**Data Sheet**
**June 17, 2009**

# QUK240 Series Power Modules; DC-DC Converters
## 36-55 Vdc Input; 9V Output; 240 W

**RoHS Compliant**

## Applications

- Distributed Power Architecture
- Wireless Networks
- Optical and Access Networks equipment
- Enterprise Networks

## Options

- Negative logic, Remote On/Off
- Auto restart after fault protection shutdown
- Basic Insulation

## Features

- Compliant to RoHS EU Directive 2002/95/EC (-Z versions)
- Compliant to ROHS EU Directive 2002/95/EC with lead solder exemption (non-Z versions)
- High power density: 173 W/in$^3$
- High efficiency – 95.5% at 9.0V full load
- Improved Thermal Performance: 240W at 70ºC at 1m/s (200LFM)
- Low output ripple and noise
- Industry standard Quarter brick:
- 57.9 mm x 36.8 mm x 10.6 mm
- (2.28 in x 1.45 in x 0.42 in)
- Cost efficient open frame design
- Single unregulated output
- Narrow input voltage range
- Constant switching frequency
- Positive Remote On/Off logic
- Output over current/voltage protection
- Over temperature protection
- Operating temperature range (0°C to 70°C)
- ISO** 9001 certified manufacturing facilities
- *UL** 60950-1 Recognized, *CSA*† C22.2 No. 60950-1-03 Certified, and EN 60950-1 (*VDE*‡ 0805: 2001-12) Licensed

## Description

The QUK-series dc-dc converters are a new generation of DC/DC power modules designed to support intermediate bus applications where multiple low voltages are generated using discrete/modular point of load (POL) converters. The QUK series provide up to 240 watts of output power in an industry standard quarter brick, which makes it an ideal choice for dense, high current and intermediate bus voltage applications. The converter incorporates synchronous rectification technology and innovative packaging techniques to achieve ultra high efficiency reaching 95.5% at 9.0V full load. The ultra high efficiency of this converter leads to lower power dissipation such that for most applications a heat sink is not required. The QUK series power modules are isolated dc-dc converters that operate over an intermediate input voltage range of 36 to 55 Vdc and provide a single unregulated output voltage with a 5:1 step-down ratio between input and output. The output is fully isolated from the input, allowing versatile polarity configurations and grounding connections. Built-in filtering for both input and output minimizes the need for external filtering.

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‡ *VDE* is a trademark of Verband Deutscher Elektrotechniker e.V.
** ISO is a registered trademark of the International Organization of Standards

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## Absolute Maximum Ratings

Stresses in excess of the absolute maximum ratings can cause permanent damage to the device. These are absolute stress ratings only, functional operation of the device is not implied at these or any other conditions in excess of those given in the operations sections of the data sheet. Exposure to absolute maximum ratings for extended periods can adversely affect the device reliability.

| Parameter | Device | Symbol | Min | Max | Unit |
|---|---|---|---|---|---|
| Input Voltage* | | | | | |
| Continuous | | $V_{IN}$ | -0.3 | 57 | Vdc |
| Non- operating continuous | | $V_{IN}$ | -0.3 | 75 | Vdc |
| Operating Ambient Temperature | All | $T_A$ | 0 | 70 | °C |
| (See Thermal Considerations section) | | | | | |
| Storage Temperature | All | $T_{stg}$ | -40 | 100 | °C |
| I/O Isolation Voltage (100% factory Hi-Pot tested) | All | — | — | 1500 | Vdc |

## Electrical Specifications

Unless otherwise indicated, specifications apply over all operating input voltage, resistive load, and temperature conditions.

| Parameter | Device | Symbol | Min | Typ | Max | Unit |
|---|---|---|---|---|---|---|
| Operating Input Voltage | | $V_{IN}$ | 36 | 48 | 55 | Vdc |
| Maximum Input Current ($V_{IN}$=0V to 75V, $I_O$=$I_{O,\ max}$) | | $I_{IN,max}$ | - | - | 8 | Adc |
| Inrush Transient | All | $I^2t$ | - | - | 1 | $A^2s$ |
| Input Reflected Ripple Current, peak-to-peak (5Hz to 20MHz, 12µH source impedance; $V_{IN}$= 48V, $I_O$= $I_{Omax}$ ; see Figure 9) | All | | - | 20 | - | mAp-p |
| Input Ripple Rejection (120Hz) | All | | - | 14 | - | dB |

**CAUTION: This power module is not internally fused. An input line fuse must always be used.**

This power module can be used in a wide variety of applications, ranging from simple standalone operation to being part of complex power architecture. To preserve maximum flexibility, internal fusing is not included, however, to achieve maximum safety and system protection, always use an input line fuse. The safety agencies require a fast-acting fuse with a maximum rating of 15 A (see Safety Considerations section). Based on the information provided in this data sheet on inrush energy and maximum dc input current, the same type of fuse with a lower rating can be used. Refer to the fuse manufacturer’s data sheet for further information.

