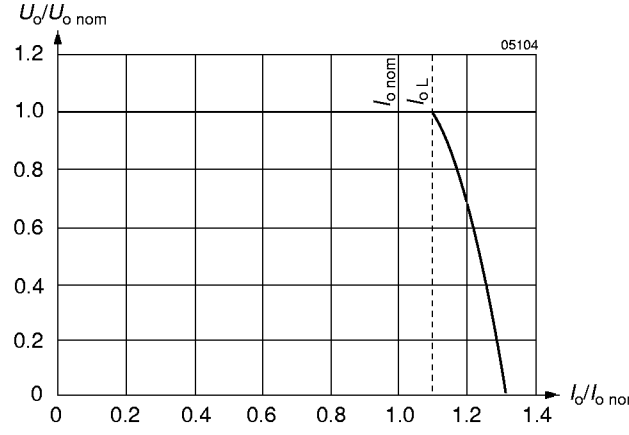


Fig. 14
Current limitation behaviour of a single or a double output unit with series- or parallel-connected outputs

Typical Efficiency

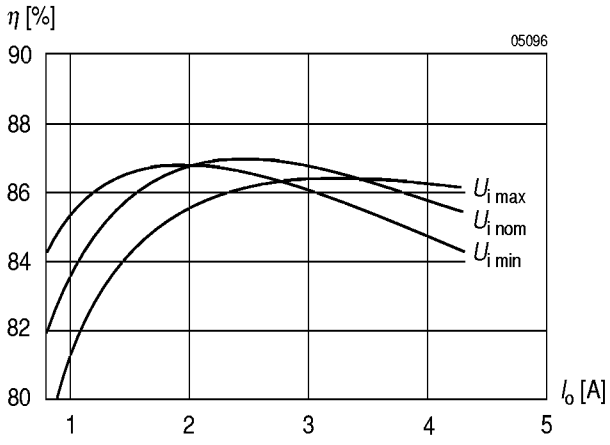


Fig. 15
Efficiency versus input voltage and output current (per output). Typical values of 24Q2320 at $U_{o\,nom}$.

Thermal Considerations

If a converter is located upright in free flowing, 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 power, 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.* The unit does not provide internal overtemperature protection.

Notes: Sufficient forced cooling or an additional heat sink allows operation at full output power and improves the reliability or allows T_A to be higher than $T_{A\,max}$ (e.g. 65°C) as long as $T_{C\,max}$ is not exceeded. In rack systems without proper thermal management, the modules must not be packed too densely! In such cases the use of a 5 or 6TE front panel is recommended.

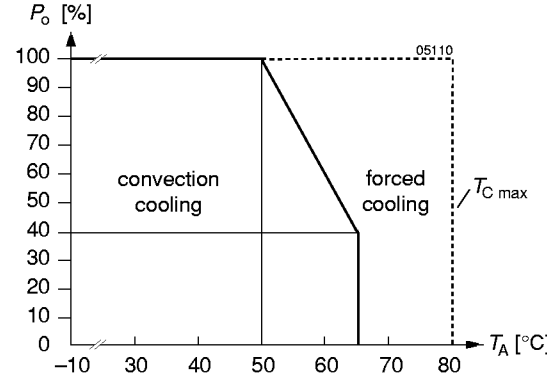


Fig. 16
Output current derating versus T_A.

Auxilary Functions

i Inhibit for Remote On and Off

Note: If this function is not actively used, the inhibit pin 28 must be interconnected with the negative input pin 32 to enable the output(s). A non-connected pin 28 will be interpreted by the internal logic as an active inhibit signal and therefore output(s) will remain disabled: Fail safe function.

An inhibit input enables (logic low, pull down) or disables (logic high, pull up) the output if a logic signal e.g. TTL, CMOS is applied. In systems consisting of several units, this feature may be used, for example, to control the activity sequence of the converters by means of logic signals, or to allow the unit's source for a proper start up before full load is applied (e.g. in combination with LT units).

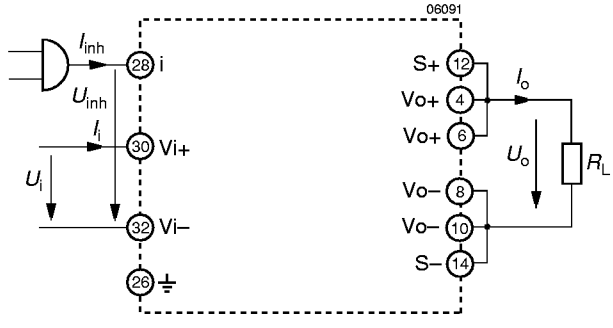


Fig. 17
Definition of input and output parameters

Table 6: Inhibit characteristics

Characteristics			Conditions	min typ max	Unit
U_{inh}	Inhibit voltage	U_o = on	$U_{i\,min}$...$U_{i\,max}$ $T_{C\,min}$...$T_{C\,max}$	–100 0.8	V DC
		U_o = off		2.4 100	
I_{inh}	Inhibit current		U_{inh} = –50 V U_{inh} = 0 V U_{inh} = 50 V U_{inh} = 100 V	–500 –40 +500 +1000	µA

Output Response

The output response when enabling and disabling the output by the inhibit input is shown in the following figure.

