

INVENTIVE

cadence designer network



India 2007

Netlist Based IR Drop and Electromigration Analysis Flow in Virtuoso® UltraSim®

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USIM EMIR Analysis : Agenda

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Overview

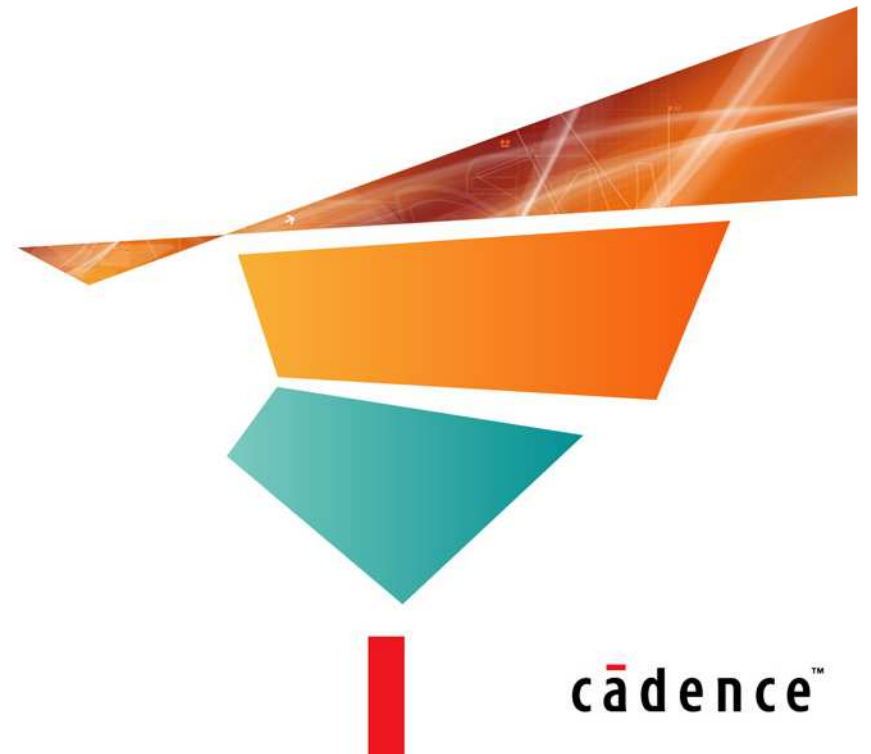
Flow

Setup

Results

Conclusion

Q & A



USIM EMIR Analysis : Overview

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Overview

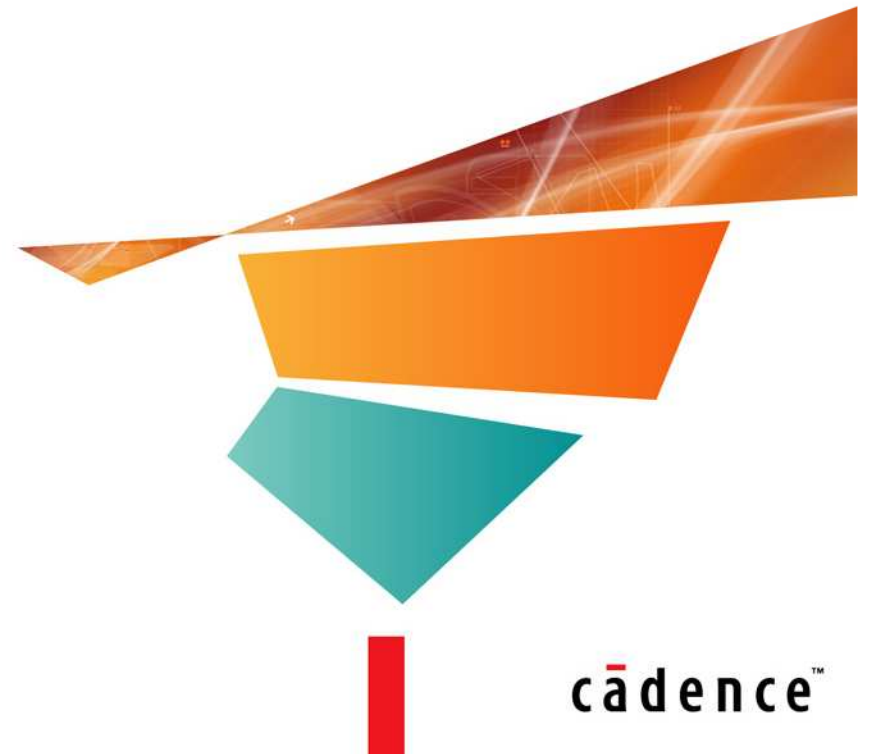
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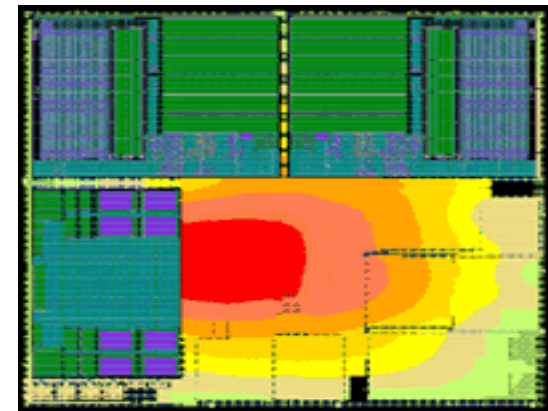
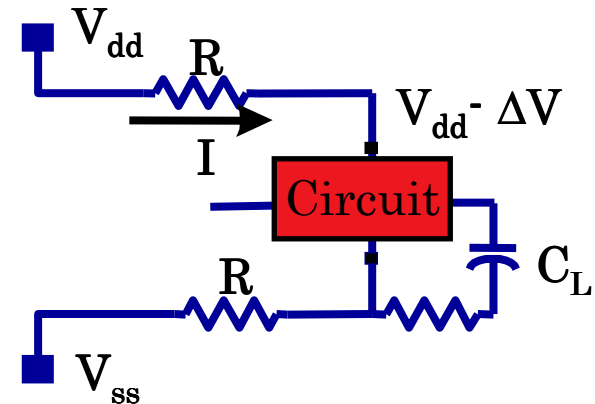
Q & A



USIM EMIR Analysis : Overview

IR Drop & Impact

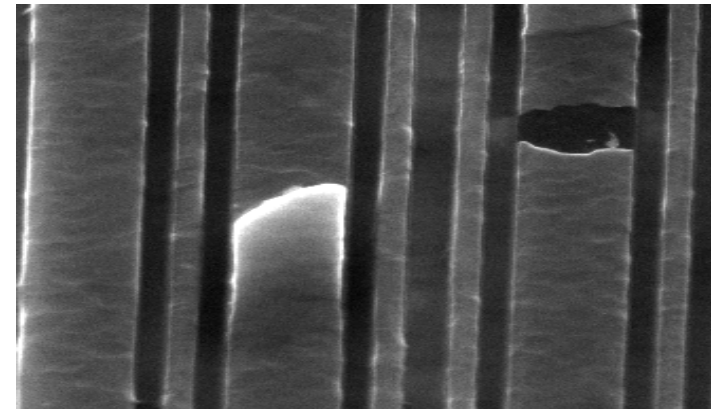
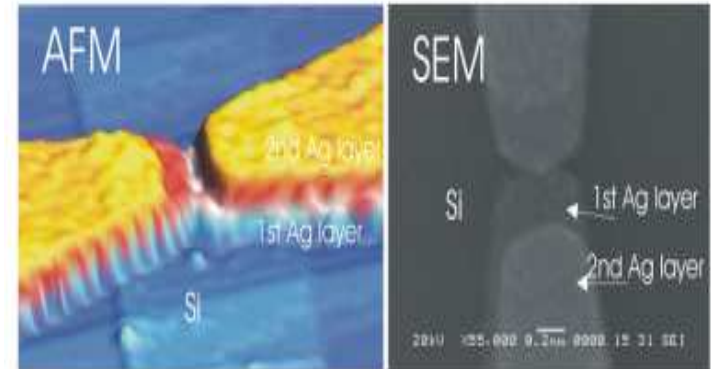
- Every chip will have IR Drop
- Designers need to understand impact of IR Drop on functionality
- Functional (Logic level) change due to noise margin reduction
- 10% IR drop may increase delay upto 8%
- Timing failures due to circuit slow down or speed-up



