Statistical IR Analysis with Ansys SigmaDvD

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1. Abstract

Problem Statement

Technology scaling tends to increase power density and metal resistance, making it ever more challenging to limit dynamic IR drop with each generation.

Traditional dynamic IR drop analysis (vectorless or vector-based) suffers from **optimism** due to coverage limitations:

- Not all instances are guaranteed to switch
- Even when all instances switch, it is infeasible to exercise all victim-aggressor combinations
- It is even more infeasible for all victim-aggressor combinations to be exercised at the worst-case point in time

Figure 1 shows the ratio of self drop to full drop measured on one of our designs. It illustrates the importance of including the full set of aggressors in the analysis.

- **self drop:** the drop measured when an instance (the victim) alone switches
- **full drop:** the drop measured when including the effect of timing-window-aligned aggressors switching concurrently with the victim

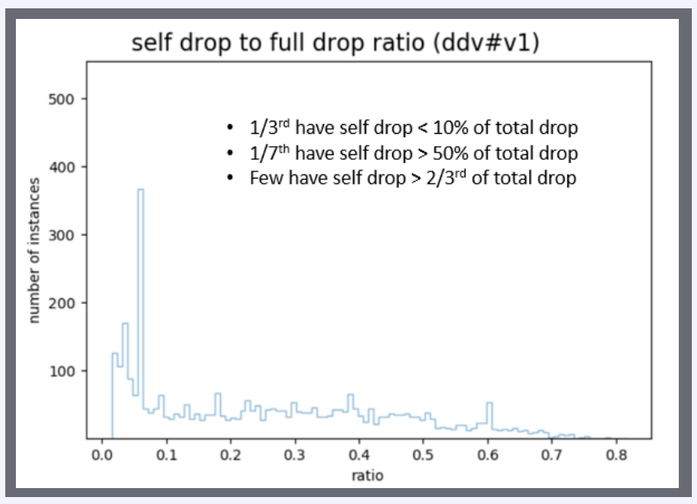

Figure 1: Self drop to full drop ratio (ddv#v1)

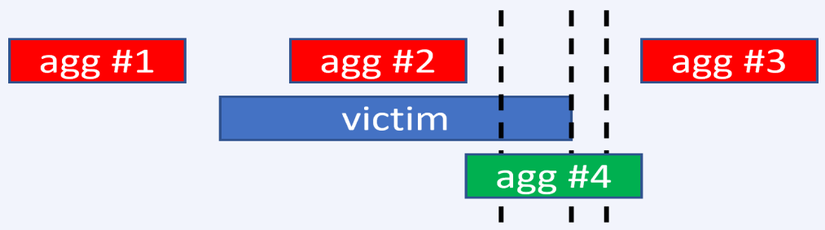

Figure 2: victim-aggressor timing window overlap

Ironically, traditional dynamic IR drop analysis also suffers from **pessimism**:

- It reports the worst drop observed by the victim across the entire simulation window
- It does not ignore drops that occur long before the critical setup arc through a victim

Figure 2 shows which aggressors **should** and **should not** be considered.

- Only aggressors that can switch near the late edge of the victim (e.g. #4) are considered
- Aggressors #1 and #3 have no overlap with the victim
- Aggressor #2's overlap ends too early to induce a setup failure

2. Introduction

SigmaDVD addresses both the optimism and pessimism issues:

- Each instance is evaluated as a victim
- All other instances are considered as possible aggressors
- Aggressors whose timing window does not overlap with the victim's late edge are ignored

The victim's self-drop is statistically combined with the effect of all valid aggressors, ignoring permutations with probability less than a user-controlled risk factor.

Application

We analyzed IR drop using 2 methods:

1. Vectorless dynamic IR drop
   - With TRs tuned to produce 1.5x max power, 100 cycles of simulation
2. SigmaDVD
   - With TRs derived by logical propagation after seeding start points with TR = 0.33 & SP = 0.5

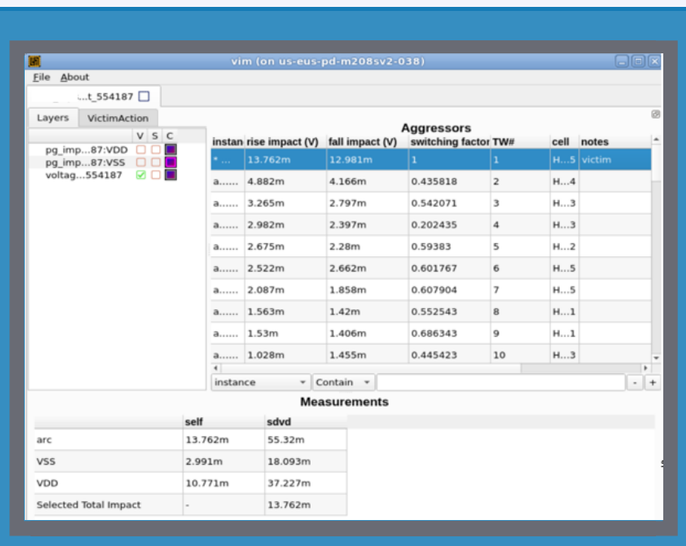

Figure 3: sigmaDVD cockpit with drop impacts from self and aggressor switching

3. Results

Figure 4 shows a comparison of the IR violation heat map in vectorless vs. sigmaDVD

