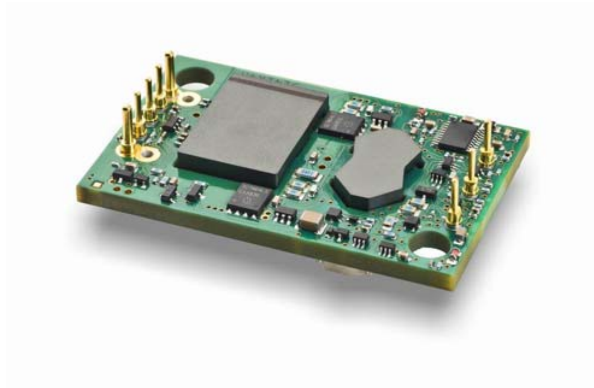
ERICSSON

Technical Specification

PKM 4000D PINB series DC/DC converters, Input 36-75 V, Output up to 35 A/132 W	EN/LZT 146 416 R3A February 2010 © Ericsson AB

Key Features

- Industry standard Quarter-brick. 57.9 x 36.8 x 9.35 mm (2.28 x 1.45 x 0.368 in)
- High efficiency, typ. 93.5% at 12 Vout half load
- 1500 Vdc input to output isolation
- Meets isolation requirements equivalent to basic insulation according to IEC/EN/UL 60950
- More than 1.67 million hours MTBF



General Characteristics

- Output over voltage protection
- Over temperature protection
- Output short-circuit protection
- Hiccup over current protection as an option
- Remote control
- Output voltage adjust function
- Highly automated manufacturing ensures quality
- ISO 9001/14001 certified supplier

Safety Approvals

c UL us

Design for Environment

Pb RoHS compatible

Meets requirements in high-temperature lead-free soldering processes.

Contents

Ordering Information

Product program	Output
PKM 4110D PI	3.3 V, 35 A / 115 W
PKM 4111D PI	5 V, 25 A / 125 W
PKM 4113D PI	12 V, 11 A / 132 W
PKM 4115D PI	15 V, 8 A / 120 W

Product number and Packaging

PKM 4XXXD PI $n_1n_2n_3n_4$ n_5					
Options	n_1	n_2	n_3	n_4	n_5
Remote Control logic	o				
Baseplate		o			
Hiccup OCP			o		
Increased stand-off height				o	
Lead length					o

Options		Description
n_1		Negative *
	P	Positive
n_2	NB	Without baseplate *
		With baseplate
n_3	HC	Hiccup OCP
		Standard stand-off height *
n_4	M	Increased stand-off height
		5.30 mm *
n_5	LA	3.69 mm
	LB	4.57 mm

Example a through-hole mounted, positive logic, short pin product with increased stand-off height would be PKM 4111DPIPNBMLB.

* Standard variant (i.e. no option selected).

General Information

Reliability

The Mean Time Between Failure (MTBF) is calculated at full output power and an operating ambient temperature (T_A) of +40°C, which is a typical condition in Information and Communication Technology (ICT) equipment. Different methods could be used to calculate the predicted MTBF and failure rate which may give different results. Ericsson Power Modules currently Telcordia SR332.

Predicted MTBF for the series is:

- 1.67 million hours according to Telcordia SR332, issue 1, Black box technique.

The Ericsson failure rate data system is based on field tracking data. The data corresponds to actual failure rates of components used in ICT equipment in temperature controlled environments (T_A = -5...+65°C).

Telcordia SR332 is a commonly used standard method intended for reliability calculations in ICT equipment. The parts count procedure used in this method was originally modelled on the methods from MIL-HDBK-217F, Reliability Predictions of Electronic Equipment. It assumes that no reliability data is available on the actual units and devices for which the predictions are to be made, i.e. all predictions are based on generic reliability parameters.

Compatibility with RoHS requirements

The products are compatible with the relevant clauses and requirements of the RoHS directive 2002/95/EC and have a maximum concentration value of 0.1% by weight in homogeneous materials for lead, mercury, hexavalent chromium, PBB and PBDE and of 0.01% by weight in homogeneous materials for cadmium.

Exemptions in the RoHS directive utilized in Ericsson Power Modules products include:

- Lead in high melting temperature type solder (used to solder the die in semiconductor packages)
- Lead in glass of electronics components and in electronic ceramic parts (e.g. fill material in chip resistors)
- Lead as an alloying element in copper alloy containing up to 4% lead by weight (used in connection pins made of Brass)

Quality Statement

The products are designed and manufactured in an industrial environment where quality systems and methods like ISO 9000, 6σ (sigma), and SPC are intensively in use to boost the continuous improvements strategy. Infant mortality or early failures in the products are screened out and they are subjected to an ATE-based final test. Conservative design rules, design reviews and product qualifications, plus the high competence of an engaged work force, contribute to the high quality of our products.

Warranty

Warranty period and conditions are defined in Ericsson Power Modules General Terms and Conditions of Sale.

Limitation of Liability

Ericsson Power Modules does not make any other warranties, expressed or implied including any warranty of merchantability or fitness for a particular purpose (including, but not limited to, use in life support applications, where malfunctions of product can cause injury to a person's health or life).

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Safety Specification

General information

Ericsson Power Modules DC/DC converters and DC/DC regulators are designed in accordance with safety standards IEC/EN/UL60950, *Safety of Information Technology Equipment*.

IEC/EN/UL60950 contains requirements to prevent injury or damage due to the following hazards:

- Electrical shock
- Energy hazards
- Fire
- Mechanical and heat hazards
- Radiation hazards
- Chemical hazards

On-board DC-DC converters and DC/DC regulators are defined as component power supplies. As components they cannot fully comply with the provisions of any Safety requirements without "Conditions of Acceptability". Clearance between conductors and between conductive parts of the component power supply and conductors on the board in the final product must meet the applicable Safety requirements. Certain conditions of acceptability apply for component power supplies with limited stand-off (see Mechanical Information for further information). It is the responsibility of the installer to ensure that the final product housing these components complies with the requirements of all applicable Safety standards and Directives for the final product.

Component power supplies for general use should comply with the requirements in IEC60950, EN60950 and UL60950 *"Safety of information technology equipment".*
There are other more product related standards, e.g. IEEE802.3af "Ethernet LAN/MAN Data terminal equipment power", and ETS300132-2 "Power supply interface at the input to telecommunications equipment; part 2: DC", but all of these standards are based on IEC/EN/UL60950 with regards to safety.

Ericsson Power Modules DC/DC converters and DC/DC regulators are UL60950 recognized and certified in accordance with EN60950.

The flammability rating for all construction parts of the products meets requirements for V-0 class material according to IEC 60695-11-10.

The products should be installed in the end-use equipment, in accordance with the requirements of the ultimate application. Normally the output of the DC/DC converter is considered as SELV (Safety Extra Low Voltage) and the input source must be isolated by minimum Double or Reinforced Insulation from the primary circuit (AC mains) in accordance with IEC/EN/UL60950.

Isolated DC/DC converters

It is recommended that a slow blow fuse with a rating twice the maximum input current per selected product be used at the input of each DC/DC converter. If an input filter is used in the circuit the fuse should be placed in front of the input filter.
In the rare event of a component problem in the input filter or in the DC/DC converter that imposes a short circuit on the input source, this fuse will provide the following functions:

- Isolate the faulty DC/DC converter from the input power source so as not to affect the operation of other parts of the system.
- Protect the distribution wiring from excessive current and power loss thus preventing hazardous overheating.

The galvanic isolation is verified in an electric strength test. The test voltage (V_{iso}) between input and output is 1500 Vdc or 2250 Vdc for 60 seconds (refer to product specification).
Leakage current is less than 1 μA at nominal input voltage.

24 V DC systems

The input voltage to the DC/DC converter is SELV (Safety Extra Low Voltage) and the output remains SELV under normal and abnormal operating conditions.

48 and 60 V DC systems

If the input voltage to the DC/DC converter is 75 Vdc or less, then the output remains SELV (Safety Extra Low Voltage) under normal and abnormal operating conditions.

Single fault testing in the input power supply circuit should be performed with the DC/DC converter connected to demonstrate that the input voltage does not exceed 75 Vdc.

If the input power source circuit is a DC power system, the source may be treated as a TNV2 circuit and testing has demonstrated compliance with SELV limits and isolation requirements equivalent to Basic Insulation in accordance with IEC/EN/UL60950.

Non-isolated DC/DC regulators

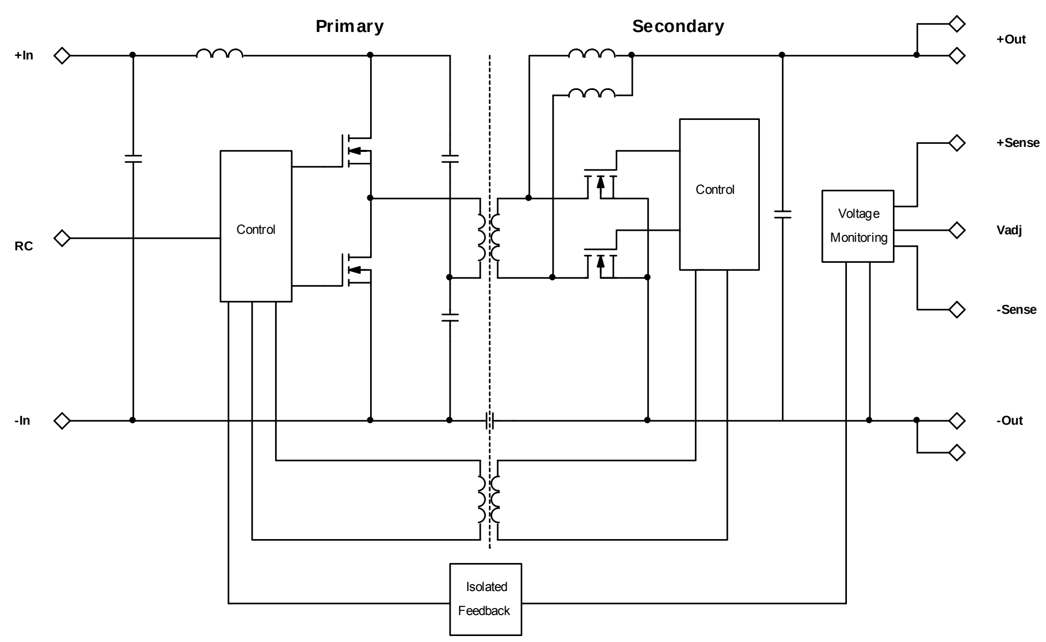
The input voltage to the DC/DC regulator is SELV (Safety Extra Low Voltage) and the output remains SELV under normal and abnormal operating conditions.

Absolute Maximum Ratings

Characteristics			min	typ	max	Unit
T_{P1}	Operating Temperature (see Thermal Consideration section)		-40		+110	°C
T_S	Storage temperature		-55		+125	°C
V_I	Input voltage		-0.5		+80	V
V_{iso}	Isolation voltage (input to output test voltage)				1500	Vdc
V_{tr}	Input voltage transient (t_p 100 ms)				100	V
V_{RC}	Remote Control pin voltage (see Operating Information section)	Positive logic option	-0.5		+15	V
		Negative logic option	-0.5		+15	V
V_{adj}	Adjust pin voltage (see Operating Information section)		-0.5		+5	V

Stress in excess of Absolute Maximum Ratings may cause permanent damage. Absolute Maximum Ratings, sometimes referred to as no destruction limits, are normally tested with one parameter at a time exceeding the limits in the Electrical Specification. If exposed to stress above these limits, function and performance may degrade in an unspecified manner.

Fundamental Circuit Diagram



3.3V, 35A /115W Electrical Specification **PKM 4110D PINB**

T_{P1} = -40 to +90ºC, V_I = 36 to 75 V, sense pins connected to output pins unless otherwise specified under Conditions.
Typical values given at: T_{P1} = +25°C, V_I= 53 V_I max I_O, unless otherwise specified under Conditions.
Additional C_{in} = 0 µF.See Operating Information section for selection of capacitor types.