## Electrical Specifications (continued)

| Parameter | Device | Symbol | Min | Typ | Max | Unit |
|---|---|---|---|---|---|---|
| Output Voltage Set-point ($V_{IN}$=$_{IN, min}$, $I_O$=$I_{O, max}$, $T_A$=25°C) | All | $V_{O, set}$ | | 9 | | $V_{dc}$ |
| Output Voltage (Over all operating input voltage, resistive load, and temperature conditions until end of life) | All | $V_O$ | — | — | — | % $V_{O, set}$ |
| Output Regulation | | | | | | |
| Line ($V_{IN}$=$V_{IN, min}$ to $V_{IN, max}$) | All | | 6.5 | — | 11.5 | $V_{O, set}$ |
| Load ($I_O$=$I_{O, min}$ to $I_{O, max}$) | All | | — | 0.5 | 1 | $V_{O, set}$ |
| Temperature ($T_{ref}$=$T_{A, min}$ to $T_{A, max}$) | All | | — | 150 | | mV |
| Output Ripple and Noise on nominal output ($V_{IN}$=$V_{IN, nom}$ and $I_O$=$I_{O, min}$ to $I_{O, max}$) | | | | | | |
| RMS (5Hz to 20MHz bandwidth) | All | | — | 20 | — | $mV_{rms}$ |
| Peak-to-Peak (5Hz to 20MHz bandwidth) | All | | — | 150 | — | $mV_{pk-pk}$ |
| External Capacitance | All | $C_{O, max}$ | — | — | 3000 | μF |
| Output Power | All | $P_o$ | 0 | | 240 | W |
| Output Current Limit Inception | All | $I_{O, lim}$ | — | 40 | — | Adc |
| Efficiency $V_{IN}$= $V_{IN, nom}$, $T_A$=25°C $I_O$=$I_{O, max}$ , $V_O$= $V_{O,set}$ | All | η | — | 95.5 | — | % |
| Switching Frequency | All | $f_{sw}$ | — | 360 | — | kHz |
| Dynamic Load Response (ΔIo/Δt=1A/10µs; $V_{in}$=$V_{in}$,nom; $T_A$=25°C; Tested with a 10 μF aluminum and a 1.0 μF tantalum capacitor across the load.) | | | | | | |
| Load Change from Io= 50% to 75% of Io,max: Peak Deviation | | $V_{pk}$ | — | 350 | — | mV |
| Settling Time (Vo<10% peak deviation) | | $t_s$ | — | 50 | — | µs |
| Load Change from Io= 75% to 50% of Io,max: Peak Deviation | | $V_{pk}$ | — | 350 | — | V |
| Settling Time (Vo<10% peak deviation) | | $t_s$ | — | 50 | | µs |

## Isolation Specifications

| Parameter | Min | Typ | Max | Unit |
|---|---|---|---|---|
| Isolation Capacitance | — | 1000 | — | pF |
| Isolation Resistance | 10 | — | — | MΩ |

## General Specifications

| Parameter | Min | Typ | Max | Unit |
|---|---|---|---|---|
| Calculated MTBF ($I_O$= 80% of $I_{O, max}$, $T_A$=40°C) | | 2,500,000 | — | Hours |
| Weight | — | 47.2(1.66) | — | g (oz.) |

## Feature Specifications

Unless otherwise indicated, specifications apply over all operating input voltage, resistive load, and temperature conditions. See Feature Descriptions for additional information.

| Parameter | Device | Symbol | Min | Typ | Max | Unit |
|---|---|---|---|---|---|---|
| Remote On/Off Signal Interface | | | | | | |
| ($V_{IN}$=$V_{IN, min}$ to $V_{IN, max}$ ; open collector or equivalent, Signal referenced to $V_{IN-}$ terminal) | | | | | | |
| Negative Logic: device code suffix “1” | | | | | | |
| Logic Low = module On, Logic High = module Off<br>Positive Logic: No device code suffix required;<br>Logic Low = module Off, Logic High = module On | | | | | | |
| Logic Low Specification | | | | | | |
| Remote On/Off Current – Logic Low | All | $I_{on/off}$ | — | | 1.2 | mA |
| On/Off Voltage: | | | | | | |
| Logic Low | All | $V_{on/off}$ | 0.0 | — | 0.8 | V |
| Logic High – (Typ = Open Collector) | All | $V_{on/off}$ | — | — | 5 | V |
| Logic High maximum allowable leakage current | All | $I_{on/off}$ | — | — | 50 | μA |
| Turn-On Delay and Rise Times ($I_O$=$I_{O, max}$) | | | | | | |
| $T_{delay}$ = Time until $V_O$ = 10% of $V_{O,set}$ from either application of Vin with Remote On/Off set to On or operation of Remote On/Off from Off to On with Vin already applied for at least one second. | S9R0 | $T_{delay}$, Enable with Vin | — | 75 | 100 | ms |
| | | $T_{delay}$, Enable with on/off | — | 1 | — | ms |
| $T_{rise}$ = time for $V_O$ to rise from 10% of $V_{O,set}$ to 90% of $V_{O,set}$. | | $T_{rise}$ | — | 3 | — | ms |
| Output Overvoltage Protection | S9R0 | | | 11.5 | | V |
| Overtemperature Protection (See Feature Descriptions) | All | $T_{ref}$ | — | 130 | — | °C |
| Input Undervoltage Lockout | | | | | | |
| Turn-on Threshold | | | — | 33.5 | 35.5 | V |
| Turn-off Threshold | | | 30 | 31.5 | — | V |

