OVERVIEW

The PQU650 is designed to be deployed in applications where thermal management (cooling airflow) is:

- Primarily considered to be by natural convection current circulation
- By "forced convection" airflow supplied by an external (system) fan; the PQU650 provides a dedicated 12VDC fan rail for this purpose (if required)

As such the design is efficient and designed to dissipate the minimum possible power. However to benefit from convection cooling, the power supply requires to be deployed in the most advantageous orientation in the system enclosure.
NB: The PQU650 is not intended for deployment in "conduction cooled" applications.

DEPLOYMENT NOTES

Convection Cooling

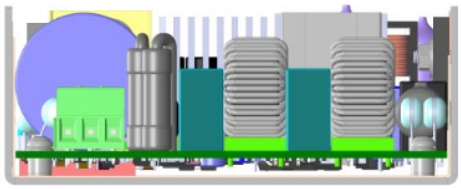
There are several factors that can influence the performance of the PQU650 when deployed in an End User application using only natural convection cooling:

1. Mounting orientation within a customer enclosure; the orientation that is selected for a particular deployment, can affect the overall temperature of components that are considered safety critical[1], that can also degrade long term reliability and life.
2. The overall enclosure size; the volume of air that surrounds the PQU650 and the freedom of circulating convection airflow currents.
3. The prevailing maximum local ambient within the enclosure.
4. Any additional "heat sources" within the enclosure that would potentially elevate the local ambient temperature.
5. The enclosure case material; i.e. a metal case will lose heat by conduction through the walls. Conversely if the enclosure material is a poor heat conductor (i.e. plastic) then heat will not be lost to the external ambient by conduction through the walls.
6. Whether the overall enclosure is sealed or if slots/louvres/holes are provided to allow cooling air to enter and exhaust.

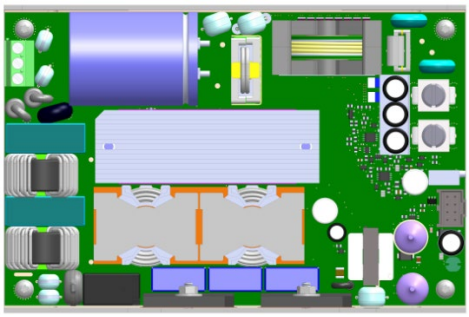
[1] See Appendix A

Mounting Orientation

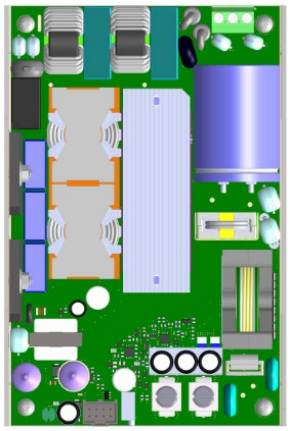
The PQU650 has been qualified with the following mounting orientations:



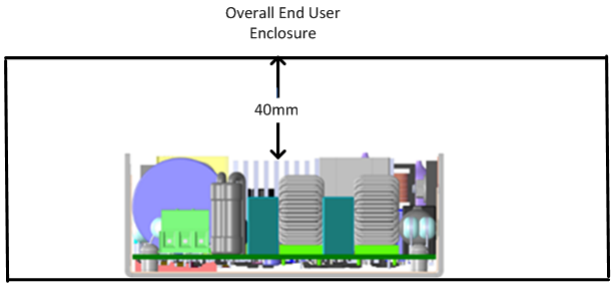
Horizontal



Vertical (Longitudinal)



Vertical (Lateral)



Testing has revealed that the most advantageous orientation is the horizontal placement where the PQU650 is affixed to the chassis of the End User enclosure.

