

## Case Temperature vs. Ambient Temperature

**Abstract:** Electronic components used in power supplies and other devices can be exposed to temperature extremes that can damage them or shorten their life or MTBF (Mean Time Between Failure). It is very important to avoid such potentially dangerous thermal conditions before they can damage the component. By measuring a base temperature (such as ambient or case temperature), component temperature can be modeled and this can then be used to avoid harmful thermal conditions. This paper looks at two base temperature measurements, Case Temperature and Ambient Temperature.

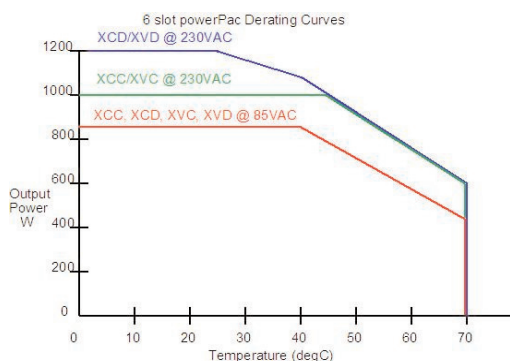
### Introduction

#### Ambient Temperature and Derating Curves

Ambient temperature is a term which refers to the temperature in a room, or the temperature which surrounds an object under discussion. For electronic components, ambient temperature, along with power dissipation in nearby components and the components own power dissipation represent the main source of temperature extremes. Temperature extremes can damage components and should be avoided where possible.

Unfortunately, it is often the case that limiting the ambient temperature is not possible due to the specific application in which the device is being used. The only option then available to the end system designer is to limit the power dissipation of the components of the device itself. This is achieved by limiting the current flowing through these components (effectively lowering the supplies power limit) in applications that have high ambient temperatures.

This lowering of the power limit is known as “derating”, and is usually specified in datasheets using a “derating curve” (see Figure 1 below).



**Figure 2 Derating Curve**

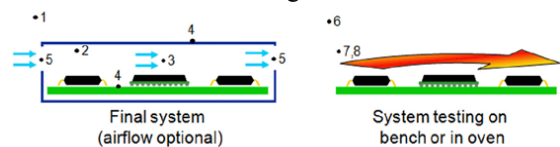
Figure 1 shows the derating curves for the Xgen power supply. Taking the XCC/XCV model operating at 230 Vac as an example, the power supply is rated to output 1000 W from 0° C to 45° C ambient. Then from 45° C to 70° C, the power supply is then derated linearly to 600 W. The power supply is not rated for operation at ambient temperatures higher than 70° C. If the power

supply is operated within these limits, any harmful thermal conditions are avoided.

However, the accuracy of the derating curve is limited by the accuracy of the ambient temperature measurement and this raises a number of issues, which will be discussed in the next section.

#### Ambient Temperature Measurement

As seen in the previous section, the ambient temperature is used as the base temperature for derating curve specifications. Unfortunately, the term ambient temperature has become quite ambiguous. Listed below are a number of interpretations of the term “ambient temperature” which are illustrated in Figure 2.



**Figure 2 Ambient Test Points**

1. The temperature of the immediate environment, unaffected by the temperature rise of the power supply itself. This is measured at either a distance from the power supply itself, or before the supply is turned on.
2. The temperature of the air inside the power supply itself (measured far enough away from any components so to not be affected by the temperature of the components themselves).
3. The temperature of the air flowing directly over the components.
4. The temperature of the board or chassis of the system (which is considered to never rise above a certain maximum temperature).
5. The temperature entering or exiting the power supply.
6. The temperature of the immediate environment during a bench test.

7. The temperature setting of the oven during elevated temperature tests.
8. The temperature that a system is preheated to prior to an operational test.

An end system designer will generally use 2, 4 or 5 as this would be the temperature they have experienced from previous systems and will ultimately be able to measure on the system in the field. A system test engineer will probably use 6, 7 or 8, since the temperature will need to be controlled in their testing scenarios. A component supplier will probably use 1 or 3, which would be used in component modelling.

This confusion of what exactly constitutes the ambient temperature of a system means that the calculation of a components predicted temperature can be quite inaccurate. To avoid this it is necessary to carefully define where and how the ambient temperature measurement is taken.

Inaccuracy of the derating curve due to ambiguity in the ambient measurement is also compounded by the fact that there can be other elements in the system which can affect the temperature of the components, while ambient conditions remain constant. These include such elements as device orientation, how the device is mounted during operation (e.g. whether attached to metal, wood, surface area exposed to air etc.) and restriction to airflow.

#### **Case Temperature Measurement**

An alternative to measuring the ambient temperature and using a derating curve is to get closer to the components themselves rather than the ambient, in effect narrowing the scope of the system being tested. This can be achieved by measuring case temperature.

Measuring case temperature rather than ambient temperature means that many external influences (such as orientation, mounting, etc) can be ignored as they are now outside the scope of the thermal test. We can now define a maximum case temperature that will ensure that the internal components do not experience dangerous temperature levels.

Also, measuring case temperature allows for a specific location on the case to be designated as a test point, which means that unlike ambient measurement, there is little confusion when it comes to thermal testing in the field.

Essentially, by measuring case temperature rather than ambient, we are simplifying and increasing the accuracy of the thermal testing procedure. Rather than measuring ambient conditions and attempting to work backwards to calculate how close to a maximum safe temperature the internal components may get, we define a maximum safe temperature for the test device itself, and treat it as we would any component, and ensure that it

operates within this well defined operating parameter.

#### **References**

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