PKM 7000A series Direct Converters
Input 66-160 V, Output up to 12.5 A / 150 W

Key Features
- Industry standard case dimensions 57.91 x 36.8 x 12.7 mm (2.28 x 1.45 x 0.5 in)
- High efficiency, typ. 89% at 24 Vout Full load
- 3000 Vdc input to output isolation
- Meets requirements according to IEC/EN/UL 60950-1
- MTBF 4 Mh
- Compliant to EN50155

General Characteristics
- Input under voltage shutdown
- Monotonic startup
- Remote control
- Output over voltage protection
- Over temperature protection
- Output short-circuit protection
- Output voltage adjust function
- ISO 9001/14001 certified supplier

Safety Approvals
- Design for Environment
- Meets requirements in high-temperature lead-free soldering processes.

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Technical Specification
28701-BMR 711 Rev. F March 2019
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Ordering Information

<table>
<thead>
<tr>
<th>Product program</th>
<th>Output</th>
</tr>
</thead>
<tbody>
<tr>
<td>PKM 7111A PIP</td>
<td>5V, 20A / 100 W</td>
</tr>
<tr>
<td>PKM 7113A PIP</td>
<td>12V, 8.3A / 100 W</td>
</tr>
<tr>
<td>PKM 7115A PIP</td>
<td>15V, 6.67A / 100 W</td>
</tr>
<tr>
<td>PKM 7116A PIP</td>
<td>24V, 4.16A / 100 W</td>
</tr>
<tr>
<td>PKM 7116JA PIP</td>
<td>48V, 2.08A / 100W</td>
</tr>
<tr>
<td>PKM 7213A PIP</td>
<td>12V, 12.5A / 150 W</td>
</tr>
<tr>
<td>PKM 7215A PIP</td>
<td>15V, 10A / 150 W</td>
</tr>
<tr>
<td>PKM 7216A PIP</td>
<td>24V, 6.25A / 150 W</td>
</tr>
<tr>
<td>PKM 7216HA PIP</td>
<td>54V, 2.78A / 150 W</td>
</tr>
</tbody>
</table>

Product number and Packaging

PKM7XXX n1n2n3

<table>
<thead>
<tr>
<th>Options</th>
<th>n1</th>
<th>n2</th>
<th>n3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mounting</td>
<td>o</td>
<td>o</td>
<td>o</td>
</tr>
<tr>
<td>Remote Control logic</td>
<td>o</td>
<td>o</td>
<td>o</td>
</tr>
<tr>
<td>Baseplate</td>
<td>o</td>
<td>o</td>
<td>o</td>
</tr>
</tbody>
</table>

Example a 150W/24V through-hole mounted, logic, standard pin length product with 20mm ½ brick heat sink would be PKM7215ZAPLHS

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

General Information

Reliability
The failure rate (λ) and mean time between failures (MTBF= 1/λ) is calculated at max output power and an operating ambient temperature (Ta) of +25°C. Flex uses Telcordia SR-332 Issue 3 Method 1 to calculate the mean steady-state failure rate and standard deviation (σ).

Telcordia SR-332 Issue 3 also provides techniques to estimate the upper confidence levels of failure rates based on the mean and standard deviation.

<table>
<thead>
<tr>
<th>Mean steady-state failure rate, λ</th>
<th>Std. deviation, σ</th>
</tr>
</thead>
<tbody>
<tr>
<td>237 nFailures/h</td>
<td>107 nFailures/h</td>
</tr>
</tbody>
</table>

MTBF (mean value) for the PKM XXX series = 4 Mh.
MTBF at 90% confidence level = 3.6 Mh

Compatibility with RoHS requirements
The products are compatible with the relevant clauses and requirements of the RoHS directive 2011/65/EU 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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PKM 7000A series Direct Converters
Input 66-160 V, Output up to 12.5 A / 150 W

Safety Specification

General information
Flex DC/DC converters and DC/DC regulators are designed in accordance with the safety standards IEC 60950-1, EN 60950-1 and 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”. Clearence 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 and Safety Certificate 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/EN/UL 60950-1 Safety of Information Technology Equipment. Product related standards, e.g. IEEE 802.3af Power over Ethernet, and ETS-300132-2 Power interface at the input to telecom equipment, operated by direct current (dc) are based on IEC/EN/UL 60950-1 with regards to safety.

Flex DC/DC converters, Power interface modules 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.

Isolated DC/DC converters & Power interface modules
The product may provide basic or functional insulation between input and output according to IEC/EN/UL 60950-1 (see Safety Certificate), different conditions shall be met if the output of a basic or a functional insulated product shall be considered as safety extra low voltage (SELV).

For basic insulated products (see Safety Certificate) the output is considered as safety extra low voltage (SELV) if one of the following conditions is met:
- The input source provides supplementary or double or reinforced insulation from the AC mains according to IEC/EN/UL 60950-1.
- The input source provides functional or basic insulation from the AC mains and the product’s output is reliably connected to protective earth according to IEC/EN/UL 60950-1.

For functional insulated products (see Safety Certificate) the output is considered as safety extra low voltage (SELV) if one of the following conditions is met:
- The input source provides double or reinforced insulation from the AC mains according to IEC/EN/UL 60950-1.
- The input source provides basic or supplementary insulation from the AC mains and the product’s output is reliably connected to protective earth according to IEC/EN/UL 60950-1.
- The input source is reliably connected to protective earth and provides basic or supplementary insulation according to IEC/EN/UL 60950-1 and the maximum input source voltage is 60 Vdc.

Galvanic isolation between input and output is verified in an electric strength test and the isolation voltage (Vin) meets the voltage strength requirement for basic insulation according to IEC/EN/UL 60950-1.

It is recommended to use a slow blow fuse 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
Absolute Maximum Ratings

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>min</th>
<th>typ</th>
<th>max</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>$T_{P1}$ Operating Temperature</td>
<td>-40</td>
<td>+115</td>
<td></td>
<td>°C</td>
</tr>
<tr>
<td>$T_{S}$ Storage temperature</td>
<td>-55</td>
<td>+125</td>
<td></td>
<td>°C</td>
</tr>
<tr>
<td>$V_I$ Input voltage</td>
<td>66</td>
<td></td>
<td>160</td>
<td>V</td>
</tr>
<tr>
<td>$C_{out}$ Output capacitance</td>
<td>100</td>
<td></td>
<td>5000</td>
<td>µF</td>
</tr>
<tr>
<td>$V_{iso}$ Isolation voltage</td>
<td>4000</td>
<td></td>
<td></td>
<td>VdC</td>
</tr>
<tr>
<td>$V_{iso}$ Isolation voltage</td>
<td>2250</td>
<td></td>
<td></td>
<td>VdC</td>
</tr>
<tr>
<td>$V_{iso}$ Isolation voltage</td>
<td>1500</td>
<td></td>
<td></td>
<td>VdC</td>
</tr>
<tr>
<td>$V_{tr}$ Input voltage transient</td>
<td>200</td>
<td></td>
<td></td>
<td>VdC</td>
</tr>
<tr>
<td>$V_{adj}$ Adjust pin voltage</td>
<td>0.9V</td>
<td>1.1V</td>
<td></td>
<td>V</td>
</tr>
<tr>
<td>$V_{RC}$ Remote Control pin</td>
<td>0</td>
<td>8</td>
<td></td>
<td>V</td>
</tr>
<tr>
<td>(see Operating Information section)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Stresses above those listed under Absolute Maximum Ratings may cause permanent damage to the device. This is a stress rating only; functional operation of the device at these or any other conditions above those indicated in the Electrical Specification section of this specification is not implied. Exposure to absolute maximum rating conditions for extended periods may affect device reliability.

Fundamental Circuit Diagram
## Technical Specification

**PKM 7000A series Direct Converters**  
Input 66-160 V, Output up to 12.5 A / 150 W

---

### Electrical Specification

**5 V, 20 A / 100 W**

\( T_{pr} = -40 \) to 105°C, \( V_i = 66 \) to 160 V, \{sense pins connected to output pins\) unless otherwise specified under Conditions.

Typical values given at: \( T_{pr} = +25^\circ C, V_i = 110 \) V, max \( I_o \), unless otherwise specified under Conditions.

Additional \( C_{in} = 47 \) \( \mu \)F, \( C_{out} = 10 \) \( \mu \)F ceramic Cap. \(+ 22 \) \( \mu \)F E-Cap. See Operating Information section for selection of capacitor types.

#### Characteristics

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Conditions</th>
<th>min</th>
<th>typ</th>
<th>max</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>( V_i ) - Input voltage range</td>
<td></td>
<td>66</td>
<td>160</td>
<td>V</td>
<td></td>
</tr>
<tr>
<td>( V_{out} ) - Turn-off input voltage</td>
<td>Decreasing input voltage</td>
<td>60</td>
<td>62</td>
<td>64</td>
<td>V</td>
</tr>
<tr>
<td>( V_{on} ) - Turn-on input voltage</td>
<td>Increasing input voltage</td>
<td>62</td>
<td>64</td>
<td>66</td>
<td>V</td>
</tr>
<tr>
<td>( C_i ) - Internal input capacitance</td>
<td></td>
<td>47</td>
<td></td>
<td></td>
<td>( \mu )F</td>
</tr>
<tr>
<td>( P_o ) - Output power</td>
<td></td>
<td>0</td>
<td>100</td>
<td>W</td>
<td></td>
</tr>
<tr>
<td>( \eta ) - Efficiency</td>
<td>50% of max ( I_o ), ( V_i = 110 ) V</td>
<td>85</td>
<td>87</td>
<td>%</td>
<td></td>
</tr>
<tr>
<td>( P_i ) - Power Dissipation</td>
<td>max ( I_o ), ( V_i = 110 ) V</td>
<td></td>
<td></td>
<td>15</td>
<td>25</td>
</tr>
<tr>
<td>( P_{id} ) - Input idling power</td>
<td>( I_o = 0 ) A, ( V_i = 110 ) V</td>
<td>1.0</td>
<td></td>
<td></td>
<td>W</td>
</tr>
<tr>
<td>( P_{rc} ) - Input standby power</td>
<td>( V_i = 110 ) V (turned off with RC)</td>
<td>0.7</td>
<td></td>
<td></td>
<td>W</td>
</tr>
<tr>
<td>( t_s ) - Switching frequency</td>
<td>0-100% of max ( I_o )</td>
<td>238</td>
<td>280</td>
<td>322</td>
<td>kHz</td>
</tr>
<tr>
<td>( V_o ) - Output voltage initial setting and accuracy</td>
<td>( T_{pr} = +25^\circ C, V_i = 110 ) V, ( I_o = 20 ) A</td>
<td>4.94</td>
<td>5</td>
<td>5.06</td>
<td>V</td>
</tr>
<tr>
<td>( V_o ) - Output adjust range</td>
<td>See operating information</td>
<td>4.5</td>
<td>5</td>
<td>5.5</td>
<td>V</td>
</tr>
<tr>
<td>( V_o ) - Output voltage tolerance band</td>
<td>0-100% of max ( I_o )</td>
<td>4.75</td>
<td>5.25</td>
<td>V</td>
<td></td>
</tr>
<tr>
<td>( I_{id} ) - Idling voltage</td>
<td>( I_o = 0 ) A</td>
<td>4.75</td>
<td>5.25</td>
<td>V</td>
<td></td>
</tr>
<tr>
<td>( V_o ) - Line regulation</td>
<td>max ( I_o )</td>
<td>10</td>
<td>25</td>
<td>mV</td>
<td></td>
</tr>
<tr>
<td>( V_o ) - Load regulation</td>
<td>( V_i = 110 ) V, 25-100% of max ( I_o )</td>
<td>20</td>
<td>50</td>
<td>mV</td>
<td></td>
</tr>
<tr>
<td>( V_o ) - Load transient voltage deviation</td>
<td>( V_i = 110 ) V, Load step 50-75-50% of max ( I_o ), di/dt = 100mA/µs</td>
<td>±170</td>
<td>±500</td>
<td>mV</td>
<td></td>
</tr>
<tr>
<td>( t_o ) - Load transient recovery time</td>
<td></td>
<td>50</td>
<td>500</td>
<td>µs</td>
<td></td>
</tr>
<tr>
<td>( t_r ) - Ramp-up time (from 10-90% of ( V_o ))</td>
<td></td>
<td>15</td>
<td></td>
<td>ms</td>
<td></td>
</tr>
<tr>
<td>( t_s ) - Start-up time (from ( V_o ) connection to 90% of ( V_o ))</td>
<td></td>
<td>60</td>
<td></td>
<td>ms</td>
<td></td>
</tr>
<tr>
<td>( t_{rc} ) - RC start-up time (from ( V_{rc} ) connection to 90% of ( V_o ))</td>
<td>max ( I_o )</td>
<td>1.5</td>
<td>10</td>
<td>ms</td>
<td></td>
</tr>
<tr>
<td>( I_o ) - Sink current</td>
<td>See operating information</td>
<td>10</td>
<td></td>
<td>mA</td>
<td></td>
</tr>
<tr>
<td>( I_{ls} ) - Output level</td>
<td>Decreasing / Increasing RC-voltage</td>
<td>0.8/2.5</td>
<td></td>
<td>V</td>
<td></td>
</tr>
<tr>
<td>( I_o ) - Output current</td>
<td></td>
<td>0</td>
<td>20</td>
<td>A</td>
<td></td>
</tr>
<tr>
<td>( I_{ls} ) - Current limit threshold</td>
<td>( V_i = 110 ) V, ( T_{pr} &lt; max T_{pr} )</td>
<td>32</td>
<td>40</td>
<td>A</td>
<td></td>
</tr>
<tr>
<td>( I_{sc} ) - Short circuit current</td>
<td>( T_{pr} = 25^\circ C, see Note 1 )</td>
<td>0.04</td>
<td>0.1</td>
<td>A</td>
<td></td>
</tr>
<tr>
<td>( C_{out} ) - Recommended Capacitive Load</td>
<td>( T_{pr} = 25^\circ C, see Note 2 )</td>
<td>0</td>
<td>2000</td>
<td>( \mu )F</td>
<td></td>
</tr>
<tr>
<td>( V_{osc} ) - Output ripple &amp; noise</td>
<td>See ripple &amp; noise section, ( V_{oi} )</td>
<td>35</td>
<td>100</td>
<td>mVp-p</td>
<td></td>
</tr>
<tr>
<td>OVP - Over voltage protection</td>
<td>( T_{pr} = +25^\circ C, V_i = 110 ) V, 0-100% of max ( I_o )</td>
<td>7</td>
<td></td>
<td>V</td>
<td></td>
</tr>
</tbody>
</table>