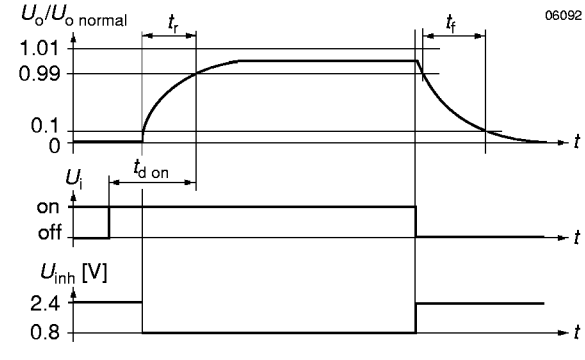


Fig. 18
Output response as a function of input voltage (on/off switching) or inhibit control

Table 7: Output response time with outputs resistively loaded and R-input and Poption not used

Characteristics		Conditions	24Q min	24Q typ	24Q max	48Q min	48Q typ	48Q max	Unit
$t_{d\,on}$	Turn-on delay time	$U_i = 0 \rightarrow U_{i\,min}$, $R_L = U_{o\,nom}/0.5\ I_{o\,nom}$		5			5		ms
		$U_i = 0 \rightarrow U_{i\,nom}$, $R_L = U_{o\,nom}/I_{o\,nom}$		3.5			3.5		
t_r	Output voltage rise time	$U_i = 0 \rightarrow U_{i\,nom}$, $R_L = U_{o\,nom}/I_{o\,nom}$		2.5			2.5		
		$U_{i\,inh} = 2.4 \rightarrow 0.8$ V, $R_L = U_{o\,nom}/I_{o\,nom}$							
t_f	Output voltage fall time	$U_i = U_{i\,nom} \rightarrow 0$, $R_L = U_{o\,nom}/I_{o\,nom}$		3			3		
		$U_{i\,inh} = 0.8 \rightarrow 2.4$ V, $R_L = U_{o\,nom}/I_{o\,nom}$							

Current Sharing (T Function)

The current sharing facility should be used where several units are to be operated in parallel for high reliability n+1 redundant systems or in order to provide higher output powers. Using this feature reduces the stress on the units and further improves the reliability of the system.

Interconnection of the current sharing terminals T causes the units to share the output current to the average of all units. The current tolerance of each unit is approx. ±20% of the sum of its nominal output currents $I_{o1\,nom} + I_{o2\,nom}$.

In n+1 redundant systems, a failure of a single unit will not lead to a system failure if the outputs are decoupled by diodes. See also *Sense Lines*.

Since the voltage on the T pin is referenced to the sense pin S–, the installer must ensure that the S– pins of all units are at the same electrical potential, i.e. voltage drops >50 mV across the connection lines between these pins shall be avoided.

24Q...48Q 2000 DC-DC converters with outputs connected in series can also be paralleled with current sharing, if pins Vo1– of all units are connected together. See *Sense Lines*.

If the output voltages are programmed to a voltage other than $U_{o\,nom}$ by means of the R pin or option P, the outputs should be adjusted individually within a tolerance of ±1%. The current sharing will be less accurate when operating with dynamic loads.

Important: For applications using the hot plug-in capabilities, dynamic output voltage changes during the plug-in/plug-out cycles must be considered.

R-Control for Output Voltage Adjustment

Note: With open R input, $U_o \approx U_{o\,nom}$. R excludes option P.

All modules offer a programmable output voltage feature. The programming is performed either by an external control voltage U_{ext} or an external resistor R_1/R_2, connected to the R-input. Trimming is limited to the values given in the table below (see also *Electrical Output Data*). With a disconnected R-input, the output voltage is set to $U_{o\,nom}$.

Simultaneous use of the R-input function and option P is not possible. If option P is built-in, the R-input will remain active but its function must not be used; do not connect pin R at all!

With double output modules, both outputs are affected by the R-input settings.

If output voltages are set higher than $U_{o\,nom}$, the output currents should be reduced accordingly, so that the maximum specified output power is not exceeded.

Caution: To prevent damage, U_{ext} should not exceed 20 V, nor be negative.

a) Adjustment by means of an external control voltage U_{ext} between R (16) and S– (14) U_o is dependent upon U_{ext}:

$$U_{ext} \approx 2.5\ V \cdot \frac{U_o}{U_{o\,nom}} \qquad U_o \approx U_{o\,nom} \cdot \frac{U_{ext}}{2.5\ V}$$

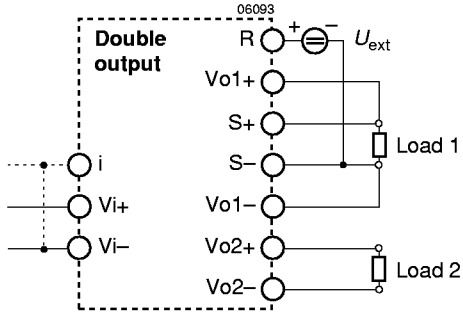


Fig. 19
Output voltage programming using a control voltage U_{ext}

b) Adjustment by means of an external resistor:

The resistor can either be connected between the pins R (16) and S– (14) to set $U_o < U_{o\,nom}$, or between the pins R (16) and S+ (12) to set $U_o > U_{o\,nom}$.

Note: R inputs of n units with paralleled outputs may be paralleled, too, but if only one external resistor is to be used, its value should be R_1/n, or R_2/n respectively.

