



Features

- · Extremly wide operating input voltage ranges from 8 to 385 VDC and 85 to 264 VAC, 47 to 440 Hz
- · RoHS lead-solder exemption compliant
- · Class I equipment
- · Input over- and undervoltage lockout
- 1, 2, or 3 individually isolated and controlled outputs up to 96 V
- · Outputs: SELV, no load, overload, short-circuit proof, rectangular current limiting characteristic
- · Adjustable output voltages with remote on/off
- Immunity according to IEC/EN 61000-4-2, -3, -4, -5, -6
- Emissions according to EN 55011/55022
- · All PCBs boards coated by protective lacquer
- · Very high reliability
- · Battery charger models available

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





Description

The M Series of DC-DC and AC-DC converters represents a broad and flexible range of power supplies for use in advanced industrial electronic systems. Features include high efficiency, reliability, low output voltage noise and excellent dynamic response to load/line changes due to individual regulation of each output.

The converter inputs are protected against surges and transients occuring at the source lines. An input over- and undervoltage lockout circuit disables the outputs, if the input voltage is outside the specified range. An inrush current limitation prevents circuit breakers and fuses from tripping at switch-on.

All outputs are open- and short-circuit proof, and are protected against overvoltages by means of built-in suppressor diodes. The outputs can be inhibited by a logic signal applied to the connector (pin 2). If the inhibit function is not used, pin 2 should be connected to pin 23 to enable the outputs.

LED indicators display the status of the converter and allow visual monitoring of the system at any time.

Full input to output, input to case, output to case, and output to output isolation is provided. The converters are designed and built according to the international safety standard IEC/EN 60950-1 and UL/CSA 60950-1.

The case design allows operation at nominal load up to 71 °C in a free-air ambient temperature. If forced cooling is provided, the ambient temperature may exceed 71 °C but the case temperature should remain below 95 °C under all conditions.

A temperature sensor generates an inhibit signal, which disables the outputs, when the case temperature $T_{\rm C}$ exceeds the limit. The outputs automatically recover, when the temperature drops below the limit.

Various options are available to adapt the converters to individual applications.

The converters may either be plugged into a 19" rack system according to IEC 60927-3 or be mounted onto a chassis or a plate.

Table of Contents	Page		Page
Description	1	Electromagnetic Compatibility (EMC)	14
		Immunity to Environmental Conditions	
Functional Description	5	Mechanical Data	17
Electrical Input Data	6	Safety and Installation Instructions	18
Electrical Output Data	8	Description of Options	20
Auxiliary Functions	11	Accessories	26



Model Selection

Non-standard input/output configurations or special custom adaptions are available on request. Table 1 provides an overview of the basic input and output configurations. More than 1000 different types have been manufactured with different input/output configurations and customized specialities. Please consult Power-One for additional information!

Table 1a: Standard models AM, BM, FM

Out	put 1	Outp	ut 2	Out	out 3	Operating input voltage range and efficiency									
V _{o nom} [VDC]	I _{o nom}	V _{o nom} [VDC]	I _{o nom}	V _{nom} [VDC]	I _{o nom}	V _{i min} – V _{i max} 8 – 35 VDC	η _{min} 1 [%]	V _{i min} – V _{i max} 14 – 70 VDC	η _{min} 1 [%]	V _{i min} – V _{i max} 20 – 100 VDC	η _{min} 1 [%]				
5.1	8.0	-	-	-	-	AM1001-9R	72	BM1001-9R	74	FM1001-9R	74	-7, P,			
12	4.0	-	-	-	-	AM1301-9R	79	BM1301-9R	80	FM1301-9R	80	D0 – D9,			
15	3.4	-	-	-	-	AM1501-9R	79	BM1501-9R	81	FM1501-9R	81	$V0 - V3^3$			
24	2.0	-	-	-	-	AM1601-9R	81	BM1601-9R	83	FM1601-9R	82	F, A, K, H,			
48	1.0	-	-	-	-	AM1901-9R	81	BM1901-9R	83	FM1901-9R	83	G			
5.1	4.0	5.0	4.0	-	-	-	-	BM2001-9	-	-	-	-7, P,			
5.1	4.0	24	1.0	-	-	-	-	BM2060-9	-	-	-	D0 – D9			
12	2.0	12	2.0	-	-	AM2320-9	77	BM2320-9	79	FM2320-9	80	A, <i>K,</i> H,			
15	1.7	15	1.7	-	-	AM2540-9	78	BM2540-9	80	FM2540-9	79	G			
24	1.0	24	1.0	-	-	-	-	BM2660-9	-						
5.1	5.0	12	0.7	12	0.7	AM3020-9	75	BM3020-9	76	FM3020-9	76	-7, P,			
5.1	5.0	15	0.6	15	0.6	AM3040-9	75	BM3040-9	76	FM3040-9	76	D0 - D9			
5.1	5.0	24	0.35	24	0.35	-	-	BM3060-9	-	-	-	<i>K</i> , H, G			

Table 1b: Standard models CM, DM, LM

Outp	ut 1	Outpu	ıt 2	Outp	ut 3	Operatii	ng inpu	t voltage range ar	nd effic	iency		Options
V _{o nom} [VDC]	I _{o nom}	V _{o nom} [VDC]	I _{o nom}	V _{nom} [VDC]	I _{o nom}	V _{i min} – V _{i max} 28 – 140 VDC	η _{min} 1 [%]	V _{i min} – V _{i max} 44 – 220 VDC	η _{min} 1 [%]	V _{i min} - V _{i max} 88 - 372 VDC 85 - 264 VAC ²	η _{min} 1 [%]	
5.1	8.0	-	-	-	-	CM1001-9R	74	DM1001-9R	74	LM1001-9R	73	-7, E ⁴, P
12	4.0	-	-	-	-	CM1301-9R	80	DM1301-9R	81	LM1301-9R	79	D0 - D9
15	3.4	-	-	-	-	CM1501-9R	82	DM1501-9R	82	LM1501-9R	78	$V0 - V3^{3}$
24	2.0	-	-	-	-	CM1601-9R	82	DM1601-9R	83	LM1601-9R	81	A, <i>K,</i> H,
48	1.0	-	-	-	-	CM1901-9R	82	DM1901-9R	83	LM1901-9R	81	G
5.1	4.0	5.0	4.0	-	-	CM2001-9	-	DM2001-9		LM2001-9	-	<i>-7,</i> E ⁴, P
5.1	4.0	24	1.0	-	-	CM2060-9	-	DM2060-9		LM2060-9	-	D0 – D9
12	2.0	12	2.0	-	-	CM2320-9	79	DM2320-9	80	LM2320-9	77	A, <i>K,</i> H,
15	1.7	15	1.7	-	-	CM2540-9	80	DM2540-9	80	LM2540-9	78	G
24	1.0	24	1.0	-	-	CM2660-9	-	DM2660-9		LM2660-9		
5.1	5.0	12	0.7	12	0.7	CM3020-9	76	DM3020-9	77	LM3020-9	73	-7, E ⁴ , P
5.1	5.0	15	0.6	15	0.6	CM3040-9	76	DM3040-9	76	LM3040-9	71	D0 - D9
5.1	5.0	24	0.35	24	0.35	CM3060-9	76	DM3060-9	76	LM3060-9	-	A, <i>K,</i> H, G

- Min. efficiency at $V_{\rm i\,nom}$ and $I_{\rm o\,nom}$. Typ. values are approx. 2% better. Operating frequency range: 47 440 Hz; see *Safety and Installation Instructions* for >60 Hz!
- Option V0, V2, V3 available only for output 1 = 5.1 V (excludes option R)
- ⁴ Option E only available for CM and LM models (not for DM)

NFND: Not for new designs. Preferred for new designs



Table 1c: EM and battery charger models

	Output 1		Outp	out 2	Outp	ut 3	Operating inpu	t voltaç	ge range and effic	ciency	Options
V _{o Bat} ³ I _{o nom} [VDC] [A]	V _{o safe} ⁴ [VDC]	V _{o max} [VDC]	V _{o nom} [VDC]	I _{o nom} [A]	V _{o nom} [VDC]	I _{o nom} [A]	V _{i min} – V _{i max} 67 – 385 VDC	η _{min} 1 [%]	V _{i min} - V _{i max} 88 - 372 VDC 85 - 264 VAC ²	η _{min} 1 [%]	
Same V _{o nom}	-	-	-	-	-	-	EM1xxx-9R	-	-	-	-7, E, D, A
and I _{o nom} as	-	-	same as D	M models	-	-	EM2xxx-9R	-	-	-	G
DM models	-	-	same as D	M models	same as D	M models	EM3xxx-9R	-	-	-	
12 3.6	12.84	14.15 – 14.6	_	_	_	-	-	-	LM1781-9RD5	79	-7, E, A
24 1.8	25.68	28.3 – 29.15	-	-	_	-	-	-	LM1782-9RD5	81	G
36 1.2	38.52	42.45 – 43.72	-	-	_	-	-	-	LM1783-9RD5	82	
48 0.9	51.36	56.6 - 58.3	_	-	_	-	-	-	LM1784-9RD5	81	
60 0.72	64.2	70.75 – 72.87	-	-	_	-	-	-	LM1785-9RD5	81	

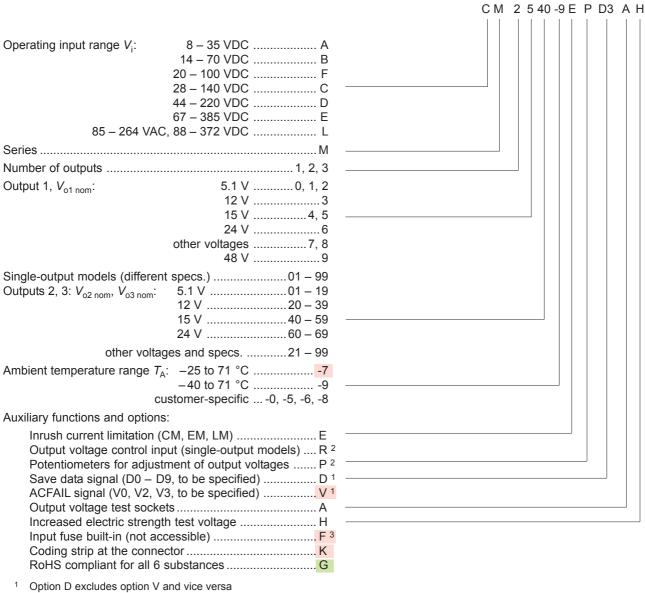
V_{o nom} for EM models
 Setting voltage with open R-input (battery chargers)

NFND: Not for new designs.	Preferred for new designs
THE FIRST TOOL TOO MOONINGTON	i referred for from deergrie

Min. efficiency at $V_{\rm i\,nom}$ and $I_{\rm o\,nom}$. Typ. values are approx. 2% better. Operating frequency range: 47 – 440 Hz; see *Safety and Installation Instructions* for >60 Hz



Part Number Description



- Feature R excludes option P and vice versa
- Only for FM1000

Note: The sequence of options must follow the order above.

