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Features

- RoHS compliant for all 6 substances
- Wide input voltage range 8 to 160 VDC
- Output: 30 to 80 VDC
- Class III equipment (no isolation input/output)
- Extremely high efficiency
- Excellent surge and transient protection
- Externally adjustable output voltage
- Programmable undervoltage lockout and inhibit
- Hold-up time with external capacitor
- EN 50155, 50121-3-2 observed

Safety-approved to IEC/EN 60950-1 and UL/CSA 60950-1 2nd Ed.

Description

The boost converters were designed in accordance with the standards EN 50155 and EN 50121-3-2 to meet the requirements of various railway and industrial applications. It is particularly suitable to increase the input voltage range of power supplies (e.g. 110IMY15 or 110IMY70 Series converters) in rugged environment. An additional circuit allows for providing a predefined interruption time.

When the input voltage reaches the predefined output voltage level, the input voltage is directly fed forward. The converters exhibit an EMC-filter on the input.

The boost converter is available in a fully enclosed case or open-frame (option Z).

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Model Selection

Table 1: Model selection

Input voltage $V_{i\,nom}$	Operating input range V_i	Output voltage V_o	Output current $I_{o\,nom}$	Type designation	Efficiency[1]		Options
					η_{min}	η_{typ}	
12 V	8.0 – 50.4 VDC	25 – 40 VDC	3.0 A	12IBX15-25-0G [2]			Z
24 V	15.4 – 160 VDC	50 – 160 VDC	1.6 A	24IBX15-50-0G	89%	93%	
36 V	24 – 160 VDC	50 – 160 VDC	2.2 A	36IBX15-50-0G	91%	95%	

[1] Efficiency at $V_i = V_{i\,min}$, $V_o = V_{o\,nom}$, $I_o = I_{o\,nom}$
[2] In preparation

Functional Description

The IBX15 boost converter is designed as step-up converter in order to increase the input voltage V_i to the regulated boost voltage V_{oBr}.

When V_i exceeds V_{oBr}, the output voltage follows V_i. The resulting voltage is in the range of V_{oBr} to $V_{i\,max}$, which is suitable for adequate DC-DC converters, e.g. 20IMX15 or 24IMX70 for 12IBX15-25 and 110IMY15 or 110IMY70 for 24/36IBX15-50. The IBX15 converters have no input-to-output isolation; isolation is provided by the DC-DC converters connected to the output.

The inrush current is not limited, but the output capacitor and the input capacitors of the connected DC-DC converters are relatively small.

The switching frequency is approximately 2×200 kHz (interleaved). A current limiting circuit protects the main FETs from overload. However, the output is not short-circuit proof.

The logic is biased by an auxiliary converter with a switching frequency of approx. 350 kHz. The boost voltage can be adjusted to a higher level. This allows together with an external storage capacitor C_{hu} the realization of an interruption time requested by the railway standard EN 50155. No other components are needed.
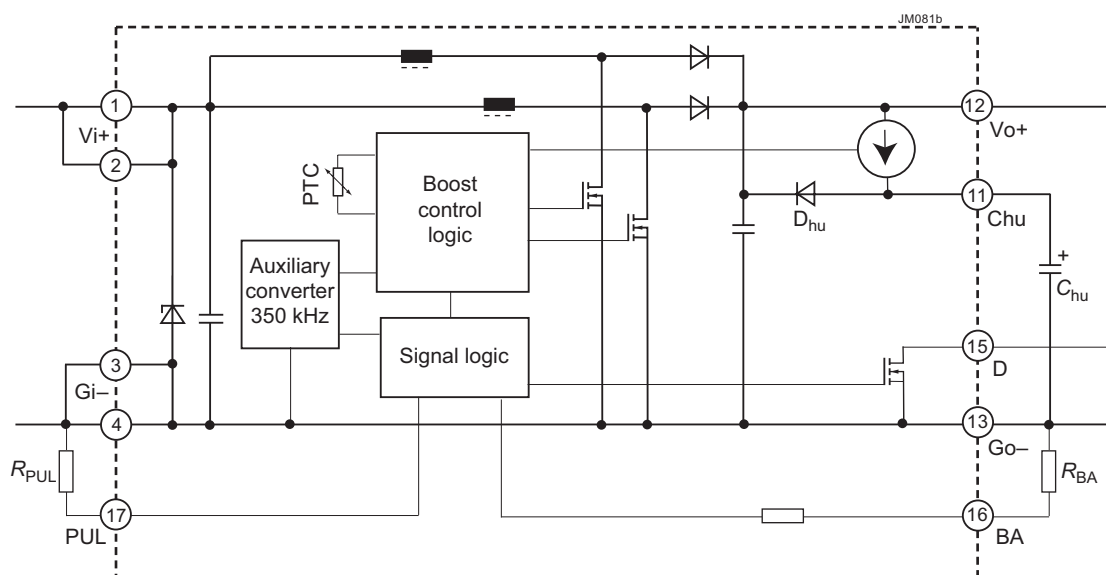

