Improved Peak Power Interval Detection Using the Sliding Window Power Profile (SWPP)

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Introduction & Motivation

Existing methods for analyzing time-based power estimation are as follows:

- Identifying the clock cycle with peak power
- Identifying the time intervals with highest average power consumption.

Identifying high power time interval for detailed low power analysis

→ Cycle Accurate Power Profile (CAPP)

→ Interval-based Power Profile (IBPP)

A different methodology is needed to identify the correct high power consuming interval.
This issue was raised by Samsung and the solution is jointly developed by Samsung and Siemens EDA.

Shortcomings of current methodologies

- It gives instantaneous timestamps of peak power. **But** It can be hard to understand how much power is increasing when you see these peaks and valleys.
- Time intervals of high power consumption are just as important as the instantaneous peak power consumption cycle.
- High computational resource and runtime are required to generate data.
- The interval of highest average power consumption may be incorrect.
- The period of high power consumption may be divided into several intervals.
- It can lead to errors of up to 50% of the average power of the interval.

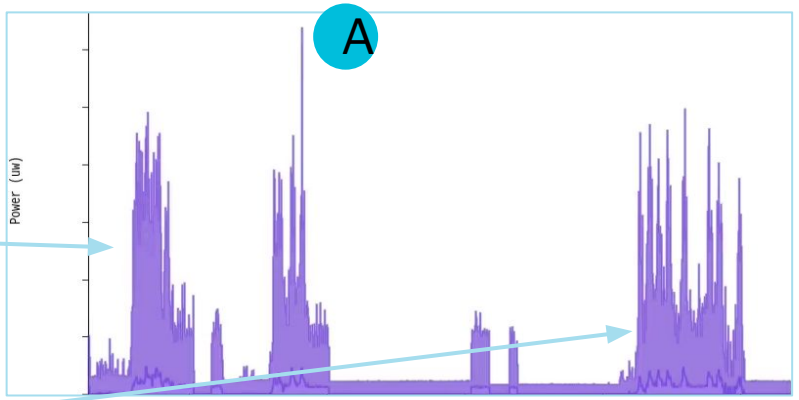


Figure 1: Cycle Accurate Power Profile(CAPP)

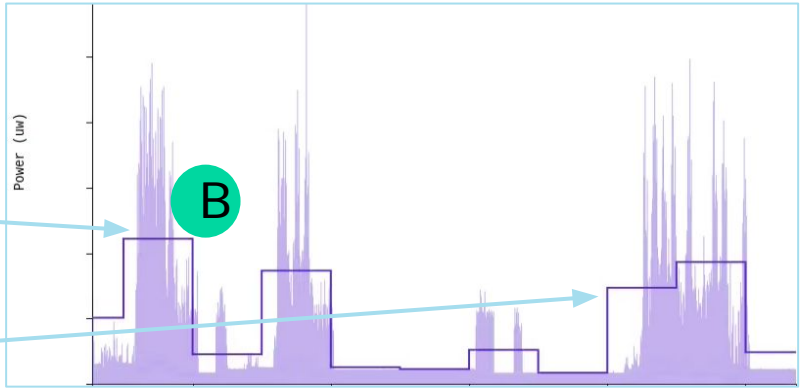
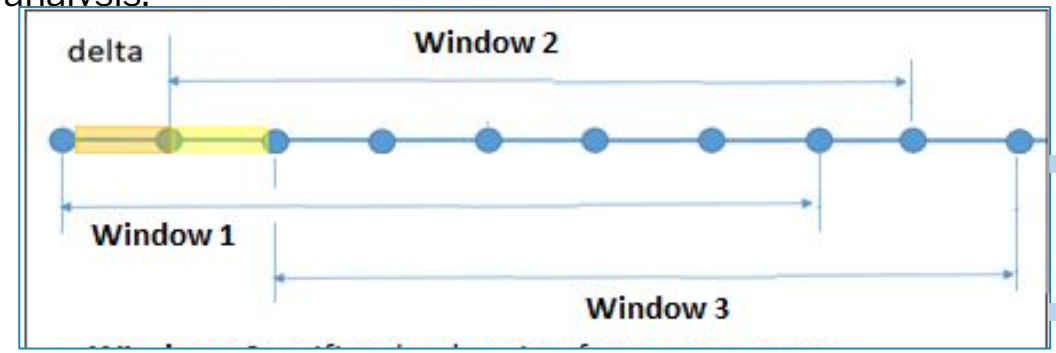


