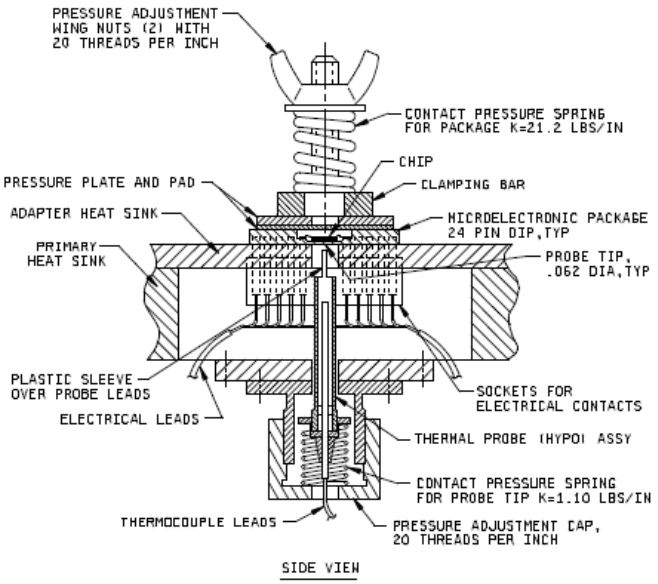
THE PRACTICALITY OF Ψ_{JC}

One of the more confusing and generally overlooked values in electronics cooling datasheets is Ψ *(psi)*, the thermal characterisation parameter. While a close cousin of the much more palatable *Θ (theta)* their correct differentiation is critical to estimating accurate device junction temperatures.

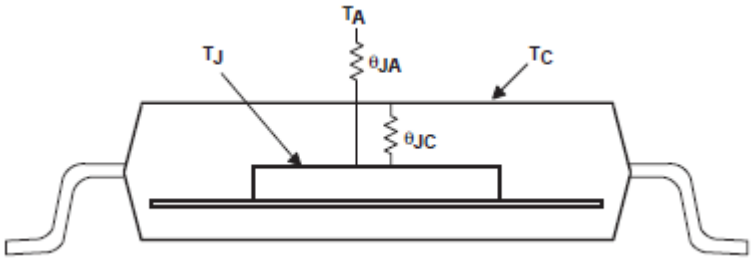
Almost universally speaking, Θ_{JC} is used to determine the thermal performance of a device between the junction (J) and the most remote part of the package casing (C), typically determined by its size and material properties. The JEDEC standards require that this value is determined by use of a cold plate on either the top or bottom of the device, forcing almost all of the power through this path, Figure 1.



[1]

FIGURE 1 - SCHEMATIC OF A TEMPERATURE CONTROLLED HEATSINK CLAMPED TO AN IC DEVICE

This resistance method was then extended a step further to incorporate the ambient conditions surrounding the device, as typically most developers know three defining parameters: the device size, the maximum junction temperature and the ambient conditions, A. This new resistance value, $\Theta_{JA,}$ enables the user to determine the power that can safely go through the chip when no cooling measures are applied to the device.



[2]

FIGURE 2 – IC THERMAL PACKAGE SCHEMATIC

In this use case, a comparatively small amount of power will flow through the device to the same case position. Using the Θ_{JC} value will give a significantly higher junction temperature than is realistic. A new parameter was required in order to calculate the junction temp in this scenario.

JEDEC developed a new standard of measuring in situ junction temperatures, Ψ_{JC}. Users could measure the device temperature with relative ease and estimate back to the junction, providing the use conditions matched the test conditions exactly. In military applications this becomes less practical, as harsher environments require direct heatsinking to the device surface to gain those extra few degrees of performance. For smaller devices, with lower thermal criticality, Ψ_{JC} may still have validity in thermal simulation work, however any application should be approached with extreme caution.

The two-resistor thermal resistances, Θ_{JB} (junction-to-board) and Θ_{JC}, are absolutely and truly constant. The corresponding Ψ values, Ψ_{JB} and Ψ_{JC}, are not constants unless the power distribution ratio is identical to the vendors' test set-up.

Ψ_{JC} can easily vary by 300% in a variable airflow situation, and by more than 1000% when the board resistance changes by a factor of 1000 [3]. Ψ_{JC} is unfortunately very often reported out by a different term in datasheets, where vendors have not taken the care to interpret the definitions correctly, and it may even surface as Θ_{JC}.

REFERENCES

[1] "MIL-STD-883E," US Department of Defense, 1996.

[2] R. H. P. Douglas W. Romm, "Thermal Characteristics of Linear and Logic ackages Using JEDEC PCB Designs," Texas Instruments, 1999.

[3] R. Stout, "Psi or Theta: Which One Should You Choose?," 01 Mar 2008. [Online]. Available: https://www.powerelectronics.com/technologies/thermal-management/article/21854312/psi-or-theta-which-one-should-you-choose.