PKU4716VA Series Fully Regulated DC-DC Converters
Input 36-60 V, Output up to 12.7 A / 70 W

Key Features
- Low profile sixteenth-brick
  33.02 x 22.86 x 8.2 mm (1.30 x 0.90 x 0.32 in)
- High efficiency, typ. 94.3% at 5.5Vout half load
- 2250 Vdc input to output isolation
- Meets safety requirements according to IEC/EN/UL 62368-1
- MTBF 19.09 million hours

General Characteristics
- Input under voltage shutdown
- Monotonic start-up
- Output short-circuit protection
- Remote control
- Adjustable output voltage
- Over temperature protection
- Highly automated manufacturing ensures quality
- ISO 9001/14001 certified supplier

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5.5 V, 12.7 A / 70 W

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Safety Approvals

Design for Environment
Meets requirements in high-temperature lead-free soldering processes.
**Ordering Information**

<table>
<thead>
<tr>
<th>Product program</th>
<th>Output</th>
</tr>
</thead>
<tbody>
<tr>
<td>PKU4716VA</td>
<td>5.5 V, 12.7 A / 70 W</td>
</tr>
</tbody>
</table>

**Product number and Packaging**

<table>
<thead>
<tr>
<th>Options</th>
<th>n1</th>
<th>n2</th>
<th>n3</th>
<th>n4</th>
<th>n5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mounting</td>
<td>o</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Remote control logic</td>
<td>o</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Trim pin on input side</td>
<td>o</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pin length</td>
<td>o</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Delivery package information</td>
<td>o</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Options**

- n1: PI Through hole
- n2: Negative *
- n3: Positive
- n4: NT Trim pin *
- n5: Without trim pin
- n6: LA 5.33 mm *
- n7: LB 3.69 mm
- n8: LC 4.57 mm (Pin-cut)
- n9: LC 2.79 mm (Pin-cut)
- n10: /C Tape and Reel

* 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 (T_A) of +40°C. Flex Power uses Telcordia SR-332 Issue 3 Method 1 to calculate the mean steady-state failure rate and standard deviation (σ).

Telcordia SR-332 Issue 4 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</th>
<th>Std. deviation, σ</th>
</tr>
</thead>
<tbody>
<tr>
<td>52 nFailures/h</td>
<td>5.0 nFailures/h</td>
</tr>
</tbody>
</table>

MTBF (mean value) for the PKU4716VA series = 19.09 Mh. MTBF at 90% confidence level = 17.00 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 Power products are found in the Statement of Compliance document.

Flex Power 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 Power General Terms and Conditions of Sale.

**Limitation of Liability**

Flex Power 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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PKU4716VA Series Fully Regulated DC-DC Converters
Input 36-60 V, Output up to 12.7 A / 70 W

Safety Specification

General information

Flex Power DC/DC converters and DC/DC regulators are designed in accordance with the safety standards IEC 62368-1, EN 62368-1 and UL 62368-1 Audio/video, information and communication technology equipment - Part 1: Safety requirements

IEC/EN/UL 62368-1 contains requirements to prevent injury or damage due to the following hazards:

- Electrical shock
- Electrically-caused fire
- Injury caused by hazardous substances
- Mechanically-caused injury
- Skin burn
- Radiation-caused injury

On-board DC/DC converters, Power interface modules 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 shall comply with the requirements in IEC/EN/UL 62368-1. 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 62368-1 with regards to safety.

Flex Power DC/DC converters, Power interface modules and DC/DC regulators are UL 62368-1 recognized and certified in accordance with EN 62368-1. 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 62368-1 (see Safety Certificate), different conditions shall be met if the output of a basic or a functional insulated product shall be considered as ES1 energy source.

For basic insulated products (see Safety Certificate) the output is considered as ES1 energy source 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 62368-1.

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 62368-1.

For functional insulated products (see Safety Certificate) the output is considered as ES1 energy source 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 62368-1.

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 62368-1.

The input source is reliably connected to protective earth and provides basic or supplementary insulation according to IEC/EN/UL 62368-1 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 (Viso) meets the voltage strength requirement for basic insulation according to IEC/EN/UL 62368-1.

