

PKM 4000E PI series Direct Converters

Input 36-75 V, Output up to 25 A / 82.5 W

EN/LZT 146 358 R4A Oct. 2017

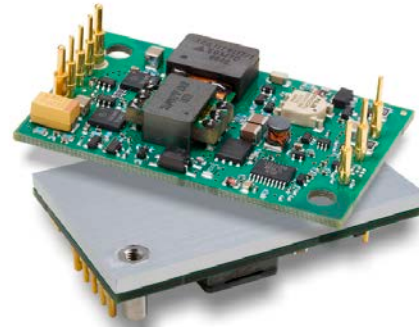
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Key Features

- Industry standard low profile Quarter-brick
57.9 x 36.8 x 8.5 mm (2.28 x 1.45 x 0.33 in)
- Low profile, max 8.5 mm (0.33 in.)
- High efficiency, typ. 91% at 3.3Vout half load
- 1500 Vdc input to output isolation
- Meets equivalent to basic insulation safety requirements according to IEC/EN/UL 60950-1
- MTBF 4.2 Mh

General Characteristics

- Narrow board pitch applications (15 mm/0.6 in)
- Output over voltage protection
- Input under voltage shutdown
- Over temperature protection
- Monotonic start-up
- Output short-circuit protection
- Remote sense
- Remote control
- Output voltage adjust function
- Highly automated manufacturing ensures quality
- ISO 9001/14001 certified supplier



Safety Approvals



Design for Environment



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

Contents

Ordering Information	2
General Information	2
Safety Specification	3
Absolute Maximum Ratings	4
Electrical Specification	
2.5V, 25A / 62.5W	PKM 4619E PI 5
3.3V, 25A / 82.5W	PKM 4810E PI 8
5.0V, 15A / 75W	PKM 4711E PI 11
EMC Specification	14
Operating Information	15
Thermal Consideration	16
Connections	17
Mechanical Information	18
Soldering Information	21
Delivery Information	21
Product Qualification Specification	22

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EN/LZT 146 358 R4A Oct. 2017

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Ordering Information

Product program	Output
PKM 4619E PI	2.5 V, 25 A / 62.5 W
PKM 4810E PI	3.3 V, 25 A / 82.5 W
PKM 4711E PI	5 V, 15 A / 75 W

Product number and Packaging

PKM 4810E PI n ₁ n ₂ n ₃ n ₄				
Options	n ₁	n ₂	n ₃	n ₄
Remote Control logic	o			
Thread		o		
Baseplate			o	
Lead length				o

Options	Description
n ₁	Negative * P Positive
n ₂	Thread * M No thread
n ₃	Open frame * HS Baseplate
n ₄	5.30 mm * LA 3.69 mm (Open frame) 2.79 mm (Baseplate)

Example: a standard positive logic, baseplate product would be PKM4810EPIPHS.

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

General Information

Reliability

The failure rate (λ) and mean time between failures (MTBF = $1/\lambda$) is calculated at max output power and an operating ambient temperature (T_A) of +40°C. Flex uses Telcordia SR-332 Issue 2 Method 1 to calculate the mean steady-state failure rate and standard deviation (σ).

Telcordia SR-332 Issue 2 also provides techniques to estimate the upper confidence levels of failure rates based on the mean and standard deviation.

Mean steady-state failure rate, λ	Std. deviation, σ
240 nFailures/h	36.5 nFailures/h

MTBF (mean value) for the PKU 70w series = 4.2 Mh.

MTBF at 90% confidence level = 3.5 Mh

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 Flex products are found in the Statement of Compliance document.

Flex fulfills and will continuously fulfill all its obligations under regulation (EC) No 1907/2006 concerning the registration, evaluation, authorization and restriction of chemicals (REACH) as they enter into force and is through product materials declarations preparing for the obligations to communicate information on substances in the products.

Quality Statement

The products are designed and manufactured in an industrial environment where quality systems and methods like ISO 9000, Six 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 the products.

Warranty

Warranty period and conditions are defined in Flex General Terms and Conditions of Sale.

Limitation of Liability

Flex 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

Flex DC/DC converters and DC/DC regulators are designed in accordance with safety standards IEC/EN/UL 60950-1 *Safety of Information Technology Equipment*.

IEC/EN/UL 60950-1 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 regulations for the final product.

Component power supplies for general use should comply with the requirements in IEC 60950-1, EN 60950-1 and UL 60950-1 *Safety of Information Technology Equipment*. There are other more product related standards, e.g. IEEE 802.3 CSMA/CD (Ethernet) Access Method, and ETS-300132-2 *Power supply interface at the input to telecommunications equipment, operated by direct current (dc)*, but all of these standards are based on IEC/EN/UL 60950-1 with regards to safety.

Flex DC/DC converters and DC/DC regulators are UL 60950-1 recognized and certified in accordance with EN 60950-1.

The flammability rating for all construction parts of the products meet requirements for V-0 class material according to IEC 60695-11-10, *Fire hazard testing, test flames* – 50 W horizontal and vertical flame test methods.

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/UL 60950-1.

Isolated DC/DC converters

It is recommended that a slow blow fuse is to 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 that imposes a short circuit on the input source, this fuse will provide the following functions:

- Isolate the fault 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 (refer to product specification).

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 TNV-2 circuit and testing has demonstrated compliance with SELV limits in accordance with IEC/EN/UL60950-1.

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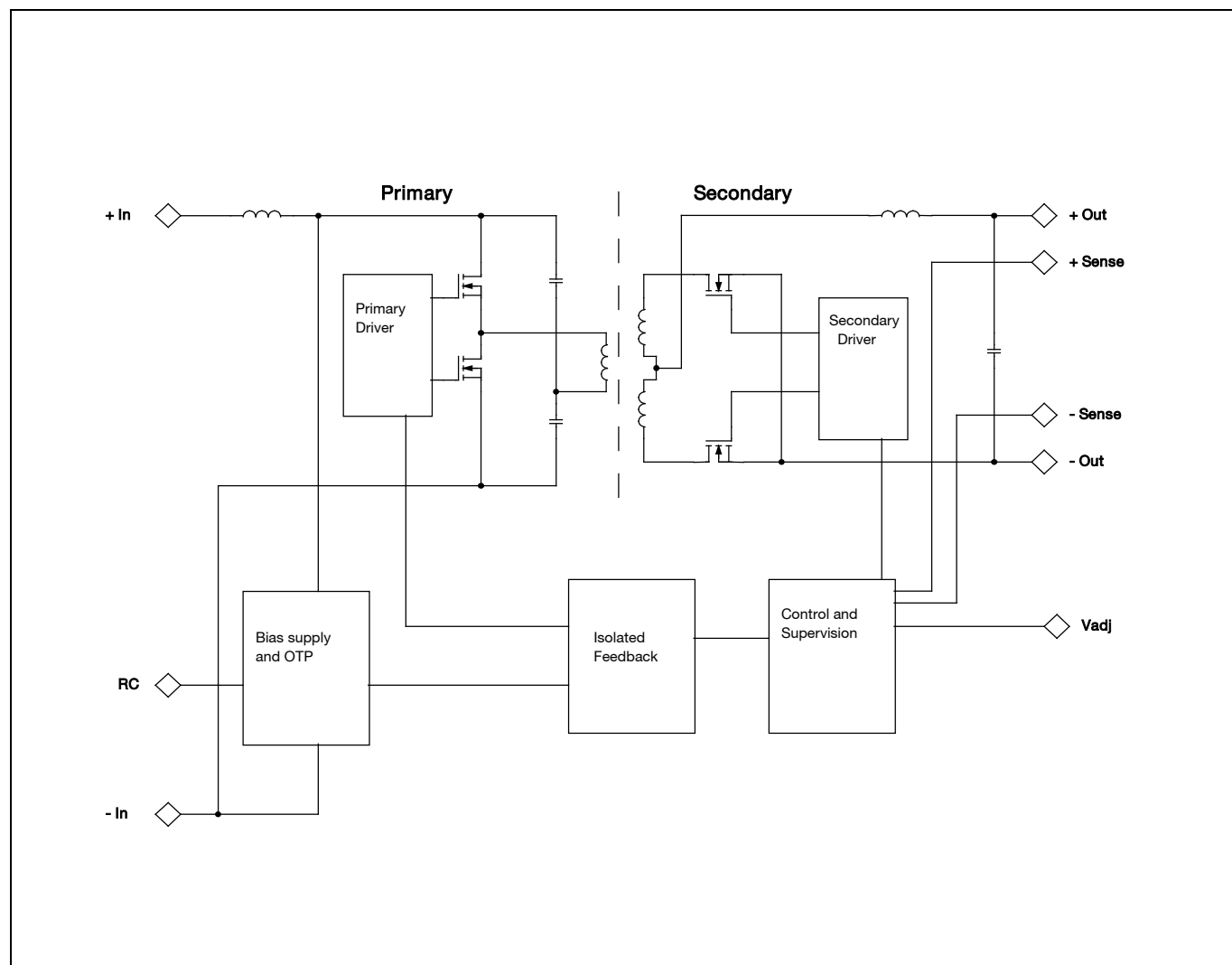
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Absolute Maximum Ratings

Characteristics			min	typ	max	Unit
T _{ref}	Operating Temperature (see Thermal Consideration section)		-40		+120	°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 (Tp 100 ms)				100	V
V _{RC}	Remote Control pin voltage (see Operating Information section)	Positive logic option	0		6	V
		Negative logic option	0		18	V
V _{adj}	Adjust pin voltage (see Operating Information section)		-0.5		2xV _{oi}	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 of Output data or Electrical Characteristics. If exposed to stress above these limits, function and performance may degrade in an unspecified manner.

Fundamental Circuit Diagram


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Input 36-75 V, Output up to 25 A / 82.5 W

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2.5 V/25 A Electrical Specification

PKM 4619E PI

$T_{ref} = -40$ to $+90^{\circ}\text{C}$, $V_I = 36$ to 75 V, sense pins connected to output pins unless otherwise specified under Conditions.
Typical values given at: $T_{ref} = +25^{\circ}\text{C}$, $V_I = 53$ V, max I_O , unless otherwise specified under Conditions.