Characteristics		Conditions	min	typ	max	Unit
V_I	Input voltage range		36		75	V
V_{Ioff}	Turn-off input voltage	Decreasing input voltage	30.0	32.0	33.5	V
V_{Ion}	Turn-on input voltage	Increasing input voltage	32.0	34.0	35.5	V
C_I	Internal input capacitance			6.0		µF
P_O	Output power		0		115	W
η	Efficiency	50 % of max I_O		91.4		%
		max I_O		90.3		
		50 % of max I_O, V_I = 48 V		91.7		
		max I_O, V_I = 48 V		90.2		
P_d	Power Dissipation	max I_O		12.7	16.5	W
P_{li}	Input idling power	I_O = 0 A, V_I = 53 V		2.6		W
P_{RC}	Input standby power	V_I = 53 V (turned off with RC)		0.15		W
f_s	Switching frequency	0-100 % of max I_O	180	200	220	kHz

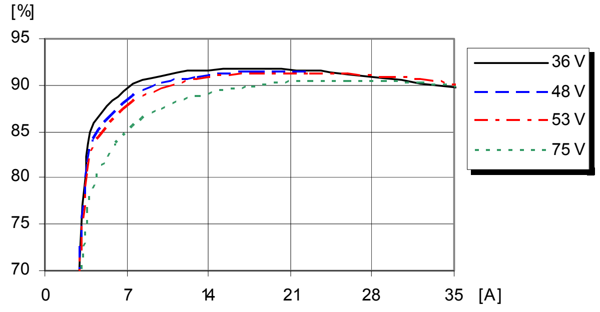
V_{Oi}	Output voltage initial setting and accuracy	T_{P1} = +25°C, V_I = 53 V, I_O = 50 A	3.24	3.30	3.36	V
V_O	Output adjust range	See operating information	2.97		3.63	V
	Output voltage tolerance band	0-100 % of max I_O	3.23		3.37	V
	Idling voltage	I_O = 0 A	3.23		3.37	V
	Line regulation	max I_O		5	15	mV
	Load regulation	V_I = 53 V, 0-100 % of max I_O		5	15	mV
V_{tr}	Load transient voltage deviation	V_I = 53 V, Load step 25-75-25 % of max I_O, di/dt = 5 A/µs see Note 1		±250	±300	mV
t_{tr}	Load transient recovery time			70	100	µs
t_r	Ramp-up time (from 10−90 % of V_{Oi})	10-100 % of max I_O	1	4	6	ms
t_s	Start-up time (from V_I connection to 90 % of V_{Oi})		8	14	20	ms
t_f	V_I shut-down fall time (from V_I off to 10 % of V_O)	max I_O		0.12		ms
		I_O = 0.35 A		0.01		s
t_{RC}	RC start-up time	max I_O		15		ms
	RC shut-down fall time (from RC off to 10 % of V_O)	max I_O		0.09		ms
		I_O = 0.35 A		0.009		s
I_O	Output current		0		35	A
I_{lim}	Current limit threshold	T_{P1} < max T_{P1}	38	44	50	A
I_{sc}	Short circuit current	T_{P1} = 25ºC		52	58	A
C_{out}	Recommended Capacitive Load	T_{P1} = 25ºC, see Note 2	0		3500	µF
V_{Oac}	Output ripple & noise	See ripple & noise section, max I_O, V_{Oi}		80	120	mVp-p
OVP	Over voltage protection	T_{P1} = +25°C, V_I = 53 V, 0-100 % of max I_O	3.6	4.2	4.8	V

Note 1: 7 pieces of 470uF and 1piece of 330uF aluminium solid capacitors are connected to the module.
Note 2: Aluminium electrolytic capacitors, ESR is lower than 10m ohm.

3.3V, 35A /115W Typical Characteristics

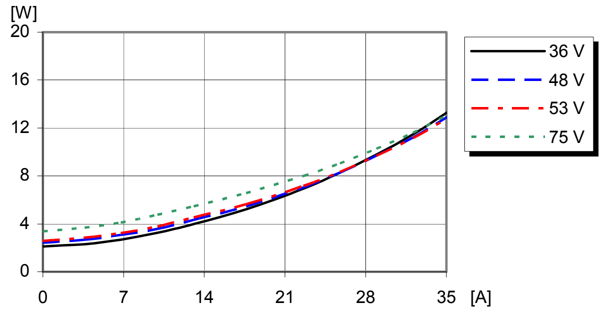
PKM 4110D PINB

Efficiency



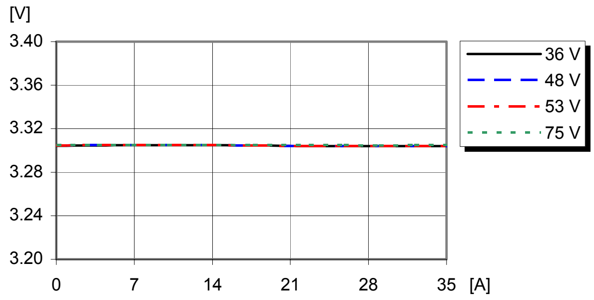
Efficiency vs. load current and input voltage at T_{P1} = +25°C

Power Dissipation



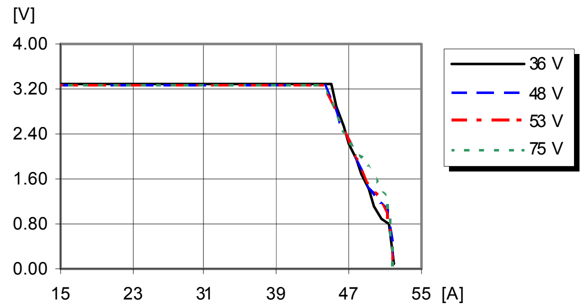
Dissipated power vs. load current and input voltage at T_{P1} = +25°C

Output Characteristics



Output voltage vs. load current at T_{P1} = +25°C

Current Limit Characteristics

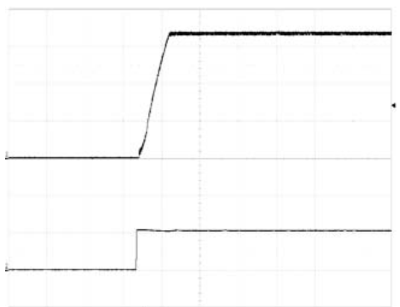


Output voltage vs. load current at I_O > max I_O , T_{P1} = +25°C

3.3V, 35A /115W Typical Characteristics

PKM 4110D PINB

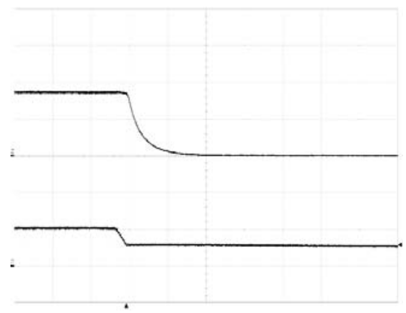
Start-up



Start-up enabled by connecting V_I at:
T_{P1} = +25°C, V_I = 53 V,
I_O = 35 A resistive load.

Top trace: output voltage 2.0 V/div.).
Bottom trace: input voltage (50 V/div.).
Time scale: (10 ms/div.).

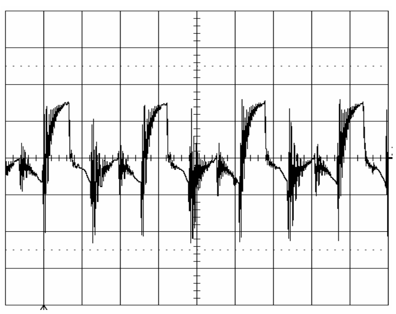
Shut-down



Shut-down enabled by disconnecting V_I at:
T_{P1} = +25°C, V_I = 53 V,
I_O = 35 A resistive load.

Top trace: output voltage (2.0 V/div.).
Bottom trace: input voltage (50 V/div.).
Time scale: (0.1 ms/div.).

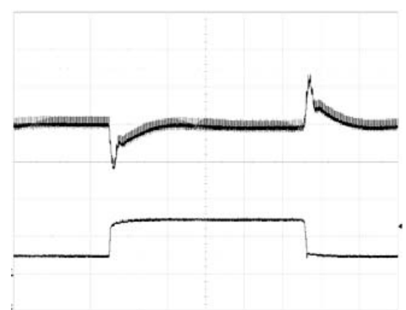
Output Ripple & Noise



Output voltage ripple at:
T_{P1} = +25°C, V_I = 53 V,
I_O = 35 A resistive load.

Trace: output voltage (20 mV/div.).
Time scale: (2 µs/div.).

Output Load Transient Response



Output voltage response to load current step-change (8.75-26.25-8.75 A}) at:
T_{P1} =+25°C, V_I = 53 V.

Top trace: output voltage (200 mV/div.).
Bottom trace: load current (20 A/div.}).
Time scale: (0.1 ms/div.).

Output Voltage Adjust (see operating information)

Passive adjust
The resistor value for an adjusted output voltage is calculated by using the following equations:

Output Voltage Adjust Upwards, Increase:

$$Radj = \left(\frac{5.11 \times 3.3(100 + \Delta\%)}{1.225 \times \Delta\%} - \frac{511}{\Delta\%} - 10.22 \right) \text{ k}\Omega$$

Example: Increase 4% =>V_{out} = 3.43 Vdc

$$\left(\frac{5.11 \times 3.3(100 + 4)}{1.225 \times 4} - \frac{511}{4} - 10.22 \right) \text{ k}\Omega = 219.9 \text{ k}\Omega$$

Output Voltage Adjust Downwards, Increase:

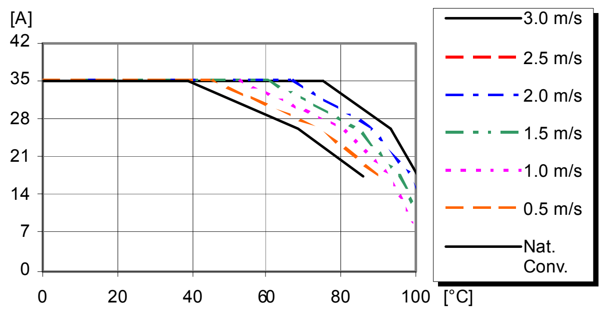
$$Radj = 5.11\left(\frac{100}{\Delta\%} - 2 \right) \text{ k}\Omega$$

Example: Decrease 2% =>V_{out} = 3.23 Vdc
kΩ = 404.32 kΩ

$$5.11\left(\frac{100}{2} - 2 \right) \text{ k}\Omega = 245.3 \text{ k}\Omega$$

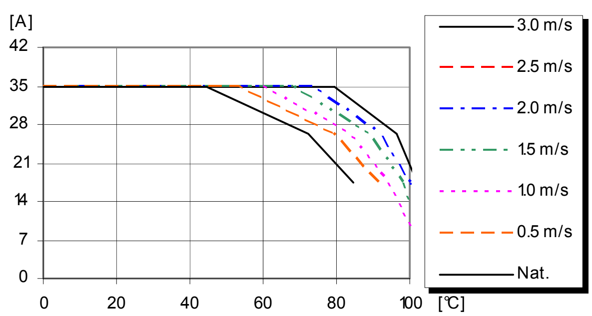
3.3V, 35A /115W Typical Characteristics **PKM 4110D PINB**

Output Current Derating – Open frame



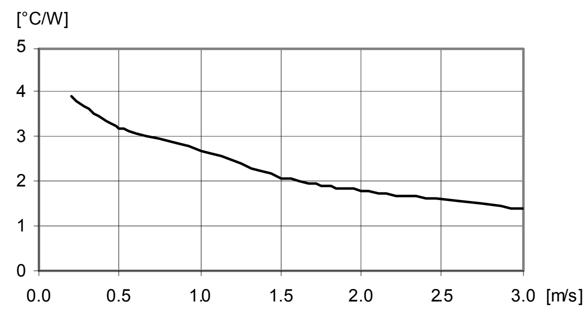
Available load current vs. ambient air temperature and airflow at V_I = 53 V. See Thermal Consideration section.