**Note 1:** hiccup mode  
**Note 2:** Test condition: Electronic Capacitor and full load
PKM 7000A series Direct Converters
Input 66-160 V, Output up to 12.5 A / 150 W

Typical Characteristics
5 V, 20 A / 100 W

Efficiency

Efficiency vs. load current and input voltage at +25°C.

Power Dissipation

Dissipated power vs. load current and input voltage at +25°C.

Current Limit Characteristics

Output voltage vs. load current at $I_o > max\ I_o$ at +25°C.

Output Current Derating (10mm ¼ brick heat sink)

Available load current vs. ambient air temperature and airflow at $V_i=110$ V. See Thermal Consideration section.

Output Current Derating (20mm ¼ brick heat sink)

Available load current vs. ambient air temperature and airflow at $V_i=110$ V. See Thermal Consideration section.
Typical Characteristics
5 V, 20 A / 100 W

Start-up

- Start-up enabled by connecting V_I at:
  - TP1 = +25°C, V_I = 110 V,
  - I_O = 20 A resistive load.

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

Output Ripple & Noise

- Output voltage ripple at:
  - TP1 = +25°C, V_I = 110 V,
  - I_O = 20 A resistive load.

- Trace: output voltage (100 mV/div.).
- Time scale: (5 µs/div.).

Output Load Transient Response

- Output voltage response to load current step-change (10-15-10 A) at:
  - TP1 = +25°C, V_I = 110 V.

- Trace: output voltage (200 mV/div.).
- Bottom trace: load current (5 A/div.).
- Time scale: (1 ms/div.).

Output Voltage Adjust (TRIM UP/TRIM DOWN)

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

Output Voltage Adjust, Increase:

$$ R_{TRIM\_UP} = \left( \frac{5.11 \times V_{out\_set} \times (100 + \Delta\%) - 511}{1.225 \times \Delta\%} - 10.22 \right) \text{k}\Omega $$

$$ \Delta\% = \left( \frac{V_{in\_adj} - V_{out\_adj}}{V_{out\_adj}} \right) \times 100 $$

Output Voltage Adjust, Decrease:

$$ R_{TRIM\_DOWN} = \left( \frac{511}{\Delta\%} - 10.22 \right) \text{k}\Omega $$

$$ \Delta\% = \left( \frac{V_{out\_adj} - V_{in\_adj}}{V_{out\_adj}} \right) \times 100 $$

Example:

To trim up the 5.0V model by 8% to 5.4V the required external resistor is:

$$ R_{TRIM\_UP} = \left( \frac{5.11 \times 5.0 \times (100 + 8) - 511}{1.225 \times 8} - 10.22 \right) = 207.48 \text{k}\Omega $$

$$ \Delta\% = \left( \frac{5.4 - 5.0}{5.0} \right) \times 100 = 8 $$

Example:

To trim down the 5.0V model by 7% to 4.65V the required external resistor is:

$$ R_{TRIM\_DOWN} = \left( \frac{511}{7} - 10.22 \right) = 62.78 \text{k}\Omega $$

PKM 7111A PIP

Output Voltage=5.0V
PKM 7000A series Direct Converters
Input 66-160 V, Output up to 12.5 A / 150 W

Technical Specification

PKM 7113A PIP

Electrical Specification

12 V, 8.3 A / 100 W

T_{P1} = -40 to 105°C, V_{i} = 66 to 160 V, (sense pins connected to output pins) unless otherwise specified under Conditions.

Typical values given at: T_{P1} = +25°C, V_{i} = 110 V, max I_{o}, unless otherwise specified under Conditions.

Additional Cin = 47 µF, Cout = 10 µF ceramic Cap. + 22 µF E-Cap. See Operating Information section for selection of capacitor types.

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Conditions</th>
<th>min</th>
<th>typ</th>
<th>max</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>V_{i}</td>
<td>Input voltage range</td>
<td>66</td>
<td>160</td>
<td>V</td>
<td></td>
</tr>
<tr>
<td>V_{on}</td>
<td>Turn-off input voltage</td>
<td>0</td>
<td>62</td>
<td>64</td>
<td>V</td>
</tr>
<tr>
<td>V_{on}</td>
<td>Turn-on input voltage</td>
<td>62</td>
<td>64</td>
<td>66</td>
<td>V</td>
</tr>
<tr>
<td>C_{i}</td>
<td>Internal input capacitance</td>
<td>47</td>
<td>µF</td>
<td></td>
<td></td>
</tr>
<tr>
<td>P_{o}</td>
<td>Output power</td>
<td>0</td>
<td>100</td>
<td>W</td>
<td></td>
</tr>
<tr>
<td>h_{i}</td>
<td>Efficiency</td>
<td>50%</td>
<td>max I_{o}, V_{i} = 110 V</td>
<td>87</td>
<td>%</td>
</tr>
<tr>
<td>h_{i}</td>
<td>max I_{o}, V_{i} = 110 V</td>
<td></td>
<td>90</td>
<td></td>
<td></td>
</tr>
<tr>
<td>P_{d}</td>
<td>Power Dissipation</td>
<td>max I_{o}</td>
<td>11</td>
<td>15</td>
<td>W</td>
</tr>
<tr>
<td>P_{i}</td>
<td>Input idling power</td>
<td>I_{o} = 0 A, V_{i} = 110 V</td>
<td>1.0</td>
<td>W</td>
<td></td>
</tr>
<tr>
<td>P_{RRC}</td>
<td>Input standby power</td>
<td>V_{i} = 110 V (turned off with RC)</td>
<td>0.7</td>
<td>W</td>
<td></td>
</tr>
<tr>
<td>f_{s}</td>
<td>Switching frequency</td>
<td>0-100 % of max I_{o}</td>
<td>238</td>
<td>280</td>
<td>322</td>
</tr>
</tbody>
</table>

V_{O}                                    | Output voltage initial setting and accuracy | T_{P1} = +25°C, V_{i} = 110 V, I_{o} = 0.3 A | 11.856 | 12   | 12.144 | V |

V_{O}                                    | Output adjust range                | See operating information | 10.8  | 12   | 13.2   | V |

V_{O}                                    | Output voltage tolerance band      | 0-100% of max I_{o}       | 11.5  | 12.5  | |

V_{O}                                    | Idling voltage                     | I_{o} = 0 A               | 11.5  | 12.5  | |

V_{O}                                    | Line regulation                    | max I_{o}                 |       | 10    | 60    | mV |

V_{O}                                    | Load regulation                    | V_{i} = 110 V, 25-100% of max I_{o} | 20   | 120   | |

V_{O}                                    | Load transient voltage deviation   | V_{i} = 110 V, Load step 50-75-50% of max I_{o} | ±450 | ±1000 | mV |

V_{O}                                    | Load transient recovery time       | di/dt = 100mA/µs          | 70    | 500   | µs   |

V_{O}                                    | Ramp-up time (from 10-90% of V_{O}) | 100% of max I_{o}        | 15    | ms    |

V_{O}                                    | Start-up time (from V, connection to 90% of V_{O}) | max I_{o} | 60    | ms    |

V_{O}                                    | RC start-up time (from Vnc connection to 90% of V_{O}) | max I_{o} | 1.5   | 10    | ms   |

RC                                      | Sink current                       | See operating information | 10    | mA    |

RC                                      | Trigger level                      | Decreasing / Increasing RC-voltage | 0.8/2.5 | V    |

I_{o}                                   | Output current                     | 0     | 8.3   | A     |

I_{oc}                                  | Current limit threshold            | V_{i} = 110 V, T_{P1} < max T_{P1} | 13    | 16    | A    |

I_{oc}                                  | Short circuit current              | T_{P1} = 25°C, see Note 1 | 0.04  | 0.1   | A    |

C_{out}                                 | Recommended Capacitive Load        | T_{P1} = 25°C, see Note 2 | 0     | 2000  | µF   |

V_{out}                                 | Output ripple & noise              | See ripple & noise section, V_{oi} | 16    | 150   | mV-p |

OVP                                    | Over voltage protection            | T_{P1} = +25°C, V_{i} = 110 V, 0-100% of max I_{o} | 15    | V     |

Note 1: hiccup mode
Note 2: Test condition: Electronic Capacitor and full load
PKM 7000A series Direct Converters
Input 66-160 V, Output up to 12.5 A / 150 W

Typical Characteristics
12 V, 8.3 A / 100 W

Efficiency

![Efficiency vs. load current and input voltage at +25°C.](image1)

Power Dissipation

![Dissipated power vs. load current and input voltage at +25°C.](image2)

Current Limit Characteristics

![Output voltage vs. load current at I_o > max I_o at +25°C.](image3)

Output Current Derating (10mm ¼ brick heat sink)

![Available load current vs. ambient air temperature and airflow at V_I=110 V. See Thermal Consideration section.](image4)

Output Current Derating (20mm ¼ brick heat sink)

![Available load current vs. ambient air temperature and airflow at V_I=110 V. See Thermal Consideration section.](image5)
Typical Characteristics

12 V, 8.3 A / 100 W

Start-up

Start-up enabled by connecting $V_i$ at: $T_p = +25°C$, $V_i = 110 V$, $i_o = 8.3 A$ resistive load.