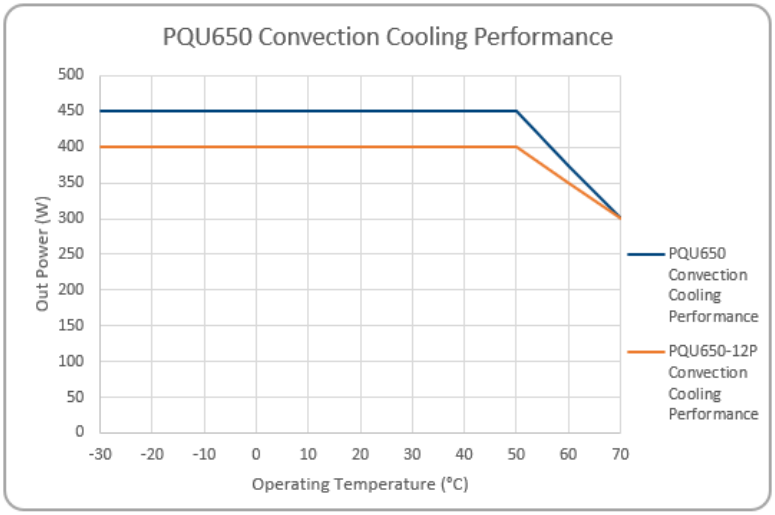
The horizontal orientation allows for the most even spread of temperatures across the area of the component side of the PCB within the "U" channel.

To make the most effective use of this orientation, additional space is required above the "U" channel to allow free circulation of convection cooling currents. It is suggested that at least 40mm is allowed above the "U" channel; however irrespective of the free space over the "U" channel verification of the critical component temperatures[1] shall be required to ensure safe and reliable operation.
Deployments in 1U "pizza boxes" (enclosures) are likely not able to provide a free space above the power supply to allow circulation of free convection air currents; therefore to prevent stagnation, it is recommended that "forced convection" airflow is provided (see the section dealing with forced convection cooling).

[1] See Appendix A

As identified, the PQU650 is capable of mounting in other orientations however although "less preferred" these can still provide acceptable operation in the End User system, providing that adequate airflow movement is provided, and component temperatures are verified (and acceptable).
Since the PQU650 is intended for deployment across multiple market segments, it is difficult to provide definitive rules that will allow operation in all diverse End User systems and operational conditions.
The PQU650 will reliably provide 450W[2] output power with no derating for AC line at a local ambient temperature of +50°C.
It is also capable of operation at up to +70°C with a modest reduction in output power:

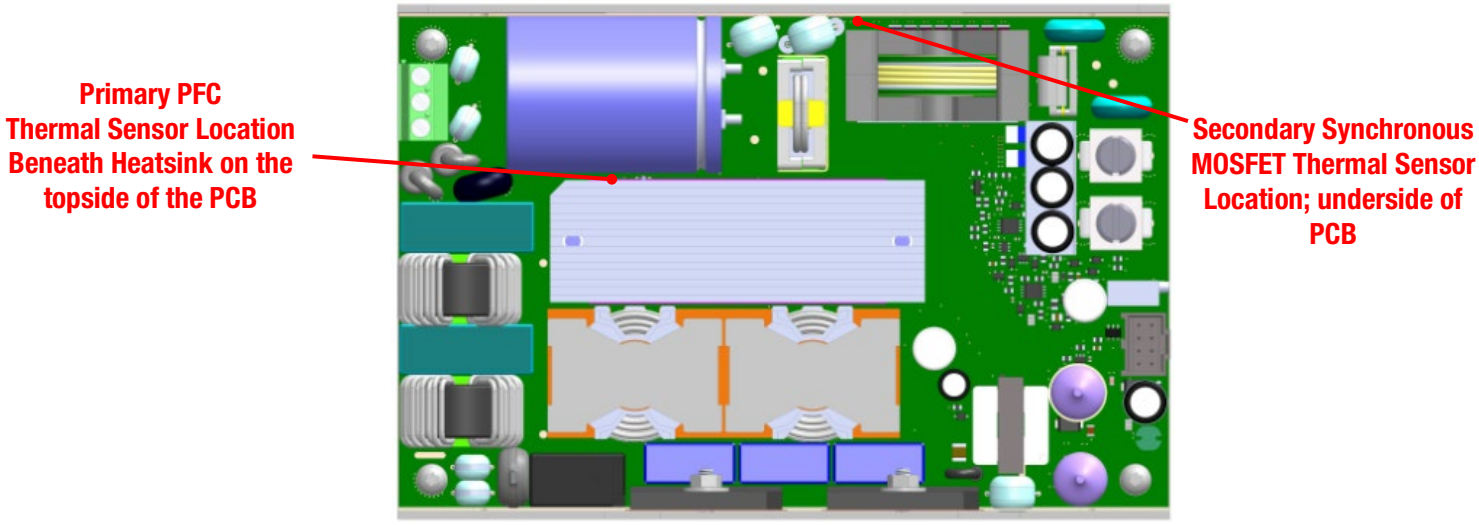
[2] PQU650-12P is derated to 400W; see following curve.