## Characteristic Curves

The following figures provide typical characteristics for QUK240S9R0 at $T_A = 25^O$ C

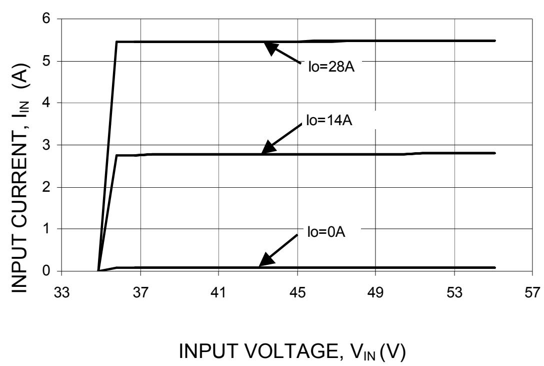



**Figure 1. Typical Input characteristics at room temperature .**

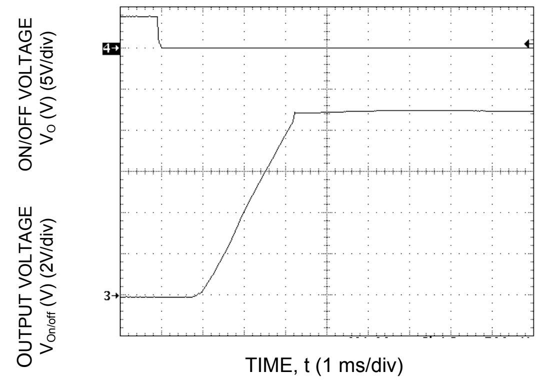



**Figure 4. Typical Start-Up Characteristics from Remote ON/OFF.**

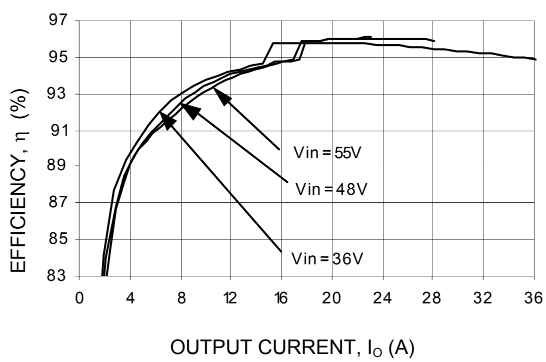



**Figure 2. Typical Converter Efficiency versus Output Current at room temperature.**

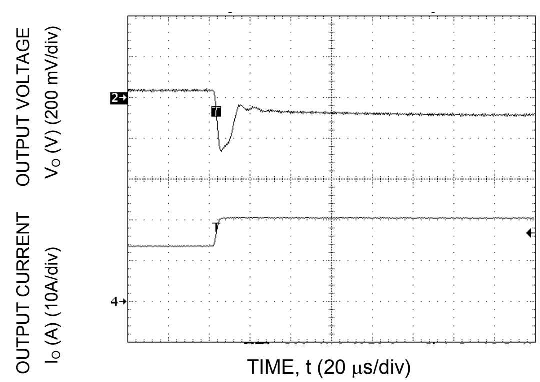



**Figure 5. Transient Response to a Dynamic Load Change from 50% to 75% of full load.**

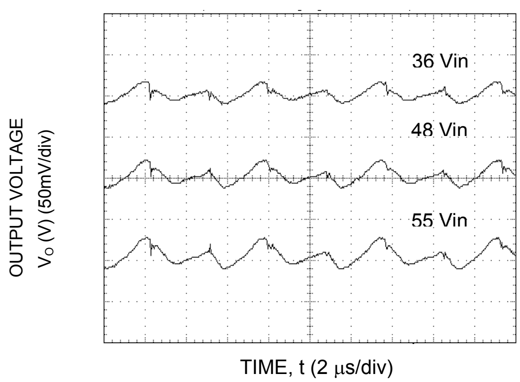



**Figure 3. Output ripple voltage at full load and minimum, nominal and maximum input voltage.**

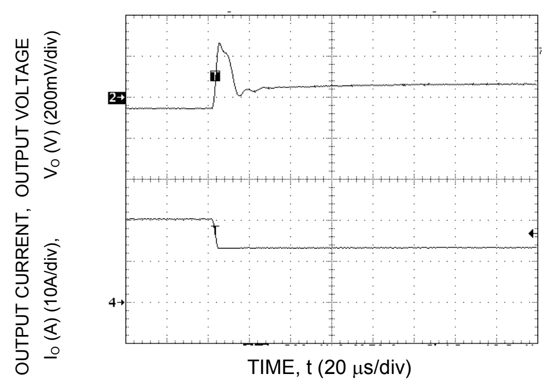



**Figure 6. Transient Response to a Dynamic Load Change from 75% to 50% of full load.**

## Characteristic Curves (continued)

The following figures provide typical characteristics for EUK240S9R0 at $T_A = 25^O$ C

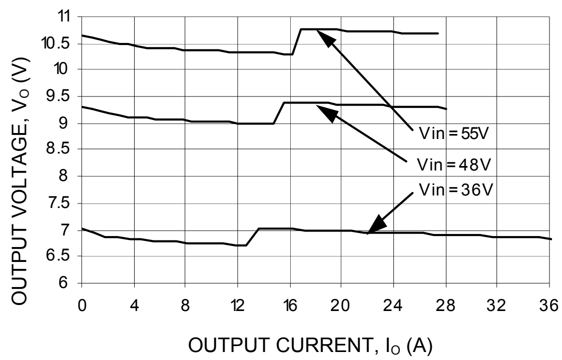



**Figure 7. Typical Output Voltage vs. Output Current Characteristic at Room Temperature.**

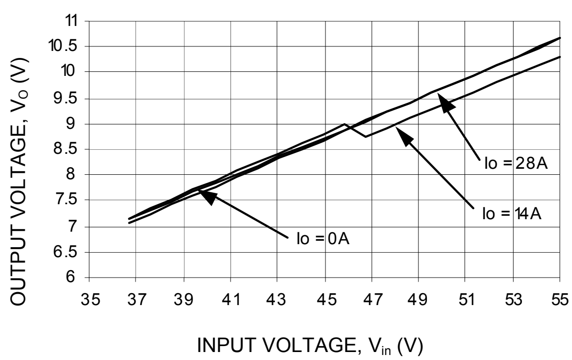
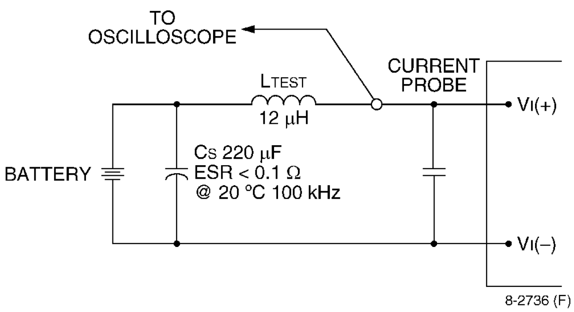


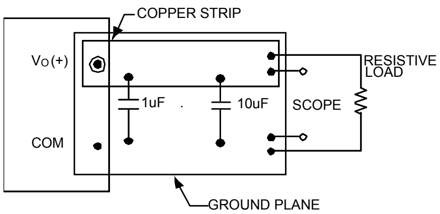

**Figure 8. Typical Output Voltage vs. Input Voltage Characteristic at Room Temperature.**

## Test Configurations



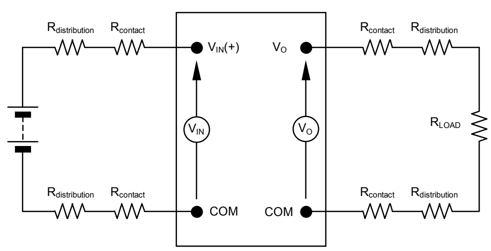

Note: Measure input reflected-ripple current with a simulated source inductance (LTEST) of 12 µH. Capacitor CS offsets possible battery impedance. Measure current as shown above.

**Figure 9. Input Reflected Ripple Current Test Setup.**




NOTE: All voltage measurements to be taken at the module terminals, as shown above. If sockets are used then Kelvin connections are required at the module terminals to avoid measurement errors due to socket contact resistance.

**Figure 10. Output Ripple and Noise Test Setup.**




NOTE: All voltage measurements to be taken at the module terminals, as shown above. If sockets are used then Kelvin connections are required at the module terminals to avoid measurement errors due to socket contact resistance.

**Figure 11. Output Voltage and Efficiency Test Setup.**

$$\text{Efficiency} \quad \eta = \frac{V_O . I_O}{V_{IN} . I_{IN}} \times 100 \ \%$$

## Design Considerations

### Input Filtering

The power module should be connected to a low ac-impedance source. A highly inductive source impedance can affect the stability of the power module. For the test configuration in Figure 9, a 100µF electrolytic capacitor (ESR<0.7Ω at 100kHz), mounted close to the power module helps ensure the stability of the unit. Consult the factory for further application guidelines.