NFND: Not for new designs

Preferred for new designs.

Example: CM2540-9EPD3AH:

DC-DC converter, operating input voltage range 28 – 140 VDC, providing output 1 with 15 V/1.7 A and output 2 with 15 V /1.7 A; temperature range -40 to +71 °C, inrush current limitation, equipped with potentiometers, undervoltage monitor D3, test sockets, and tested with higher voltage output to case.

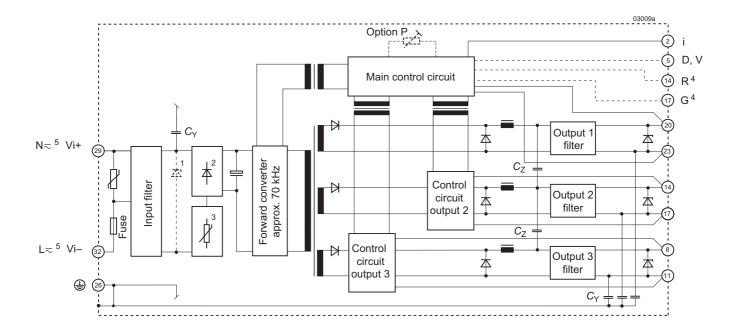


Functional Description

The input voltage is fed via an input fuse, an input filter, a bridge rectifier, and an inrush current limiter to the input capacitor. This capacitor sources a single-transistor forward converter. Each output is powered by a separate secondary winding of the main transformer. The resultant voltages are rectified and their ripple smoothed by a power choke and an output filter. The main control circuit senses the main output voltage $V_{\rm ol}$ and generates, with respect to the maximum

admissible output currents, the control signal for the primary switching transistor. This signal is transferred to the primary side by a coupling transformer.

The auxiliary output voltages $V_{\rm o2}$ and $V_{\rm o3}$ are individually regulated by means of secondary switching transistors. Each auxiliary output's current is sensed using a current transformer. If one of the outputs is driven into current limit, the other outputs will reduce their output voltages as well, because all output currents are controlled by the same main control circuit.



- 1 Transient suppressor diode in AM, BM, CM, FM models.
- ² Bridge rectifier in LM, series diode in EM models.
- 3 Inrush current limiter (NTC) in CM, DM, EM, LM models (option E: refer to the description of option E).
- ⁴ Single-output models with feature R.
- 5 LM-models

Fig. 1
Block diagram, triple-output models



Electrical Input Data

General conditions:

- $-T_A$ = 25 °C, unless T_C is specified.
- Connector pins 2 and 23 interconnected, R input not connected; with option P: $V_0 = V_{0 \text{ nom}}$

Table 2a: Input data

Input				AM			вм			FM			CM		Unit
Chara	cteristics	Conditions	min	typ	max	min	typ	max	min	typ	max	min	typ	max	
V _i	Operating input voltage	$I_0 = 0 - I_{0 \text{ nom}}$	8		35	14		70	20		100	28		154 ⁷	VDC
V _{i nom}	Nominal input voltage	$T_{\text{C min}} - T_{\text{C max}}$		15			30			50			60		
<i>I</i> _i	Input current	V _{i nom} , I _{o nom} ²		4.0			2.0			1.2			1.0		Α
P _{i 0}	No-load input power: - single-output models - double-output models - triple-output models	$V_{\text{i nom}}$ $I_{\text{o1,2,3}} = 0$		1 7 6	1.5 9 9		1 7 6	1.5 9 9		1 7 6	1.5 9 9		1 7 6	1.5 9 9	W
P _{i inh}	Idle input power	inhibited, $V_{\rm inom}$		1	1.5		1	1.5		1	1.5		1	1.5	
I _{inr p} 6	Peak inrush current	$V_i = V_{i \max}$			400			500			400			170 4	Α
t _{inr r}	Rise time	$R_{\rm S} = 0 \ \Omega^{3}$ $T_{\rm C} = 25 \ ^{\circ}{\rm C}$		60			50			40			60		μs
t _{inr h}	Time to half-value	76 - 25 0		170			100			60			280		•
Ri	Input resistance	T _C = 25 °C	87.5			140			250			824 ⁴			mΩ
Ci	Input capacitance		2600		4000	670		1100	370		600	370		600	μF
V _{i abs}	Input voltage limits without any damage		0		40	0		80	0		120	0		160	VDC

Table 2b: Input data

Input				DM			EM			LM		Unit
Chara	cteristics	Conditions	min	typ	max	min	typ	max	min	typ	max	
V _i	Operating input voltage	$I_{\rm o} = 0 - I_{\rm o nom}$		-			-		85		264	VAC ¹
		$T_{\text{C min}} - T_{\text{C max}}$	44		220	67		385	88		372	VDC
V _{i nom}	Nominal input voltage			110			220			310		
I _i	Input current	V _{i nom} , I _{o nom} ²		0.55			0.275			0.20		Α
P _{i0}	No-load input power: - single-output models - double-output models - triple-output models	$V_{\text{i nom}}$ $I_{\text{o1,2,3}} = 0$		1 7 6	1.5 9 9		1 7 6	1.5 9 9		1 7 6	1.5 9 9	W
P _{i inh}	Idle input power	inhibited, V _{i nom}		1	1.5		1	1.5		1	1.5	
I _{inr p} 6	Peak inrush current	$V_i = V_{i \text{ max}}$			1104			160 4			60 4	Α
t _{inr r}	Rise time	$R_{\rm S} = 0 \ \Omega^{3}$ $T_{\rm C} = 25 \ ^{\circ}{\rm C}$		40			40			300		μs
t _{inr h}	Time to half-value	7 _C = 23 C		250			240			900		
R _i	Input resistance	T _C = 25 °C	2000 4			2400 ⁴			6200 ⁴			mΩ
C _i	Input capacitance		140		270	140		270	140		270	μF
V _{i abs}	Input voltage limits		0		400 5	-400		400	-400		400	VDC
	without any damage		_		_	_		_	0		284	VAC

- 1 In AC powered mode (LM models): Nominal input voltage range: 100-240 VAC, operating input frequency range: 47-440 Hz
- With multiple-output models, the same condition for each output applies.
- 3 $R_{\rm S}$ = source resistance.
- ⁴ Value for initial switch-on cycle.
- ⁵ 1 s max., duty cycle 1% max.
- ⁶ $I_{inr p} = V_i/(R_s + R_i)$; see Inrush Current.
- ⁷ 140 V continuously. CM models with version V106 or greater (or with suffix /131) withstand 154 V for 2 s.



Input Fuse

A fuse holder containing a slow-blow type fuse (size: 5×20 mm) is mounted in the back plate of the converter. The fuse protects the converter against severe defects. It may not fully protect it at input voltages exceeding 200 VDC. In applications, where the converters operate at DC source voltages above 200 VDC, an external fuse or a circuit breaker at system level should be installed.

The fuse and a VDR form together with the input filter an effective protection against high input transients.

Note: For applications, where the fuse should not be accessible; see $Option\ F$.

Table 3: Fuse types (slow-blow)

Series	Schurter type	Part number
AM1000 – 3000	SPT 10 A /250 V	0001.2514
BM1000 - 3000	SPT 8 A /250 V	0001.2513
FM1000 – 3000	SPT 5 A /250 V	0001.2511
CM1000 - 3000	SPT 3.15 A /250 V	0001.2509
DM1000 - 3000 EM1000 - 3000 LM1000 - 3000	SPT 2.5 A /250 V	0001.2508

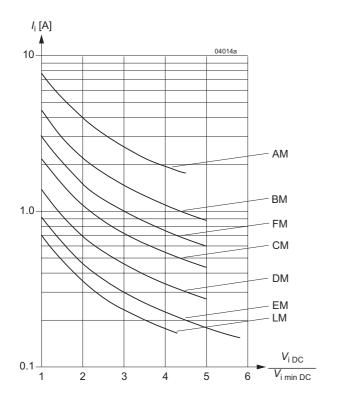


Fig. 2
Typical input current versus relative input voltage at nominal output load

Input Under-/Overvoltage Lockout

If the input voltage remains below $0.8~V_{i\,min}$ or exceeds approx. 1.1 $V_{i\,max}$, an internally generated inhibit signal disables the output(s). When checking this function the absolute maximum input voltage rating $V_{i\,abs}$ must be carefully considered (see table *Input data*).

Note: When V_i is between $V_{i \min}$ and the undervoltage lockout level, the output voltage may be below the value defined in table *Output data*.

Reverse Polarity

Reverse polarity at the input of AM, BM, CM, DM, and FM models will cause the fuse to blow. In EM and LM models a series diode will protect the converter. A series diode is not incorporated in AM, BM, CM, DM and FM types to avoid unwanted power losses.