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>$T_{PH}$ Operating Temperature (see Thermal Consideration section)</td>
<td>-40</td>
<td>+125</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>-0.5</td>
<td>+80</td>
<td></td>
<td>V</td>
</tr>
<tr>
<td>$C_{OUT}$ Output capacitance</td>
<td>270</td>
<td>1200</td>
<td></td>
<td>µF</td>
</tr>
<tr>
<td>$V_{IN}$ Isolation voltage (input to output test voltage)</td>
<td>2250</td>
<td></td>
<td></td>
<td>Vdc</td>
</tr>
<tr>
<td>$V_{IS}$ Input voltage transient according to ETSI EN 300 132-2 and Telcordia GR-1089-CORE</td>
<td>100</td>
<td></td>
<td></td>
<td>V</td>
</tr>
<tr>
<td>$V_{RC}$ Remote Control pin voltage (see Operating Information section)</td>
<td>Positive logic option</td>
<td>0</td>
<td>6</td>
<td>V</td>
</tr>
<tr>
<td></td>
<td>Negative logic option</td>
<td>0</td>
<td>6</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

![Fundamental Circuit Diagram](image-url)
### PKU4716VA Series

**Fully Regulated DC-DC Converters**

Input 36-60 V, Output up to 12.7 A / 70 W

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#### Technical Specification

**PKU4716VA**

**Electrical Specification**

**5.5 V/12.72A/70W**

- $T_{P1} = -40 \text{ to } +95^\circ C, V_i = 36 \text{ to } 60 \text{ V}, V_{out} = 5.5V$ for all table conditions and setting unless otherwise specified under Conditions.
- Typical values given at: $T_{P1} = +25^\circ C, V_i = 53 \text{ V}$ max $I_o$, unless otherwise specified under Conditions.
- Additional $C_o = 100 \mu F$ Nichicon, $C_{out} = 270 \mu F$ OS-CON.