Characteristics	Conditions	min	typ	max	Unit
V_I	Input voltage range	36		75	V
V_{loff}	Turn-off input voltage	28	31	33	V
V_{lon}	Turn-on input voltage	32	34	36	V
C_I	Internal input capacitance		1		μF
P_O	Output power	0		62.5	W
SVR	Supply voltage rejection (ac)	$f = 100$ Hz sinewave, 1 Vp-p		70	dB
η	Efficiency	50 % of max I_O	90		%
		max I_O	88		
		50 % of max I_O , $V_I = 48$ V	90		
		max I_O , $V_I = 48$ V	88		
P_d	Power Dissipation	max I_O	8.6	12	W
P_{li}	Input idling power	$I_O = 0$ A, $V_I = 53$ V	1.3		W
P_{RC}	Input standby power	$V_I = 53$ V (turned off with RC)	0.1		W
f_s	Switching frequency	0-100 % of max I_O	175		kHz

V_{Oi}	Output voltage initial setting and accuracy	$T_{ref} = +25^{\circ}\text{C}$, $V_I = 53$ V, $I_O = 25$ A	2.45	2.50	2.55	V
V_O	Output adjust range	See operating information	2.25		2.75	V
	Output voltage tolerance band	10-100% of max I_O	2.42		2.58	V
	Idling voltage	$I_O = 0$ A	2.42		2.58	V
	Line regulation	max I_O		0	10	mV
	Load regulation	$V_I = 53$ V, 1-100% of max I_O		2	10	mV
V_{tr}	Load transient voltage deviation	$V_I = 53$ V, Load step 25-75-25 % of max I_O , $di/dt = 0.5$ A/ μs , see Note 1		± 350		mV
t_{tr}	Load transient recovery time			50		μs
t_r	Ramp-up time (from 10-90 % of V_{Oi})	10-100% of max I_O , $T_{ref} = 25^{\circ}\text{C}$, $V_I = 53$ V		6	10	ms
t_s	Start-up time (from V_I connection to 90% of V_{Oi})			8	15	ms
t_f	Vin shutdown fall time (from V_I off to 10% of V_O)	max I_O		0.1		ms
		$I_O = 0$ A		20		s
t_{RC}	RC start-up time	max I_O		8		ms
		max I_O		0.1		ms
		$I_O = 0$ A		20		s
I_O	Output current		0		25	A
I_{lim}	Current limit threshold	$V_O = 2.4$ V, $T_{ref} < \text{max } T_{ref}$	26	29	34	A
I_{sc}	Short circuit current	$T_{ref} = 25^{\circ}\text{C}$, $V_O < 0.2$ V		34	38	A
V_{Oac}	Output ripple & noise	See ripple & noise section, max I_O , V_{Oi}		40	100	mVp-p
OVP	Over voltage protection	$T_{ref} = +25^{\circ}\text{C}$, $V_I = 53$ V, 10-100% of max I_O	3.5		5.0	V

Note 1: Output filter according to Ripple & Noise section

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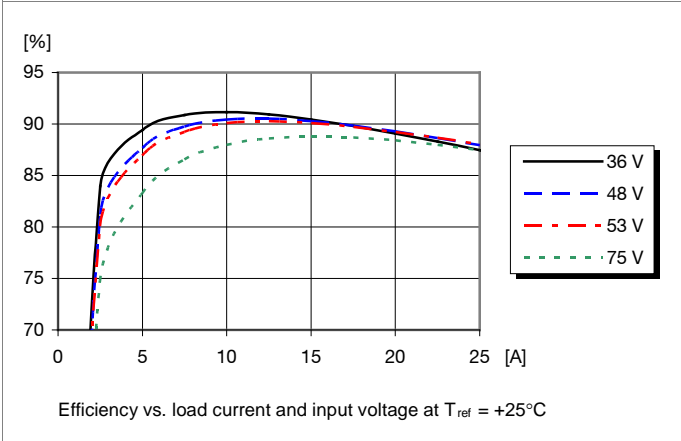
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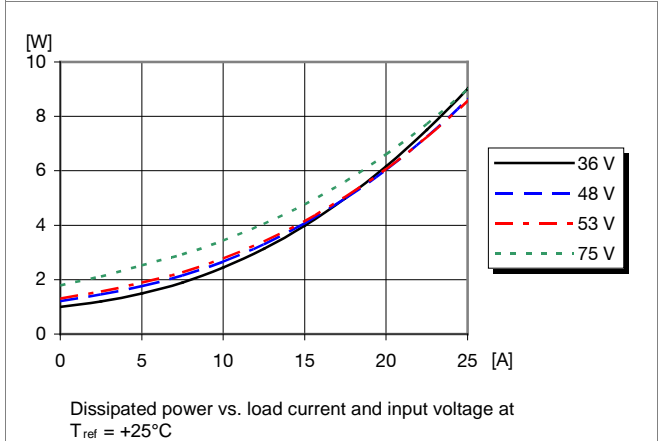
2.5 V/25 A Typical Characteristics

PKM 4619E PI

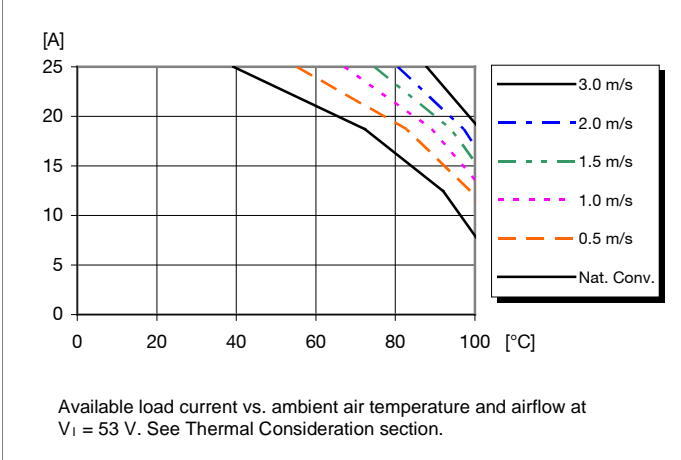
Efficiency



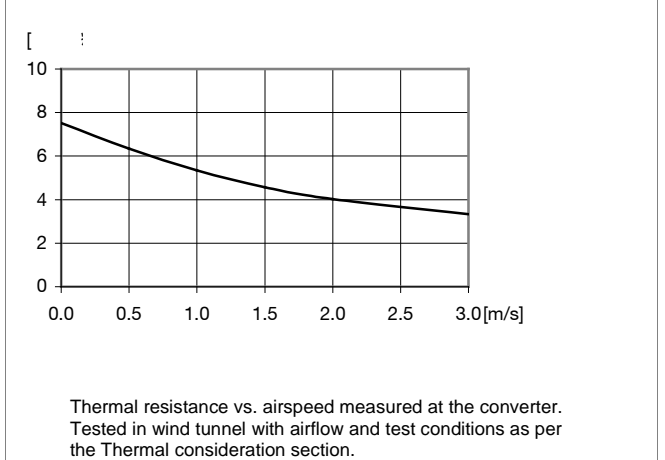
Power Dissipation



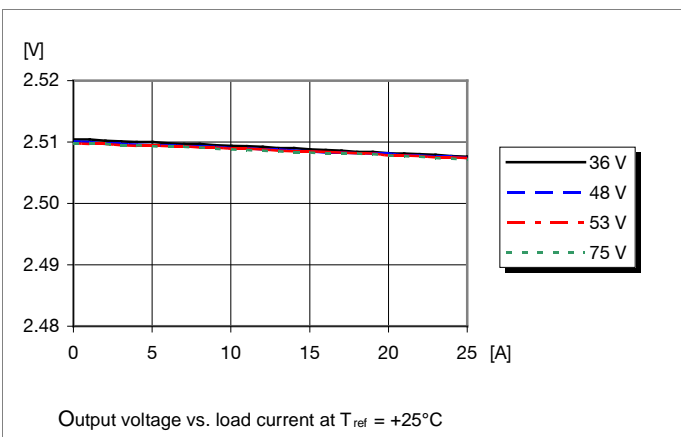
Output Current Derating



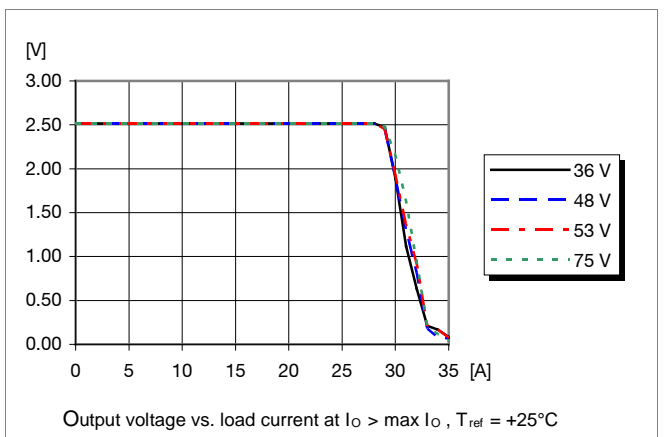
Thermal Resistance



Output Characteristics



Current Limit Characteristics



PKM 4000E PI series Direct Converters
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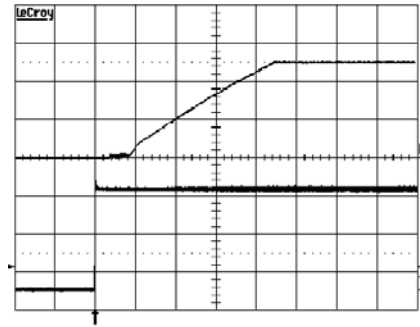
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2.5 V/25 A Typical Characteristics

PKM 4619E PI

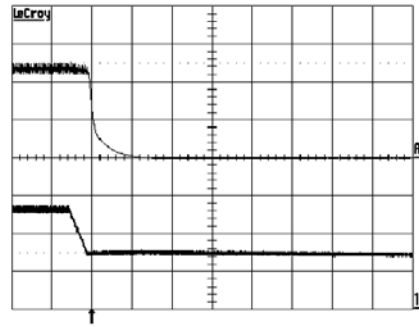
Start-up



Start-up enabled by connecting V_I at:
 $T_{ref} = +25^\circ\text{C}$, $V_I = 53\text{ V}$,
 $I_O = 25\text{ A}$ resistive load.

