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# SmartDRD Technology

## Innovative Design-Rule-Driven Technology

November 2010

## Introduction

SmartDRD is a new, innovative technology built into Custom Designer Layout Editor for interactive DRC violation visualization, detection and correction commonly known as Design Rule Driven (DRD) editing. SmartDRD addresses real-time DRC for both mainstream and advanced semiconductor processes with three high performance features - DRDVisual, DRDAssist and DRDAutoFix.

- **DRDVisual** concurrently checks hundreds of rules, including table-based, and provides visual feedback in real time
- **DRDAssist** enables “high altitude” DRC correct editing with “push through” technology working in-real time
- **DRDAutoFix** feature employs automatic DRC violation detection and correction that will help greatly reduce the tasks of manually repairing DRC violations, which can take as much as 40% of the overall layout design cycle time

This new technology provides a powerful productivity boost in custom layout.

## Challenges Facing DRC-Correct Custom Layout

As semiconductor process geometries have shrunk, the number of manufacturing design rules and the interrelationships between them have grown in quantity and complexity, making it increasingly difficult and time-consuming for full-custom layout designers to track, remember and comply with all design rules during layout creation.

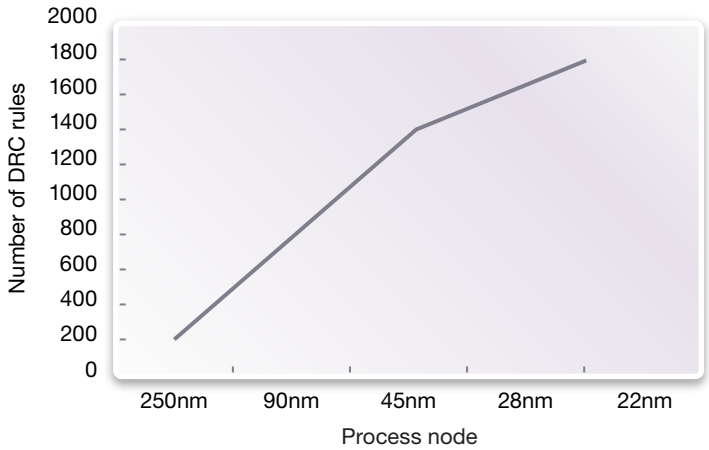



**Figure 1: Design rule complexity**

Advanced processes are no longer driven by simple spacing and enclosure checks but now contain complex and situation-dependent rules. At 45nm, there are almost 1,400 rules, mostly described as complex mathematical equations. At 28- and 22nm, design rule counts exceed 1,800. Table 1 shows how the types of rules have increased in complexity from 0.25µm down to 45nm.|

| Types of Rules | 0.25µm | 90nm | ≤ 45nm |
|---|---|---|---|
| Separation | ● | ● | ● |
| Dimension | ● | ● | ● |
| Extension | ● | ● | ● |
| Overlap | ● | ● | ● |
| Asymmetric Extension | | ● | ● |
| Notch Separation | | ● | ● |
| Width-dependent Separation | | ● | ● |
| Common Run-dependent Separation | | ● | ● |
| Area | | ● | ● |
| Enclosed Area | | ● | ● |
| Recommended Rules | | ● | ● |
| Multiple Recommended Rules | | | ● |
| Gridded Poly/Gate Support | | | ● |
| Dummy Poly Structure | | | ● |
| Interval Separation | | | ● |
| End-of-Line Separation | | | ● |
| End-of-Line Extension | | | ● |
| Table-based Rules Extension/Space | | | ● |
| Edge Length | | | ● |
| Corner-Edge Length | | | ● |
| Conditional Gate Extensions | | | ● |
| Halo Extensions | | | ● |
| Protrusion Separation | | | ● |

**Table 1. Growing Design Rule Complexity with Process Node**

The following example of a 45nm two-dimensional table-based rule describes M1-to-M1 (metal layer 1) spacing that depends on both the width of M1 and the minimum common-run (CR) distance:

M1-M1 spacing is 0.09µm minimum AND
M1 width ≥ 0.20µm & CR ≥ 0.15, min spacing = 0.12µm
M1 width ≥ 0.30µm & CR ≥ 0.20, min spacing = 0.16µm
M1 width ≥ 0.40µm & CR ≥ 0.25, min spacing = 0.18µm

This is just one of many such rules. To manually achieve compliance, the layout designer would have to continuously measure the lengths and spacing of every wire segment for every edit performed.

