Unique Metric driven Vector Qualification & Ranking for Peak Power Coverage

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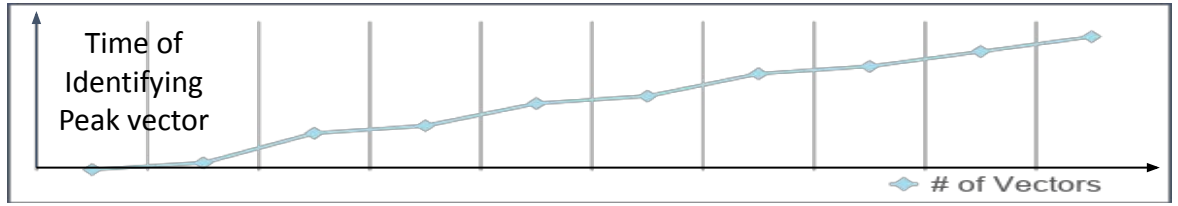
Motivation & Introduction

How to get more accuracy for identifying peak power vector

- As chip size is increased and development period becomes shorter, It has become more important to predict peak power from early stage like RTL.
- Design decisions, including power grid design, rely on Peak Power consumption of the design.
- For realistic Peak Power, simulation must toggle cells that consume high power.
- Current Cycle-based power methodologies do not have cell weight information, so do not identify vector deficiencies.

Category	Power Impact	Local coverage	Global coverage
Register	19.7489	51.596	10.1895
Memory	15.3747	28.2233	4.33924
Logic	64.3915	28.9	18.6092
Clock	0.490884	54.2111	0.266113

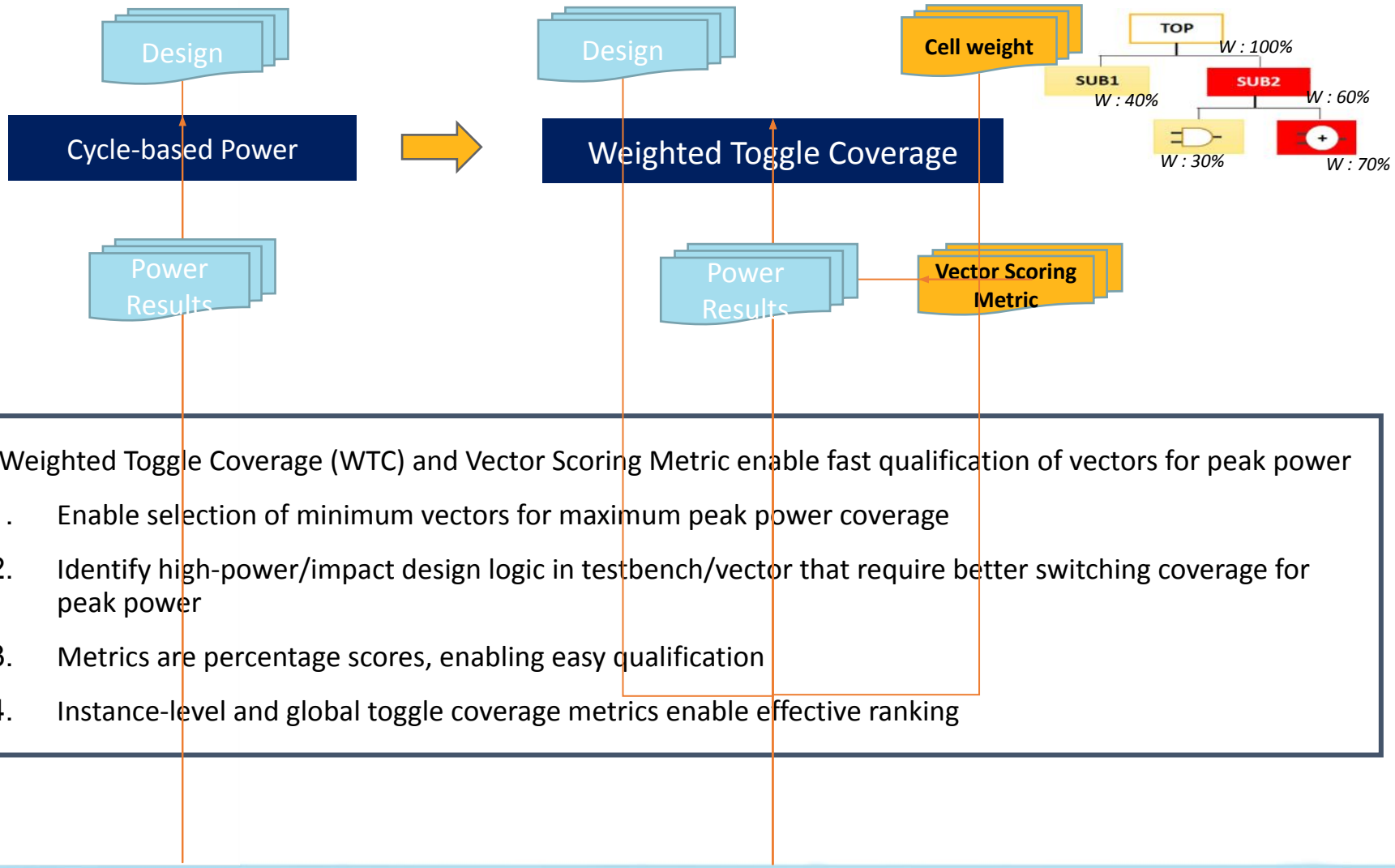
- Instance coverage is similar between Memory and Logic. ~28-29%
- Memory has 15.37% less power impact but Logic has 64.39%
- Logic's global coverage is higher than Memory , it means cycle-based power methodology did not identify vector deficiencies