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

Output Ripple & Noise

Output voltage ripple at: $T_p = +25°C$, $V_i = 110 V$, $i_o = 8.3 A$ resistive load.
Trace: output voltage (50 mV/div.).
Time scale: (5 µs/div.).

Output Load Transient Response

Trace: output voltage (500 mV/div.).
Bottom trace: load current (5 A/div.).
Time scale: (1 ms/div.).

Output Voltage Adjust (TRIM UP/TRIM DOWN)

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

Output Voltage Adjust, Increase:

$$R_{TRIM\_UP} = \left( \frac{5.11 \times V_{\text{out}} \times (100 + \Delta \%)}{1.225 \times \Delta \%} - 10.22 \right) \text{k}\Omega$$

$$\Delta \% = \left( \frac{V_{\text{desired}} - V_{\text{out}}}{V_{\text{out}}} \right) \times 100$$

Output Voltage Adjust, Decrease:

$$R_{TRIM\_DOWN} = \left( \frac{5.11}{\Delta \%} - 10.22 \right) \text{k}\Omega$$

$$\Delta \% = \left( \frac{V_{\text{out}} - V_{\text{desired}}}{V_{\text{out}}} \right) \times 100$$

Example:

To trim up the 12V model by 8% to 12.96V the required external resistor is:

$$R_{TRIM\_UP} = \left( \frac{5.11 \times 12 \times (100 + 8)}{1.225 \times 8} - 10.22 \right) = 601.68 \text{k}\Omega$$

$$\Delta \% = \left( \frac{12.96 - 12}{12} \right) \times 100 = 8$$

Example:

To trim down the 12V model by 7% to 11.16V the required external resistor is:

$$R_{TRIM\_DOWN} = \left( \frac{5.11}{7} - 10.22 \right) = 62.78 \text{k}\Omega$$
**PKM 7000A series Direct Converters**  
Input 66-160 V, Output up to 12.5 A / 150 W

**PKM 7115A PIP**

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Conditions</th>
<th>min</th>
<th>typ</th>
<th>max</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>$V_i$</td>
<td>Input voltage range</td>
<td>66</td>
<td>160</td>
<td>V</td>
<td></td>
</tr>
<tr>
<td>$V_{out}$</td>
<td>Decreasing input voltage</td>
<td>60</td>
<td>62</td>
<td>64</td>
<td>V</td>
</tr>
<tr>
<td>$V_{on}$</td>
<td>Increasing input voltage</td>
<td>62</td>
<td>64</td>
<td>66</td>
<td>V</td>
</tr>
<tr>
<td>$C_i$</td>
<td>Internal input capacitance</td>
<td>47</td>
<td>µF</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$P_{o}$</td>
<td>Output power</td>
<td>0</td>
<td>100</td>
<td>W</td>
<td></td>
</tr>
<tr>
<td>$\eta$</td>
<td>Efficiency</td>
<td>50%</td>
<td>of max $I_o$, $V_i = 110$ V</td>
<td>87</td>
<td>%</td>
</tr>
<tr>
<td>$P_{d}$</td>
<td>Power Dissipation</td>
<td>$I_o$</td>
<td>11</td>
<td>25</td>
<td>W</td>
</tr>
<tr>
<td>$P_{id}$</td>
<td>Input idling power</td>
<td>$I_o = 0$, $V_i = 110$ V</td>
<td>1.0</td>
<td>W</td>
<td></td>
</tr>
<tr>
<td>$P_{nc}$</td>
<td>Input standby power</td>
<td>$V_i = 110$ V (turned off with RC)</td>
<td>0.7</td>
<td>W</td>
<td></td>
</tr>
<tr>
<td>$t_s$</td>
<td>Switching frequency</td>
<td>0-100% of max $I_o$</td>
<td>238</td>
<td>280</td>
<td>322</td>
</tr>
</tbody>
</table>

| $V_{oa}$                         | Output voltage initial setting and accuracy                               | 14.82 | 15   | 15.18 | V     |
| $V_o$                            | Output adjust range                                                       | See operating information | 13.5  | 15   | 16.5  | V     |
| $I_o$                            | Idling voltage                                                            | $I_o = 0$ A                     | 14.5  | 15.5 | V     |
| $f_o$                            | Line regulation                                                           | max $I_o$ | 10   | 75   | mV    |
| $V_o$                            | Load regulation                                                           | $V_i = 110$ V, 25-100% of max $I_o$ | ±500  | ±1000 | mV    |
| $V_o$                            | Load transient voltage deviation                                         | $V_i = 110$ V, Load step 50-75-50% of max $I_o$, $di/dt = 100mA/µs$ | ±500  | ±1000 | mV    |
| $t_o$                            | Load transient recovery time                                              | 70    | 500  | µs    |
| $t_r$                            | Ramp-up time                                                               | 100% of max $I_o$               | 15    | ms    |
| $t_s$                            | Start-up time                                                             | 100% of max $I_o$               | 60    | ms    |
| $t_{sc}$                         | RC start-up time                                                          | max $I_o$ | 1.5  | 10    | ms    |
| $I_o$                            | Sink current                                                              | See operating information       | 10    | mA    |
| $I_{th}$                         | Trigger level                                                              | Decreasing / Increasing RC-voltage | 0.8/2.5 | V     |
| $I_{in}$                         | Current limit threshold                                                   | $V_i = 110$ V, $T_{PI} < max T_{P1}$ | 10    | 12    | A     |
| $t_{sc}$                         | Short circuit current                                                     | $T_{P1} = 25$ºC, see Note 1    | 0.04  | 0.1   | A     |
| $C_{out}$                        | Recommended Capacitive Load                                               | $T_{P1} = 25$ºC, see Note 2    | 0     | 2000  | µF    |
| $V_{acc}$                        | Output ripple & noise                                                     | See ripple & noise section, $V_{oi}$ | 44    | 150   | mVp-p |
| $OVP$                            | Over voltage protection                                                   | $T_{P1} = +25$ºC, $V_i = 110$ V, 0-100% of max $I_o$ | 18    | V     |

Note 1: hiccup mode  
Note 2: Test condition: Electronic Capacitor and full load

**Technical Specification**

15 V, 6.67 A / 100 W

$T_{PI} = -40$ to 105ºC, $V_i = 66$ to 160 V, (sense pins connected to output pins) unless otherwise specified under Conditions.

Typical values given at: $T_{P1} = +25$ºC, $V_i = 110$ V, max $I_o$, unless otherwise specified under Conditions.

Additional Cin = 47 µF, Cout = 10 µF ceramic Cap. + 22 µF E-Cap. See Operating Information section for selection of capacitor types.
**Typical Characteristics**

15 V, 6.67 A / 100 W

**Efficiency**

Efficiency vs. load current and input voltage at +25°C.

**Power Dissipation**

Dissipated power vs. load current and input voltage at +25°C.

**Current Limit Characteristics**

Output voltage vs. load current at $I_o > I_o$ max at +25°C.

**Output Current Derating (10mm ¼ brick heat sink)**

Available load current vs. ambient air temperature and airflow at $V_i=110$ V. See Thermal Consideration section.

**Output Current Derating (20mm ¼ brick heat sink)**

Available load current vs. ambient air temperature and airflow at $V_i=110$ V. See Thermal Consideration section.
Typical Characteristics

15 V, 6.67 A / 100 W

Output Voltage Adjust (TRIM UP/TRIM DOWN)

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

Output Voltage Adjust, Increase:

\[
R_{TRIM,UP} = \left( \frac{5.11 \times V_{out,adj} \times (100 + \Delta\%) - 511}{1.225 \times \Delta\%} - 10.22 \right) \text{k} \Omega
\]

\[
\Delta\% = \left( \frac{V_{adj} - V_{out}}{V_{out}} \right) \times 100
\]

Output Voltage Adjust, Decrease:

\[
R_{TRIM,DOWN} = \left( \frac{511}{\Delta\%} - 10.22 \right) \text{k} \Omega
\]

\[
\Delta\% = \left( \frac{V_{adj} - V_{out}}{V_{out}} \right) \times 100
\]

Example:

To trim up the 15V model by 8% to 16.2V the required external resistor is:

\[
R_{TRIM,UP} = \left( \frac{5.11 \times 15 \times (100 + 8) - 511}{1.225 \times 8} - 10.22 \right) = 770.62 \text{ k}\Omega
\]

Ex:

\[
\Delta\% = \left( \frac{16.2 - 15}{15} \right) \times 100 = 8
\]

Example:

To trim down the 15V model by 7% to 13.95V the required external resistor is:

\[
R_{TRIM,DOWN} = \left( \frac{511}{7} - 10.22 \right) = 62.78 \text{ k}\Omega
\]
## Electrical Specification

### PKM 7000A series Direct Converters

**Input 66-160 V, Output up to 12.5 A / 150 W**

### PKM 7116ZA PIP

**24 V, 4.16 A / 100 W**

- $T_{PR} = -40$ to $105^\circ C$, $V_i = 66$ to 160 V, (sense pins connected to output pins) unless otherwise specified under Conditions.
- Typical values given at: $T_{PR} = +25^\circ C$, $V_i = 110$ V, max $I_o$, unless otherwise specified under Conditions.
- Additional Cin = 47 µF, Cout = 10 µF ceramic Cap. + 22 µF E-Cap. See Operating Information section for selection of capacitor types.