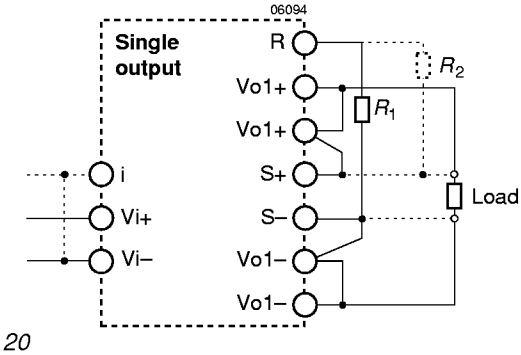


Fig. 20
Output voltage programming using R_1 or R_2

Table 8a: R_1 for $U_o < U_{o\,nom}$; approximate values ($U_{i\,nom}$, $I_{o\,nom}$, series E 96 resistors); $R_2 = \infty$

$U_{o\,nom}$ = 5.1 V		$U_{o\,nom}$ = 12 V			$U_{o\,nom}$ = 15 V			$U_{o\,nom}$ = 24 V		
U_o (V)	R_1 [kΩ]	U_o [V] [1]		R_1 [kΩ]	U_o [V] [1]		R_1 [kΩ]	U_o [V] [1]		R_1 [kΩ]
4.0	14.7	5.5	11.0	3.40	8.0	16.0	4.53	14.0	28.0	5.62
4.1	16.5	6.0	12.0	4.02	8.5	17.0	5.23	15.0	30.0	6.65
4.2	18.2	6.5	13.0	4.75	9.0	18.0	6.04	16.0	32.0	8.06
4.3	21.5	7.0	14.0	5.76	9.5	19.0	6.98	17.0	34.0	9.76
4.4	25.5	7.5	15.0	6.65	10.0	20.0	8.06	18.0	36.0	12.1
4.5	30.1	8.0	16.0	8.06	10.5	11.0	9.31	19.0	38.0	15.4
4.6	37.4	8.5	17.0	9.76	11.0	22.0	11.0	20.0	40.0	20.0
4.7	47.5	9.0	18.0	12.1	11.5	23.0	13.3	20.5	41.0	23.7
4.8	64.9	9.5	19.0	15.4	12.0	24.0	16.2	21.0	42.0	28.0
4.9	97.6	10.0	20.0	20.0	12.5	25.0	20.0	21.5	43.0	34.8
5.0	200.0	10.5	11.0	28.0	13.0	26.0	26.1	22.0	44.0	44.2
		11.0	22.0	44.2	13.5	27.0	36.5	22.5	45.0	60.4
		11.5	23.0	93.1	14.0	28.0	56.2	23.0	46.0	90.9
					14.5	29.0	115.0	23.5	47.0	190.0

Table 8b: R_2 for $U_o > U_{o\,nom}$; approximate values ($U_{i\,nom}$, $I_{o\,nom}$, series E 96 resistors); $R_1 = \infty$

$U_{o\,nom}$ = 5.1 V		$U_{o\,nom}$ = 12 V			$U_{o\,nom}$ = 15 V			$U_{o\,nom}$ = 24 V		
U_o [V]	R_2 [kΩ]	U_o [V] [1]		R_2 [kΩ]	U_o [V] [1]		R_2 [kΩ]	U_o [V] [1]		R_2 [kΩ]
5.2	215.0	12.2	24.4	931	15.3	30.6	1020	24.5	49.0	1690
5.3	110.0	12.4	24.8	475	15.5	31.0	619	25.0	50.0	866
5.4	75.0	12.6	25.2	316	15.7	31.4	453	25.5	51.0	590
5.5	57.6	12.8	25.6	243	16.0	32.0	324	26.0	52.0	453
5.6	46.4	13.0	26.0	196	16.2	32.4	274	26.4	52.8	383
		13.2	26.4	169	16.5	33.0	221			

[1] First column: single output units or double output units with separated/paralleled outputs, second column: outputs in series connection

Output good signal (Out OK)

The isolated Out OK output gives a status indication of the module and the output voltage. It can be used for control functions such as data protection, central system monitoring or as a part of a self-testing system. It can be connected to get a centralized fault detection or may be used for other system specific applications at the primary or the secondary side of the converter.

Connecting the Out OK as per figure below, U_{OK} <1.5 V indicates that the output voltage U_{o1} of the converter is within the range $U_{t1\,low}$...$U_{t1\,high}$. $U_{t1\,low}$ corresponds with 0.95...0.98 $U_{o1\,normal}$, $U_{t1\,high}$ with 1.02...1.05 $U_{o1\,normal}$, where $U_{o1\,normal}$ is the effective output voltage appearing in normal condition. (Using the R-input or the option P, the monitor level is tracking the programmed output voltage.) In case of an error condition, i.e. the output voltage U_{o1} is out of the range $U_{t1\,low}$...$U_{t1\,high}$ due to an overload condition or to an external overvoltage, U_{OK} will be almost as high as the voltage U_p.

The output is formed by a NPN transistor capable of driving 3...6 mA max. The emitter (Out OK–) can be connected to primary Vi– or secondary Vo1– to get an open collector output. With several independent units the Out OK pins can be series-connected in order to get a system level signal. If one of the units fails the series-connected outputs rise to a high impedance. This series-connection can be completed by other transistors providing extended user specific error information.