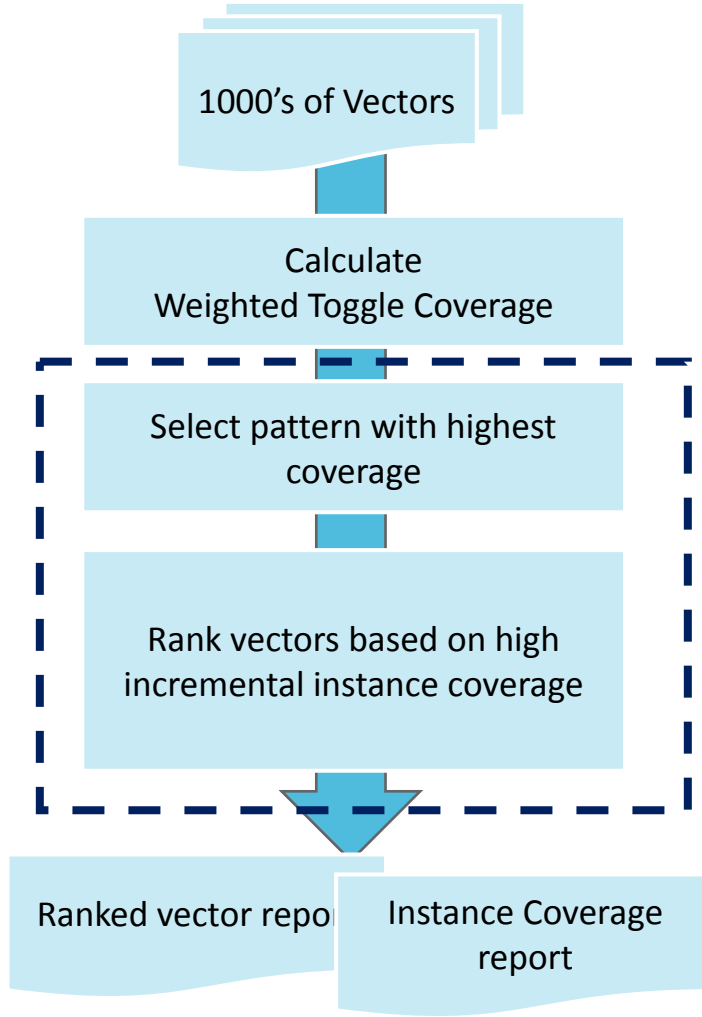


How to more faster identifying peak power vector

- The number of vectors is increased, so simulation and estimation case are more increased too.
- Designer must run simulation and power estimation with many vectors for peak power, It takes a lot of time.