Fig. 1
Functional diagram

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Electrical Input Data

General Conditions:
– T_A = 25 °C, unless T_C is specified.

Table 2: Input data

Model			12IBX15-25-0G			24IBX15-50-0G			36IBX15-50-0G			Unit
Characteristics		**Conditions**	**min**	**typ**	**max**	**min**	**typ**	**max**	**min**	**typ**	**max**	
V_i	Operating input voltage		8.0		50.4	15.4		160	24		160	V
$V_{i\,2s}$	Temporary input voltage	2 s	6.0		60	12		168	21.3		168	
$V_{i\,abs}$	Input voltage limits	2 s, without damage			60			176			176	
$\Delta V_{i\,o}$	Voltage drop $V_i - V_o$	$V_i > V_{oB}$			0.7			1			1	
I_i	Typ. input current	$V_{i\,min}$, $I_{o\,nom}$		10			8			6		A
C_i	Input capacitance	for surge calculation								4		µF
t_{start}	Start-up time of V_o	$V_i \rightarrow V_{i\,min}$ or after shutdown		500			500			500		ms
$P_{i\,0}$	No-load input power	$V_{i\,min} - V_{i\,max}$, $I_o = 0$					1.0	1.5		1.0	1.5	W
$P_{i\,SD}$	Input power with shutdown	$V_{i\,min} - V_{i\,max}$, $V_{PUL} = 0$										

Electrical Output Data

General Conditions:
– T_A = 25 °C, unless T_C is specified. $V_i < V_{oB\,min}$, $I_o < I_{o\,nom}$

Table 3: Output data

Model			12IBX15-25-0G			24IBX15-50-0G			36IBX15-50-0G			Unit
Characteristics		**Conditions**	**min**	**typ**	**max**	**min**	**typ**	**max**				
$V_{oB\,r}$	Boost voltage regulated	$V_{i\,min}$, $I_{o\,nom}$, $R_{BA} = \infty$	24.5	25	25.5	49	50	51	49	50	51	V
$V_{oB\,tr}$	Boost voltage trim range	depending on R_{BA}	24.5		50	49		80	49		80	
$I_{o\,nom}$	Output current, nom.	$V_{i\,min} - V_{i\,max}$, $V_{oB\,r}$		3.0			1.6			2.2		A
V_{ow}	Static line/load regulation	$V_{i\,min} - V_{oB\,r}$, $0 - I_{o\,nom}$		±0.5	±1		±1	±2		±1	±2	V
v_{od}	Dynamic line/load regul.				±1.5			±2			±2	
t_d	Dynamic recovery time							2			2	ms
I_{BC}	Current to boost capacitor	$V_o \geq V_{oB\,r}$		15		3.9	4.3	4.8	3.9	4.3	4.8	mA
t_{hu}	Interruption time[1]	C_{hu} = 1000 µF, $V_{oB\,tr}$ = 50 V, $V_i = V_{i\,min}$					--			--		ms
t_{loadC}	Load time for C_{hu}[1]						--			--		s
t_{hu}	Interruption time[1]	C_{hu} = 560 µF, $V_{oB\,tr}$ = 80 V, $V_i = V_{i\,min}$		--		10	11		10	11		ms
t_{loadC}	Load time for C_{hu}[1]			--		12	15	18	12	15	18	s

[1] For other values use the formula in section *Interruption Time* !