Output Current Derating – Base plate



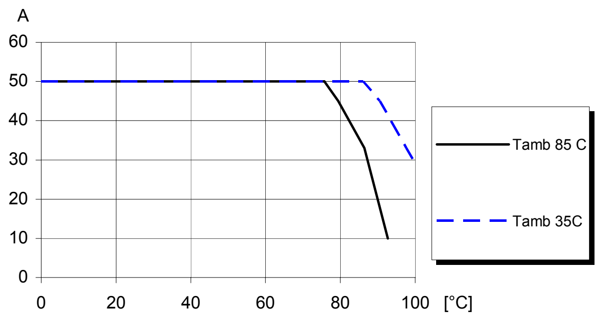
Available load current vs. ambient air temperature and airflow at V_I = 53 V. See Thermal Consideration section.

Thermal Resistance – Base plate



Thermal resistance vs. airspeed measured at the converter. Tested in wind tunnel with airflow and test conditions as per the Thermal consideration section. V_I = 53 V.

Output Current Derating – Cold wall sealed box



Available load current vs. base plate temperature.
V_I = 53 V. See Thermal Consideration section.

5.0V, 25A /125W Electrical Specification — PKM 4111D PINB

T_{P1} = -40 to +90ºC, V_I = 36 to 75 V, sense pins connected to output pins unless otherwise specified under Conditions.
Typical values given at: T_{P1} = +25°C, V_I= 53 V_I max I_O, unless otherwise specified under Conditions.
Additional C_{in} = 0 µF.See Operating Information section for selection of capacitor types.

Characteristics		Conditions	min	typ	max	Unit
V_I	Input voltage range		36		75	V
V_{Ioff}	Turn-off input voltage	Decreasing input voltage	30.0	32.0	33.5	V
V_{Ion}	Turn-on input voltage	Increasing input voltage	32.0	34.0	35.5	V
C_I	Internal input capacitance			6.0		µF
P_O	Output power		0		125	W
η	Efficiency	50 % of max I_O		91.8		%
		max I_O		91.3		
		50 % of max I_O, V_I = 48 V		92.1		
		max I_O, V_I = 48 V		91.4		
P_d	Power Dissipation	max I_O		11.8	14.1	W
P_{li}	Input idling power	I_O = 0 A, V_I = 53 V		2.9		W
P_{RC}	Input standby power	V_I = 53 V (turned off with RC)		0.15		W
f_s	Switching frequency	0-100 % of max I_O	180	200	220	kHz

V_{Oi}	Output voltage initial setting and accuracy	T_{P1} = +25°C, V_I = 53 V, I_O = 25 A	4.90	5.00	5.10	V
V_O	Output adjust range	See operating information	4.50		5.50	V
	Output voltage tolerance band	0-100 % of max I_O	4.80		5.20	V
	Idling voltage	I_O = 0 A	4.80		5.20	V
	Line regulation	max I_O		5	15	mV
	Load regulation	V_I = 53 V, 0-100 % of max I_O		5	15	mV
V_{tr}	Load transient voltage deviation	V_I = 53 V, Load step 25-75-25 % of max I_O, di/dt = 5 A/µs see Note 1		±200	±300	mV
t_{tr}	Load transient recovery time			20	50	µs
t_r	Ramp-up time (from 10−90 % of V_{Oi})	10-100 % of max I_O	1	5	15	ms
t_s	Start-up time (from V_I connection to 90 % of V_{Oi})		7	10	30	ms
t_f	V_I shut-down fall time (from V_I off to 10 % of V_O)	max I_O		0.2		ms
		I_O = 0.4 A		0.02		s
t_{RC}	RC start-up time	max I_O		9		ms
	RC shut-down fall time (from RC off to 10 % of V_O)	max I_O		0.2		ms
		I_O = 0.4 A		0.02		s
I_O	Output current		0		25	A
I_{lim}	Current limit threshold	T_{P1} < max T_{P1}	28	32	36	A
I_{sc}	Short circuit current	T_{P1} = 25ºC		40	45	A
C_{out}	Recommended Capacitive Load	T_{P1} = 25ºC, see Note 2	0		2500	µF
V_{Oac}	Output ripple & noise	See ripple & noise section, max I_O, V_{Oi}		60	130	mVp-p
OVP	Over voltage protection	T_{P1} = +25°C, V_I = 53 V, 0-100 % of max I_O	6.2	6.8	7.2	V

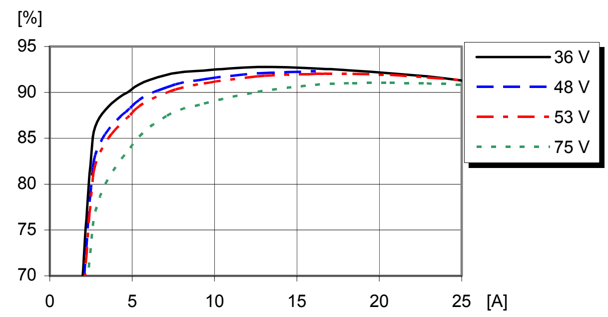
Note 1: 6 pieces of 470uF aluminium solid capacitors are connected to the module.

Note 2: Aluminium electrolytic capacitors, ESR is lower than 10 mohm.

5.0V, 25A /125W Typical Characteristics

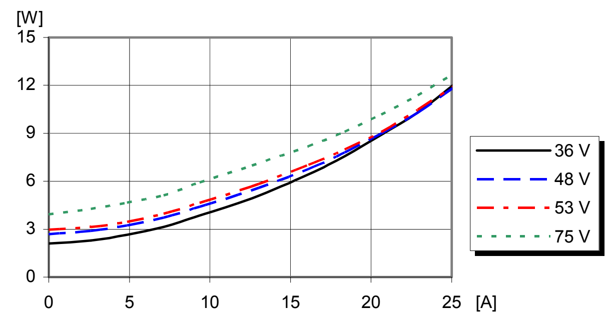
PKM 4111D PINB

Efficiency



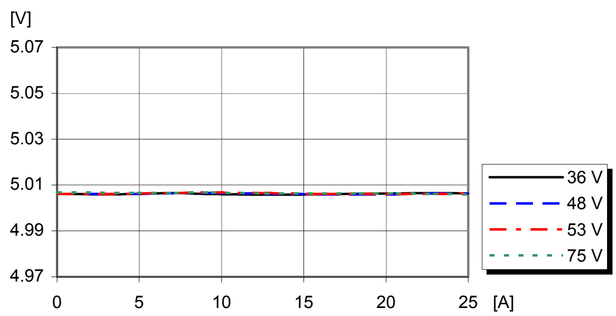
Efficiency vs. load current and input voltage at T_{P1} = +25°C

Power Dissipation



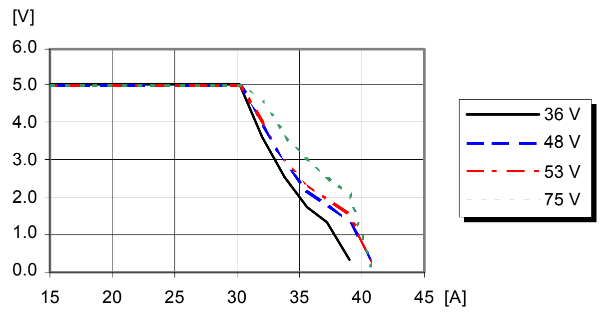
Dissipated power vs. load current and input voltage at T_{P1} = +25°C

Output Characteristics



Output voltage vs. load current at T_{P1} = +25°C

Current Limit Characteristics

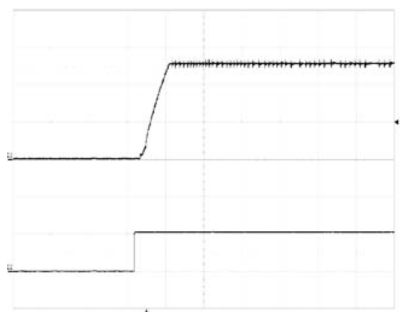


Output voltage vs. load current at I_O > max I_O , T_{P1} = +25°C

5.0V, 25A /125W Typical Characteristics

PKM 4111D PINB

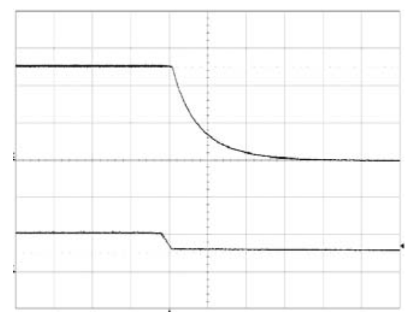
Start-up



Start-up enabled by connecting V_I at:
T_{P1} = +25°C, V_I = 53 V
I_O = 25 A resistive load.

Top trace: output voltage (2 V/div.).
Bottom trace: input voltage (50 V/div.).
Time scale: (5 ms/div.).

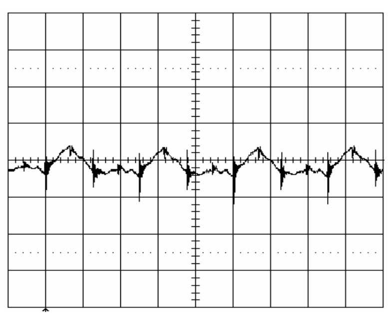
Shut-down



Shut-down enabled by disconnecting V_I at:
T_{P1} = +25°C, V_I = 53 V,
I_O = 25 A resistive load.

Top trace: output voltage (2 V/div.).
Bottom trace: input voltage (50 V/div.).
Time scale: (0.1 ms/div.).

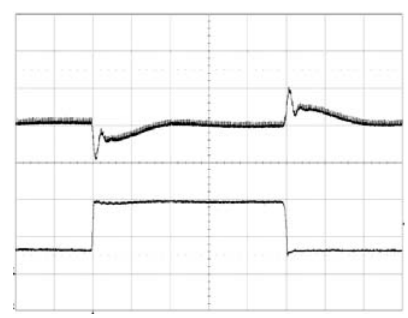
Output Ripple & Noise



Output voltage ripple at:
T_{P1} = +25°C, V_I = 53 V,
I_O = 25 A resistive load.

Trace: output voltage (50 mV/div.).
Time scale: (2 µs/div.).

Output Load Transient Response



Output voltage response to load current step-change (6.25-18.75-6.25 A) at:
T_{P1} =+25°C, V_I = 53 V.

Top trace: output voltage (200 mV/div.).
Bottom trace: load current (10 A/div.).
Time scale: (0.1 ms/div.).