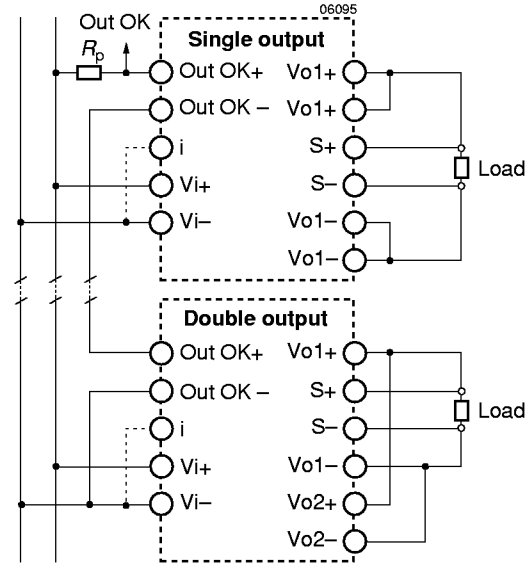


Fig. 21
Series connection of the output good signal at the primary side of the converters for system supervision

Table 9: Output OK data

Characteristics		Conditions	min	typ	max	Unit
U_{OK}	Out OK voltage	good: $U_{t1\ low} < U_{01} < U_{t1\ high}$, $I_{OK} < 0.5$ mA [1]		1.0	1.5	V
I_{OK}	Out OK current	error: $U_{o1} < U_{t1\ low}$, $U_{OK} \leq 15$ V			25	µA
		error: $U_{o1} > U_{t1\ high}$, $U_{OK} \leq 15$ V				

[1] Higher current capability is available on request.

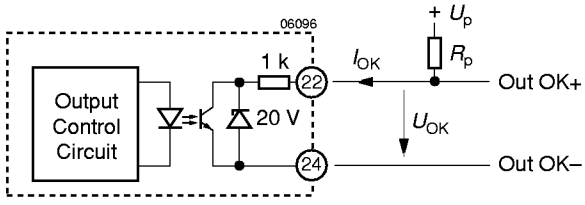


Fig. 22
Output OK function

Dimensioning of resistor value $R_p \geq \frac{U_p}{0.5\ mA}$

Caution: The Out OK is protected by an internal series resistor and a Zener diode. To prevent damage, the applied current I_{OK} should be limited to ±20 mA maximum and the applied voltage U_{OK} to ±25 V maximum.

Display status of LED

Table 10: Display status of LED

LED Out OK	Operating condition
green	normal operation
x	incorrect sense line connection
off	overload output overvoltage output undervoltage no input voltage input voltage too low inhibit open/high input voltage too high

x = dependent on actual operating condition

Sense Lines

Important: Sense lines must always be connected! Incorrectly connected sense lines may activate the overvoltage limitation, i.e. shuting down the output.

This feature enables compensation of voltage drop across the connector contacts and the load lines including the diode in true redundant wired-OR system configurations. In case the sense lines are connected at the load rather than directly at the connector, the user must ensure that $U_{o\ max}$ (between Vo1+ and Vo1–) is not exceeded.

Applying generously dimensioned cross-section load leads avoids troublesome voltage drop. To minimize noise pick-up wire sense lines parallel or twisted. For unsymmetrical loads it is recommended to connect the sense lines directly at the female connector.

To ensure correct operation, both sense lines must be connected to their respective power output potential. With double output units the sense lines must be connected to output 1 only. Caution should be exercised when outputs are series-connected as the compensated voltage is effectively doubled (refer to *Electrical Output Data*). The voltage difference between any sense line and its respective power output pin (as measured on the connector) should not exceed the following values at nominal output voltage.

Table 11: Voltage compensation allowed using sense lines

Output voltage	Total voltage difference between sense lines and their respective outputs
5.1 V	<0.5 V
12, 15, 24 V	<1.0 V

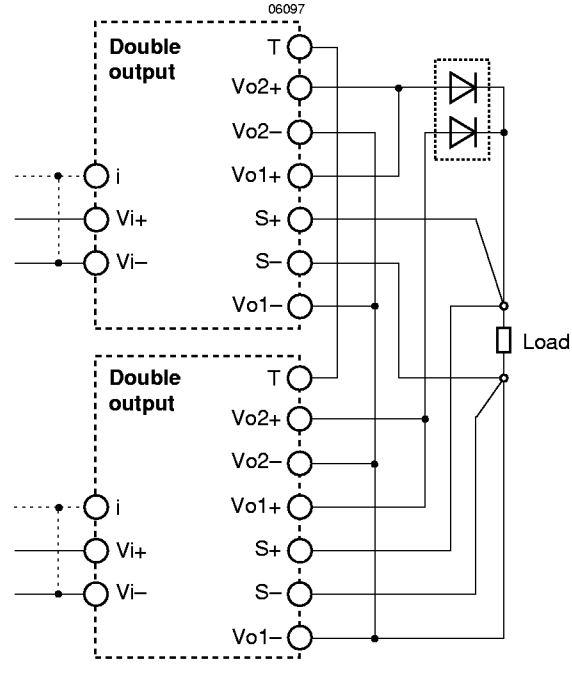


Fig. 23
Sense lines connection for redundant (n+1) or parallel operation using wired-OR diodes

Electromagnetic Compatibility (EMC)

A metal oxide VDR together with an input fuse and a symmetrical input filter form an effective protection against high input transient voltages which typically occur in most installations, but especially in battery driven applications. The Q-family has been successfully tested to the following specifications:

Electromagnetic Emissions

Table 12: Emissions at $U_{i\,nom}$ and $I_{o\,nom}$

Types	Level		
	CISPR 11/EN 55011 CISPR 22/EN 55022		CISPR 14/ EN 55014
	≤30 MHz	≥30 MHz	≥30 MHz
24Q1000	B	-	<limit
24Q2000	B	A [1]	<limit
48Q1000	B	A [1]	<limit
48Q2000	B	A [1]	<limit

[1] Level B with external ferrites in the load lines.