USIM EMIR Analysis : Overview

EM Effect & Impact

- High Current Density with ULSI microelectronic circuits
- Material Degradation due to Current Driven Migration of Metal Atoms
- Defects like Voids or Hillocks
- Cause interruptions or Short cuts in the line
- Signal Degradation causes Design Failure



USIM EMIR Analysis : Overview

Existing Flow : VAVO/VAEO

- Two Analysis Options in Virtuoso Platform
- Virtuoso Analog VoltageStorm Option (VAVO)
 - Power Integrity Verification
 - IR Drop (Power & Ground rails)
 - Power Rail Electromigration
- Virtuoso Analog Electron Storm Option (VAEO)
 - Signal Electromigration
- Flow Dependency on other Cadence products
 - Assura-LVS
 - Assura-RCX
 - Spectre or UltraSim

USIM EMIR Analysis : Overview

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Motivation

- VAVO/VAEO provides EM/IR solutions for small and medium size analog designs with powerful display features
- VAVO/VAEO doesn't provide solution for larger designs (>20K MOS) due to capacity limitation
- VAVO/VAEO doesn't provide a solution for customers using extraction tools other than Assura

USIM EMIR Analysis : Flow

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Overview

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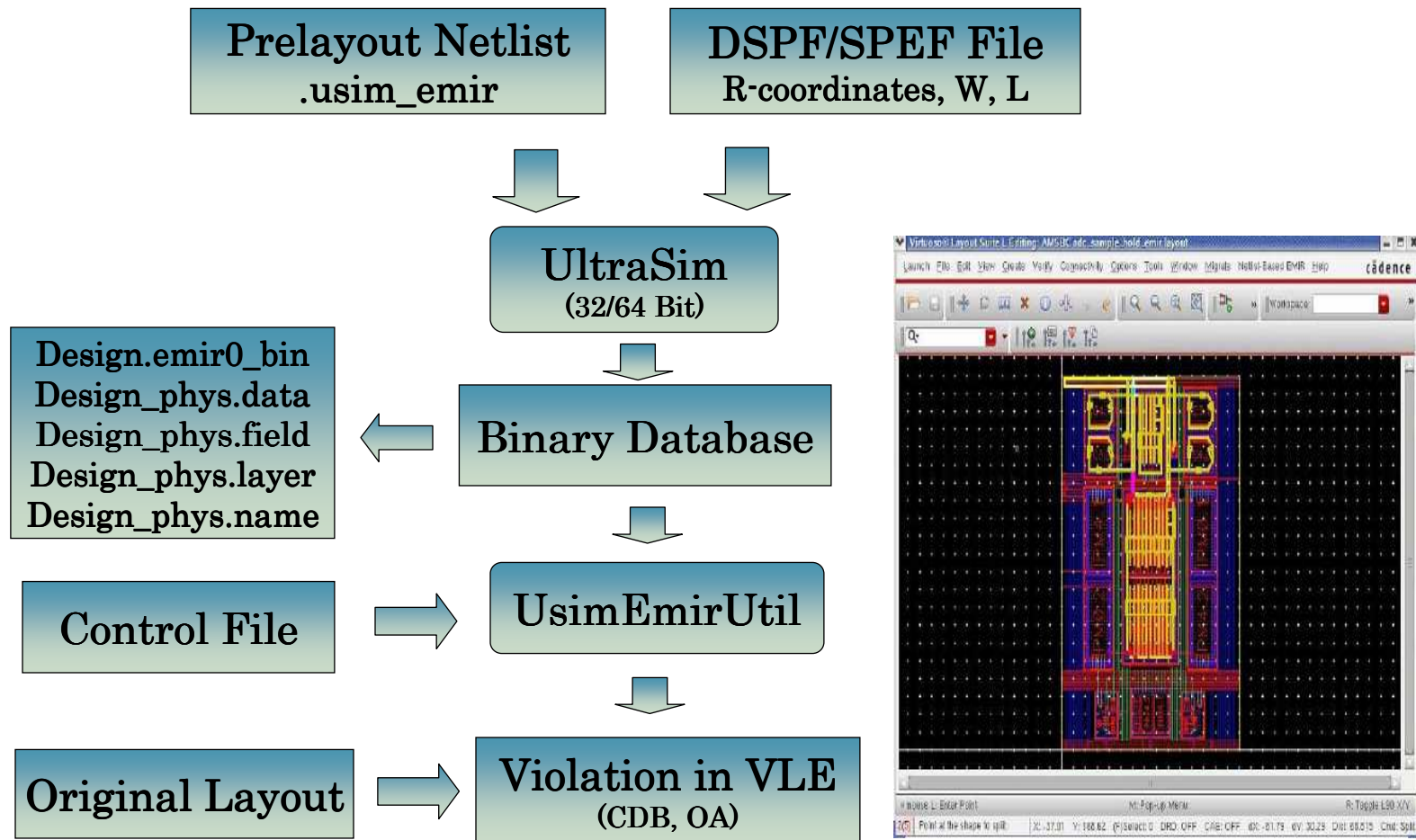
Conclusion