Input Protection and Fuse

No fuse is incorporated inside the converter. Consequently, an external fuse or a circuit breaker at system level should be installed to protect against severe defects; see table 4.

Reverse polarity protection is provided by an antiparallel diode across the input, causing the external input fuse or circuit breaker to trip.

Table 4: Recommended external fuses in the non-earthed input line

Converter model	Fuse type
12IBX15-25-0G	Littlefuse 218, 10 A / 250 VAC, fast
24IBX15-50-0G	Littlefuse 218, 10 A / 250 VAC, fast
36IBX15-50-0G	Littlefuse 218, 8 A / 250 VAC, fast, or: Schurter SPT 8A, 300 VDC

Note: The fuses in table 4 apply to batteries with $V_{i\,nom} = 24$ or 36 V. In applications using batteries with higher voltage, fuses with lower current may suit better.

Programmable Undervoltage Lockout PUL

The programmable input undervoltage lockout (PUL, pin 17) should be adjusted adequately in order to limit the input current. Table 5 shows the values of the resistor R_{PUL}, connected between PUL and Vi−, versus the resultant minimum input voltage and the resultant maximum input current.

*Table 5a: Typical values for R_{PUL} and the resultant turn-on input voltage $V_{i\,LO}$.*

12IBX15-25-0G			
R_{PUL} [kΩ]	$V_{i\,LO}$ [V]		
∞	9		
	10		
	12		
	14		
	16		

Table 5b: Typical values for R_{PUL} and the resultant turn-on input voltage $V_{i\,LO}$.

24IBX15-50-0G		36IBX15-50-0G	
R_{PUL} [kΩ]	$V_{i\,LO}$ [V]	R_{PUL} [kΩ]	$V_{i\,LO}$ [V]
∞	16	∞	23
86.4	18	53	27
53.3	20	26.5	30
34.0	23	13.4	34
22.6	27	7.3	38

**Note:** If PUL is connected to Vi−, the converter is disabled (shutdown).

Efficiency
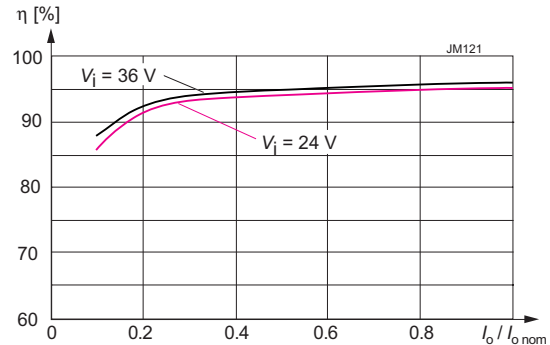
Fig. 2
Efficiency versus input voltage and output current (24IBX15-50-0G)

Interruption Time

The interruption time (hold-up time) of a system comprised of a step-up converter and connected converters can easily be increased by an external capacitor C_{hu} and adjusting the boost voltage $V_{oB\,tr}$ to a higher level. As an example, fig. 3 shows a 36IBX15-50 supplying a DC-DC converter 110IMY70-12; see fig. 3a
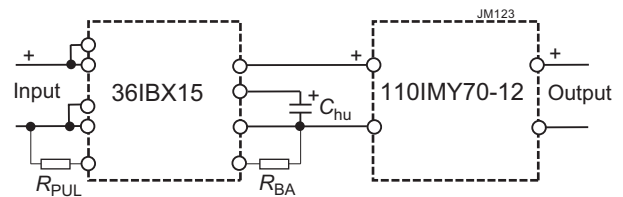
Fig. 3
System with increased interruption time

Formula for the external boost capacitor C_{hu}:

$$C_{hu} = \frac{2 \cdot P_o \cdot t_{hu} \cdot 100}{(V_{oB\,tr}^2 - V_{i\,min}^2)}$$

whereas:

C_{hu} = external boost capacitance [mF]
P_o = output power = input power of the supplied converter [W]
t_{hu} = interruption or hold-up time [ms]
$V_{i\,min}$ = min. input voltage of supplied converters [V]
$V_{oB\,tr}$ = boost voltage trimmed using R_{BA} [V]

The external boost capacitor is loaded by a current source to the preselected boost voltage $V_{oB\,tr}$. This current source is only activated after V_{oB} has reached or exceeded $V_{oB\,r}$. If the input voltage is increasing further, the boost capacitor is not charged beyond $V_{oB\,tr}$. Consequently, its rated voltage needs not to be much higher than $V_{oB\,tr}$.

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In the case of input voltage loss, the output voltage V_{oB} drops rapidly to $V_{oB\,tr}$ until the diode D_{hu} connects the output to the boost capacitor, sustaining the output voltage; see fig. 4. Because $V_{i\,min}$ of the supplied converter is not reached during t_{hu}, the output voltage remains constant.

Fig. 4
Increased interruption time. $V_i = 110$ V, $C_{hu} = 560$ µF/100 V, $P_o = 90$ W, $V_{oB\,tr} = 80$ V, $R_{BA} = 0$ Ω. (24IBX15-50-0G)

Parallel or Series Operation

This is not possible.

Thermal Considerations

If a converter, mounted on a PCB, is located in free, quasi-stationary air (convection cooling) at the indicated maximum ambient temperature $T_{A\,max}$ (see table *Temperature specifications*) and is operated at its nominal operating conditions, the case 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, temperature of surrounding components and surfaces, and the properties of the printed circuit board. $T_{A\,max}$ is therefore only an indicative value.

Caution: The case temperature T_C measured at the measuring point of case temperature T_C (see *Mechanical Data*) may under no circumstances exceed the specified maximum value. The installer must ensure that under all operating conditions T_C remains within the limits stated in the table *Temperature specifications*.

Overtemperature Protection

The converters are protected from possible overheating by means of an internal temperature monitoring circuit. It shuts down the converter above the internal temperature limit, and automatically restarts, after the temperature dropped to the specified value.
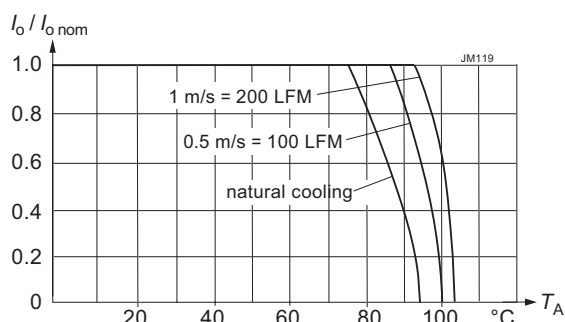
Fig. 5a
Max. output current versus temperature (24IBX15)
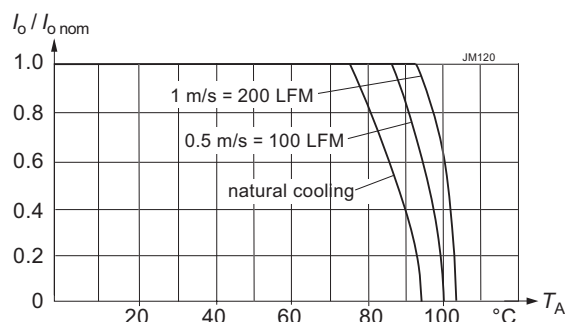
Fig. 5b Option Z
Max. output current versus temperature (24IBX15)

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Auxiliary Functions

Boost Voltage Adjust

The regulated boost voltage V_{oBr} can be adjusted by an external adjust resistor R_{BA}; see fig. 1. The values of R_{BA} are specified in table 6.

Table 6a: Typical values for R_{BA} and the resultant boost voltage V_{oBr} and the possible output current I_o.

R_{BA} [kΩ]	12IBX15-25-0G	
	V_{oBr} [V]	I_o [A]
∞	25	3.0
	30	
	35	
	40	
	45	
	50	

Table 6b: Typical values for R_{BA} and the resultant boost voltage V_{oBr} and the possible output current I_o.

