

# **Design Optimization and Implementation Methodology using Cells with Different Diffusion Breaks**

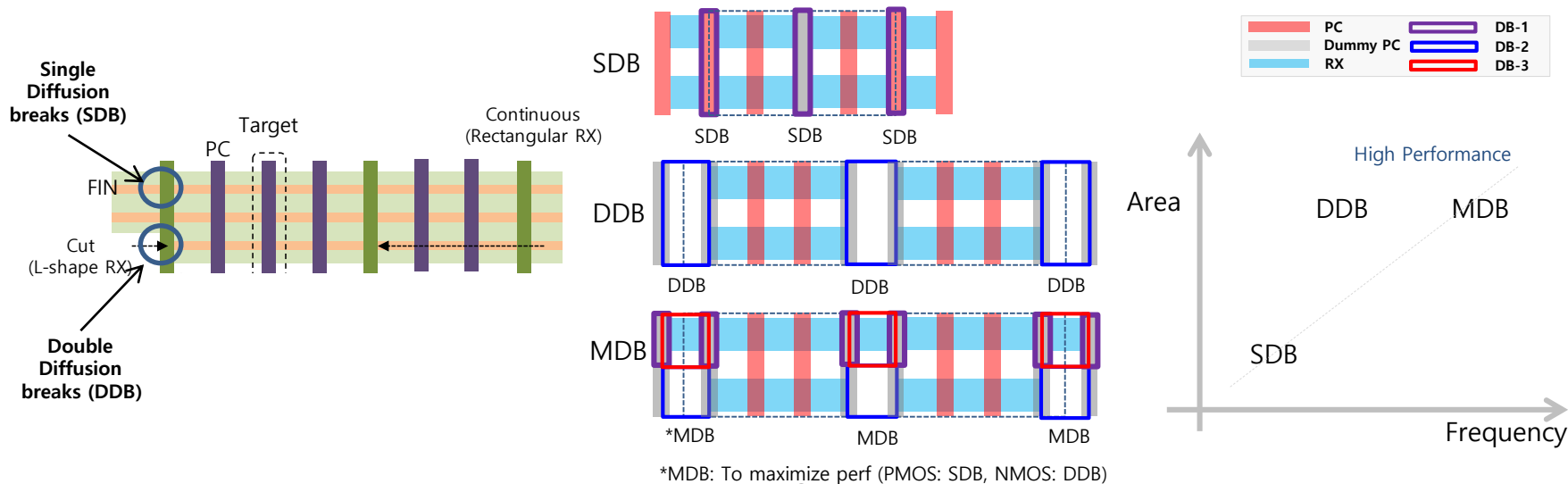
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# Motivation

## Standard cells: Types of Diffusion Breaks

- The performance (speed, leakage, power) of the STD cell varies depending on the types of diffusion breaks; LLE impact
- Several types of diffusion breaks have been enabled to support different application (SDB: for lower power, MDB: for higher performance)



# Motivation

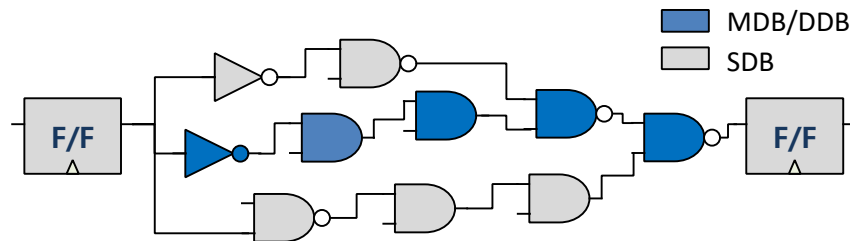
- Goal: Achieving the Same-level of Performance with MDB/DDB Only Design Whereas Less Power and Less Area Cost

- Taking best of both worlds with mixed MDB/DDB + SDB implementation
- Fit-for-purpose cell usage (MDB/DDB: critical path, SDB: non-critical path)
- Smaller power could result in better performance in power-limited scenarios