Q & A



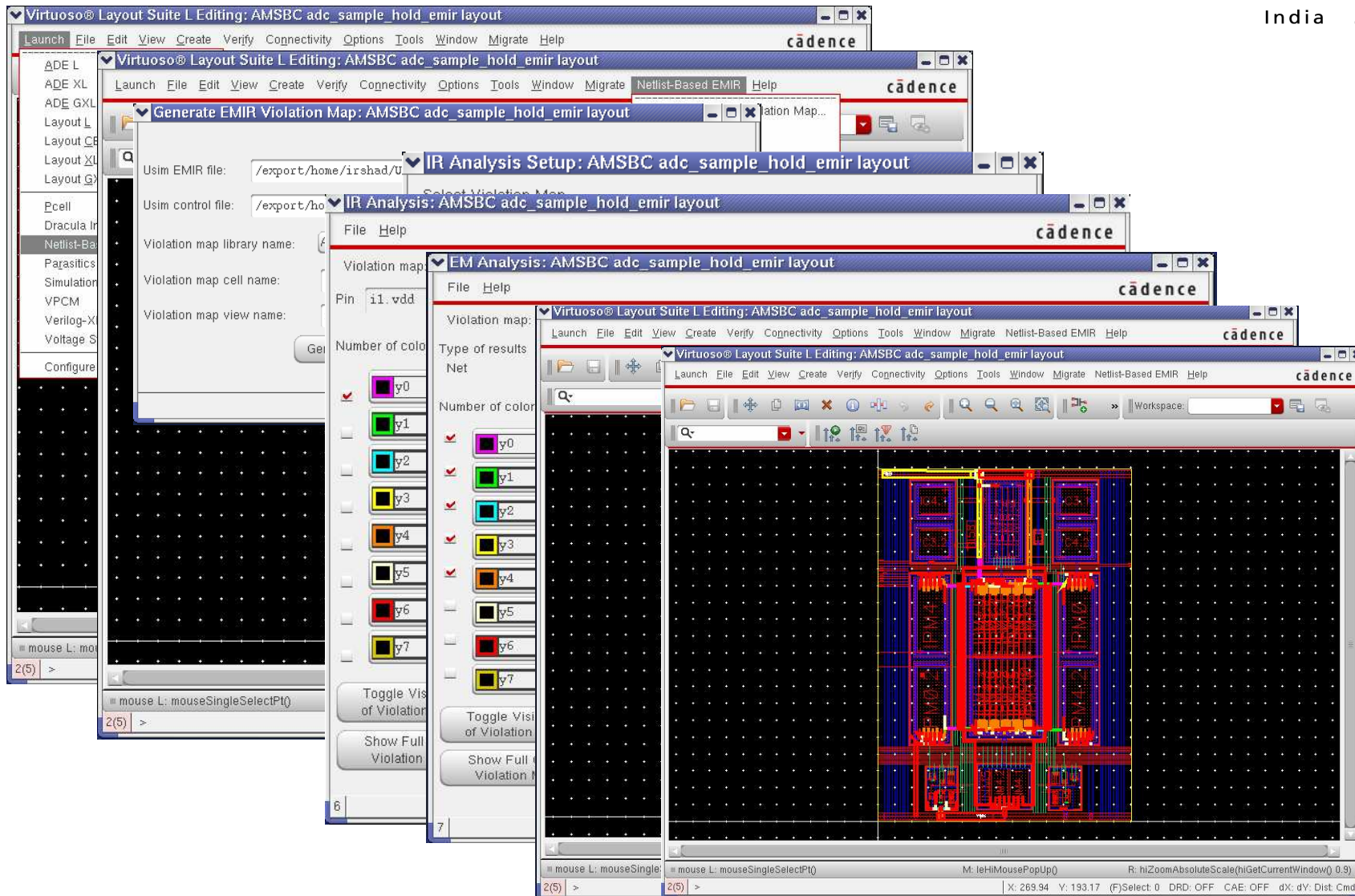
USIM EMIR Analysis : Flow

Basic Flow Chart



USIM EMIR Analysis : Flow

DFII GUI Flow



USIM EMIR Analysis · Setup

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USIM EMIR Analysis : Setup

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Step 1 : Required Files

- Prelayout Netlist File
- Models
- DSPF/SPEF files with necessary geometry information
- EM Data File containing current density limits per layer
- usimEmirUtil Control File (dictates how the violation maps are generated)
- Original layout design in DFII database to overlay the violation maps on top of the original

USIM EMIR Analysis : Setup

Step 2 : Define .usim_emir

```
.usim_emir [type=all | selected] [nets=net1 net2 ...] format=[layout]  
          [start=time] [stop=time]
```

- Type**
- 'all' : All the nets and resistors are considered
 - 'selected' : User must explicitly specify nets
 - Default is 'all'
- Nets**
- Specify the nets for which the necessary information are saved in the database
 - Applicable only when 'type=selected'
- Format**
- 'layout' : To be specified for Netlist Based Flow
- Start/Stop**
- Define time window
 - Default is beginning and end time of the transient simulation

Example : `.usim_emir type=selected nets=[vdd gnd] format=layout`

USIM EMIR Analysis : Setup



Step 3 : usimEmirUtil

```
usimEmirUtil -layout -db dbFilename -control Control_filename -lib  
LibName -cell CellName -view ViewName -text TextFile -log LogFile
```

- dbFilename** - Binary data file [netlist.emir0_bin]
- Control_filename** - Control File
- LibName** - Library name of the Violation Map
- CellName** - Cell name of the Violation Map
- ViewName** - View name of the Violation Map
- TextFile** - File name of the textual EM & IR Report
- LogFile** - EmirLog filename [UsimEmirUtil.emirlog]

```
Example : usimEmirUtil -layout -db ./design/input.emir0_bin -control  
./design/control.txt -lib myLib -cell adc -view new_emir
```

USIM EMIR Analysis : Setup



usimEmirUtil Control File

```
color level = 8
layout format = [cdb]
pwnet net=[i1.vdd] analysis=[vmax iavg] net=[i1.vss] analysis=[vmax iavg]
signal net=[i1.*] analysis=[iavg]
emdata file = “./design/emDataFile.txt”
report text=1
```

- color** - Define number of colors [Default=10]
- layout format** - Defines what format used for Violation Map
- Available options : cdb, oa, none
- emdata file** - Specifies file containing Current Density Limits per layer
- pwnet** - Defines nets for IR Analysis
- Analysis Options : vmax, vavg, imax, iavg
- signal** - Defines nets for EM Analysis
- Analysis Options : vmax, vavg, imax, iavg
- report** - '1' : Print Textual Report [Default]
- '0' : No Textual Report

USIM EMIR Analysis : Results

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Overview

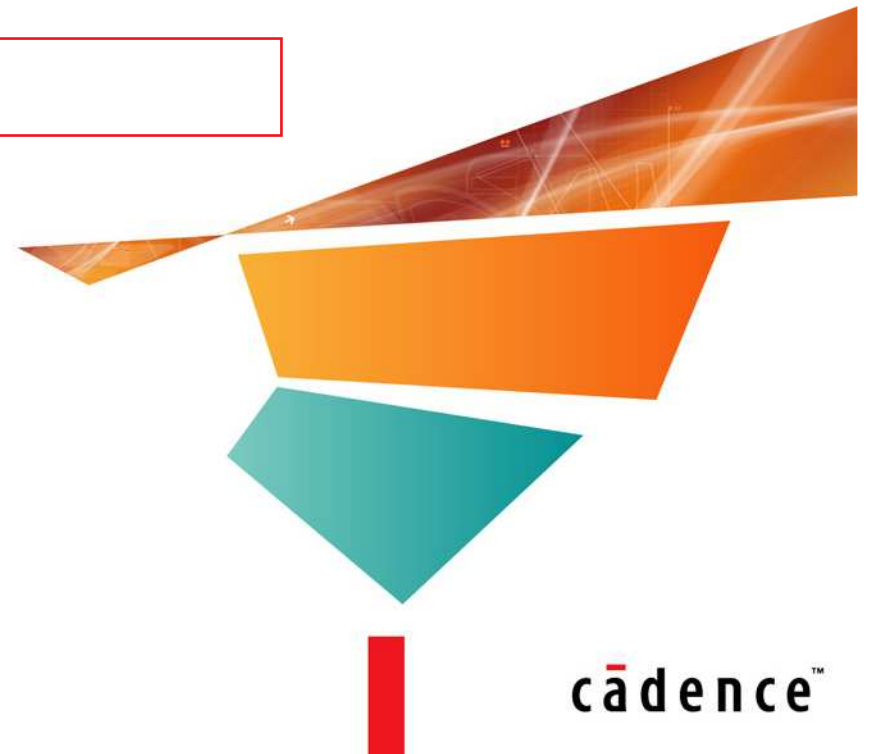
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USIM EMIR Analysis : Results



Textual Report

The image shows two overlapping WordPad windows. The left window, titled 'input.rpt_ir - WordPad', displays an IR Report. The right window, titled 'input.rpt_em - WordPad', displays an EM Report. Green callout boxes with white text identify each report.