<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>36</td>
<td>53</td>
<td>60</td>
<td>V</td>
</tr>
<tr>
<td>$V_{out}$</td>
<td>Turn-off input voltage</td>
<td>31</td>
<td>32</td>
<td>33</td>
<td>V</td>
</tr>
<tr>
<td>$V_{on}$</td>
<td>Turn-on input voltage</td>
<td>33</td>
<td>34</td>
<td>35</td>
<td>V</td>
</tr>
<tr>
<td>$C_i$</td>
<td>Internal input capacitance</td>
<td>$V_i = 53 \text{ V}$</td>
<td>3</td>
<td>31</td>
<td>µF</td>
</tr>
<tr>
<td>$P_o$</td>
<td>Output power Average</td>
<td>0</td>
<td>70</td>
<td>3</td>
<td>W</td>
</tr>
<tr>
<td>$\eta$</td>
<td>Efficiency</td>
<td>50%</td>
<td>94.3</td>
<td>max $I_o$</td>
<td>%</td>
</tr>
<tr>
<td></td>
<td>max $I_o$</td>
<td></td>
<td>94.2</td>
<td>%</td>
<td></td>
</tr>
<tr>
<td>$P_{st}$</td>
<td>Power Dissipation</td>
<td>max $I_o$</td>
<td>4.2</td>
<td>W</td>
<td></td>
</tr>
<tr>
<td>$I_{ID}$</td>
<td>Input idling power</td>
<td>0</td>
<td>1.1</td>
<td>W</td>
<td></td>
</tr>
<tr>
<td>$P_{in}$</td>
<td>Input standby power</td>
<td>$V_i = 53 \text{ V}$ (turned off with RC)</td>
<td>0.1</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>280</td>
<td>300</td>
<td>320</td>
</tr>
<tr>
<td>$V_{Gi}$</td>
<td>Nominally Output voltage initial setting and accuracy</td>
<td>$T_{P1} = +25^\circ C, V_i = 53 \text{ V}$, $I_o = 6 \text{ A}$</td>
<td>5.52</td>
<td>V</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Output voltage tolerance band typically value,</td>
<td>0-100% of max $I_o$, $V_i = 36-60 \text{ V}$</td>
<td>5.24</td>
<td>5.52</td>
<td>5.79</td>
</tr>
<tr>
<td></td>
<td>Output adjust range See Note 1</td>
<td>Max $I_o = 10.7A, P_o = 70W$, Resistor added Vadj-pin to GND-pin for Vout-Max ~15 kΩ</td>
<td>5.5</td>
<td>6.5</td>
<td>V</td>
</tr>
<tr>
<td></td>
<td>Idling voltage</td>
<td>$I_o = 0 \text{ A}, V_i = 36-60 \text{ V}$</td>
<td>5.56</td>
<td>V</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Line regulation</td>
<td>$V_i = 36-60 \text{ V}$, max $I_o$</td>
<td>-10</td>
<td>+10</td>
<td>mV</td>
</tr>
<tr>
<td></td>
<td>Load regulation</td>
<td>$V_i = 53 \text{ V}$, 10-100% of max $I_o$</td>
<td>-100</td>
<td>+100</td>
<td>mV</td>
</tr>
<tr>
<td>$V_{Ts}$</td>
<td>Load transient voltage deviation</td>
<td>$V_i = 53 \text{ V}$, Load step 25-75-25% of max $I_o$, di/dt = 0.5 A/µs, $C_o = 0.27$ mF</td>
<td>±350</td>
<td>mV</td>
<td></td>
</tr>
<tr>
<td>$t_r$</td>
<td>Load transient recovery time</td>
<td></td>
<td>±250</td>
<td>µs</td>
<td></td>
</tr>
<tr>
<td>$t_r$</td>
<td>Ramp-up time</td>
<td>100-100% of max $I_o$</td>
<td>10</td>
<td>ms</td>
<td></td>
</tr>
<tr>
<td>$t_s$</td>
<td>Start-up time (from $V_{Gi}$ connection to 90% of $V_{Gi}$)</td>
<td>120</td>
<td>ms</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$t_{rec}$</td>
<td>RC start-up time (from Vcc connection to 90% of Vcc)</td>
<td>max $I_o$</td>
<td>10</td>
<td>ms</td>
<td></td>
</tr>
<tr>
<td>RC</td>
<td>Sink current, See Note 2</td>
<td>See operating information</td>
<td>0.16</td>
<td>mA</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Trigger level</td>
<td>Enable Threshold</td>
<td>1.22</td>
<td>V</td>
<td></td>
</tr>
<tr>
<td>$I_o$</td>
<td>Output current</td>
<td>0</td>
<td>12.72</td>
<td>A</td>
<td></td>
</tr>
<tr>
<td>$I_{lim}$</td>
<td>Current limit threshold</td>
<td>$T_{P1} &lt; \text{ max } T_{P1}$</td>
<td>20</td>
<td>A</td>
<td></td>
</tr>
<tr>
<td>$I_{sc}$</td>
<td>Short circuit current</td>
<td>$T_{P1} = 25^\circ C$, See Note 3</td>
<td>17.5</td>
<td>A</td>
<td></td>
</tr>
<tr>
<td>$C_{cut}$</td>
<td>Recommended Capacitive Load</td>
<td>$T_{P1} = 25^\circ C$, See Note 4</td>
<td>270</td>
<td>1200</td>
<td>µF</td>
</tr>
<tr>
<td>$V_{ripple}$</td>
<td>Output ripple &amp; noise</td>
<td>See ripple &amp; noise section, $V_{Gi}$</td>
<td>50</td>
<td>mVp-p</td>
<td></td>
</tr>
</tbody>
</table>

**Note 1:** Vadj-setting

**Note 2:** Sink current drawn by external device connected to the RC pin

**Note 3:** RMS current shorted output

**Note 4:** Low ESR=20mO value, OS-CON
PKU4716VA Series Fully Regulated DC-DC Converters
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Typical Characteristics:
5.5 V, 12.72 A / 70 W

**Efficiency**

![Efficiency graph]

Efficiency vs. load current and input voltage at $T_{P1} = +25^\circ$C.

**Power Dissipation**

![Power Dissipation graph]

Dissipated power vs. load current and input voltage at $T_{P1} = +25^\circ$C.

**Output Characteristics**

![Output Characteristics graph]

Output voltage vs. load current at $T_{P1} = +25^\circ$C.

**Current Limit Characteristics**

![Current Limit Characteristics graph]

Output voltage vs. load current at $I_0 > max I_0$, $T_{P1} = +25^\circ$C.

**Output Characteristics Vadj = 6.5V**

![Output Characteristics Vadj graph]

Output voltage vs. input voltage and load current at $T_{P1} = +25^\circ$C. See note 1.
**Typical Characteristics**

5,5 V, 12.72 A / 70 W

### Start-up

Start-up with RC at:
- $T_{	ext{IP}} = +25^\circ \text{C}$, $V_{\text{IP}} = 53$ V,
- $I_{\text{C}} = 12.72$ A resistive load.

**Top trace:** RC Voltage (2 V/div).
**Middle trace:** Output Voltage (2 V/div).
**Bottom trace:** Output Current (10 A/div).