However, there are two overriding factors that **must be observed** for reliable operation of the power supply:

a. The PQU650 is provided with two internal Over Temperature Protection (OTP) sensors that are hardware driven and provide OTP shutdown that aligns with safety agency certification limits.
   The OTP sensors are mounted adjacent to the following components:
   1. In close proximity to the primary side PFC MOSFETS; the OTP trip point is calibrated to operate at +125 to +130ºC
   2. In close proximity to the Secondary side synchronous MOSFETS; the OTP trip point is calibrated to operate at +125 to +130ºC

For successful deployment the End User should measure the temperature of the sensor locations to ensure that the temperatures do not closely approach the OTP trip point temperatures; it is suggested that an operating margin of at least 10ºC is preserved **under worst case operational conditions.**



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b. Even assuming that the OTP temperature limits are not exceeded other components may reach temperatures that will provide a limitation of operational life.

In general, operation life is primarily limited by electrolytic capacitors where their case temperature is directly proportional to the expected life.
The case temperature is affected by the following drivers:

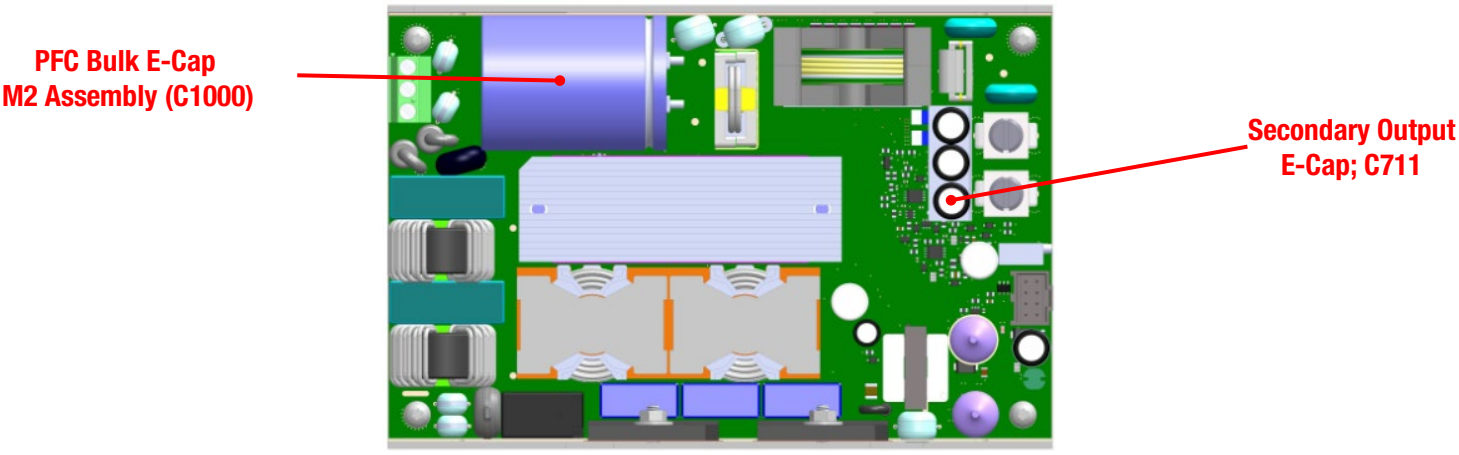
1. The ambient temperature surrounding the case of the capacitor
2. The internal heating effect due to ripple current within the capacitor
3. The airflow that influences the cooling effect of the capacitor case temperature.