Inrush Current

The CM, DM, EM, and LM (excluding FM) models incorporate an NTC resistor in the input line, which (during the initial switch-on cycle) limits the peak inrush current in order to prevent the connectors and external switching devices from damage. Subsequent switch-on cycles within a short interval will cause an increase of the peak inrush current due to the warming-up of the NTC resistor. Refer to *Option E* (only availabel for CM, EM, and LM.

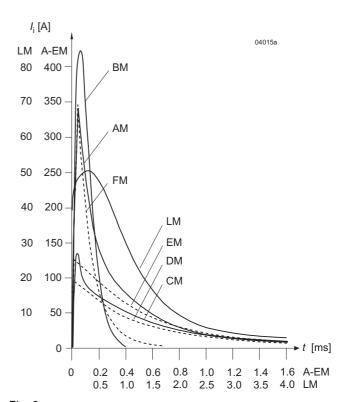


Fig. 3 Typical inrush current at initial switch-on. $V_{i\,max}$ (DC) and nominal output load



Electrical Output Data

General conditions

- $-T_A$ = 25°C, unless T_C is specified.
- Connector pins 2 and 23 interconnected, R input not connected; with option P: $V_0 = V_{0 \text{ nom}}$

Table 4: Output data

Outpu	it		V _{o nom}		5.1 V	,		12 V		15 V	,		24 V	/		48 V		Unit
Chara	cteristics		Conditions	min	typ	max	min	typ	max	min typ	max	min	typ	max	min	typ	max	
V _o	Output vol	tage	V _{i nom} , I _{o nom} 1	5.07		5.13	11.93		12.07	14.91	15.09	23.86		24.14	47.72	4	48.28	V
V _{op}	Output over	0			7.5			21		25			41			85		
I _{o nom}	Output cui	rrent	V _{i min} – V _{i max}					se	e tabl	e 1 <i>Model</i>	Select	ion						
I _{o L}	Output cur limitation	rrent	$T_{\text{C min}} - T_{\text{C max}}$	see fig. 4 Typical voltage V ₀₁ versus output currents I ₀														
V _o		Switch. freq.	V _{i nom} , I _{o nom} 1		15	30		25	50	35	70		40	80		50	100	mV _{pp}
	voltage noise	Total	IEC/EN 61204 BW = 20 MHz		60	120		40	80	40	80		40	80		-		
ΔV_{oV}	Static line	regulation	$V_{i \min} - V_{i \text{ nom}}$ $V_{i \text{ nom}} - V_{i \max}$ $I_{o \text{ nom}}$ 1		±10	±30		±12	±50	±15	±60		±15	±60		±15	±60	mV
ΔV_{ol}	Static load	regulation	$V_{\text{i nom}}$ $I_{\text{o nom}} - 0^2$		6	25		13	50	17	60		30	80		60	150	
$\Delta V_{\text{o Ic}}$	Static cros regulation		V _{i nom} I _{o nom} - 0 ³		0	±15		0	±20	0	±30		0	±40		-		
V _{o d}	Dynamic load	Voltage deviation	$V_{\text{i nom}}$ $I_{\text{o nom}} \leftrightarrow {}^{1}/{}_{3} I_{\text{o nom}} {}^{2}$		±220			±110		±150)	:	±130)	:	±150		
t_{d}	regulation	Recovery time	IEC/EN 61204		0.6			0.6		0.5			1			2		ms
V _{odc}	Dynamic cross load	Voltage deviation	$V_{\text{i nom}}$ $I_{\text{o nom}} \leftrightarrow {}^{1}/_{3} I_{\text{o nom}} {}^{3}$		+10 –100			+10 -75		+10 –140			+20 -200			-		mV
t _{d c}	regulation ⁴	Recovery	IEC/EN 61204		0.05 0.5			0.2		0.5 0.7			1			-		ms
α_{Vo}	Temperatu		V _{i min} – V _{i max}	:	±0.02	2	:	±0.02	<u> </u>	±0.02	2	4	0.0	2	=	±0.02	2	%/K
	coefficient $\Delta V_{\rm o}/\Delta T_{\rm C}$		$0-I_{\text{o nom}}$		±1.0			±2.4		±3.0			±4.8	3		±9.6		mV/K

¹ With multiple-output models, all outputs are loaded with the nominal current.

² Condition for specified output. With multiple-output models, other output(s) loaded with constant current I_{o nom}. See fig. 5 Dynamic load regulation.

³ Condition for non-specified output, individually tested, other output(s) loaded with constant current I_{o nom}. See fig. 5 Dynamic load regulation.

Multiple-output models.

⁵ By suppressor diode.



Output Characteristic and Protection

Each output is protected by a suppressor diode, which under worst case conditions may become a short circuit. The suppressor diodes are not designed to withstand externally applied overvoltages. Overload at any of the outputs will cause a shutdown of all outputs. A red LED indicates the overload condition of the respective output.

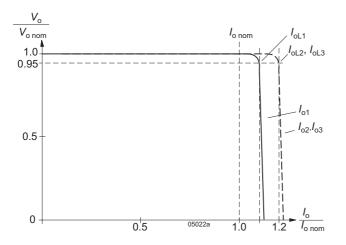


Fig. 4 Typical voltage V_0 versus output currents I_0 .

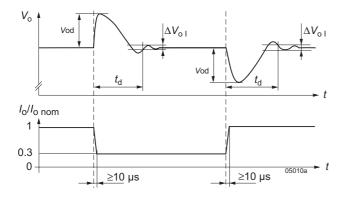


Fig. 5 Dynamic load regulation V_{od} versus load change.

Thermal Considerations and Protection

If a converter is located in free, quasi-stationary air (convection cooling) at the indicated maximum ambient temperature $T_{\rm A\,max}$ (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 $T_{\rm C}$ (see *Mechanical Data*) will approach the indicated value $T_{\rm C\,max}$ after the warm-up phase. However, the relationship between $T_{\rm A}$ and $T_{\rm C}$ 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. $T_{\text{A max}}$ is therefore, contrary to $T_{\text{C max}}$, an indicative value only.

Caution: The installer must ensure that under all operating conditions $T_{\mathbb{C}}$ remains within the limits stated in the table *Temperature specifications*.

Notes: Sufficient forced cooling or an additional heat sink allow $T_{\rm A}$ to pass over 71 °C, if $T_{\rm C~max}$ is not exceeded.

For -7 or -9 models at an ambient temperature T_A of 85 °C with only convection cooling, the maximum permissible current for each output is approx. 50% of its nominal value; see figure 6.

A temperature sensor generates an internal inhibit signal disabling the outputs, when the case temperature exceeds $T_{\rm C\ max}$. The outputs automatically recover, when the temperature drops below this limit.

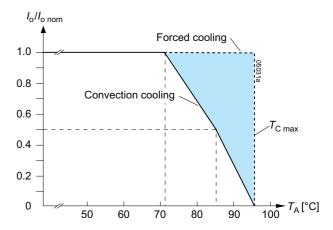


Fig. 6
Output current derating versus temperature

Parallel and Series Connection

Main outputs of equal nominal voltage can be connected in parallel. It is important to assure that the main output of a multiple-output converter is forced to supply a minimum current of 0.1 A to enable correct operation of its own auxiliary outputs.

In parallel operation, one or more of the main outputs may operate continuously in current limitation, causing an increase of the case temperature $T_{\rm C}$. Consequently, a reduction of the max. ambient temperature by 10 K is recommended.

Main or auxiliary outputs can be connected in series with any other output of the same or another converter. In series connection, the maximum output current is limited by the lowest current limit. Output ripple and regulation values are added. Connection wiring should be kept as short as possible.

If output terminals are connected together in order to establish multi-voltage configurations, e.g., +5.1 V, ±12 V etc., the common-ground connecting point should be as close as possible to the connectors of the converter in order to avoid excessive output ripple voltages.

Note: Auxiliary outputs should never be connected in parallel!



Output Current Allocation for Special Models

Output currents differing from those given for standard models (see *Model Selection*) can be provided on request. A maximum output power of 50 W should be considered, if an ambient temperature range of -40 to 71 °C is required. The maximum permissible output currents are indicated in the table below. If

the output voltages are different from standard values, the relevant output currents have to be adapted accordingly.

With reduced maximum ambient temperature or with forced cooling, the total output power may exceed 50 W. Customized configurations always need to be checked by a feasibility study first. Please ask Power-One for more information.

Table 5: Current allocation with special models

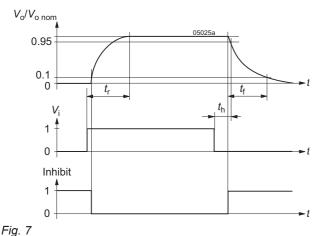
(Output voltage all types	Output 1 all types	Output 2 AM – LM2000	Output 2 AM – LM3000	Output 3 AM – LM3000	Tempo	erature
	V _{o1/2/3 nom} [V]	I _{o1 max} [A]	I _{o2 max} [A]	I _{o2 max} [A]	I _{o3 max} [A]	T _A [°C]	<i>T</i> _C [°C]
	5.1	8.0	4.0	1.8 (2.5 ¹)	1.5	-40 to 71	-25 to 95
	12	4.0	2.0	1.5	1.2		
	15	3.4	1.7	1.2	1.0		
	24	2.0	1.0	0.7	0.5		
2	5.1	10.0	4.5	2.1 (2.8 ¹)	1.8	-25 to 60	-25 to 90
	12	5.0	2.5	1.7	1.5		
	15	4.0	2.0	1.5	1.3		
	24	2.5	1.3	0.9	0.7		
	5.1	11.0	5.0	2.4 (3.0 ¹)	2.0	-25 to 50	-25 to 85
	12	6.0	3.0	2.0	1.7		
	15	4.6	2.3	1.7	1.5		
	24	3.0	1.5	1.0	0.8		

Special high-current components required. ² V_{i min} has to be increased.