Top trace: output voltage (1 V/div.).
Bottom trace: input voltage (20 V/div.).
Time scale: (2 ms/div.).

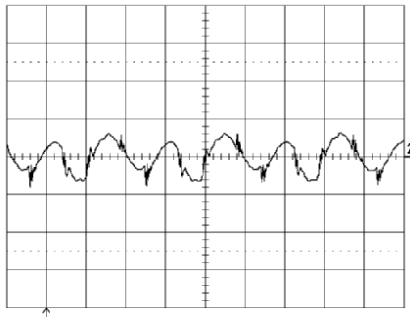
Shut-down



Shut-down enabled by disconnecting V_I at:
 $T_{ref} = +25^\circ\text{C}$, $V_I = 53\text{ V}$,
 $I_O = 25\text{ A}$ resistive load.

Top trace: output voltage (1 V/div.).
Bottom trace: input voltage (20 V/div.).
Time scale: (0.1 ms/div.).

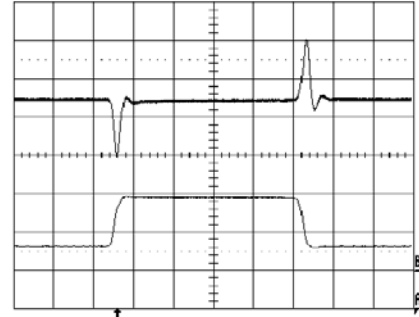
Output Ripple & Noise



Output voltage ripple at:
 $T_{ref} = +25^\circ\text{C}$, $V_I = 53\text{ V}$,
 $I_O = 25\text{ A}$ resistive load.

Trace: output voltage (20mV/div.).
Time scale: (5 μs/div.).

Output Load Transient Response



Output voltage response to load current step-change (6.25-18.75-6.25 A) at:
 $T_{ref} = +25^\circ\text{C}$, $V_I = 53\text{ V}$.

Top trace: output voltage (200mV/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:

$$R_{adj} = 5.11 \times \left(\frac{2.5(100 + \Delta\%)}{1.225 \times \Delta\%} - \frac{(100 + 2 \times \Delta\%)}{\Delta\%} \right) \text{ k}\Omega$$

Example: Increase 4% $\Rightarrow V_{out} = 2.6\text{ Vdc}$

$$5.11 \times \left(\frac{2.5(100 + 4)}{1.225 \times 4} - \frac{(100 + 2 \times 4)}{4} \right) \text{ k}\Omega = 133 \text{ k}\Omega$$

Output Voltage Adjust Downwards, Decrease:

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

Example: Decrease 2% $\Rightarrow V_{out} = 2.45\text{ Vdc}$

$$5.11 \times \left(\frac{100}{2} - 2 \right) \text{ k}\Omega = 245 \text{ k}\Omega$$

PKM 4000E PI series Direct Converters
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EN/LZT 146 358 R4A Oct. 2017

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3.3 V/25 A Electrical Specification

PKM 4810E PI

$T_{ref} = -40$ to $+90^{\circ}\text{C}$, $V_I = 36$ to 75 V, sense pins connected to output pins unless otherwise specified under Conditions.

Typical values given at: $T_{ref} = +25^{\circ}\text{C}$, $V_I = 53$ V, max I_O , unless otherwise specified under Conditions.

Characteristics	Conditions	min	typ	max	Unit
V_I	Input voltage range	36		75	V
V_{loff}	Turn-off input voltage	28	31	33	V
V_{lon}	Turn-on input voltage	32	34	36	V
C_I	Internal input capacitance		1		μF
P_O	Output power	0		82.5	W
SVR	Supply voltage rejection (ac)	$f = 100$ Hz sinewave, 1 Vp-p		74	dB
η	Efficiency	50 % of max I_O	92		%
		max I_O	90		
		50 % of max I_O , $V_I = 48$ V	92		
		max I_O , $V_I = 48$ V	90		
P_d	Power Dissipation	max I_O	9.2	14	W
P_{li}	Input idling power	$I_O = 0$ A, $V_I = 53$ V	1.5		W
P_{RC}	Input standby power	$V_I = 53$ V (turned off with RC)	0.1		W
f_s	Switching frequency	0-100 % of max I_O	200		kHz

V_{Oi}	Output voltage initial setting and accuracy	$T_{ref} = +25^{\circ}\text{C}$, $V_I = 53$ V, $I_O = 25$ A	3.23	3.3	3.37	V
V_O	Output adjust range	See operating info and Note 2	2.97		3.63	V
	Output voltage tolerance band	10-100% of max I_O	3.2		3.4	V
	Idling voltage	$I_O = 0$ A	3.2		3.4	V
	Line regulation	max I_O		4	10	mV
	Load regulation	$V_I = 53$ V, 1-100% of max I_O		1	10	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 1		± 400		mV
t_{tr}	Load transient recovery time			50		μs
t_r	Ramp-up time (from 10-90 % of V_{Oi})	10-100% of max I_O , $T_{ref} = 25^{\circ}\text{C}$, $V_I = 53$ V		5.8	10	ms
t_s	Start-up time (from V_I connection to 90% of V_{Oi})			7.9	15	ms
t_f	Vin shutdown fall time (from V_I off to 10% of V_O)	max I_O		0.2		ms
		$I_O = 0$ A		25		s
t_{RC}	RC start-up time	max I_O		7.7		ms
		max I_O		0.2		ms
		$I_O = 0$ A		25		s
I_O	Output current		0		25	A
I_{lim}	Current limit threshold	$V_O = 3.2$ V, $T_{ref} < \text{max } T_{ref}$	26	30	36	A
I_{sc}	Short circuit current	$T_{ref} = 25^{\circ}\text{C}$, $V_O < 0.2$ V		33	38	A
V_{Oac}	Output ripple & noise	See ripple & noise section, max I_O , V_{Oi}		40	100	mVp-p
OVP	Over voltage protection	$T_{ref} = +25^{\circ}\text{C}$, $V_I = 53$ V, 10-100% of max I_O	3.9		6.0	V

Note 1: Output filter according to Ripple & Noise section

Note 2: Output current is limited to 15A to obtain $V_O = 3.63$ V at $V_I = 36$ V.

PKM 4000E PI series Direct Converters
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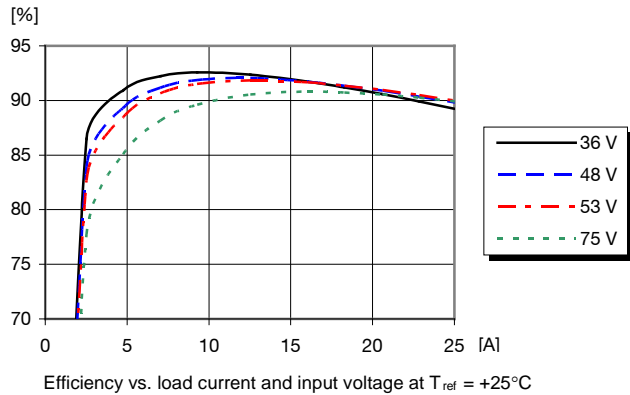
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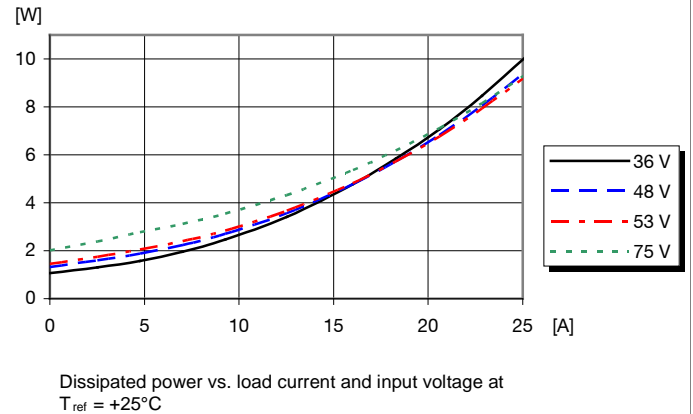
3.3 V/25 A Typical Characteristics

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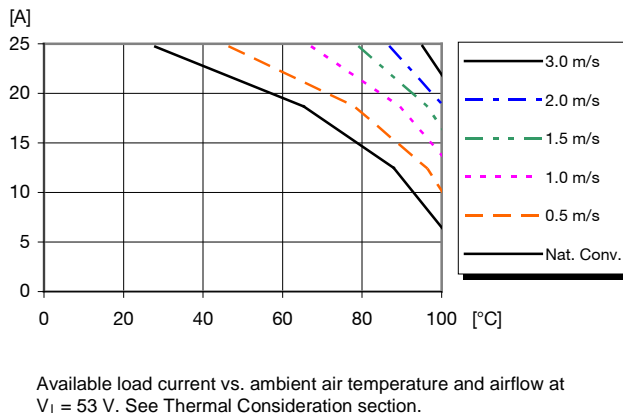
Efficiency



