PKB 4216C series Direct Converters
Input 36-75 V, Output up to 6.67 A / 200 W

Key Features
• Industry standard low Eight-brick
  58.40 x 22.70 x 8.6 mm (2.30 x 0.89 x 0.34 in)
• High efficiency, typ. 95 % at 30 Vout half load
• Variable output voltage adjust 15 to 33 Vout
• Open frame intended for conducted cooling (cold wall)
• Optional radio optimized baseplate with GND-pin
• 1500 Vdc input to output isolation
• Meets safety requirements according to IEC/EN/UL 60950-1
• MTBF 3.53 Mh

General Characteristics
• Output over voltage protection
• Input under voltage shutdown
• Over temperature protection
• Monotonic start-up
• Pre-bias start up capability
• Output short-circuit protection
• Remote sense
• Remote control
• Highly automated manufacturing ensures quality
• ISO 9001/14001 certified supplier

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PKB 4216C series Direct Converters
Input 36-75 V, Output up to 6.67 A / 200 W

Ordering Information

<table>
<thead>
<tr>
<th>Product program</th>
<th>Output</th>
</tr>
</thead>
<tbody>
<tr>
<td>PKB 4216C</td>
<td>30 V, 6.67 A / 200 W</td>
</tr>
</tbody>
</table>

Product number and Packaging

<table>
<thead>
<tr>
<th>Options</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>PKB 4XXXX n1n2n3n4</td>
<td></td>
</tr>
<tr>
<td>Mounting</td>
<td>o</td>
</tr>
<tr>
<td>Remote Control logic</td>
<td>o</td>
</tr>
<tr>
<td>Lead length</td>
<td>o</td>
</tr>
<tr>
<td>Delivery package information</td>
<td>o</td>
</tr>
</tbody>
</table>

Options | Description
---|--------------------------------------------------

- **n1**: SI: Surface mount*
- **n2**: Negative *
- **n3**: 5.30 mm *
- **n4**: /B: Tray

Example a SMD mounted, negative logic, with tray packaging would be PKB4216C SI/B.

* 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 +40°C. Flex uses Telcordia SR-332 Issue 2 Method 1 to calculate the mean steady-state failure rate and standard deviation (σ).

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

<table>
<thead>
<tr>
<th>Mean steady-state failure rate, λ</th>
<th>Std. deviation, σ</th>
</tr>
</thead>
<tbody>
<tr>
<td>284 nFailures/h</td>
<td>35.4 nFailures/h</td>
</tr>
</tbody>
</table>

MTBF (mean value) for the PKB series = 3.53 Mh.
MTBF at 90% confidence level = 3.04 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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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 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 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”. Clearance between conductors and between conductive parts of the component power supply and conductors on the board in the final product must meet the applicable safety requirements. Certain conditions of acceptability apply for component power supplies with limited stand-off (see Mechanical Information for further information). It is the responsibility of the installer to ensure that the final product housing these components complies with the requirements of all applicable safety standards and regulations for the final product.

Component power supplies for general use should comply with the requirements in IEC/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 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

Galvanic isolation between input and output is verified in an electric strength test and the isolation voltage (\(V_{iso}\)) meets the voltage strength requirement for basic insulation according to IEC/EN/UL 60950-1.
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>$T_{\text{P1}}$ Operating Temperature (see Thermal Consideration section)</td>
<td>-40</td>
<td>+125</td>
<td>°C</td>
<td></td>
</tr>
<tr>
<td>$T_{\text{S}}$ Storage temperature</td>
<td>-55</td>
<td>+125</td>
<td>°C</td>
<td></td>
</tr>
<tr>
<td>$V_{\text{I}}$ Input voltage</td>
<td>-0.5</td>
<td>+80</td>
<td>V</td>
<td></td>
</tr>
<tr>
<td>$C_{\text{out}}$ Output capacitance</td>
<td>100</td>
<td></td>
<td></td>
<td>µF</td>
</tr>
<tr>
<td>$V_{\text{iso}}$ isolation voltage (input to output test voltage)</td>
<td></td>
<td>1500</td>
<td>Vdc</td>
<td></td>
</tr>
<tr>
<td>$V_{\text{iso}}$ isolation voltage (input to baseplate qualification test voltage)</td>
<td></td>
<td>750</td>
<td>Vdc</td>
<td></td>
</tr>
<tr>
<td>$V_{\text{iso}}$ isolation voltage (baseplate to output qualification test voltage)</td>
<td></td>
<td>750</td>
<td>Vdc</td>
<td></td>
</tr>
<tr>
<td>$V_{\text{tr}}$ Input voltage transient according to ETSI EN 300 132-2 and Telcordia GR-1089-CORE</td>
<td></td>
<td></td>
<td></td>
<td>Vdc</td>
</tr>
<tr>
<td>$V_{\text{RC}}$ Remote Control pin voltage (see Operating Information section)</td>
<td>Positive logic option</td>
<td>-0.5</td>
<td>6</td>
<td>V</td>
</tr>
<tr>
<td></td>
<td>Negative logic option</td>
<td>-0.5</td>
<td>6</td>
<td>V</td>
</tr>
<tr>
<td>$V_{\text{adj}}$ Adjust pin voltage (see Operating Information section)</td>
<td></td>
<td>-0.5</td>
<td>5</td>
<td>V</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
## Electrical Specification

