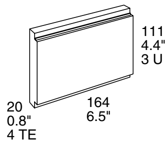
60...132 Watt DC-DC Converters Q Series

Input voltage ranges up to 168 V DC
1 or 2 isolated outputs 3.3...48 V DC
3 kV AC I/O electric strengh test voltage

- Extremely high efficiency of up to 88%
- Flexible output power
- Excellent surge and transient protection
- Safety according to IEC/EN 60950 and EN 41003
- 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 CQ units according to prETS 300132-2 (35...75 V DC)

Safety according to IEC/EN 60950, UL 1950, EN 41003

LGA c UL us CE



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 applications. The converters provide important advantages such as flexible output power through primary current limitation, extremely high efficiency, excellent reliability, very low ripple and RFI noise levels, full input to output isolation, negligible inrush current, overtemperature protection and input over-/undervoltage lock-out. The converter inputs are protected against surges and transients occuring on the source lines.

The outputs are continuously open- and short-circuit proof. An isolated output power good signal and LEDs at the front panel indicate the status of the power supply modules. Test sockets at the front panel provide for a check of the main output voltage.

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 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. It is particularly suitable for 19" rack systems occupying 3U/4TE only, but can also be chassis-mounted by means of four M3 screws.

Connector type according to DIN 41612: H15.

Table of Contents

Type Survey and Key Data

Table 1a: Type survey BQ, GQ

Output 1		Output 2		Output power [1]		Input voltage range and efficiency [2]				Options
$U_{o\,nom}$ [V DC]	I_o [A]	$U_{o\,nom}$ [V DC]	I_o [A]	$T_A = 50°C$ $P_{o\,max}$ [W]	$T_A = 71°C$ $P_{o\,nom}$ [W]	$U_{i\,min}...U_{i\,max}$ **14.4...36 V DC**	η_{min} [%]	$U_{i\,min}...U_{i\,max}$ **21.6...54 V DC**	η_{min} [%]	
3.3	0...22	-	-	73	60	BQ 1101-7	79	GQ 1101-7	79	-9
5.1	0...20	-	-	102	82	BQ 1001-7R	86	GQ 1001-7R	86	-9, P
12.0 [3]	0...10	-	-	120	96	BQ 2320-7R	87	GQ 2320-7R	87	-9, P
15.0 [3]	0...8	-	-	120	99	BQ 2540-7R	88	GQ 2540-7R	88	-9, P
24.0 [3]	0...5.5	-	-	132	106	BQ 2660-7R	88	GQ 2660-7R	88	-9, P
24.0 [4]	0.8...5	-	-	120	96	BQ 2320-7R	87	GQ 2320-7R	87	-9, P
30.0 [4]	0.6...4	-	-	120	99	BQ 2540-7R	88	GQ 2540-7R	88	-9, P
48.0 [4]	0.4...2.75	-	-	132	106	BQ 2660-7R	88	GQ 2660-7R	88	-9, P
12.0	0.8...9.2	12.0 [5]	0.8...9.2	120	96	BQ 2320-7R	87	GQ 2320-7R	87	-9, P
15.0	0.6...7.4	15.0 [5]	0.6...7.4	120	99	BQ 2540-7R	88	GQ 2540-7R	88	-9, P
24.0	0.4...5.1	24.0 [5]	0.4...5.1	132	106	BQ 2660-7R	88	GQ 2660-7R	88	-9, P

Table 1b: Type survey CQ, DQ

Output 1		Output 2		Output power [1]		Input voltage range and efficiency [2]				Options
$U_{o\,nom}$ [V DC]	I_o [A]	$U_{o\,nom}$ [V DC]	I_o [A]	$T_A = 50°C$ $P_{o\,max}$ [W]	$T_A = 71°C$ $P_{o\,nom}$ [W]	$U_{i\,min}...U_{i\,max}$ **35...75 V DC**	η_{min} [%]	$U_{i\,min}...U_{i\,max}$ [6] **43...108 V DC**	η_{min} [%]	
3.3	0...22	-	-	73	60	CQ 1101-7	79	DQ 1101-7	79	-9
5.1	0...20	-	-	102	82	CQ 1001-7R	86	DQ 1001-7R	86	-9, P
12.0 [3]	0...10	-	-	120	96	CQ 2320-7R	87	DQ 2320-7R	87	-9, P
15.0 [3]	0...8	-	-	120	99	CQ 2540-7R	88	DQ 2540-7R	88	-9, P
24.0 [3]	0...5.5	-	-	132	106	CQ 2660-7R	88	DQ 2660-7R	88	-9, P
24.0 [4]	0.8...5	-	-	120	96	CQ 2320-7R	87	DQ 2320-7R	87	-9, P
30.0 [4]	0.6...4	-	-	120	99	CQ 2540-7R	88	DQ 2540-7R	88	-9, P
48.0 [4]	0.4...2.75	-	-	132	106	CQ 2660-7R	88	DQ 2660-7R	88	-9, P
12.0	0.8...9.2	12.0 [5]	0.8...9.2	120	96	CQ 2320-7R	87	DQ 2320-7R	87	-9, P
15.0	0.6...7.4	15.0 [5]	0.6...7.4	120	99	CQ 2540-7R	88	DQ 2540-7R	88	-9, P
24.0	0.4...5.1	24.0 [5]	0.4...5.1	132	106	CQ 2660-7R	88	DQ 2660-7R	88	-9, P

Table 1c: Type survey EQ

Output 1		Output 2		Output power [1]		Input voltage range and efficiency [2]		Options
$U_{o\,nom}$ [V DC]	I_o [A]	$U_{o\,nom}$ [V DC]	I_o [A]	$T_A = 50°C$ $P_{o\,max}$ [W]	$T_A = 71°C$ $P_{o\,nom}$ [W]	$U_{i\,min}...U_{i\,max}$ [6, 7] **65...150 V DC**	η_{min} [%]	
3.3	0...22	-	-	73	60	EQ 1101-7	79	-9
5.1	0...20	-	-	102	82	EQ 1001-7R	85	-9, P
12.0 [3]	0...10	-	-	120	96	EQ 2320-7R	87	-9, P
15.0 [3]	0...8	-	-	120	99	EQ 2540-7R	88	-9, P
24.0 [3]	0...5.5	-	-	132	106	EQ 2660-7R	88	-9, P
24.0 [4]	0.8...5	-	-	120	96	EQ 2320-7R	87	-9, P
30.0 [4]	0.6...4	-	-	120	99	EQ 2540-7R	88	-9, P
48.0 [4]	0.4...2.75	-	-	132	106	EQ 2660-7R	88	-9, P
12.0	0.8...9.2	12.0 [5]	0.8...9.2	120	96	EQ 2320-7R	87	-9, P
15.0	0.6...7.4	15.0 [5]	0.6...7.4	120	99	EQ 2540-7R	88	-9, P
24.0	0.4...5.1	24.0 [5]	0.4...5.1	132	106	EQ 2660-7R	88	-9, P

[1] The cumulated power of both outputs may not exceed the total power for the specified ambient temperature. See also: *Electrical Output Data: Output power at reduced temperature.*
[2] Minimum 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] Symmetrical configuration with second output semi-regulated (±5% $U_{o\,nom}$).
[6] For $U_{i\,min}$, $U_{i\,max}$ during ≤100 ms refer to: *Input Data.*
[7] 168 V for ≤2 s.

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*.