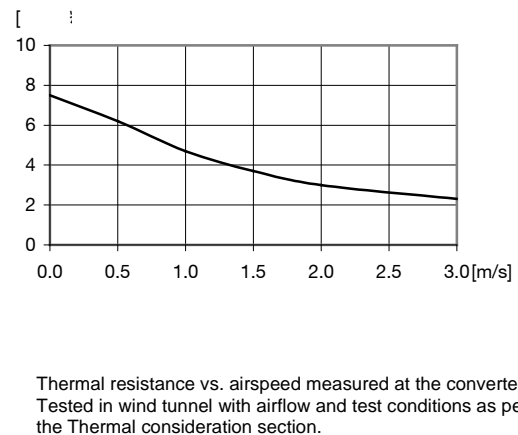
Power Dissipation



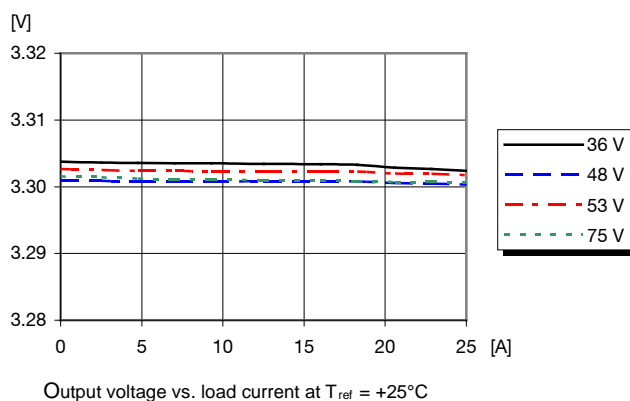
Output Current Derating



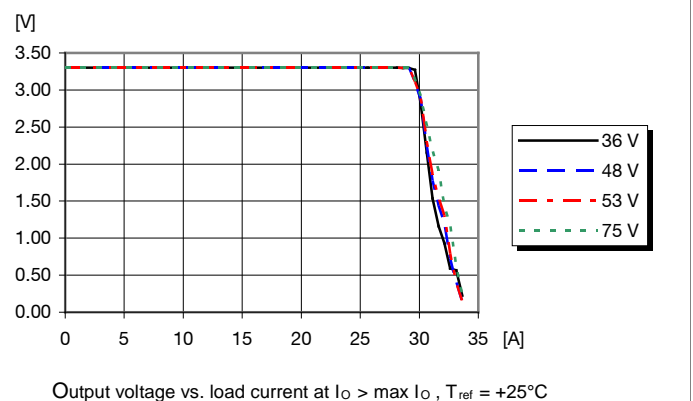
Thermal Resistance



Output Characteristics



Current Limit Characteristics



PKM 4000E PI series Direct Converters
Input 36-75 V, Output up to 25 A / 82.5 W

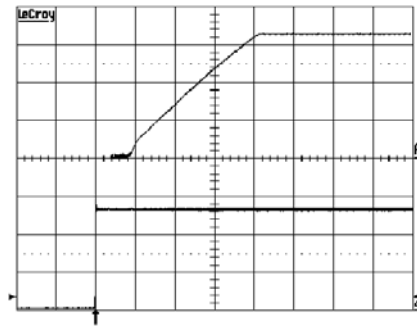
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3.3 V/25 A Typical Characteristics

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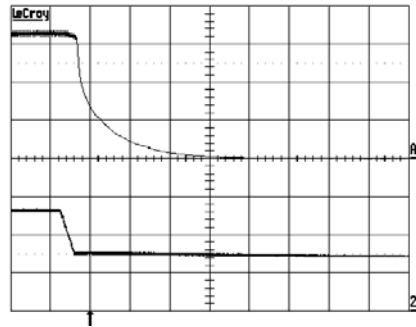
Start-up



Start-up enabled by connecting V_I at:
 $T_{ref} = +25^\circ\text{C}$, $V_I = 53\text{ V}$,
 $I_O = 25\text{ A}$ resistive load.

Top trace: output voltage (1 V/div.).
Bottom trace: input voltage (20 V/div.).
Time scale: (2 ms/div.).

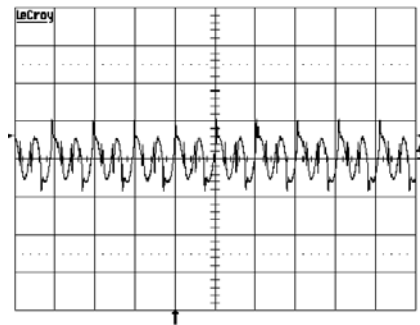
Shut-down



Shut-down enabled by disconnecting V_I at:
 $T_{ref} = +25^\circ\text{C}$, $V_I = 53\text{ V}$,
 $I_O = 25\text{ A}$ resistive load.

Top trace: output voltage (1 V/div.).
Bottom trace: input voltage (20 V/div.).
Time scale: (0.2 ms/div.).

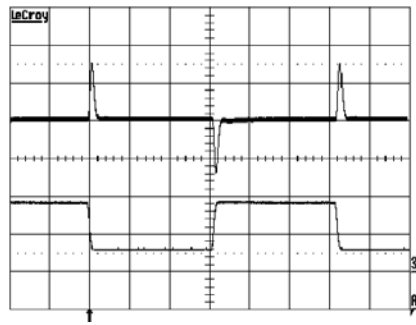
Output Ripple & Noise



Output voltage ripple at:
 $T_{ref} = +25^\circ\text{C}$, $V_I = 53\text{ V}$,
 $I_O = 25\text{ A}$ resistive load.

Trace: output voltage (20mV/div.).
Time scale: (5 μs /div.).

Output Load Transient Response



Output voltage response to load current step-
change (6.25-18.75-6.25 A) at:
 $T_{ref} = +25^\circ\text{C}$, $V_I = 53\text{ V}$.

Top trace: output voltage (200mV/div.).
Bottom trace: load current (10 A/div.).
Time scale: (0.2 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:

$$R_{adj} = 5.11 \times \left(\frac{3.30(100 + \Delta\%)}{1.225 \times \Delta\%} - \frac{(100 + 2 \times \Delta\%)}{\Delta\%} \right) \text{ k}\Omega$$

Example: Increase 4% $\Rightarrow V_{out} = 3.432\text{ Vdc}$

$$5.11 \times \left(\frac{3.30(100 + 4)}{1.225 \times 4} - \frac{(100 + 2 \times 4)}{4} \right) \text{ k}\Omega = 220 \text{ k}\Omega$$

Output Voltage Adjust Downwards, Decrease:

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

Example: Decrease 2% $\Rightarrow V_{out} = 3.234\text{ Vdc}$

$$5.11 \times \left(\frac{100}{2} - 2 \right) \text{ k}\Omega = 245 \text{ k}\Omega$$

PKM 4000E PI series Direct Converters
Input 36-75 V, Output up to 25 A / 82.5 W

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5 V/15 A Electrical Specification

PKM 4711E PI

$T_{ref} = -40$ to $+90^{\circ}\text{C}$, $V_I = 36$ to 75 V, sense pins connected to output pins unless otherwise specified under Conditions.

Typical values given at: $T_{ref} = +25^{\circ}\text{C}$, $V_I = 53$ V, max I_O , unless otherwise specified under Conditions.

Characteristics	Conditions	min	typ	max	Unit
V_I	Input voltage range	36		75	V
V_{loff}	Turn-off input voltage	28	31	33	V
V_{lon}	Turn-on input voltage	32	34	36	V
C_I	Internal input capacitance		1		μF
P_O	Output power	0		75	W
η	Efficiency	50 % of max I_O	91		%
		max I_O	90		
		50 % of max I_O , $V_I = 48$ V	91		
		max I_O , $V_I = 48$ V	90		
P_d	Power Dissipation	max I_O	8.2	12	W
P_{li}	Input idling power	$I_O = 0$ A, $V_I = 53$ V	1.6		W
P_{RC}	Input standby power	$V_I = 53$ V (turned off with RC)	0.1		W
f_s	Switching frequency	0-100 % of max I_O	200		kHz

V_{Oi}	Output voltage initial setting and accuracy	$T_{ref} = +25^{\circ}\text{C}$, $V_I = 53$ V, $I_O = 15$ A	4.9	5.0	5.1	V
V_O	Output adjust range	See operating information and Note 1	4.5		5.5	V
	Output voltage tolerance band	10-100 % of max I_O	4.85		5.15	V
	Idling voltage	$I_O = 0$ A	4.85		5.15	V
	Line regulation	max I_O		2	10	mV
	Load regulation	$V_I = 53$ V, 0-100 % of max I_O		2	10	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	± 400			mV
t_{tr}	Load transient recovery time		50			μs
t_r	Ramp-up time (from 10-90 % of V_{Oi})	10-100 % of max I_O		6	10	ms
t_s	Start-up time (from V_I connection to 90 % of V_{Oi})	$T_{ref} = +25^{\circ}\text{C}$, $V_I = 53$ V		8	15	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		15		s
t_{RC}	RC start-up time	max I_O		6		ms
	RC shut-down fall time (from RC off to 10 % of V_O)	max I_O		0.3		ms
		$I_O = 0$ A		15		s
I_O	Output current		0		15	A
I_{lim}	Current limit threshold	$T_{ref} < \max T_{ref}$, $V_O = 4.9$ V	16	19	23	A
I_{sc}	Short circuit current	$T_{ref} = 25^{\circ}\text{C}$, $V_O < 0.5$ V		22	26	A
V_{Oac}	Output ripple & noise	See ripple & noise section, max I_O , V_{Oi}		40	100	mVp-p
OVP	Over voltage protection	$T_{ref} = +25^{\circ}\text{C}$, $V_I = 53$ V, 10-100 % of max I_O	6.5		10	V

Note 1: Output current is limited to 12A to obtain $V_O = 5.5$ V at $V_I = 36$ V

PKM 4000E PI series Direct Converters
Input 36-75 V, Output up to 25 A / 82.5 W

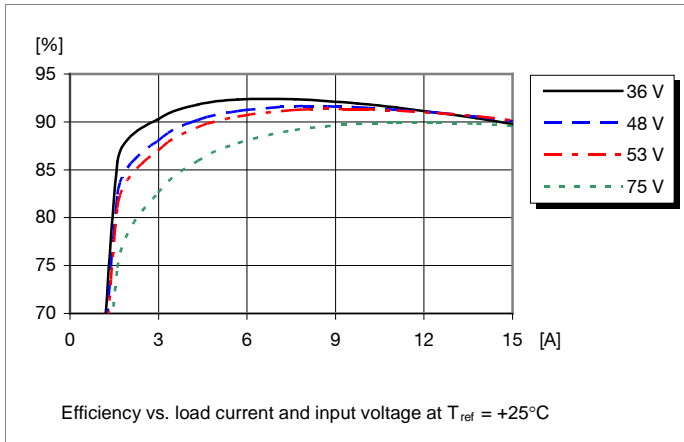
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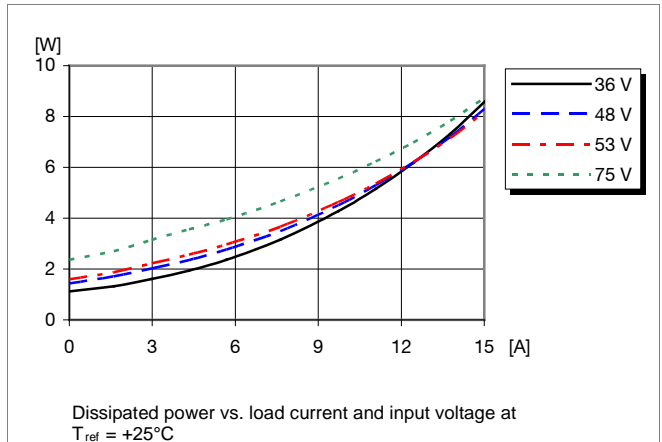
5 V/15 A Typical Characteristics