### Characteristics

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Conditions</th>
<th>min</th>
<th>typ</th>
<th>max</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>$V_i$</td>
<td>Input voltage range</td>
<td>66</td>
<td>160</td>
<td>V</td>
<td></td>
</tr>
<tr>
<td>$V_{off}$</td>
<td>Turn-off input voltage</td>
<td>60</td>
<td>62</td>
<td>64</td>
<td>V</td>
</tr>
<tr>
<td>$V_{on}$</td>
<td>Turn-on input voltage</td>
<td>62</td>
<td>64</td>
<td>66</td>
<td>V</td>
</tr>
<tr>
<td>$C_i$</td>
<td>Internal input capacitance</td>
<td>47</td>
<td></td>
<td>µF</td>
<td></td>
</tr>
<tr>
<td>$P_o$</td>
<td>Output power</td>
<td>0</td>
<td>100</td>
<td>W</td>
<td></td>
</tr>
<tr>
<td>$\eta$</td>
<td>Efficiency</td>
<td>50%</td>
<td>87</td>
<td>%</td>
<td></td>
</tr>
<tr>
<td>$P_s$</td>
<td>Power Dissipation</td>
<td>max $I_o$</td>
<td>13</td>
<td>17</td>
<td>W</td>
</tr>
<tr>
<td>$P_i$</td>
<td>Input idling power</td>
<td>$I_o = 0$ A, $V_i = 110$ V</td>
<td>1.0</td>
<td></td>
<td>W</td>
</tr>
<tr>
<td>$P_{RC}$</td>
<td>Input standby power</td>
<td>$V_i = 110$ V (turned off with RC)</td>
<td>0.7</td>
<td></td>
<td>W</td>
</tr>
<tr>
<td>$f_o$</td>
<td>Switching frequency</td>
<td>0-100 % of max $I_o$</td>
<td>297.5</td>
<td>350</td>
<td>402.5</td>
</tr>
<tr>
<td>$V_{O_a}$</td>
<td>Output voltage initial setting and accuracy</td>
<td>$T_{PR} = +25^\circ C$, $V_i = 110$ V, $I_o = 4.16$ A</td>
<td>23.70</td>
<td>24</td>
<td>24.30</td>
</tr>
<tr>
<td>$V_o$</td>
<td>Output adjust range</td>
<td>See operating information</td>
<td>21.6</td>
<td>26.4</td>
<td>V</td>
</tr>
<tr>
<td>$V_{t_{r}}$</td>
<td>Output voltage tolerance band</td>
<td>0-100% of max $I_o$</td>
<td>23.4</td>
<td>24.6</td>
<td>V</td>
</tr>
<tr>
<td>$I_{o}$</td>
<td>Idling voltage</td>
<td>$I_o = 0$ A</td>
<td>23.4</td>
<td>24.6</td>
<td>V</td>
</tr>
<tr>
<td>$V_{L}$</td>
<td>Line regulation</td>
<td>max $I_o$</td>
<td>10</td>
<td>120</td>
<td>mV</td>
</tr>
<tr>
<td>$V_{L_{r}}$</td>
<td>Load regulation</td>
<td>$V_i = 110$ V, 25-100% of max $I_o$</td>
<td>20</td>
<td>240</td>
<td>mV</td>
</tr>
<tr>
<td>$V_{t_{r}}$</td>
<td>Load transient voltage deviation</td>
<td>$V_i = 110$ V, Load step 50-75-50% of max $I_o$, di/dt = 100mA/µs</td>
<td>±377</td>
<td>±1000</td>
<td>mV</td>
</tr>
<tr>
<td>$t_{o}$</td>
<td>Load transient recovery time</td>
<td>70</td>
<td>500</td>
<td>µs</td>
<td></td>
</tr>
<tr>
<td>$t_{r}$</td>
<td>Ramp-up time (from 10-90% of $V_o$)</td>
<td>100% of max $I_o$</td>
<td>15</td>
<td></td>
<td>ms</td>
</tr>
<tr>
<td>$t_{s}$</td>
<td>Start-up time (from $V_i$ connection to 90% of $V_o$)</td>
<td>60</td>
<td></td>
<td>ms</td>
<td></td>
</tr>
<tr>
<td>$t_{RC}$</td>
<td>RC start-up time (from $V_{RC}$ connection to 90% of $V_o$)</td>
<td>max $I_o$</td>
<td>1.5</td>
<td>10</td>
<td>ms</td>
</tr>
<tr>
<td>$I_o$</td>
<td>Sink current</td>
<td>See operating information</td>
<td>10</td>
<td></td>
<td>mA</td>
</tr>
<tr>
<td>$I_{o_{max}}$</td>
<td>Current limit threshold</td>
<td>$V_i = 110$ V, $T_{PR} &lt; max T_{PR}$</td>
<td>9</td>
<td>11</td>
<td>A</td>
</tr>
<tr>
<td>$I_{SC}$</td>
<td>Short circuit current</td>
<td>$T_{PR} = 25^\circ C$, see Note 1</td>
<td>0.04</td>
<td>0.1</td>
<td>A</td>
</tr>
<tr>
<td>$C_{out}$</td>
<td>Recommended Capacitive Load</td>
<td>$T_{PR} = 25^\circ C$, see Note 2</td>
<td>0</td>
<td>2000</td>
<td>µF</td>
</tr>
<tr>
<td>$V_{O_{out}}$</td>
<td>Output ripple &amp; noise</td>
<td>See ripple &amp; noise section, $V_o$</td>
<td>30.7</td>
<td>500</td>
<td>mV/µp</td>
</tr>
<tr>
<td>OVP</td>
<td>Over voltage protection</td>
<td>$T_{PR} = +25^\circ C$, $V_i = 110$ V, 0-100% of max $I_o$</td>
<td>28</td>
<td></td>
<td>V</td>
</tr>
</tbody>
</table>

**Note 1:** hiccup - mode

**Note 2:** Test condition: Electronic Capacitor and full load
Typical Characteristics
24 V, 4.16 A / 100 W

Efficiency vs. load current and input voltage at +25°C.

Power Dissipation vs. load current and input voltage at +25°C.

Current Limit Characteristics
Output voltage vs. load current at $I_o > max I_o$ at +25°C.

Output Current Derating
(10mm ¼ brick heat sink)
Available load current vs. ambient air temperature and airflow at $V_i=110$ V. See Thermal Consideration section.

Output Current Derating
(20mm ¼ brick heat sink)
Available load current vs. ambient air temperature and airflow at $V_i=110$ V. See Thermal Consideration section.
**PKM 7000A series Direct Converters**

Input 66-160 V, Output up to 12.5 A / 150 W

---

**Typical Characteristics**

**24 V, 4.16 A / 100 W**

### Start-up

Start-up enabled by connecting $V_I$ at:
- $T_P = +25^\circ C$, $V_I = 110 V$.
- $I_O = 4.16$ A resistive load.

Top trace: output voltage (10 V/div.).
Bottom trace: input voltage (50 V/div.).
Time scale: (20 ms/div.).

### Shut-down

Start-up enabled by connecting $V_I$ at:
- $T_P = +25^\circ C$, $V_I = 110 V$.
- $I_O = 4.16$ A resistive load.

Top trace: output voltage (10 V/div.).
Bottom trace: input voltage (50 V/div.).
Time scale: (500 ms/div.).

### Output Ripple & Noise

Output voltage ripple at:
- $T_P = +25^\circ C$, $V_I = 110 V$.
- $I_O = 4.16$ A resistive load.

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

### Output Load Transient Response

Output voltage response to load current step-change (2.08-3.12-2.08 A) at:
- $T_P = +25^\circ C$, $V_I = 110 V$.

Trace: output voltage (200 mV/div.).
Bottom trace: load current (1 A/div.).
Time scale: (1 ms/div.).

### Output Voltage Adjust (see operating information)

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

Output Voltage Adjust, Increase:

$$ R_{ADJ\_UP} = \left( \frac{14.6061}{\Delta} - 120 \right) k\Omega $$

Output Voltage Adjust, Decrease:

$$ R_{ADJ\_DOWN} = \left( \frac{17.2133}{\Delta} - 151.819 \right) k\Omega $$

**Example:**

To trim up the 24V model by 8% to 25.92V the required external resistor is:

$$ R_{ADJ\_UP} = \left( \frac{14.6061}{0.08} - 120 \right) = 62.58 \ k\Omega $$

**Example:**

To trim down the 24V model by 7% to 22.32V the required external resistor is:

$$ R_{ADJ\_DOWN} = \left( \frac{17.2133}{0.07} - 151.819 \right) = 94.08 \ k\Omega $$

---

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Technical Specification
### Electrical Specification

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Conditions</th>
<th>min</th>
<th>typ</th>
<th>max</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>( V_i ) Input voltage range</td>
<td>( T_{\text{ref}} = +25^\circ \text{C}, V_i = 110 \text{ V}, I_o = 6.25 \text{ A} )</td>
<td>47.4</td>
<td>48</td>
<td>48.6</td>
<td>V</td>
</tr>
<tr>
<td>( V_{\text{out}} ) Output adjust range</td>
<td>See operating information</td>
<td>43.2</td>
<td>48</td>
<td>52.8</td>
<td>V</td>
</tr>
<tr>
<td>( V_{\text{out}} ) Output voltage tolerance band</td>
<td>0-100% of max ( I_o )</td>
<td>46.8</td>
<td>49.2</td>
<td>V</td>
<td></td>
</tr>
<tr>
<td>( I_o ) Idling voltage</td>
<td>( I_o = 0 \text{ A} )</td>
<td>46.8</td>
<td>49.2</td>
<td>V</td>
<td></td>
</tr>
<tr>
<td>( V_{\text{lin}} ) Line regulation</td>
<td>max ( I_o )</td>
<td>24</td>
<td>240</td>
<td>mV</td>
<td></td>
</tr>
<tr>
<td>( V_{\text{load}} ) Load regulation</td>
<td>( V_i = 110 \text{ V}, 25-100% of max ( I_o )</td>
<td>48</td>
<td>480</td>
<td>mV</td>
<td></td>
</tr>
<tr>
<td>( \text{tp} ) Load transient recovery time</td>
<td>( V_i = 110 \text{ V}, \text{Load step }50-75-50% ) of max ( I_o ), di/dt = 100mA/μs</td>
<td>±800</td>
<td>±1000</td>
<td>mV</td>
<td></td>
</tr>
<tr>
<td>( t_{\text{ramp}} ) Ramp-up time</td>
<td>(from ( 10-90% ) of ( V_{\text{in}} ))</td>
<td>90</td>
<td>500</td>
<td>μs</td>
<td></td>
</tr>
<tr>
<td>( t_{\text{start}} ) Start-up time</td>
<td>(from ( V_{\text{in}} ) connection to ( 90% ) of ( V_{\text{in}} ))</td>
<td>15</td>
<td></td>
<td>ms</td>
<td></td>
</tr>
<tr>
<td>( t_{\text{rc}} ) RC start-up time</td>
<td>(from ( V_{\text{in}} ) connection to ( 90% ) of ( V_{\text{in}} ))</td>
<td>60</td>
<td></td>
<td>ms</td>
<td></td>
</tr>
<tr>
<td>( I_{\text{sink}} ) Sink current</td>
<td>See operating information</td>
<td>1.55</td>
<td>10</td>
<td>mA</td>
<td></td>
</tr>
<tr>
<td>( I_{\text{trig}} ) Trigger level</td>
<td>Decreasing / Increasing RC-voltage</td>
<td>0.8/2.5</td>
<td>V</td>
<td></td>
<td></td>
</tr>
<tr>
<td>( I_o ) Output current</td>
<td></td>
<td>0</td>
<td>2.08</td>
<td>A</td>
<td></td>
</tr>
<tr>
<td>( I_{\text{lim}} ) Current limit threshold</td>
<td>( V_i = 110 \text{ V}, T_{\text{lim}} &lt; \text{max } T_{\text{lim}} )</td>
<td>3.2</td>
<td>5.2</td>
<td>A</td>
<td></td>
</tr>
<tr>
<td>( I_{\text{sc}} ) Short circuit current</td>
<td>( T_{\text{lim}} = 25^\circ \text{C}, \text{see Note 1} )</td>
<td>0.05</td>
<td>0.1</td>
<td>A</td>
<td></td>
</tr>
<tr>
<td>( C_{\text{out}} ) Recommended Capacitive Load</td>
<td>( T_{\text{lim}} = 25^\circ \text{C}, \text{see Note 2} )</td>
<td>0</td>
<td>500</td>
<td>μF</td>
<td></td>
</tr>
<tr>
<td>( V_{\text{dropout}} ) Output ripple &amp; noise</td>
<td>See ripple &amp; noise section, ( V_{\text{in}} )</td>
<td>272</td>
<td>500</td>
<td>mV</td>
<td></td>
</tr>
<tr>
<td>( \text{OVP} ) Over voltage protection</td>
<td>( T_{\text{lim}} = +25^\circ \text{C}, V_i = 110 \text{ V}, 0-100% ) of max ( I_o )</td>
<td>55</td>
<td></td>
<td>V</td>
<td></td>
</tr>
</tbody>
</table>

Note 1: hiccup mode

Note 2: Test condition: Electronic Capacitor and full load
PKM 7000A series Direct Converters
Input 66-160 V, Output up to 12.5 A / 150 W

Typical Characteristics
48 V, 2.08 A / 100 W

**Efficiency**

- Efficiency vs. load current and input voltage at +25°C.

**Power Dissipation**

- Dissipated power vs. load current and input voltage at +25°C.

**Current Limit Characteristics**

- Output voltage vs. load current at I_o > max I_o at +25°C.