Output Voltage Adjust (see operating information)

Passive adjust

The resistor value for an adjusted output voltage is calculated by using the following equations:

Output Voltage Adjust Upwards, Increase:

$$Radj = \left(\frac{5.11 \times 5.0(100 + \Delta\%)}{1.225 \times \Delta\%} - \frac{511}{\Delta\%} - 10.22 \right) \text{ k}\Omega$$

Example: Increase 4% =>V_{out} = 5.20 Vdc

$$\left(\frac{5.11 \times 5.0(100 + 4)}{1.225 \times 4} - \frac{511}{4} - 10.22 \right) \text{ k}\Omega = 404.3 \text{ k}\Omega$$

Output Voltage Adjust Downwards, Increase:

$$Radj = 5.11\left(\frac{100}{\Delta\%} - 2 \right) \text{ k}\Omega$$

Example: Decrease 2% =>V_{out} = 4.90 Vdc

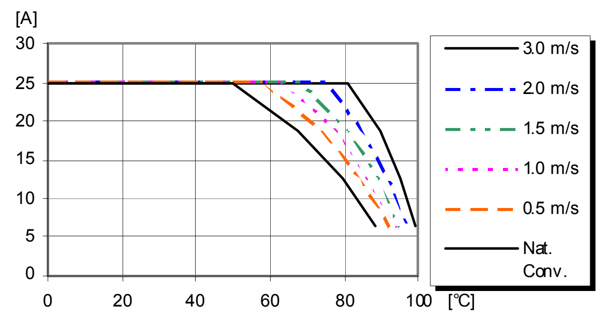
kΩ = 404.32 kΩ

$$5.11\left(\frac{100}{2} - 2 \right) \text{ k}\Omega = 245.3 \text{ k}\Omega$$

5.0V, 25A /125W Typical Characteristics

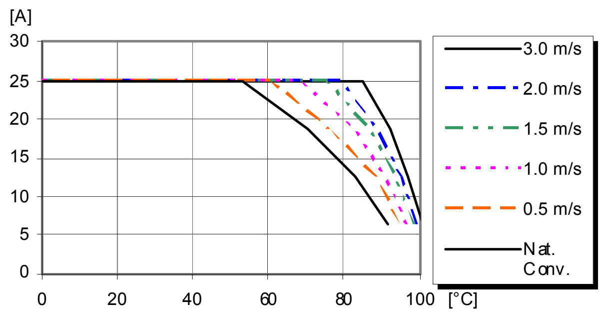
PKM 4111D PINB

Output Current Derating – Open frame



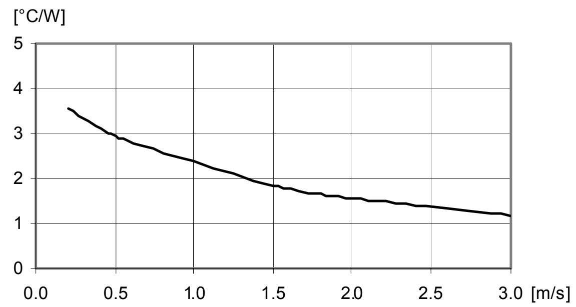
Available load current vs. ambient air temperature and airflow at V_I = 53 V. See Thermal Consideration section.

Output Current Derating – Base plate



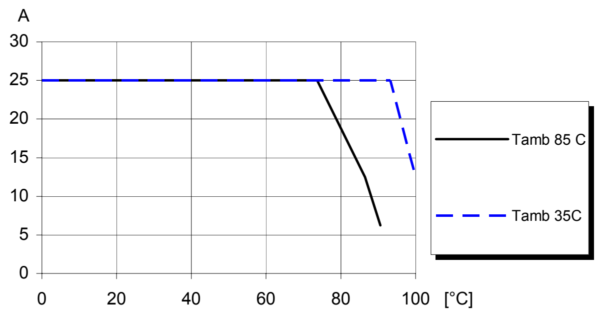
Available load current vs. ambient air temperature and airflow at V_I = 53 V. See Thermal Consideration section.

Thermal Resistance – Base plate



Thermal resistance vs. airspeed measured at the converter. Tested in wind tunnel with airflow and test conditions as per the Thermal consideration section. V_I = 53 V.

Output Current Derating – Cold wall sealed box



Available load current vs. base plate temperature.
V_I = 53 V. See Thermal Consideration section.

12V, 11A/132W Electrical Specification

PKM 4113D PINB

T_{P1} = -40 to +90ºC, V_I = 38 to 75 V, sense pins connected to output pins unless otherwise specified under Conditions.
Typical values given at: T_{P1} = +25°C, V_I= 53 V_I max I_O, unless otherwise specified under Conditions.
Additional C_{in} = 0 µF.See Operating Information section for selection of capacitor types.

Characteristics		Conditions	min	typ	max	Unit
V_I	Input voltage range		38		75	V
V_{Ioff}	Turn-off input voltage	Decreasing input voltage	30	31	32	V
V_{Ion}	Turn-on input voltage	Increasing input voltage	32	33	34	V
C_I	Internal input capacitance			6.0		µF
P_O	Output power		0		132	W
η	Efficiency	50 % of max I_O		93.5		%
		max I_O		94.2		
		50 % of max I_O, V_I = 48 V		93.8		
		max I_O, V_I = 48 V		94.3		
P_d	Power Dissipation	max I_O		8.1	12	W
P_{li}	Input idling power	I_O = 0 A, V_I = 53 V		2.7		W
P_{RC}	Input standby power	V_I = 53 V (turned off with RC)		0.14		W
f_s	Switching frequency	0-100 % of max I_O	180	200	220	kHz

V_{Oi}	Output voltage initial setting and accuracy	T_{P1} = +25°C, V_I = 53 V, I_O = 40 A	11.8	12	12.2	V
V_O	Output adjust range	See operating information	10.8		13.2	V
	Output voltage tolerance band	0-100 % of max I_O	11.7		12.3	V
	Idling voltage	I_O = 0 A	11.8		12.2	V
	Line regulation	max I_O		10	20	mV
	Load regulation	V_I = 53 V, 0-100 % of max I_O		10	20	mV
V_{tr}	Load transient voltage deviation	V_I = 53 V, Load step 25-75-25 % of max I_O, di/dt = 5A/µs,see Note 1		±300	±450	mV
t_{tr}	Load transient recovery time			100	170	µs
t_r	Ramp-up time (from 10−90 % of V_{Oi})	10-100 % of max I_O	4	6	20	ms
t_s	Start-up time (from V_I connection to 90 % of V_{Oi})		6	8	20	ms
t_f	V_I shut-down fall time (from V_I off to 10 % of V_O)	max I_O		0.3		ms
		I_O = 0 A		9		s
t_{RC}	RC start-up time	max I_O		8		ms
	RC shut-down fall time (from RC off to 10 % of V_O)	max I_O		0.3		ms
		I_O = 0 A		9		s
I_O	Output current		0		11	A
I_{lim}	Current limit threshold	T_{P1} < max T_{P1}	12	15	19	A
I_{sc}	Short circuit current	T_{P1} = 25ºC, see Note 2		21		A
C_{out}	Recommended Capacitive Load	T_{P1} = 25ºC, see Note 3	0		1100	µF
V_{Oac}	Output ripple & noise	See ripple & noise section, max I_O, V_{Oi}		100	150	mVp-p
OVP	Over voltage protection	T_{P1} = +25°C, V_I = 53 V, 0-100 % of max I_O		14.8		V

Note 1: 1100uF aluminium solid capacitors are connected to the module.

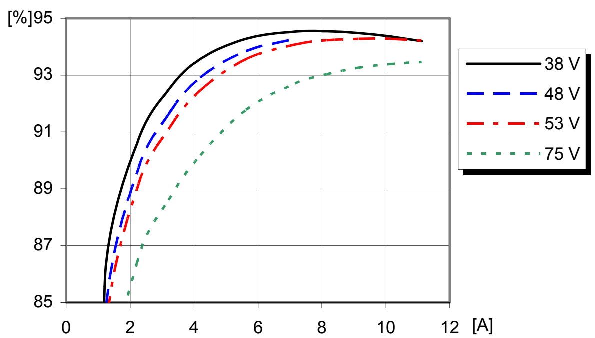
Note 2: short circuit load is 5mohm.

Note 3: Aluminium electrolytic capacitors, ESR is lower than 10 mohm.

12V, 11A /132W Typical Characteristics

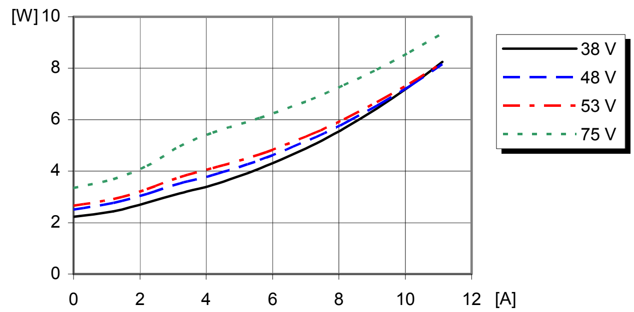
PKM 4113D PINB

Efficiency



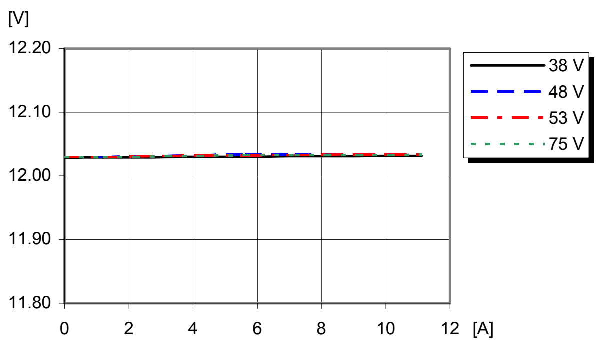
Efficiency vs. load current and input voltage at T_{P1} = +25°C

Power Dissipation



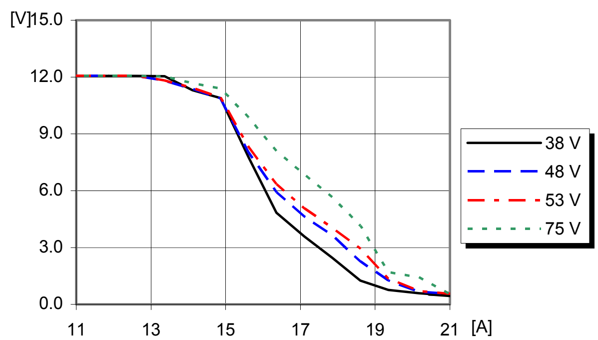
Dissipated power vs. load current and input voltage at T_{P1} = +25°C

Output Characteristics



Output voltage vs. load current at T_{P1} = +25°C

Current Limit Characteristics

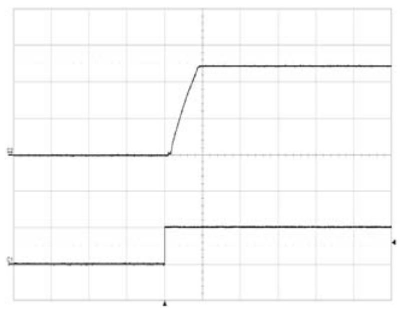


Output voltage vs. load current at I_O > max I_O, T_{P1} = +25°C

12V, 11A /132W Typical Characteristics

PKM 4113D PINB

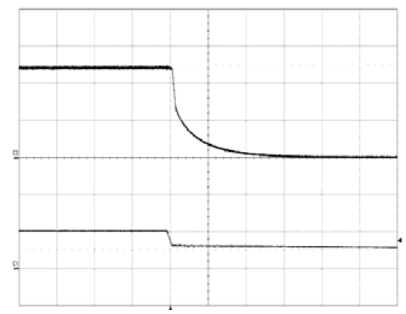
Start-up



Start-up enabled by connecting V_I at:
T_{P1} = +25°C, V_I = 53 V,
I_O = 11 A resistive load.

Top trace: output voltage (5 V/div.).
Bottom trace: input voltage (50 V/div.}).
Time scale: (10 ms/div.).

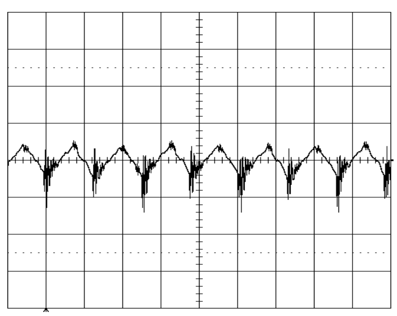
Shut-down



Shut-down enabled by disconnecting V_I at:
T_{P1} = +25°C, V_I = 53 V,
I_O = 11 A resistive load.

Top trace: output voltage (5 V/div.}).
Bottom trace: input voltage (50 V/div.).
Time scale: (0.2 ms/div.).