**PKB4216C**

### PKB 4216C series Direct Converters

Input 36-75 V, Output up to 6.67 A / 200 W

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#### Technical Specification

**Note 3:** Sink current drawn by external device connected to the RC pin.

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### Characteristics

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Conditions</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>V&lt;sub&gt;i&lt;/sub&gt;</strong> Input voltage range</td>
<td>min</td>
</tr>
<tr>
<td><strong>V&lt;sub&gt;off&lt;/sub&gt;</strong> Turn-off input voltage</td>
<td>Decreasing input voltage</td>
</tr>
<tr>
<td><strong>V&lt;sub&gt;on&lt;/sub&gt;</strong> Turn-on input voltage</td>
<td>Increasing input voltage</td>
</tr>
<tr>
<td><strong>C&lt;sub&gt;i&lt;/sub&gt;</strong> Internal input capacitance</td>
<td>9.4</td>
</tr>
<tr>
<td><strong>P&lt;sub&gt;o&lt;/sub&gt;</strong> Output power</td>
<td>0</td>
</tr>
<tr>
<td><strong>η</strong> Efficiency</td>
<td>50% of max I&lt;sub&gt;o&lt;/sub&gt;</td>
</tr>
<tr>
<td></td>
<td>max I&lt;sub&gt;o&lt;/sub&gt;</td>
</tr>
<tr>
<td></td>
<td>50% of max I&lt;sub&gt;o&lt;/sub&gt;, V&lt;sub&gt;i&lt;/sub&gt; = 53 V</td>
</tr>
<tr>
<td></td>
<td>max I&lt;sub&gt;o&lt;/sub&gt;, V&lt;sub&gt;i&lt;/sub&gt; = 53 V</td>
</tr>
<tr>
<td><strong>P&lt;sub&gt;DS&lt;/sub&gt;</strong> Power Dissipation</td>
<td>max I&lt;sub&gt;o&lt;/sub&gt;</td>
</tr>
<tr>
<td><strong>P&lt;sub&gt;idling&lt;/sub&gt;</strong> Input idling power</td>
<td>I&lt;sub&gt;o&lt;/sub&gt; = 0 A, V&lt;sub&gt;i&lt;/sub&gt; = 48 V</td>
</tr>
<tr>
<td><strong>P&lt;sub&gt;stby&lt;/sub&gt;</strong> Input standby power</td>
<td>V&lt;sub&gt;i&lt;/sub&gt; = 48 V (turned off with RC)</td>
</tr>
<tr>
<td><strong>f&lt;sub&gt;s&lt;/sub&gt;</strong> Switching frequency</td>
<td>0-100 % of max I&lt;sub&gt;o&lt;/sub&gt;</td>
</tr>
</tbody>
</table>

### V<sub>cl</sub> Output voltage initial setting and accuracy

<table>
<thead>
<tr>
<th>Conditions</th>
<th>T&lt;sub&gt;p1&lt;/sub&gt;</th>
<th>V&lt;sub&gt;i&lt;/sub&gt;</th>
<th>I&lt;sub&gt;o&lt;/sub&gt;</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>T&lt;sub&gt;p1&lt;/sub&gt;</strong> = +25°C, V&lt;sub&gt;i&lt;/sub&gt; = 48 V, I&lt;sub&gt;o&lt;/sub&gt; = 6.67 A</td>
<td>29.7</td>
<td>30</td>
<td>30.3</td>
<td>V</td>
</tr>
</tbody>
</table>

