Work in progress

App Note - How to calculate maximum operating temperature

{TODO: Publish this with the power-test source code}

This application note shows a simplified way to approximate the maximum operating temperature at a known operating frequency and current for the The Parallax Propeller 2 (P2) Microcontroller.

Parallax Propeller 2 (P2) Microcontroller Thermal Specifications

- Maximum junction temperature T_J max : 150°C
- Thermal resistance θ_{JA} : 20.6 °C/watt (°C/W)

The example in this App Note was performed with the Parallax P2-EVAL board (#64000), as that board includes a jumper between the 1V8 and VDD rails for connection of an inline current meter or bench-top power supply.

TODO:

<photo/s here>
(P2-EVAL and Bench PSU hookup)
(P2-EVAL and inline current meter hookup) - for lower current applications

Measurement steps:

You need to know:

Operating frequency (f) of the P2 code - will be set in the P2 user source code file
In this example we will assume f = 180 MHz

You need to measure:

Maximum instantaneous current draw
Voltage at VDD (P2 core voltage)

Steps:

1) Upload the user code to the P2-EVAL and monitor the current level. You want to capture the maximum current reading (Imax).

Tip: If your multimeter has a “max” or “peak” current capture function, then use that!

Tip: If using a general purpose multimeter to monitor the current inline, then consider adding a large capacitor from VDD to GND (470uF to 1000uF would be suitable) to help the slow-sampling multimeter to display the peak current readings. You can expect the current to increase a little once the capacitor is added, closer to the real value.

2) Once you have your maximum current reading (and whilst the P2-EVAL code is still running), take another multimeter and measure the voltage between VDD and GND.

3) Measurements complete! You can disconnect the P2-EVAL and multimeter/s now.

Calculation:

Power sourced by P2 = VDD * Imax (In our example, 1.79V * 0.776A = 1.389W)

Temperature rise of P2 at the internal junction = θ_{JA} * P = 20.6°C * 1.389W = 28.62°C

As this is a simplified calculation, add 30% to account for tolerances, die-to-junction temperature delta and to provide a reasonable margin, so 28.62°C + 30% = 37.21°C

Deduct the result from the Maximum junction temperature T_J max to calculate the maximum ambient operating Temperature T_A max, so 150°C - 37.21°C = 112.79°C

Understanding the result:

For this example we have established:

P2 code frequency (f) = 180 MHz
Maximum current (A) = 0.776A
Power for P2 core = 1.389W
Maximum ambient operating temperature (T_A max) = 112.79°C

ie. When the P2 Microcontroller is running user code at 180MHz that requires maximum 0.776A current, then the P2 core will be drawing 1.389W and is expected[1] to operate up until 112.79°C.

[1] Theoretical limits should always be tested and confirmed by the user in their application.

Tip: These calculations are simplified. You would typically want to derate all values according to the worst case tolerances possible. For example, the power supply may be 1.8V +- 5%, so

you may want to calculate both for the typical values based on your measured readings, and then recalculate again for maximum values by increasing the measured data to the maximum possible including tolerances. This will give you the typical and maximum expected values of operation.

Glossary of terms

process condition = worst case, FIXED
voltage supply = -5%, FIXED
temperature = variable, function of activity
max frequency = variable, function of temperature, which is a function of activity