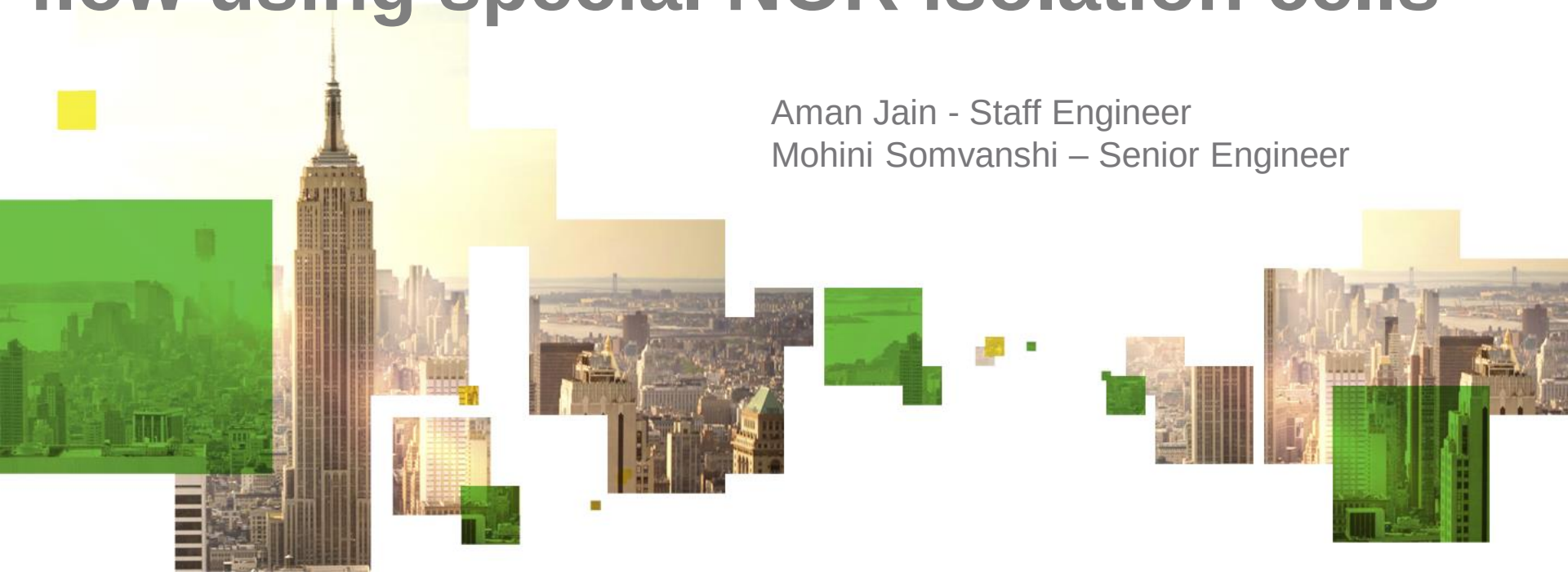
Improving low power implementation flow using special NOR isolation cells