### V<sub>i</sub>

<table>
<thead>
<tr>
<th>Output adjust range</th>
<th>See operating information</th>
</tr>
</thead>
<tbody>
<tr>
<td>Output voltage tolerance band</td>
<td>0-100% of max I&lt;sub&gt;o&lt;/sub&gt;</td>
</tr>
<tr>
<td>Idling voltage</td>
<td>I&lt;sub&gt;o&lt;/sub&gt; = 0 A</td>
</tr>
<tr>
<td>Line regulation</td>
<td>max I&lt;sub&gt;o&lt;/sub&gt;</td>
</tr>
<tr>
<td>Load regulation</td>
<td>V&lt;sub&gt;i&lt;/sub&gt; = 48 V, 10-100% of max I&lt;sub&gt;o&lt;/sub&gt;</td>
</tr>
</tbody>
</table>

### V<sub>d</sub>

<table>
<thead>
<tr>
<th>Load transient voltage deviation</th>
<th>V&lt;sub&gt;i&lt;/sub&gt; = 48 V, Load step 25-75-25% of max I&lt;sub&gt;o&lt;/sub&gt;, di/dt = 1 A/μs, C&lt;sub&gt;o&lt;/sub&gt; = 1.5 mF</th>
</tr>
</thead>
<tbody>
<tr>
<td>T&lt;sub&gt;p1&lt;/sub&gt;</td>
<td>100</td>
</tr>
</tbody>
</table>

### I<sub>tr</sub>

<table>
<thead>
<tr>
<th>Load transient recovery time</th>
<th>200</th>
<th>400</th>
<th>μs</th>
</tr>
</thead>
</table>

### t<sub>tr</sub>

<table>
<thead>
<tr>
<th>Ramp-up time (from 10-90% of V&lt;sub&gt;cl&lt;/sub&gt;)</th>
<th>10-100% of max I&lt;sub&gt;o&lt;/sub&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>Start-up time (from V&lt;sub&gt;i&lt;/sub&gt; connection to 90% of V&lt;sub&gt;cl&lt;/sub&gt;)</td>
<td>11</td>
</tr>
<tr>
<td>V&lt;sub&gt;i&lt;/sub&gt; shut-down fall time (from V&lt;sub&gt;i&lt;/sub&gt; off to 10% of V&lt;sub&gt;cl&lt;/sub&gt;)</td>
<td>max I&lt;sub&gt;o&lt;/sub&gt;</td>
</tr>
<tr>
<td>RC start-up time</td>
<td>max I&lt;sub&gt;o&lt;/sub&gt;</td>
</tr>
<tr>
<td>RC shut-down fall time (from RC off to 10% of V&lt;sub&gt;cl&lt;/sub&gt;)</td>
<td>max I&lt;sub&gt;o&lt;/sub&gt;</td>
</tr>
<tr>
<td>I&lt;sub&gt;o&lt;/sub&gt; Output current</td>
<td>0</td>
</tr>
<tr>
<td>I&lt;sub&gt;stby&lt;/sub&gt; Current limit threshold</td>
<td>T&lt;sub&gt;p1&lt;/sub&gt; &lt; max T&lt;sub&gt;p1&lt;/sub&gt;</td>
</tr>
<tr>
<td>I&lt;sub&gt;sc&lt;/sub&gt; Short circuit current</td>
<td>T&lt;sub&gt;p1&lt;/sub&gt; = 25°C, see Note 1</td>
</tr>
<tr>
<td>C&lt;sub&gt;out&lt;/sub&gt; Recommended Capacitive Load</td>
<td>T&lt;sub&gt;p1&lt;/sub&gt; = 25°C, see Note 2</td>
</tr>
</tbody>
</table>

### V<sub>on</sub> Output ripple & noise

<table>
<thead>
<tr>
<th>See ripple &amp; noise section, V&lt;sub&gt;i&lt;/sub&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>OVP Over voltage protection</td>
</tr>
<tr>
<td>RC Sink current, see Note 3</td>
</tr>
</tbody>
</table>

### Note 1: RMS current at DCP in hic-up mode

### Note 2: Low ESR value

### Note 3: Sink current drawn by external device connected to the RC pin.
Typical Characteristics

**30.0 V, 6.7 A / 200 W**

### Efficiency

![Efficiency graph]

Efficiency vs. load current and input voltage at $T_{PI} = +25^\circ C$.