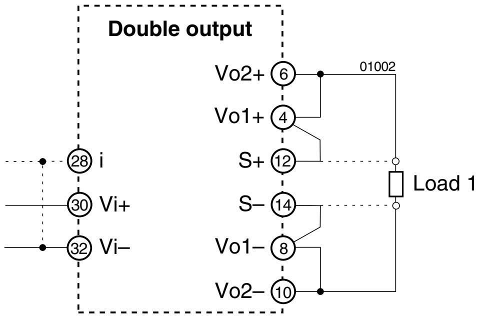


Fig. 2
Parallel output configuration

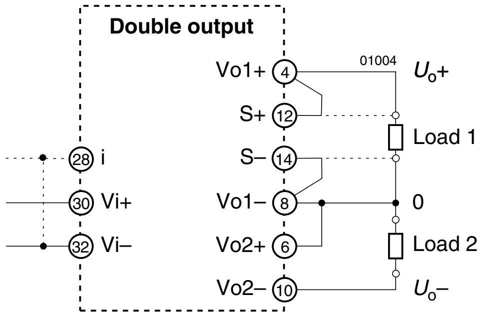


Fig. 4
Symmetrical common ground output configuration

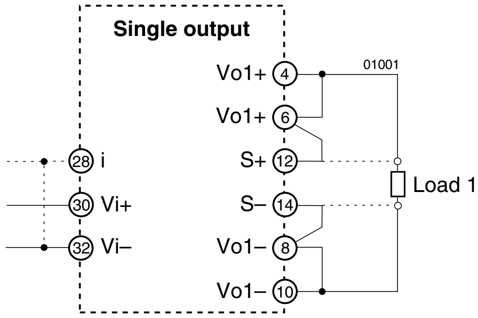


Fig. 1
Single output configuration

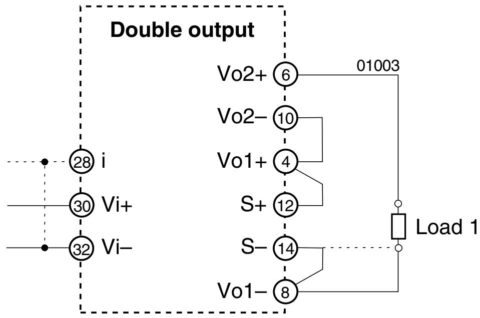


Fig. 3
Series output configuration (negative sense at load only)

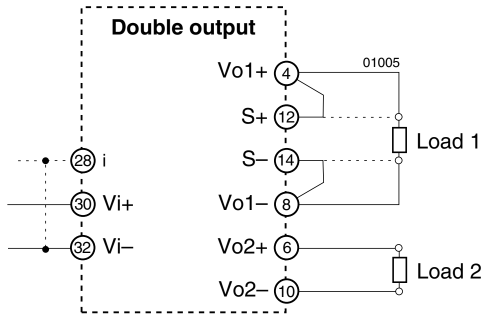


Fig. 5
Independent symmetrical output configuration

Type Key and Product Marking

Type Key CQ 2 5 40 -7 R P

Input voltage range U_i:
- 14.4...36 V DC .... B
- 35...75 V DC C
- 43...108 V DC .... D
- 65...150 (168/2 s) V DC .... E
- 21.6...54 V DC .... G

Series Q

Number of outputs:
- Single output 1
- Double output 2
- Single Output (long case) 6
- Double Output (long case) 7

Nominal voltage output 1 (main output), $U_{o1\ nom}$:
- 5.1 V 0
- 3.3 V 1
- 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:
- –25…71 °C .... -7
- –40...71 °C (option) .... -9
- customer specific .... -0...-6

Output voltage control input (auxiliary function) [1] .... R
Potentiometer (option) [1] .... P

[1] Option P excludes feature R and vice versa

Example: CQ 2540-7P: DC-DC converter, input voltage range 35...75 V, double output, each providing 15 V/3.3 A, equipped with potentiometer and operating ambient temperature of –25...71 °C.

Note: All units feature the following auxiliary functions which are not shown in the type designation: input and output filter, inhibit, sense lines, current sharing, Out OK signal, LED indicators and test sockets.

Product Marking

Basic type designation, applicable safety approval and recognition marks, CE mark, warnings, pin allocation of input, output and auxiliary functions, Power-One patents and company logo.

Identification of LED's, test sockets and potentiometer.

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

Label with batch no., serial no. and data code including production site, modification status and date of production. Confirmation of success fully 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 high efficient 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*).

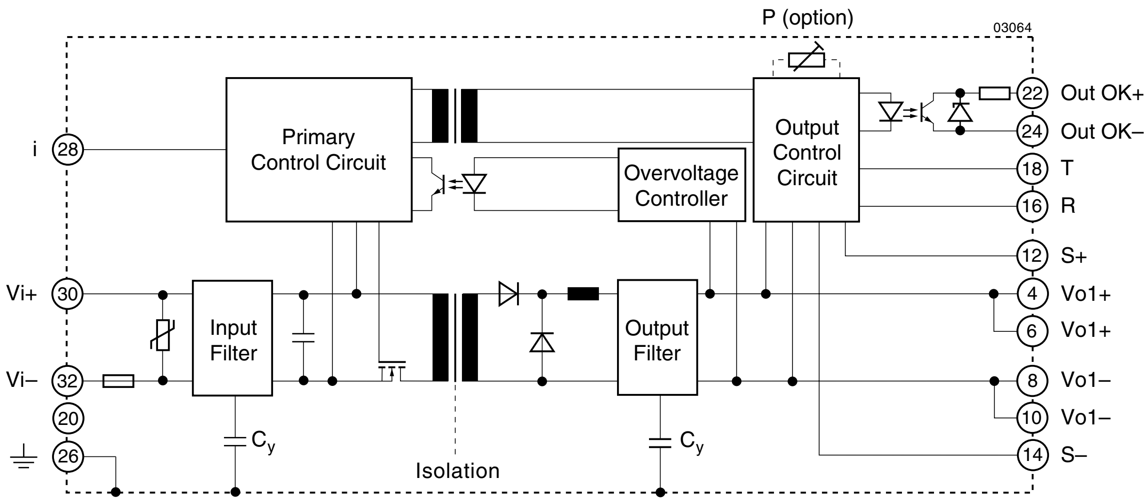


Fig. 6
Block diagram of a single output converter

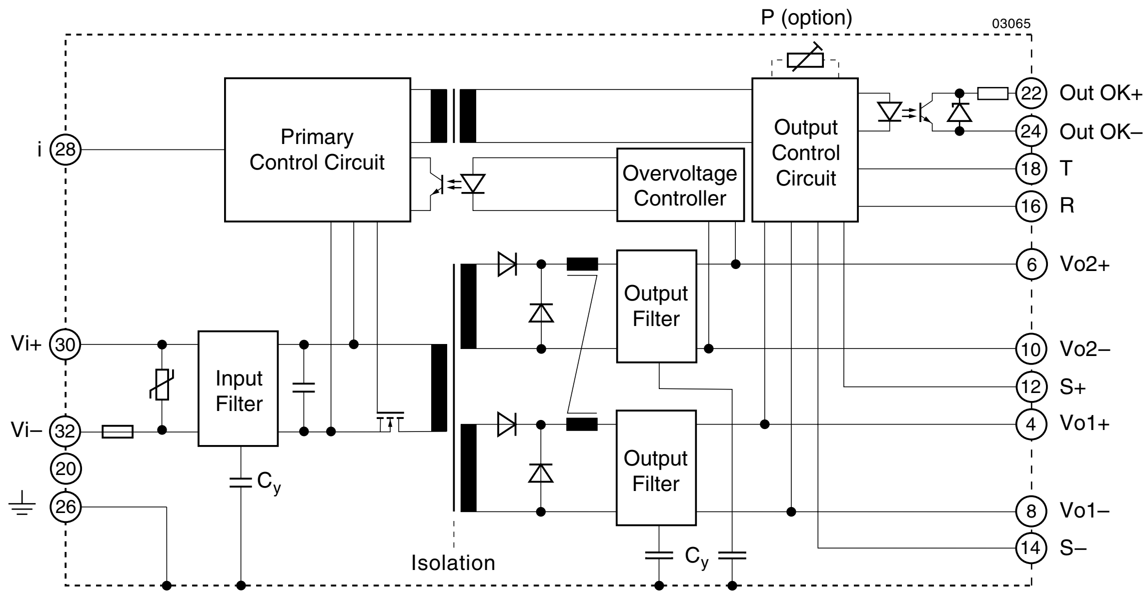


Fig. 7
Block diagram of a double output converter

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 2a: Input data

Input			BQ			GQ			CQ [2]			
Characteristics		Conditions	min	typ	max	min	typ	max	min	typ	max	Unit
U_i	Operating input voltage	I_o = 0...$I_{o\,max}$ $T_{C\,min}$...$T_{C\,max}$	14.4		36	22		54	35		75	V DC
$U_{i\,nom}$	Nominal input voltage			24			36			48		
$U_{i\,abs}$	Input voltage limits	without damage	0		50	0		63	0		100	
I_i	Typical input current [1]	$U_{i\,nom}$, $I_{o\,nom}$		4.5			3.0			2.2		A
$P_{i\,0}$	No-load input power	$U_{i\,min}$...$U_{i\,max}$ I_o = 0			2.5			3.0			2.5	W
$P_{i\,inh}$	Idle input power	unit inhibited			1.0			1.5			1.5	
$I_{inr\,p}$	Peak inrush current [2]	$U_{i\,nom}$, $I_{o\,nom}$		55			40			35		A
$t_{inr\,r}$	Rise time			50			40			35		µs
$t_{inr\,h}$	Trailing edge half-life			130			110			80		