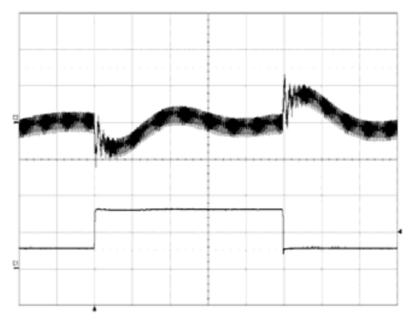
Output Ripple & Noise



Output voltage ripple at:
T_{P1} = +25°C, V_I = 53 V,
I_O = 11 A resistive load.

Trace: output voltage (50 mV/div.).
Time scale: (2 µs/div.).

Output Load Transient Response



Output voltage response to load current step-change (2.75-8.25-2.75 A) at:
T_{P1} =+25°C, V_I = 53 V.

Top trace: output voltage (200mV/div.).
Bottom trace: load current (5 A/div.).
Time scale: (0.1 ms/div.).

Output Voltage Adjust (see operating information)

Passive adjust
The resistor value for an adjusted output voltage is calculated by using the following equations:

Output Voltage Adjust Upwards, Increase:

$$Radj = \left(\frac{5.11 \times 12 \times (100 + \Delta\%)}{1.225 \times \Delta\%} - \frac{511}{\Delta\%} - 10.22 \right) \text{k}\Omega$$

Example: Increase 4% =>V_{out} = 12.48 Vdc

$$\left(\frac{5.11 \times 12 \times (100 + 4)}{1.225 \times 4} - \frac{511}{4} - 10.22 \right) \text{k}\Omega = 1163.5 \text{ k}\Omega$$

Output Voltage Adjust Downwards, Increase:

$$Radj = 5.11 \left(\frac{100}{\Delta\%} - 2 \right) \text{k}\Omega$$

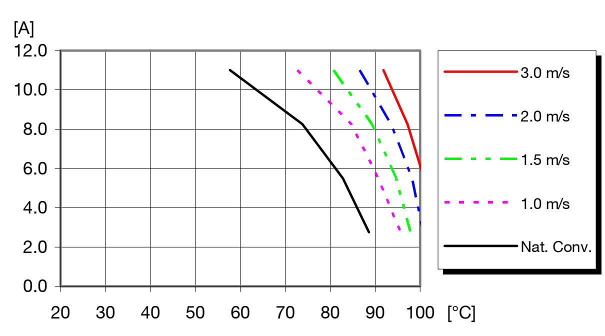
Example: Decrease 2% =>V_{out} = 11.76 Vdc

$$5.11 \left(\frac{100}{2} - 2 \right) \text{k}\Omega = 245.3 \text{ k}\Omega$$

12V, 11A /132W Typical Characteristics

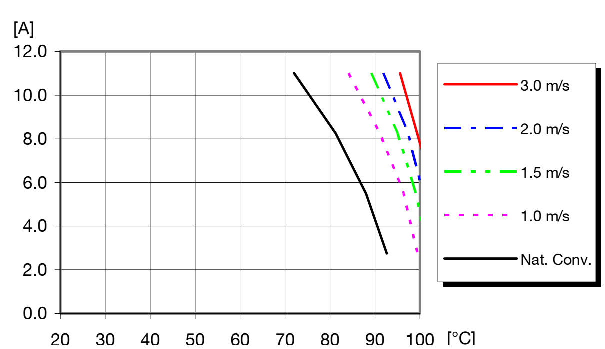
PKM 4113D PINB

Output Current Derating – Open frame



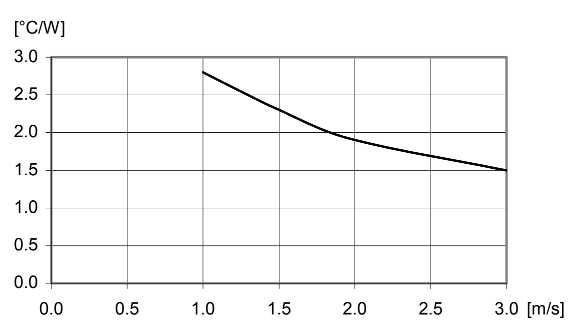
Available load current vs. ambient air temperature and airflow at V_I = 53 V. See Thermal Consideration section.

Output Current Derating – Base plate



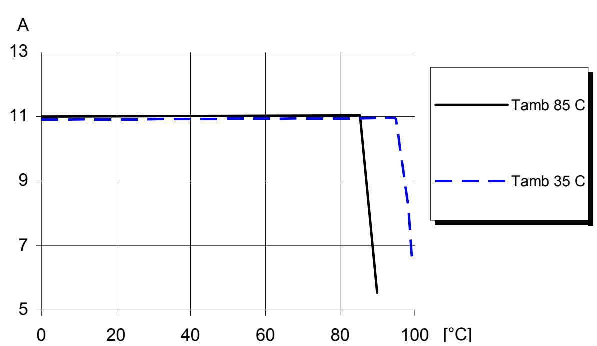
Available load current vs. ambient air temperature and airflow at V_I = 53 V. See Thermal Consideration section.

Thermal Resistance – Base plate



Thermal resistance vs. airspeed measured at the converter. Tested in wind tunnel with airflow and test conditions as per the Thermal consideration section. V_I = 53 V.

Output Current Derating – Cold wall sealed box



Available load current vs. base plate temperature.
V_I = 53 V. See Thermal Consideration section.

15V, 8A /120W Electrical Specification — PKM 4115D PINB

T_{P1} = -40 to +90ºC, V_I = 36 to 75 V, sense pins connected to output pins unless otherwise specified under Conditions.
Typical values given at: T_{P1} = +25°C, V_I= 53 V_I max I_O, unless otherwise specified under Conditions.
Additional C_{in} = 0 µF.See Operating Information section for selection of capacitor types.

Characteristics		Conditions	min	typ	max	Unit
V_I	Input voltage range		36		75	V
V_{Ioff}	Turn-off input voltage	Decreasing input voltage	29.0	31.3	33.0	V
V_{Ion}	Turn-on input voltage	Increasing input voltage	32.0	33.9	35.5	V
C_I	Internal input capacitance			6.0		µF
P_O	Output power		0		120	W
η	Efficiency	50 % of max I_O		91.4		%
		max I_O		92.7		
		50 % of max I_O, V_I = 48 V		92.0		
		max I_O, V_I = 48 V		92.9		
P_d	Power Dissipation	max I_O		9.4	13	W
P_{li}	Input idling power	I_O = 0 A, V_I = 53 V		4.0		W
P_{RC}	Input standby power	V_I = 53 V (turned off with RC)		0.11		W
f_s	Switching frequency	0-100 % of max I_O	180	200	220	kHz

V_{Oi}	Output voltage initial setting and accuracy	T_{P1} = +25°C, V_I = 53 V, I_O = 8 A	14.70	15.00	15.30	V
V_O	Output adjust range	See operating information	12.00		16.50	V
	Output voltage tolerance band	0-100 % of max I_O	14.55		15.45	V
	Idling voltage	I_O = 0 A	14.70		15.30	V
	Line regulation	max I_O, see Note 1		2	30	mV
	Load regulation	V_I = 53 V, 0-100 % of max I_O		8	20	mV
V_{tr}	Load transient voltage deviation	V_I = 53 V, Load step 25-75-25 % of max I_O, di/dt = 1 A/µs see Note 2		±300	±550	mV
t_{tr}	Load transient recovery time			260	300	µs
t_r	Ramp-up time (from 10−90 % of V_{Oi})	10-100 % of max I_O	9	11	15	ms
t_s	Start-up time (from V_I connection to 90 % of V_{Oi})		15	20	30	ms
t_f	V_I shut-down fall time (from V_I off to 10 % of V_O)	max I_O		0.55		ms
		I_O = 0 A		2.3		s
t_{RC}	RC start-up time	max I_O		20		ms
	RC shut-down fall time (from RC off to 10 % of V_O)	max I_O		0.52		ms
		I_O = 0 A		2.4		s
I_O	Output current		0		8	A
I_{lim}	Current limit threshold	T_{P1} < max T_{P1}	9	11.3	14	A
I_{sc}	Short circuit current	T_{P1} = 25ºC		14	18	A
C_{out}	Recommended Capacitive Load	T_{P1} = 25ºC, see Note 3	0		800	µF
V_{Oac}	Output ripple & noise	See ripple & noise section, max I_O, V_{Oi}		50	150	mVp-p
OVP	Over voltage protection	T_{P1} = +25°C, V_I = 53 V, 0-100 % of max I_O		19.2		V

Note 1: There can be some voltage drop at Vin<38V, full load, easier to occur at high temperature.
Note 2: one 470uF +one 330uF low ESR electrolytic capacitors are connected to the module.
Note 3: Aluminium electrolytic capacitors, ESR is lower than 10m ohm.

PKM 4000D PINB series DC/DC converters, Input 36-75 V, Output up to 35 A/132 W	EN/LZT 146 416 R3A February 2010
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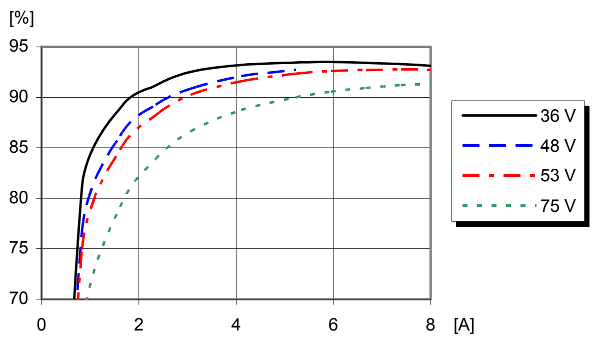
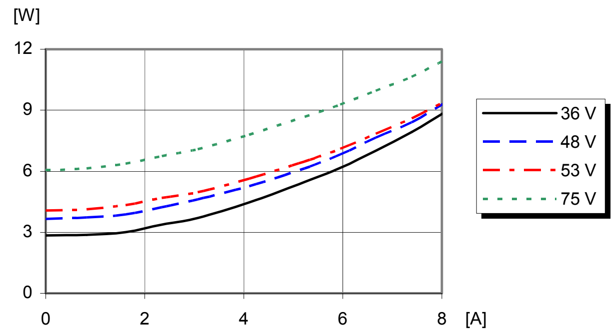
15V, 8A /120W Typical Characteristics **PKM 4115D PINB**

Efficiency



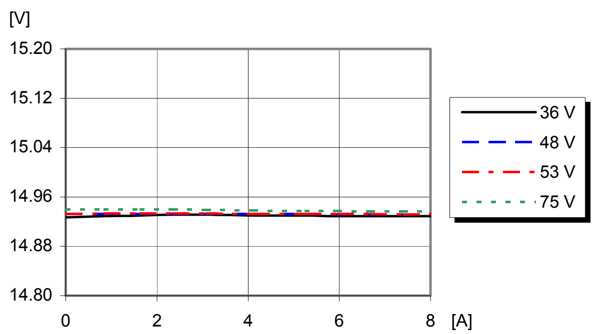
Efficiency vs. load current and input voltage at T_{P1} = +25°C

Power Dissipation



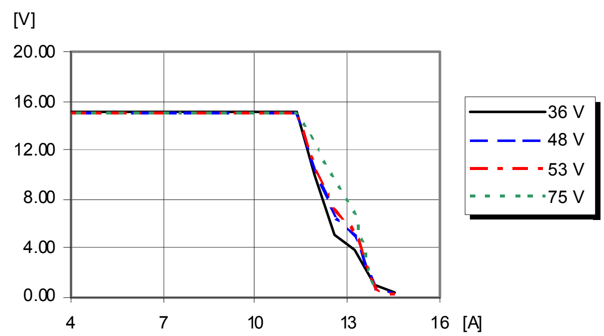
Dissipated power vs. load current and input voltage at T_{P1} = +25°C

Output Characteristics



Output voltage vs. load current at T_{P1} = +25°C

Current Limit Characteristics

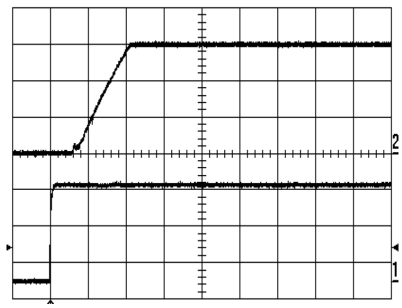


Output voltage vs. load current at I_O > max I_O , T_{P1} = +25°C

15V, 8A /120W Typical Characteristics

PKM 4115D PINB

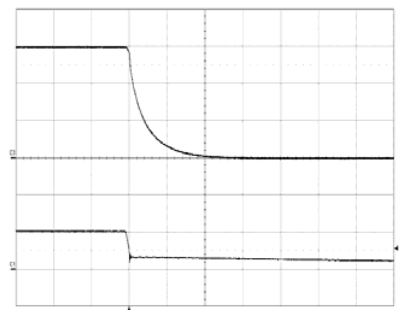
Start-up



Start-up enabled by connecting V_I at:
T_{P1} = +25°C, V_I = 53 V,
I_O = 8 A resistive load.