Aman Jain - Staff Engineer
Mohini Somvanshi – Senior Engineer

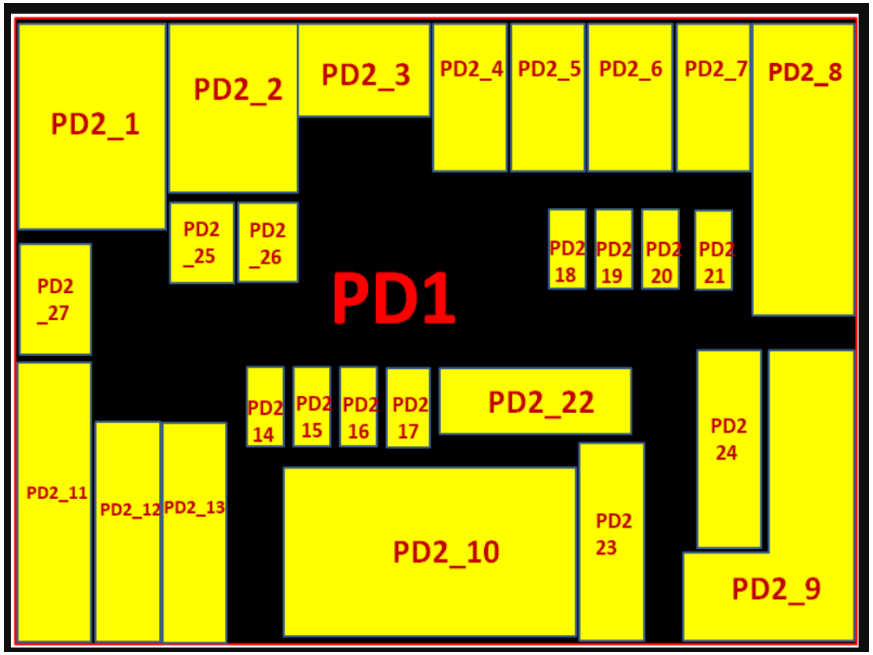


Agenda

- ✓ SOC power structure overview
- ✓ Motivation to use NOR isolation cell
- ✓ Concept of Single Rail NOR Isolation
- ✓ Methodology of using NOR isolation cell
- ✓ Results
- ✓ Summary

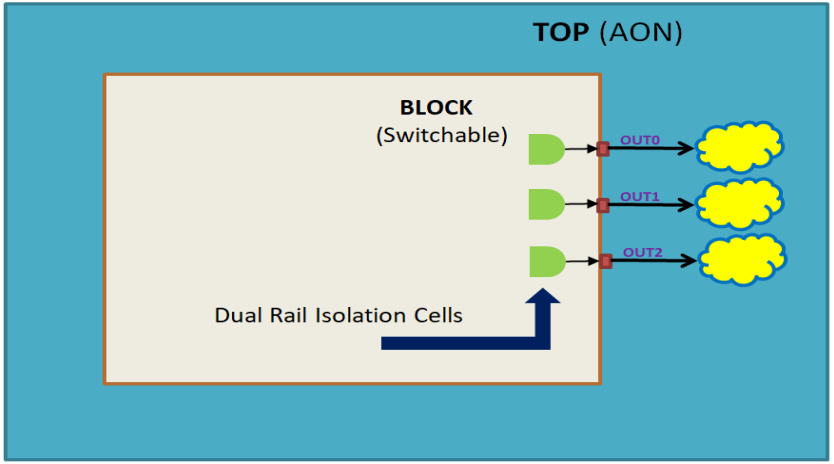
SOC power structure overview

1. 28nm technology, HPC Synopsys libraries
2. Top level is PD1 – AON Domain,
3. The blocks are in PD2_x – self scoped and nested power domains having both AON & switchable domain
4. Total number of power domains : 55
5. Total 10 blocks with 27 instances
6. Few blocks are MIM (multiple instantiated modules)



Motivation to use NOR isolation cells

1. **At the output port of all blocks, there is requirement to add isolation cells because of transition from switchable to AON power domain**
2. **The isolation cells were placed in blocks close to output ports**
3. **The dual rail isolation cells having 2 PG pins of VDD and VDDR (backup rail) were used**



Motivation to use NOR isolation cells……..(contd)

1. **~18k clamp-0 dual rail isolation cells and ~2k clamp-1 dual rail isolation cells were used**

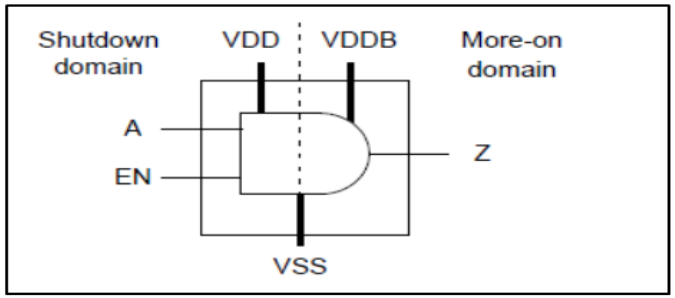
```
pt_shell> sizeof_collection [get_cells -hie * -f "ref_name =~ *ISO*CL0*"]
18752
pt_shell> sizeof_collection [get_cells -hie * -f "ref_name =~ *ISO*CL1*"]
1823
pt_shell>
```

```
pg_pin (VDD) {
    direction : input;
    pg_type : "primary_power"
    related_bias_pin : VBP;
    voltage_name : "VDD";
}
pg_pin (VDDR) {
    direction : input;
    pg_type : "backup_power";
    related_bias_pin : VBP;
    voltage_name : "VDDR";
}
```