Table 2b: Input data

Input			DQ			EQ			
Characteristics		Conditions	min	typ	max	min	typ	max	Unit
U_i	Operating input voltage	I_o = 0...$I_{o\,max}$ $T_{C\,min}$...$T_{C\,max}$	43		108	65		150	V DC
	for ≤2 s			n.a.		65		168	
	for ≤100 ms		36		115	55		176	
$U_{i\,nom}$	Nominal input voltage			72			110		
$U_{i\,abs}$	Input voltage limits	without damage	0		125	0		200	
I_i	Typical input current [1]	$U_{i\,nom}$, $I_{o\,nom}$		1.5			1.0		A
$P_{i\,0}$	No-load input power	$U_{i\,min}$...$U_{i\,max}$ I_o = 0			5.5			4.0	W
$P_{i\,inh}$	Idle input power	unit inhibited			3.5			3.5	
$I_{inr\,p}$	Peak inrush current [2]	$U_{i\,nom}$, $I_{o\,nom}$		20			45		A
$t_{inr\,r}$	Rise time			50			15		µs
$t_{inr\,h}$	Trailing edge half-life			90			25		

[1] Typical input current depends on individual module
[2] According to prETS 300132-2

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	
BQ	fast-blow	Littelfuse 275	2 × 7 A, 125 V
GQ	fast-blow	Littelfuse 275	2 × 7 A, 125 V
CQ	fast-blow	Littelfuse 275	10 A, 125 V
DQ	fast-blow	Littelfuse 275	7 A, 125 V
EQ	very fast-blow	Littelfuse 263	5 A, 250 V

Input Transient Protection

A metal oxide VDR (Voltage Dependent Resistor) together with the 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 mobile applications.

Nominal battery voltages in use are: 24, 36, 48, 60, 72, 96 and 110 V. In most cases each nominal value is specified in a tolerance of –30%...+25%, with short excursions to ±40% or even more.

In certain applications, surges according to RIA 12 are specified in addition to those defined in IEC 60571-1 or EN 50155. The power supply must not switch off during these surges and since their energy can practically not be absorbed an extremely wide input range is required. The Q series input range has been designed and tested to meet most of these requirements. See also: *EMC (surge B).*

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.

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 rating $U_{i\,abs}$ should be considered!

Electrical Output 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 4a: Output data for single output modules and modules with output 1 and output 2 in parallel configuration

Output			BQ...GQ 1101 3.3 V			BQ...GQ 1001 5.1 V			BQ...GQ 2320 12.0 V			
Characteristics		Conditions	min	typ	max	min	typ	max	min	typ	max	Unit
U_o	Output voltage [1]	$U_{i\,nom}$, $I_{o\,nom}$	3.28		3.32	5.07		5.13	11.94		12.06	V
U_{ow}	Worstcase output voltage	$U_{i\,min}...U_{i\,max}$ $T_{C\,min}...T_{C\,max}$ $I_o = 0...I_{o\,max}$	3.24		3.35	5.02		5.18	11.82		12.18	
$U_{o\,P}$	Overvoltage limitation of second control loop		4.5		4.9	5.9		6.4	13.5		15.0	
I_o	Output current [2]	$U_{i\,min}...U_{i\,max}$ $T_{C\,min}...T_{C\,max}$	0		22.0	0		20.0	0		10.0	A
$I_{o\,nom}$	Nominal output current [3]			18.0			16.0			8.0		
I_{oL}	Output current limit [2]		23.0	24.0	29.0	21.0	22.0	26.0	10.5	11.0	13.0	
u_o	Output voltage noise [4]: Switch. frequ.	$U_{i\,nom}$, $I_{o\,nom}$ IEC/EN 61204 BW = 20 MHz		15	25		10	15		10	20	mV_{pp}
	Output voltage noise [4]: Total			25	40		15	25		20	40	
P_o	Output power [1]	$U_{i\,min}...U_{i\,max}$ $T_{C\,min}...T_{C\,max}$			75			110			130	W
$u_{o\,d}$ [5]	Dynamic load regulation: Voltage deviation	$U_{i\,nom}$ $I_{o\,nom} \leftrightarrow {}^1/_2\ I_{o\,nom}$ IEC/EN 61204 [4]		±300			±250			±350		mV
t_d	Dynamic load regulation: Recovery time			800			700			150		µs
$U_{o\,tr}$	Output voltage trimming range [6]	$U_{i\,min}...U_{i\,max}$ (0.08...1) $I_{o\,max}$ $T_{C\,min}...T_{C\,max}$	n.a. n.a.		n.a. n.a.	4.0 4.6		5.6 5.6	5.5 10.8		13.2 13.2	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* and *Output power at reduced temperature.*
[3] In parallel and symmetrical configuration, $I_{o\,nom} = I_{o1\,nom} + I_{o2\,nom}$.
[4] See: *Technical Information*: *Measuring and Testing.*
[5] Recovery time until U_o remains within ±1% of U_o, see: *Dynamic load regulation.*
[6] Upper row represents setting via R-input, lower row option P range.

Table 4b: Output data for single output modules and modules with output 1 and output 2 in parallel configuration

Output				**BQ...GQ 2540 15.0 V**			**BQ...GQ 2660 24.0 V**			
Characteristics			Conditions	min	typ	max	min	typ	max	Unit
U_o	Output voltage [1]		$U_{i\,nom}$, $I_{o\,nom}$	14.93		15.08	23.88		24.12	V
U_{ow}	Worstcase output voltage		$U_{i\,min} \ldots U_{i\,max}$ $T_{C\,min} \ldots T_{C\,max}$ $I_o = 0 \ldots I_{o\,max}$	14.78		15.23	23.64		24.36	
$U_{o\,P}$	Overvoltage limitation of second control loop			17.0		19.0	27.5		30.0	
I_o	Output current [2]		$U_{i\,min} \ldots U_{i\,max}$ $T_{C\,min} \ldots T_{C\,max}$	0		8.0	0		5.5	A
$I_{o\,nom}$	Nominal output current [3]				6.6			4.4		
I_{oL}	Output current limit [2]			8.4	8.8	10.4	5.8	6.1	7.7	
u_o	Output voltage noise [4]	Switch. frequ.	$U_{i\,nom}$, $I_{o\,nom}$ IEC/EN 61204 BW = 20 MHz		10	25		60	90	mV_{pp}
		Total			15	40		70	100	
P_o	Output power [1]		$U_{i\,min} \ldots U_{i\,max}$ $T_{C\,min} \ldots T_{C\,max}$			130			140	W
$u_{o\,d}$ [5]	Dynamic load regulation	Voltage deviation	$U_{i\,nom}$ $I_{o\,nom} \leftrightarrow 1/2\ I_{o\,nom}$ IEC/EN 61204 [4]		±350			±550		mV
t_d		Recovery time			100			100		µs
$U_{o\,tr}$	Output voltage trimming range [6]		$U_{i\,min} \ldots U_{i\,max}$ (0.08...1) $I_{o\,max}$ $T_{C\,min} \ldots T_{C\,max}$	8.0 13.5		16.5 16.5	14.0[7] 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.
[2] See: *Output Current Limitation* and *Output power at reduced temperature.*
[3] In parallel and symmetrical configuration, $I_{o\,nom} = I_{o1\,nom} + I_{o2\,nom}$.
[4] See: *Technical Information*: *Measuring and Testing*.
[5] Recovery time until U_o remains within ±1% of U_o, see: *Dynamic load regulation*.
[6] Upper row represents setting via R-input, lower row option P range.
[7] For DQ 2660 and EQ 2660: $U_{o\,tr\,min}$ = 19 V.

Table 4b: Output data for double output modules with output 1 and output 2 in series configuration

Output				**BQ...GQ 2320 24 V (2 × 12 V)**			**BQ...GQ 2540 30 V (2 × 15 V)**			**BQ...GQ 2660 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		$U_{i\,min}...U_{i\,max}$ $T_{C\,min}...T_{C\,max}$ $I_{o\,min}...I_{o\,max}$ [5]	23.52		24.48	29.40		30.60	47.04		48.96	
$U_{o\,P}$	Overvoltage limitation of second control loop			27.0		30.0	34.0		38.0	55.0		60.0	
I_o	Output current [2]		$U_{i\,min}...U_{i\,max}$ $T_{C\,min}...T_{C\,max}$	0.8		5.0	0.6		4.0	0.4		2.75	A
$I_{o\,nom}$	Nominal output current				4.0			3.3			2.2		
I_{oL}	Output current limit [2]			5.25	5.50	6.50	4.20	4.40	5.20	2.9	3.1	3.9	
u_o	Output voltage noise [5]	Switch. frequ.	$U_{i\,nom}$, $I_{o\,nom}$ IEC/EN 61204 BW = 20 MHz		20	40		20	50		120	180	mV_{pp}
		Total			40	80		30	80		140	200	
P_o	Output power [1]		$U_{i\,min}...U_{i\,max}$ $T_{C\,min}...T_{C\,max}$			130			130			140	W
$u_{o\,d}$ [3]	Dynamic load regulation	Voltage deviation	$U_{i\,nom}$ $I_{o\,nom} \leftrightarrow 1/2\,I_{o\,nom}$ IEC/EN 61204 [5]		±650			±650			±950		mV
t_d		Recovery time			150			100			100		µs
$U_{o\,tr}$	Output voltage trimming of output voltage [4]		$U_{i\,min}...U_{i\,max}$ $I_{o\,min}...I_{o\,max}$ $T_{C\,min}...T_{C\,max}$	11.0 21.6		26.4 26.4	16.0 27.0		33.0 33.0	28.0 [6] 43.2		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* and *Output power at reduced temperature.*
[3] Recovery time until U_o remains within ±1% of U_o, see: *Dynamic load regulation*.
[4] Upper row represents setting via R-input, lower row option P range.
[5] See: *Technical Information*: *Measuring and Testing*.
[6] For DQ 2660: $U_{o\,tr\,min}$ = 38 V.