Top trace: output voltage (5.0 V/div.).
Bottom trace: input voltage (20 V/div.).
Time scale: (10 ms/div.).

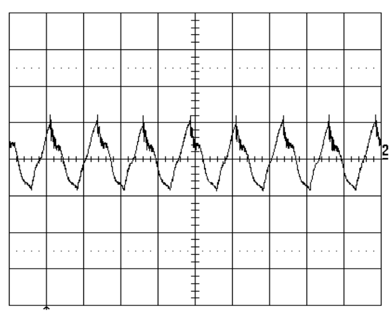
Shut-down



Shut-down enabled by disconnecting V_I at:
T_{P1} = +25°C, V_I = 53 V,
I_O = 8 A resistive load.

Top trace: output voltage (5.0 V/div.).
Bottom trace: input voltage (50 V/div.).
Time scale: (0.5 ms/div.).

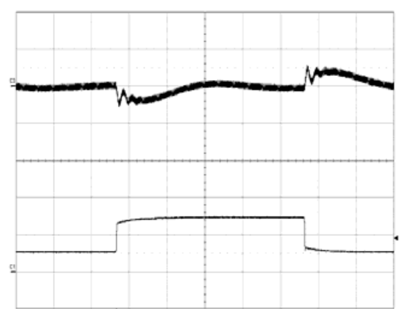
Output Ripple & Noise



Output voltage ripple at:
T_{P1} = +25°C, V_I = 53 V,
I_O = 8 A resistive load.

Trace: output voltage (20 mV/div.).
Time scale: (2 µs/div.).

Output Load Transient Response



Output voltage response to load current step-change (2-6-2 A}) at:
T_{P1} =+25°C, V_I = 53 V.

Top trace: output voltage (500 mV/div.).
Bottom trace: load current (4 A/div.}).
Time scale: (0.1 ms/div.).

Output Voltage Adjust (see operating information)

Passive adjust
The resistor value for an adjusted output voltage is calculated by using the following equations:

Output Voltage Adjust Upwards, Increase:

$$Radj = \left(\frac{5.11 \times 15 (100 + \Delta\%)}{1.225 \times \Delta\%} - \frac{511}{\Delta\%} - 10.22 \right) k\Omega$$

Example: Increase 4% =>V_{out} = 15.6 Vdc

$$\left(\frac{5.11 \times 15 (100 + 4)}{1.225 \times 4} - \frac{511}{4} - 10.22 \right) k\Omega = 1488.89\, k\Omega$$

Output Voltage Adjust Downwards, decrease:

$$Radj = 5.11 \left(\frac{100}{\Delta\%} - 2 \right) k\Omega$$

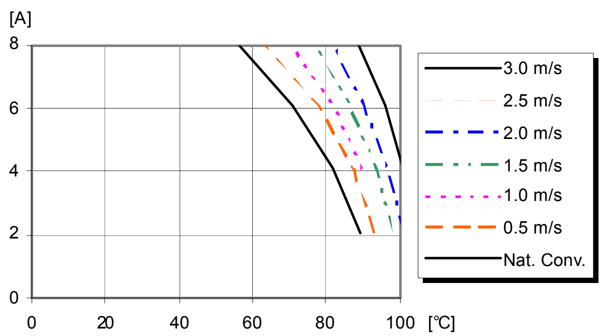
Example: Decrease 2% =>V_{out} = 14.7 Vdc

$$5.11 \left(\frac{100}{2} - 2 \right) k\Omega = 245.3\ k\Omega$$

15V, 8A /120W Typical Characteristics

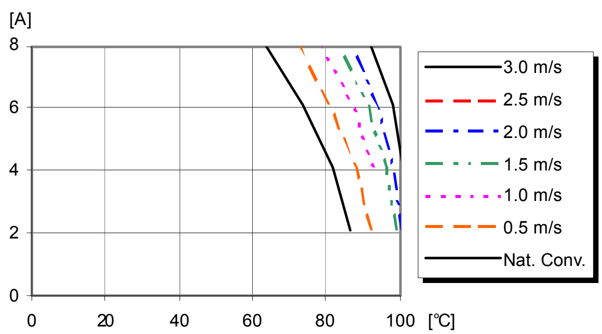
PKM 4115D PINB

Output Current Derating – Open frame



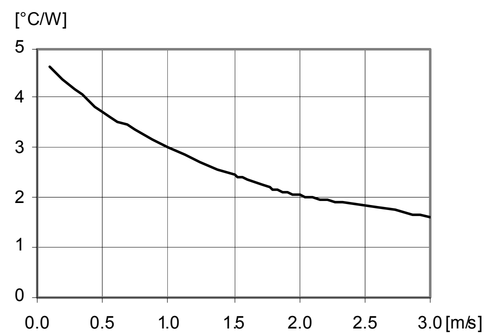
Available load current vs. ambient air temperature and airflow at V_I = 53 V. See Thermal Consideration section.

Output Current Derating – Base plate



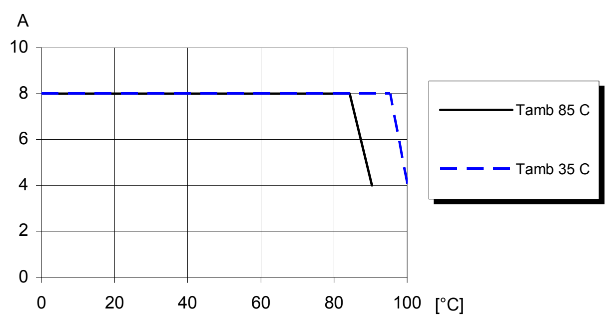
Available load current vs. ambient air temperature and airflow at V_I = 53 V. See Thermal Consideration section.

Thermal Resistance – Base plate



Thermal resistance vs. airspeed measured at the converter. Tested in wind tunnel with airflow and test conditions as per the Thermal consideration section. V_I = 53 V.

Output Current Derating – Cold wall sealed box

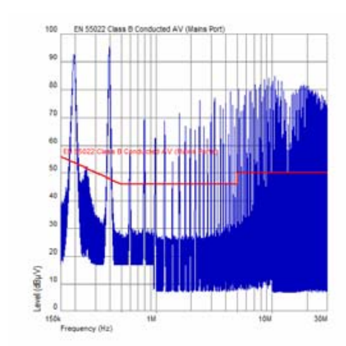


Available load current vs. base plate temperature.
V_I = 53 V. See Thermal Consideration section.

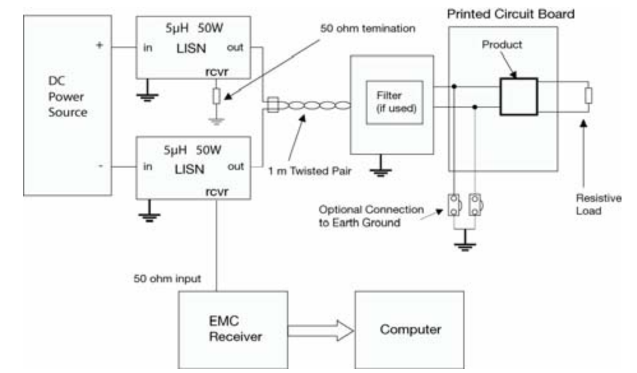
EMC Specification

Conducted EMI measured according to EN55022, CISPR 22 and FCC part 15J (see test set-up). See Design Note 009 for further information. The fundamental switching frequency is 200 kHz for PKM 4111D PINB@ V_I = 53 V, max I_O.

Conducted EMI Input terminal value (typ)



EMI without filter



Test set-up

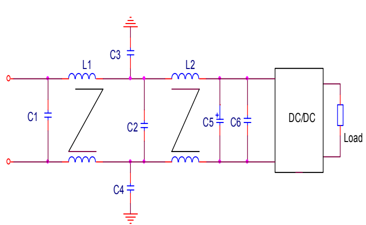
Layout recommendations

The radiated EMI performance of the Product will depend on the PCB layout and ground layer design. It is also important to consider the stand-off of the product. If a ground layer is used, it should be connected to the output of the product and the equipment ground or chassis.

A ground layer will increase the stray capacitance in the PCB and improve the high frequency EMC performance.

External filter (class B)

Required external input filter in order to meet class B in EN 55022, CISPR 22 and FCC part 15J.

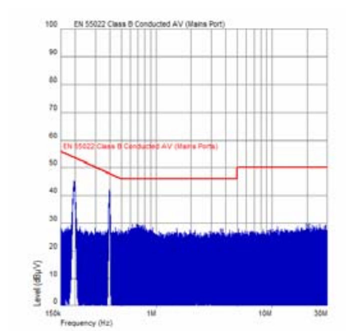


Filter components:
C1,2,6 = 1 µF
Ceramic

C3,4 = 2.2 nF
Ceramic

C5 = 220 µF
Electrolytic

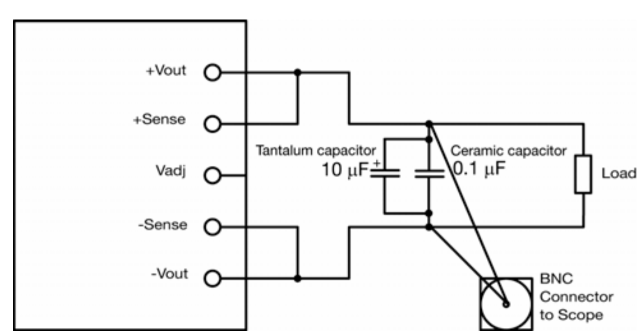
L1,2 = 0.81 mH
common mode



EMI with filter

Output ripple and noise

Output ripple and noise measured according to figure below. See Design Note 022 for detailed information.



Output ripple and noise test setup

Operating information

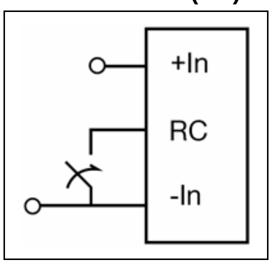
Input Voltage

The input voltage range 36 to 75Vdc meets the requirements of the European Telecom Standard ETS 300 132-2 for normal input voltage range in –48 and –60 Vdc systems, -40.5 to -57.0 V and –50.0 to -72 V respectively.
At input voltages exceeding 75 V, the power loss will be higher than at normal input voltage and T_{P1} must be limited to absolute max +110°C. The absolute maximum continuous input voltage is 80 Vdc.

Turn-off Input Voltage

The products monitor the input voltage and will turn on and turn off at predetermined levels.
The minimum hysteresis between turn on and turn off input voltage is 1V.

Remote Control (RC)



The products are fitted with a remote control function referenced to the primary negative input connection (-In), with negative and positive logic options available. The RC function allows the product to be turned on/off by an external device like a semiconductor or mechanical switch.
The maximum required sink current is 1 mA. When the RC pin is left open, the voltage generated on the RC pin is 5.0 – 7.0 V. The standard product is provided with “negative logic” remote control and will be off until the RC pin is connected to the -In. To turn on the product the voltage between RC pin and -In should be less than 1V. To turn off the converter the RC pin should be left open, or connected to a voltage higher than 13 V referenced to -In. In situations where it is desired to have the product to power up automatically without the need for control signals or a switch, the RC pin can be wired directly to -In.