### Power Dissipation

![Power Dissipation graph]

Dissipated power vs. load current and input voltage at $T_{PI} = +25^\circ C$.

### Output Characteristics

![Output Characteristics graph]

Output voltage vs. load current at $T_{PI} = +25^\circ C$.

### Current Limit Characteristics

![Current Limit Characteristics graph]

Output voltage vs. load current at $I_O > \text{max } I_O$, $T_{PI} = +25^\circ C$.

### Maximum start-up current vs. Output capacitance

![Maximum start-up current graph]

Maximum start-up current with resistive load at $V_O = 30 V$, $T_{PI} = +25^\circ C$.
PKB 4216C series Direct Converters
Input 36-75 V, Output up to 6.67 A / 200 W

Typical Characteristics
30.0 V, 6.7 A / 200 W

Start-up

Shut-down

Output Ripple & Noise

Output Load Transient Response

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:

\[ \text{Radj} = 5.11 \times \left( \frac{30(100 + \Delta V)}{1.2 \times \Delta V} - \frac{(100 + 2 \times \Delta V)}{\Delta V} \right) \text{k}\Omega \]

Example: Increase 4% => V_out = 31.2 Vdc
\[ 5.11 \times \left( \frac{30(100 + 4)}{1.2 \times 4} - \frac{(100 + 2 \times 4)}{4} \right) \text{k}\Omega = 3183 \text{k}\Omega \]

Output Voltage Adjust Downwards, Decrease:

\[ \text{Radj} = 5.11 \times \left( \frac{100}{\Delta V} - 2 \right) \text{k}\Omega \]

Example: Decrease 2% => V_out = 29.4 Vdc
\[ 5.11 \times \left( \frac{100}{2} - 2 \right) \text{k}\Omega = 245 \text{k}\Omega \]

Active trimming formula:
Vout = 15.03 + 12.27 x Uc
Vout: output voltage
Vc: control voltage between Vadj and -sense
PKB 4216C series Direct Converters
Input 36-75 V, Output up to 6.67 A /200 W

Typical Characteristics
30 V, 6.7 A / 200 W

Output Current Derating – Open frame

Available load current vs. ambient air temperature and airflow at $V_I = 48$ V. See Thermal Consideration section.

Output Current Derating – Base plate

Available load current vs. ambient air temperature and airflow at $V_I = 48$ V. See Thermal Consideration section.

Output Current Derating – Cold wall sealed box

Available load current vs. cold wall temperature. $V_I = 48$ V. See Thermal Consideration section.
EMC Specification
Conducted EMI measured according to EN55022, CISPR 22 and FCC part 15J (see test set-up). See Design Note 009 for further information. The fundamental switching frequency is 400 kHz for PKB4216C. The EMI characteristics below is measured at \( V_i = 48 \text{ V} \) and max \( I_o \).

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:
- \( C_1 = 4.7 \mu\text{F} \)
- \( C_2 = 2 \times 4.7 \mu\text{F} \)
- \( C_3 = 2 \times 4.7 \mu\text{F} + 100 \mu\text{F (e-lyt)} \)
- \( C_4, C_5 = 4 \times 4.7\text{nF} \)
- \( L_1 = 1.47 \text{ mH} \)
- \( L_2 = 2.2 \mu\text{H} \)

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 to 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 is measured according to figure below. See Design Note 022 for detailed information.
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 75 V, the power loss will be higher than at normal input voltage and $P_{IN}$ must be limited to absolute max +105°C. The absolute maximum continuous input voltage is 80 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 dependent 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 V.

Remote Control (RC)
The products are fitted with a remote control function referenced to the primary negative input connection (-In), with negative and positive logic options available. The RC function allows the product to be turned on/off by an external device like a semiconductor or mechanical switch. The RC pin has an internal pull up resistor of 10 kΩ to +5V.

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 5 V.

The standard product is provided with “negative logic” RC. To turn off the product the RC pin should be left open, or connected to a voltage higher than 4 V referenced to -In. In situations where it is desired to have the product to power up automatically without the need for control signals or a switch, the RC pin can be wired directly to -In. To turn on the product the RC pin should be lower than 1V referenced to -In.