**Output Current Derating**

- Available load current vs. ambient air temperature and airflow at V_i=110 V. See Thermal Consideration section.
**Typical Characteristics**

**48 V, 2.08 A / 100 W**

**Start-up**

Start-up enabled by connecting V1 at:
- $T_{P1} = +25^\circ C$, $V_i = 110$ V,
- $I_o = 2.08$ A resistive load.

Top trace: output voltage (20 V/div.).
Bottom trace: input voltage (50 V/div.).
Time scale: (200 ms/div.).

**Output Voltage Adjust (TRIM UP/TRIM DOWN)**

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

**Output Voltage Adjust, Increase:**

$$ R_{ADJ\_UP} = \left( \frac{29.2214}{\Delta} - 240 \right) \text{k}\Omega $$

**Output Voltage Adjust, Decrease:**

$$ R_{ADJ\_DOWN} = \left( \frac{34.4607}{\Delta} - 303.682 \right) \text{k}\Omega $$

Example:

To trim up the 48V model by 8% to 51.84V the required external resistor is:

$$ R_{ADJ\_UP} = \left( \frac{29.2214}{0.08} - 240 \right) = 125.27 \text{ k}\Omega $$

Example:

To trim down the 48V model by 7% to 44.64V the required external resistor is:

$$ R_{ADJ\_DOWN} = \left( \frac{34.4607}{0.07} - 303.682 \right) = 188.61 \text{ k}\Omega $$

**Output Load Transient Response**

Output voltage response to load current step change (1.04-1.56-1.04 A) at:
- $T_{P1} = +25^\circ C$, $V_i = 110$ V.
- $I_o = 2.08$ A resistive load.

Top trace: output voltage (2 V/div.).
Bottom trace: load current (1 A/div.).
Time scale: (10 ms/div.).
PKM 7000A series Direct Converters
Input 66-160 V, Output up to 12.5 A / 150 W

Technical Specification

PKM 7213A PIP

Electrical Specification
12 V, 12.5 A / 150 W

- Input 66-160 V, Output up to 12.5 A / 150 W
- Additional Cin = 47 µF, Cout = 10 µF ceramic Cap. + 22 µF E-Cap. See Operating Information section for selection of capacitor types.

### Characteristics

<table>
<thead>
<tr>
<th>Condition</th>
<th>Conditions</th>
<th>min</th>
<th>typ</th>
<th>max</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>+25°C, V1 = 110 V, Io = 12.5 A</td>
<td>11.856</td>
<td>12</td>
<td>12.144</td>
<td>V</td>
<td></td>
</tr>
<tr>
<td>V1</td>
<td>Input voltage</td>
<td>66</td>
<td>160</td>
<td>V</td>
<td></td>
</tr>
<tr>
<td>Vout</td>
<td>Turn-off input voltage</td>
<td>Decreasing input voltage</td>
<td>60</td>
<td>62</td>
<td>64</td>
</tr>
<tr>
<td>Vin</td>
<td>Turn-on input voltage</td>
<td>Increasing input voltage</td>
<td>62</td>
<td>64</td>
<td>66</td>
</tr>
<tr>
<td>Crit</td>
<td>Internal input capacitance</td>
<td>47</td>
<td></td>
<td>µF</td>
<td></td>
</tr>
<tr>
<td>P0</td>
<td>Output power</td>
<td>0</td>
<td>150</td>
<td>W</td>
<td></td>
</tr>
<tr>
<td>Eff</td>
<td>Efficiency</td>
<td>50% of max Io, V1 = 110 V</td>
<td>89</td>
<td></td>
<td>%</td>
</tr>
<tr>
<td>Ps</td>
<td>Power Dissipation</td>
<td>max Io</td>
<td>18</td>
<td>25</td>
<td>W</td>
</tr>
<tr>
<td>Ii</td>
<td>Input idling power</td>
<td>Io = 0 A, V1 = 110 V</td>
<td>1.0</td>
<td></td>
<td>W</td>
</tr>
<tr>
<td>Pin</td>
<td>Input standby power</td>
<td>V1 = 110 V (turned off with RC)</td>
<td>0.7</td>
<td></td>
<td>W</td>
</tr>
<tr>
<td>fO</td>
<td>Switching frequency</td>
<td>0-100 % of max Io</td>
<td>238</td>
<td>280</td>
<td>322</td>
</tr>
</tbody>
</table>

### Electrical Specification

- Tp1 = +25°C, V1 = 110 V, Io = 12.5 A
- V1 = 40 to 105°C, Vin = 66 to 160 V (sense pins connected to output pins) unless otherwise specified under Conditions.
- Typical values given at: Tp1 = +25°C, V1= 110 V, max Io, unless otherwise specified under Conditions.
- Input standby power
- Power Dissipation
- Output ripple & noise

**Note:**

1. hiccup mode
2. Test condition: Electronic Capacitor and full load
Typical Characteristics

12 V, 12.5 A / 150 W

**Efficiency**

Efficiency vs. load current and input voltage at +25°C.

**Power Dissipation**

Dissipated power vs. load current and input voltage at +25°C.

**Current Limit Characteristics**

Output voltage vs. load current at \( I_O > max \ I_O \) at +25°C.

**Output Current Derating (20mm \( \frac{1}{4} \) brick heat sink)**

Available load current vs. ambient air temperature and airflow at \( V_I=110 \ V \). See Thermal Consideration section.
Typical Characteristics

12 V, 12.5 A / 150 W

Start-up

Start-up enabled by connecting \( V_I \) at:

\[
T_{PI} = +25°C, \ V_I = 110 V, \ I_O = 12.5 \text{ A resistive load.}
\]

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

Output Ripple & Noise

Output voltage ripple at:

\[
T_{PI} = +25°C, \ V_I = 110 V, \ I_O = 12.5 \text{ A resistive load.}
\]

Trace: output voltage (20 mV/div.).
Time scale: (5 \mu s/div.).

Output Voltage Adjust (TRIM UP/TRIM DOWN)

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

Output Voltage Adjust, Increase:

\[
R_{\text{TRIM,UP}} = \left( \frac{5.11 \times V_{\text{set}} \times (100 + \Delta \%)}{1.225 \times \Delta \%} - \frac{511}{10.22} \right) \text{k}\Omega
\]

\[
\Delta \% = \left( \frac{V_{\text{set}} - V_{\text{adj}}}{V_{\text{set}}} \right) \times 100
\]

Output Voltage Adjust, Decrease:

\[
R_{\text{TRIM,DOWN}} = \left( \frac{5.11}{\Delta \%} - 10.22 \right) \text{k}\Omega
\]

\[
\Delta \% = \left( \frac{V_{\text{adj}} - V_{\text{set}}}{V_{\text{adj}}} \right) \times 100
\]

Example:

To trim up the 12V model by 8% to 12.96V the required external resistor is:

\[
R_{\text{TRIM,UP}} = \left( \frac{5.11 \times 12 \times (100 + 8)}{1.225 \times 8} - \frac{511}{10.22} \right) = 601.68 \text{k}\Omega
\]

\[
\Delta \% = \left( \frac{12.96 - 12}{12} \right) \times 100 = 8
\]

Example:

To trim down the 12V model by 7% to 11.16V the required external resistor is:

\[
R_{\text{TRIM,DOWN}} = \left( \frac{5.11}{7} - 10.22 \right) = 62.78 \text{ k}\Omega
\]

Output Voltage=12V

Output Voltage Transient Response

Output voltage response to load current step:

Top trace: output voltage (500 mV/div.).
Bottom trace: load current (5 A/div.).
Time scale: (1 ms/div.).

PKM 7000A series Direct Converters
Input 66-160 V, Output up to 12.5 A / 150 W

© Flex
Technical Specification
PKM 7000A series Direct Converters
Inputs 66-160 V, Output up to 12.5 A / 150 W

Electrical Specification
15 V, 10 A / 150 W

$T_{\text{op}} = -40$ to 105°C, $V_{i} = 66$ to 160 V, {sense pins connected to output pins} unless otherwise specified under Conditions.

Typical values given at: $T_{\text{op}} = 25^\circ\text{C}$, $V_{i} = 110$ V, max $I_{o}$, unless otherwise specified under Conditions.

Additional $C_{\text{in}} = 47 \mu F$, $C_{\text{out}} = 10 \mu F$ ceramic Cap. + $22 \mu F$ E-Cap. See Operating Information section for selection of capacitor types.

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Conditions</th>
<th>min</th>
<th>typ</th>
<th>max</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>$V_{i}$ Input voltage range</td>
<td></td>
<td>66</td>
<td>150</td>
<td>V</td>
<td></td>
</tr>
<tr>
<td>$V_{\text{cut}}$ Turn-off input voltage</td>
<td>Decreasing input voltage</td>
<td>60</td>
<td>64</td>
<td>V</td>
<td></td>
</tr>
<tr>
<td>$V_{\text{on}}$ Turn-on input voltage</td>
<td>Increasing input voltage</td>
<td>62</td>
<td>66</td>
<td>V</td>
<td></td>
</tr>
<tr>
<td>$C_{i}$ Internal input capacitance</td>
<td></td>
<td>47</td>
<td>µF</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$P_{o}$ Output power</td>
<td></td>
<td>0</td>
<td>150</td>
<td>W</td>
<td></td>
</tr>
<tr>
<td>η Efficiency</td>
<td></td>
<td>89</td>
<td>%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$P_{\text{diss}}$ Power Dissipation</td>
<td>max $I_{o}$</td>
<td>10</td>
<td>30</td>
<td>W</td>
<td></td>
</tr>
<tr>
<td>$I_{\text{di}}$ Input idling power</td>
<td>$I_{o} = 0$ A, $V_{i} = 110$ V</td>
<td>1.0</td>
<td>W</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$P_{\text{nc}}$ Input standby power</td>
<td>$V_{i} = 110$ V (turned off with RC)</td>
<td>0.7</td>
<td>W</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$f_{s}$ Switching frequency</td>
<td></td>
<td>238</td>
<td>322</td>
<td>kHz</td>
<td></td>
</tr>
<tr>
<td>$V_{\text{Vo}}$ Output voltage initial setting and accuracy</td>
<td>$T_{\text{op}} = 25^\circ\text{C}$, $V_{i} = 110$ V, $I_{o} = 10$ A</td>
<td>14.82</td>
<td>15</td>
<td>15.18</td>
<td>V</td>
</tr>
<tr>
<td>$V_{0}$ Output adjust range</td>
<td>See operating information</td>
<td>13.5</td>
<td>16.5</td>
<td>V</td>
<td></td>
</tr>
<tr>
<td>$V_{\text{io}}$ Output voltage tolerance band</td>
<td>0-100% of max $I_{o}$</td>
<td>14.5</td>
<td>15</td>
<td>V</td>
<td></td>
</tr>
<tr>
<td>Idling voltage</td>
<td>$I_{o} = 0$ A</td>
<td>14.5</td>
<td>15.5</td>
<td>V</td>
<td></td>
</tr>
<tr>
<td>Line regulation</td>
<td>max $I_{o}$</td>
<td>15</td>
<td>75</td>
<td>mV</td>
<td></td>
</tr>
<tr>
<td>$V_{\text{load}}$ Load regulation</td>
<td>$V_{i} = 110$ V, 25-100% of max $I_{o}$</td>
<td>25</td>
<td>150</td>
<td>mV</td>
<td></td>
</tr>
<tr>
<td>$V_{\text{ls}}$ Load transient voltage deviation</td>
<td>$V_{i} = 110$ V, Load step 50-75-50% of max $I_{o}$, di/dt = 100mA/µs</td>
<td>±400</td>
<td>±1000</td>
<td>mV</td>
<td></td>
</tr>
<tr>
<td>$t_{s}$ Load transient recovery time</td>
<td></td>
<td>90</td>
<td>500</td>
<td>µs</td>
<td></td>
</tr>
<tr>
<td>$t_{r}$ Ramp-up time</td>
<td></td>
<td>90</td>
<td>500</td>
<td>µs</td>
<td></td>
</tr>
<tr>
<td>$t_{s}$ Start-up time</td>
<td></td>
<td>15</td>
<td>ms</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$I_{\text{ec}}$ RC start-up time (from $V_{i}$ connection to 90% of $V_{o}$)</td>
<td>max $I_{o}$</td>
<td>1.55</td>
<td>10</td>
<td>ms</td>
<td></td>
</tr>
<tr>
<td>$I_{\text{rc}}$ Sink current</td>
<td></td>
<td>10</td>
<td>mA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$I_{\text{tr}}$ Current level</td>
<td></td>
<td>0.8/2.5</td>
<td>V</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$I_{\text{ou}}$ Output current</td>
<td></td>
<td>0</td>
<td>10</td>
<td>A</td>
<td></td>
</tr>
<tr>
<td>$I_{\text{im}}$ Current limit threshold</td>
<td>$V_{i} = 110$ V, $T_{\text{op}} &lt; \text{max } T_{\text{op}}$</td>
<td>15</td>
<td>18</td>
<td>A</td>
<td></td>
</tr>
<tr>
<td>$I_{\text{sh}}$ Short circuit current</td>
<td>$T_{\text{op}} = 25^\circ\text{C}$, see Note 1</td>
<td>0.05</td>
<td>0.1</td>
<td>A</td>
<td></td>
</tr>
<tr>
<td>$C_{\text{out}}$ Recommended Capacitive Load</td>
<td>$T_{\text{op}} = 25^\circ\text{C}$, see Note 2</td>
<td>0</td>
<td>2000</td>
<td>µF</td>
<td></td>
</tr>
<tr>
<td>$V_{\text{osc}}$ Output ripple &amp; noise</td>
<td>See ripple &amp; noise section, $V_{o}$</td>
<td>43</td>
<td>150</td>
<td>mVp-p</td>
<td></td>
</tr>
<tr>
<td>OVP Over voltage protection</td>
<td></td>
<td>18</td>
<td>V</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note 1: hiccup mode
Note 2: Test condition: Electronic Capacitor and full load
PKM 7000A series Direct Converters
Input 66-160 V, Output up to 12.5 A / 150 W