IR Report

```
*****
*
* usimEmirUtil version 6.2.0 32bit 06/11/2007 16:26 (usimlx109)
* sub-version 6.2.0.420
* Ultrasim EMIR Post Processing Utility
* Copyright(C) 2006, Cadence Design Systems, Inc.
*
*****

This file contains the voltage drop results.

RESULTS FILE CREATED = Mon Oct 1 11:39:13 2007
SIMULATOR           = ultrasim
USER SUPPLIED VALUES:
RESULTS TYPE         = TRANSIENT PEAK
TRANSIENT START      = 0
TRANSIENT STOP       = 1.2e-07
PIN NAME             = 11.vdd 11.vss

----- "11.vdd" PIN -----
VOLTAGE-DROP      NETNAME      TIME      X      Y
(V)              (s)              (um)      (um)
0.025            MPM3:s           549.191p  78.560  76.080
0.025            MPM1@58:s       549.191p  78.560  76.080
0.025            VDD:318         549.191p  78.560  91.940
0.025            MPM1@74:s       549.191p  71.680  76.080
0.025            MPM3@48:s       549.191p  71.680  76.080
0.025            VDD:302         549.191p  71.680  91.940
0.025            VDD:317         549.191p  78.560  83.880
0.025            VDD:315         549.191p  78.560  76.080
0.025            VDD:301         549.191p  71.680  83.880
0.025            VDD:299         549.191p  71.680  76.080
0.025            VDD:314         549.191p  78.560  68.280
0.025            VDD:298         549.191p  71.680  68.280
0.025            MPM1@65:s       549.191p  68.240  76.080
0.025            MPM3@49:s       549.191p  68.240  76.080
0.025            VDD:294         549.191p  68.240  91.940
0.025            MPM1:s          549.191p  82.000  76.080
0.025            MPM3@41:s       549.191p  82.000  76.080
0.025            VDD:326         549.191p  82.000  91.940
```

EM Report

```
*****
16:26 (usimlx109)
c.
*****

ld 11.hold_test 11.inm 11.inm_test 11.inp 11.inp_test 11.outm 11.outp

-----
ensity      limit      X1      Y1      X2      Y2
k/um       (k/um)    (um)    (um)    (um)    (um)
.480        0.001     400.000u 60.190 206.060 60.190 206.060
.480        811.917u 400.000u 90.040 206.110 90.040 206.110
.004        0.002     64.050  143.240 60.200  156.960
.003        0.002     90.050  143.240 85.810  143.240
.120        545.613u 400.000u 60.200 199.280 60.200 199.280
.002        0.002     60.200  199.280 60.190  206.060
38.316u    400.000u 67.270  199.280 67.270  199.280
.002        0.002     60.200  156.960 60.200  199.280
.002        0.002     60.190  206.060 55.250  206.090
.002        0.002     2.820   206.100 55.250  206.090
.960        404.731u 400.000u 64.050 143.240 64.050 143.240
.002        0.002     90.040  156.960 90.050  143.240
.002        0.002     90.040  199.280 90.040  156.960
.002        0.002     90.040  206.110 90.040  199.280
.960        358.078u 400.000u 85.810 143.240 85.810 143.240
49.906u    400.000u 64.050  143.240 64.050  143.240
342.571u   400.000u 90.400  142.720 74.970  52.240
.002        0.002     64.800  143.160 64.800  134.740
.002        0.002     85.440  142.479 85.440  134.740
.002        0.002     85.810  143.240 85.440  142.479
```

USIM EMIR Analysis : Results

IR Report in GUI

The screenshot shows the 'IR Analysis' window in Cadence. The interface includes a menu bar (File, Help), a title bar, and a main workspace. On the left, there are controls for 'Pin' (set to 'i1.vdd'), 'Number of colors' (set to 8), and a 'Tap' dropdown menu. Below these are eight color bins labeled 'y0' through 'y7', each with a color swatch and a 'dg' dropdown. At the bottom left are buttons for 'Toggle Visibility of Violation Map', 'Toggle Visibility of Reference View', and 'Show Full Chip Violation Map'. The main workspace is divided into two panes. The left pane shows a table of voltage drops with columns for Voltage Drop (V), Node Name, Node, and Time. The right pane is a 'Text Sub window' containing a list of nodes and their corresponding voltage drops. On the right side of the main workspace are buttons for 'Save Highlight', 'Search', 'Load Text Output', 'Sort By IR Drop', and 'Zoom To Node'. A 'Cross Probing' callout points to the 'Zoom To Node' button.

