PKM 4516ZE PI Direct Converters
Input 36-75 V, Output up to 2.1 A / 50 W

Key Features
- Industry standard 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. 89 % at 24 Vout full load
- 1500 Vdc input to output isolation
- Meets isolation requirements equivalent to basic insulation according to IEC/EN/UL 60950
- More than 2.0 million hours MTBF

General Characteristics
- Suited for narrow board pitch applications (15 mm/0.6 in)
- Output over voltage protection
- Input under voltage shutdown
- Over temperature protection
- Monotonic start-up
- Pre-biased start-up capability
- 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
24V, 2.1A / 50W PKM 4516ZE PI .......................................... 5

EMC Specification .............................................................. 8
Operating Information ............................................................ 9
Thermal Consideration .......................................................... 10
Connections ................................................................. 11
Mechanical Information ........................................................ 12
Soldering Information .......................................................... 14
Delivery Information .......................................................... 14
Product Qualification Specification ......................................... 15
General Information

Ordering Information
See Contents for individual product ordering numbers.

<table>
<thead>
<tr>
<th>Option</th>
<th>Suffix</th>
<th>Ordering No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Positive Remote Control Logic</td>
<td>P</td>
<td>PKM 4516ZE PIP</td>
</tr>
<tr>
<td>Heatsink</td>
<td>HS</td>
<td>PKM 4516ZE PIHS</td>
</tr>
<tr>
<td>Lead length 3.69 mm (0.145 in)</td>
<td>LA</td>
<td>PKM 4516ZE PILA</td>
</tr>
</tbody>
</table>

Note: As an example a positive logic, heatsink, short pin product would be PKM 4516ZE PIPHLA.

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

Predicted MTBF for the series is:
- 2.0 million hours according to Telcordia SR332, issue 1, Black box technique.

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

Compatibility with RoHS requirements
The products are compatible with the relevant clauses and requirements of the RoHS directive 2011/65/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 include:
- Lead in high melting temperature type solder (used to solder the die in semiconductor packages)
- Lead in glass of electronics components and in electronic ceramic parts (e.g. fill material in chip resistors)
- Lead as an alloying element in copper alloy containing up to 4% lead by weight (used in connection pins made of Brass)

The exemption for lead in solder for servers, storage and storage array systems, network infrastructure equipment

for switching, signaling, transmission as well as network management for telecommunication are only utilized in products intended for end-users' leaded (SnPb Eutectic) soldering processes.

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

Warranty
Warranty period and conditions are defined in 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).

© Flex 2017
The information and specifications in this technical specification is believed to be correct at the time of publication. However, no liability is accepted for inaccuracies, printing errors or for any consequences thereof. Flex Power reserves the right to change the contents of this technical specification at any time without prior notice.
Safety Specification

**General information**
Flex DC/DC converters and DC/DC regulators are designed in accordance with safety standards IEC/EN/UL60950, *Safety of Information Technology Equipment*.

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

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

On-board DC-DC converters are defined as component power supplies. As components they cannot fully comply with the provisions of any Safety requirements without “Conditions of Acceptability”. It is the responsibility of the installer to ensure that the final product housing these components complies with the requirements of all applicable Safety standards and Directives for the final product.

Component power supplies for general use should comply with the requirements in IEC60950, EN60950 and UL60950 “Safety of information technology equipment”.

There are other more product related standards, e.g. IEEE802.3af “Ethernet LAN/MAN Data terminal equipment power”, and ETS300132-2 “Power supply interface at the input to telecommunications equipment; part 2: DC”, but all of these standards are based on IEC/EN/UL60950 with regards to safety.

Flex DC/DC converters and DC/DC regulators are UL60950 recognized and certified in accordance with EN60950.

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

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

**Isolated DC/DC converters**

It is recommended that a slow blow fuse with a rating twice the maximum input current per selected product be used at the input of each DC/DC converter. If an input filter is used in the circuit the fuse should be placed in front of the input filter.

In the rare event of a component problem in the input filter or in the DC/DC converter that imposes a short circuit on the input source, this fuse will provide the following functions:

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

The galvanic isolation is verified in an electric strength test. The test voltage \( V_{iso} \) between input and output is 1500 Vdc or 2250 Vdc for 60 seconds (refer to product specification).

Leakage current is less than 1 µA at nominal input voltage.