### Safety Considerations

For safety-agency approval of the system in which the power module is used, the power module must be installed in compliance with the spacing and separation requirements of the end-use safety agency standard, i.e., UL 1950, CSA C22.2 No. 60950-00, and VDE 0805:2001-12 (IEC60950 3rd Ed).

If the input source is non-SELV (ELV or a hazardous voltage greater than 60 Vdc and less than or equal to 75Vdc), for the module's output to be considered as meeting the requirements for safety extra-low voltage (SELV), all of the following must be true:

- The input source is to be provided with reinforced insulation from any other hazardous voltages, including the ac mains.
- One $V_{IN}$ pin and one $V_{OUT}$ pin are to be grounded, or both the input and output pins are to be kept floating.
- The input pins of the module are not operator accessible.
- Another SELV reliability test is conducted on the whole system (combination of supply source and subject module), as required by the safety agencies, to verify that under a single fault, hazardous voltages do not appear at the module's output.

**Note:** Do not ground either of the input pins of the module without grounding one of the output pins. This may allow a non-SELV voltage to appear between the output pins and ground.

The power module has extra-low voltage (ELV) outputs when all inputs are ELV. The input to these units is to be provided with a maximum 15 A fast-acting (or time-delay) fuse in the unearthed lead.

## Feature Description

### Remote On/Off

Two remote on/off options are available. Positive logic remote on/off turns the module on during a logic-high voltage on the ON/OFF pin, and off during a logic low. Negative logic remote on/off turns the module off during a logic high and on during a logic low. Negative logic, device code suffix "1," is the factory-preferred configuration. To turn the power module on and off, the user must supply a switch to control the voltage between the on/off terminal and the VI (-) terminal (Von/off). The switch can be an open collector or equivalent (see Figure 12). A logic low is Von/off = 0 V to I.2 V. The maximum Ion/off during a logic low is 1 mA. The switch should maintain a logic-low voltage while sinking 1 mA. During a logic high, the maximum Von/off generated by the power module is 15 V. The maximum allowable leakage current of the switch at Von/off = 15V is 50 µA. If not using the remote on/off feature, perform one of the following to turn the unit on:

For negative logic, short ON/OFF pin to VI(-).

For positive logic: leave ON/OFF pin open.

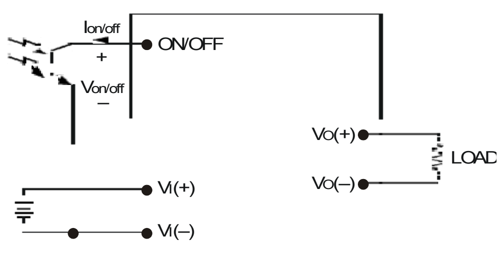



**Figure 12. Remote On/Off Implementation**

### Overcurrent Protection

To provide protection in a fault output overload condition, the module is equipped with internal current-limiting circuitry and can endure current limiting for a few mili-seconds. If the overcurrent condition persists beyond a few milliseconds, the module will shut down and remain latched off. The overcurrent latch is reset by either cycling the input power or by toggling the on/off pin for one second. If the output overload condition still exists when the module restarts, it will shut down again. This operation will continue indefinitely until the overcurrent condition is corrected.

An auto-restart option is also available. An auto-restart feature continually attempts to restore the operation until fault condition is cleared.

### Input Undervoltage Lockout

At input voltages above or below the input under/over voltage lockout limits, module operation is disabled. The module will begin to operate when the input voltage level changes to within the under and overvoltage lockout limits.

### Overtemperature Protection

These modules feature an overtemperature protection circuit to safeguard against thermal damage. The circuit shuts down and latches off the module when the maximum device reference temperature is exceeded. The module can be restarted by cycling the dc input power for at least one second or by toggling the remote on/off signal for at least one second.

### Input/Output Overvoltage Protection

The input/output overvoltage protection circuit is designed to shut down the module when the input voltage exceeds the overvoltage threshold. The module will resume operation when the input voltage enters the normal input operating range.

## Thermal Considerations

The power modules operate in a variety of thermal environments and sufficient cooling should be provided to help ensure reliable operation.

Thermal considerations include ambient temperature, airflow, module power dissipation, and the need for increased reliability. A reduction in the operating temperature of the module will result in an increase in reliability. The thermal data presented here is based on physical measurements taken in a wind tunnel.

Heat-dissipating components are mounted on the top side of the module. Heat is removed by conduction, convection and radiation to the surrounding environment. Proper cooling can be verified by measuring the thermal reference temperatures ($T_{H1}$ and $T_{H2}$). Peak temperature ($T_{H1}$ or $T_{H2}$ ) occurs at either of the positions indicated in Figure 13 for the open frame power module and Figure 14 for the base plate version. For reliable operation these temperatures should not exceed 120 ºC for open frame power module and 100 ºC for base plate version of power module.