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.

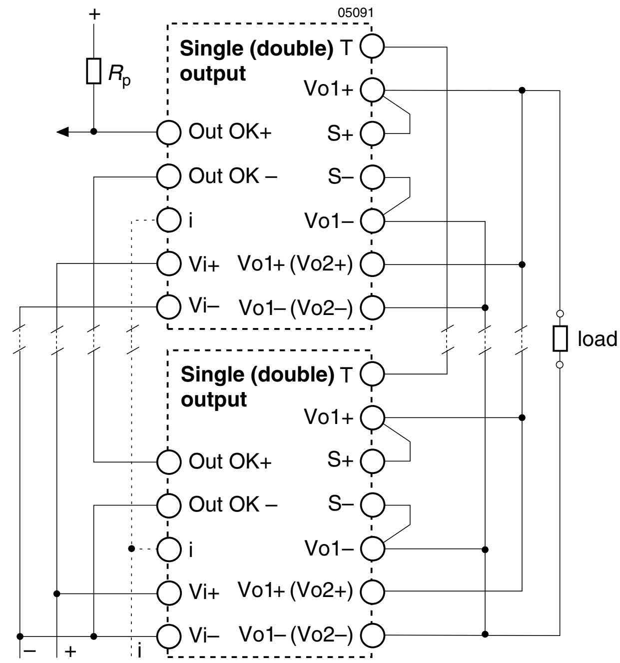


Fig. 8
Parallel connection of outputs and/or several modules, sense lines connected at connector side

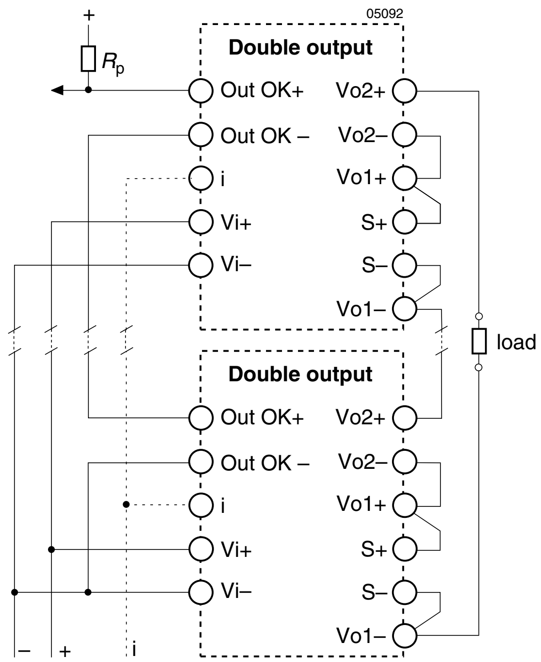


Fig. 9
Series connection of outputs and/or several modules, sense lines connected at connector side only

Dynamic Load Regulation

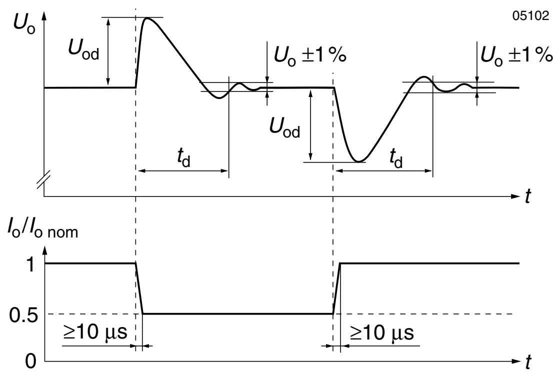


Fig. 10
Control deviation of U_o versus dynamic load change

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

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

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]

Table 5a: Output data for double output modules with output 1 and output 2 in symmetrical configuration

Output			BQ...GQ 2320 12 V/12 V						BQ...GQ 2540 15 V/15 V						
Characteristics		Conditions	Output 1			Output 2			Output 1			Output 2			
			min	typ	max	min	typ	max	min	typ	max	min	typ	max	Unit
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	$U_{i\,min}...U_{i\,max}$ $T_{C\,min}...T_{C\,max}$ $I_o = 0...I_{o\,max}$	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	Output current [2]	$U_{i\,min}...U_{i\,max}$ $T_{C\,min}...T_{C\,max}$	0.8		9.2	0.8		9.2	0.6		7.4	0.6		7.4	A
$I_{o\,nom}$	Nominal output current [3]		8.0						6.6						
$I_{o\,L}$	Output current limit [2]		10.5	11.0	13.0	10.5	11.0	13.0	8.4	8.8	10.4	8.4	8.8	10.4	
u_o	Output voltage noise [4]: Switch. frequ.	$U_{i\,nom}$, $I_{o\,nom}$ IEC/EN 61204 BW = 20 MHz		10	20		10	20		10	25		10	25	mV_{pp}
	Output voltage noise [4]: Total			20	40		20	40		15	40		15	40	
P_o	Output power [1]	$U_{i\,min}...U_{i\,max}$ $T_{C\,min}...T_{C\,max}$	130						130						W
$u_{o\,d}$ [5]	Dynamic load regulation: Voltage deviation	$U_{i\,nom}$, ΔI_{o1} = $^1/_2 \leftrightarrow {}^1/_4$ $I_{o\,nom}$ $I_{o2} = {}^1/_2$ $I_{o\,nom}$ IEC/EN 61204 [4]	±300			±350			±300			±350			mV
t_d	Dynamic load regulation: Recovery time		120						100						µs
$U_{o\,tr}$	Output voltage trimming range [6]	$U_{i\,min}...U_{i\,max}$ $I_{o\,min}...I_{o\,max}$ $T_{C\,min}...T_{C\,max}$	5.5 10.8		13.2 13.2				8.0 13.5		16.5 16.5				V

Table 5b: Output data for double output modules with output 1 and output 2 in symmetrical configuration

Output			BQ...GQ 2660 24 V/24 V						
Characteristics		Conditions	Output 1			Output 2			
			min	typ	max	min	typ	max	Unit
U_o	Output voltage [1]	$U_{i\,nom}$, $I_{o\,nom}$	23.88		24.12	23.64		24.36	V
U_{ow}	Worstcase output voltage	$U_{i\,min}...U_{i\,max}$ $T_{C\,min}...T_{C\,max}$ $I_o = 0...I_{o\,max}$	23.64		24.36	see *Output voltage regulation*			
$U_{o\,P}$	Overvoltage limitation of second control loop					27.5		30.0	
I_o	Output current [2]	$U_{i\,min}...U_{i\,max}$ $T_{C\,min}...T_{C\,max}$	0.4		5.1	0.4		5.1	A
$I_{o\,nom}$	Nominal output current [3]		4.4						
$I_{o\,L}$	Output current limit [2]		5.8	6.1	7.7	5.8	6.1	7.7	
u_o	Output voltage noise [4]: Switch. frequ.	$U_{i\,nom}$, $I_{o\,nom}$ IEC/EN 61204 BW = 20 MHz		60	90		60	90	mV_{pp}
	Output voltage noise [4]: Total			70	100		70	100	
P_o	Output power [1]	$U_{i\,min}...U_{i\,max}$ $T_{C\,min}...T_{C\,max}$	140						W
$u_{o\,d}$ [5]	Dynamic load regulation: Voltage deviation	$U_{i\,nom}$, ΔI_{o1} = $^1/_2 \leftrightarrow {}^1/_4$ $I_{o\,nom}$ $I_{o2} = {}^1/_2$ $I_{o\,nom}$ IEC/EN 61204 [4]	±550			±400			mV
t_d	Dynamic load regulation: Recovery time		100						µs
$U_{o\,tr}$	Output voltage trimming range [6]	$U_{i\,min}...U_{i\,max}$ $I_{o\,min}...I_{o\,max}$ $T_{C\,min}...T_{C\,max}$	14.0 [7] 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.
2 See: *Output Current Limitation* and *Output power at reduced temperature.*
3 In parallel and symmetrical configuration, $I_{o\,nom} = I_{o1\,nom} + I_{o2\,nom}$.
4 See: *Technical Information*: *Measuring and Testing.*
5 Recovery time until U_o remains within ±1% of U_o, see: *Dynamic load regulation.*
6 Upper row represents setting via R-input, lower row option P range.
7 For DQ 2660: $U_{o\,tr\,min}$ =19 V.