Main idea



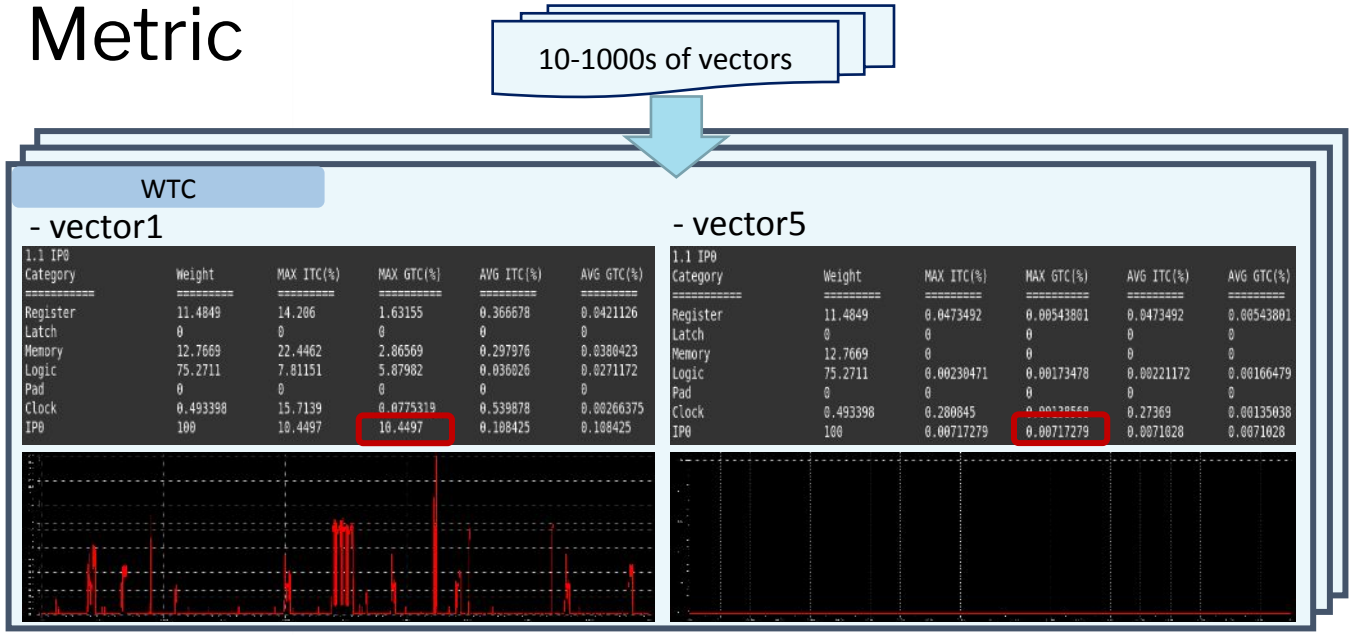


Weighted Toggle Coverage (WTC) and Vector Scoring Metric enable fast qualification of vectors for peak power

1. Enable selection of minimum vectors for maximum peak power coverage
2. Identify high-power/impact design logic in testbench/vector that require better switching coverage for peak power
3. Metrics are percentage scores, enabling easy qualification
4. Instance-level and global toggle coverage metrics enable effective ranking

Results

- Identifying peak power vector flow using WTC and Vector Scoring Metric



1.1 IP0

Category	Weight	MAX ITC(%)	MAX GTC(%)	AVG ITC(%)	AVG GTC(%)
Register	11.4849	14.286	1.63155	0.366678	0.0421126
Latch	0	0	0	0	0
Memory	12.7669	22.4462	2.86569	0.297976	0.0380423
Logic	75.2711	7.81151	5.87982	0.036826	0.0271172
Pad	0	0	0	0	0
Clock	0.493398	15.7139	0.0775319	0.539878	0.00266375
IP0	100	10.4497	10.4497	0.108425	0.108425

1.1 IP0

Category	Weight	MAX ITC(%)	MAX GTC(%)	AVG ITC(%)	AVG GTC(%)
Register	11.4849	0.0473492	0.00543801	0.0473492	0.00543801
Latch	0	0	0	0	0
Memory	12.7669	0	0	0	0
Logic	75.2711	0.00230471	0.00173478	0.00221172	0.00166479
Pad	0	0	0	0	0
Clock	0.493398	0.280845	[illegible]	0.27369	0.00135038
IP0	100	0.00717279	0.00717279	0.0071028	0.0071028

- Weight is not changed if design is same.
- vector1 is peak vector with high GTC, but vector5 is idle vector with low GTC.
- Low GTC means this vector is worthless in terms of peak power.
- Find peak power duration with WTC time-based graph.
- vector1 is more good vector than vector5 for peak power

Vector Scoring Metric

Rank	Pattern-Name	Top-GTC	Incremental Coverage Score	%Toggled Instances	%Toggled Registers	Total Register Max
1	Vector1	10.45	10.45	10.22	26.64	1.63
2	Vector2	9.07	6.85	6.92	19.48	1.51
3	Vector3	9.93	2.03	7.95	23.98	1.48
4	Vector4	8.59	0.08	8.26	25.5	1.45
5	Vector5	0.01	0.00	0.04	0.74	0.01
6	Vector6	0.00	0.00	0.01	0.15	0.00
Overall Coverage	All-Patterns(Score>0)	19.41	NA	15.41	34.55	NA