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

The RC function incorporates a short delay in order to not trigger on glitches. Typically this filter has a settling time of 0.1-0.5 ms. This setup reduces the risk that the noise may cause the converter to shut down or power up accidently.

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 with a minimum of 100μF external capacitors connected to the input and output. The electrolytic capacitors will be degraded in low temperature and the ESR value may increase. The needed input capacitance in low temperature should be equivalent to 100μF at 20°C. This means that the input capacitor value may need to be substantially larger to guarantee a stable input at low temperatures. The performance in some applications can be enhanced by addition of external capacitance as described under External Decoupling Capacitors.

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 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 lower 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 >10 mΩ across the output connections.

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

**Output Voltage Adjust (V\textsubscript{adj})**

The products have an Output Voltage Adjust pin (V\text{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. At minimum input voltage the output voltage adjust range may be decreased depending on load and temperature.

To increase the output voltage a resistor should be connected between the V\text{adj} pin and +Sense pin. The value of the adjust resistor should be calculated according to the formulas provided in the Electrical Specification section for the respective product.

To decrease the output voltage, the resistor should be connected between the V\text{adj} pin and –Sense pin.

**Over Temperature Protection (OTP)**

The products are protected from thermal overload by an internal over temperature shutdown circuit. When T\text{P1} as defined in thermal consideration section exceeds 130°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 OCP works in a hiccup mode and will make continuous attempts to start up and will resume normal operation automatically after removal of the over current condition. The load distribution should be designed for continuous overload. The OCP works in a hiccup mode and will make continuous attempts to start up and will resume normal operation automatically after removal of the over current condition. The load distribution should be designed for the specified maximum output short circuit current.

**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 load is present at the output terminals.

**Parallel Operation**

This product is not designed for paralleling without using external current sharing circuits. See Design Note 006 for detailed information.

**Remote Sense**

The products have remote sense that can be used to compensate for voltage drops between the output and the 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.
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 baseplate attached, cooling is achieved mainly by conduction, from the pins to the host board, and convection, which is dependant on the airflow across the product. Increased airflow enhances the cooling of the product. The Output Current Derating graph found in the Output section for each model provides the available output current vs. ambient air temperature and air velocity at $V_{I} = 48$ V.

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

Gap-pad between cold wall and module ferrites:
Bergquist 5000S35, 2mm compressed to 1.2mm.
Hardness shore (00) 35.
Thermal conductivity 5.0 W/m-K

Definition of product operating temperature
The temperature at the positions ($T_{P1}$, $T_{P2}$, $T_{P3}$, $T_{P4}$) should not exceed the maximum temperatures in the table below. The number of measurement points may vary with different thermal design and topology. Temperatures above maximum measured at the reference point P1, P2, P3, P4 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>Mosfet, Reference point</td>
<td>$T_{P1}=125^\circ$ C</td>
</tr>
<tr>
<td>P2</td>
<td>Resistor</td>
<td>$T_{P2}=125^\circ$ C</td>
</tr>
<tr>
<td>P3</td>
<td>Opto-coupler</td>
<td>$T_{P3}=110^\circ$ C</td>
</tr>
<tr>
<td>P4</td>
<td>Mosfet, Reference point, baseplate</td>
<td>$T_{P4}=125^\circ$ C</td>
</tr>
</tbody>
</table>

For products with baseplate or gap-pad used in a sealed box/cold wall application, cooling is achieved mainly by conduction through the cold wall. Modules without a base plate will have the best thermal performance if a profiled cold wall and gap filler is used. Look in the Thermal Management section for detailed drawings. The Output Current Derating graphs are found in the Output section for each model. The product performance has been tested in a sealed box presented in the figure below. The ambient temperature (inside the box) has been set to 85°C. The cold wall temperature varied. See Design Note 028 for further details.
Ambient Temperature Calculation

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

1. The power loss is calculated by using the formula 

\[ \frac{1}{\eta} - 1 \times \text{output power} = \text{power losses (Pd)} \]

\( \eta = \) efficiency of product. E.g. 94.5% = 0.945

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

Calculate the temperature increase (\( \Delta T \)).

\[ \Delta T = Rth \times Pd \]

3. Max allowed ambient temperature is:

\[ \text{Max } T_{P1} = \Delta T \]

E.g. PKB4216C at 1m/s:

1. \( \left( \frac{1}{0.945} - 1 \right) \times 200 \text{ W} = 11.6 \text{ W} \)

2. 11.6 W \( \times 4.6^\circ\text{C/W} = 53.5^\circ\text{C} \)

3. 125 \( ^\circ\text{C} - 53.5^\circ\text{C} = \) max ambient temperature is 71.5°C

The actual temperature will be dependent on several factors such as the PWB size, number of layers and direction of airflow.
PKB 4216C series Direct Converters
Input 36-75 V, Output up to 6.67 A / 200 W

Mechanical Information – Surface Mount Version

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.
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 – Wing base plate Version

Pin positions according to recommended footprint

RECOMMENDED FOOTPRINT – TOP VIEW

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 – Base plate version

Pin positions according to recommended footprint

RECOMMENDED FOOTPRINT - TOP VIEW

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.
Thermal Management

The thermal gap pads are intended to withdraw heat from ferrites and tets and transport the heat through the thermal material to the cold wall. The gap pads must be carefully chosen in accordance with thermal conductivity and mounting pressure. To choose the correct gap filler material, height difference between the two ferrites must be taken into consideration.
PKB 4216C series Direct Converters
Input 36-75 V, Output up to 6.67 A / 200 W

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.
Soldering Information - Surface Mounting

The surface mount product is intended for forced convection or vapor phase reflow soldering in SnPb and Pb-free processes.

The reflow profile should be optimised to avoid excessive heating of the product. It is recommended to have a sufficiently extended preheat time to ensure an even temperature across the host PWB and it is also recommended to minimize the time in reflow.

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, since cleaning residues may affect long time reliability and isolation voltage.

### Lead-free (Pb-free) solder processes

For Pb-free solder processes, a pin temperature (T\text{PIN}) in excess of the solder melting temperature (T\text{L}, 217 to 221°C for SnAgCu solder alloys) for more than 60 seconds and a peak temperature of 245°C on all solder joints is recommended to ensure a reliable solder joint.

### Maximum Product Temperature Requirements

Top of the product PWB near pin 2 is chosen as reference location for the maximum (peak) allowed product temperature (T\text{PRODUCT}) since this will likely be the warmest part of the product during the reflow process.

#### SnPb solder processes

For SnPb solder processes, the product is qualified for MSL 1 according to IPC/JEDEC standard J-STD-020C.

**During reflow** T\text{PRODUCT} must not exceed 225 °C at any time.

**Pb-free solder processes**

For Pb-free solder processes, the product is qualified for MSL 3 according to IPC/JEDEC standard J-STD-020C.

**During reflow** T\text{PRODUCT} must not exceed 260 °C at any time.

### Dry Pack Information

Products intended for Pb-free reflow soldering processes are delivered in standard moisture barrier bags according to IPC/JEDEC standard J-STD-033 (Handling, packing, shipping and use of moisture/reflow sensitivity surface mount devices).

Using products in high temperature Pb-free soldering processes requires dry pack storage and handling. In case the products have been stored in an uncontrolled environment and no longer can be considered dry, the modules must be baked according to J-STD-033.

### Thermocoupler Attachment

Top of PWB near pin 2 for measurement of maximum product temperature, T\text{PRODUCT}

Pin 4 for measurement of minimum pin (solder joint) temperature, T\text{PIN}
Soldering Information - Hole Mounting

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

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

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

Delivery Package Information

The products are delivered in antistatic injection molded trays (Jedec design guide 4.10D standard) and in antistatic trays.

<table>
<thead>
<tr>
<th>Tray Specifications – SMD /Pin in paste</th>
</tr>
</thead>
<tbody>
<tr>
<td>Material</td>
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<tr>
<td>Surface resistance</td>
</tr>
<tr>
<td>Bakability</td>
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<tr>
<td>Tray thickness</td>
</tr>
<tr>
<td>Box capacity</td>
</tr>
<tr>
<td>Tray weight</td>
</tr>
</tbody>
</table>

JEDEC standard tray for 2x10 = 20 products. All dimensions in mm [inch].
Tolerances: X.x ±0.26 [0.01], X.xx ±0.13 [0.005]
Note: pick up positions refer to center of pocket.
See mechanical drawing for exact location on product.
PKB 4216C series Direct Converters
Input 36-75 V, Output up to 6.67 A / 200 W