Figure 2: Interval-based Power Profile(IBPP)

References
https://semiengineering.com/thermal-damage-to-chips-widens/
https://www.edn.com/low-power-design-techniques-design-methodology-and-tools/#genecy-interstitial-ad

Proposal – Sliding Window Power Profile (SWPP)

- To mitigate the problem of high power being split into several intervals, we would like to propose a methodology that applies Simple Moving Average(SMA) technique over cycle accurate time series power data to generate a SWPP graph.
  - This technique smooths the profile data and filters out the cycle-to-cycle instantaneous power fluctuations, thereby highlighting **the true** peak power intervals.
- SWPP can be generated on top of CAPP using Window and Delta values for any long simulation length without re-running the power analysis.



- **Window**: Specifies the duration for average computation.
- **Delta**: Specifies the duration by which the interval is moving.

SWPP Graph can easily be used to identify time intervals with high power consumption.

"Delta" = "Window" = 1

"Delta" = 1 and "Window" = 100*Fastest Clock period

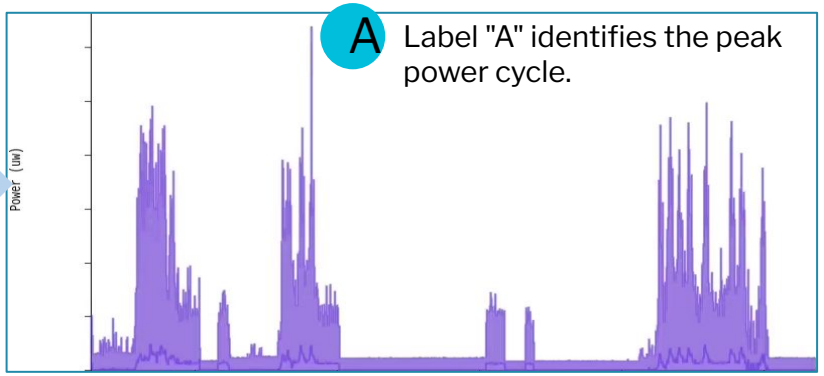


Figure 1 : Cycle Accurate Power Profile (**CAPP**)

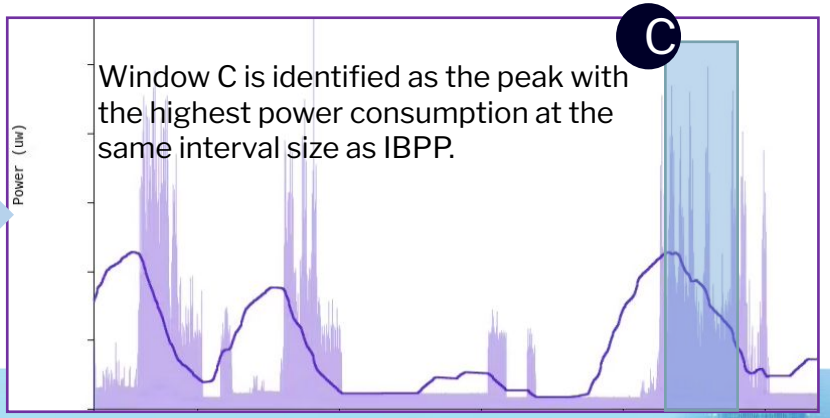


Figure 2 : Sliding Window Power Profile (SWPP)

Proposal – Sliding Window Power Profile (SWPP)