Hold-up Time and Output Response

When the input voltage is switched off, the output voltage will remain high for a certain hold-up time $t_{\rm h}$ (see fig. 7) before the output voltage falls below 0.95 $V_{\rm o\ nom}$. To achieve the hold-up times indicated in fig. 8, AM, BM, CM, DM, and FM models require an external series diode in the input line. This is necessary to prevent the discharge of the input capacitor through the source impedance or other circuits connected to the same source. EM and LM models have a built-in series diode. In AM, BM, CM, DM, and FM models, no series diode is built-in, since it would generate additional power losses inside the converter.

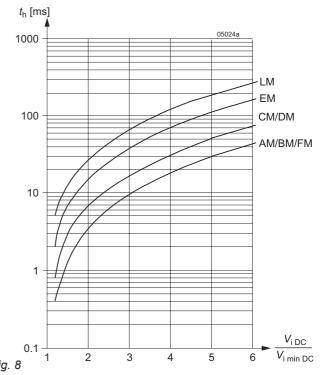
Note: For hold-up time with option V, refer to Option V.



Output response times versus V_i or inhibit control

The behavior of the outputs is similar with either the input voltage applied or the inhibit switched low.

No output voltage overshoot occurs, when the converter is turned on or off.



Typical hold-up time t_h versus input voltage at I_{o nom}



Table 6: Output response time t_r and t_f (see fig. 7). Values not applicable for models equipped with option E.

Type of converter	$t_{\rm r}$ at $P_{\rm o}$ = 0 and	$t_{\rm r}$ at $P_{\rm o}$ = 0 and $t_{\rm f}$ at $P_{\rm o}$ = $P_{\rm o nom}$		$P_0 = \frac{3}{4} P_{\text{o nom}}$	t _r at P _o	= P o nom	Unit
	typ	max	typ	max	typ	max	
AM – LM1001-9R	5	10	5	10	10	20	ms
AM – LM1301-9R	10	20	15	30	20	40	
AM – LM1501-9R	5	10	10	20	30	60	
AM – LM1601-9R	15	30	25	50	40	80	
AM – LM1901-9R	65	130	100	200	165	330	
AM – LM2320-9	20	40	30	60	50	100	
AM – LM2540-9	15	30	20	40	35	70	
AM – LM3020-9	55	110	85	170	145	290	
AM – LM3040-9	40	80	60	120	100	200	

Conditions:

R input not connected. For multiple-output models the figures indicated in the table relate to the output, which reacts slowest. All outputs are resistively loaded. Variation of the input voltage within $V_{i \text{ min}} - V_{i \text{ max}}$ does not influence the values considerably.

Auxiliary Functions

Inhibit

The outputs of the converters may be enabled or disabled by means of a logic signal (TTL, CMOS, etc.) applied between the inhibit input i and the negative pin of output 1 (Vo1–). In systems with several converters, this feature can be used, for example, to control the activation sequence of the converters. If the inhibit function is not required, connect the inhibit pin 2 to pin 23 to enable the outputs (active low logic, fail safe). The response times are specified in table 6.

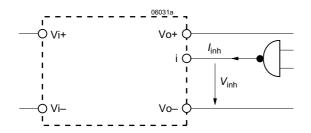


Fig. 9
Definition of V_{inh} and I_{inh}.

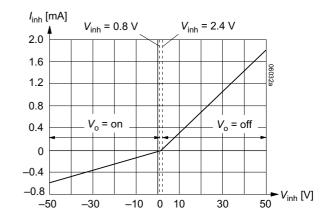


Fig. 10 Typical inhibit current I_{inh} versus inhibit voltage V_{inh}

Table 7: Inhibit data

Chara	acteristics		Conditions	min	typ	max	Unit
V_{inh}	Inhibit input voltage to keep	V_0 = on	V _{i min} – V _{i max}	-50		0.8	V
	output voltage	V _o = off	$T_{\text{C min}} - T_{\text{C max}}$	2.4		50	
/ _{inh}	Inhibit current		V _{inh} = 0	-60	-100	-220	μA



R-Control for Output Voltage Adjustment

As a standard feature, single-output models without option P offer an adjustable output voltage identified by letter R in the type designation.

Note: With open R input, $V_0 = V_{0 \text{ nom}}$.

The output voltage V_0 can either be adjusted by an external voltage $(V_{\rm ext})$ or by an external resistor $(R_{\rm ext1})$ or $R_{\rm ext2}$. The adjustment range is approximative 0-110% of $V_{\rm o\,nom}$. For output voltages $V_0 > V_{\rm o\,nom}$, the minimum input voltage $V_{\rm i\,min}$ specified in *Electrical Input Data* increases proportionally to $V_0/V_{\rm o\,nom}$.

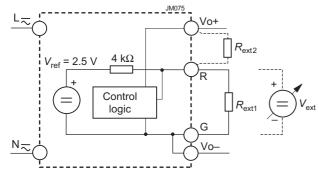


Fig. 11
Output voltage adjustment

a) Adjustment by means of an external resistor R_{ext} . Depending upon the value of the required output voltage, the resistor shall be connected:

either: Between the R and G pin to achieve an output voltage adjustment range of $V_0 \approx 0$ to 100 % of $V_{0 \text{ nom}}$.

$$R_{\text{ext1}} \approx 4 \text{ k}\Omega \cdot \frac{V_{\text{o}}}{V_{\text{o nom}} - V_{\text{o}}}$$

or: Between the R pin and Vo+ to achieve an output voltage range of $V_0 \approx 100$ to 110% of $V_{0 \text{ nom}}$.

$$R_{\text{ext2}} \approx 4 \text{ k}\Omega \cdot \frac{(V_0 - 2.5 \text{ V})}{2.5 \text{ V} \cdot (V_0 / V_{0 \text{ nom}} - 1)}$$

Caution: To prevent damage, R_{ext2} should never be less than 47 k Ω .

Note: R inputs of n converters with paralleled outputs may be paralleled too, but if only one external resistor is used, its value should be $R_{\rm ext1}/n$ or $R_{\rm ext2}/n$ respectively.

b) Adjustment by means of an external control voltage $V_{\rm ext}$ between G and R pin.

The control voltage range is 0 to 2.75 V and allows for adjustment in the range of $V_0 \approx 0$ to 110% of $V_{0 \text{ nom}}$.

$$V_{\text{ext}} \approx \frac{V_{\text{o}} \cdot 2.5 \text{ V}}{V_{\text{o,nom}}}$$

Caution: The external control voltage should be in the range 0 to +3 V to prevent the converter from damage.

Table 8a: R_{ext1} for $V_0 < V_{\text{o nom}}$ (conditions: $V_{\text{i nom}}$, $I_{\text{o nom}}$, rounded up to resistor values E 96, R_{ext2} is not fitted)

V _{o nom}	= 5.1 V	V _{o nom}	= 12 V	12 V V _{o nom} =		= 15 V		V _{o non}	_n = 48 V
<i>V</i> _o [V]	$R_{\rm ext1}$ [k Ω]	<i>V</i> _o [V]	$R_{\rm ext1}$ [k Ω]	<i>V</i> _o [V]	$R_{\rm ext1}$ [k Ω]	<i>V</i> _o [V]	$R_{\rm ext1}$ [k Ω]	<i>V</i> _o [V]	$R_{\rm ext1}$ [k Ω]
0.5	0.432	2.0	0.806	2.0	0.619	4.0	0.806	8.0	0.806
1.0	0.976	3.0	1.33	4.0	1.47	6.0	1.33	12.0	1.33
1.5	1.65	4.0	2.0	6.0	2.67	8.0	2.0	16.0	2.0
2.0	2.61	5.0	2.87	8.0	4.53	10.0	2.87	20.0	2.87
2.5	3.83	6.0	4.02	9.0	6.04	12.0	4.02	24.0	4.02
3.0	5.76	7.0	5.62	10.0	8.06	14.0	5.62	28.0	5.62
3.5	8.66	8.0	8.06	11.0	11.0	16.0	8.06	32.0	8.06
4.0	14.7	9.0	12.1	12.0	16.2	18.0	12.1	36.0	12.1
4.5	30.1	10.0	20.0	13.0	26.1	20.0	20.0	40.0	20.0
5.0	200.0	11.0	44.2	14.0	56.2	22.0	44.2	44.0	44.2

Table 8b: R_2 for $V_0 > V_{0 \text{ nom}}$ (conditions: $V_{1 \text{ nom}}$, $I_{0 \text{ nom}}$, rounded up to resistor values E 96, $R_{\text{ext}1}$ is not fitted)

V _{o nom}	$V_{\rm o \ nom} = 5.1 \ {\rm V}$		V _{o nom} = 12 V		$V_{\text{o nom}}$ = 15 V		= 24 V	V _{o nom} = 48 V	
<i>V</i> _o [V]	$R_{\rm ext2}$ [k Ω]	<i>V</i> _o [V]	$R_{ m ext2}$ [k Ω]	<i>V</i> _o [V]	$R_{\rm ext2}$ [k Ω]	<i>V</i> _o [V]	$R_{\rm ext2}$ [k Ω]	<i>V</i> _o [V]	$R_{\rm ext2}$ [k Ω]
5.15	464	12.1	1780	15.2	1470	24.25	3160	48.5	6810
5.20	215	12.2	909	15.4	750	24.50	1620	49.0	3480
5.25	147	12.3	619	15.6	511	24.75	1100	49.5	2370
5.30	110	12.4	464	15.8	383	25.00	825	50.0	1780
5.35	90.9	12.5	383	16.0	332	25.25	715	50.5	1470
5.40	78.7	12.6	316	16.2	274	25.50	590	51.0	1270
5.45	68.1	12.7	274	16.4	237	25.75	511	51.5	1100
5.50	61.9	12.8	249	16.5	226	26.00	453	52.0	953
		13.0	200			26.25	402	52.5	845
		13.2	169			26.40	383	52.8	806



