

NAME

power-calibrate – a tool to calibrate power consumption.

SYNOPSIS

power-calibrate [*options*]

DESCRIPTION

Power-calibrate calibrates the power consumption of a mobile device that has a battery power source or a recent Intel processor using the RAPL (Running Average Power Limit) interface. It will attempt to calculate the power usage of 1% of CPU utilisation. If perf is available, power-calibrate will also attempt to estimate the power consumption of 1 CPU cycle and 1 CPU instruction (one may need to run as root or set /proc/sys/kernel/perf_event_paranoid to below 2 for this to work).

OPTIONS

power-calibrate options are as follow:

- d** specify the delay in seconds from starting a new test configuration and before starting the sampling. The default is 20 seconds, which is normally enough time to allow the battery statistics to settle down during the current test.
- e** Calibrate for each CPU run, rather than for all the CPUs. By default, power-calibrate will run tests on all the CPUs and produce one set of results for all the runs. While this provides a good average result, it may be misleading for processors where power utilisation or performance is not uniform across the processors, for example, with hyperthreading.
- h** show help.
- n** specify a list CPU numbers to run on. By default, the number of CPUs is determined automatically, but this option allows one to override this by listing the CPUs (range 0..number of CPUs-1) using a comma separated list.
- o file** output results into a YAML formatted file.
- p** show progress. This will display the progress in terms of % completion of a test run and also % completion of the total run. The progress is based on work done rather than on an accurate time estimate.
- r secs** Set run duration. Normally, the default of 120 seconds is suitable for most laptop devices where discharge rates from the battery can be fairly accurately determined over this duration. Setting this to a shorter duration will complete the calibration tests in less time but may be less accurate.
- R** read power statistics from the RAPL (Running Average Power Limit) domains. This is supported by recent Linux kernels and Sandybridge and later Intel processors. This option just measures the per processor package power utilization so the readings do not cover the entire machine.
- s samples** specify the number of samples for the CPU (-c) test. The CPU test will measure 0% to 100% CPU loading across 1..number of CPUs. The number of test rounds to be done per CPU is controlled by the samples value. If samples is low then less data points are gathered for the calculation of the power utilisation and this leads to less accurate results.

OUTPUT

During the testing/data sampling phase, power-calibrate will show the following information:

Column	Description
CPU load	The loading of each CPU in terms of % utilisation for each CPU and the number of CPUs being loaded. For example, 80% x 2 means 2 CPUs each at 80% utilisation and for an 8 CPU machine this is effectively 20% total utilisation since 6 other CPUs are idle.
User	% load of the CPU consumed by user space programs.

Sys	% load of the CPU consumed by the kernel.
Idle	% idle time of the CPU.
Ctxt/s	Context switches per second.
IRQ/s	Interrupts per second.
Ops/s	Bogo operations per second. This is the number of compute operations per second (computation of a random number using a 32 bit multiple-with-carry).
Watts	Power used in Watts.

The following is an example of the output for the `-c` option:

Power (Watts) = (% CPU load * 0.424631) + 10.131925
 Each 1% CPU load is about 424.63 mW (about 37.87 mA @ 11.21 V)
 Coefficient of determination R^2 = 0.999015 (very strong)

Power (Watts) = (bogo op * 4.267444e-08) + 10.666399
 1 bogo ops is about 42.67 nW (about 3.81 nA @ 11.21 V)
 Coefficient of determination R^2 = 0.999460 (very strong)

Power-calibrate will determine a suitable way of calculating the power consumed based on the CPU load and an estimation of the amount of power consumed for each 1% of CPU loading.

The Coefficient of determination shows how close the results are to the measured data; a perfect match results in R^2 = 1.0 and this will drop towards zero as the accuracy drops. Power-calibrate will annotate R^2 to provide some hint on how strong the relationship between the raw data and the linear estimation of power consumption.

An estimate of the power used per bogo-op is estimated, that is, the power consumed to perform 1 computation of a random number using a 64 bit multiple-with-carry. This can be used a very naïve compute benchmarking metric when comparing different processors or power configurations.

EXAMPLES

`power-calibrate -d 60 -s 5 -n 0,1 -r 200 -p`

Measure Watts per 1% CPU (and bogo compute ops per Watt) with a 60 second warm-up delay per test round, 5 tests in the CPU load level (0%, 25%, 50%, 75%, 100%) on CPUs 0 and 1 with a 200 second run time per test round while showing progress.

`power-calibrate -n 0,2,1,3`

Measure Watts per 1% CPU (and bogo compute oper per Watt) on 4 CPUs. 4 rounds of tests will be run for each CPU load interval, measuring:

1 CPU: CPU 0
 2 CPUs: CPUs 0,2
 3 CPUs: CPUs 0,2,1
 4 CPUs: CPUs 0,2,1,3

`power-calibrate -R -r 10 -d 5 -s 21 -n 0 -p`

Measure per-CPU package Watts consumed using the Intel RAPL interface. This example has a 5 second warm-up delay per test round, 21 tests in the CPU load level (0%, 5%, 10%, ..., 95%, 100%) on CPUs 0 with a 10 second run time per test round while showing progress.

BUGS

Power-calibrate attempts to find a linear relationship between power consumed and the CPU loading, bogo operations per second and the context switching. This is not necessarily the case for all processors. If the R^2 coefficient of determination is not close to 1.0 then this indicates there may not be a linear relationship.

NOTES

Power-calibrate relies on the battery interface to provide timely stats on battery power consumption and this will vary from device to device. Software or firmware may adjust the battery readings from gas-gauges and even re-calibrate the values during battery drain hence skewing the final results from power-calibrate. Batteries also show a non-linear discharge characteristic, so running power-calibrate on low battery charge is not advised.

Processors with hyperthreading or non-uniform processing performance will skew the bogo-ops calculations since different logical CPUs will vary in processing throughput.

In general, the more samples gathered, the more accurate the final results will be, however, the calibration will take longer to run. With more samples, the tendency to get a few random outliers in the samples may increase, and that may affect the final R^2 coefficient of determination.

Power-calibrate is a power estimation tool, so results will vary between different runs. It is not meant to be an accurate substitute for power measurements using a high precision multimeter.

SEE ALSO

powerstat(8), eventstat(8)

AUTHOR

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This manual page was written by Colin Ian King <colin.i.king@gmail.com>, for the Ubuntu project (but may be used by others).

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