Read design inputs

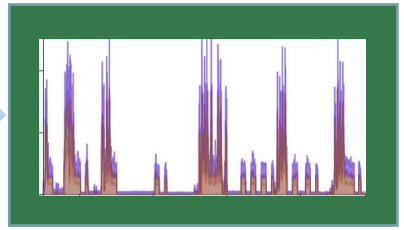
Cycle Accurate Power Analysis

Specify 'window' and 'delta'

Scalable multicore architecture

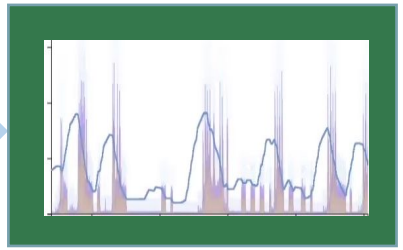
Window == 1 & Delta == 1

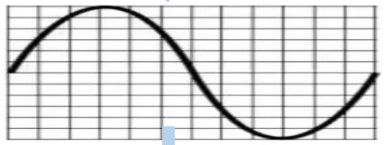
CAPP Graph



Window >> Delta

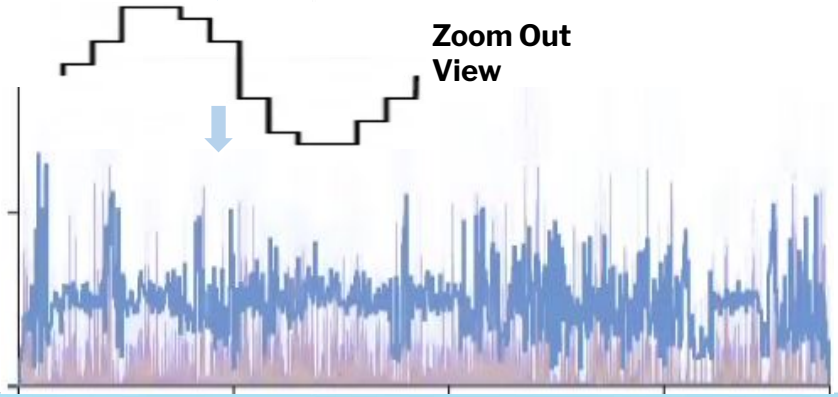
SWPP Graph





Low resolution samples stored in Top Layer for quick plotting

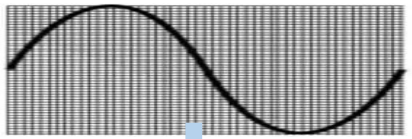
samples reduction in each layer (1 for 100)

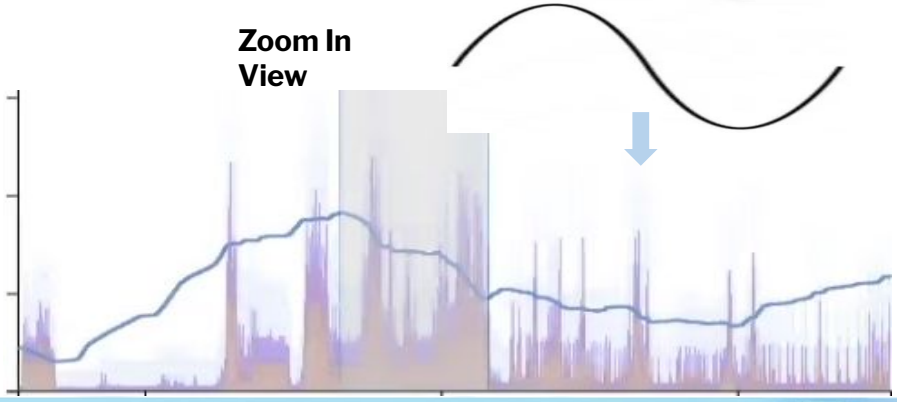


The database of multi-layer power time series for SWPP is designed for higher speed and low memory usage.