The second option is “positive logic” remote control, which can be ordered by adding the suffix “P” to the end of the part number. When the RC pin is left open, the product starts up automatically when the input voltage is applied. Turn off is achieved by connecting the RC pin to the -In. To ensure safe turn off the voltage difference between RC pin and the -In pin shall be less than 1V. The product will restart automatically when this connection is opened.

See Design Note 021 for detailed information.

Input and Output Impedance

The impedance of both the input source and the load will interact with the impedance of the product. It is important that the input source has low characteristic impedance. The products are designed for stable operation without external capacitors connected to the input or output. The performance in some applications can be enhanced by addition of external capacitance as described under External Decoupling Capacitors.

If the input voltage source contains significant inductance, the addition of a 22 - 100 μF capacitor across the input of the product will ensure stable operation. The capacitor is not required when powering the product from an input source with an inductance below 10 μH. The minimum required capacitance value depends on the output power and the input voltage. The higher output power the higher input capacitance is needed. Approximately doubled capacitance value is required for a 24 V input voltage source compared to a 48V input voltage source.

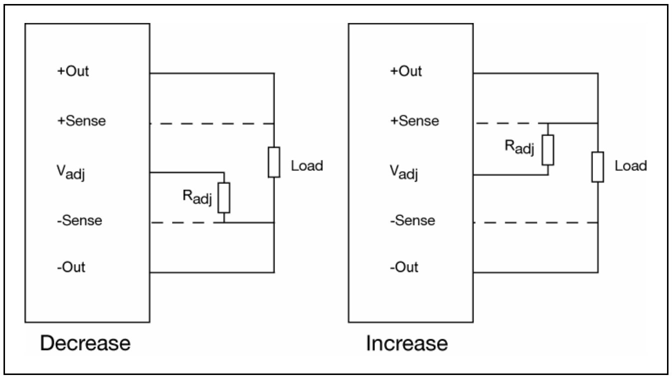
External Decoupling Capacitors

When powering loads with significant dynamic current requirements, the voltage regulation at the point of load can be improved by addition of decoupling capacitors at the load. The most effective technique is to locate low ESR ceramic and electrolytic capacitors as close to the load as possible, using several parallel capacitors to lower the effective ESR. The ceramic capacitors will handle high-frequency dynamic load changes while the electrolytic capacitors are used to handle low frequency dynamic load changes. It is equally important to use low resistance and low inductance PCB layouts and cabling.

External decoupling capacitors will become part of the product’s control loop. The control loop is optimized for a wide range of external capacitance and the maximum recommended value that could be used without any additional analysis is found in the Electrical specification.
The ESR of the capacitors is a very important parameter. Stable operation is guaranteed with a verified ESR value of >5 mΩ across the output connections.
For further information please contact your local Ericsson Power Modules representative.

Output Voltage Adjust (V_{adj})

The products have an Output Voltage Adjust pin (V_{adj}). This pin can be used to adjust the output voltage above or below Output voltage initial setting.
When increasing the output voltage, the voltage at the output pins (including any remote sense compensation) must be kept below the threshold of the over voltage protection, (OVP) to prevent the product from shutting down. At increased output voltages the maximum power rating of the product remains the same, and the max output current must be decreased correspondingly.
To increase the voltage the resistor should be connected between the V_{adj} pin and +Sense pin. The resistor value of the Output voltage adjust function is according to information given under the Output section for the respective product.
To decrease the output voltage, the resistor should be connected between the V_{adj} pin and –Sense pin.



Parallel Operation

Two products may be paralleled for redundancy if the total power is equal or less than P_O max. It is not recommended to parallel the products without using external current sharing circuits.

See Design Note 006 for detailed information.

Remote Sense

The products have remote sense that can be used to compensate for voltage drops between the output and the point of load. The sense traces should be located close to the PCB ground layer to reduce noise susceptibility. The remote sense circuitry will compensate for up to 10% voltage drop between output pins and the point of load.

If the remote sense is not needed +Sense should be connected to +Out and -Sense should be connected to -Out.

Over Temperature Protection (OTP)

The products are protected from thermal overload by an internal over temperature shutdown circuit.
When T_{P1} as defined in thermal consideration section exceeds 135°C the product will shut down. The product will make continuous attempts to start up (non-latching mode) and resume normal operation automatically when the temperature has dropped >15°C below the temperature threshold.

Over Voltage Protection (OVP)

The products have output over voltage protection that will shut down the product in over voltage conditions. The product will make continuous attempts to start up (non-latching mode) and resume normal operation automatically after removal of the over voltage condition.

Over Current Protection (OCP)

The products include current limiting circuitry for protection at continuous overload.
PKMD standard module, the output voltage will decrease towards zero for output currents in excess of max output current (Iomax).
The converter will resume normal operation after removal of the overload. The load distribution system should be designed to carry the maximum output short circuit current specified.

The PKMD series include hiccup OCP option, the output voltage will decrease when the output current in excess of its current limit point, when the load continue to increase to some higher level, the module will enter into hiccup mode.

During hiccup, the module will try to restart and shutdown again for the overload. When the overload is removed, the products will continue to work normally.

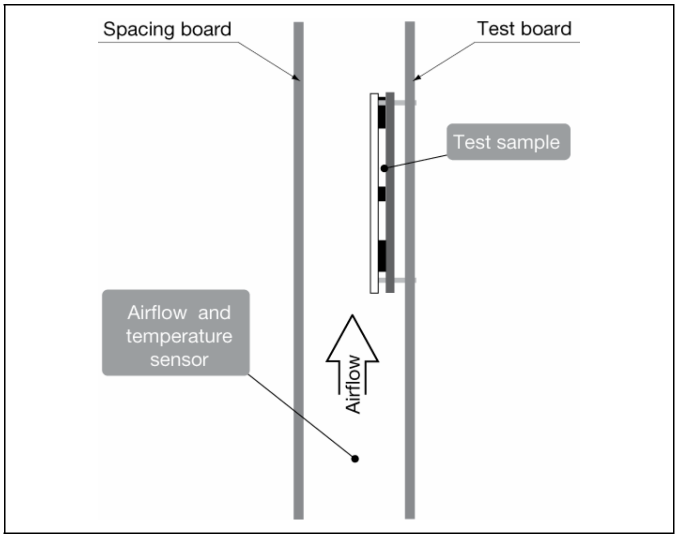
Thermal Consideration

General

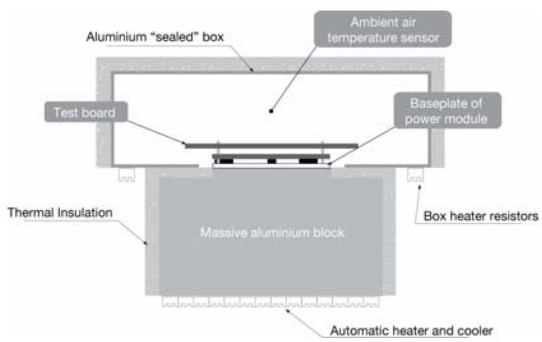
The products are designed to operate in different thermal environments and sufficient cooling must be provided to ensure reliable operation.

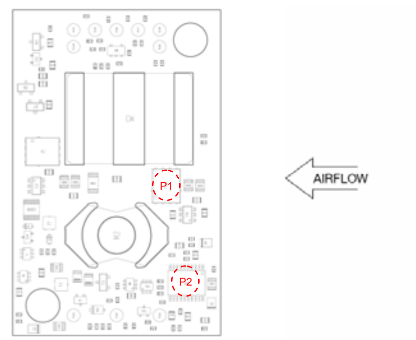
For products mounted on a PCB without a heat sink attached, cooling is achieved mainly by conduction, from the pins to the host board, and convection, which is dependant on the airflow across the product. Increased airflow enhances the cooling of the product. The Output Current Derating graph found in the Output section for each model provides the available output current vs. ambient air temperature and air velocity at V_I = 53 V.

The product is tested on a 254 x 254 mm, 35 µm (1 oz), 16-layer test board mounted vertically in a wind tunnel with a cross-section of 608 x 203 mm.



For products with base plate used in a sealed box/cold wall application, cooling is achieved mainly by conduction through the cold wall. The Output Current Derating graphs are found in the Output section for each module. The product is tested in a sealed box test set up with ambient temperatures 85 and 35°C. See Design Note 028 for further details.



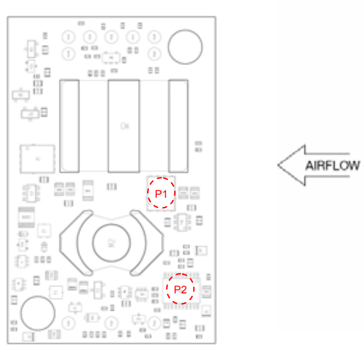


Base plate

Definition of product operating temperature

The product operating temperatures is used to monitor the temperature of the product, and proper thermal conditions can be verified by measuring the temperature at positions P1, P2. The temperature at these positions T_{P1}, T_{P2} should not exceed the maximum temperatures in the table below. The number of measurement points may vary with different thermal design and topology. Temperatures above maximum T_{P1}, measured at the reference point P1 are not allowed and may cause permanent damage.

Position	Description	Max Temp.
P1	MOSFET	T_{P1}=125° C
P2	Control IC	T_{P2}=125° C



Open frame

Ambient Temperature Calculation

For products with base plate the maximum allowed ambient temperature can be calculated by using the thermal resistance.

1. The power loss is calculated by using the formula ((1/η) – 1) × output power = power losses (Pd).
H = efficiency of product. E.g. 89.5% = 0.895

2. Find the thermal resistance (Rth) in the Thermal Resistance graph found in the Output section for each model. ***Note that the thermal resistance can be significantly reduced if a heat sink is mounted on the top of the base plate.***

Calculate the temperature increase (ΔT).
ΔT = Rth x Pd

3. Max allowed ambient temperature is:
Max T_{P1} - ΔT.

E.g. PKM 4111D PINBat 1.5m/s:

1. $((\frac{1}{0.91}) - 1) \times 125\ W = 12.4W$

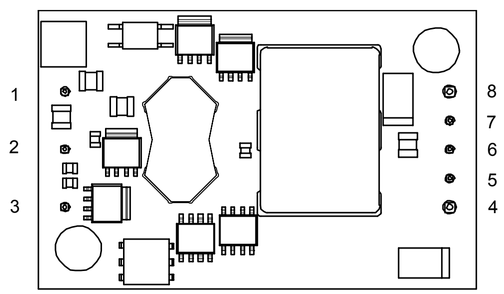
2. 12.4 W × 3.5°C/W = 43.4°C

3. 125 °C – 43.4°C = max ambient temperature is 81.6°C

The actual temperature will be dependent on several factors such as the PCB size, number of layers and direction of airflow.