For the PQU650 the case temperature of all of the electrolytic capacitors has been measured at:

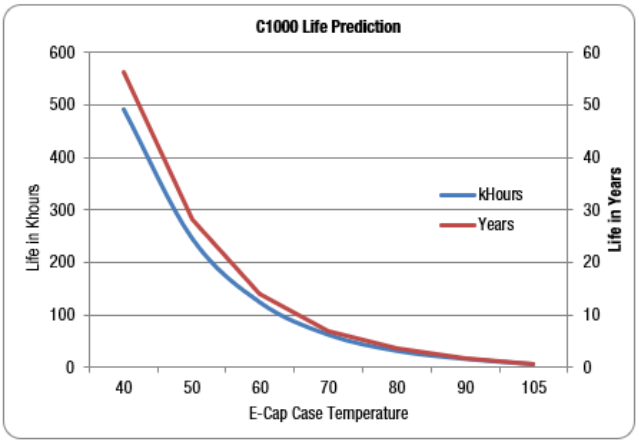
- ❒ 80% loading conditions
- ❒ 110VAC input
- ❒ Up to +40ºC.

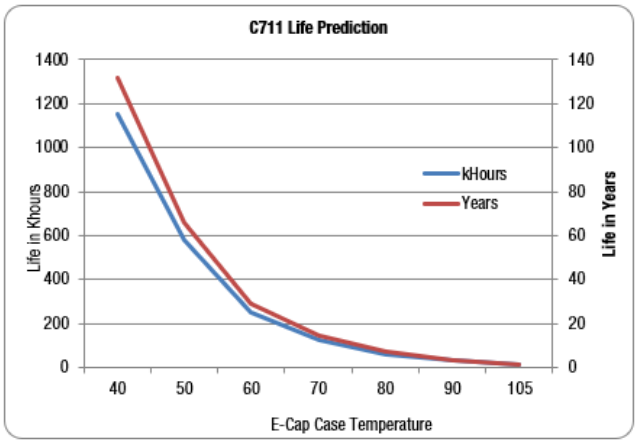
A minimum 10 year life is guaranteed for all caps with the above conditions.
As a “rule of thumb” the predicted life (of the electrolytic capacitor) halves for each +10ºC increase in case temperature.
The following curves are based upon the lowest predicted life of the following components:

- ❒ M2 Assembly; this component is the PFC bulk electrolytic capacitor (E-Cap)
- ❒ C711; this component is a Main output electrolytic capacitor (E-Cap)



The predicated life vs. case temperature for the most critical electrolytic capacitors is shown in the curves below:





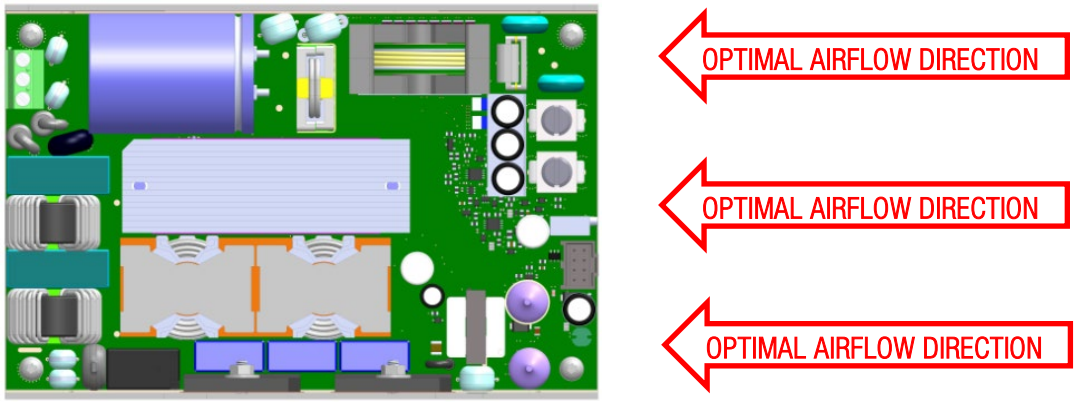
As illustrated in the above curves, the expected life of the referenced E-Caps is inversely proportional to the case temperature. The End User should measure the case temperature of the relevant component to ensure that the expected service life (either in hours or years) aligns with that predicted by the curves above.
Irrespective of the conditions and environment of the deployment (whether convection cooled or provided with some “forced convection” airflow) the PQU650 is safety rated for 650W operation.