Often, layout designers are “driving blind”, unable to determine if edits are right or wrong. As a result, they spend many iterations zooming in and out and depend on tedious “place, measure, move” cycles that negatively impact productivity. Additionally, continual iterations with a DRC tool to check for violations interrupt the work flow and further reduce productivity.

DRD automation capabilities have been available in most custom layout editors for several years. The intent was to help prevent custom layout designers from making mistakes due to rule complexity. However, older-generation DRD capability has failed to achieve significant adoption because the rule checking was too simplistic, implementation performance was unacceptably slow, and the features were incomplete, unintuitive and hard to use. A new approach is needed, and the key to solving this productivity challenge lies in new automation technology.

## Galaxy Custom Designer's SmartDRD Technology

Synopsys developed SmartDRD technology to address this productivity challenge and provide design-rule-driven automation. The SmartDRD capabilities include:

- DRDVisual: interactive DRC rule visualization
- DRDAssist: flexible DRC-correct editing
- DRDAutoFix: incremental, automatic DRC fixing

These editing modes automate the tedious tasks of running DRC and making manual corrections. SmartDRD interactive functions automate the task of achieving design rule compliance for today's advanced and mainstream process nodes with little or no performance degradation.

### DRDVisual

The first step to achieving increased layout productivity is error prevention. DRDVisual dynamically displays DRC markers and rulers during manual editing to help guide designers to the recommended and minimum rules. DRDVisual runs in real-time, works with all editing commands and has no impact on Galaxy Custom Designer's performance. The key innovation of DRDVisual is its ability to handle hundreds of design rules in real-time on large designs.

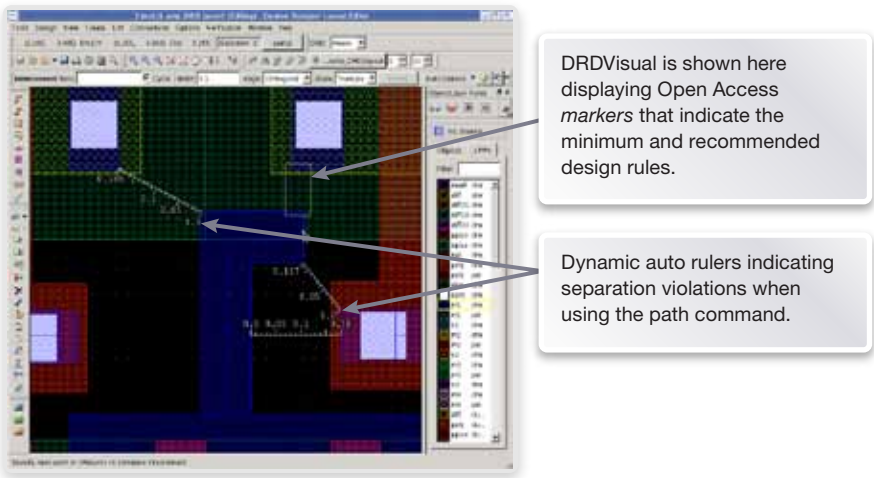
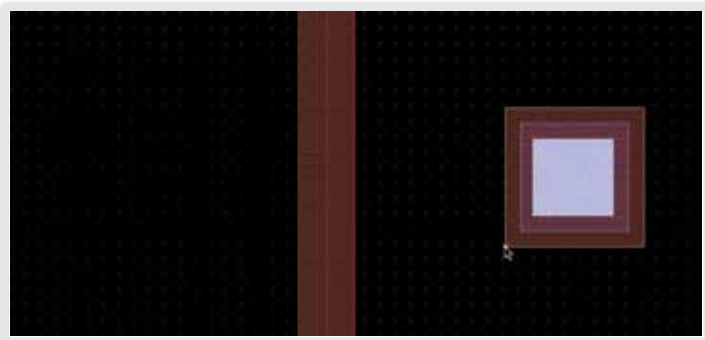