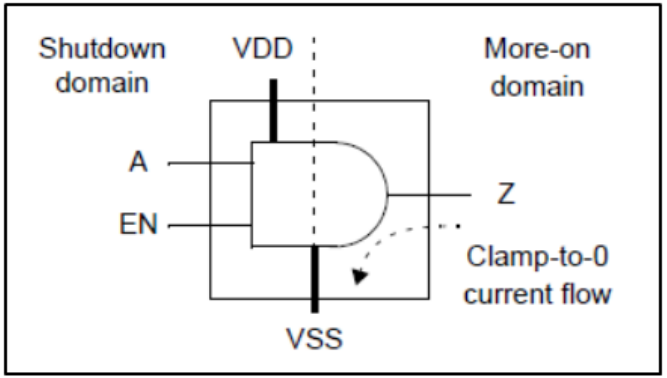
2. **If through some methodology we can replace the clamp-0 dual rail isolation cells by single rail isolation cells, it would help saving significant silicon area and significant power routing resources**

Concept of Single Rail NOR Isolation

- Conventional Isolation Cell has two power rails: a primary rail (VDD) that can be powered down and a backup rail (VDDB) that drives the isolation output during power-down

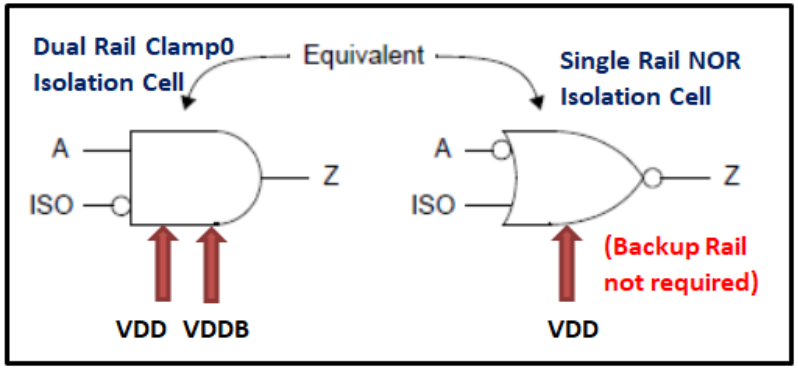


- A single-rail NOR-type isolation cell has only the primary rail (VDD) and lacks the backup rail. It relies only on the ground rail (VSS) as a power supply for implementing a clamp-to-0 strategy



Details of single rail NOR Isolation

1. This type of isolation cell can be implemented very efficiently in hardware by using just a NOR gate and an inverter, and using only a single power rail and a single ground rail.



2. Benefits of using NOR isolation cells
   - Less Routing Resources as compared to dual rail isolation cells
   - Less Area as compared to dual rail isolation cells
   - Win-win solution

3. To use NOR isolation, it must have clamp0 behavior and the cell must have stable ground, no “footer switch” methodology should be used.

Methodology of using NOR Isolation

1. The UPF had to be modified to change the isolation policy for clamp-0 cells

```
set_isolation ntw_iso_out_clamp0 \
 -domain PD_BlockA \
 -isolation_supply_set "" \
 -clamp_value 0 \
 -isolation_sense high \
 -isolation_signal pwr_if_isolate \
 -location self \
 -applies_to outputs

map_isolation_cell \
ntw_iso_out_clamp0 \
-domain PD_BlockA \
 -lib_cells {ISO*NOR* }
```

2. The “-isolation_supply_set” argument needs to be remain empty as there is no back up rail connection required

Methodology of using NOR Isolation…(contd)

1. The target library needs to include single rail NOR isolation cells

2. The NOR isolation cell library needs to have specific pin attributes on data and VDD pins

```
pin (ISO) {
        related_power_pin : "VDD";
        related_ground_pin : "VSS";
        direction : "input";
        isolation_cell_enable_pin : true
        alive_during_partial_power_down : true ;
}
pin (Y) {
        related_power_pin : "VDD";
        related_ground_pin : "VSS";
        direction : "output";
        power_down_function : "!ISO*!VDD+VSS";
        function : "!(ISO|(!A2))";
        alive_during_partial_power_down : true ;
}
        pg_pin (VDD) {
                voltage_name : "VDD";
                pg_type : "primary_power";
                permit_power_down : true ;
        }
```