- Fully indexed **memory mapped** pages
- Random access to arbitrary windows from disk
- Minimal peak memory usage
- Real-time response, for any window and for any file size

High resolution samples stored in Lowest Layer





Results & Comparison

Requirement	IBPP	SWPP
Instantaneous high power consumption cycles	✅	✅
Power accuracy	✅	✅
Correct high power consumption intervals	❌	✅

Design	# of Instance Count	Simulation Length (ns)	Fastest Clock Period (ps)	Interval width (ns)	Time of peak power consumption (ps)		Power consumption at peak window **(uW)**	
					IBPP	SWPP	IBPP	SWPP
D1	26,663	18,800,000	10,000	10,000	2,230,000,000	8,902,400,000	2,182.86	2,512.55
D2	53,072	47,873.75	2,500	1,000	6,250	8,750	3,001.73	3,009.82
D3	2,897,469	28,022	2,000	1,000	23,007,000	22,871,000	167,852.63	169,740.71
D4	498,151	28,022	2,000	1,000	18,007,000	21,661,000	9,111.70	9,119.15
D5	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	33,835.92

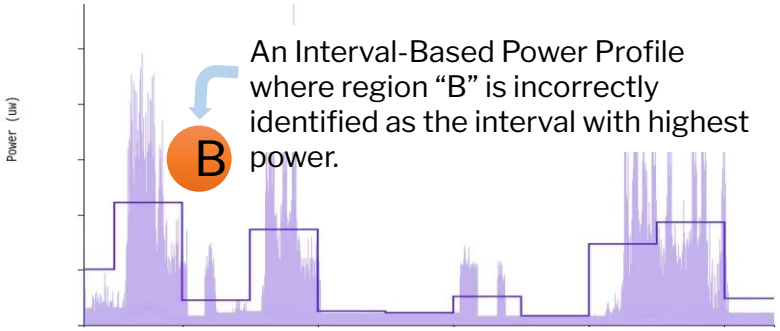
IBPP : Interval Based Power Profile
SWPP: Sliding Window Power Profile

The peak power interval identified by SWPP is different from IBPP

The peak power consumption with SWPP is higher compared to the peak power consumption with IBPP

Summary & Future Scope

- We found a gap in the identification of the correct peak power interval in existing methods of interval-based power profile of the design. (Figure 1)
- Samsung and Siemens EDA jointly proposed a methodology using SMA(Simple Moving Average) to create Sliding Window Power Profile which can be used to identify the correct interval with the highest power consumption. (Figure 2)
- From the results it is evident that for the same interval width,
  - The peak power interval identified by the Sliding Window Power Profile is different from the Interval Based Power Profile.
  - The peak power consumption with the Sliding Window Power Profile is greater than the peak power consumption with the Interval Based Power Profile.



An Interval-Based Power Profile where region “B” is incorrectly identified as the interval with highest power.

Figure 1:
Time Interval ‘B’ with highest average power
Delta = Window = (100 * FastedClockPeriod)

The Sliding Window Power Profile for the same setup, where region C is identified as the peak with highest power.

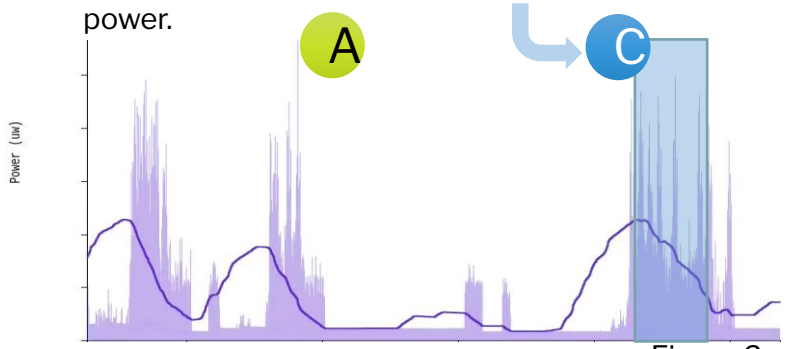


Figure 2:
Time Interval ‘C’ with peak power
Delta = 1 & Window = (100*FastestClockperiod)

Future Scope

- WMA (Weighted Moving Average)
  An improvement over SMA that gives greater weight to more recent delta regions than to older ones.
- EMA (Exponential Moving Average)
  An improvement over WMA where a weighting factor is assigned to each delta region according to its age.