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: If 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 at least $I_{o\ min}$.

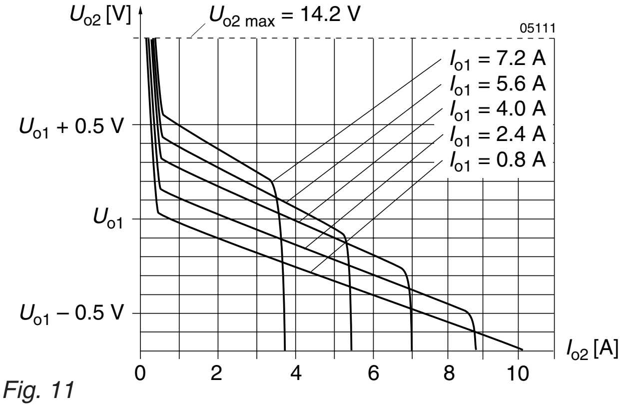


Fig. 11
BQ...GQ 2320 output 2 voltage deviation vs. output 2 current with different currents on output 1

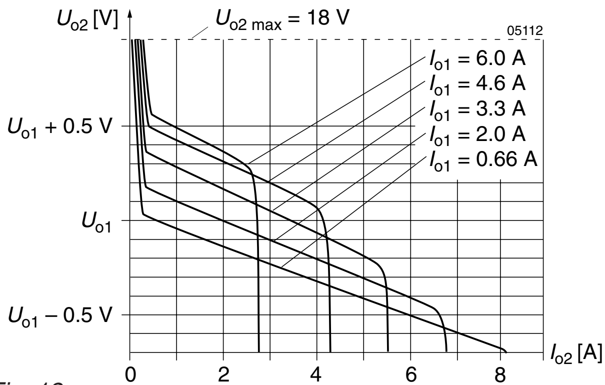


Fig. 12
BQ...GQ 2540 output 2 voltage deviation vs. output 2 current with different currents on output 1

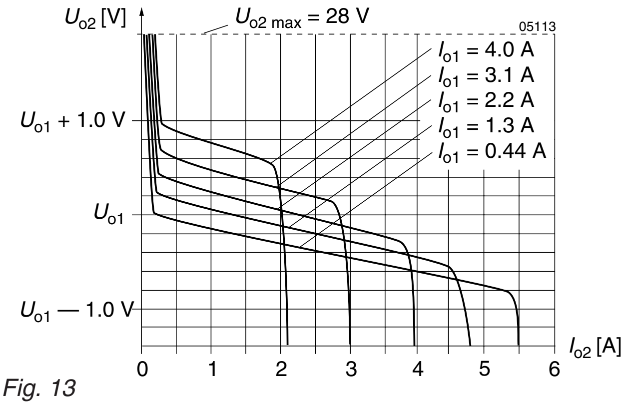


Fig. 13
BQ...GQ 2660 output 2 voltage deviation vs. output 2 current with different currents on output 1

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 BQ...GQ 2000 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 Modules*). In overload ($I_{o1} + I_{o2} > I_{o\ max}$) both output voltages are reduced simultaneously.

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.

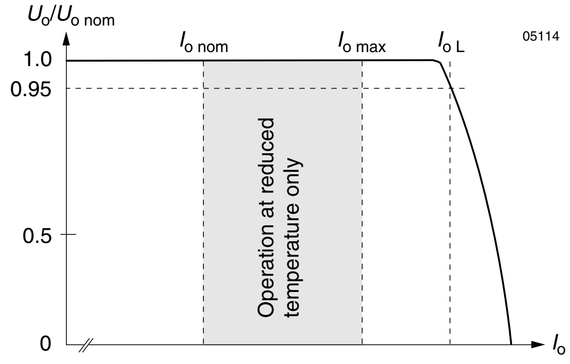


Fig. 14
Current limitation behaviour of a single or a double output unit with series- or parallel-connected outputs

Typical Efficiency

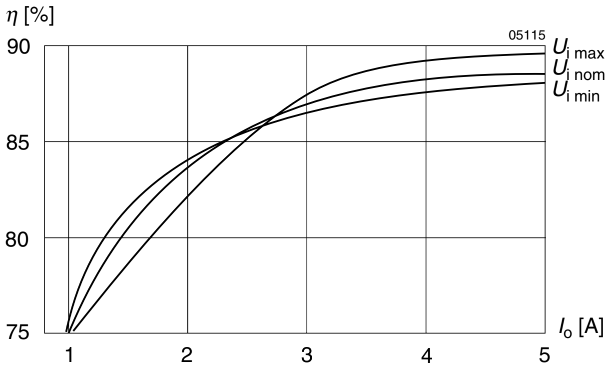


Fig. 15
Efficiency versus input voltage and output current (per output). Typical values of EQ 2320 at $U_{o\ nom}$.

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.*

Notes: Sufficient forced cooling or an additional heat sink improves the reliability or allows T_A to be higher than $T_{A\,max}$ (e.g. 85°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.

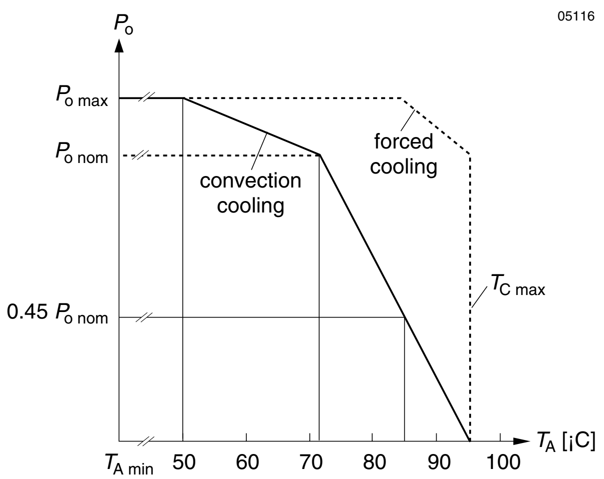


Fig. 16
Output current derating versus T_A.

Thermal Protection

A temperature sensor generates an internal inhibit signal which disables the outputs if the case temperature exceeds $T_{C\ max}$. The outputs are automatically re-enabled if the temperature drops below this limit.

Output Power at Reduced Temperature

Operating the units with output current from $I_{o\ nom}$...$I_{o\ max}$ requires a reduction of ambient temperature to $T_{A\ max}$ = 50°C or forced cooling in order to keep T_C below 85°C. If $T_{C\,max}$ is exceeded, the unit runs into its thermal protection and switches off (e.g. $T_A > 50$°C and $P_o > P_{o\ nom}$).

Important: Short-term operation within the shaded area (e.g. start-up current, peak current) is possible without additional measures, provided the case temperature remains below $T_{C\,max}$.

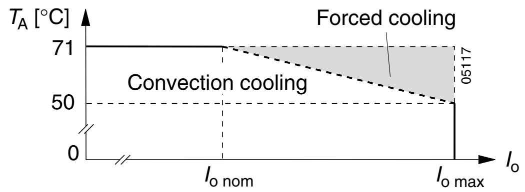


Fig. 17
Output current versus ambient temperature

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 activation 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).