PKM 4711E PI

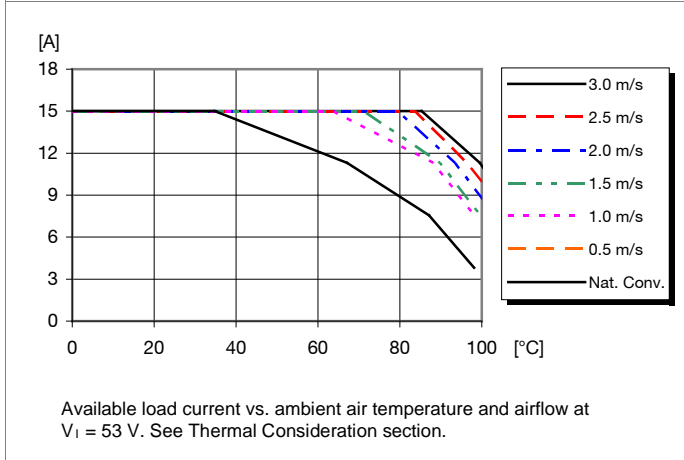
Efficiency



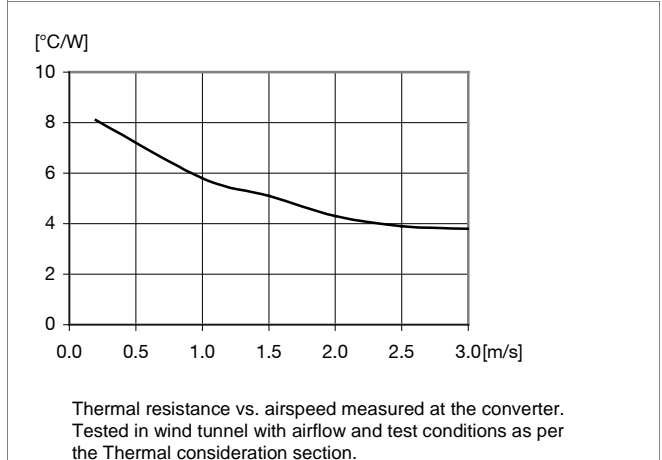
Power Dissipation



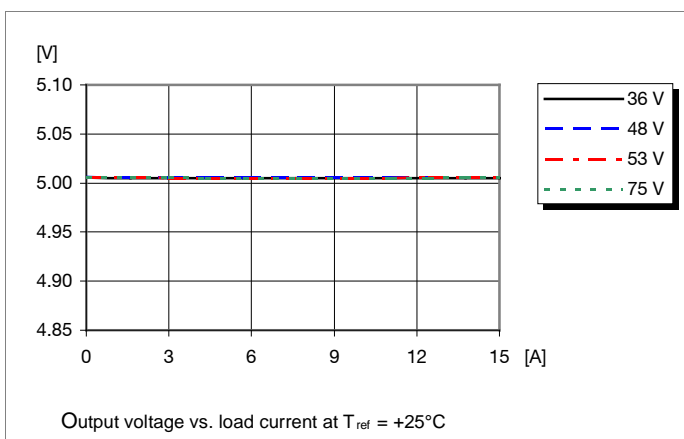
Output Current Derating



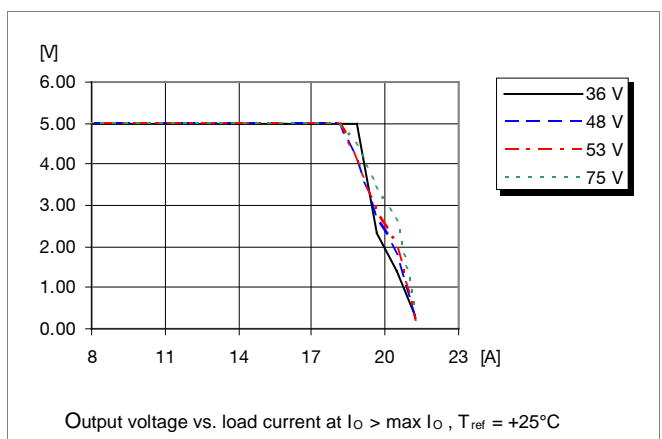
Thermal Resistance



Output Characteristics



Current Limit Characteristics



PKM 4000E PI series Direct Converters
Input 36-75 V, Output up to 25 A / 82.5 W

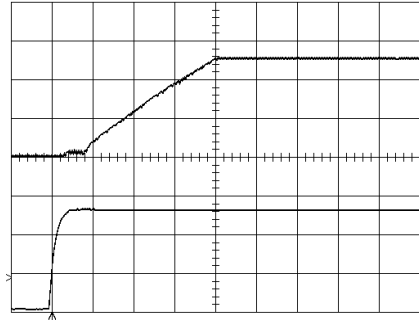
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5 V/15 A Typical Characteristics

PKM 4711E PI

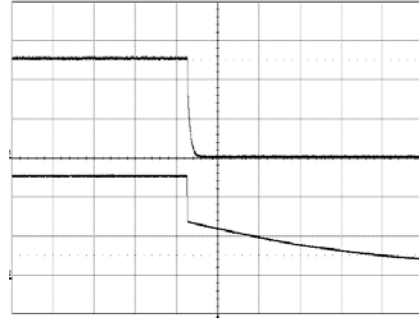
Start-up



Start-up enabled by connecting V_I at:
 $T_{ref} = +25^\circ\text{C}$, $V_I = 53\text{ V}$,
 $I_O = 15\text{ A}$ resistive load.

Top trace: output voltage (2 V/div.).
Bottom trace: input voltage (20 V/div.).
Time scale: (2 ms/div.).

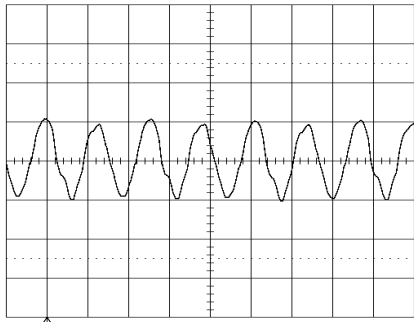
Shut-down



Shut-down enabled by disconnecting V_I at:
 $T_{ref} = +25^\circ\text{C}$, $V_I = 53\text{ V}$,
 $I_O = 15\text{ A}$ resistive load.

Top trace: output voltage (2 V/div.).
Bottom trace: input voltage (20 V/div.).
Time scale: (2 ms/div.).

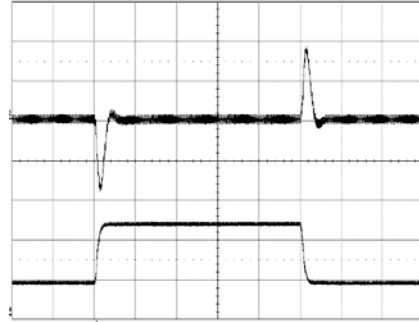
Output Ripple & Noise



Output voltage ripple at:
 $T_{ref} = +25^\circ\text{C}$, $V_I = 53\text{ V}$,
 $I_O = 15\text{ A}$ 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 (3.75-11.25-3.75 A) at:
 $T_{ref} = +25^\circ\text{C}$, $V_I = 53\text{ V}$.

Top trace: output voltage (200 mV/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:

$$R_{adj} = 5.11 \times \left(\frac{5(100 + \Delta\%)}{1.225 \times \Delta\%} - \frac{(100 + 2 \times \Delta\%)}{\Delta\%} \right) \text{ k}\Omega$$

Example: Increase 4% $\Rightarrow V_{out} = 5.2\text{ Vdc}$

$$5.11 \times \left(\frac{5(100 + 4)}{1.225 \times 4} - \frac{(100 + 2 \times 4)}{4} \right) \text{ k}\Omega = 404 \text{ k}\Omega$$

Output Voltage Adjust Downwards, Decrease:

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

Example: Decrease 2% $\Rightarrow V_{out} = 4.9\text{ Vdc}$

$$5.11 \times \left(\frac{100}{2} - 2 \right) \text{ k}\Omega = 245 \text{ k}\Omega$$

PKM 4000E PI series Direct Converters
Input 36-75 V, Output up to 25 A / 82.5 W

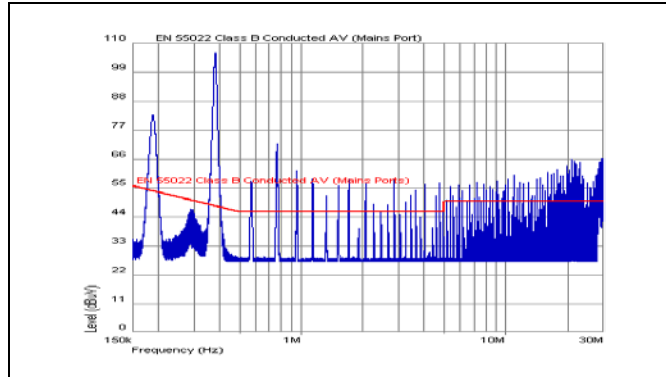
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EMC Specification

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 4810E PI @ $V_I = 53$ V, max I_O .