Navigate Pins

Color Bins

Choose Tap, Internal or All

Text Sub window

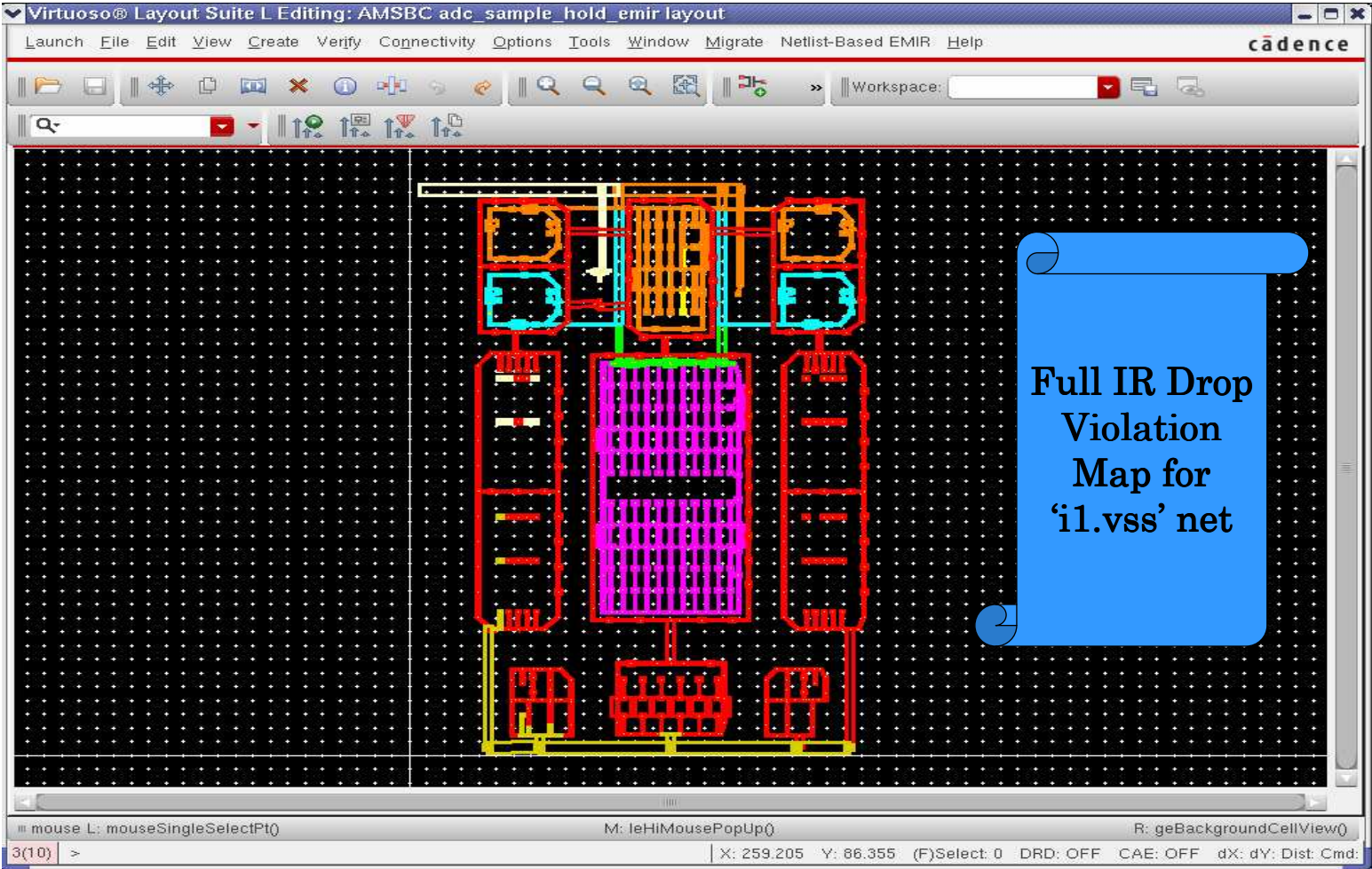
Cross Probing

Voltage Drop (V)	Node Name	Node	Time
24.7679m	MPM1@s	tap	549.1
24.7677m	MPM1@58:s	tap	549.1
24.7642m	MPM1@74:s	tap	549.1
24.764m	MPM3@48:s	tap	549.1
24.6522m	MPM1@65:s	tap	549.1
24.6519m	MPM3@49:s	tap	549.1
24.6471m	MPM1@s	tap	549.1
24.6469m	MPM3@41:s	tap	549.1
24.6363m	MPM3@40:s	tap	549.1
24.636m	MPM1@60:s	tap	549.1
24.6355m	MPM3@46:s	tap	549.1
24.6353m	MPM1@66:s	tap	549.1
24.6296m	MPM1@73:s	tap	549.1
24.6294m	MPM3@39:s	tap	549.1
24.4965m	MPM3@57:s	tap	549.1
24.4963m	MPM1@59:s	tap	549.1
24.4774m	MPM1@71:s	tap	549.1
24.4772m	MPM3@47:s	tap	549.1
23.4788m	MPM3@56:s	tap	549.1
23.4711m	MPM1@72:s	tap	549.1
22.93m	MPM1@76:s	tap	549.1
22.9297m	MPM3@44:s	tap	549.1
22.8845m	MPM3@42:s	tap	549.1
22.8842m	MPM1@64:s	tap	549.1
22.8791m	MPM1@61:s	tap	549.1
22.8788m	MPM3@43:s	tap	549.1