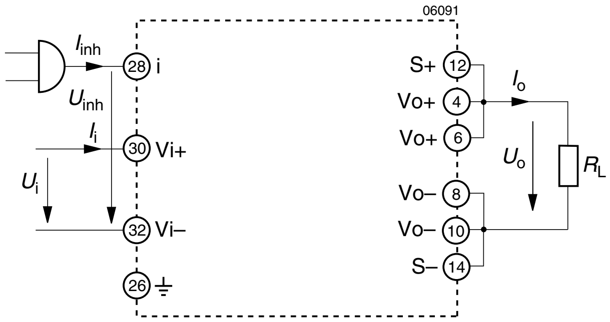


Fig. 18
Definition of input and output parameters

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		–500		μA
			U_{inh} = 0 V		–40		
			U_{inh} = 50 V		+500		
			U_{inh} = 100 V		+1000		

Output Response

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

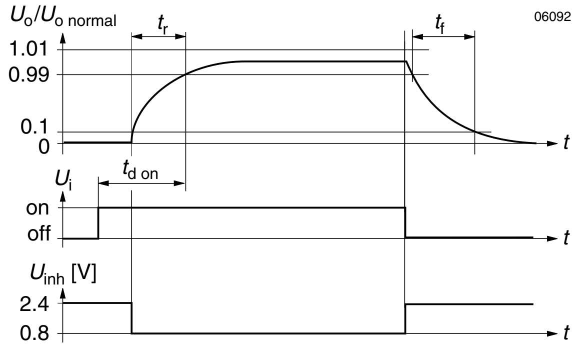


Fig. 19
Output response as a function of input voltage (on/off switching) or inhibit control

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

Characteristics		Conditions	BQ, CQ, GQ min	typ	max	DQ, EQ min	typ	max	Unit
$t_{d\,on}$	Turn-on delay time	$U_i = 0 \to U_{i\,min}$, $R_L = U_{o\,nom}/0.5\ I_{o\,nom}$		5			850		ms
		$U_i = 0 \to U_{i\,nom}$, $R_L = U_{o\,nom}/I_{o\,nom}$		3.5			250		
t_r	Output voltage rise time	$U_i = 0 \to U_{i\,nom}$, $R_L = U_{o\,nom}/I_{o\,nom}$		2.5			2.5		
		$U_{i\,inh} = 2.4 \to 0.8$ V, $R_L = U_{o\,nom}/I_{o\,nom}$							
t_f	Output voltage fall time	$U_i = U_{i\,nom} \to 0$, $R_L = U_{o\,nom}/I_{o\,nom}$		3			3		
		$U_{i\,inh} = 0.8 \to 2.4$ 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.

BQ...GQ 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 or 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 $U_{o\,nom}$.

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

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

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

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.

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.

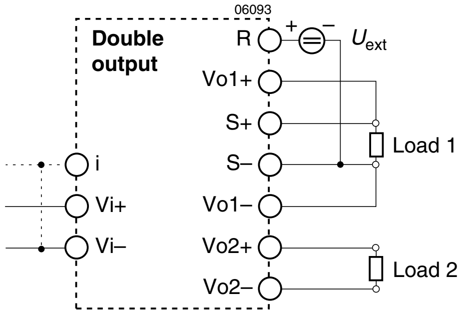


Fig. 20
Output voltage programming using a control voltage U_{ext}

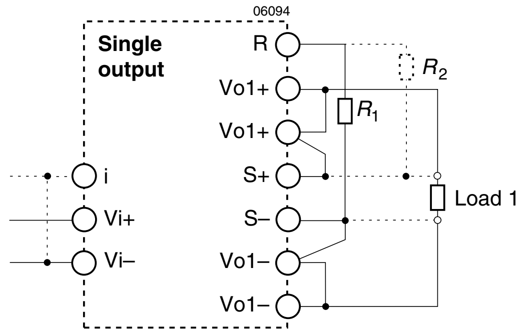


Fig. 21
Output voltage programming using R_1 or R_2

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 [2]	28.0 [2]	5.62
4.1	16.5	6.0	12.0	4.02	8.5	17.0	5.23	15.0 [2]	30.0 [2]	6.65
4.2	18.2	6.5	13.0	4.75	9.0	18.0	6.04	16.0 [2]	32.0 [2]	8.06
4.3	21.5	7.0	14.0	5.62	9.5	19.0	6.98	17.0 [2]	34.0 [2]	9.76
4.4	25.5	7.5	15.0	6.65	10.0	20.0	8.06	18.0 [2]	36.0 [2]	12.1
4.5	30.1	8.0	16.0	8.06	10.5	21.0	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	316	26.0	52.0	442
5.6	46.4	13.0	26.0	196	16.2	32.4	267	26.4	52.8	374
		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.
[2] For DQ 2660: $U_{o\,tr\,min}$ = 19/38 V.

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. 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.

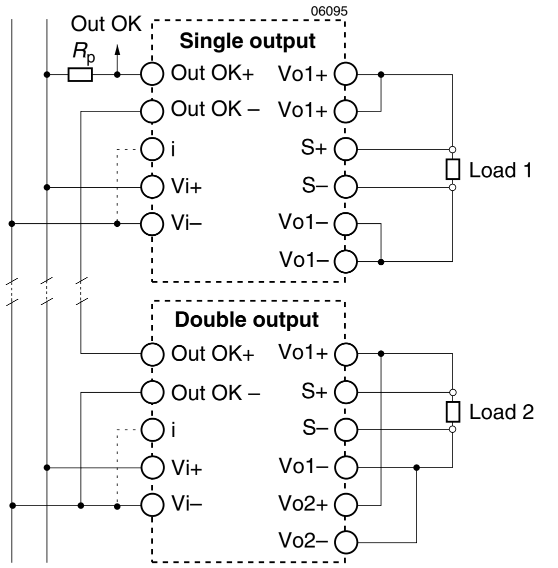


Fig. 22
Series connection of the output good signal at the primary side of the converters for system supervision

Table 9: Output OK data

Characteristics		Conditions	min	typ	max	Unit
U_{OK}	Out OK voltage	good: $U_{t1\ low} < U_{o1} < U_{t1\ high}$, $I_{OK} < 0.5$ mA [1]		0.8	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.

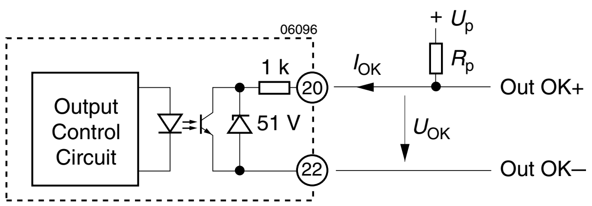


Fig. 23
Output OK function

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

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 ±10 mA maximum.

Test Sockets

Test sockets (for pin diameter 2 mm) are located at the front of the module monitoring the main output voltage at the sense line terminals. The test sockets are short circuit protected by internal series resistors. Test sockets for monitoring the symmetrical output 2 are not available. Double output modules always show the sense line voltage of output 1 at the test sockets only.

Display status of LED's

Table 10: Display status of LED's

LED In OK	LED Out OK	Operating condition
green	green	normal operation
green	x	incorrect sense line connection
green	off	overtemperature overload output overvoltage output undervoltage
off	green	not possible
off	off	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. shutting down the output.

This feature enables compensation of voltage drop at output 1 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 $U_{o\ P\ min}$ (between Vo1+ and Vo1–) is not exceeded. For output voltages $U_o > U_{o\ tr\ max}$, the minimum input voltage according to: *Electrical Input Data* increases proportionally to $U_o/U_{o\ tr\ max}$.

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

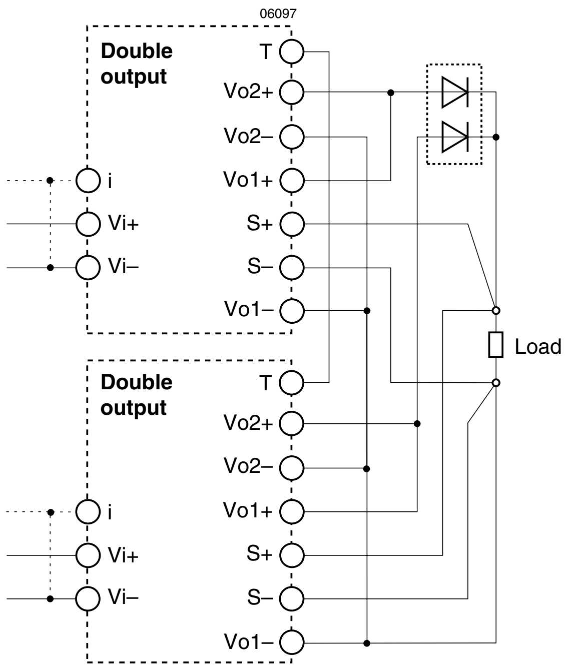


Fig. 24
Sense lines connection for redundant (n + 1) or parallel operation using wired-OR diodes