Maximize coverage with minimum vectors, eliminate redundant vectors

Vector1 is Peak Power vector. Because vector1 have highest GTC value

Vectors 5 and 6 are redundant as they provide no incremental coverage over other vectors

Results

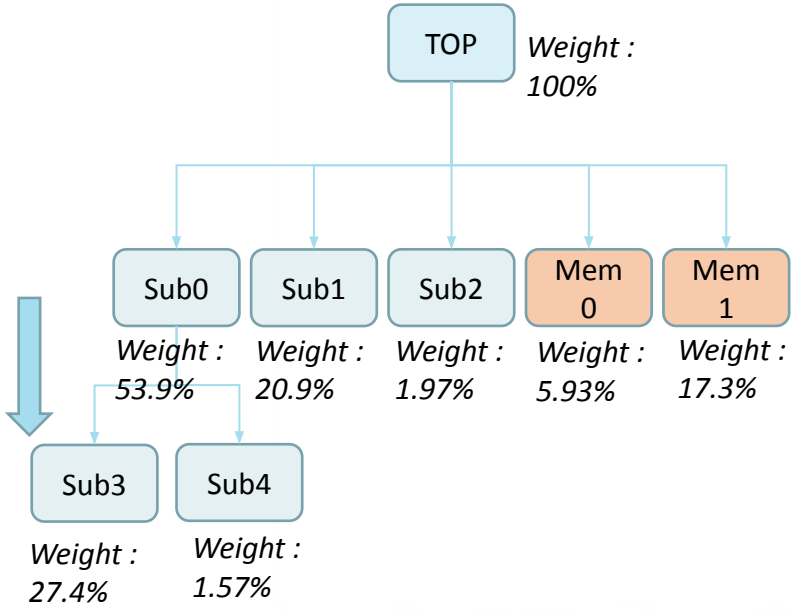
- Identifying peak power vector for sub instance using WTC and Vector Scoring Metric

Rank	Pattern-Name	Top-GTC	Incremental Coverage Score	%Toggled Instances	%Toggled Registers	Total Register Max
1	Vector1	10.45	10.45	10.22	26.64	1.63
2	Vector2	9.07	6.85	6.92	19.48	1.51
3	Vector3	9.93	2.03	7.95	23.98	1.48
4	Vector4	8.59	0.08	8.26	25.5	1.45
5	Vector5	0.01	0.00	0.04	0.74	0.01
6	Vector6	0.00	0.00	0.01	0.15	0.00
Overall Coverage	All-Patterns(Score>0)	19.41	NA	15.41	34.55	NA

Vector1 has TOP-GTC value and it is peak vector, but which one is peak vector about sub-module?

- Vector1 has TOP-GTC value and it is peak vector, but which one is peak vector about sub instances?

- Peak vector is different for each sub instances.
- Calculate with hierarchical instances and identify peak vector using ranking score metric



Vector2 / Vector1 / Vector4

Instance hier	GTC [%]
Top	9.92%
Top/Sub0	5.48%
Top/Sub0/Sub3	0.79%
Top/Sub0/Sub4	0.69%
Top/Sub1	1.08%
Top/Sub2	0.10%
Top/Mem0	0.18%
Top/Mem1	2.84%

Max Coverage Pattern

Instance hier	Top-GTC [%]	Pattern-name
Top	10.44%	IP0_Vector1
Top/Sub0	5.54%	IP0_Vector3
Top/Sub0/Sub3	1.38%	IP0_Vector3
Top/Sub0/Sub4	1.25%	IP0_Vector3
Top/Sub1	2.38%	IP0_Vector2
Top/Sub2	0.12%	IP0_Vector2
Top/Mem0	0.69%	IP0_Vector2
Top/Mem1	3.15%	IP0_Vector3

Summary

- Design decisions, including power grid design, rely on Peak Power consumption of the design
- Current cycle-based power methodologies do not identify vector deficiencies for peak power coverage
- Unique methodology using ANSYS PowerArtist coverage metrics enables:
  - Identifying vector deficiencies to improve peak power coverage
  - Ranking vectors to identify peak power scenarios in minimum simulation window
- WTC-based vector ranking has cut down number of vectors to be analyzed by 50%
  - Accelerating design schedule