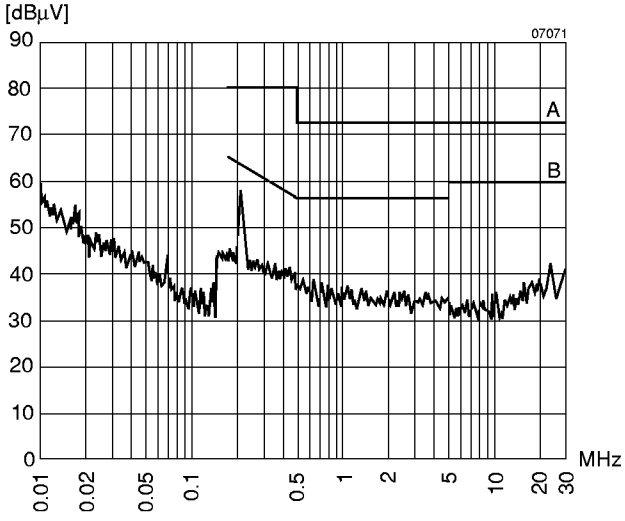


Fig. 24
Typical disturbance voltage (quasi-peak) at the input according to CISPR 11/22 and EN 55011/22, measured at $U_{i\,nom}$ and $I_{o\,nom}$.

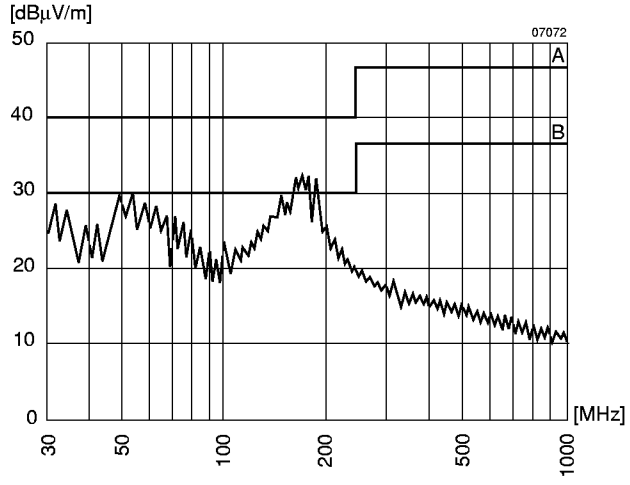


Fig. 25
Typical radiated electromagnetic field strength (quasi-peak) according to CISPR 11/22 and EN 55011/22, normalized to a distance of 10 m, measured at $U_{i\,nom}$ and $I_{o\,nom}$.

Electromagnetic Immunity

Table 13: Immunity type tests

Phenomenon	Standard [1]	Level	Coupling mode [2]	Value applied	Waveform	Source imped.	Test procedure	In oper.	Perform. [3]
Electrostatic discharge (to case)	IEC/EN 61000-4-2	3	contact discharge	6000 V_p	1/50 ns	330 Ω	10 positive and 10 negative discharges	yes	B
			air discharge	8000 V_p					
Electromagnetic field	IEC/EN 61000-4-3	3	antenna	10 V/m	AM 80% 1 kHz	n.a.	26…1000 MHz	yes	A
Electromagnetic field, pulse modulated	ENV 50204	x		20 V/m	50% duty cycle, 200 Hz repetition frequency		900 ±5 MHz	yes	A
Electrical fast transient/burst	IEC/EN 61000-4-4	4	capacitive, o/⏚	2000 V_p	bursts of 5/50 ns 5 kHz over 15 ms; burst period: 300 ms	50 Ω	1 min positive 1 min negative transients per coupling mode	yes	B
			direct, i/c, +i/–i	4000 V_p					
Surge	IEC/EN 61000-4-5	2	i/c	1000 V_p	1.2/50 µs	12 Ω	5 pos. and 5 neg. surges per coupling mode	yes	B
			+i/–i			2 Ω			
	19 Pfl 1			150 V_p	0.1/0.3 ms	<100 A	3 pos. 5 repetitions	yes	A [4]
Conducted disturbances	IEC/EN 61000-4-6	3	i, o, signal wires	3 V_{rms} (130 dBµV)	AM 80% 1 kHz	150 Ω	0.15...80 MHz	yes	A

[1] Related and previous standards are referenced in *Technical Information: Standards*.
[2] i = input, o = output, c = case, ⏚ = protective earth.
[3] A = Normal operation, no deviation from specifications, B = Temporary deviation from specs possible.
[4] Valid for 48Q only.