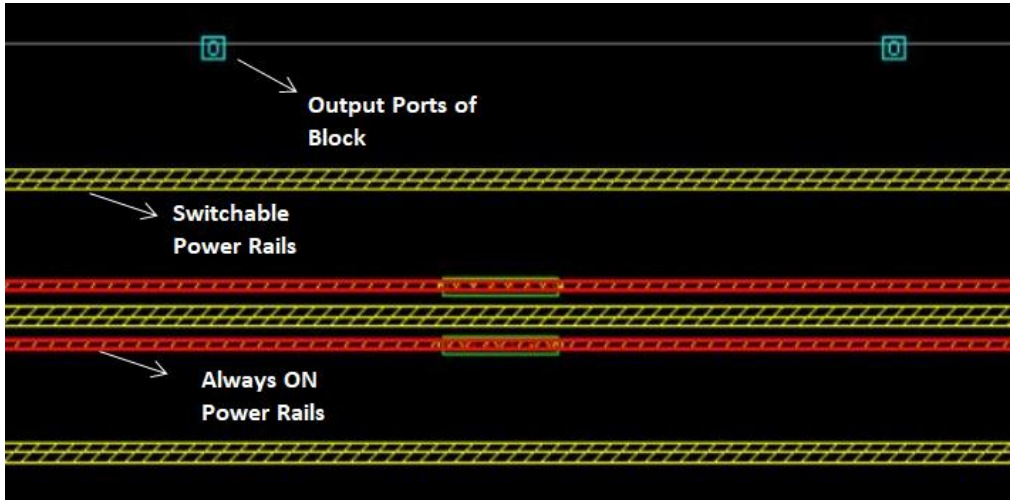
Results

Following are the results by changing the methodology and doing synthesis with modified UPF and using NOR isolation library. **NOR isolation cell is 66% smaller than dual rail isolation cell**

	Number of Clamp 0 Isolation Cells	Area Savings by using NOR isolation cells (micron mm^2)
Block1	801	881.1
Block2	1271	1398.1
Block3	6015	6616.5
Flat	18752	20627.2

Results……(contd)

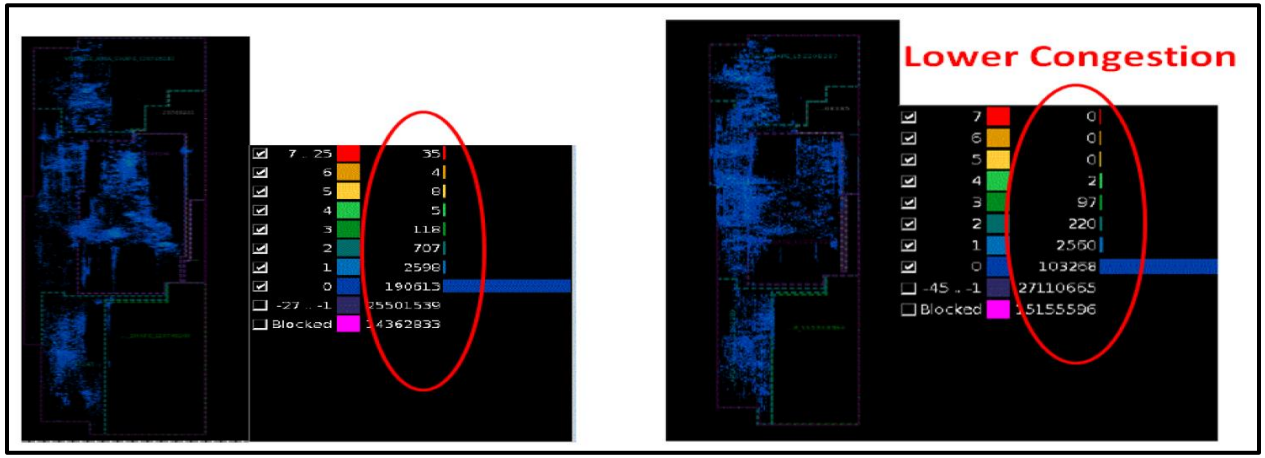
Following is snapshot from physical design tool where AON rail was connected to VDDR (backup rail) of regular dual rail isolation cells. These connections are not required with NOR isolation cells make it easier and less complex for Physical Design Tool.



Results……(contd)

1. During timing closure we had faced challenges associated with certain congested narrow channels in physical design.

2. In these narrow channels there were many dual rail clamp-0 isolation cells present. By swapping them to single rail NOR isolation cells the congestion reduced to some extent because now the power strap for Always ON rail was not required in those congested regions.



Summary

1. Single Rail NOR isolation cells can replace dual rail clamp0 isolation cells

2. It requires less routing resources as backup rail connection is not required

3. It has smaller area as compared to dual rail isolation cell , so it is win-win solution from both routing resources & area perspective

4. For implementation of NOR isolation it requires adjustment of libraries and methodology in terms of change in UPF in isolation policy for clamp0

5. The overall physical design flow becomes less complex as it eliminates the step of connecting AON power rails to isolation cells

Thank You