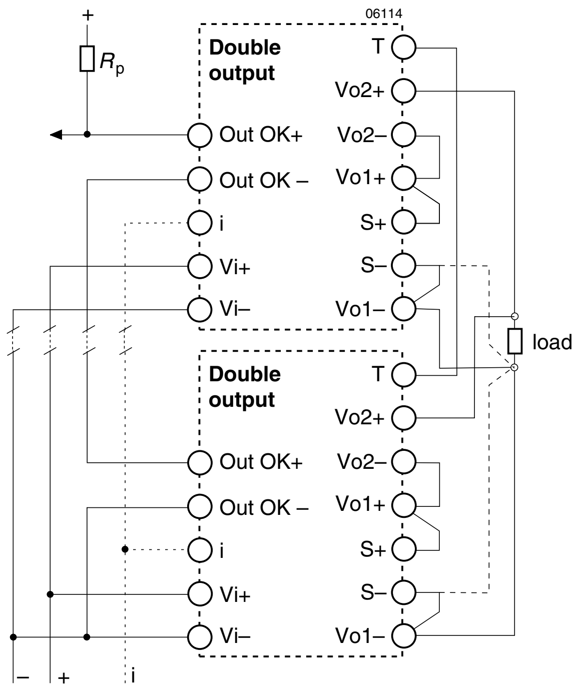


Fig. 25
Parallel connection of several modules with series connection of outputs

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 mobile applications. The Q series has been successfully tested to the following specifications:

Electromagnetic Immunity

Table 12: Immunity type tests

Phenomenon	Standard [1]	Level	Coupling mode [2]	Value applied	Waveform	Source imped.	Test procedure	In oper.	Per-form. [3]
Supply related surge	RIA 12	B	+i/–i	1.5 • U_{batt}	0.1/1/0.1 s	0.2 Ω	1 positive surge	yes	A
	EN 50155			1.4 • U_{batt}		1 Ω			
Direct transient	RIA 12 EN 50155	D	–i/c, +i/–i	1800 V_p	5/50 µs	5 Ω	5 pos. and 5 neg. impulses	yes	B
		G		8400 V_p	0.05/0.1 µs	100 Ω			
Indirect coupled transient		H	–o/c, +o/–o, –o/–i	1800 V_p	5/50 µs				
		L		8400 V_p	0.05/0.1 µs				
Electrostatic discharge (to case)	IEC/EN 61000-4-2	4	contact discharge	8000 V_p	1/50 ns	330 Ω	10 positive and 10 negative discharges	yes	B
			air discharge	15000 V_p					
Electromagnetic field	IEC/EN 61000-4-3	x	antenna	20 V/m	AM 80% 1 kHz	n.a.	26…1000 MHz	yes	A
Electromagnetic field, pulse modulated	ENV 50204	4		30 V/m	50% duty cycle, 200 Hz repetition frequency		900 ±5 MHz		
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	3	i/c	2000 V_p	1.2/50 µs	12 Ω	5 pos. and 5 neg. surges per coupling mode	yes	B
		2	+i/–i	1000 V_p		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	10 V_{rms} (140 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 CQ only.

Electromagnetic Emissions

Table 13: 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
BQ 1000 BQ 2000	B B	- A	- B [1]	<limit <limit
CQ 1000 CQ 2000	B B	A A	B [1] B [1]	<limit <limit
DQ 1000 DQ 2000	A A	A A	B [1] B [1]	<limit <limit
EQ 1000 EQ 2000	A A	- A	- A [1]	>limit >limit
GQ 1000 GQ 2000	B B	A -	A [1] -	>limit <limit

[1] With decoupled load lines.

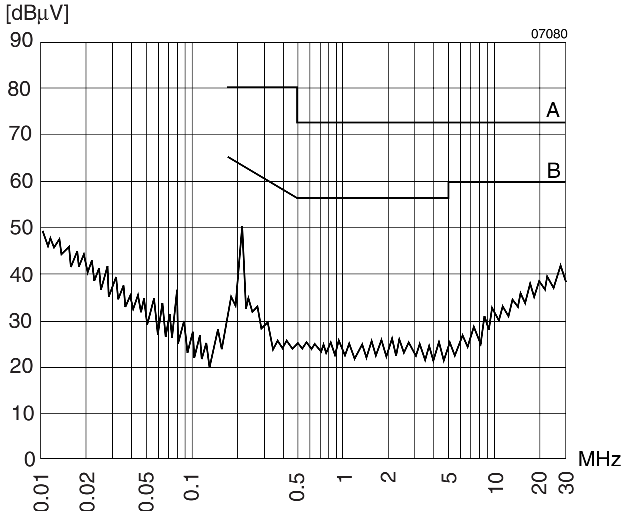


Fig. 26
Typical disturbance voltage (quasi-peak) at the input according to CISPR 11/22 and EN 55011/22, measured at $U_{i\ nom}$ and $I_{o\ nom}$.

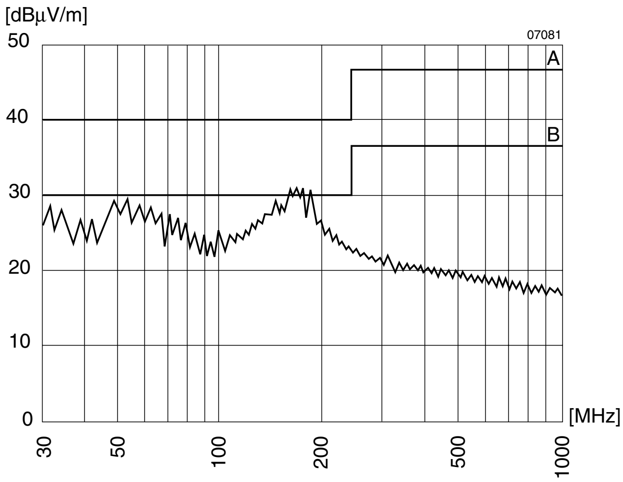


Fig. 27
Typical radiated electromagnetic field strength (quasi-peak, load lines not decoupled) according to CISPR 11/22 and EN 55011/22, normalized to a distance of 10 m, measured at $U_{i\ nom}$ and $I_{o\ nom}$.

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 $93^{+2/-3}$ % 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:	50 g_n = 490.5 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:	25 g_n = 245 m/s^2 11 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) 10 g_n = 98 m/s^2 (60...2000 Hz) 10...2000 Hz 7.5 h (2.5 h each axis)	Unit operating
Fda	Random vibration wide band Reproducibility high	IEC 60068-2-35 DIN 40046 part 23	Acceleration spectral density: Frequency band: Acceleration magnitude: Test duration:	0.05 g_n^2/Hz 20...500 Hz 4.9 $g_{n\ rms}$ 3 h (1 h each axis)	Unit operating
Kb	Salt mist, cyclic (sodium chloride NaCl solution)	IEC/EN/DIN IEC 60068-2-52	Concentration: Duration: Storage: Storage duration: Number of cycles:	5% (30°C) 2 h per cycle 40°C, 93% rel. humidity 22 h per cycle 3	Unit not operating

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

Temperature			Standard -7			Option -9			
Characteristics		Conditions	min	typ	max	min	typ	max	Unit
T_A	Ambient temperature [1]	Operational [2]	–25		71	–40		71	°C
T_C	Case temperature [3]		–25		95	–40		95	
T_S	Storage temperature [1]	Non operational	–40		100	–55		100	
$R_{th\ C-A}$	Thermal resistance case to ambient in still air			2			2		K/W

[1] MIL-STD-810D section 501.2 and 502.2.
[2] See: *Thermal Considerations*. Operation with $P_{o\ max}$ requires reduction to $T_{A\ max}$ = 50°C, $T_{C\ max}$ = 85°C respectively.
[3] Overtemperature lock-out at T_C >95°C (PTC).

Table 16: MTBF and device hours

Ratings at specified Case Temperature	Modules	Ground benign 40°C	Ground fixed 40°C	Ground fixed 70°C	Ground mobile 50°C	Naval, sheltered	Device hours [1]
MTBF acc. to MIL-HDBK-217F	CQ 1000	588'000 h	196'000 h	96'000 h	74'000 h		880'000 h
	BQ 1000	594'000 h	194'000 h	94'000 h	74'000 h		
MTBF acc. to MIL-HDBK-217F, notice 2	BQ 2000	853'000 h	164'000 h	65'100 h	57'700 h	152'000 h	

[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.