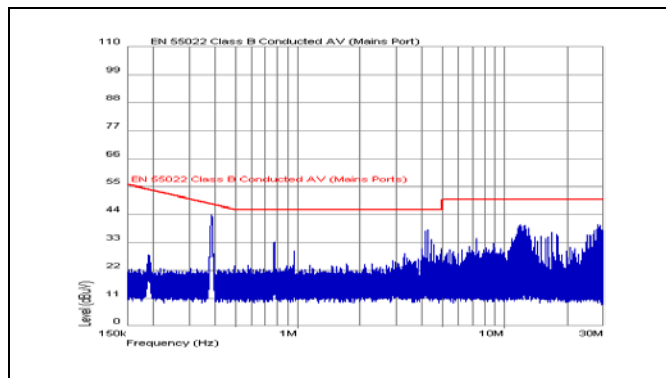
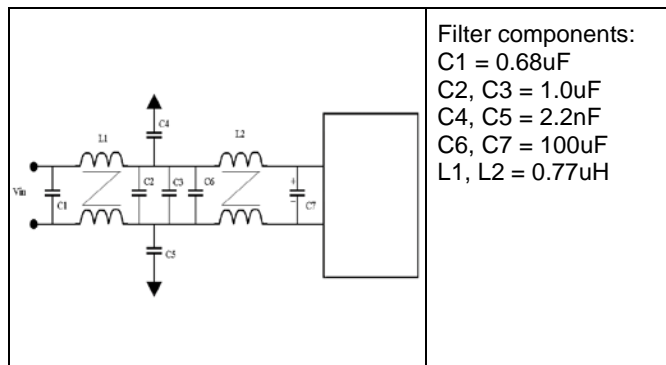
Conducted EMI Input terminal value (typ)



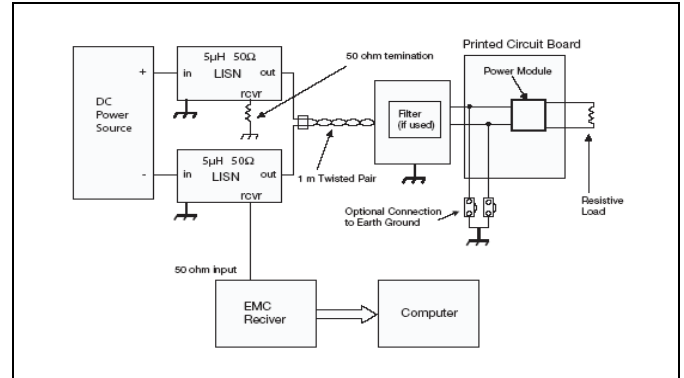
EMI without filter

External filter (class B)

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



EMI with filter



Test set-up

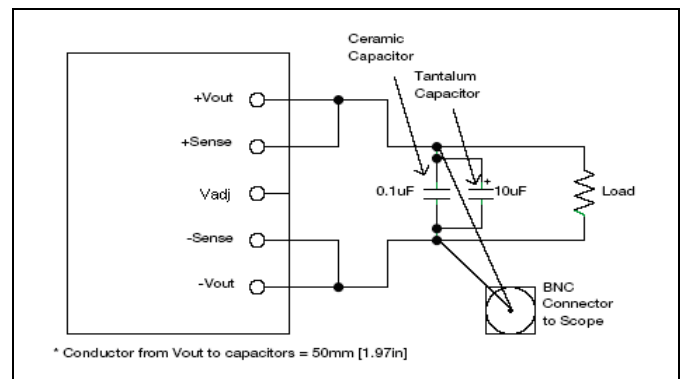
Layout recommendation

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

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

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

PKM 4000E PI series Direct Converters
Input 36-75 V, Output up to 25 A / 82.5 W

EN/LZT 146 358 R4A Oct. 2017

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Operating information

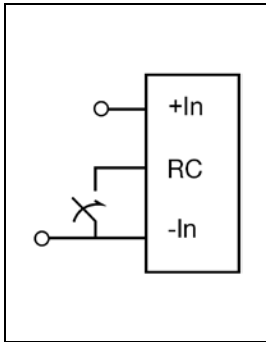
Input Voltage

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_{ref} must be limited to absolute max +90°C. The absolute maximum continuous input voltage is 80 Vdc.

Turn-off Input Voltage

The DC/DC converters 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 2V.

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 converter to be turned on/off by an external device like a semiconductor or mechanical switch. When the RC pin is left open, the voltage generated on the RC pin is 7-8 V.

The standard converter is provided with “negative logic” remote control and will be off until the RC pin is connected to the minus input. To turn on the converter the voltage between RC pin and minus input should be less than 1V. To turn off the converter the RC pin should be left open, or connected to a voltage higher than 4V referenced to minus input. In situations where it is desired to have the converter power up automatically without the need for control signals or a switch, the RC pin can be wired directly to the -Input circuit on the application board.

The second option is “positive logic” remote control, which can be ordered by adding the suffix “P” to the end of the part number. The converter will turn on when the input voltage is applied with the RC pin open. 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 converter will restart automatically when this connection is opened.

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. Ceramic capacitors will also reduce any high frequency noise at the load.

It is equally important to use low resistance and low inductance PCB layouts and cabling.

External decoupling capacitors will become part of the control loop of the DC/DC converter and may affect the stability margins. As a “rule of thumb”, 100 μ F/A of output current can be added without any additional analysis. The ESR of the capacitors is a very important parameter. Power Modules guarantee stable operation with a verified ESR value of >10 m Ω across the output connections.

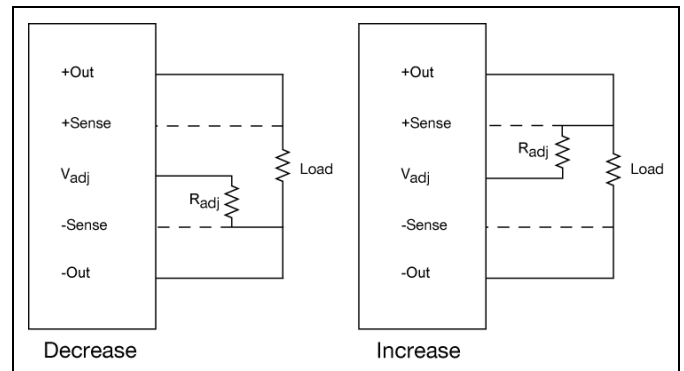
For further information please contact your local Flex Power Modules representative.

Output Voltage Adjust (V_{adj})

The DC/DC converters 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 converter from shutting down. At increased output voltages the maximum power rating of the converter 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.



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

PKM 4000E PI series Direct Converters
Input 36-75 V, Output up to 25 A / 82.5 W

EN/LZT 146 358 R4A Oct. 2017

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Operating information continued

Parallel Operation

Two converters may be paralleled for redundancy if external o-ring diodes are used in series with the output. It is not recommended to parallel the converters without using external current sharing circuits.

Remote Sense

The DC/DC converters have remote sense that can be used to compensate for moderate amounts of resistance in the distribution system and allow for voltage regulation at the load or other selected point. The remote sense lines will carry very little current and do not need a large cross sectional area. However, the sense lines on PCB should be located close to a ground trace or ground plane. In a discrete wiring situation, the use of twisted pair wires or other technique to reduce noise susceptibility is highly recommended. The remote sense circuitry will compensate for up to 10% voltage drop between the sense voltage and the voltage at the output pins. The output voltage and the remote sense voltage offset must be less than the minimum over voltage trip point. If the remote sense is not needed the -Sense should be connected to -Out and +Sense should be connected to +Out.

Over Temperature Protection (OTP)

The converters are protected from thermal overload by an internal over temperature shutdown circuit. When the PCB temperature close to the PWM control circuit exceeds 130°C the converter will shut down immediately. The converter will restart when the temperature drops below 120°C.

Over Voltage Protection (OVP)

The converters have output over voltage protection that will shut down the converter in over voltage conditions. The converter 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 converters include current limiting circuitry for protection at continuous overload.

The output voltage will decrease towards zero for output currents in excess of max output current (max I_o). The converter will resume normal operation after removal of the overload. The load distribution should be designed for the maximum output short circuit current specified.

Input and Output Impedance

The impedance of both the input source and the load will interact with the impedance of the DC/DC converter. It is important that the input source has low characteristic impedance. The converters 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 100 µF capacitor

across the input of the converter will ensure stable operation. The capacitor is not required when powering the DC/DC converter from an input source with an inductance below 10 µH.

Thermal Consideration

General

The converters are designed to operate in different thermal environments and sufficient cooling must be provided to ensure reliable operation. Cooling is achieved mainly by conduction, from the pins to the host board, and convection, which is dependant on the airflow across the converter. Increased airflow enhances the cooling of the converter.

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_{in} = 53 V.

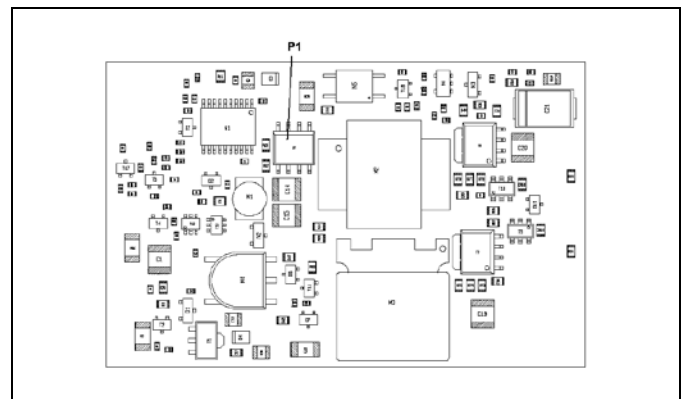
The DC/DC converter is tested on a 254 x 254 mm, 35 µm (1 oz), 8-layer test board mounted vertically in a wind tunnel with a cross-section of 305 x 305 mm.

Proper cooling of the DC/DC converter can be verified by measuring the temperature at positions P1. The temperature at this position should not exceed the max values provided in the table below.

Note that the max value is the absolute maximum rating (non destruction) and that the electrical Output data is guaranteed up to T_{ref} +90°C.

See Design Note 019 for further information.