Display Status of LEDs

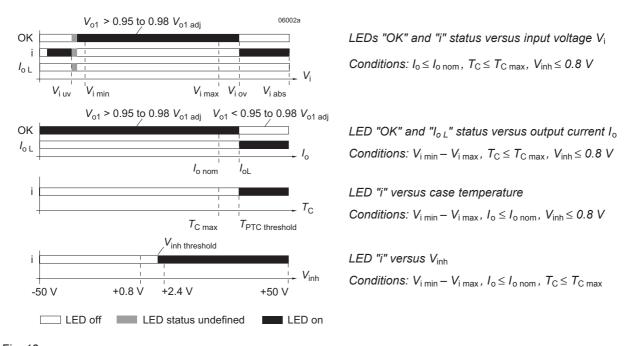


Fig. 12
Status of LEDs. $V_{i \text{ uv}} = \text{undervoltage lockout}, \ V_{i \text{ ov}} = \text{overvoltage lockout}$



Electromagnetic Compatibility (EMC)

A suppressor diode or a metal oxide VDR (depending upon converter model) together with an input fuse and an 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 M Series has been successfully tested to the following specifications:

Electromagnetic Immunity

Table 9: Immunity type tests

Phenomenon	Standard	Level	Coupling mode ¹	Value applied	Waveform	Source imped.	Test procedure	In oper.	Perf. crit. ²
Supply related	RIA 12 ³	A 4	+i/_i	3.5 • V _{batt}	2/20/2 ms	0.2 Ω	1 positive	yes	Α
surges		В		1.5 • V _{batt}	0.1/1/0.1 s		surge		
Direct transients		С	_i/c, +i/_i	960 V _p	10/100 μs	5 Ω	5 pos. and 5 neg.	yes	Α
		D 3		1800 V _p	5/50 µs		impulses		
		Е		3600 V _p	0.5/5 µs	100 Ω			
		F		4800 V _p	0.1/1 µs				
		G		8400 V _p	0.05/0.1 µs				
Indirect coupled		Н	-o/c, +o/-o, -o/-i	1800 V _p	5/50 µs				
transients		J		3600 V _p	0.5/5 µs				
		K		4800 V _p	0.1/1 µs				
		L		8400 V _p	0.05/0.1 µs				A 11
Electrostatic	IEC/EN	4 ⁵	contact discharge	±8000 V _p	1/50 ns	330 Ω	10 positive and	yes	Α
discharge (to case)	61000-4-2		air discharge	±15000 V _p		150 pF	10 negative discharges		
Electromagnetic field	IEC/EN 61000-4-3	x ⁶	antenna	20 V/m	AM 80% 1 kHz	n.a.	80 to 1000 MHz	yes	A 11
Electromagnetic field, pulse modulated	ENV 50204	4 7		30 V/m	50% duty cycle, 200 Hz repetition frequency		900 ±5 MHz	yes	A
Electrical fast	IEC/EN	3 8	capacitive, o/c	±2000 V _p	bursts of 5/50 ns	50 Ω	60 s positive	yes	A 11
transient/burst	61000-4-4	3 8	direct, i/c, +i/-i	±2000 V _p	2.5/5 kHz over 15 ms; burst		60 s negative transients per		A 11
		4		±4000 V _p	period: 300 ms		coupling mode		В
Surge	IEC/EN	3 9	i/c	4000 V _p	1.2/50 µs	12 Ω	5 pos. and 5 neg.	yes	Α
	61000-4-5	3 9	+i/_i	2000 V _p		2 Ω	surges per	0 1	
Conducted disturbances	IEC/EN 61000-4-6	3 10	i, o, signal wires	10 VAC (140 dBμV)	AM 80% 1 kHz	150 Ω	0.15 to 80 MHz	yes	Α

- i = input, o = output, c = case
- ² A = normal operation, no deviation from specs.; B = normal operation, temporary loss of function or deviation from specs possible
- ³ RIA 12 covers or exceeds IEC 60571-1 and EN 50155:1995. Surge D corresponds to EN 50155:2001, waveform A; surge G corresponds to EN 50155:2001, waveform B.
- Only met with EM (110 V battery) and extended input range models (customer-specific) of BM (24 V battery) and CM (48 V battery). Standard DK models (72 V battery) are not damaged, but overvoltage lockout will occur during the surge.
- ⁵ Exceeds EN 50121-3-2:2006 table 9.3 and EN 50121-4:2006 table 1.4.
- ⁶ Corresponds to EN 50121-3-2:2006 table 9.1 and exceeds EN 50121-4:2006 table 1.1. Valid for version V104 or higher.
- Compliance with digital mobile phones.
- 8 Corresponds to EN 50121-3-2:2006 table 7.2 and EN 50121-4:2006 table 2.2.
- 9 Covers or exceeds EN 50121-3-2:2006 table 7.3 and EN 50121-4:2006 table 2.3.
- 10 Corresponds to EN 50121-3-2:2006 table 7.1 and EN 50121-4:2006 table 3.1 (radio frequency common mode).
- ¹¹ Perf. criterion B for triple-ouput models.



Electromagnetic Emissions

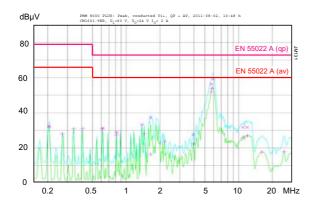


Fig. 13a Typ. conducted disturbances at the input (quasi-peak and average) of CM1601-9ER according to IEC/EN 55011/22, measured at V_i = 60 VDC and $I_{0 \text{ nom}}$.

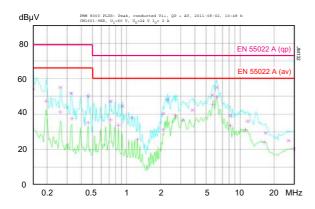


Fig. 13b

Typ. conducted disturbances at the input (quasi-peak and average) of LM1601-9R according to IEC/EN 55011/22, measured at V_i = 230 VAC and $I_{o \text{ nom}}$.

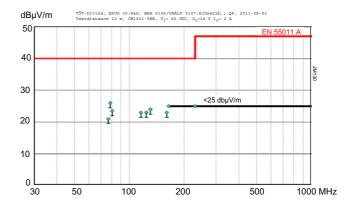


Fig. 14a Typical radiated emissions of CM1601-9ER according to IEC/EN 55011/22, normalized to a distance of 10 m, measured at $V_{\rm i}$ = 60 VDC and $I_{\rm o\,nom}$.

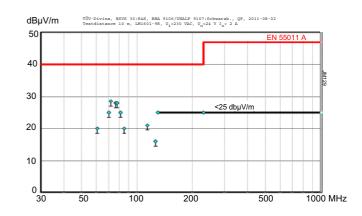


Fig. 14b Typical radiated emissions of LM1601-9R according to IEC/EN 55011/22, normalized to a distance of 10 m, measured at $V_{\rm i}$ = 230 VAC and $I_{\rm o\ nom}$.



Immunity to Environmental Conditions

Table 10: Mechanical and climatic stress

Test r	nethod	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 ±2 °C 93 +2/-3 % 56 days	Converter not operating
Ea	Shock (half-sinusoidal)	IEC/EN 60068-2-27 MIL-STD-810D section 516.3	Acceleration amplitude: Bump duration: Number of bumps:	100 g _n = 981 m/s ² 6 ms 18 (3 each direction)	Converter operating
Eb	Bump (half-sinusoidal)	IEC/EN 60068-2-29 MIL-STD-810D section 516.3	Acceleration amplitude: Bump duration: Number of bumps:	40 g _n = 392 m/s ² 6 ms 6000 (1000 each direction)	Converter 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 each axis)	Converter 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)	Converter operating
Kb	Salt mist, cyclic (sodium chloride NaCl solution)	IEC/EN 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	Converter not operating

Temperatures

Table 11: Temperature specifications, valid for an air pressure of 800 – 1200 hPa (800 – 1200 mbar)

Temperature		-7 (o _l	ption)	-9 (sta	Unit		
Cha	racteristics	Conditions	min	max	min	max	
TA	Ambient temperature	Operational	-25	71	-40	71	°C
T _C	Case temperature		-25	95	-40	95	
Ts	Storage temperature	Non operational	-40	100	-55	100	

Reliability

Table 12: MTBF

Values at specified case temperature	Converter model	Ground benign 40 °C	Ground 40 °C	d fixed 70 °C	Ground mobile 50 °C	Unit
MTBF ¹	AM – LM1000 AM – LM2000 AM – LM3000	320 000 225 000 225 000	130 000 105 000 80 000	40 000 32 000 28 000	35 000 28 000 25 000	h
Device hours ²	AM – LM1000 AM – LM2000 AM – LM3000		880 000 720 000 740 000			

¹ Calculated in accordance with MIL-HDBK-217E

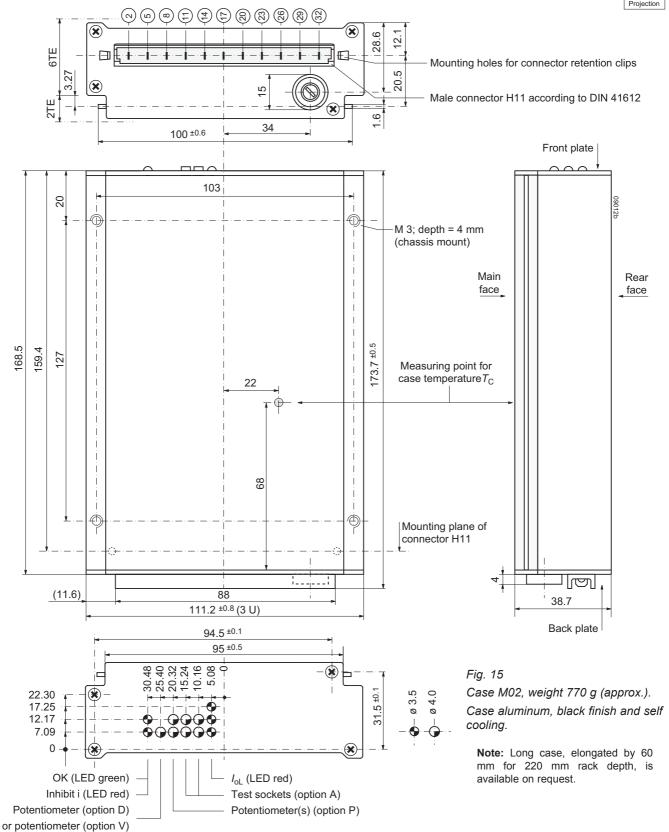
 $^{^{2}}$ Statistical values, based on an average of 4300 working hours per year in general field use over 3 years



Mechanical Data

Dimensions in mm.