SigmaDVD showed a considerable increase in both magnitude and quantity of the IR violation profile relative to vectorless

- Areas 1 and 2 were completely missed by vectorless
- Areas 3, 4, and 5 highlight regions where the area and magnitude of the IR hotspot increased significantly vs. vectorless
- Differences were traced back to the fundamental limitation of vectorless missing critical victim-aggressor scenarios

Cases were also observed in which violating instances in the vectorless analysis were not seen in sigmaDVD

- Area 6 represents cases where sigmaDVD did not consider attackers that exceeded the risk threshold
- Area 7 captures a case where the aggressor timing windows were outside the victim's late edge and were ignored by sigmaDVD

Our analysis suggests that signing off with vectorless not only creates exposure (vectorless optimism) but causes effort to be spent unnecessarily (vectorless pessimism)

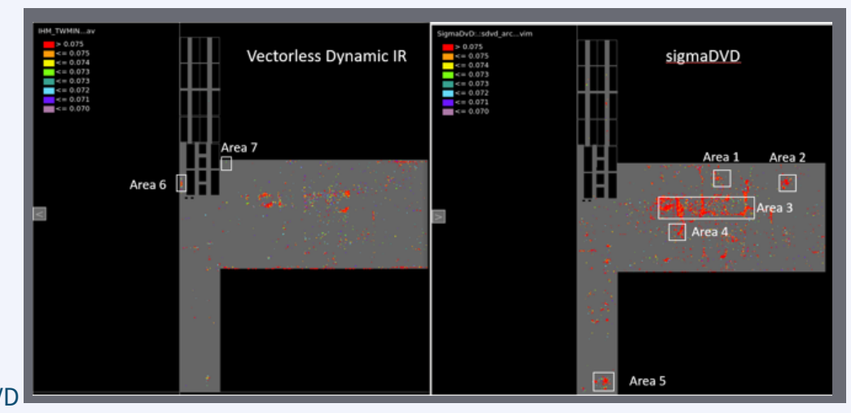

Figure 4: IR heatmap comparison between vectorless and SigmaDVD

4. Summary & Future Goals

Summary

SigmaDVD exposed many shortcomings with traditional dynamic IR drop analysis

- Violations exclusive to sigmaDVD appeared real
- Violations exclusive to vectorless appeared unimportant

Future Work

We intend to adopt the following long-term strategy:

- Split our IR drop budget into "global" and "local" budgets
- Use vectorless to analyze "global" effects (upper layers of PG grid) & generate model for package co-simulation
  - > *This analysis should be power constrained to make it realistic for global effects*
  - > *But it is optimistic for local effects*
- Use sigmaDVD to analyze "local" effects (lower layers of PG grid)
  - > *This analysis should be realistic worst case*

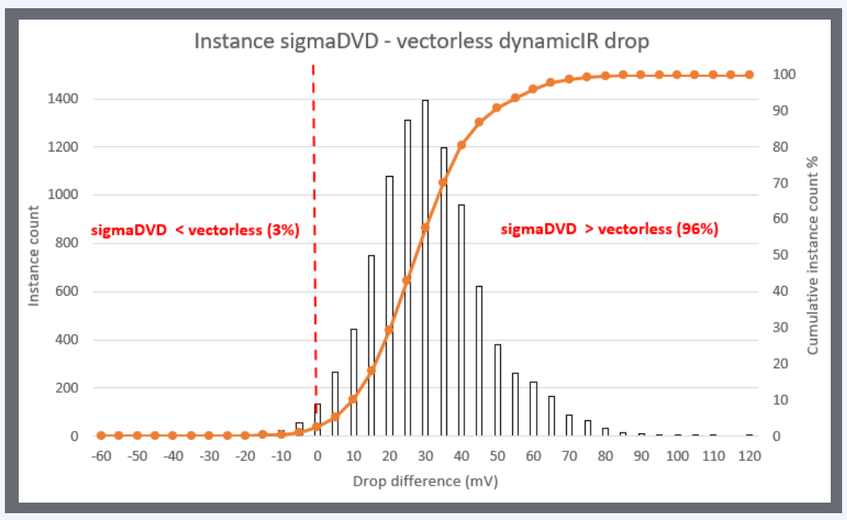

Figure 5: IR drop comparison for instances > 50 mV sigmaDVD drop