Immunity to Environmental Conditions

Table 14: 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 $^{+2/-3}$ % 21 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:	15 g_n = 147 m/s^2 11 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:	10 g_n = 98 m/s^2 16 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:	0.15 mm (10...60 Hz) 2 g_n = 20 m/s^2 (60...150 Hz) 10...150 Hz 3.75 h (1.25 h each axis)	Unit operating

Table 15: Temperature specifications, valid for air pressure of 800...1200 hPa (800...1200 mbar)

Temperature			Standard		
Characteristics		Conditions	min	max	Unit
T_A	Ambient temperature	Operational [1]	–10	50	°C
T_C	Case temperature		–10	80	
T_S	Storage temperature	Non operational	–25	100	
$R_{th\,C}$	Temperature coefficient of case in still air			2	K/W

[1] See *Thermal Considerations*

Table 16: MTBF and device hours

Ratings at specified Case Temperature	Modules	Ground Benign 40 °C	Ground Fixed 40 °C	Device Hours [1]	Unit
MTBF acc. to MIL-HDBK-217F	24Q1000	588'000	196'000	880'000	h
	48Q1000	588'000	196'000		

[1] Statistical values, based on an average of 4300 working hours per year and in general field use, over 3 years

Mechanical Data

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

European Projection

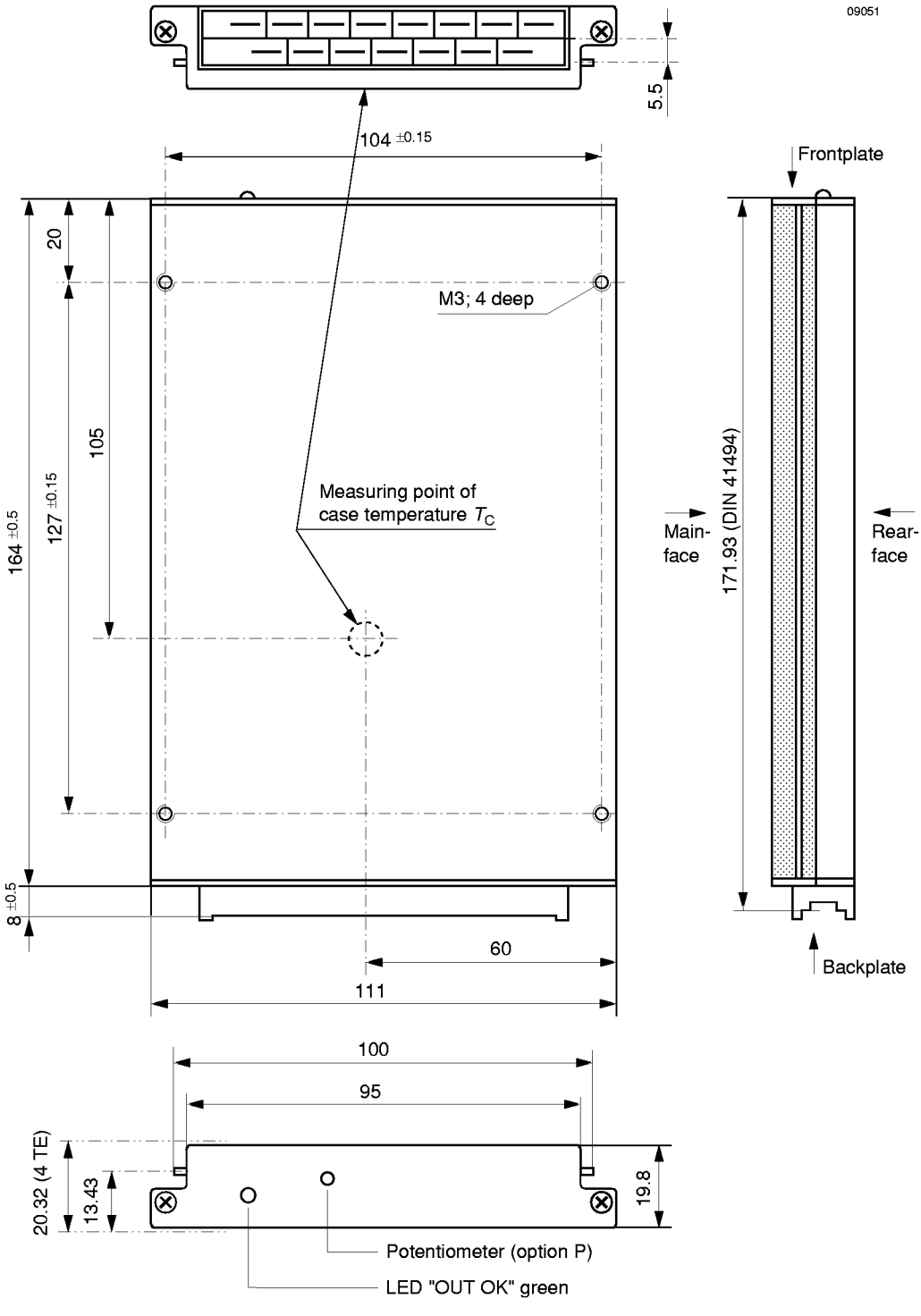


Fig. 26
Case Q01, weight 480 g
Aluminium, fully enclosed,
black finish and self cooling

Note: Long case, elongated by 60 mm for 220 mm rack depth is available on request.