Safety and Installation Instructions

Connector Pin Allocation

Pin no. 26 (protective earth) is a leading pin, ensuring that it makes contact with the female connector first.

Table 13: Pin allocation

Electrical determination	AM –	AM – LM1000		LM2000	AM –	LM3000
	Pin	Pin Ident		Ident	Pin	Ident
Inhibit	2	i	2	i	2	i
Safe Data or ACFAIL	5 ⁵	D or V	5 ⁵	D or V	5 ⁵	D or V
Output voltage (positive)	8	Vo+	8	n.c.	8	Vo3+
Output voltage (negative)	11	Vo-	11	n.c.	11	Vo3-
Voltage adjust Adjust return	14 17	R ¹ G ¹				
Output voltage (positive) Output voltage (negative)			14 17	Vo2+ Vo2-	14 17	Vo2+ Vo2-
Output voltage (positive) Output voltage (negative)	20	Vo+	20	Vo1+	20	Vo1+
	23	Vo-	23	Vo1–	23	Vo1–
Protective earthing PE ²	26	\(\bar{\pi} \)	26		26	(
DC input voltage ³ DC input voltage	29	Vi+	29	Vi+	29	Vi+
	32	Vi–	32	Vi–	32	Vi–
AC input voltage ⁴	29	N≂	29	N≂	29	N≂
AC input voltage	32	L≂	32	L≂	32	L≂

- ¹ Not connected if option P is fitted
- ² Leading pin
- 3 AM, BM, CM, DM, EM, and FM models
- 4 LM models
- ⁵ Not connected if option neither option D or V is fitted

Installation Instructions

All M Series converters are components, intended exclusively for inclusion within other equipment 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 H11. Other installation methods may not meet the safety requirements.

The converters are provided with the leading pin 26 ($\textcircled{\blacksquare}$), which is reliably connected with the case. For safety reasons, it is essential to connect pin 26 with the protective earth of the supply system.

An input fuse is connected in the line to pin 32 (Vi– or $L_{\rm T}$). Since this fuse is designed to protect the converter in case of an overcurrent and does not necessarily cover all customer needs, an external fuse suitable for the application and in compliance with the local requirements may be necessary in the wiring to one or both input pins (no. 29 and/or no. 32), particularily if the phase or neutral line cannot be assigned to the corresponding terminals (LM models operated with AC).

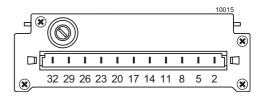


Fig. 16
View of male H11 connector.

Important: Whenever the inhibit function is not in use, pin 2 (i) should be connected to pin 23 (Vo–) to enable the output(s).

Caution: Do not open the converters, or warranty will be invalidated.

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

Cleaning Liquids

In order to avoid possible damage, any penetration of liquids (e.g. cleaning fluids) has to be prevented,

since the power supplies are not hermetically sealed.

Operation of LM Models at Greater than 63 Hz

In such a case, the converters may exceed the leakage current of 3.5 mA imposed in the safety standards. A warning marking is required in the end-use product.

Protection Degree

Condition: Female connector fitted to the converter.

- IP 40: All models, except those with options P or A, and except those with option D/V with potentiometer.
- IP 30: All models fitted with options A or option D/V without potentiometer.
- IP 20: All models fitted with option P or with option D/V with potentiometer.

Railway Applications

The M Series converters have been designed observing the railway standards EN 50155 and EN 50121. All boards are coated with a protection lacquer.

Standards and Approvals

The converters correspond to class I equipment and have been approved according to the standards IEC/EN 60950-1 and UL/CSA 60950-1 2nd Ed.



The converters have been evaluated for:

- · Class I equipment
- · Building in
- Basic insulation between input and case and double or reinforced insulation between input and output, based on the input voltage of 250 VAC or 400 VDC
- · Functional insulation between output(s) and case
- Functional insulation between the outputs
- · Pollution degree 2 environment
- Overvoltage catagory II

Altitude up to 2000 m

The converters are subject to manufacturing surveillance in accordance with the above mentioned standards and with ISO 9001:2000.

Isolation

The electric strength test is performed in the factory as routine test in accordance with EN 50116 and IEC/EN 60950, and should not be repeated in the field. Power-One will not honor any warranty claims resulting from electric strength field tests.

Table 14: Isolation

Characteristic		Input to case and output(s)	Output(s) to case (standard)	Output(s) to case (option H)	Output to output	Unit
Electric	Factory test >1 s	2.8 1	1.4	2.8	0.3	kVDC
strength test	AC test voltage equivalent to factory test	2.0	1.0	2.0	0.2	kVAC
Insulation	resistance at 500 VDC	>300	>300	>300	>100 ²	ΜΩ
Creapage	distances	≥3.2 ³				mm

- According to EN 50116 and IEC/EN 60950, subassemblies connecting input to output are pre-tested with 5.6 kVDC or 4 kVAC.
- ² Tested at 300 VDC
- ³ Input to outputs: ≥6.4 mm

Safety of Operator-Accessible Output Circuits

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

Since the M Series converters provide double or reinforced insulation between input and output based upon a rated primary input voltage of 250 VAC or 400 VDC, only functional insulation is needed between the AC mains and the input of the converter. Only voltage adaption and rectification to the specified input voltage range of a DC/DC converter is needed.

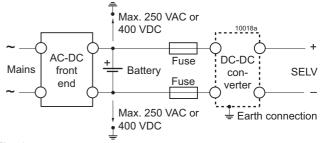


Fig. 17
Schematic safety concept

Table 15: Safety concept leading to an SELV output circuit

Conditions	Front end			DC-DC	converter	Result
Nominal supply voltage	Minimum required grade of insulation, to be pro- vided by the AC-DC front end, including mains supplied battery charger	Maximum rated DC output voltage from the front end	Minimum required safety status of the front end output circuit	Equip- ment	Measures to achieve the specified safety status of the output circuit	Safety status of the DC-DC converter output circuit
Mains 250 VAC	Operational (i.e. there is no need for electrical isolation between the mains supply voltage and theDC-DC converter input voltage)	400 VDC ¹ (The rated voltage between any input pin and earth can be up to 250 VAC or 400 VDC.)	Primary circuit	A – LM	Double or reinforced insulation, based on 250 VAC and 400 VDC (provided by the DC-DC converter) and earthed case ²	SELV circuit

¹ The front end output voltage should match the specified operating input voltage range of the DC-DC converter.

The following table shows a possible installation configuration, 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 48 V. However, it is the sole responsibility of the installer to assure the compliance with the relevant and applicable safety regulations.

The earth connection has to be provided by the installer according to the safety standard IEC/EN 60950.



Description of Options

Table 16: Survey of options

Option	Function of option	Characteristic
-7	Former standard operational ambient temperature range	$T_{\rm A} = -25 \text{ to } 71^{\circ}{\rm C}$
Α	Test sockets at front panel for check of output voltage	V _o internally measured at the connector terminals
Е	Electronic inrush current limitation circuitry	Active inrush current limitation, only for CM, EM, LM models
P1	Potentiometer for fine adjustment of output voltage	Adjustment range ±5% of V _{o nom} , excludes R input
F	Input fuse built-in	Fuse not externally accessible, only for FM1000
Н	Enhanced output to case electric strength test voltage	See table Isolation
D 2	Input and/or output undervoltage monimtoring circuitry	Safe data signal output (D0 – D9)
V ²³	Input and/or output undervoltage monitoring circuitry	ACFAIL signal according to VME specifications (V0, V2, V3)
K	Coding strip at the connector	Ensuring correct population of DIN-racks
G	RoHS	RoHS-compatible for all six substances

- Models equipped with option P do not provide the R function; pins 14 and 17 are not connected.
- ² Option D excludes option V and vice versa.
- Only available if main output voltage V_{o1} = 5.1 V

Table 17: Configuration of option A and option P

Type of option	AM - LM1000	AM – L	.M2000	AM - LM3000			
	Output 1	Output 1	Output 2	Output 1	Output 2	Output 3	
Potentiometer ¹	yes	yes	yes	yes	no	no	
Test sockets	yes	yes	yes	yes	no	no	

Models equipped with option P do not provide the R function; pins 14 and 17 are not connected.

-7 Former Standard Temperature Range

Option -7 stays for the operational ambient temperature range from –25 to 71 °C, which may be preferred by some customers for reasons of documentation or approvals.

A Test Sockets

Test sockets (pin \emptyset = 2 mm, distance d = 5.08 mm) are located at the front of the converter. The output voltage is sensed at the connector pins inside of the converter. Outputs 2 and 3 of triple-output models are not sensed.

P Potentiometer

Built-in multi-turn potentiometers provide an output voltage adjustment range of minimum $\pm 5\%$ of $V_{o\;nom}$ and are accessible through holes in the front cover. Compensation of voltage drop across connector and wiring becomes easily achievable. For output voltages $V_o > V_{o\;nom}$, the minimum input voltage according to *Electrical Input Data* increases proportionally to $V_o/V_{o\;nom}$. Triple-output models allow only the adjustment of V_{o1} .

Note: Potentiometers are not recommended for mobile applications.

E Electronic Inrush Current Limitation

Available for CM, EM and LM models.