USIM EMIR Analysis : Results



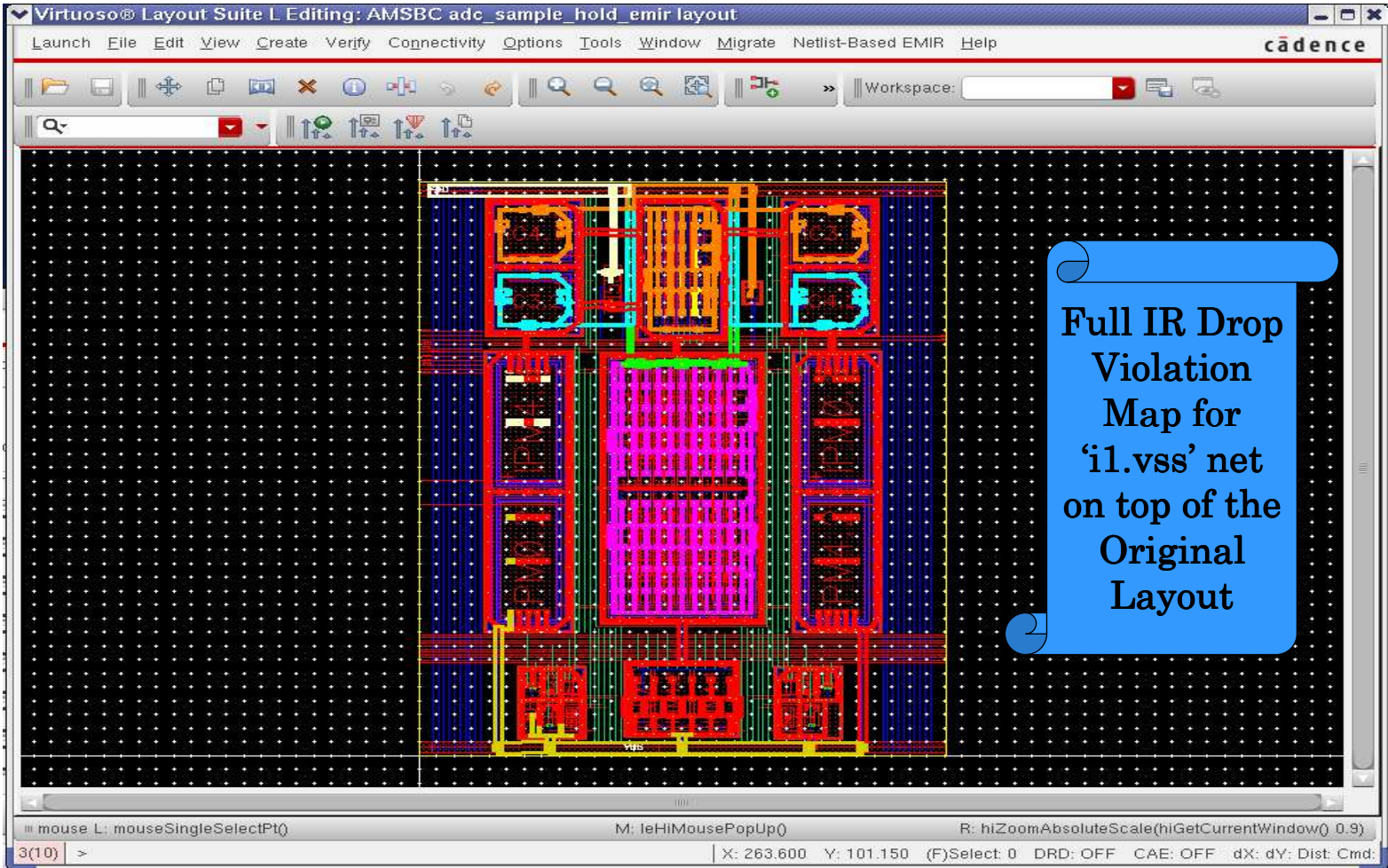
IR Report in GUI



USIM EMIR Analysis : Results

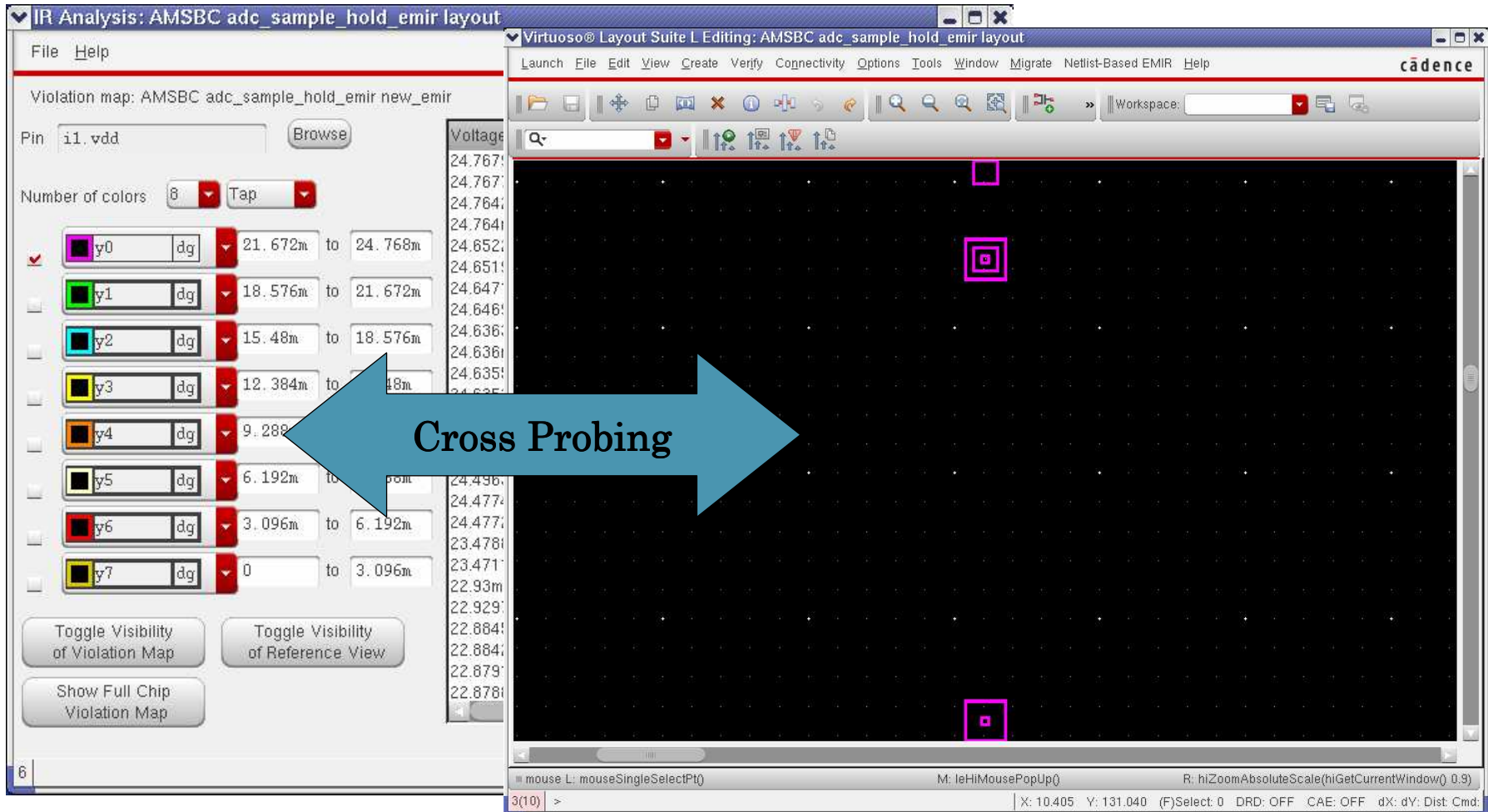


IR Report in GUI



USIM EMIR Analysis : Results

IR Report in GUI



The screenshot displays the Virtuoso GUI for IR Analysis. On the left, a panel titled "Violation map: AMSBC adc_sample_hold_emir new_emir" shows a list of violations with columns for color, name, and voltage range. A large blue arrow labeled "Cross Probing" points from the violation list to the layout view on the right. The layout view shows a dark background with several pink squares highlighting specific areas.

Color	Name	Start Voltage	End Voltage
Red	y0 dg	21.672m	24.768m
Green	y1 dg	18.576m	21.672m
Cyan	y2 dg	15.48m	18.576m
Yellow	y3 dg	12.384m	15.48m
Orange	y4 dg	9.288m	12.384m
Black	y5 dg	6.192m	9.288m
Dark Red	y6 dg	3.096m	6.192m
Light Yellow	y7 dg	0	3.096m

USIM EMIR Analysis : Results

EM Report in GUI

The screenshot shows the 'EM Analysis: AMSBC adc_sample_hold_emir_layout' window. The interface includes a menu bar (File, Help), a violation map title, and a 'Type of results' dropdown set to 'AVERAGE'. The 'Net' is 'i1.vdd' and the 'Number of colors' is '8'. A table lists color bins (y0 to y7) with their respective density ranges. A large table on the right shows '% Failed' and 'Density' for various components. A vertical toolbar on the right contains buttons like 'Mark', 'Unmark', 'Save Highlight', 'Select Presistors In A Window', 'View Current Density Limits', 'Search', 'Load Text Output', 'Sort By Density', and 'Zoom To Resistor'. Callouts point to the 'AVERAGE' dropdown, the right-hand table, the color bin list, and the 'Zoom To Resistor' button.

Choose Analysis Type

Text Sub window

Navigate Pins

Color Bins

Cross Probing

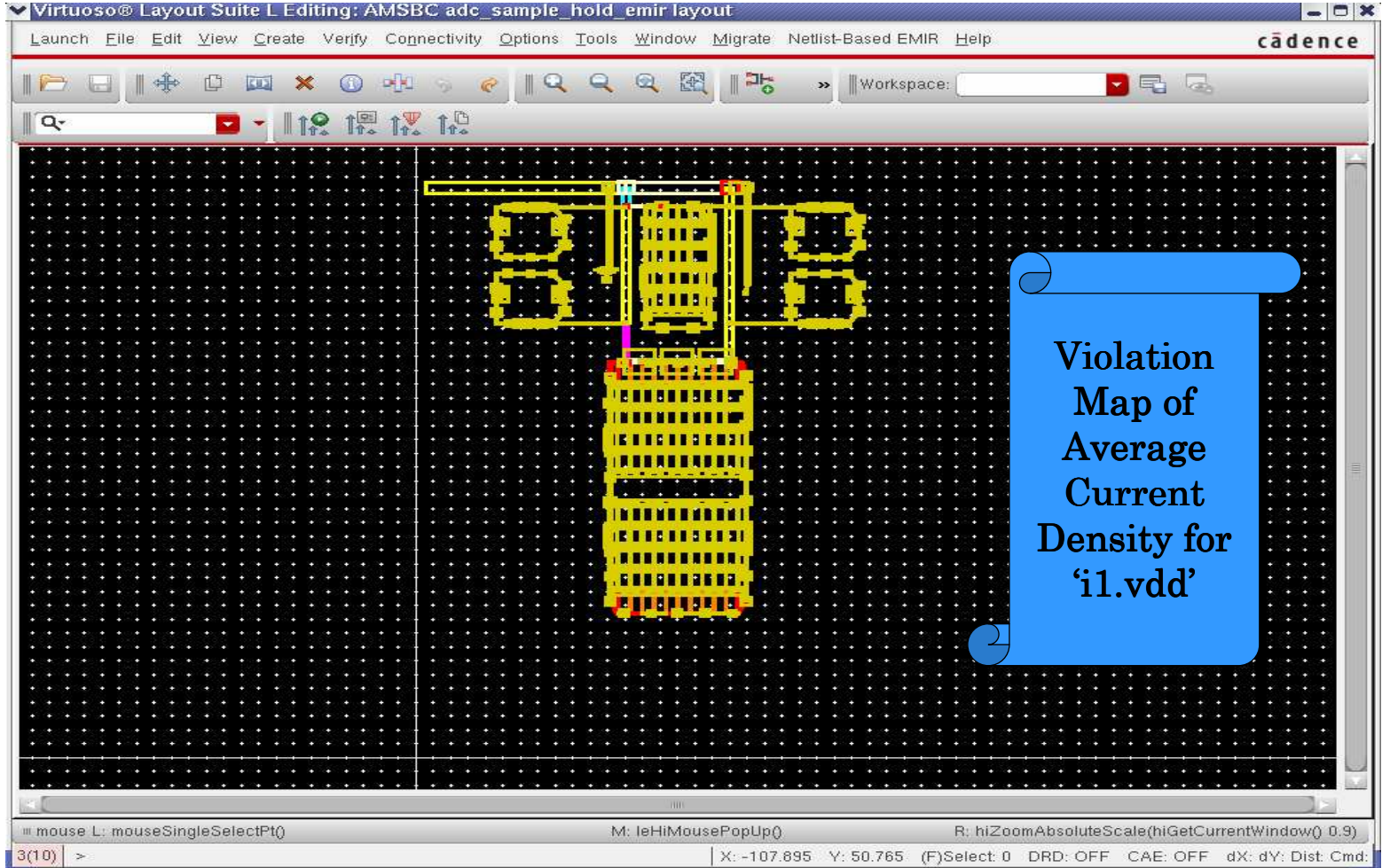
Color Bin	Min Density	Max Density
y0	3.1478m	3.5975m
y1	2.6981m	3.1478m
y2	2.2484m	2.6981m
y3	1.7988m	2.2484m
y4	1.3491m	1.7988m
y5	899.38u	1.3491m
y6	449.69u	899.38u
y7	0	449.69u