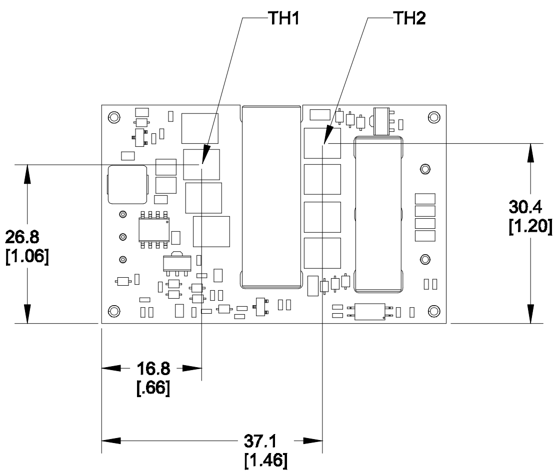



**Figure 13. $T_{H1 \text{ and } H2}$ Temperature Measurement Location for the QUK240S9R0 module.**

Please refer to the Application Note “Thermal Characterization Process For Open-Frame Board-Mounted Power Modules” for a detailed discussion of thermal aspects including maximum device temperatures.

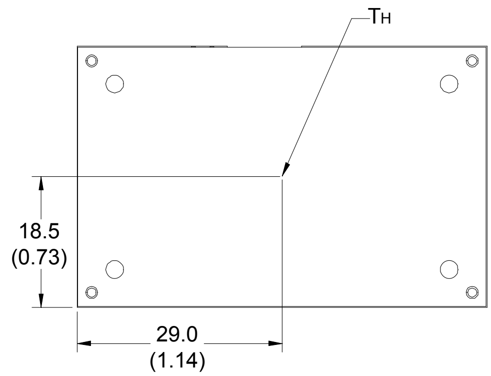



**Figure 14. Temperature Measurement Location $T_{H1}$ for the base plate version of the QUK240S9R0 module.**

The output power of the module should not exceed the rated power for the module as listed in the Ordering Information table. Although the maximum temperature ($T_{H1 \text{ or } H2}$) of the power module is 120 °C, you can limit this temperature to a lower value for improved reliability.

## Heat Transfer via Convection

Increased airflow over the module enhances the heat transfer via convection. The derating plots in figures 15-18 show the maximum output power that can be delivered by each module in the respective orientation and at different ambient air temperatures without exceeding the maximum $T_{ref}$ temperature. The plots are for different airflow conditions ranging from natural convection to 3m/s (600 ft./min).

Note that the natural convection condition was measured at 0.05 m/s to 0.1 m/s (10ft./min. to 20 ft./min.); however, systems in which these power modules may be used typically generate natural convection airflow rates of 0.3 m/s (60 ft./min.) due to other heat dissipating components in the system. The use of Figures 15 - 18 is shown in the following example:

**Example**

What is the minimum airflow necessary for a QUK240S9R0 operating at VI = 48 V, an output power of 240W, and a maximum ambient temperature of 70 °C in the transverse orientation?

Solution:

Given: VI = 48V, Po = 240W, $T_A$ = 70 °C

Determine airflow (V) (Use Figure 16):

V = 1.0 m/sec. (200 ft./min.)

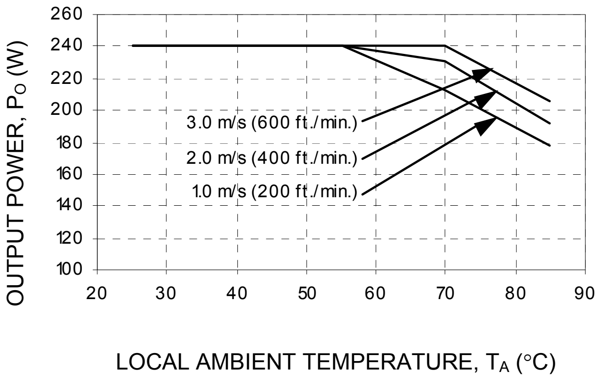



**Figure 15. Output Power Derating for QUK240S9R0 in the Transverse Orientation with no baseplate; Airflow Direction From Vin(-) to Vin(+); Vin = 38V.**

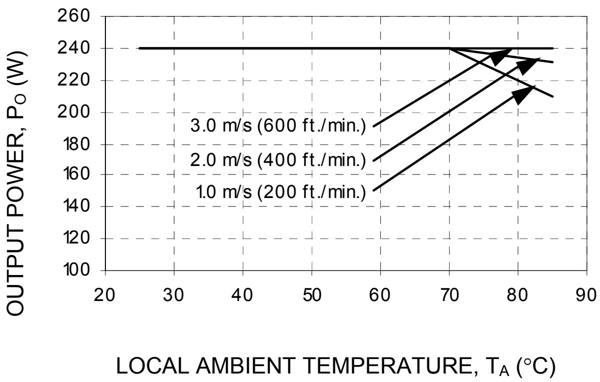



**Figure 16. Output Power Derating for QUK240S9R0 in the Transverse Orientation with baseplate; Airflow Direction From Vin(-) to Vin(+); Vin = 48V**