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

**48 and 60 V DC systems**
If the input voltage to Flex DC/DC converter is 75 Vdc or less, then the output remains SELV (Safety Extra Low Voltage) under normal and abnormal operating conditions.

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

If the input power source circuit is a DC power system, the source may be treated as a TNV2 circuit and testing has demonstrated compliance with SELV limits and isolation requirements equivalent to Basic Insulation in accordance with IEC/EN/UL60950.
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>$T_{ref}$ Operating Temperature (see Thermal Consideration section)</td>
<td>-40</td>
<td>+110</td>
<td>°C</td>
<td></td>
</tr>
<tr>
<td>$T_S$ Storage temperature</td>
<td>-55</td>
<td>+125</td>
<td>°C</td>
<td></td>
</tr>
<tr>
<td>$V_I$ Input voltage</td>
<td>-0.5</td>
<td>+80</td>
<td>V</td>
<td></td>
</tr>
<tr>
<td>$V_{iso}$ Isolation voltage (input to output test voltage)</td>
<td>1500</td>
<td></td>
<td>Vdc</td>
<td></td>
</tr>
<tr>
<td>$V_{in}$ Input voltage transient ($t_p$ 100 ms)</td>
<td>100</td>
<td></td>
<td>V</td>
<td></td>
</tr>
<tr>
<td>$V_{RC}$ Remote Control pin voltage (see Operating Information section)</td>
<td>Positive logic option -0.5</td>
<td>8</td>
<td>V</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Negative logic option -0.5</td>
<td>18</td>
<td>V</td>
<td></td>
</tr>
<tr>
<td>$V_{adj}$ Adjust pin voltage (see Operating Information section)</td>
<td>-0.5</td>
<td>2x$V_{oi}$</td>
<td>V</td>
<td></td>
</tr>
</tbody>
</table>

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
## 24 V/2.1 A Electrical Specification

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

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

### 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>36</td>
<td>75</td>
<td></td>
<td>V</td>
</tr>
<tr>
<td>$V_{\text{off}}$ Turn-off input voltage</td>
<td>Decreasing input voltage</td>
<td>28</td>
<td>31</td>
<td>33</td>
<td>V</td>
</tr>
<tr>
<td>$V_{\text{on}}$ Turn-on input voltage</td>
<td>Increasing input voltage</td>
<td>32</td>
<td>34</td>
<td>36</td>
<td>V</td>
</tr>
<tr>
<td>$C_i$ Internal input capacitance</td>
<td></td>
<td>5</td>
<td></td>
<td>0.5</td>
<td>μF</td>
</tr>
<tr>
<td>$P_o$ Output power</td>
<td>Output voltage initial setting</td>
<td>0</td>
<td>50</td>
<td>50</td>
<td>W</td>
</tr>
<tr>
<td>SVR Supply voltage rejection (ac)</td>
<td>$f = 100\text{ Hz} \text{ sinewave}, 1\text{ Vp-p}$</td>
<td>60</td>
<td></td>
<td></td>
<td>dB</td>
</tr>
<tr>
<td>$\eta$ Efficiency</td>
<td>$50% \text{ of max } I_o$</td>
<td>87.0</td>
<td></td>
<td></td>
<td>%</td>
</tr>
<tr>
<td></td>
<td>max $I_o$</td>
<td>89.0</td>
<td></td>
<td></td>
<td>%</td>
</tr>
<tr>
<td></td>
<td>$50% \text{ of max } I_o, V_i = 48\text{V}$</td>
<td>88.0</td>
<td></td>
<td></td>
<td>%</td>
</tr>
<tr>
<td></td>
<td>max $I_o, V_i = 48\text{V}$</td>
<td>89</td>
<td></td>
<td></td>
<td>%</td>
</tr>
<tr>
<td>$P_d$ Power Dissipation</td>
<td>max $I_o$</td>
<td>6.2</td>
<td>7.8</td>
<td>7.8</td>
<td>W</td>
</tr>
<tr>
<td>$P_i$ Input idling power</td>
<td>$I_o = 0\text{ A, } V_i = 53\text{V}$</td>
<td>1.2</td>
<td></td>
<td></td>
<td>W</td>
</tr>
<tr>
<td>$P_{\text{RC}}$ Input standby power</td>
<td>$V_i = 53\text{V} \text{ (turned off with RC)}$</td>
<td>0.15</td>
<td></td>
<td></td>
<td>W</td>
</tr>
<tr>
<td>$I_s$ Switching frequency</td>
<td>0-100 $% \text{ of max } I_o$</td>
<td>270</td>
<td>300</td>
<td>330</td>
<td>kHz</td>
</tr>
</tbody>
</table>