**Figure 2: DRDVisual capabilities**

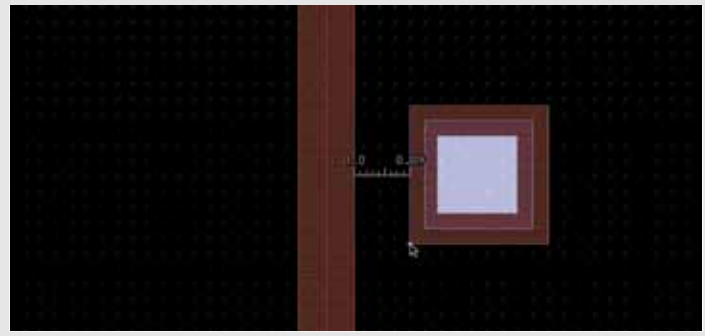
### DRDAssist

Enables layout designers to perform DRC correct layout tasks at zoomed-out "high altitude", greatly reducing the number of zooming-in and zooming-out iterations. DRDAssist will ensure DRC correctness by keeping objects separated at the minimum design rule distance, in-real time, providing a flexible use model with DRDAssist "push through" technology allowing the layout designer to override a design rule violation at anytime just by pushing the cursor through the violation if desired. The repelling function is temporally disabled and then re-enabled to check for the next violation as the designer continues to work. The layout designer is in complete control and the sensitivity threshold for "push through" is user controllable. See example figures on next page.



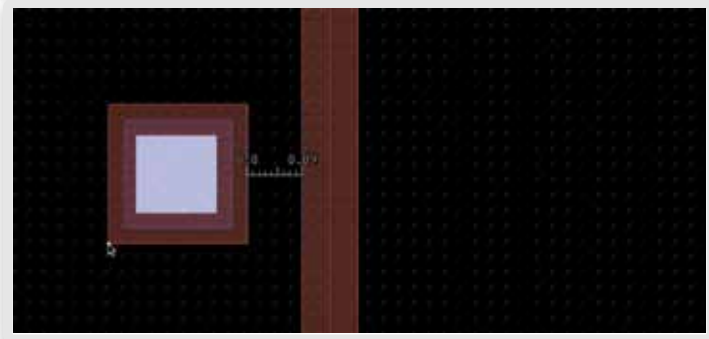
### Step 1

With the move command, the user is moving the poly- M1 contact cell to the left.



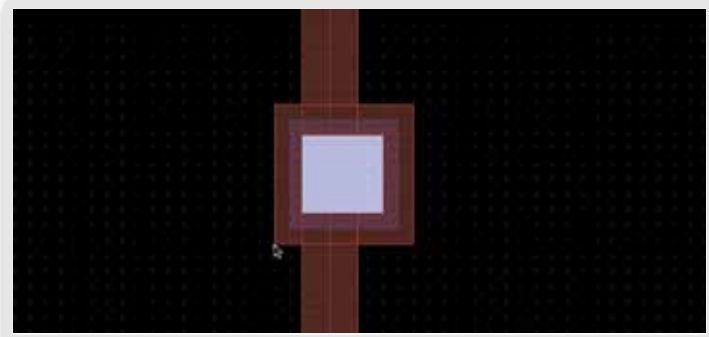
### Step 2

As the cell hits the minimum poly to poly separation distance, the repelling function stops the movement at the legal design rule limit. A dynamic ruler is also displayed for reference.



### Step 3

The user can override the repelling function by simply pushing past the sensitivity threshold, allowing the cell to continue moving past the poly path.



### Step 4.

After passing over the poly path, the repell function is re-enabled and snaps the cell at the minimum design rule spacing on the other side - again with a dynamic ruler displayed.

## DRDAutoFix

Layout errors are unavoidable. DRDAutoFix is designed to significantly reduce the amount of time a layout designer spends fixing these errors by automatically finding and correcting the DRC violations, resulting in considerable productivity improvement over manual methods.

The use model for DRDAutoFix is simple and straightforward. The layout designer specifies a window around the layout area to be fixed and DRDAutoFix automatically finds and corrects DRC rule violations within the specified window area. To help ensure no other violations are introduced outside the window perimeter, a user-defined “halo” parameter is specified. Custom Designer’s flexible transaction history assistant is available for undos throughout the editing session to recall any DRDAutoFix actions. Figure 2 is an example of DRDAutoFix results.