Safety and Installation Instructions

Connector Pin Allocation

The connector pin allocation table defines the electrical potentials and the physical pin positions on the H15 connector. Pin no. 26, the protective earth pin present on all 24Q and 48Q DC-DC converters is leading, ensuring that it makes contact with the female connector first.

Table 17: Pin allocation of the H 15 connector

Pin No.	Electrical determination	Q 1000	Q 2000
4	Output voltage (positive)	Vo1+	Vo1+
6	Output voltage (positive)	Vo1+	Vo2+
8	Output voltage (negative)	Vo1–	Vo1–
10	Output voltage (negative)	Vo1–	Vo2–
12	Sense line (positive)	S+	S+
14	Sense line (negative)	S–	S–
16	Output voltage control input [1]	R	R
18	Current sharing control input	T	T
20	Do not connect (internal Gnd.)	-	-
22	Output good signal (positive)	Out OK+	Out OK+
24	Output good signal (negative)	Out OK–	Out OK–
26	Protective ground (leading) [2]	⏚	⏚
28	Inhibit control input [3]	i	i
30	Input voltage (positive)	Vi+	Vi+
32	Input voltage (negative)	Vi–	Vi–

[1] With option P, R-input must remain unconnected.
[2] Leading pin (pre-connecting).
[3] If not actively used, connect to pin 32.

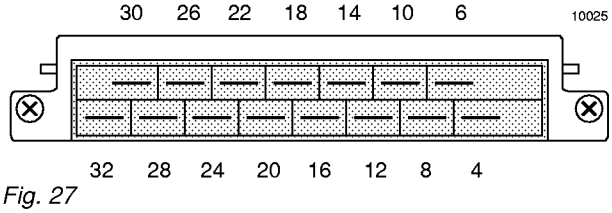


Fig. 27
View of male H15 connector

Standards and approvals

All Q-family DC-DC converters correspond to class I equipment. They are UL recognized according to UL 1950, UL recognized for Canada to CAN/CSA C22.2 No. 950-95 and LGA approved to IEC/EN 60950 standards.

The units have been evaluated for:

- Building in
- Basic insulation between input and case and double or reinforced insulation between input and output, based on their maximum rated input voltage
- Basic insulation between Out OK and case and double or reinforced insulation between Out OK and input and between Out OK and output, based on their maximum rated input voltage
- Use in a pollution degree 2 environment
- Connecting the input to a circuit which is subject to a maximum transient rating of 1500 V

The DC-DC copnverters are subject to manufacturing surveillance in accordance with the above mentioned UL, CSA, EN and with ISO 9001 standards.

Installation Instructions

The Q-family 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.

Connection to the system shall be made via the female connector H15 (see *Accessories*). Other installation methods may not meet the safety requirements.

The DC-DC converters are provided with pin no. 26 (⏚), which is reliably connected with the case. For safety reasons it is essential to connect this pin to the protective earth of the supply system if required in the table *Safety concept leading to an SELV output circuit.*

The Vi input (pin no. 32) is internally fused. This fuse is designed to protect the unit in case of overcurrent and may not be able to satisfy all customer requirements. External fuses in the wiring to one or both input pins (no. 30 and/or no. 32) may therefore be necessary to ensure compliance with local requirements.

Important: Whenever the inhibit function is not in use, pin no. 28 (i) must be connected to pin no. 32 (Vi–) to enable the output(s). Do not open the modules, or guarantee will be invalidated.

Due to high output currents, the 24Q and 48Q 1001 units provide two internally parallel connected contacts for both the positive and the negative output path (pins 4/6 and pins 8/10 respectively). It is recommended to connect the load to both female connector pins of each path in order to keep the voltage drop across the connector pins to an absolute minimum.

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 user's application. The maximum specified case temperature $T_{C\,max}$ shall not be exceeded. See also *Thermal Considerations.*

Check for hazardous voltages before altering any connections.

Ensure that a unit failure (e.g. by an internal short-circuit) does not result in a hazardous condition. See also *Safety of operator accessible output circuit.*

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.

Degree of Protection

Condition: Female connector fitted to the unit.

IP 30: All units, except those with option P (potentiometer).
IP 20: All units fitted with option P (includes potentiometer).

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 18: Isolation

Characteristic		Input to case	Input to output	Output to case	Output to output	Out OK to input	Out OK to case	Out OK to output	Unit
Electric strength test voltage	Required according to IEC/EN 60950	1.0	2.0 [1]	0.5	-	2.0 [1]	1.0	2.0 [1]	kV_{rms}
		1.4	2.8 [1]	0.7	-	2.8 [1]	1.4	2.8 [1]	kV DC
	Actual factory test 1 s	2.1	4.2 [1]	2.1	0.3	4.2 [1]	2.1	4.2 [1]	
	AC test voltage equivalent to actual factory test	1.5	3.0 [1]	1.5	0.2	3.0 [1]	1.5	3.0 [1]	kV_{rms}
Insulation resistance at 500 V DC		>300	>300	>300	>100 [2]	>300	>300	>300	MΩ

[1] In accordance with IEC/EN 60950 only subassemblies are tested in factory with this voltage.
[2] Tested at 300 V DC.

For creepage distances and clearances refer to *Technical Information: Safety.*

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 35 V.