**Typical Characteristics**

**15 V, 10 A / 150 W**

**Efficiency**

![Efficiency vs. load current and input voltage at +25°C.](image1)

**Power Dissipation**

![Dissipated power vs. load current and input voltage at +25°C.](image2)

**Current Limit Characteristics**

![Output voltage vs. load current at I_o > max I_o at +25°C.](image3)

**Output Current Derating**

**Output Current Derating (20mm ¼ brick heat sink)**

![Available load current vs. ambient air temperature and airflow at V=110 V. See Thermal Consideration section.](image4)

**Output Current Derating (20mm ½ brick heat sink)**

![Available load current vs. ambient air temperature and airflow at V=110 V. See Thermal Consideration section.](image5)

PKM 7215A PIP

**Efficiency vs. load current and input voltage at +25°C.**

**Dissipated power vs. load current and input voltage at +25°C.**

**Output voltage vs. load current at I_o > max I_o at +25°C.**

**Available load current vs. ambient air temperature and airflow at V=110 V. See Thermal Consideration section.**
Typical Characteristics

**15 V, 10 A / 150 W**

### Start-up

Start-up enabled by connecting VΙ at:

- \( T_{P1} = +25^\circ C \)
- \( V_I = 110 V \)
- \( I_O = 10 A \) resistive load.

Top trace: output voltage (5 V/div.).
Bottom trace: input voltage (50 V/div.).
Time scale: (100 ms/div.).

### Shut-down

Shut-down enabled by disconnecting VΙ at:

- \( T_{P1} = +25^\circ C \)
- \( V_I = 110 V \)
- \( I_O = 10 A \) resistive load.

Top trace: output voltage (5 V/div.).
Bottom trace: input voltage (50 V/div.).
Time scale: (500 ms/div.).

### Output Ripple & Noise

Output voltage ripple at:

- \( T_{P1} = +25^\circ C \)
- \( V_I = 110 V \)
- \( I_O = 10 A \) resistive load.

Trace: output voltage (50 mV/div.).
Time scale: (5 μs/div.).

### Output Load Transient Response

Output voltage response to load current step change (5.0-7.5-5.0 A) at:

- \( T_{P1} = +25^\circ C \)
- \( V_I = 110 V \)

Top trace: output voltage (500 mV/div.).
Bottom trace: load current (2 A/div.).
Time scale: (1ms/div.).

### Output Voltage Adjust (TRIM UP/TRIM DOWN)

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

**Output Voltage Adjust, Increase:**

\[
R_{TRIM\_UP} = \left( \frac{5.11 \times V_{o\_up} \times (100 + \Delta \%)}{1.225 \times \Delta \%} - 511 \right) \times 10^{-2} \text{ kΩ}
\]

\[
\Delta \% = \frac{V_{\text{desired}} - V_{o\_up}}{V_{o\_up}} \times 100
\]

**Output Voltage Adjust, Decrease:**

\[
R_{TRIM\_DOWN} = \left( \frac{511}{\Delta \%} - 10.22 \right) \text{ kΩ}
\]

\[
\Delta \% = \frac{V_{o\_up} - V_{\text{desired}}}{V_{o\_up}} \times 100
\]

**Example:**

To trim up the 15V model by 8% to 16.2V the required external resistor is:

\[
R_{TRIM\_UP} = \left( \frac{5.11 \times 15 \times (100 + 8)}{1.225 \times 8} - \frac{511}{8} - 10.22 \right) = 770.62 \text{ kΩ}
\]

\[
\Delta \% = \left( \frac{16.2 - 15}{15} \right) \times 100 = 8
\]

**Example:**

To trim down the 15V model by 7% to 13.95V the required external resistor is:

\[
R_{TRIM\_DOWN} = \left( \frac{511}{7} - 10.22 \right) = 62.78 \text{ kΩ}
\]
### Electrical Specification

**PKM 7000A series Direct Converters**

*Input 66-160 V, Output up to 12.5 A / 150 W*

**PKM 7216ZA PIP**

**24 V, 6.25 A / 150 W**

- \( T_{P1} = -40 \) to 105\(^\circ\)C, \( V_i = 66 \) to 160 V (sense pins connected to output pins) unless otherwise specified under Conditions.
- Typical values given at: \( T = +25 \)\(^\circ\)C, \( V_i = 110 \) V, max \( I_o \), unless otherwise specified under Conditions.
- Additional \( C_i = 47 \mu F, C_o = 10 \mu F \) ceramic Cap. + 22 \mu F E-Cap. See Operating Information section for selection of capacitor types.

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Conditions</th>
<th>min</th>
<th>typ</th>
<th>max</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>( V_i )</td>
<td>Input voltage range</td>
<td>66</td>
<td>160</td>
<td>V</td>
<td></td>
</tr>
<tr>
<td>( V_{out} )</td>
<td>Turn-off input voltage</td>
<td>Decreasing input voltage</td>
<td>60</td>
<td>62</td>
<td>64</td>
</tr>
<tr>
<td>( V_{vin} )</td>
<td>Turn-on input voltage</td>
<td>Increasing input voltage</td>
<td>62</td>
<td>64</td>
<td>66</td>
</tr>
<tr>
<td>( C_i )</td>
<td>Internal input capacitance</td>
<td>47</td>
<td>( \mu F )</td>
<td></td>
<td></td>
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<tr>
<td>( P_o )</td>
<td>Output power</td>
<td>0</td>
<td>150</td>
<td>W</td>
<td></td>
</tr>
<tr>
<td>( \eta )</td>
<td>Efficiency</td>
<td>50% of max ( I_o), ( V_i = 110 ) V</td>
<td>87</td>
<td>%</td>
<td></td>
</tr>
<tr>
<td>( P_{ds} )</td>
<td>Power Dissipation</td>
<td>max ( I_o), ( V_i = 110 ) V</td>
<td>88</td>
<td>%</td>
<td></td>
</tr>
<tr>
<td>( P_i )</td>
<td>Input idling power</td>
<td>( I_o = 0 ) A, ( V_i = 110 ) V</td>
<td>1.0</td>
<td>W</td>
<td></td>
</tr>
<tr>
<td>( P_{nc} )</td>
<td>Input standby power</td>
<td>( V_i = 110 ) V (turned off with RC)</td>
<td>0.7</td>
<td>W</td>
<td></td>
</tr>
<tr>
<td>( f_s )</td>
<td>Switching frequency</td>
<td>0-100% of max ( I_o)</td>
<td>297.5</td>
<td>350</td>
<td>402.5</td>
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<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Conditions</th>
<th>min</th>
<th>typ</th>
<th>max</th>
<th>Unit</th>
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<tbody>
<tr>
<td>( V_{GI} )</td>
<td>Output voltage initial setting and accuracy</td>
<td>( T_{P1} = +25 )(^\circ)C, ( V_i = 110 ) V, ( I_o = 6.25 ) A</td>
<td>23.7</td>
<td>24</td>
<td>24.3</td>
</tr>
<tr>
<td>( V_o )</td>
<td>Output adjust range</td>
<td>See operating information</td>
<td>21.6</td>
<td>24</td>
<td>26.4</td>
</tr>
<tr>
<td>( V_{out} )</td>
<td>Output voltage tolerance band</td>
<td>0-100% of max ( I_o)</td>
<td>23.4</td>
<td>24</td>
<td>24.6</td>
</tr>
<tr>
<td>( I_d )</td>
<td>Idling voltage</td>
<td>( I_o = 0 ) A</td>
<td>23.4</td>
<td>24</td>
<td>24.6</td>
</tr>
<tr>
<td>( L_{line} )</td>
<td>Line regulation</td>
<td>max ( I_o)</td>
<td>12</td>
<td>120</td>
<td>mV</td>
</tr>
<tr>
<td>( V_{load} )</td>
<td>Load regulation</td>
<td>( V_i = 110 ) V, 25-100% of max ( I_o)</td>
<td>25</td>
<td>240</td>
<td>mV</td>
</tr>
<tr>
<td>( V_{load} )</td>
<td>Load transient voltage deviation</td>
<td>( V_i = 110 ) V, Load step 50-75-50% of max ( I_o), ( di/dt = 100mA/\mu s )</td>
<td>( \pm 400 )</td>
<td>( \pm 1000 )</td>
<td>mV</td>
</tr>
<tr>
<td>( t_{tr} )</td>
<td>Load transient recovery time</td>
<td>90</td>
<td>500</td>
<td>( \mu s )</td>
<td></td>
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<tr>
<td>( t_{ramp} )</td>
<td>Ramp-up time</td>
<td>( \text{from } I_o \text{ to } 90% \text{ of } V_o )</td>
<td>15</td>
<td>ms</td>
<td></td>
</tr>
<tr>
<td>( t_{st} )</td>
<td>Start-up time</td>
<td>( \text{from } V_o \text{ to } 90% \text{ of } V_o )</td>
<td>60</td>
<td>ms</td>
<td></td>
</tr>
<tr>
<td>( t_{rc} )</td>
<td>RC start-up time</td>
<td>( \text{from } V_{cin} \text{ to } 90% \text{ of } V_o )</td>
<td>max ( I_o)</td>
<td>1.55</td>
<td>10</td>
</tr>
<tr>
<td>( RC )</td>
<td>Sink current</td>
<td>See operating information</td>
<td>10</td>
<td>mA</td>
<td></td>
</tr>
<tr>
<td>( \text{Trigger level} )</td>
<td>Decreasing / Increasing RC-voltage</td>
<td>0.8/2.5</td>
<td>V</td>
<td></td>
<td></td>
</tr>
<tr>
<td>( I_o )</td>
<td>Output current</td>
<td>0</td>
<td>6.25</td>
<td>A</td>
<td></td>
</tr>
<tr>
<td>( I_{lim} )</td>
<td>Current limit threshold</td>
<td>( V_i = 110 ) V, ( T_{P1} &lt; max ) ( T_{P1} )</td>
<td>10</td>
<td>12</td>
<td>A</td>
</tr>
<tr>
<td>( I_{sc} )</td>
<td>Short circuit current</td>
<td>( T_{P1} = +25 )(^\circ)C, see Note 1</td>
<td>0.05</td>
<td>0.1</td>
<td>A</td>
</tr>
<tr>
<td>( C_{init} )</td>
<td>Recommended Capacitive Load</td>
<td>( T_{P1} = +25 )(^\circ)C, see Note 2</td>
<td>0</td>
<td>2000</td>
<td>( \mu F )</td>
</tr>
<tr>
<td>( V_{op} )</td>
<td>Output ripple &amp; noise</td>
<td>See ripple &amp; noise section, ( V_o )</td>
<td>27</td>
<td>500</td>
<td>mVpp</td>
</tr>
<tr>
<td>( OVP )</td>
<td>Over voltage protection</td>
<td>( T_{P1} = +25 )(^\circ)C, ( V_i = 110 ) V, 0-100% of max ( I_o)</td>
<td>28</td>
<td>V</td>
<td></td>
</tr>
</tbody>
</table>