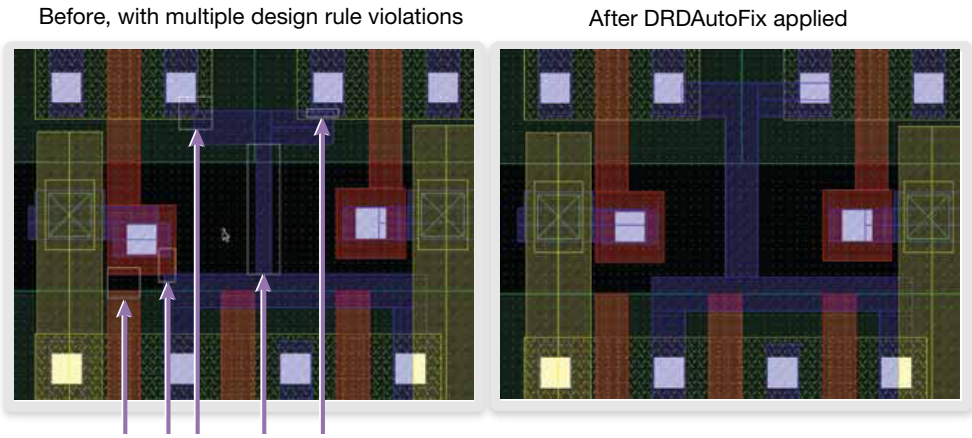



**Figure 3: DRDAutoFix corrects violations in seconds**

The automatic corrections made by DRDAutoFix are comparable to those achieved by hand. Using patent-pending minimum perturbation technology, the algorithm incrementally moves and adjusts paths (nets), polygons, and cells while considering all design rules to bring the layout into DRC compliance.

DRDAutoFix supports user-intent functions for precise control of alignment, grouping and locking of layout objects. This enables layout designers to specify and maintain absolute control over specified layout objects such as devices, nets and pins.  These functions are:

- **Align**: Allows the user to define reference points for rapid alignment of objects during the DRDAutoFix phase
- **Group**: Allows a user to group a selected set of objects together so that the relative relationship between all objects will not change
- **Lock**: Locks down nets or devices to ensure DRDAutoFix does not move them

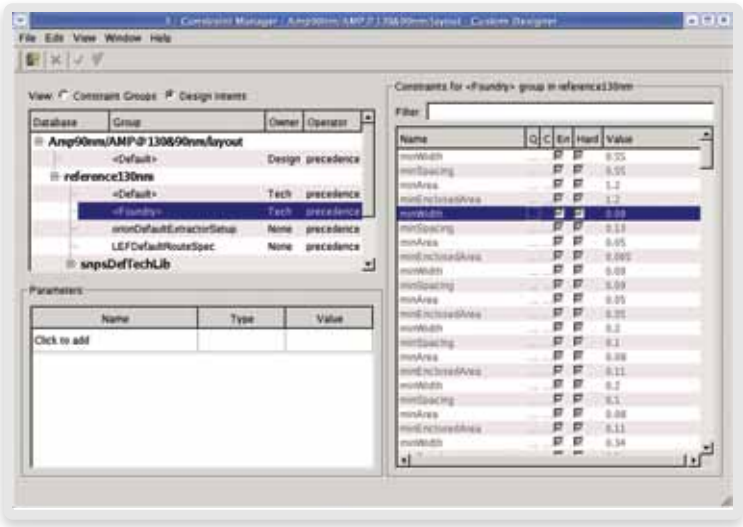
In addition to standard layout rules, DRDAutoFix can also correct Optical Proximity Correction (OPC) rules violations, such as notch fill and undesirable corner patterns.

## The Unified Constraint Manager

SmartDRD's design rule checks are managed by the GUI-driven Unified Constraint Manager (UCM). This system displays, organizes, and edits rule sets for Customer Designer's DRC-correct functions. The UCM manages all the foundry process rules but can also be used and to define design-dependant rules. An example of a design-dependant rule is the wide-wire rule required for signal nets carrying a high current.

The UCM manages all design rules but makes it possible to choose only a subset of the full design rules for checking. For example, the user may want to check only metal 1, poly and contact rules during an editing session. Design rule checks can be managed on a net-by-net basis or on a selected group of nets. An example of this could be a set of special width and spacing rules for the clock nets.

With the movement of custom design towards advanced silicon processes and the increasing use of automation, the UCM system is an efficient, intuitive and flexible way of managing today's complex design rules.




The Unified Constraint Manager GUI panel allows you to easily view, select, group and edit design rules.

### Performance and capacity

SmartDRD is architected for performance and capacity, and is intended for everyday use by layout designers. DRDVisual and DRDAssist provides nearly instantaneous feedback, and DRDAutoFix corrections are often accomplished in fractions of a second. Using SmartDRD, hours of painstaking layout error correction work can be eliminated.

## Conclusion

SmartDRD is a new generation of design-rule-driven technology available today in Galaxy Custom Designer LE. Its capabilities, performance and capacity are designed to make DRD accessible and beneficial for everyday use by the layout design community.