### $V_{\text{Oi}}$

Output voltage initial setting and accuracy: $T_{\text{ref}} = +25^\circ$C, $V_i = 53\text{V}, I_o = 2.1\text{ A}$

<table>
<thead>
<tr>
<th>$V_o$ Output voltage</th>
<th>Conditions</th>
<th>min</th>
<th>typ</th>
<th>max</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Output adjust range</td>
<td>See operating info. and Note 1</td>
<td>21.6</td>
<td>26.4</td>
<td></td>
<td>V</td>
</tr>
<tr>
<td>Output voltage tolerance band</td>
<td>10-100 $% \text{ of max } I_o$</td>
<td>23.2</td>
<td>24.8</td>
<td></td>
<td>V</td>
</tr>
<tr>
<td>Idling voltage $I_o = 0\text{ A}$</td>
<td></td>
<td>23.1</td>
<td>25.0</td>
<td></td>
<td>V</td>
</tr>
<tr>
<td>Line regulation</td>
<td>max $I_o$</td>
<td>10</td>
<td>20</td>
<td></td>
<td>mV</td>
</tr>
<tr>
<td>Load regulation $V_i = 53\text{V}, 0-100 $% \text{ of max } I_o$</td>
<td>10</td>
<td>25</td>
<td></td>
<td>mV</td>
<td></td>
</tr>
<tr>
<td>$V_{\text{tr}}$ Load transient voltage deviation</td>
<td>$V_i = 53\text{V}, \text{ Load step 25-75-25} $ $% \text{ of max } I_o, \text{ di/dt = 1 A/μs}$</td>
<td>600</td>
<td></td>
<td></td>
<td>mV</td>
</tr>
<tr>
<td>$t_{\text{tr}}$ Load transient recovery time</td>
<td>$V_i = 53\text{V}$</td>
<td>250</td>
<td></td>
<td></td>
<td>μs</td>
</tr>
<tr>
<td>$t_{r}$ Ramp-up time (from 10–90 $% \text{ of } V_o$)</td>
<td>10-100 $% \text{ of max } I_o, T_{\text{ref}} = +25^\circ$C, $V_i = 53\text{V}$</td>
<td>5</td>
<td>10</td>
<td>15</td>
<td>ms</td>
</tr>
<tr>
<td>$t_{s}$ Start-up time (from $V_i$ connection to 90 $% \text{ of } V_o$)</td>
<td>10</td>
<td>15</td>
<td>20</td>
<td>ms</td>
<td></td>
</tr>
<tr>
<td>$t_{\text{f}}$ $V_i$ shut-down fall time (from $V_i$ off to 10 $% \text{ of } V_o$)</td>
<td>max $I_o$</td>
<td>1</td>
<td></td>
<td></td>
<td>ms</td>
</tr>
<tr>
<td>$t_{\text{RC}}$ RC start-up time (from RC off to 10 $% \text{ of } V_o$)</td>
<td>max $I_o$</td>
<td>12</td>
<td></td>
<td></td>
<td>ms</td>
</tr>
<tr>
<td>$t_{\text{RC}}$ RC shut-down fall time (from RC off to 10 $% \text{ of } V_o$)</td>
<td>max $I_o$</td>
<td>1</td>
<td></td>
<td></td>
<td>ms</td>
</tr>
<tr>
<td>$I_o$ Output current</td>
<td>0</td>
<td>2.1</td>
<td></td>
<td></td>
<td>A</td>
</tr>
<tr>
<td>$I_{\text{lim}}$ Current limit threshold</td>
<td>$V_o = 23.4\text{V} &lt; \text{ max } T_{\text{ref}}$</td>
<td>2.2</td>
<td>2.5</td>
<td>2.9</td>
<td>A</td>
</tr>
<tr>
<td>$I_{\text{sc}}$ Short circuit current</td>
<td>$T_{\text{ref}} = 25^\circ\text{C}, V_o &lt; 0.2$</td>
<td>3.3</td>
<td>3.9</td>
<td>3.9</td>
<td>A</td>
</tr>
<tr>
<td>$V_{\text{OAC}}$ Output ripple &amp; noise</td>
<td>See ripple &amp; noise section, max $I_o, V_o$</td>
<td>25</td>
<td>50</td>
<td></td>
<td>mVp-p</td>
</tr>
<tr>
<td>OVP Over voltage protection</td>
<td>$T_{\text{ref}} = +25^\circ\text{C}, V_i = 53\text{V}, 0-100 $% \text{ of max } I_o$</td>
<td>28</td>
<td>32</td>
<td></td>
<td>V</td>
</tr>
</tbody>
</table>