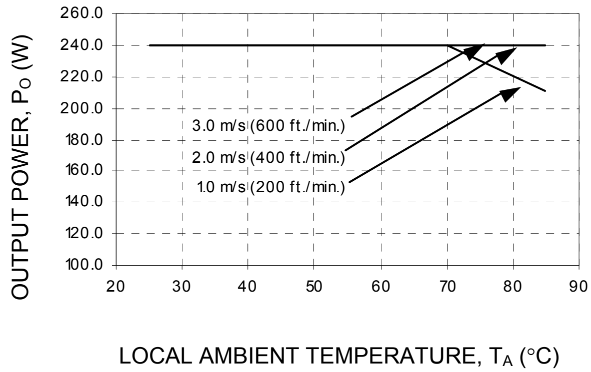



**Figure 17. Output Power Derating for QUK240S9R0 in the Transverse Orientation with baseplate and multi directional fin 0.5 inch heatsink; Airflow Direction From Vin(-) to Vin(+); Vin = 38V**

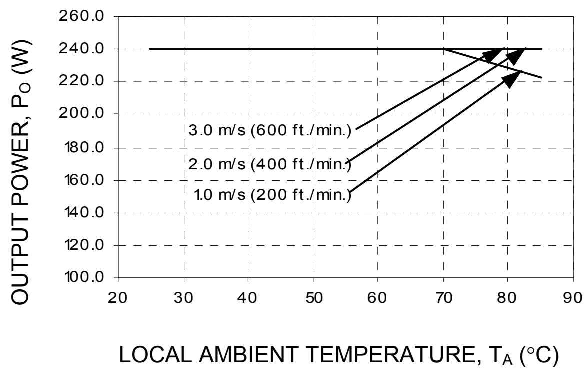



**Figure 18. Output Power Derating for QUK240S9R0 in the Transverse Orientation with baseplate and multi directional fin 0.5 inch heatsink; Airflow Direction From Vin(-) to Vin(+); Vin = 48V**

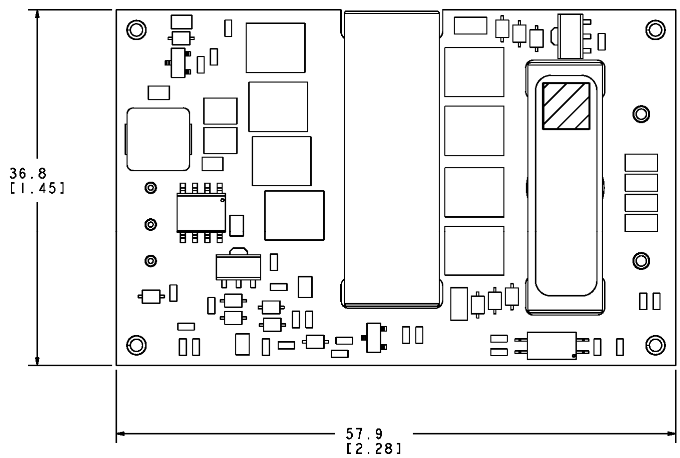
## Mechanical Outline

Dimensions are in millimeters and [inches].

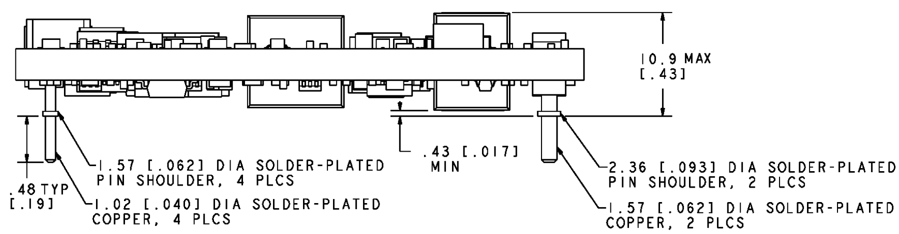
Tolerances: x.x mm ± 0.5 mm [x.xx in. ± 0.02 in.] (Unless otherwise indicated)

x.xx mm ± 0.25 mm [x.xxx in ± 0.010 in.]