Component	% Failed	Density (A/um, f)	Density L
fail+	79.8756%	3.59751m	2m
fail+	52.6998%	3.054m	2m
fail+	23.1211%	2.46242m	2m
fail+	7.84395%	2.15688m	2m
fail+	7.0279%	2.14056m	2m
fail+	7.0279%	2.14056m	2m
pass-	8.38012%	1.8324m	2m
pass-	8.44383%	1.83112m	2m
pass-	9.06532%	1.81869m	2m
pass-	14.7617%	1.70477m	2m
pass-	14.841%	1.70318m	2m
pass-	14.841%	1.70318m	2m
pass-	15.092%	1.69816m	2m
pass-	15.092%	1.69816m	2m
pass-	15.1558%	1.69688m	2m
pass-	15.2554%	1.69489m	2m
pass-	15.2861%	1.69428m	2m
pass-	15.3545%	1.69291m	2m
pass-	15.3624%	1.69275m	2m
pass-	15.4313%	1.69137m	2m
pass-	18.5515%	1.62897m	2m
pass-	18.5841%	1.62832m	2m
pass-	18.8802%	1.6224m	2m
pass-	18.8816%	1.62237m	2m
pass-	18.8838%	1.62232m	2m
pass-	18.9103%	1.62179m	2m
pass-	18.9165%	1.62167m	2m