The standard version of the models CM, DM, EM and LM include a passive inrush current limitation with an NTC resistor.

For applications requiring an improved inrush current limitation, an active electronic circuit as shown in fig.18 has been developed. Typical inrush current waveforms of units equipped with this option are shown below.

CM models meet the CEPT/ETSI standards for 48 V supply voltage according to ETS 300132-2, if fitted with option E combined with option D6 (input voltage monitoring). Option D6, externally adjustable via potentiometer, is necessary to disable the converter at input voltages below the actual service ranges, avoiding an excessive input current when the input voltage is raised slowly according to ETS 300132-2. Option D6 threshold level $V_{\rm t\,i}$ + $V_{\rm h\,i}$ (refer to description of option D) should be adjusted to 36 – 40.5 V for 48 V nominal supply voltage (for 60 V systems, threshold should be set to 44 – 50 V). The D output (pin 5) should be connected to the inhibit (pin 2). For applications, where potentiometers are not allowed, refer to option D9.

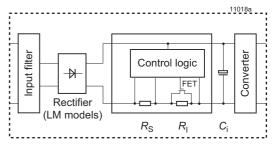


Fig. 18
Option E block diagram



Table 18: Inrush current characteristics with option E

Characteristic		CM at <i>V</i> _i = 110 VDC		EM, LM at <i>V</i> _i = 110 VDC		EM, LM at <i>V</i> _i = 372 VDC		Unit
		typ	max	typ	max	typ	max	
I _{inr p}	Peak inrush current	6.5	8	2.2	4	7.3	10	Α
t _{inr}	Inrush current duration	22	30	10	20	20	40	ms

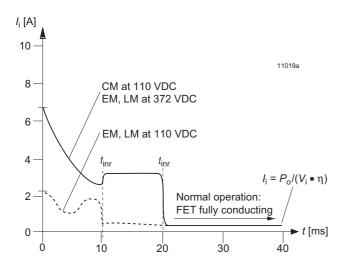


Fig. 19
Typical inrush current waveforms of CM, EM, and LM converters with option E

Precautions:

In order to avoid overload of the series resistor $R_{\rm I}$, the on/off switching cycle should be limited to 12 s, if switched on/off continuously. There should not be more than 10 start-up cycles within 20 s at a case temperature of 25 °C.

If CM models are driven by input voltages below 35 VDC or LM models below 100 VAC, the maximum case temperature should be derated by 10 °C, or the total output power should be derated by 20%. EM and LM models driven

by DC input voltages do not need to be derated within the full specified input voltage range.

F Fuse Not Accessible

Standard M converters have a fuseholder containing a 5×20 mm fuse, which is externally accessible and located in the back plate near to the connector. Some applications require an inaccessible fuse. Option F provides a fuse mounted directly onto the main PCB inside the case (only FM1000).

The full self-protecting functions of the converter do normally not lead to a broken fuse, except as a result of inverse polarity at the input of an AM, BM, CM, or FM models, or if a power component inside fails. In such cases the defective converter must be returned to Power-One for repair.

H Enhanced Electric Strenght Test

Electric strength test output to case; see table Isolation.

D Undervoltage Monitor

The input and/or output undervoltage monitor operates independently of the built-in input undervoltage lock-out circuit. A logic "low" (JFET output) or "high" signal (NPN output) is generated at pin 5, when one of the monitored voltages drops below the preselected threshold level $V_{\rm t}$. The return for this signal is Vo1– (pin 23). The D output recovers, when the monitored voltage(s) exceed(s) $V_{\rm t} + V_{\rm h}$. The threshold level $V_{\rm t}$ is either adjustable by a potentiometer accessible through a hole in the front cover, or adjusted in the factory to a fixed value specified by the customer.

Option D exists in various versions D0 – D9, as shown in table 20.

Table 19: Undervoltage monitor functions

Outpu JFET	it type	Monit V _i	oring V _{o1}	Minimum adjustment range of threshold level V _t		Typical hysteresis V_h [% of V_t] for $V_{t min} - V_{t max}$	
0.2.			- 01	V _{ti}	V _{to}	V _{hi}	V _{ho}
D1	D5	no	yes	_	3.5 V – 48 V ¹	_	2.3 – 1
D2	D6	yes	no	$V_{i \min} - V_{i \max}^{1}$	-	3.0 - 0.5	_
D3	D7	yes	yes	V _{i min} – V _{i max} ¹	0.95 - 0.98 V _{o1} ²	3.0 – 0.5	"0"
D4	D8	no	yes	_	0.95 - 0.98 V _{o1} ²	_	"0"
D0	D9	no	yes	_	3.5 V – 48 V ³	_	1.8 – 1
		yes	no	$V_{i \min} - V_{i \max}^{34}$	_	2.2 – 0.4	_
		yes	yes	$V_{i \min} - V_{i \max}^{34}$	0.95 - 0.98 V ₀₁ ²	2.2 – 0.4	"0"

- ¹ Threshold level adjustable by potentiometer (not recommended for mobile applications)
- ² Fixed value between 95% and 98% of V_{o1} (tracking)
- Fixed value, resistor-adjusted according to customer's specifications ±2% at 25 °C; individual type number is determined by Power-One
- 4 Adjusted at I_{o nom}



JFET output (D0 - D4):

Connector pin D is internally connected via the drain-source path of a JFET (self-conducting type) to the negative potential of output 1. V_D - 0.4 V (logic low) corresponds to a monitored voltage level (V_i and/or V_{o1}) < V_t . The current I_D through the JFET should not exceed 2.5 mA. The JFET is protected by a 0.5 W Zener diode of 8.2 V against external overvoltages.

V _i , V _{o1} status	D output, $V_{\rm D}$		
$V_{\rm i}$ or $V_{\rm o1} < V_{\rm t}$	low, L, $V_D - 0.4 \text{ V}$ at $I_D = 2.5 \text{ mA}$		
$V_{\rm i}$ and $V_{\rm o1} > V_{\rm t} + V_{\rm h}$	high, H, I_D – 25 μ A at V_D = 5.25 V		

NPN output (D5 - D9):

Connector pin D is internally connected via the collectoremitter path of a NPN transistor to the negative potential of output 1. V_D – 0.4 V (logic low) corresponds to a monitored voltage level (V_i and/or V_{o1}) > V_t + V_h . The current I_D through the open collector should not exceed 20 mA. The NPN output is not protected against external overvoltages. V_D should not exceed 40 V.

V _i , V _{o1} status	D output, V _D		
$V_{\rm i}$ or $V_{\rm o1} < V_{\rm t}$	high, H, I_D – 25 μ A at V_D = 40 V		
$V_{\rm i}$ and $V_{\rm o1} > V_{\rm t} + V_{\rm h}$	low, L, $V_D - 0.4 \text{ V}$ at $I_D = 20 \text{ mA}$		

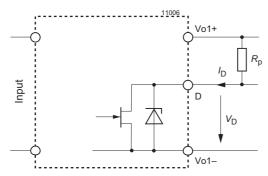


Fig. 20 Options D0 – D4, JFET output

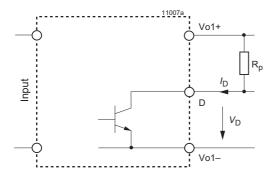


Fig. 21
Options D5 – D9, NPN output

Threshold tolerances and hysteresis:

If V_i is monitored, the internal input voltage after the input filter and rectifier (EM and LM types) is measured. Consequently, this voltage differs from the voltage at the connector pins by the voltage drop ΔV_{ti} across input filter and rectifier. The threshold level of the D0 and D9 options is adjusted in the factory at nominal output current $I_{0 \text{ nom}}$ and T_A = 25 °C. The value of ΔV_{ti} depends upon input voltage range (AM, BM, etc.), threshold level V_t , temperature, and input current.

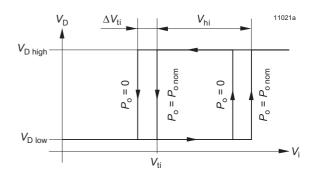
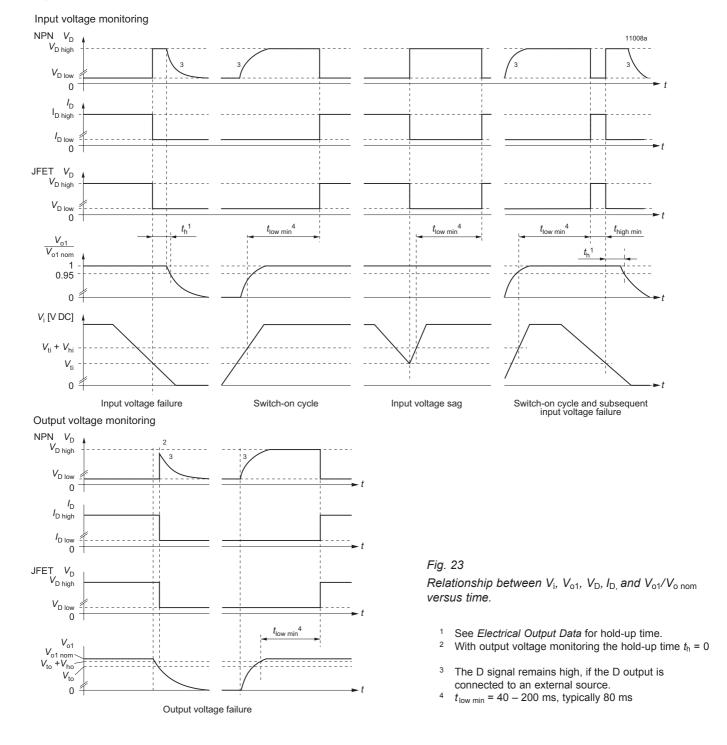


Fig. 22 Definition of V_{ti} , ΔV_{ti} , and V_{hi} (JFET output)





V ACFAIL Signal (VME)

Available for converters with V_{01} = 5.1 V. This option defines an undervoltage monitoring circuit for the input or the input and main output voltage equivalent to option D and generates the ACFAIL signal (V signal), which conforms to the VME standard. The low state level of the ACFAIL signal is specified at a sink current of I_V = 48 mA to V_V – 0.6 V (open-collector

output). The pull-up resistor feeding the open-collector output should be placed on the VME backplane.