*Time scale:* (5 ms/div.)

### Shut-down

Shut-down with RC:
- $T_{	ext{IP}} = +25^\circ \text{C}$, $V_{\text{IP}} = 53$ V,
- $I_{\text{C}} = 12.72$ A resistive load.

**Top trace:** RC Voltage (2 V/div).
**Bottom trace:** Output Voltage (5 V/div).

*Time scale:* (20 ms/div.)

### Output Ripple & Noise

Output voltage ripple at:
- $T_{	ext{IP}} = +25^\circ \text{C}$, $V_{\text{IP}} = 53$ V,
- $I_{\text{C}} = 12.72$ A resistive load.

**Trace:** output voltage (50 mV/div.).
**20 MHz bandwidth filter** 10 µF+0.1 µF

### Output Load Transient Response

Output voltage response to load current step change (3.18 – 9.56 – 3.18 A) at:
- $T_{\text{IP}} = +25^\circ \text{C}$, $V_{\text{IP}} = 53$ V.

**Top trace:** output voltage (0.2 V/div.).
**Bottom trace:** output current (5 A/div.).

*Time scale:* (0.5 ms/div.)

### Output Current Derating – Open frame

Available load current vs. ambient air temperature and airflow at $V_{\text{Ip}} = 53$ V. See Thermal Consideration section.

### Output Current Derating – Cold wall sealed box

Available load current vs. cold wall temperature. $V_{\text{Ip}} = 53$ V. See Thermal Consideration section.
**PKU4716VA Series** Fully Regulated DC-DC Converters
Input 36-60 V, Output up to 12.7 A / 70 W

Thermal Resistance

![Thermal Resistance Graph](Vth=53V, Vout=5.5V)

**Air velocity (m/s)**
Thermal resistance vs. airspeed measured at the converter. Tested in wind tunnel with airflow and test conditions as per the Thermal consideration section. \( V_i = 53 \text{ V} \).
EMC Specification
Conducted EMI measured according to EN55022/EN 55032, CISPR 22/CISPR 23 and FCC part 15J (see test set-up). See Design Note 029 for further information. The fundamental switching frequency is 300 kHz for PKU-A. The EMI characteristics below is measured at \( V_i = 53 \) V and max \( I_o \).

Conducted EMI Input terminal value (typ)

EMI without filter, EN55032 Test method and limits are the same as EN55022

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:
- \( C_1 = 2.2 \ \mu F \)
- \( C_2 = 2.2 \ \mu F \)
- \( C_3 = 2.2 \ \mu F + 100 \ \mu F \) (e-lyt)
- \( C_4, C_5 = 4.7nF \)
- \( L_1 = 1.59 \) mH
- \( L_2 = 22 \) \mu H

EMI with filter, EN55032 Test method and limits are the same as EN55022

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.
PKU4716VA Series Fully Regulated DC-DC Converters
Input 36-60 V, Output up to 12.7 A / 70 W

Technical Specification

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Operating information

Input Voltage
The input voltage range 36 to 60 Vdc meets the customer specification.

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 ~ 2.0 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 first option is “negative logic” RC, which can be ordered by adding the suffix “1” to the third position from the end of the part number. To turn off the product the RC pin is left open or connect to voltage source higher than 2 V referenced to -In. Turn on is achieved by connecting the RC pin to the –In.

The second option is “positive logic” RC, which can be ordered by adding the suffix “2” to the third position from the end of the part number. When the RC pin is left open or connect to voltage source higher than 2 V referenced to -In, the product starts up automatically when the input voltage is applied. Turn off is achieved by connecting the RC pin to the -In.

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 100 µF external capacitors connected to the input. 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 100 µF 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 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 and minimum 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 >1 mΩ across the output connections.

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

Output Voltage Adjust (Vadj)
The products have an Output Voltage Adjust pin (Vadj). This pin can be used to adjust the output voltage above Output voltage initial setting. To increase the output voltage, resistor should be connected between the Vadj pin and –In pin. Table below Vout-set vs Vadj resistor value.
PKU4716VA Series Fully Regulated DC-DC Converters
Input 36-60 V, Output up to 12.7 A / 70 W

Vout-set [V]  Vadj-Resistor [kOhm]
5.7          69.2
5.9          37.1
6.1          25.2
6.3          17.1
6.5          15.4

Parallel Operation
This product is not designed for paralleling.