PKM 4000D PINB series DC/DC converters, Input 36-75 V, Output up to 35 A/132 W	EN/LZT 146 416 R3A February 2010 © Ericsson AB

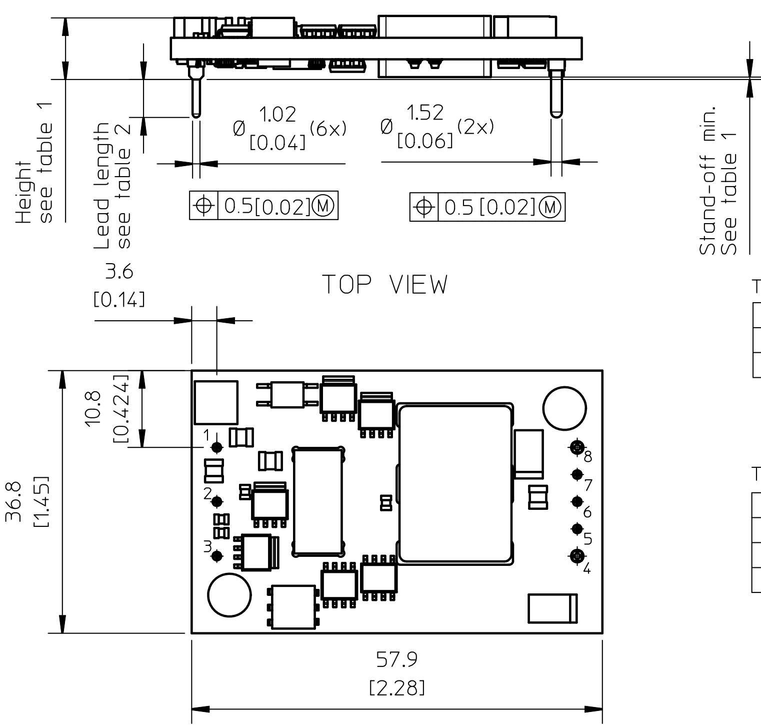
Connections



Top view

Pin	Designation	Function
1	+In	Positive input
2	RC	Remote control
3	- In	Negative input
4	- Out	Negative output
5	- Sen	Negative remote sense
6	Vadj	Output voltage adjust
7	+ Sen	Positive remote sense
8	+ Out	Positive output

Mechanical Drawing for open frame with holes



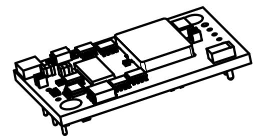


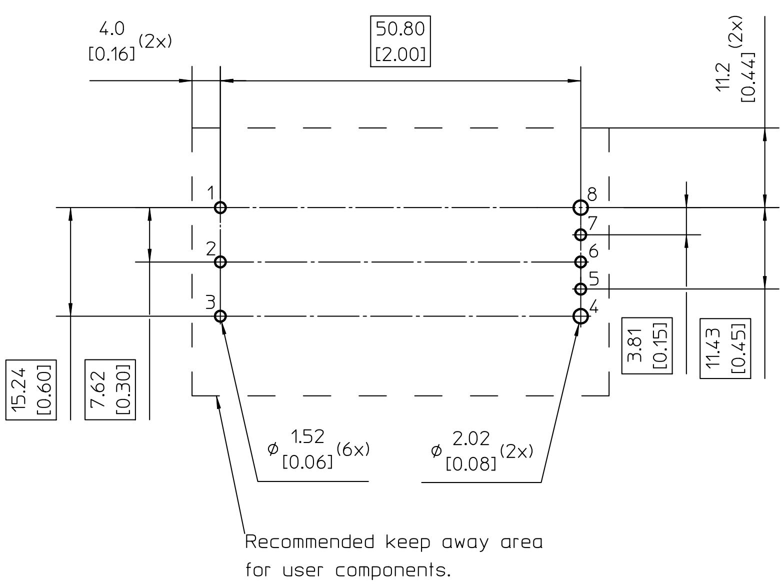
Table 1

Height option	Height max.	Stand-off min.
Standard	9.35 [0.368]	0.07 [0.003]
M	10.53 [0.415]	1.25 [0.049]

Table 2

Pin option	Lead Length
Standard	5.33 [0.210]
LA	3.69 [0.145]
LB	4.57 [0.180]

Recommended footprint - TOP VIEW



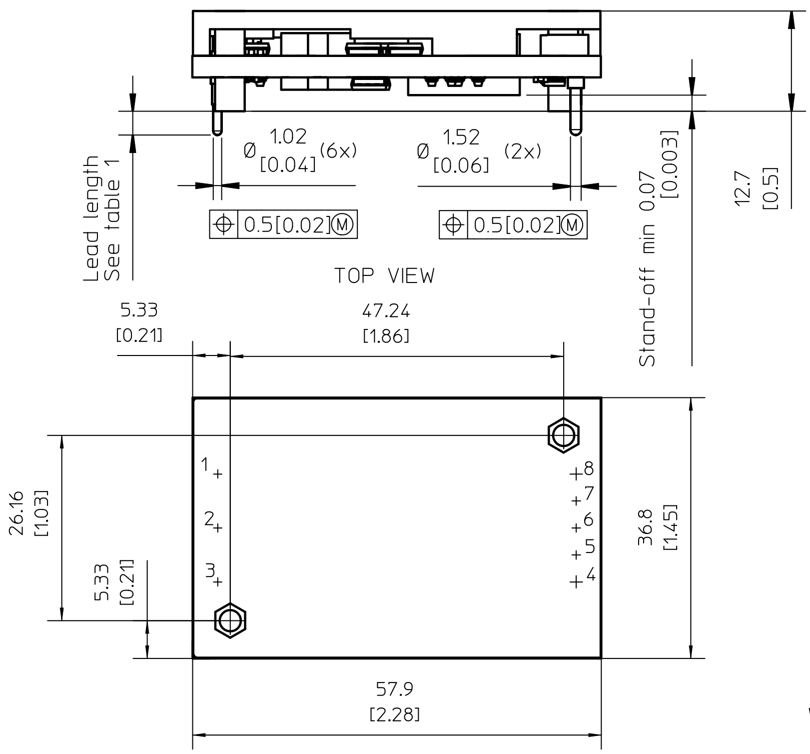
Weight: Typical 40g

Pins:
Material, pins 1-3, 5-7: Brass
Material, pins 4,8,: Copper alloy
Plating: 0,1 μm Gold over 2 μm Nickel

All dimensions are in mm [inches]
Tolerances unless specified
x.x ± 0.5 [0.02]
x.xx ± 0.25 [0.01]
Not applied on the recommended footprint

PKM 4000D PINB series DC/DC converters, Input 36-75 V, Output up to 35 A/132 W	EN/LZT 146 416 R3A February 2010 © Ericsson AB

Mechanical Drawing for base plate with inserts



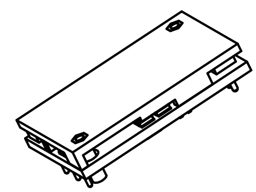
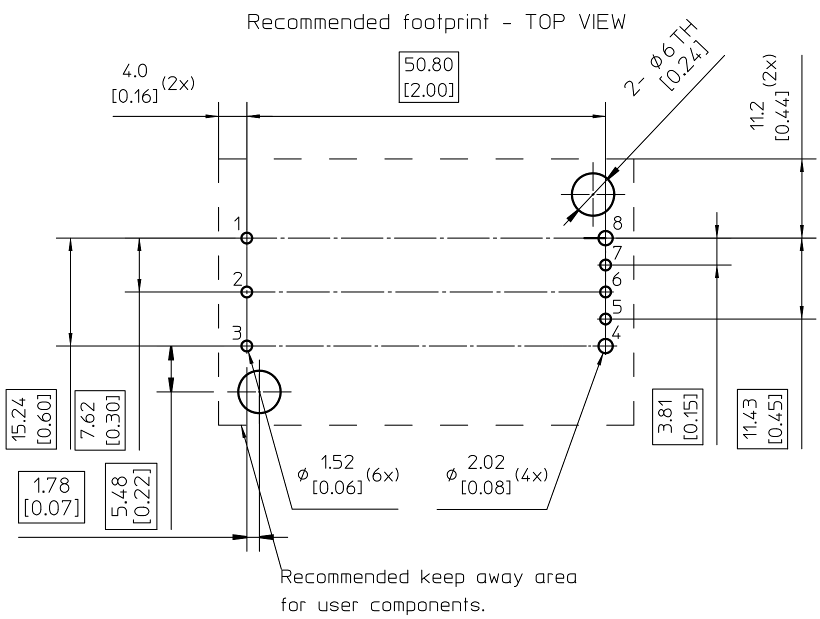


Table 1

Pin option	Lead Length
Standard	5.33 +0/-0.1 [0.210]
LA	3.69 [0.145]
LB	4.57 [0.180]

Weight: Typical 65g

Pins:
Material, pins 1-3, 5-7: Brass
Material, pins 4-8: Copper alloy
Plating: 0,1 μm Gold over 2 μm Nickel



All dimensions are in mm [inches]
Tolerances unless specified
x.x ± 0.5 [0.02]
x.xx ± 0.25 [0.01]
Not applied on the recommended footprint

PKM 4000D PINB series DC/DC converters, Input 36-75 V, Output up to 35 A/132 W	EN/LZT 146 416 R3A February 2010
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Soldering Information - Hole Mounting

The hole mounted product is intended for plated through hole mounting by wave or manual soldering. The pin temperature is specified to maximum to 270°C for maximum 10 seconds.

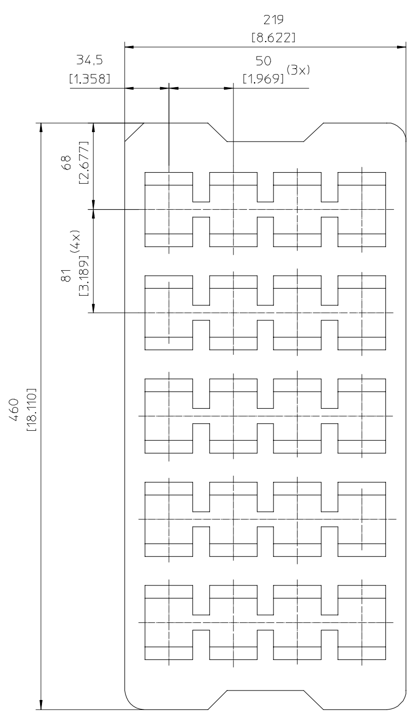
A maximum preheat rate of 4°C/s and maximum preheat temperature of 150°C is suggested. When soldering by hand, care should be taken to avoid direct contact between the hot soldering iron tip and the pins for more than a few seconds in order to prevent overheating.

A no-clean flux is recommended to avoid entrapment of cleaning fluids in cavities inside the product or between the product and the host board. The cleaning residues may affect long time reliability and isolation voltage.

Delivery Package Information

The products are delivered in antistatic trays

Tray Specifications	
Material	Antistatic PS
Surface resistance	10^5 < Ohm/square < 10^{12}
Tray capacity	20 products/tray
Tray weight	140 g empty, 940 g full
Box capacity	20 products/full box



Product Qualification Specification

Characteristics			
External visual inspection	IPC-A-610		
Change of temperature (Temperature cycling)	IEC 60068-2-14 Na	Temperature range Number of cycles Dwell/transfer time	-40 to 100°C 300 30 min/0-1 min
Cold (in operation)	IEC 60068-2-1 Ad	Temperature T_A Duration	-40°C 2 h
Damp heat	IEC 60068-2-67 Cy	Temperature Humidity Duration	85°C 85 % RH 1000 hours
Storage test	IEC 60068-2-2 Ba	Temperature Duration	125°C 1000 h
Immersion in cleaning solvents	IEC 60068-2-45 XA, method 2	Water Glycol ether Isopropyl alcohol	55°C 35°C 35°C
Mechanical shock	IEC 60068-2-27 Ea	Peak acceleration Duration Pulse shape Directions Number of pulses	200 g 3 ms Half sine 6 18
Solder heat stability	IEC 60068-2-20 Tb, method 1A	Solder temperature Duration	260°C 10 s
Robustness of terminations	IEC 60068-2-21 Test Ua1	Through hole mount products	All leads
Solder-ability	IEC 60068-2-58 test Td [1]	Preconditioning Temperature, SnPb Eutectic Temperature, Pb-free	150°C dry bake 16 h 215°C 235°C
Vibration random	IEC 60068-2-34 Eb,	Frequency Spectral density Duration	10 to 500 Hz 0.025 g^2/Hz 10 min in each 3 directions
Vibration sinusoidal	IEC 60068-2-6 Fc	Frequency Acceleration Duration	10 to 500 Hz 10 g 2 h in each 3 directions