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

Table 19: Insulation concept leading to an SELV output circuit

Conditions	Front end			DC-DC converter	Result
Nominal supply voltage	Minimum required grade of insulation, to be provided by the AC-DC front end, including mains supplied battery charger [8]	Maximum DC output voltage from the front end [1]	Minimum required safety status of the front end output circuit [8]	Measures to achieve the specified safety status of the output circuit	Safety status of the DC-DC converter output circuit
Mains ≤150 V AC	Basic	≤60 V	ELV circuit	Supplementary insulation, based on 150 V AC (provided by the DC-DC converter) and earthed case [2]	SELV circuit
		≤75 V [9]	Hazardous voltage secondary circuit	Supplementary insulation, based on 150 V AC and double or reinforced insulation [3] (both provided by the DC-DC converter) and earthed case [2]	
Mains ≤250 V AC		≤60 V	Earthed SELV circuit [2]	Operational insulation (provided by the DC-DC converter)	
		≤75 V	ELV circuit	Input fuse [4], output suppressor diodes [5], earthed output circuit [2] and earthed [2] or non user accessible case	Earthed SELV circuit
			Unearthed hazardous voltage secondary circuit		
			Earthed hazardous voltage secondary circuit [2] or earthed ELV circuit [2]	Double or reinforced insulation [3] (provided by the DC-DC converter) and earthed case [2]	SELV circuit
	Double or reinforced	≤60 V	SELV circuit	Operational insulation (provided by the DC-DC converter)	
		≤75 V	TNV-2 circuit	Basic insulation [3] and earthed case [6]	
		≤75 V	Double or reinforced insulated unearthed hazardous voltage secondary circuit [7]		

[1] The front end output voltage should match the specified input voltage range of the DC-DC converter.
[2] The earth connection has to be provided by the installer according to the relevant safety standards, e.g. IEC/EN 60950.
[3] Based on the maximum rated output voltage from the front end.
[4] The installer shall provide an approved fuse with the lowest rating suitable for the application in a non-earthed input conductor directly at the input of the DC-DC converter (see fig. *Schematic safety concept*). For UL's purposes, the fuse needs to be UL-listed. See also *Input Fuse*.
[5] Each 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 (<60V) until the input fuse blows (see fig. *Schematic safety concept*).
[6] The earth connection has to be provided by the installer according to the relevant safety standards, e.g. IEC/EN 60950. If the converter case cannot be connected to earth, the front end output circuit has to be insulated from the converter case by at least basic insulation, based on the maximum nominal output voltage from the front end. The converter case can then be considered to be a double insulated accessible part.
[7] Has to be insulated from earth according to the relevant safety standards, e.g. IEC/EN 60950, by at least supplementary insulation, based on the maximum nominal output voltage from the front end.
[8] Q-units marked "Input SELV" require an SELV or a TNV input circuit or an input circuit which is insulated from primary by double or reinforced insulation and from earth by at least supplementary insulation.
[9] The nominal voltage between any input pin and earth can be up to 75 V AC or DC.

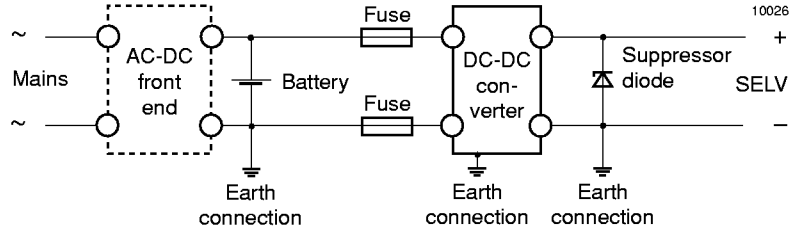


Fig. 28
Schematic safety concept
Use fuse, suppressor diode and earth connections as per table *Safety concept leading to an SELV output circuit.*
Use fuse(s) also if required by the application. See *Installation Instructions*.

Description of Option

Option P Output Voltage Adjustment

Option P is a built-in multi-turn potentiometer which provides an output voltage adjustment of ±10% of $U_{o\,nom}$. The potentiometer is accessible through a hole in the front cover. Static voltage drops across connectors and wires can easily be compensated.

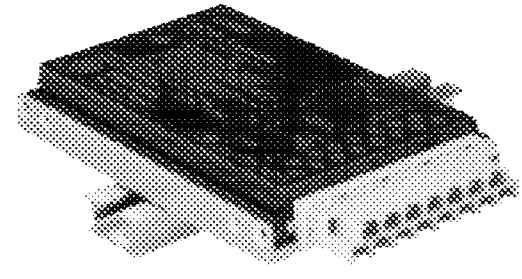
With double output modules, both outputs are affected by the potentiometer settings. If different units are parallel-connected, their individual output voltages should be set within a tolerance of ±1%. If output voltages U_o are set higher than $U_{o\,nom}$, the output currents should be reduced accordingly, so that the maximum specified output power is not exceeded.

Accessories

A great variety of electrical and mechanical accessories are available including:

- Mating connectors either with fast-on, screw, solder or press-fit terminals
- Connector retension facilities
- Front panels for 19" rack mounting in 3U or 6U configuration
- Additional external input or output filters and chokes
- Mechanical mounting supports for chassis, DIN-rail and PCB mounting

For more precise details please refer to Accessory Products.



Universal mounting bracket for DIN-rail mouinting.