R_{BA} [kΩ]	24IBX15-50-0G		36IBX15-50-0G	
	V_{oBr} [V]	I_o [A]	V_{oBr} [V]	I_o [A]
∞	50	1.6	50	2.2
121	55	1.42	55	1.95
46.5	60	1.27	60	1.75
23	65	1.05	65	1.45
11.2	70	0.92	70	1.26
4.3	75	0.84	75	1.16
0	80	0.79	80	1.08

Of course, the real output voltage V_o follows V_i when V_i is higher than V_{Br}. However, the voltage on pin 11 will never exceed the adjusted value of V_{oBr}. Then external capacitor C_{hu} must only be rated to V_{Br}.

The max. output current will decrease with higher V_{Br}, but the output power remains constant.

Note: The connected 110IMY converters need a lower input current with higher input voltage, according to the IBX15.

Out-OK Signal

An open-collector signal controls the function of the boost converter. When V_{oBr} is exceeded, the D-output is connected with a FET to Go– (pin 15); see table 7.

Table 7: Out-OK data

Characteristics		Conditions	min	typ	max	Unit
V_{OK}	Out-OK voltage	Output okay, I_{OK}<50 mA		0.3	0.5	V
I_{OK}	Out-OK current	Output fail, $V_{OK} \leq 80$ V	15		60	µA

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Electromagnetic Compatibility (EMC)

A suppressor diode together with the input choke and an the output capacitor form an effective protection against high input transient voltages which typically occur in many installations, but especially in battery-driven mobile applications. The auxiliary converter has a separate input filter.

Electromagnetic Immunity

Table 8: Immunity type tests

Phenomenon	Standard	Class Level	Coupling mode [1]	Value applied	Waveform	Source imped.	Test procedure	In oper.	Perf-crit.[2]
Electrostatic discharge to case	IEC/EN 61000-4-2 [3]		contact discharge (R pin open)	$\pm 6000\ V_p$	1/50 ns	330 Ω	10 positive and 10 negative discharges	yes	B
		3	air discharge (R pin open)	$\pm 8000\ V_p$					
Electromagnetic field	IEC/EN 61000-4-3	x [4]	antenna	20 V/m	80% AM, 1 kHz	n.a.	80 – 1000 MHz	yes	A
		5	antenna	20 V/m	80% AM, 1 kHz	n.a.	800 – 1000 MHz	yes	A
				10 V/m			1400 – 2100 MHz		
				5 V/m			2100 – 2500 MHz		
Electrical fast transients/burst	IEC/EN 61000-4-4: 2004	3[6]	direct coupl. (fig. 9) +i/c,–i/c,+i/–i	$\pm 2000\ V_p$[6]	bursts of 5/50 ns 5 kHz over 15 ms burst period: 300 ms	50 Ω	60 s positive 60 s negative transients per coupling mode	yes	A
		4		$\pm 4000\ V_p$				yes	B
		3	capacit. (fig. 10), o/c	$\pm 2000\ V_p$				yes	B
Surges	IEC/EN 61000-4-5	3[7]	+i/c, –i/c	$\pm 2000\ V_p$[3]	1.2/50 µs	12 Ω	5 pos. and 5 neg. surges per coupling mode	yes	A
		2[7]	+i/–i	$\pm 1000\ V_p$[3]		2 Ω		yes	B
Conducted disturbances	IEC/EN 61000-4-6	3[8]	i, o, signal wires	10 VAC (140 dBµV)	AM 80% 1 kHz	150 Ω	0.15 – 80 MHz	yes	A

[1] i = input, o = output, c = case (not for option Z)

[2] A = normal operation, no deviation from specification, B = temporary deviation from specs. possible.

[3] Corresponds to EN 50121-3-2:2006, table 9.3

[4] Corresponds to EN 50121-3-2:2006 table 9.1 and exceeds EN 50121-4:2006 table 1.1.

[5] Corresponds to EN 50121-3-2:2006 table 9.2 and EN 50121-4:2006 table 1.2 (compliance with digital mobile phones).