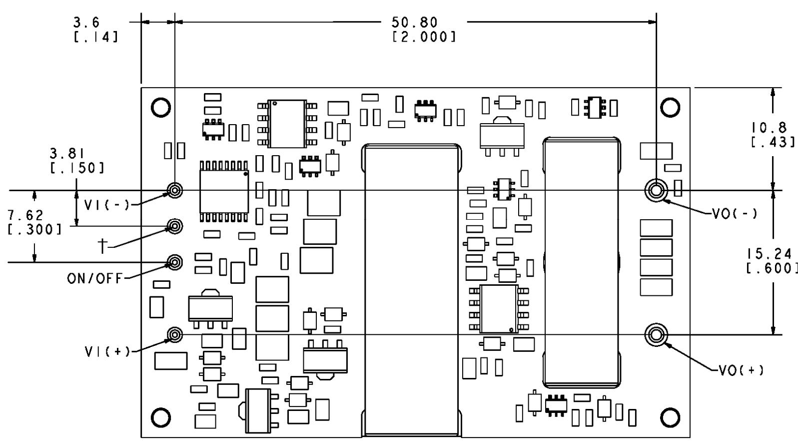
**TOP VIEW**




**SIDE VIEW**




**BOTTOM VIEW**



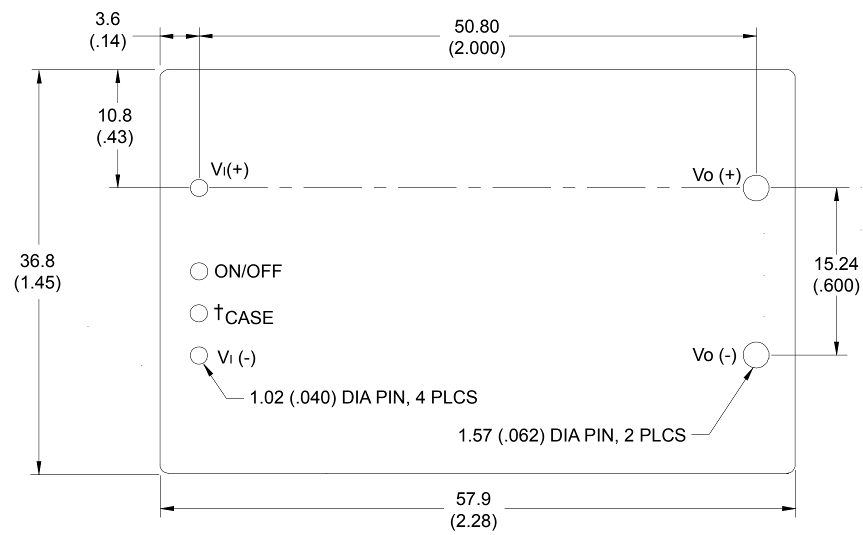

† Optional case pin

## Recommended Pad Layout for Through-Hole Modules

Dimensions are in millimeters and (inches).

Tolerances: x.x mm ± 0.5 mm ( x.xx in. ± 0.02 in.) [unless otherwise indicated]

x.xx mm ± 0.25 mm ( x.xxx in ± 0.010 in.)




† Optional case pin

## Post solder Cleaning and Drying Considerations

Post solder cleaning is usually the final circuit-board assembly process prior to electrical board testing. The result of inadequate cleaning and drying can affect both the reliability of a power module and the testability of the finished circuit-board assembly. For guidance on appropriate soldering, cleaning and drying procedures, refer to Lineage Power *Board Mounted Power Modules: Soldering and Cleaning* Application Note.

## Through-Hole Lead-Free Soldering Information

The RoHS-compliant through-hole products use the SAC (Sn/Ag/Cu) Pb-free solder and RoHS-compliant components. They are designed to be processed through single or dual wave soldering machines. The pins have an RoHS-compliant finish that is compatible with both Pb and Pb-free wave soldering processes. A maximum preheat rate of 3°C/s is suggested. The wave preheat process should be such that the temperature of the power module board is kept below 210°C. For Pb solder, the recommended pot temperature is 260°C, while the Pb-free solder pot is 270°C max. Not all RoHS-compliant through-hole products can be processed with paste-through-hole Pb or Pb-free reflow process. If additional information is needed, please consult with your Lineage Power representative for more details.

## Ordering Information

Please contact your Lineage Power Sales Representative for pricing, availability and optional features.

**Table 1. Device Codes**

| Input Voltage | Output Voltage | Output Power | Efficiency | Connector Type | Product codes | Comcodes |
|---|---|---|---|---|---|---|
| 48V (36-55Vdc) | 9.0V | 240W | 95.5% | Through hole | QUK240S9R041Z | CC109149101 |

-Z RoHS Compliant

**Table 2. Device Options**

| Option | Suffix |
|---|---|
| Negative remote on/off logic | 1 |
| Auto-restart | 4 |
| Case ground pin (offered with baseplate option only) | 7 |

Note: Legacy device codes may contain a -B option suffix to indicate 100% factory Hi-Pot tested to the isolation voltage specified in the Absolute Maximum Ratings table. The 100% Hi-Pot test is now applied to all device codes, with or without the -B option suffix. Existing comcodes for devices with the -B suffix are still valid; however, no new comcodes for devices containing the -B suffix will be created.

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