Note 1: Output current is limited to 0.6A to obtain $V_o = 26.4$ at $V_i = 36\text{V}$.
PKM 4516ZE PI Direct Converters
Input 36-75 V, Output up to 2.1 A / 50 W

24 V/2.1 A Typical Characteristics

Efficiency

![Efficiency graph](image1)

Efficiency vs. load current and input voltage at T\textsubscript{ref} = +25°C

Power Dissipation

![Power Dissipation graph](image2)

Dissipated power vs. load current and input voltage at T\textsubscript{ref} = +25°C

Output Current Derating

![Output Current Derating graph](image3)

Available load current vs. ambient air temperature and airflow at V\textsubscript{i} = 53 V. See Thermal Consideration section.

Thermal Resistance

![Thermal Resistance graph](image4)

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

Output Characteristics

![Output Characteristics graph](image5)

Output voltage vs. load current at T\textsubscript{ref} = +25°C

Current Limit Characteristics

![Current Limit Characteristics graph](image6)

Output voltage vs. load current at I\textsubscript{O} > max I\textsubscript{O}, T\textsubscript{ref} = +25°C
**24 V/2.1 A Typical Characteristics**

**Start-up**
- Top trace: output voltage (10 V/div).
- Bottom trace: input voltage (20 V/div).
- Time scale: (5 ms/div.).
- Start-up enabled by connecting V: at:
  - $T_{ref} = +25 \, ^\circ C$, $V_i = 53 \, V$.
  - $I_o = 2.1 \, A$ resistive load.

**Shut-down**
- Top trace: output voltage (10 V/div).
- Bottom trace: input voltage (50 V/div).
- Time scale: (10 ms/div.).
- Shut-down enabled by disconnecting V: at:
  - $T_{ref} = +25 \, ^\circ C$, $V_i = 53 \, V$.
  - $I_o = 2.1 \, A$ resistive load.

**Output Ripple & Noise**
- Top trace: output voltage (5 mV/div.).
- Time scale: (2 µs/div.).
- Output voltage ripple at:
  - $T_{ref} = +25 \, ^\circ C$, $V_i = 53 \, V$.
  - $I_o = 2.1 \, A$ resistive load.

**Output Load Transient Response**
- Top trace: output voltage (0.5 V/div.).
- Bottom trace: load current (1 A/div.).
- Time scale: (0.1 ms/div.).
- Output voltage response to load current step-change (0.52-1.58-0.52 A) at:
  - $T_{ref} = +25 \, ^\circ C$, $V_i = 53 \, V$.

**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:**
  \[
  R_{adj} = \frac{10}{4.8 \left( 1 + \frac{\Delta V}{100} \right)} - 4.785 - 10 \, k\Omega
  \]

  Example: Increase 5\% $\Rightarrow V_{out} = 25.2 \, V_{dc}$
  \[
  \left( \frac{10}{4.8 \left( 1 + \frac{5}{100} \right)} - 4.785 \right) - 10 \, k\Omega = 29.2 \, k\Omega
  \]

  **Output Voltage Adjust Downwards, Decrease:**
  \[
  R_{adj} = \frac{1}{\frac{0.528 \left( \frac{1}{24} \left( 1 - \frac{\Delta V}{100} \right) \right)}{-2.6405} - 0.1}
  \]

  Example: Decrease 5\% $\Rightarrow V_{out} = 22.8 \, V_{dc}$
  \[
  \left( \frac{1}{\frac{0.528 \left( \frac{1}{24} \left( 1 - \frac{5}{100} \right) \right)}{-2.6405} - 0.1} \right) \, k\Omega = 156.7 \, k\Omega
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 300 kHz for PKM 4516ZE 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.