[6] Corresponds to EN 50121-3-2:2006 table 7.2 and EN 50121-4:2006 table 2.2.

[7] Measured with an external input capacitor: 600 µF due to the standard network impedance for surge testing

[8] Corresponds to EN 50121-3-2:2006 table 7.1 and EN 50121-4:2006 table 2.2.

Electromagnetic Emissions

The EMC requirements must be observed at the end product system level. However, Power-One tests the converters to EMC standards. The integrated input filter reduces the reflected input current and improves EMC features. Further improvements are possible by adding simple external filters; see fig. below.

The large input capacitor C1 (600 µF/200 V) is necessary to provide stability during surge tests. The other components are:

C2 = 4.7 nF, Y2; C51 = C52 = 10 nF, Y2
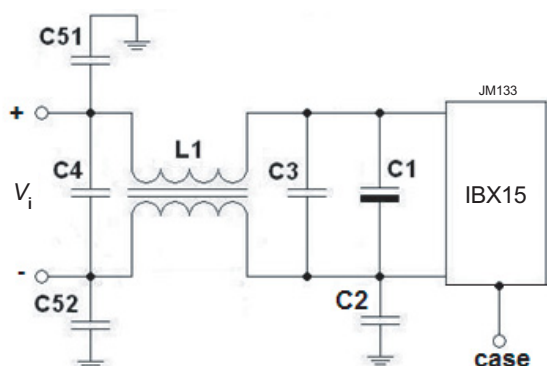
C3 = 3 µF, X7R; C4 = 5 µF, X7R

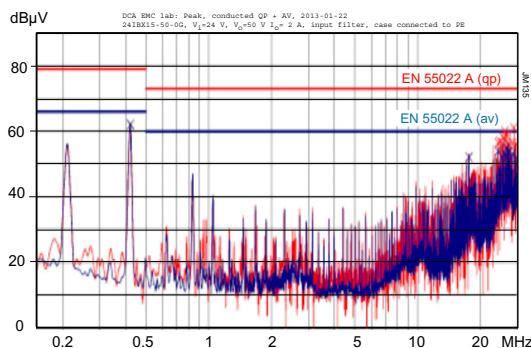L1 = 4.4 mH

Fig. 6
Input filter for disturbance tests

Fig. 7
Conducted emissions of 24IBX15-50-0G. Vi = 24 V, Vo = 50 V, 2 A; case connected to PE; with input filter.

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Immunity to Environmental Conditions

Table 9: Mechanical and climatic stress

Test	method	Standard	Test conditions		Status
Cab	Damp heat steady state	IEC/EN 60068-2-78 MIL-STD-810D section 507.2	Temperature: Relative humidity: Duration:	$40^{\pm2}$ °C $93^{+2/-3}$ % 56 days	Converter not operating
--	Salt mist test sodium chloride (NaCl) solution [2]	EN 50155:2007 sect. 12.2.10 class ST2 [2]	Temperature: Duration:	$35^{\pm2}$ °C 16 h	Converter not operating
Fc	Vibration (sinusoidal)	IEC/EN 60068-2-6 MIL-STD-810D section 514.3	Acceleration amplitude: Frequency (1 Oct/min): Test duration:	0.35 mm (10 – 60 Hz) 5 g_n = 49 m/s^2 (60 - 2000 Hz) 10 – 2000 Hz 7.5 h (2.5 h in each axis)	Converter operating
Fh	Random vibration broad band (digital control) and guidance	IEC/EN 60068-2-64	Acceleration spectral density: Frequency band: Acceleration magnitude: Test duration:	0.05 g_n^2/Hz 8 – 500 Hz 4.9 $g_{n\ rms}$ 1.5 h (0.5 h in each axis)	Converter operating
Eb	Bump (half-sinusoidal)	IEC/EN 60068-2-29 MIL-STD-810D section 516.3	Acceleration amplitude: Bump duration: Number of bumps:	25 g_n = 245 m/s^2 6 ms 6000 (1000 in each direction)	Converter operating
Ea	Shock (half-sinusoidal)	IEC/EN 60068-2-27 MIL-STD-810D section 516.3	Acceleration amplitude: Bump duration: Number of bumps:	50 g_n = 490 m/s^2 11 ms 18 (3 in each direction)	Converter operating
--	Shock	EN 50155:2007 sect. 12.2.11, EN 61373 sect. 10, class B, body mounted[1]	Acceleration amplitude: Bump duration: Number of bumps:	5.1 g_n 30 ms 18 (3 in each direction)	Converter operating
--	Simulated long life testing at increased random vibration levels	EN 50155:2007 sect. 12.2.11, EN 61373 sect. 8 and 9, class B, body mounted[1]	Acceleration spectral density: Frequency band: Acceleration magnitude: Test duration:	0.02 g_n^2/Hz 5 – 150 Hz 0.8 $g_{n\ rms}$ 15 h (5 h in each axis)	Converter operating