	Library Option Comparison		
	MDB	MDB + SDB	SDB
Performance	1.08	~1.08	1
Leakage	1.20	~1.05	1
Area	1.18	~1.04	1

**Samsung Foundry Unique Solution**

Speed increase @Same Area		Speed increase @Same Area		
Cell Type	10nm	8nm	7nm	5nm
High Speed	DDB	HSDB/MDB	MDB	MDB
Low Power/Area	SDB	SDB	DDB	SDB



# Mixed Cell Implementation Methodology

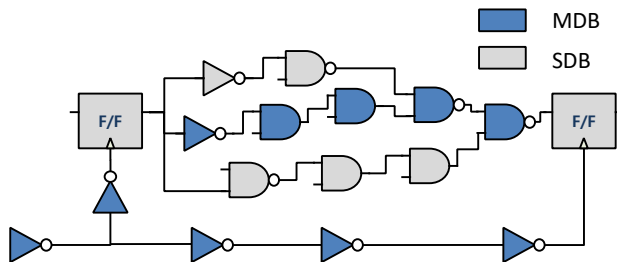
## Refined Design Flow for Mixed Cell Implementation (ex. Mixed MDB/SDB)

### Cell Usage: Fit-for-Purpose

- Use MDB for clock cells (clock-gating cells)
- SDB for data path

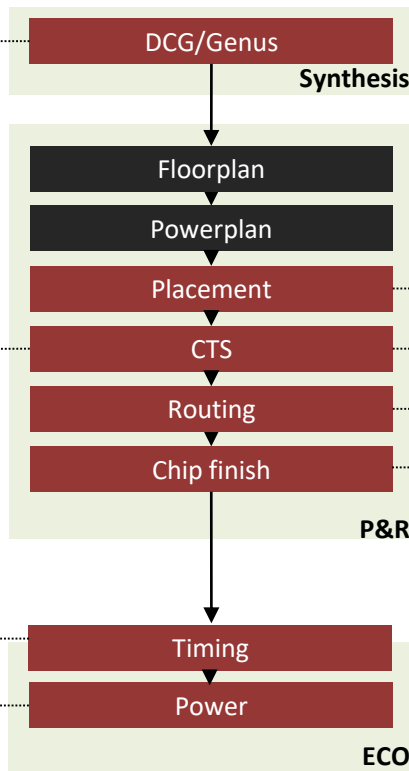
### Clock Tree Synthesis with MDB

- Minimize clock latency and clock skew



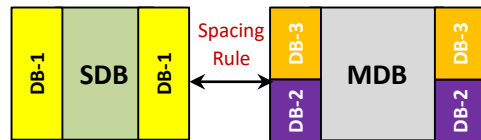
### Mixed ECO Flow

- Timing fixing respect to MDB/SDB spacing
- Dynamic power recovery across MDB and SDB
- Leakage power recovery inside each type



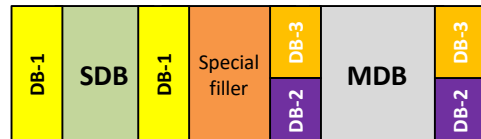
### Mixed Cell Placement

- Special legalization (spacing) for design rule between SDB and MDB cells is required