After the ACFAIL signal has gone low, the VME standard requires a hold-up time $t_{\rm h}$ of at least 4 ms before the 5.1 V output drops to 4.875 V, when the 5.1 V output is fully loaded. This hold-up time $t_{\rm h}$ is provided by the internal input capacitance. Consequently the working input voltage and the



threshold level $V_{\rm ti}$ should be adequately above the minimum input voltage $V_{\rm i\,min}$ of the converter, so that enough energy is remaining in the input capacitance. If the input voltage is below the required level, an external hold-up capacitor ($C_{\rm i\,ext}$) should be added.

Formula for threshold level for desired value of t_h :

$$V_{\text{ti}} = \sqrt{\frac{2 \cdot P_{\text{o}} \cdot (t_{\text{h}} + 0.3 \text{ ms}) \cdot 100}{C_{\text{i} \text{ min}} \cdot \eta} + V_{\text{i} \text{ min}}^2}$$

Formula for additional external input capacitor

$$C_{i \text{ ext}} = \frac{2 \cdot P_0 \cdot (t_h + 0.3 \text{ ms}) \cdot 100}{\eta \cdot (V_{ti}^2 - V_{i \text{ min}}^2)} - C_{i \text{ min}}$$

whereas:

 $C_{i \, min}$ = minimum internal input capacitance [mF], according to the table below

 $C_{i,ext}$ = external input capacitance [mF]

 P_{o} = output power [W] η = efficiency [%] t_{h} = hold-up time [ms]

 $V_{i \min}$ = minimum input voltage [V]

 V_{ti} = threshold level [V]

Notes: The threshold level $V_{\rm ti}$ of option V2 and V3 is adjusted in the factory to a value according to the table below. A decoupling diode should be connected in series with the input of AM, BM, CM, DM, and FM converters to avoid the input capacitance discharging through other loads connected to the same source voltage. If LM models are powered by AC, an external input capacitor cannot be applied unless an additional rectifier is provided.

Table 20: Available internal input capacitance and factory potentiometer setting of Uti with resulting hold-up time

Types	AM	ВМ	СМ	DM	EM	FM	LM	Unit
C _{i min}	2.6	0.67	0.37	0.14	0.14	0.37	0.14	mF
V _{t i}	9.5	19.5	39	61	104	39	120	VDC
t _h	0.34	0.69	1.92	1.73	6.69	2.92	8.18	ms

Option V operates independently of the built-in input undervoltage lockout circuit. A logic "low" signal is generated at pin 5 as soon as one of the monitored voltages drops below the preselected threshold level $V_{\rm t}$. The return for this signal is Vo1– (pin 23). The V output recovers, when the monitored voltage exceeds $V_{\rm t}$ + $V_{\rm h}$. The threshold level $V_{\rm t}$ is either adjustable by a potentiometer, accessible through a hole in the front cover, or adjusted in the factory to a determined customer-specific value.

Versions V0, V2 and V3 are available as shown below.

Table 21: Undervoltage monitor functions

V output (VME compatible)	Monitoring		Minimum adjustment range of threshold level $V_{\rm t}$		Typical hysteresis U_h [% of V_t] for $V_{t min} - V_{t max}$	
	V _i	V _{o1}	V _{ti}	V_{to}	V _{hi}	V_{ho}
V2	yes	no	$V_{i \min} - V_{i \max}^{1}$	-	3.0 – 0.5	-
V3	yes	yes	V _{i min} – V _{i max} ¹	0.95 – 0.98 V _{o1} ²	3.0 – 0.5	"0"
V0	yes	no	V _{i min} – V _{i max} ^{3 4}	-	2.2 – 0.4	-
	yes	yes	V _{i min} – V _{i max} ^{3 4}	0.95 - 0.98 V _{o1} ²	2.2 – 0.4	"0"

- ¹ Threshold level adjustable by potentiometer (not recommended for mobile applications).
- ² Fixed value between 95% and 98% of V_{o1} (tracking), output undervoltage monitoring is not a requirement of VME standard.
- ³ Adjusted at I_{o nom}.
- ⁴ Fixed value, resistor-adjusted (±2%) acc. to customer's specifications; individual type designation is determined by Power-One.

V output (V0, V2, V3):

Connector pin V is internally connected to the open collector of a NPN transistor. The emitter is connected to the negative potential of output 1. V_V - 0.6 V (logic low) corresponds to a monitored voltage level (V_i and/or V_{o1}) < U_t . The current I_V through the open collector should not exceed 50 mA. The NPN output is not protected against external overvoltages. V_V should not exceed 80 V.

V _i , V _{o1} status	V output, V _V
$V_{\rm i}$ or $V_{\rm o1} < V_{\rm t}$	low, L, V_V - 0.6 V at I_V = 50 mA
$V_{\rm i}$ and $V_{\rm o1} > V_{\rm t} + V_{\rm h}$	high, H, I_V - 25 μ A at V_V = 5.1 V

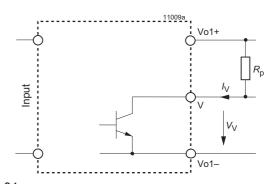
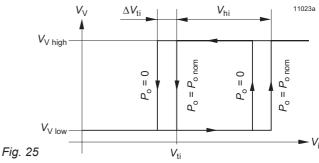


Fig. 24
Output configuration of options V0, V2, V3

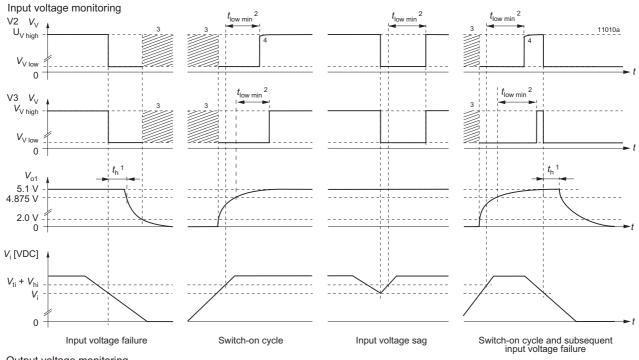


Threshold tolerances and hysteresis:

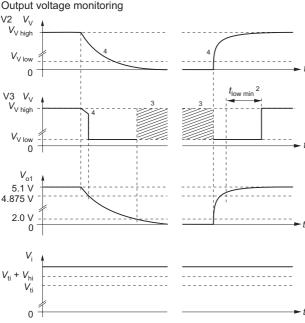
V_i is monitored after the input filter and rectifier (EM and LM models). Consequently, this voltage differs from the voltage at the connector pins by the voltage drop ΔV_{ti} across input filter and rectifier. The threshold level of option V0 is factoryadjusted at $I_{\text{o nom}}$ and T_{A} = 25 °C. $\Delta V_{\text{t i}}$ depends upon the input voltage range (AM, BM, ...), threshold level $V_{t\,i}$, temperature, and input current.



Definition of V_{ti} , ΔV_{ti} and V_{hi}



Output voltage monitoring



Output voltage failure

Fig. 26

Relationship between V_i, V_{o1}, V_V, I_V, and V_{o1}/V_{o nom} versus time.

- VME request: minimum 4 ms
- $t_{\text{low min}}$ = 40 200 ms, typically 80 ms
- $V_{\rm V}$ level not defined at $V_{\rm o1}$ < 2.0 V
- The V signal drops simultaneously with the output voltage, if the pull-up resistor R_P is connected to Vo1+. The V signal remains high, if R_P is connected to an external source.

K Coding Strip

A plastic part across the connector ensures correct population of the DIN-rack.

G RoHS

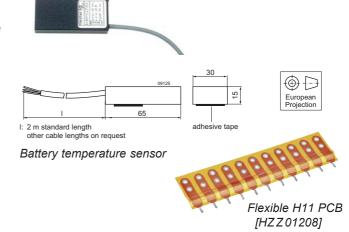
RoHS-compatible for all six substances.



Accessories

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

- Various mating H11 connectors STV-H11-xxx including screw, solder, fast-on, or press-fit terminals
- Connector retention clips [HZZ01209]
- Code key system CODIERKEIL(5X) [HZZ00202]
- Various front panels for 19" rack mounting
- Flexible H11 PCB for mounting to a PCB [HZZ01208]
- Universal mounting bracket UMB-LHMQ [HZZ00610] for chassis or DIN-rail mounting in upright position.
- DIN-rail mounting brackets DMB-MHQ [HZZ00619]
- Mounting plate M [HZZ01208] for chassis or a wall mounting, where only frontal access is given
- Battery sensor [S-KSMH...] for using the converter as battery charger (different cell characteristics).





H11 female connector with screw terminals, code key system, and a coding wedge [HZZ00202]



Connector retention clip [HZZ01209]





Mounting plate M [HZZ01210], connector with fast-on terminals (STV-H11-F/CO), secured with retention clips [HZZ01209]



Universal mounting bracket for DIN-rail mounting UMB-LHMQ [HZZ00610]



Different front panels

NUCLEAR AND MEDICAL APPLICATIONS - Power-One products are not designed, intended for use in, or authorized for use as critical components in life support systems, equipment used in hazardous environments, or nuclear control systems without the express written consent of the respective divisional president of Power-One, Inc.

TECHNICAL REVISIONS - The appearance of products, including safety agency certifications pictured on labels, may change depending on the date manufactured. Specifications are subject to change without notice.

Mouser Electronics

Authorized Distributor

Click to View Pricing, Inventory, Delivery & Lifecycle Information:

Power-One:

DM1601-9R LM3020-7 LM1626-5R DM1301-9R LM2540-9 LME1601-6PG AM1601-7R