[1] Body mounted = chassis of a railway coach

Temperatures

Table 10: Temperature specifications, valid for an air pressure of 800 - 1200 hPa (800 - 1200 mbar)

Temperature			-0 (with case)			-0Z				Unit
Characteristics		**Conditions**	min	typ	max	min	typ	max		
T_A	Ambient temperature	Converter operating	−40		70	−40		70		°C
T_C, T_{CZ}	Case temperature		−40		100	−40		120		
T_S	Storage temperature	Non operational	−55		100	−55		100		

Reliability

Table 11: MTBF and device hours

Ratings	Model	Ground benign	Ground fixed		Ground mobile	Device hours	Unit
Case Temperature		**40 °C**	**40 °C**	**70 °C**	**50 °C**	**40 °C**	
MTBF accord. to Bellcore SR-332, issue 1	36IBX15-50	850 000	425 000	160 000	104 000		h

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Mechanical Data

Dimensions are in mm (inches).

Recommended PCB hole diameter for the square pins: 1 mm

4 × M3

⌀ 0.8 (0.03") for holes with ⌀ 1.4 mm

European Projection

JM115a

54.9 (2.16")
48.26 (1.91")
5.08 (0.2")
5.08

1
2
3
4

11
12
13
15
16
17

T_C

45.72 (1.8")
48.06 (1.89")
54.7 (2.15")

11.5 +0.2 -0.1

3.3
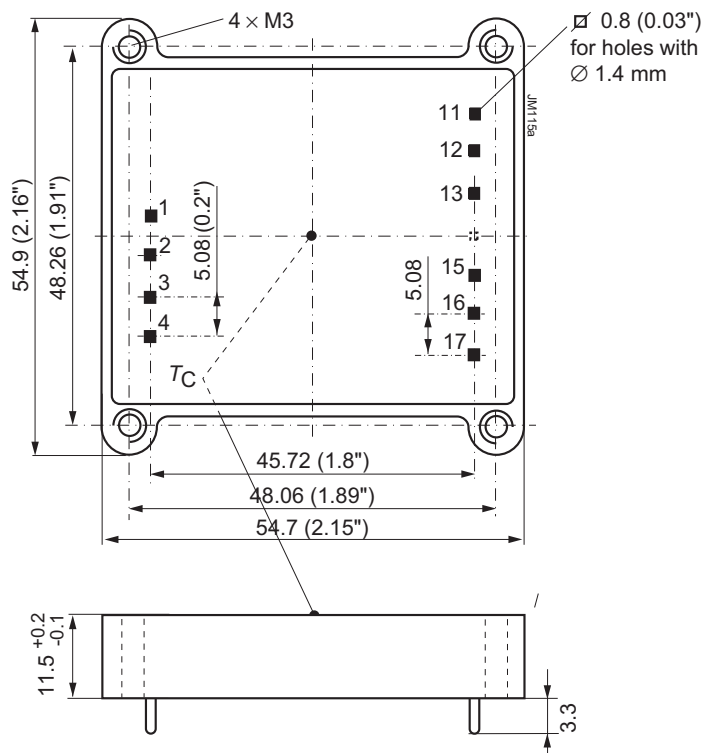
Fig. 7
Case Zinc,
weight approx. 80 g