As such it will be the remit of the End User to verify critical component temperatures[1] fall within the safe operating scope of the product to align with safety certification and provide reliable operation (MTBF and service life).

[1] See Appendix A

Forced Convection Cooling

To maximize the power delivery of the PQU 650 it is necessary to provide “forced convection” airflow.
As with convection cooling, the orientation of the power module (with respect to the direction of airflow) is important and the optimal airflow direction is as shown as follows:



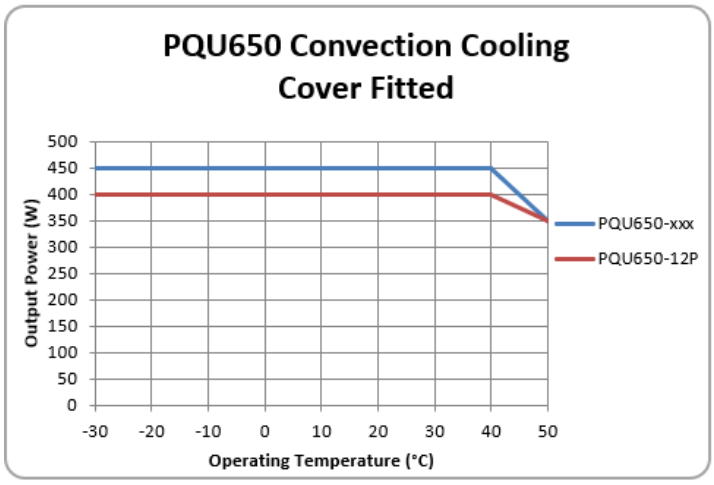
However, this does not preclude other airflow directions and module orientations as these may still provide acceptable performance in the End User deployment; again it will be necessary to verify safety critical component temperatures[1] (as measured in the End User deployment).

[1] See Appendix A

The minimum recommended airflow is 300LFM (1.5m/s) and for the opening area of the “U” channel (4.0” x 1.55 or 101.6mm x 40mm) this equates to circa 13CFM (circa 6.14 litre/s).
Variation in the airflow rate/volume will impact the power delivery vs. temperature rise of safety critical components; again it will be necessary to verify safety critical component temperatures (as measured in the End User deployment).

Power Rating with PQU-COVER kit Fitted

PQU650 series can be fitted with an optional cover for additional protection in deployments where system enclosures do not limit access to components considered to be “hazardous”.
The provision of the cover has an impact on convection cooling of the PQU650 since, although the cover is provided with slots to allow convection current airflow, it does present an additional blocking factor impeding air circulation.
The following curve shows the maximum power vs. the prevailing local ambient:



Appendix A

The following is a subset of components considered critical for safety and/or reliability or life. The full list of critical components are detailed in the PQU650 Series safety reports that can be provided to support system level safety certification. Contact you sales channel for availability.

Critical Component	Maximum Allowed Temperature
Main Transformer (M701): Primary Winding	130
Main Transformer (M701): Secondary PCB Winding	130
Main Transformer (M701): Core	130
Diode (D313, 12V_fan)	125
Inductor (L303, 12V_fan)	105
Input Connector (J1, Neutral pin 2)	100
Bias Transformer (T301): Winding	110
LLC FET (Q201)	130
Main Output Inductor (L701): Winding	130
Sync FET (Q702)	130
Main Output Capacitor (C704)	125
Optocoupler (U501)	110
Optocoupler (U503)	110
Fuse (F1)	125

Murata Power Solutions, Inc.
129 Flanders Road
Westborough, MA 01581
ISO 9001 and 14001 REGISTERED