Filter components:
- C1,C2 = 0.68 μF
- C3,C4 = 2.2 nF
- L1 = 1.17 mH

**EMI with filter**

Output ripple and noise

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

![Output ripple and noise test setup]
PKM 4516ZE PI Direct Converters
Input 36-75 V, Output up to 2.1 A / 50 W

Operating information

Input Voltage
The input voltage range 36 to 75 Vdc 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 75V, the power loss will be higher than at normal input voltage and Tamb 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. The RC pin has an internal pull up resistor to +In.

The maximum required sink current is 1 mA. When the RC pin is left open, the voltage generated on the RC pin is 7-8 V. 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.

See Design Note 021 for detailed information.

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. 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 µF/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 mΩ 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.

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.
Parallel Operation
Convertible may be paralleled for redundancy. It is not recommended to parallel the converters without using external current sharing circuits.

See Design Note 006 for detailed information.

Remote Sense
The DC/DC converters have remote sense that can be used to compensate for voltage drops between the output and the point of load. The sense traces should be located close to the PCB ground layer to reduce noise susceptibility. The remote sense circuits 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 converters are protected from thermal overload by an internal over temperature shutdown circuit. When $T_{\text{ref}}$ as defined in thermal consideration section exceeds 110°C the converter will shut down. The DC/DC converter 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 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.

Pre-bias Start-up
The product has a Pre-bias start up functionality and will not sink current during start up if a pre-bias source is present at the output terminals.

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 $V_{\text{in}} = 53$ 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 and P2. The temperature at these positions 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 $T_{\text{ref}} + 90^\circ$C.

See Design Note 019 for further information.

<table>
<thead>
<tr>
<th>Position</th>
<th>Device (topside)</th>
<th>Designation</th>
<th>max value</th>
</tr>
</thead>
<tbody>
<tr>
<td>P1</td>
<td>Pcb</td>
<td>$T_{\text{ref}}$</td>
<td>110°C</td>
</tr>
<tr>
<td>P2</td>
<td>Transformer</td>
<td>$T_{\text{core}}$</td>
<td>130°C</td>
</tr>
</tbody>
</table>
Thermal Consideration continued

The PKM4000E series DC/DC converters can be ordered with a heatsink (HS) option. The heatsink option have approximately 2 °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 \( T_{\text{ref}} \)

The reference temperature is used to monitor the temperature limits of the product. Temperatures above maximum \( T_{\text{ref}} \) are not allowed and may cause degradation or permanent damage to the product. \( T_{\text{ref}} \) is also used to define the temperature range for normal operating conditions. \( T_{\text{ref}} \) 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 \( \left( \frac{1}{\eta} - 1 \right) \times \text{output power} = \text{power losses (Pd)} \). 
   \( \eta \) = efficiency of converter. E.g 89 % = 0.89

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

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

E.g PKM 4516ZE PI at 1m/s:

1. \( \left( \frac{1}{0.89} - 1 \right) \times 50 \text{ W} = 6.18 \text{ W} \)
2. \( 6.18 \text{ W} \times 6.8^\circ\text{C/W} = 42.0^\circ\text{C} \)
3. \( 110^\circ\text{C} - 42.0^\circ\text{C} = \text{max ambient temperature is } 68.0^\circ\text{C} \)

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

Connections

<table>
<thead>
<tr>
<th>Pin</th>
<th>Designation</th>
<th>Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>+In</td>
<td>Positive input</td>
</tr>
<tr>
<td>2</td>
<td>RC</td>
<td>Remote Control</td>
</tr>
<tr>
<td>3</td>
<td>-In</td>
<td>Negative input</td>
</tr>
<tr>
<td>4</td>
<td>- Out</td>
<td>Negative output</td>
</tr>
<tr>
<td>5</td>
<td>- Sense</td>
<td>Negative sense</td>
</tr>
<tr>
<td>6</td>
<td>Vadj</td>
<td>Output voltage adjust</td>
</tr>
<tr>
<td>7</td>
<td>+ Sense</td>
<td>Positive sense</td>
</tr>
<tr>
<td>8</td>
<td>+ Out</td>
<td>Positive output</td>
</tr>
</tbody>
</table>