Position	Device	Designation	max value
P ₁	Mosfet	T _{ref}	120° C



PKM 4000E PI series Direct Converters

Input 36-75 V, Output up to 25 A / 82.5 W

EN/LZT 146 358 R4A Oct. 2017

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Thermal Consideration continued

The PKM4000E series DC/DC converters can be ordered with a heatsink (HS) option. The heatsink option have approximately 5 °C improved derating compared with the PKM4000E without heatsink. The HS option is intended to be mounted on a cold wall or heatsink to transfer heat away from the converter and further improve the cooling of the converter.

Definition of reference temperature (T_{ref})

The reference temperature is used to monitor the temperature limits of the product. Temperatures above maximum T_{ref} are not allowed and may cause degradation or permanent damage to the product. T_{ref} is also used to define the temperature range for normal operating conditions.

T_{ref} is defined by the design and used to guarantee safety margins, proper operation and high reliability of the module.

Ambient Temperature Calculation

By using the thermal resistance the maximum allowed ambient temperature can be calculated.

1. The power loss is calculated by using the formula $((1/\eta) - 1) \times \text{output power} = \text{power losses (Pd)}$.
 η = efficiency of converter. E.g 90 % = 0.90

2. Find the thermal resistance (R_{th}) in the Thermal Resistance graph found in the Output section for each model.
 Calculate the temperature increase (ΔT).
 $\Delta T = R_{th} \times P_d$

3. Max allowed ambient temperature is:
 $\text{Max } T_{ref} - \Delta T$.

E.g PKM 4810E PI at 1m/s:

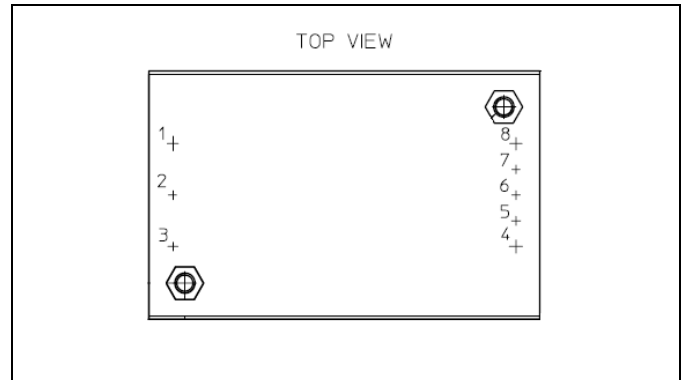
$$1. ((\frac{1}{0.90}) - 1) \times 82.5 \text{ W} = 9.17 \text{ W}$$

$$2. 9.17 \text{ W} \times 4.7^\circ\text{C/W} = 43.1^\circ\text{C}$$

$$3. 120^\circ\text{C} - 43.1^\circ\text{C} = \text{max ambient temperature is } 76.9^\circ\text{C}$$

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

Connections



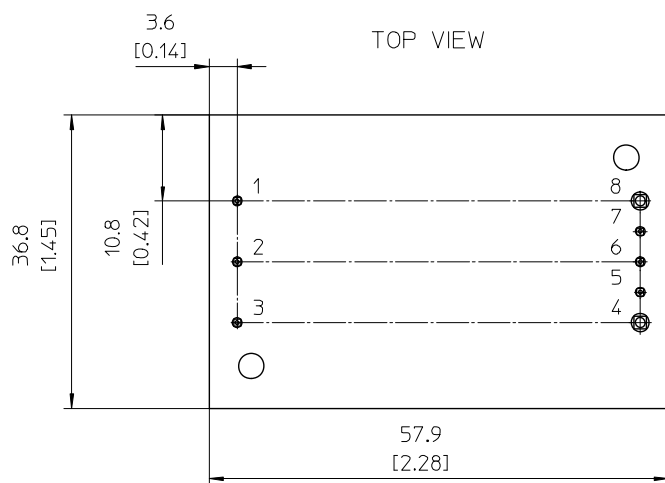
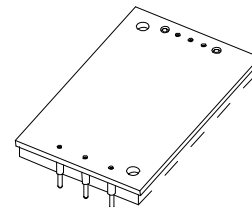
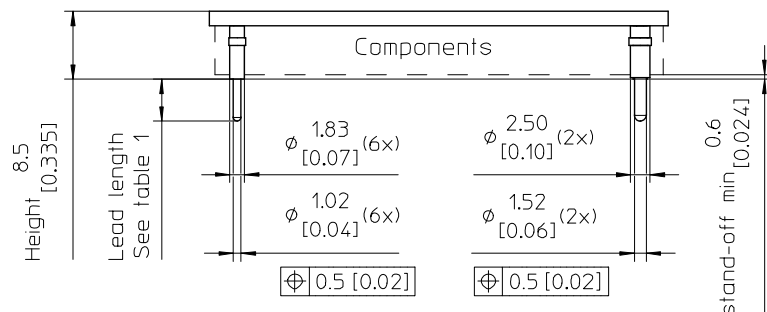
Pin	Designation	Function
1	+In	Positive input
2	RC	Remote Control
3	-In	Negative input
4	- Out	Negative output
5	- Sense	Negative sense
6	Vadj	Output voltage adjust
7	+ Sense	Positive sense
8	+ Out	Positive output

PKM 4000E PI series Direct Converters
Input 36-75 V, Output up to 25 A / 82.5 W

EN/LZT 146 358 R4A Oct. 2017

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Mechanical Information- Open Frame Version



Recommended footprint - TOP VIEW

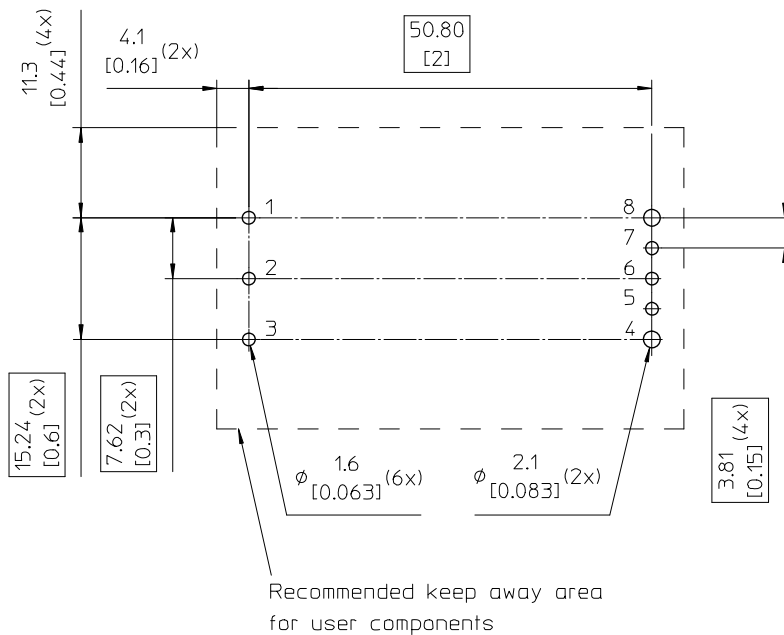


Table 1

Pin option	Lead Length
Standard	5.25 [0.207]
LA	3.69 [0.145]

Weight: Typical 24g

Pins:

Material: Brass

Plating: 0.1 μ m Gold over 2 μ m Nickel

All dimensions are in mm [inches]

Tolerances unless specified

x.x mm ± 0.5 mm [0.02]

x.xx mm ± 0.25 mm [0.01]

Not applied on the recommended footprint



PKM 4000E PI series Direct Converters
Input 36-75 V, Output up to 25 A / 82.5 W

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Mechanical Information- Base Plate Version

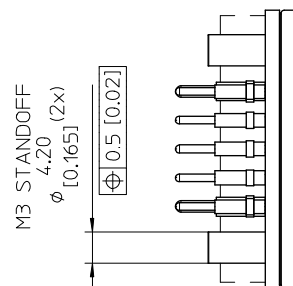
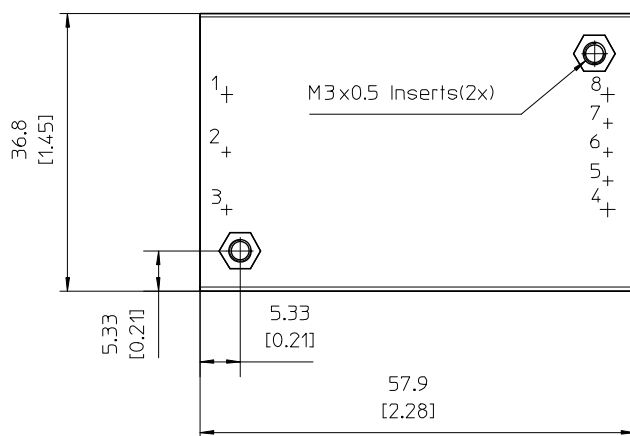
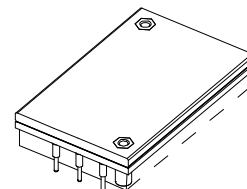
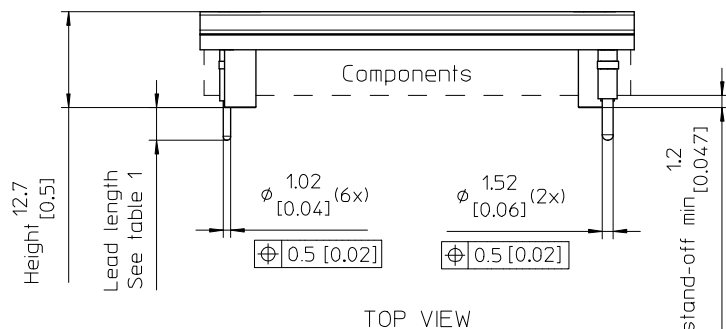
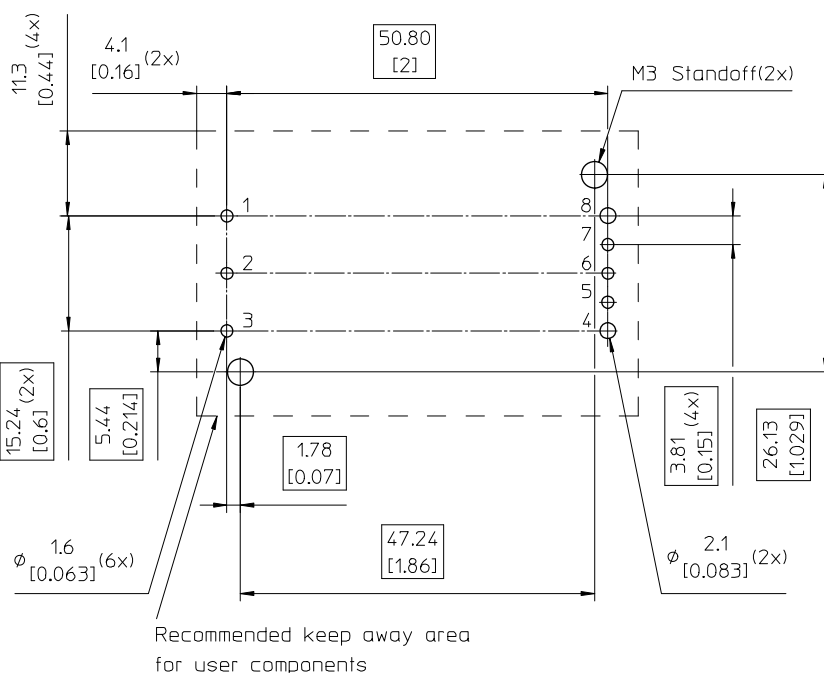