JM104b

⌀ 0.8 (0.03") for holes with ⌀ 1.4 mm

11
12
13
15
16
17

41.2 (1.62")
5.08 (0.2")
6 × 5.08 (0.2")

1
2
3
4

bottom view

45.72 (1.8")
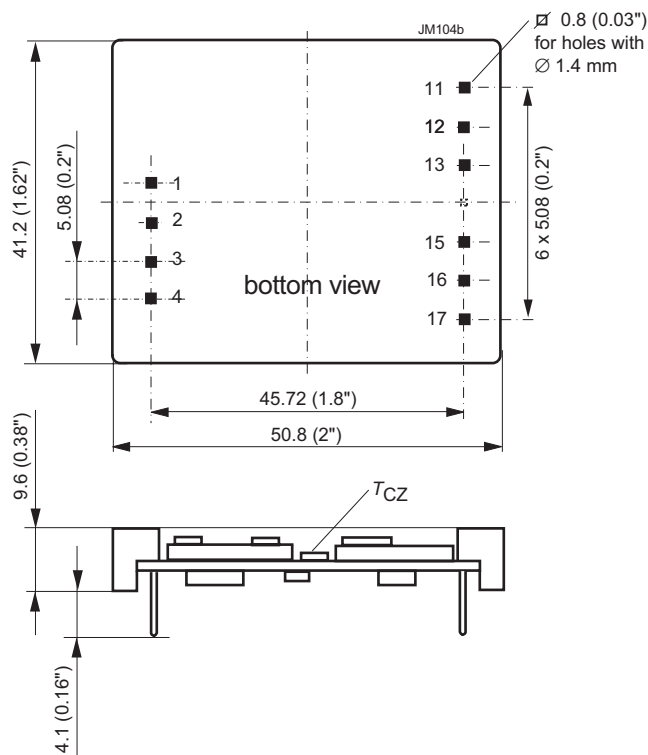50.8 (2")

9.6 (0.38")

T_{CZ}

4.1 (0.16")

Fig. 8
Open frame (option Z),
weight approx. 30 g

Safety and Installation Instructions

Pin allocation

Table 15: Pin allocation (standard and option Z)

Pin	Name	Description
1	Vi+	Pos. input
2	Vi+	Pos. input
3	Gi−	Neg. input
4	Gi−	Neg. input
11	Chu	External hold-up capacitor
12	Vo+	Pos. output voltage
13	Go−	Neg. output (connected to pins 3 and 4)
14	--	No pin
15	D	Boost function okay
16	BA	Boost voltage adjust
17	PUL	Programmable undervoltage lockout / inhibit

Installation Instructions

Connection to the system shall be made via a printed circuit board with hole diameters of 1.4 mm ±0.1 mm for the pins.

The converter must be connected to a secondary circuit.

Do not open the converter!

Ensure that a converter failure (e.g. by an internal short-circuit) does not result in hazardous conditions.

Note: To prevent excessive current flowing through the input supply lines in case of a malfunction an external fuse should be installed in a non-earthed input supply line; see *table 4*.

Standards, Approvals, Isolation

The converters have been approved according to UL/CSA 60950-1 and IEC/EN 60950-1 2nd Ed. The CE mark is fitted.

All pins are tested against the case with 1500 VAC (2120 VDC) for ≥ 1 s as routine test in the factory according to EN 50116 and IEC/EN 60950.

The converters are subject to manufacturing surveillance in accordance with the above mentioned standards and with ISO9001:2000.

Railway Applications

To comply with railway standards, all components are coated with a protective lacquer (except option Z).

Protection Degree

The protection degree of the converters is IP 40, except open-frame models (option Z).

Cleaning Liquids

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

However, open-frame models (option Z) leave the factory unlacquered; they may be lacquered by the customer, for instance together with the mother board. Cleaning liquids are not permitted – except washing at room temperature with isopropyl alcohol and de-inonized/destilled water (1 : 1).

The mother board can also be cleaned, before fitting the open-frame converter.

Note: Other cleaning liquids may damage the adhesive joints of the ferrite cores.

Options

Option Z: Open-frame model without case.