USIM EMIR Analysis : Results

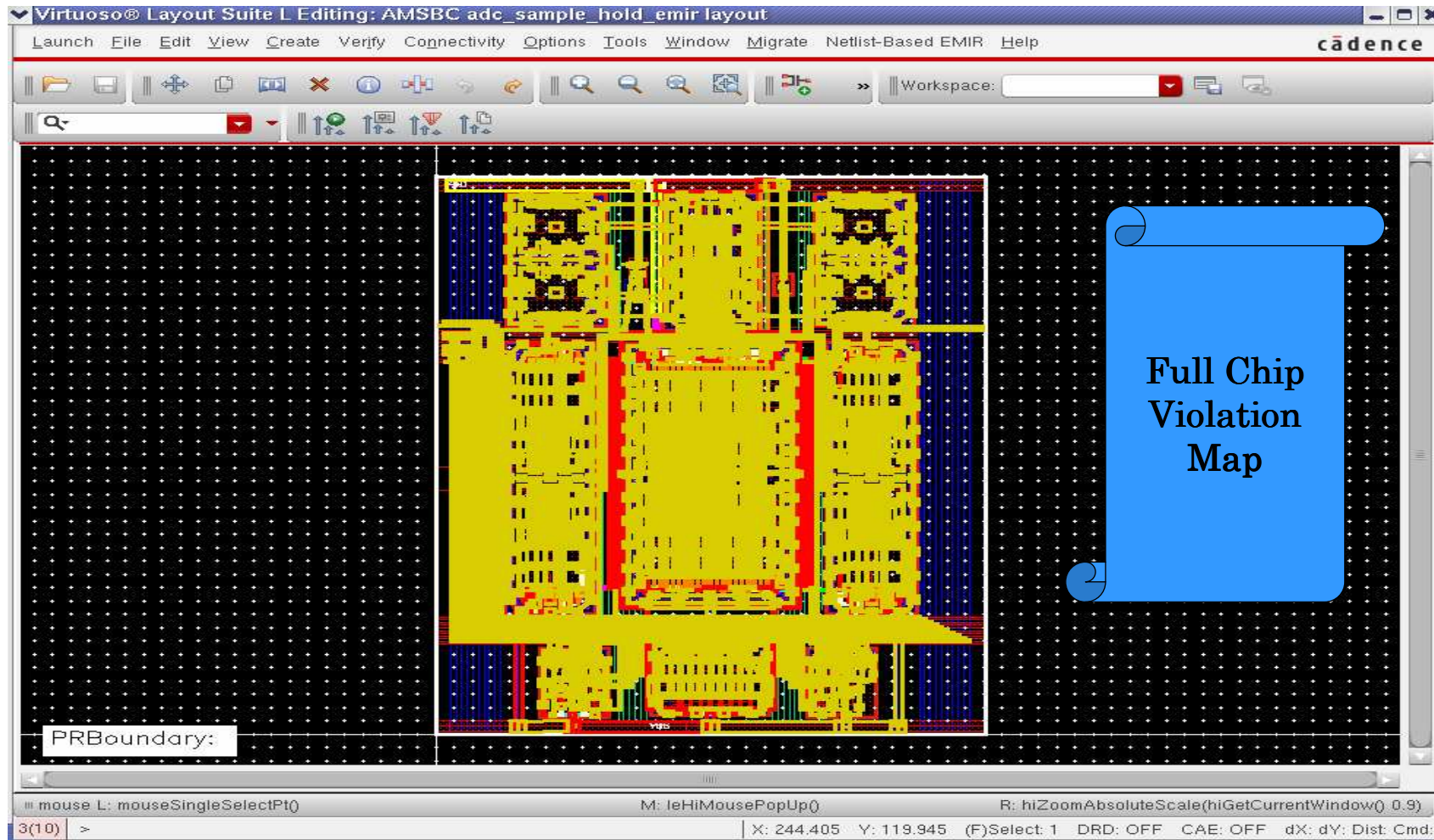


EM Report in GUI



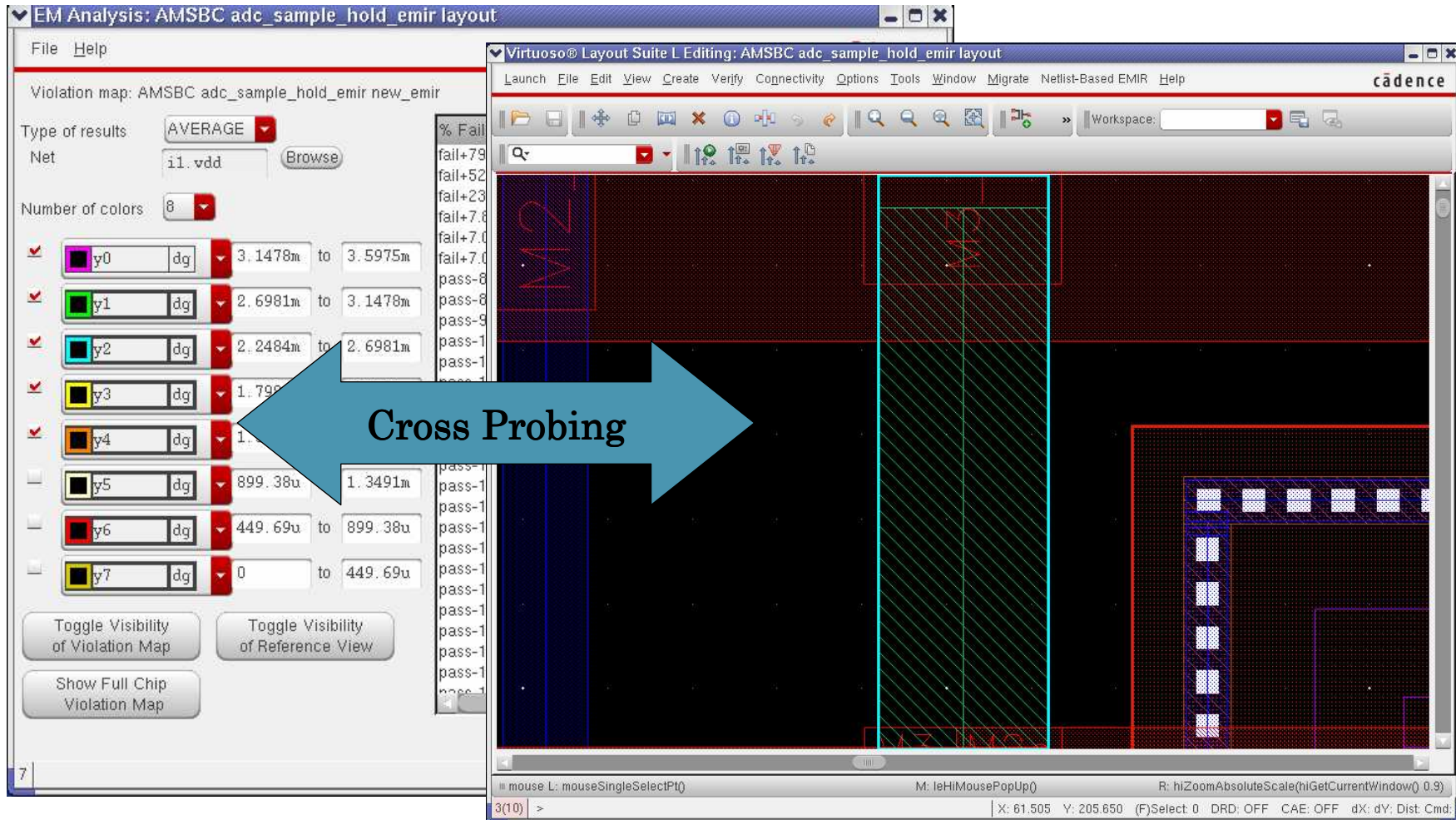
USIM EMIR Analysis : Results

EM Report in GUI



USIM EMIR Analysis : Results

EM Report in GUI



The screenshot displays the Virtuoso EMIR GUI. On the left, the 'Violation map' panel shows a table of results for net 'i1.vdd'. A large blue arrow labeled 'Cross Probing' points from the table to the layout view on the right.

Type of results	Net	Number of colors	Color	dg	Value 1	Value 2	Pass/Fail
AVERAGE	i1.vdd	8	y0	dg	3.1478m	3.5975m	fail+79
			y1	dg	2.6981m	3.1478m	fail+52
			y2	dg	2.2484m	2.6981m	fail+23
			y3	dg	1.7987m	2.2484m	fail+7.8
			y4	dg	1.3491m	1.7987m	fail+7.0
			y5	dg	899.38u	1.3491m	fail+7.0
			y6	dg	449.69u	899.38u	pass-8
			y7	dg	0	449.69u	pass-8

Buttons in the Violation map panel include: Toggle Visibility of Violation Map, Toggle Visibility of Reference View, and Show Full Chip Violation Map.

USIM EMIR Analysis : Conclusion

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Overview

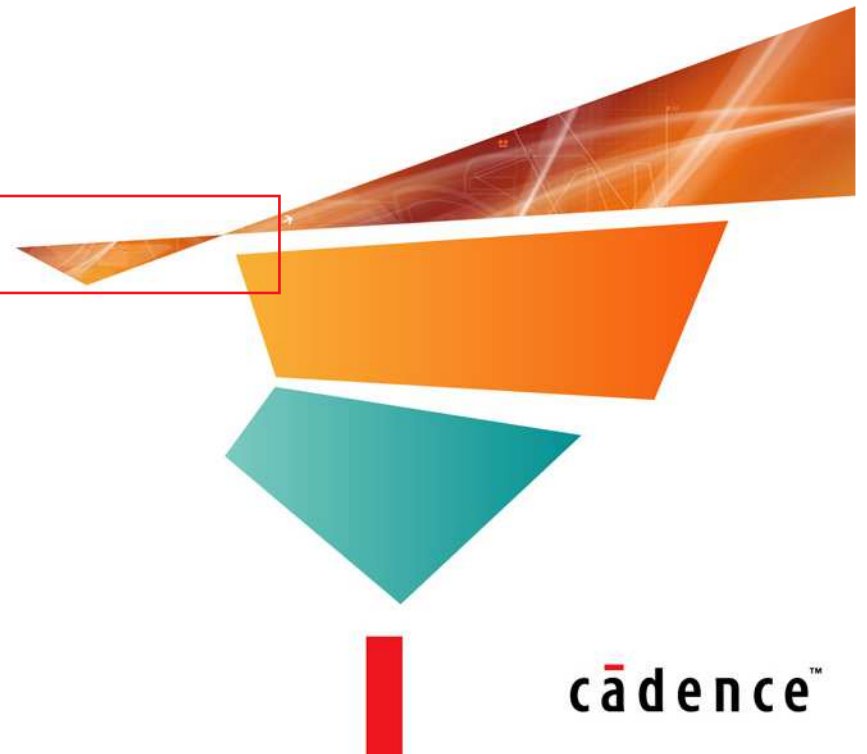
Flow

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USIM EMIR Analysis : Conclusion

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- UltraSim Netlist based EM/IR flow complements VAVO/VAEO flow
- UltraSim hierarchical stitching technique provides much needed Capacity for large designs
- Independent of the Extraction Tool
- Supports overlaying the violation map over the layout in VLE
- Cross referencing between violation report and layout
- Searching/Sorting functionality in the violation report

USIM EMIR Analysis : Conclusion

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Overview

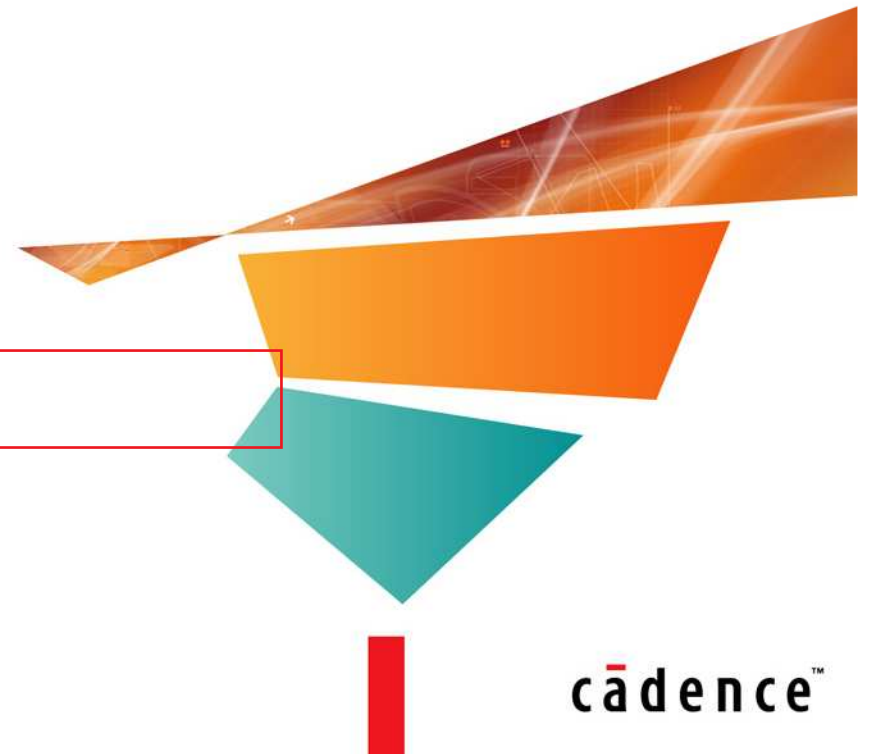
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CONNECT: IDEAS