Table 1

Pin option	Lead Length
Standard	4.35 [0.171]
LA	2.79 [0.109]



Weight: Typical 44g

Case: Aluminium base plate.
For screw attachment, apply mounting
Torque of max 0.44 Nm [3.9 IN-LBS]

Pins:
Material: Brass
Plating: 0.1 μ m Gold over 2 μ m Nickel

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

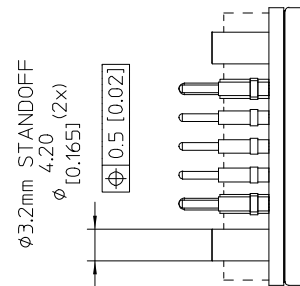
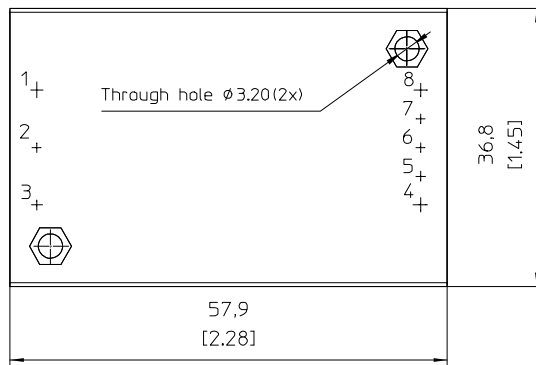
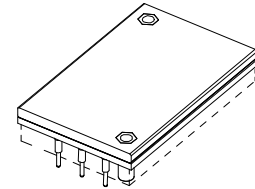
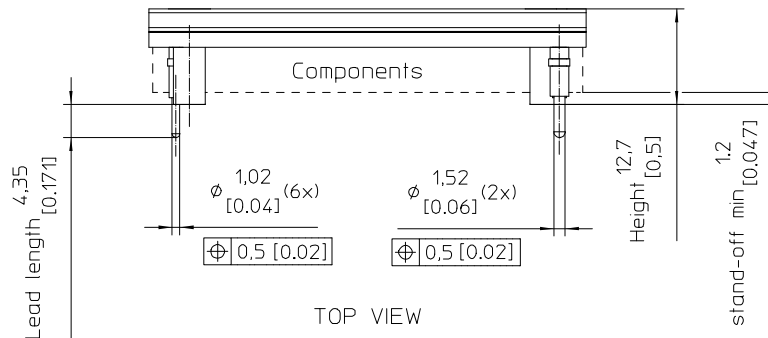


PKM 4000E PI series Direct Converters
Input 36-75 V, Output up to 25 A / 82.5 W

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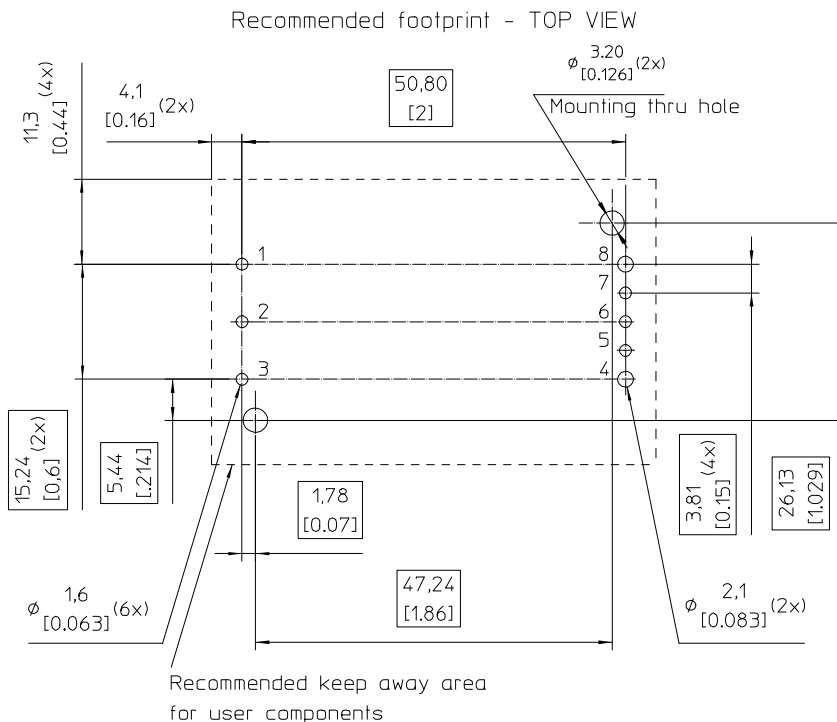
Mechanical Information – Base plate version with non-threaded inserts



Weight: Typical 46g

Case: Aluminium base plate. Black anodized
For screw attachment, apply mounting
Torque of max 0.44 Nm [3.9 IN-LBS]

Pins:
Material: Brass
Plating: 0,1 μ m Gold over 2 μ m Nickel



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



PKM 4000E PI series Direct Converters
Input 36-75 V, Output up to 25 A / 82.5 W

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Soldering Information – Through hole mounting

The product is intended for through hole mounting in a PCB. When wave soldering is used, the temperature on the pins is specified to maximum 260 °C for maximum 10 seconds.

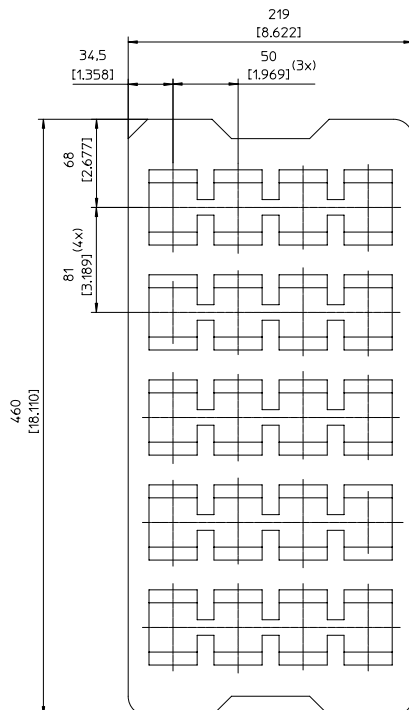
Maximum preheat rate of 4 °C/s and temperature of max 150 °C is suggested. When hands soldering care should be taken to avoid direct contact between the hot soldering iron tip and the pins for more than a few seconds in order to prevent overheating.

A no-clean (NC) flux is recommended to avoid entrapment of cleaning fluids in cavities inside of the DC/DC power module. The residues may affect long time reliability and isolation voltage.

Delivery package information

The products are delivered in antistatic trays.

Tray specifications	
Material	Polyethylene foam, dissipative
Surface resistance	$10^5 < \Omega/\text{square} < 10^{12}$
Bake ability	The trays are not bakeable
Tray capacity	20 products/tray
Tray height	25.4 mm [1.0 inch]
Box capacity	60 products (3 full trays/box)
Tray weight	80 g empty, 960 g full (Base plated products) 560 g full (Open frame products)



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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 1000 15 min/0-1 min
Cold (in operation)	IEC 60068-2-1 Ad	Temperature T _A Duration	-45 °C 72 h
Damp heat	IEC 60068-2-67 Cy	Temperature Humidity Duration	+85 °C 85 % RH 1000 hours
Dry heat	IEC 60068-2-2 Bd	Temperature Duration	+125 °C 1000 h
Electrostatic discharge susceptibility	IEC 61340-3-1, JESD 22-A114 IEC 61340-3-2, JESD 22-A115	Human body model (HBM) Machine model (MM)	Class 2, 2000 V Class 3, 200 V
Immersion in cleaning solvents	IEC 60068-2-45 XA Method 2	Water Glycol ether Isopropanol	+55 ±5 °C +35 ±5 °C +35 ±5 °C
Mechanical shock	IEC 60068-2-27 Ea	Peak acceleration Duration Pulse shape Directions Number of pulses	100 g 6 ms Half sine 6 18 (3 + 3 in each perpendicular direction)
Moisture reflow sensitivity	J-STD-020C	Level 1 (SnPb-eutectic) Level 3 (Pb Free)	225 +0 -5 °C 260 +0 -45 °C
Operational life test	MIL-STD-202G method 108A	Duration	1000 h
Resistance to soldering heat	IEC 60068-2-20 Tb Method 1A	Solder temperature Duration	270 °C 10-13 s
Robustness of terminations	IEC 60068-2-21 Test Ua1		All leads
Solderability	IEC 60068-2-20 Test Ta	Preconditioning Temperature, SnPb Eutectic Temperature, Pb-free	Steam ageing for 1 h 235 °C 260 °C
Vibration, broad band random	IEC 60068-2-64 Fh method 1	Frequency Spectral density Duration	10 to 500 Hz 0.07 g ² /Hz 10 min in each 3 perpendicular directions