**Tray Specifications – Through hole version**

<table>
<thead>
<tr>
<th>Material</th>
<th>PE Foam, dissipative</th>
</tr>
</thead>
<tbody>
<tr>
<td>Surface resistance</td>
<td>$10^5 \leq \text{Ohm/square} &lt; 10^{12}$</td>
</tr>
<tr>
<td>Bakability</td>
<td>The trays are not bakable</td>
</tr>
<tr>
<td>Tray thickness</td>
<td>22 mm [0.866 inch]</td>
</tr>
</tbody>
</table>
| Box capacity        | 100 products (4 full trays/box) Open frame
                        | 25 products (1 full tray/box) Base plate
                        | 20 products (1 full tray/box) Wing base plate
| Tray weight         | Product – Open frame
                        | 793 g full tray, 54 g empty tray
                        | Product – Base plate option
                        | 930 full tray, 60 g empty tray
                        | Product – Wing base plate option
                        | 880 full tray, 60 g empty tray

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**Soft tray for Wing base plate version**

**Soft tray for open frame & base plate version**
# Product Qualification Specification

<table>
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<tr>
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<td>IPC-A-610</td>
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</tr>
<tr>
<td>Change of temperature (Temperature cycling)</td>
<td>IEC 60068-2-14 Na</td>
<td>Number of cycles</td>
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<tr>
<td></td>
<td></td>
<td>Dwell/transfer time</td>
</tr>
<tr>
<td>Cold (in operation)</td>
<td>IEC 60068-2-1 Ad</td>
<td>Temperature $T_A$</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Duration</td>
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<tr>
<td>Damp heat</td>
<td>IEC 60068-2-67 Cy</td>
<td>Temperature</td>
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<tr>
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<td>Humidity</td>
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<tr>
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<td>Duration</td>
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<td>Dry heat</td>
<td>IEC 60068-2-2 Bd</td>
<td>Temperature</td>
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<tr>
<td></td>
<td></td>
<td>Duration</td>
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<tr>
<td>Electrostatic discharge susceptibility</td>
<td>IEC 61340-3-1, JESD 22-A114</td>
<td>Human body model (HBM)</td>
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<tr>
<td></td>
<td>IEC 61340-3-2, JESD 22-A115</td>
<td>Machine Model (MM)</td>
</tr>
<tr>
<td>Immersion in cleaning solvents</td>
<td>IEC 60068-2-45 XA, method 2</td>
<td>Water</td>
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<tr>
<td></td>
<td></td>
<td>Glycol ether</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Isopropyl alcohol</td>
</tr>
<tr>
<td>Mechanical shock</td>
<td>IEC 60068-2-27 Ea</td>
<td>Peak acceleration</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Duration</td>
</tr>
<tr>
<td>Moisture reflow sensitivity ¹</td>
<td>J-STD-020C</td>
<td>Level 1 (SnPb-eutectic)</td>
</tr>
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<td></td>
<td></td>
<td>Level 3 (Pb Free)</td>
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<tr>
<td>Operational life test</td>
<td>MIL-STD-202G, method 108A</td>
<td>Duration</td>
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<tr>
<td>Resistance to soldering heat ²</td>
<td>IEC 60068-2-20 Tb, method 1A</td>
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</tr>
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<td></td>
<td>Duration</td>
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<tr>
<td>Robustness of terminations</td>
<td>IEC 60068-2-21 Test Ua1</td>
<td>Through hole mount products</td>
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<tr>
<td></td>
<td>IEC 60068-2-21 Test Ue1</td>
<td>Surface mount products</td>
</tr>
<tr>
<td>Solderability</td>
<td>IEC 60068-2-58 test Td ¹</td>
<td>Preconditioning</td>
</tr>
<tr>
<td></td>
<td>IEC 60068-2-20 test Ta ²</td>
<td>Temperature, SnPb Eutectic</td>
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<tr>
<td></td>
<td></td>
<td>Temperature, Pb-free</td>
</tr>
<tr>
<td>Vibration, broad band random</td>
<td>IEC 60068-2-64 Fh, method 1</td>
<td>Frequency</td>
</tr>
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<td>Spectral density</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Duration</td>
</tr>
</tbody>
</table>

Notes

¹ Only for products intended for reflow soldering (surface mount products)
² Only for products intended for wave soldering (plated through hole products)