### Filler Insertion (including special filler)

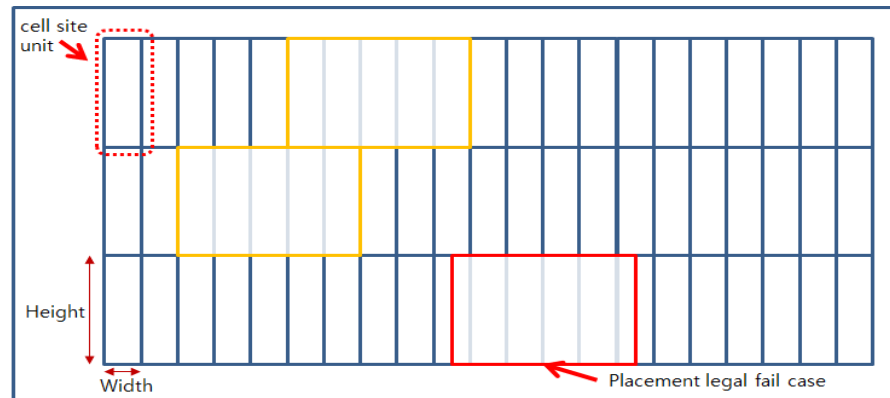
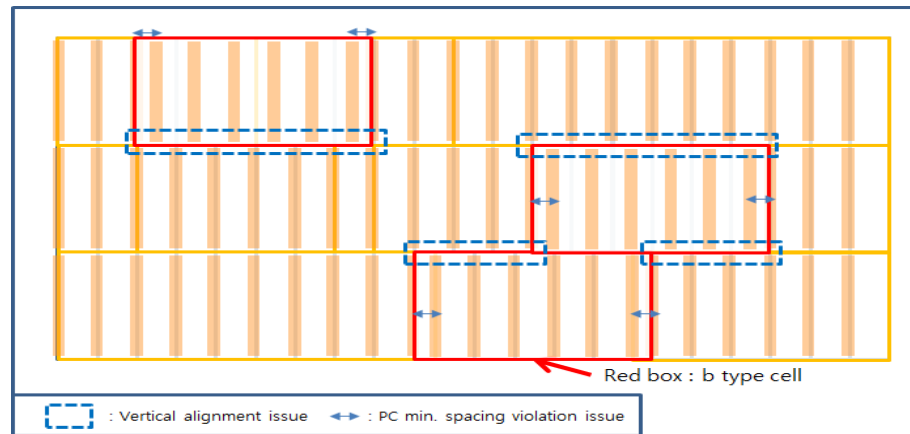
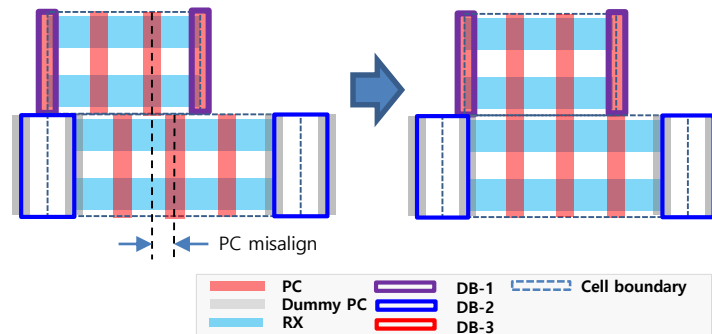
- Three types of filler cells are required to finish layout (MDB/SDB/Special)
- Special filler cell must be placed at MDB and SDB interfaces



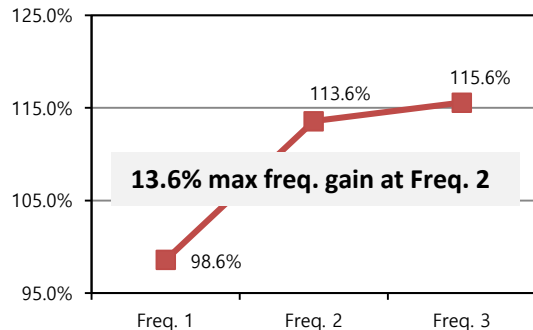
# Smart Legalizer: Front-end DRC Handling