PKM 4516ZE PI Direct Converters
Input 36-75 V, Output up to 2.1 A / 50 W
PKM 4516ZE PL Direct Converters
Input 36-75 V, Output up to 2.1 A / 50 W

Mechanical Drawing

Table 1

<table>
<thead>
<tr>
<th>Pin option</th>
<th>Lead Length</th>
</tr>
</thead>
<tbody>
<tr>
<td>Standard</td>
<td>5.25 [0.207]</td>
</tr>
<tr>
<td>LA</td>
<td>3.69 [0.145]</td>
</tr>
</tbody>
</table>

Weight: Typical 22g

Pins:
Material: Brass
Plating: 0.1 μm Gold over 2 μm Nickel

All dimensions are in mm [inches].
Tolerances unless specified
x±0.5 mm [0.02]
x±0.25 mm [0.01]

Not applied on the recommended footprint
PKM 4516ZE PI Direct Converters
Input 36-75 V, Output up to 2.1 A / 50 W

Technical Specification
EN/LZT 146 359 R2A Oct. 2017
© Flex

Mechanical Drawing HS-Option

Table 1

<table>
<thead>
<tr>
<th>Pin option</th>
<th>Lead Length</th>
</tr>
</thead>
<tbody>
<tr>
<td>Standard</td>
<td>5.25 (0.207)</td>
</tr>
<tr>
<td>T.A</td>
<td>3.69 (0.145)</td>
</tr>
</tbody>
</table>

Weight: Typical 43g

Case: Aluminium base plate.
For screw attachment, apply mounting Torque of max 0.44 Nm (3.5 IN-LBS)

Pins:
Material: Brass
Plating: 0.1 µm Gold over 2 µm 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
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.

<table>
<thead>
<tr>
<th>Tray specifications</th>
</tr>
</thead>
<tbody>
<tr>
<td>Material</td>
</tr>
<tr>
<td>Surface resistance</td>
</tr>
<tr>
<td>Bake ability</td>
</tr>
<tr>
<td>Tray capacity</td>
</tr>
<tr>
<td>Tray height</td>
</tr>
<tr>
<td>Box capacity</td>
</tr>
<tr>
<td>Tray weight</td>
</tr>
</tbody>
</table>
### Product Qualification Specification

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>IEC</th>
<th>Specifications</th>
</tr>
</thead>
<tbody>
<tr>
<td>External visual inspection</td>
<td></td>
<td>IPC-A-610</td>
</tr>
</tbody>
</table>
| Change of temperature (Temperature cycling)                  | IEC 60068-2-14 Na | Temperature range
|                                                             |     | Number of cycles                                    |
|                                                             |     | Dwell/transfer time                                 |
| Cold (in operation)                                          | IEC 60068-2-1 Ad | Temperature $T_A$
|                                                             |     | Duration                                            |
| Damp heat                                                    | IEC 60068-2-67 Cy | Temperature $T_A$
|                                                             |     | Humidity                                            |
|                                                             |     | Duration                                            |
| Dry heat                                                     | IEC 60068-2-2 Bd | Temperature $T_A$
|                                                             |     | Duration                                            |
| Electrostatic discharge susceptibility                       | IEC 61340-3-1, JESD 22-A114, IEC 61340-3-2, JESD 22-A115 | Human body model (HBM)
|                                                             |     | Machine model (MM)                                  |
| Immersion in cleaning solvents                               | IEC 60068-2-45 XA | Water
|                                                             |     | Glycol ether                                        |
|                                                             |     | Isopropanol                                         |
| Mechanical shock                                             | IEC 60068-2-27 Ea | Peak acceleration
|                                                             |     | Duration                                            |
|                                                             |     | Pulse shape                                         |
|                                                             |     | Directions                                          |
|                                                             |     | Number of pulses                                    |
| Moisture reflow sensitivity                                  | J-STD-020C | Level 1 (SnPb-eutectic)
|                                                             |     | Level 3 (Pb Free)                                   |
| Operational life test                                        | MIL-STD-202G method 108A | Duration |
| Resistance to soldering heat                                 | IEC 60068-2-20 Tb | Solder temperature
|                                                             |     | Duration                                            |
| 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                                |
| Vibration, broad band random                                 | IEC 60068-2-64 Fh method 1 | Frequency
|                                                             |     | Spectral density                                    |
|                                                             |     | Duration                                            |