Over Temperature Protection (OTP)
The products are protected from thermal overload by an internal over temperature shutdown circuit.
When control circuit as defined in thermal consideration section exceeds critical temperature, 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)
This product is not designed with that function.

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 the specified maximum output short circuit current.

Thermal Consideration

General
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 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 V1 = 53 V.

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

For products used in a sealed box/cold wall application, cooling is achieved mainly by conduction through the cold wall. The Output Current Derating graphs are found in the Output section for each 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.
Definition of product operating temperature
The temperature at the positions (TP1, TP2) 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 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-T210, Reference point</td>
<td>Tp=125°C</td>
</tr>
<tr>
<td>P2</td>
<td>Transformer PWB Winding Bottom</td>
<td>Tp=125°C</td>
</tr>
</tbody>
</table>

Ambient Temperature Calculation
The maximum allowed ambient temperature can be calculated by using the thermal resistance.

1. The power loss is calculated by using the formula 

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

\[ \eta = \text{efficiency of product. E.g. } 94.5\% = 0.945 \]

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 Gap Pad and heatsink is mounted on the top of the module.** (see below, Gap Pad picture)

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

\[ \Delta T = R_{th} \times P_d \]

3. Max allowed ambient temperature is:

\[ \text{Max } T_{P1} - \Delta T. \]

E.g. PKU 4716VA at 1m/s:

1. \( ((\frac{1}{0.94} - 1) \times 70 \text{ W} = 4.5 \text{ W} \)

2. \( 4.5 \text{ W} \times 9^\circ\text{C/W} = 40.5^\circ\text{C} \)

3. \( 125^\circ\text{C} - 40.5^\circ\text{C} = \text{max ambient temperature is } 84.5^\circ\text{C} \).

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

Heat sink and Gap Pad

To guarantee isolation between primary and secondary part of the module the isolation distance between heatsink and ferrite on the top of module must be 1.7mm. Recommended Gap Pad Laird’s Tflex™ HD90000, 7.5 W/mK.
**PKU4716VA Series** Fully Regulated DC-DC Converters
Input 36-60 V, Output up to 12.7 A / 70 W

**Connections**

Open frame (bottom view)

<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>6</td>
<td>Adj</td>
<td>Vout Adjust</td>
</tr>
<tr>
<td>8</td>
<td>+Out</td>
<td>Positive Output</td>
</tr>
</tbody>
</table>
PKU4716VA Series Fully Regulated DC-DC Converters
Input 36-60 V, Output up to 12.7 A / 70 W

PKU4716VA Series

Mechanical information - Hole mount version

Pin positions according to recommended footprint

RECOMMENDED FOOTPRINT - TOP VIEW

Pin
Material: Copper alloy
Plating: 0.3µm Gold (Au) over 2µm Nickel

Layout considerations:
Use sufficient numbers of via's connected to output pin pad for proper thermal and current conductivity

Recommended pad dimensions are only for reference. It is the end user's decision based on different situations like production processes, substrate thickness etc.

Weight, typical 12.9 g
All dimensions in mm (inches)
Tolerances unless specified
x.xx ±0.25 mm (0.01"
xx.xx ±0.25 mm (0.01"

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 or 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 \(T_L\) (217 to 221°C for SnAgCu solder alloys) for more than 30 seconds and a peak temperature of 235°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 surface mount products are delivered in an antistatic carrier tape (Jedec design EIA 481 standard).

<table>
<thead>
<tr>
<th>Carrier Tape Specifications</th>
<th>SMD Version</th>
<th>TH version</th>
</tr>
</thead>
<tbody>
<tr>
<td>Material</td>
<td>Antistatic PS</td>
<td>Antistatic PS</td>
</tr>
<tr>
<td>Surface resistance</td>
<td>$10^7 &lt; \text{Ohm/square}$</td>
<td>$10^7 &lt; \text{Ohm/square}$</td>
</tr>
<tr>
<td>Bakeability</td>
<td>The tape is not bakeable</td>
<td>The tape is not bakeable</td>
</tr>
<tr>
<td>Tape width, $W$</td>
<td>56 mm [2.2 inch]</td>
<td>56 mm [2.2 inch]</td>
</tr>
<tr>
<td>Pocket pitch, $P_1$</td>
<td>36 mm [1.42 inch]</td>
<td>36 mm [1.42 inch]</td>
</tr>
<tr>
<td>Pocket depth, $K_0$</td>
<td>9.3 mm [0.366 inch]</td>
<td>14.35 mm [0.565 inch]</td>
</tr>
<tr>
<td>Reel diameter</td>
<td>380 mm [15 inch]</td>
<td>380 mm [15 inch]</td>
</tr>
<tr>
<td>Reel capacity</td>
<td>200 products /reel</td>
<td>150 products /reel</td>
</tr>
<tr>
<td>Reel weight</td>
<td>2.5 kg/full reel</td>
<td>1.8kg / full reel</td>
</tr>
</tbody>
</table>