## DRC Constraints

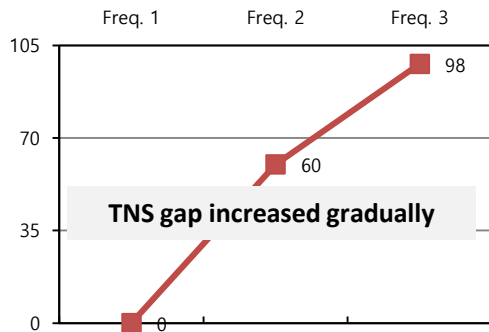
- MDB and SDB cells have different diffusion break; boundary for SDB cell is aligned to PC, boundary for DDB cell is not aligned on PC center
- Traditional legalization methodology, cell boundary based legalization, induces DRCs → smart legalization required
- DR exists between DB-1 and DB-2/DB-3: additional spacing rule necessary



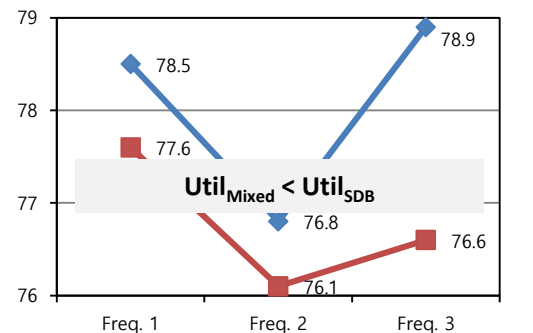
# Results: Library-level Comparison



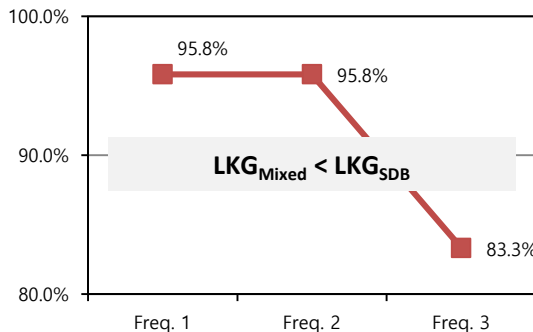
**Max Frequency Comparison;** x-axis: target frequency, y-axis: max frequency gain.



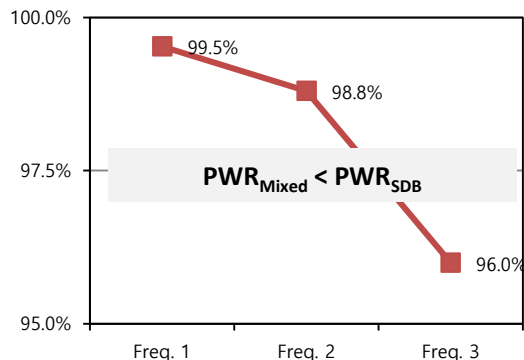
**TNS Comparison;** x-axis: target frequency, y-axis: total negative slack gap.



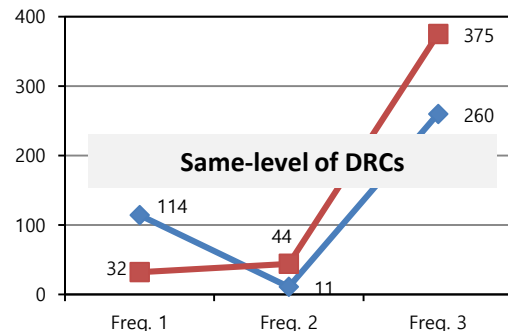
**Utilization Comparison;** x-axis: target frequency, y-axis: utilization (%); red-line: mixed, blue-line: sdb



**Leakage Comparison;** x-axis: target frequency, y-axis: leakage current saving.



**Total Power Comparison;** x-axis: target frequency, y-axis: power saving (Internal, switching, leakage).



**DRC Comparison;** x-axis: target frequency, y-axis: # of DRCs; red-line: mixed, blue-line: sdb

# Summary

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- Several types of cells having different diffusion breaks have been enabled to support different application
- We developed a comprehensive method for achieving the same-level of performance with MDB/DDB only design whereas less power and less area cost
  - Cell usage guide
  - Mixed cell placement methodology
  - Filler cell development and insertion flow
  - ECO flow
- The results show the mixed cell implementation leads to improvements in timing, power, while maintaining the same-level of DRCs