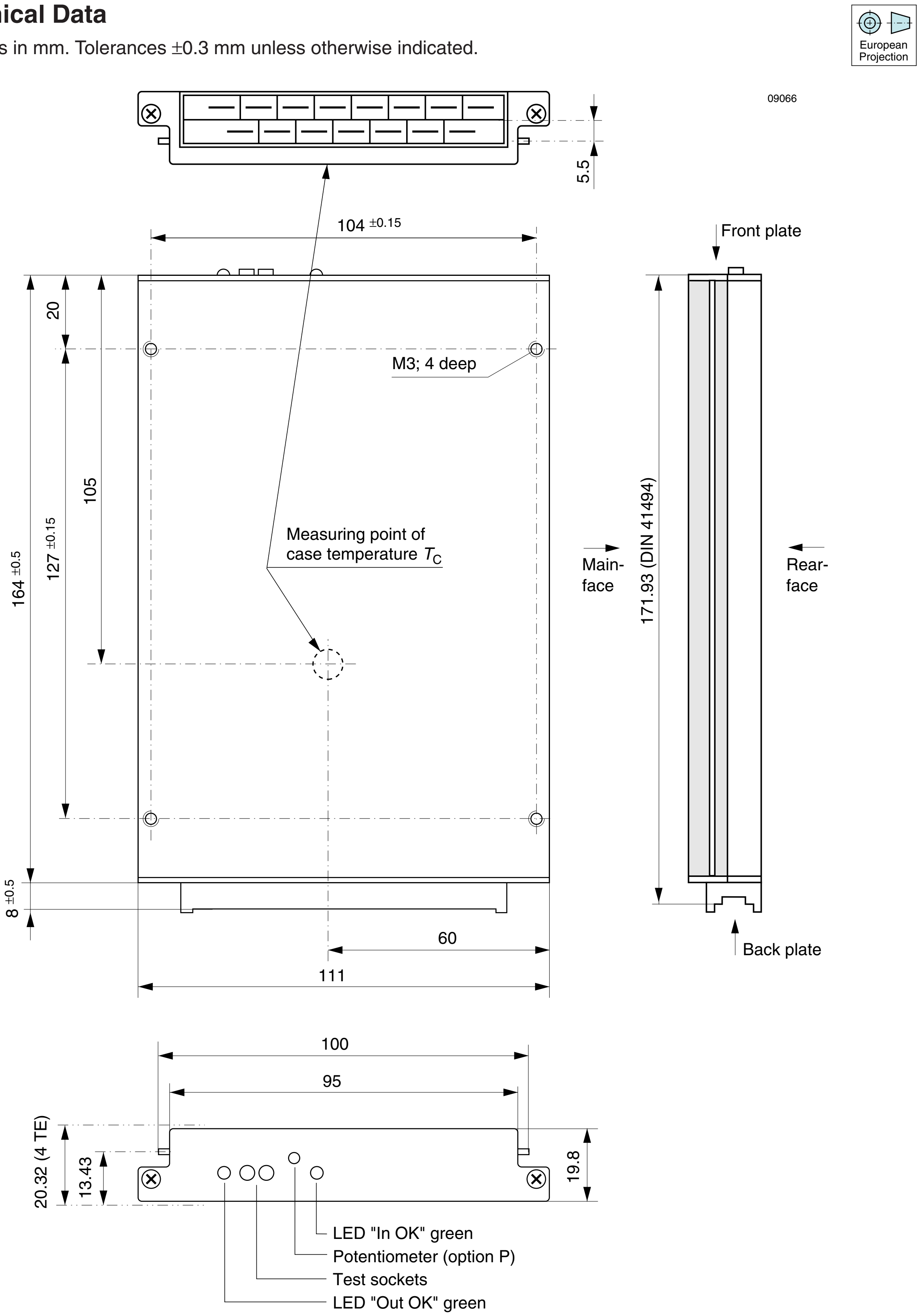


Fig. 28
Case Q01, weight 480 g
Aluminium, fully enclosed,
black finish and self cooling

Note: Long Cases, elongated by 60 mm for 220 mm rack depth is available on request. See also: *Type Key*.

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 BQ...GQ DC-DC converters is leading, ensuring that it makes contact with the female connector first.

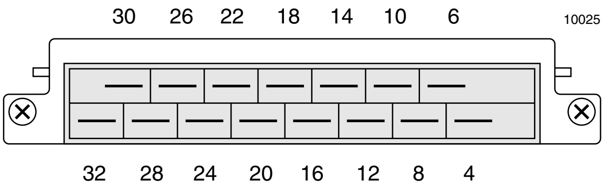


Fig. 29
View of male H15 connector

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) [2]	S+	S+
14	Sense line (negative) [2]	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 [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.

Protection Degree

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).

Installation Instructions

The Q series 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, creep-age, 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.

Long input, output and auxiliary lines or lines with inductors, filters or coupling/decoupling networks may cause instabilities. See also: *Technical Information: Sense Lines*.

Due to high output currents, the BQ...GQ 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.

Standards and approvals

All Q series 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,
- Operational insulation between output(s) and case
- Operational insulation between the outputs
- 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 converters are subject to manufacturing surveillance in accordance with the above mentioned UL, CSA, EN and with ISO 9001 standards.

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. Power-One 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.*

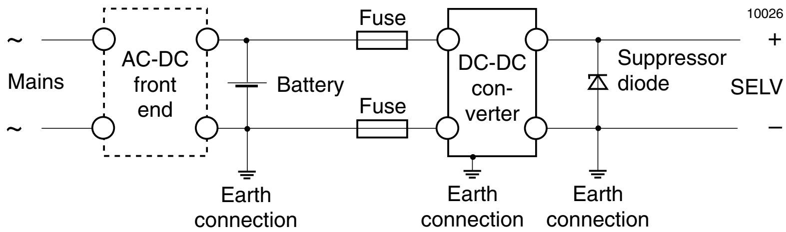


Fig. 30
Schematic safety concept
Use fuse, suppressor diode and earth connections as per table: *Safety concept leading to an SELV output circuit*. Use fuse(s) also if required by the application. See: *Installation Instructions*.

Table 19: Safety concept leading to an SELV output circuit

Conditions	Front end			DC-DC converter		Result
Nominal supply voltage	Minimum required grade of insolation, 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	Types	Measures to achieve the specified safety status of the output circuit	Safety status of the DC-DC converter output circuit
Mains ≤150 V AC	Operational (i.e. there is no need for electrical isolation between the mains supply circuit and the DC-DC converter input circuit)	≤150 V [2]	Primary circuit	DQ EQ	Double or reinforced insulation, based on 150 V AC and DC (provided by the DC-DC converter) and earthed case [3]	SELV circuit
	Basic	≤60 V	ELV circuit	BQ CQ GQ	Supplementary insulation, based on 150 V AC (provided by the DC-DC converter) and earthed case [3]	
		≤75 V [9]	Hazardous voltage secondary circuit	CQ	Supplementary insulation, based on 150 V AC and double or reinforced insulation [4] (both provided by the DC-DC converter) and earthed case [3]	
Mains ≤250 V AC		≤60 V	Earthed SELV circuit [3]	BQ CQ GQ	Operational insulation (provided by the DC-DC converter)	
			ELV circuit		Input fuse [5], output suppressor diodes [6], earthed output circuit [3] and earthed [3] or non user accessible case	Earthed SELV circuit
		≤75 V	Unearthed hazardous voltage secondary circuit	CQ		
		≤150 V [2]	Earthed hazardous voltage secondary circuit [3] or earthed ELV circuit [3]	BQ, CQ DQ, EQ GQ	Double or reinforced insulation [4] (provided by the DC-DC converter) and earthed case [3]	SELV circuit
			Unearthed hazardous voltage secondary circuit	DQ EQ	Supplementary insulation, based on 250 V AC and double or reinforced insulation [4] (both provided by the DC-DC converter) and earthed case [3]	
	Double or reinforced	≤60 V	SELV circuit	BQ, CQ GQ	Operational insulation (provided by the DC-DC converter)	
		≤120 V	TNV-2 circuit	CQ DQ EQ	Basic insulation [4] and earthed case [7]	
		≤150 V [2]	Double or reinforced insulated unearthed hazardous voltage secondary circuit [8]			

1 The front end output voltage should match the specified input voltage range of the DC-DC converter.
2 The maximum rated input voltage of the EQ units according to IEC/EN 60950/UL 1950 is 150 V. Power-One specifies the tolerance as +12%, i.e. 168 V max.
3 The earth connection has to be provided by the installer according to the relevant safety standards, e.g. IEC/EN 60950.
4 Based on the maximum rated output voltage from the front end.
5 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*.
6 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*).
7 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.
8 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.
9 The nominal voltage between any input pin and earth can be up to 75 V AC or DC.

Description of Options

Option P Output Voltage Adjustment

Option P provides a built-in multi-turn potentiometer which allows 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.

Option -9 Extended temperature range

Option -9 extends the operational ambient temperature range from –25...71 °C (standard) to –40...71 °C. The power supplies provide full nominal output power with convection cooling.

Accessories

A great variety of electrical and mechanical accessories are available:

– Maiting connectors including 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

– Mechanical mounting supports for chassis, DIN-rail and PCB mounting.

For more precise details please refer to: *Accessory Products*.