X = Vacuum pick up
All dimensions in mm [inch]
Tolerances: X.xx mm ±0.13 mm [0.005], X.x mm ±0.26 mm [0.01]
Note: tray dimensions refer to pocket center. For exact location of product pick up surface, refer to mechanical drawing.
## Product Qualification Specification

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Method</th>
<th>Description</th>
<th>Test Conditions</th>
</tr>
</thead>
<tbody>
<tr>
<td>External visual inspection</td>
<td>IPC-A-610</td>
<td>Temperature range</td>
<td>-40 to 100°C</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Number of cycles</td>
<td>500</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Dwell/transfer time</td>
<td>15 min/0-1 min</td>
</tr>
<tr>
<td>Change of temperature (Temperature cycling)</td>
<td>IEC 60068-2-14 Na</td>
<td>Temperature T&lt;sub&gt;A&lt;/sub&gt;</td>
<td>-45°C</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Duration</td>
<td>72 h</td>
</tr>
<tr>
<td>Cold (in operation)</td>
<td>IEC 60068-2-1 Ad</td>
<td>Temperature T&lt;sub&gt;A&lt;/sub&gt;</td>
<td>85°C</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Duration</td>
<td>85% RH</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>1000 hours</td>
</tr>
<tr>
<td>Damp heat</td>
<td>IEC 60068-2-67 Cy</td>
<td>Temperature T&lt;sub&gt;A&lt;/sub&gt;</td>
<td>70°C</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Humidity</td>
<td>85% RH</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>1000 hours</td>
</tr>
<tr>
<td>Dry heat</td>
<td>IEC 60068-2-2 Bd</td>
<td>Temperature T&lt;sub&gt;A&lt;/sub&gt;</td>
<td>125°C</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Duration</td>
<td>1000 h</td>
</tr>
<tr>
<td>Electrostatic discharge susceptibility</td>
<td>IEC 61340-3-1, JESD 22-A114</td>
<td>Human body model (HBM).machine model (MM)</td>
<td>Class 2, 2000 V</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Class 3, 200 V</td>
</tr>
<tr>
<td></td>
<td>IEC 61340-3-2, JESD 22-A115</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Immersion in cleaning solvents</td>
<td>IEC 60068-2-45 XA, method 2</td>
<td>Water, glycol ether, isopropyl alcohol</td>
<td>55°C, 35°C, 35°C</td>
</tr>
<tr>
<td>Mechanical shock</td>
<td>IEC 60068-2-27 Ea</td>
<td>Peak acceleration</td>
<td>100 g</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Duration</td>
<td>6 ms</td>
</tr>
<tr>
<td>Moisture reflow sensitivity</td>
<td>J-STD-020C</td>
<td>Level 1 (SnPb-eutectic), Level 3 (Pb Free)</td>
<td>225°C, 260°C</td>
</tr>
<tr>
<td>Operational life test</td>
<td>MIL-STD-202G, method 108A</td>
<td>Duration</td>
<td>1000 h</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>
</tr>
<tr>
<td></td>
<td></td>
<td>Duration</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>
</tr>
<tr>
<td></td>
<td>IEC 60068-2-21 Test Ue1</td>
<td>Surface mount products</td>
<td>All leads</td>
</tr>
<tr>
<td>Solderability</td>
<td>IEC 60068-2-58 test Td&lt;sup&gt;1&lt;/sup&gt;</td>
<td>Preconditioning, temperature, SnPb eutectic, temperature, Pb-free</td>
<td>150°C dry bake 16 h, 215°C, 235°C</td>
</tr>
<tr>
<td></td>
<td>IEC 60068-2-20 test Ta&lt;sup&gt;2&lt;/sup&gt;</td>
<td>Preconditioning, temperature, SnPb eutectic, temperature, Pb-free</td>
<td>Steam ageing, 235°C, 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>
</tr>
<tr>
<td></td>
<td></td>
<td>Spectral density</td>
<td>0.07 g/Hz</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Duration</td>
<td>10 min in each direction</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)