**Note 1:** hiccup mode

**Note 2:** Test condition: Electronic Capacitor and full load
**PKM 7000A series** Direct Converters
Input 66-160 V, Output up to 12.5 A / 150 W

**Typical Characteristics**

**Efficiency**

![Efficiency vs. load current and input voltage at +25°C.](image)

*Efficiency vs. load current and input voltage at +25°C.*

**Power Dissipation**

![Dissipated power vs. load current and input voltage at +25°C.](image)

*Dissipated power vs. load current and input voltage at +25°C.*

**Current Limit Characteristics**

![Output voltage vs. load current at I_o > max I_o at +25°C.](image)

*Output voltage vs. load current at I_o > max I_o at +25°C.*

**Output Current Derating (20mm ¼ brick heat sink)**

![Available load current vs. ambient air temperature and airflow at V_I=110 V. See Thermal Consideration section.](image)

*Available load current vs. ambient air temperature and airflow at V_I=110 V. See Thermal Consideration section.*

**Output Current Derating (20mm ½ brick heat sink)**

![Available load current vs. ambient air temperature and airflow at V_I=110 V. See Thermal Consideration section.](image)

*Available load current vs. ambient air temperature and airflow at V_I=110 V. See Thermal Consideration section.*
Typical Characteristics
24 V, 6.25 A / 150 W

Start-up
Start-up enabled by connecting \( V_i \) at:
\[ T_{1i} = +25°C, V_i = 110 V, \]
\( I_O = 6.25 A \) resistive load.
Top trace: output voltage (10 V/div.).
Bottom trace: input voltage (50 V/div.).
Time scale: (50 ms/div.).

Output Ripple & Noise
Output voltage ripple at:
\[ T_{1i} = +25°C, V_i = 110 V, \]
\( I_O = 6.25 A \) resistive load.
Trace: output voltage (20 mV/div.).
Time scale: (5 \( \mu \)s/div.).

Output Load Transient Response
Output voltage response to load current step change (3.125-4.68-3.125 A) at:
\[ T_{1i} = +25°C, V_i = 110 V. \]
Top trace: output voltage (500 mV/div.).
Bottom trace: load current (1 A/div.).
Time scale: (1 ms/div.).

Output Voltage Adjust (see operating information)
The resistor value for an adjusted output voltage is calculated by using the following equations:
Output Voltage Adjust, Increase:
\[
R_{\text{ADJ\_UP}} = \left( \frac{14.6061}{\Delta} - 120 \right) \text{k}\Omega
\]
Output Voltage Adjust, Decrease:
\[
R_{\text{ADJ\_DOWN}} = \left( \frac{17.2133}{\Delta} - 151.819 \right) \text{k}\Omega
\]
Example:
To trim up the 24V model by 8% to 25.92V the required external resistor is:
\[
R_{\text{ADJ\_UP}} = \left( \frac{14.6061}{0.08} - 120 \right) = 62.58 \text{k}\Omega
\]
Example:
To trim down the 24V model by 7% to 22.32V the required external resistor is:
\[
R_{\text{ADJ\_DOWN}} = \left( \frac{17.2133}{0.07} - 151.819 \right) = 94.08 \text{k}\Omega
\]

PKM 7216ZA PIP

Shut-down
Shut-down enabled by disconnecting \( V_i \) at:
\[ T_{1i} = +25°C, V_i = 110 V, \]
\( I_O = 6.25 A \) resistive load.
Top trace: output voltage (10 V/div.).
Bottom trace: input voltage (50 V/div.).
Time scale: (50 ms/div.).

Output Voltage=24V
### PKM 7000A series Direct Converters

Input 66-160 V, Output up to 12.5 A / 150 W

---

**Electrical Specification**

54 V, 2.78 A / 150 W

$T_{pr} = -40$ to 105$^\circ$C, $V_i = 66$ to 160 V, (sense pins connected to output pins) unless otherwise specified under Conditions.

Typical values given at: $T_{pr} = +25^\circ$C, $V_i = 110$ V max $I_o$, unless otherwise specified under Conditions.

Additional Cin = 47 µF, Cout = 10uF ceramic Cap. + 22uF E-Cap. See Operating Information section for selection of capacitor types.

#### Technical Specification

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Conditions</th>
<th>min</th>
<th>typ</th>
<th>max</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>$V_i$</td>
<td>Input voltage range</td>
<td>66</td>
<td>160</td>
<td>V</td>
<td></td>
</tr>
<tr>
<td>$V_{on}$</td>
<td>Turn-off input voltage</td>
<td>Decreasing input voltage</td>
<td>60</td>
<td>62</td>
<td>64</td>
</tr>
<tr>
<td>$V_{on}$</td>
<td>Turn-on input voltage</td>
<td>Increasing input voltage</td>
<td>62</td>
<td>64</td>
<td>66</td>
</tr>
<tr>
<td>$C_i$</td>
<td>Internal input capacitance</td>
<td>47</td>
<td>µF</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$P_o$</td>
<td>Output power</td>
<td>0</td>
<td>150</td>
<td>W</td>
<td></td>
</tr>
<tr>
<td>$\eta$</td>
<td>Efficiency</td>
<td>50% of max $I_o$, $V_i = 110$ V</td>
<td>89</td>
<td>%</td>
<td></td>
</tr>
<tr>
<td>$P_{di}$</td>
<td>Power Dissipation</td>
<td>max $I_o$</td>
<td>10</td>
<td>18</td>
<td>W</td>
</tr>
<tr>
<td>$P_{in}$</td>
<td>Input idling power</td>
<td>$I_o = 0$ A, $V_i = 110$ V</td>
<td>1.0</td>
<td>W</td>
<td></td>
</tr>
<tr>
<td>$P_{inc}$</td>
<td>Input standby power</td>
<td>$V_i = 110$ V (turned off with RC)</td>
<td>0.7</td>
<td>W</td>
<td></td>
</tr>
<tr>
<td>$f_s$</td>
<td>Switching frequency</td>
<td>0-100 % of max $I_o$</td>
<td>297.5</td>
<td>350</td>
<td>402.5</td>
</tr>
</tbody>
</table>

$V_o$ | Output voltage initial setting and accuracy | $T_{pr} = +25^\circ$C, $V_i = 110$ V, $I_o = 2.78$ A | 53.352 | 54 | 54.648 | V |

$V_o$ | Output adjust range | See operating information | 48.6 | 54 | 59.4 | V |

$V_o$ | Output voltage tolerance band | 0-100% of max $I_o$ | 52.38 | 55.62 | V |
| Idling voltage | $I_o = 0$ A | 52.38 | 55.62 | V |
| Line regulation | max $I_o$ | 150 | 270 | mV |
| Load regulation | $V_i = 110$ V, 25-100% of max $I_o$ | 300 | 540 | mV |

$V_o$ | Load transient voltage deviation | $V_i = 110$ V, Load step 50-75-50% of max $I_o$, di/dt = 100mA/µs | ±800 | ±1000 | mV |

$t_o$ | Load transient recovery time | See operating information | 50 | 500 | µs |

$t_{r}$ | Ramp-up time (from 10-90% of $V_o$) | 15 | ms |

$t_{s}$ | Start-up time (from $V_o$ connection to 90% of $V_o$) | 60 | ms |

$T_{sec}$ | RC start-up time (from $V_o$ connection to 90% of $V_o$) | max $I_o$ | 1.5 | 10 | ms |

$R_C$ | Sink current | See operating information | 10 | mA |

$T_{sec}$ | Trigger level | Decreasing / Increasing RC-voltage | 0.8/2.5 | V |

$I_o$ | Output current | 0 | 2.78 | A |

$I_{sec}$ | Current limit threshold | $V_i = 110$ V, $T_{pr} < max T_{pr}$ | 3.8 | 5.56 | A |

$I_{sec}$ | Short circuit current | $T_{pr} = 25^\circ$C, see Note 1 | 0.1 | 0.2 | A |

$C_{out}$ | Recommended Capacitive Load | $T_{pr} = 25^\circ$C, see Note 2 | 0 | 2000 | µF |

$V_{sec}$ | Output ripple & noise | See ripple & noise section, $V_{oi}$ | 100 | 200 | mVp-p |

$OVP$ | Over voltage protection | $T_{pr} = +25^\circ$C, $V_i = 110$ V, 0-100% of max $I_o$ | 62 | V |

**Note 1:** hiccup mode

**Note 2:** Test condition: Electronic Capacitor and full load
PKM 7000A series Direct Converters
Input 66-160 V, Output up to 12.5 A / 150 W

Typical Characteristics

54 V, 2.78 A / 150 W

Efficiency

Efficiency vs. load current and input voltage at +25°C.

Power Dissipation

Dissipated power vs. load current and input voltage at +25°C.

Current Limit Characteristics

Output voltage vs. load current at $I_o > max I_o$ at +25°C.

Output Current Derating (20mm $\frac{1}{4}$ brick heat sink)

Available load current vs. ambient air temperature and airflow at $V_i=110$ V. See Thermal Consideration section.

Output Current Derating (20mm $\frac{1}{2}$ brick heat sink)

Available load current vs. ambient air temperature and airflow at $V_i=110$ V. See Thermal Consideration section.
Typical Characteristics
54 V, 2.78 A / 150 W

Start-up

Top trace: output voltage (20 V/div.).
Bottom trace: input voltage (50 V/div.).
Time scale: (50 ms/div.).

Output Voltage Adjust (TRIM UP/TRIM DOWN)

\[
R_{ADJ\_UP} = \left( \frac{32.667}{\Delta} - 270 \right) \text{k}\Omega
\]

Output Voltage Adjust, Decrease:

\[
R_{ADJ\_DOWN} = \left( \frac{40.524}{\Delta} - 343.191 \right) \text{k}\Omega
\]

Example:
To trim up the 54V model by 8% to 58.32V the required external resistor is:

\[
R_{ADJ\_UP} = \left( \frac{32.667}{0.08} - 270 \right) = 138.34 \text{ k}\Omega
\]

Example:
To trim down the 54V model by 7% to 50.22V the required external resistor is:

\[
R_{ADJ\_DOWN} = \left( \frac{40.524}{0.07} - 343.191 \right) = 235.723 \text{ k}\Omega
\]

Output Voltage=54V

Output Load Transient Response

Trace: output voltage (200 mV/div.).
Bottom trace: load current (1 A/div.).
Time scale: (1 ms/div.).
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 350 kHz for PKM 7116ZA (100W/24V) at Vi = 110 V and max Io.

Conducted EMI Input terminal value (typ)

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

Filter components:
- C01, C02, C03 = 10 µF
- CY1, CY2, CY9, CY10 = 10K pF
- L01 = 8 mH
- L02 = 45 mH

Layout recommendations
The radiated EMI performance of the product will depend on the PWB 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 PWB 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.
Operating information

Input Voltage
The input voltage range 66 to 160 Vdc meets the railway systems. At input voltages exceeding 160 V, the power loss will be higher than at normal input voltage and Tp1 must be limited to absolute max 115°C. The absolute maximum continuous input voltage is 200 Vdc.

Short duration transient disturbances can occur on the DC distribution and input of the product when a short circuit fault occurs on the equipment side of a protective device (fuse or circuit breaker). The voltage level, duration and energy of the disturbance are dependant on the particular DC distribution network characteristics and can be sufficient to damage the product unless measures are taken to suppress or absorb this energy. The transient voltage can be limited by capacitors and other energy absorbing devices like zener diodes connected across the positive and negative input conductors at a number of strategic points in the distribution network. The end-user must secure that the transient voltage will not exceed the value stated in the Absolute maximum ratings. ETSI TR 100 283 examines the parameters of DC distribution networks and provides guidelines for controlling the transient and reduce its harmful effect.

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 1.7 V.

Remote Control (RC)

The products are fitted with a remote control function referenced to the primary negative input Econnection (-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 RC pin has an internal pull up resistor to +In.

The external device must provide a minimum required sink current to guarantee a voltage not higher than maximum voltage on the RC pin (see Electrical characteristics table). When the RC pin is left open, the voltage generated on the RC pin is 3 - 5 V.

The standard product is provided with “negative logic” (Active Low) remote control. When the RC pin is left open, or connected to a voltage higher than 2V referenced to -In, the product will be off when the input voltage is applied. To turn on the product, the RC pin should be connected 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 must be wired directly to -In.

The Second option is “positive logic” (Active High) remote control, which can be ordered by adding the suffix “P” to the end of the part number. In this case, 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. 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.

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 PWB 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 Flex representative.
Output Voltage Adjust (V\textsubscript{adj})
The products have an Output Voltage Adjust pin (V\textsubscript{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\textsubscript{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\textsubscript{adj} pin and –Sense pin.

Parallel Operation
Two products may be paralleled for redundancy if the total power is equal or less than P\textsubscript{O max}. It is not recommended to parallel the products without using external current sharing circuits.

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 PWB 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\textsubscript{P1} as defined in thermal consideration section exceeds 115°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 >10°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. The output voltage will decrease towards zero for output currents in excess of max output current (max I\textsubscript{O}). The product will resume normal operation after removal of the overload. The load distribution should be designed for the maximum output short circuit current specified.
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 PWB without a heat sink attached, cooling is achieved mainly by conduction, from the pins to the host board, and convection, which is dependent 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 $V_I = 110V$.

The product 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 608 x 203 mm.

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. The temperature at this position ($T_{P1}$) should not exceed the maximum temperatures in the table below. Temperature above maximum $T_{P1}$, measured at the reference point P1 are not allowed and may cause permanent damage.

<table>
<thead>
<tr>
<th>Position</th>
<th>Description</th>
<th>Max Temp.</th>
</tr>
</thead>
<tbody>
<tr>
<td>P1</td>
<td>Reference point</td>
<td>115°C</td>
</tr>
</tbody>
</table>
PKM 7000A series Direct Converters
Input 66-160 V, Output up to 12.5 A / 150 W

Connections

<table>
<thead>
<tr>
<th>Pin</th>
<th>Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>-Vin</td>
</tr>
<tr>
<td>2</td>
<td>Remote On/Off Control</td>
</tr>
<tr>
<td>3</td>
<td>+Vin</td>
</tr>
<tr>
<td>4</td>
<td>-Vout</td>
</tr>
<tr>
<td>5</td>
<td>-Vsense</td>
</tr>
<tr>
<td>6</td>
<td>Trim</td>
</tr>
<tr>
<td>7</td>
<td>+Vsense</td>
</tr>
<tr>
<td>8</td>
<td>+Vout</td>
</tr>
</tbody>
</table>
PKM 7000A series Direct Converters
Input 66-160 V, Output up to 12.5 A / 150 W

Mechanical Information - Enclosure Type

<table>
<thead>
<tr>
<th>Pin</th>
<th>Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>-Vin</td>
</tr>
<tr>
<td>2</td>
<td>Remote On/Off Control</td>
</tr>
<tr>
<td>3</td>
<td>+Vin</td>
</tr>
<tr>
<td>4</td>
<td>-Vout</td>
</tr>
<tr>
<td>5</td>
<td>-Vsense</td>
</tr>
<tr>
<td>6</td>
<td>Trim</td>
</tr>
<tr>
<td>7</td>
<td>+Vsense</td>
</tr>
<tr>
<td>8</td>
<td>+Vout</td>
</tr>
</tbody>
</table>

Notes:
1. Pins:
   Material: Brass
   Plating: Nickel

2. Weight: typical 70g
   All dimensions in inches (mm).
   Tolerance .xx= ±0.04"
   .xxx=±0.010"

All component placements – whether shown as physical components or symbolical outline – are for reference only and are subject to change throughout the product's life cycle, unless explicitly described and dimensioned in this drawing.
Notes:
1. Pins:
   Material: Brass
   Plating: Nickel

2. Heatsink:
   Material: aluminum
   Plating: Anodized

3. Weight: typical 110g
   All dimensions in inches (mm).
   Tolerance .xx = ±0.04”
   .xxx = ±0.010”
Mechanical Information - 20mm ¼ brick heat sink

Notes:
1. Pins:
   Material: Brass
   Plating: Nickel

2. Heatsink:
   Material: aluminum
   Plating: Anodized

3. Weight: typical 130g
   All dimensions in inches (mm).
   Tolerance: xx = ±0.04"  
   xxx = ±0.010"

All component placements – whether shown as physical components or symbolical outline – are for reference only and are subject to change throughout the product’s life cycle, unless explicitly described and dimensioned in this drawing.
Mechanical Information - 20mm ½ brick heat sink

Notes:
1. Pins:
   Material: Brass
   Plating: Nickel

2. Heatsink:
   Material: aluminum
   Plating: Anodized

3. Weight: typical 140g
   All dimensions in inches (mm).
   Tolerance .xx= ±0.04"
   .xxx=±0.010"
PKM 7000A series Direct Converters
Input 66-160 V, Output up to 12.5 A / 150 W

RECOMMENDED FOOTPRINT
TOP VIEW

2.28" (57.9)
2.000" (50.80)
1.858" (47.20)

2-Ø0.075" (Ø1.90)

6-Ø0.055" (Ø1.40)
Soldering Information

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 clamshell trays

<table>
<thead>
<tr>
<th>Tray Specifications</th>
</tr>
</thead>
<tbody>
<tr>
<td>Material</td>
</tr>
<tr>
<td>Surface resistance</td>
</tr>
<tr>
<td>Bakability</td>
</tr>
<tr>
<td>Tray thickness</td>
</tr>
<tr>
<td>Box capacity</td>
</tr>
<tr>
<td>Tray weight</td>
</tr>
</tbody>
</table>

PKM 7000A series Direct Converters
Input 66-160 V, Output up to 12.5 A / 150 W

A. Package (with no heat sink)

B. Package (with 10mm ¼ brick heat sink)

C. Package (with 20mm ¼ brick heat sink)

D. Package (with 20mm ½ brick heat sink)
## Product Qualification Specification

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>IPC-A-610</th>
<th>Temperature range</th>
<th>Number of cycles</th>
<th>Dwell/transfer time</th>
</tr>
</thead>
<tbody>
<tr>
<td>External visual inspection</td>
<td>IEC 60068-2-14 Na</td>
<td>-55 to 105°C</td>
<td>20</td>
<td>30 min/3 min</td>
</tr>
<tr>
<td>Change of temperature (Temperature cycling)</td>
<td>IEC 60068-2-1 Ad</td>
<td></td>
<td>-45°C</td>
<td>72 h</td>
</tr>
<tr>
<td>Cold (in operation)</td>
<td>IEC 60068-2-30</td>
<td></td>
<td>45°C</td>
<td>95 % RH</td>
</tr>
<tr>
<td>Damp heat</td>
<td>IEC 60068-2-2 Bd</td>
<td></td>
<td>125°C</td>
<td>1000 h</td>
</tr>
<tr>
<td>Dry heat</td>
<td>IEC 61340-3-1, JESD 22-A114</td>
<td></td>
<td>Human body model (HBM)</td>
<td>Class 2, 2000 V</td>
</tr>
<tr>
<td>Electrostatic discharge susceptibility</td>
<td></td>
<td>Water</td>
<td>55°C</td>
<td>35°C</td>
</tr>
<tr>
<td>Immersion in cleaning solvents</td>
<td>IEC 60068-2-45 XA, method 2</td>
<td>Glycol ether</td>
<td>35°C</td>
<td>(35°C)</td>
</tr>
<tr>
<td>Mechanical shock</td>
<td>IEC 60068-2-27 Ea</td>
<td>Peak acceleration</td>
<td>200 g</td>
<td>6 ms</td>
</tr>
<tr>
<td>Moisture reflow sensitivity</td>
<td>J-STD-020 E</td>
<td>Level 1 (SnPb-eutectic)</td>
<td>225°C</td>
<td></td>
</tr>
<tr>
<td>Resistance to soldering heat</td>
<td>IEC 60068-2-20 Tb, method 1A</td>
<td>Solder temperature</td>
<td>270°C</td>
<td>10-13 s</td>
</tr>
<tr>
<td>Robustness of terminations</td>
<td>IEC 60068-2-21 Test Ua1</td>
<td>Through hole mount products</td>
<td>All leads</td>
<td></td>
</tr>
<tr>
<td>Solderability</td>
<td>IEC 60068-2-20 test Ta ¹</td>
<td>Preconditioning</td>
<td>235°C</td>
<td>245°C</td>
</tr>
<tr>
<td>Vibration, broad band random</td>
<td>IEC 60068-2-64 Fh, method 1</td>
<td>Frequency</td>
<td>10 to 500 Hz</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Spectral density</td>
<td>0.07 g²/Hz</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Duration</td>
<td>10 min in each direction</td>
<td></td>
</tr>
</tbody>
</table>

### Notes

¹ Only for products intended for wave soldering (plated through hole products)

### EN 50155

<table>
<thead>
<tr>
<th>Phenomenon</th>
<th>EN 50155 Reference Clause(s)</th>
<th>Reference Standard</th>
</tr>
</thead>
<tbody>
<tr>
<td>Characteristic Test</td>
<td>12.2.1, 12.2.2, 5.1.1.1, 5.1.3, 12.2.9, 12.2.6</td>
<td>-</td>
</tr>
<tr>
<td>EMC</td>
<td>12.2.7, 12.2.8</td>
<td>EN 50121-3-2, EN 61000-4, EN 55011</td>
</tr>
<tr>
<td>Environmental Tests</td>
<td>12.2.3, 12.2.4, 12.2.5, 12.2.11</td>
<td>EN 60068-2, EN 61373</td>
</tr>
</tbody>
</table>