

## Problem Statement

- Designs with parameters require a separate formal verification run for every parameter combination.

### Example of a design with parameters:

- ❖ FIFO\_DEPTH: 2,4,8 (3 options)
- ❖ FIFO\_WIDTH: 8-11 (4 options)
- ❖ NUM\_LOOPS: 3-6 (4 options)
- ❖ ADD\_MODE: 0,1 (2 options)

Total:  $3 * 4 * 4 * 2 =$  requires 96 runs

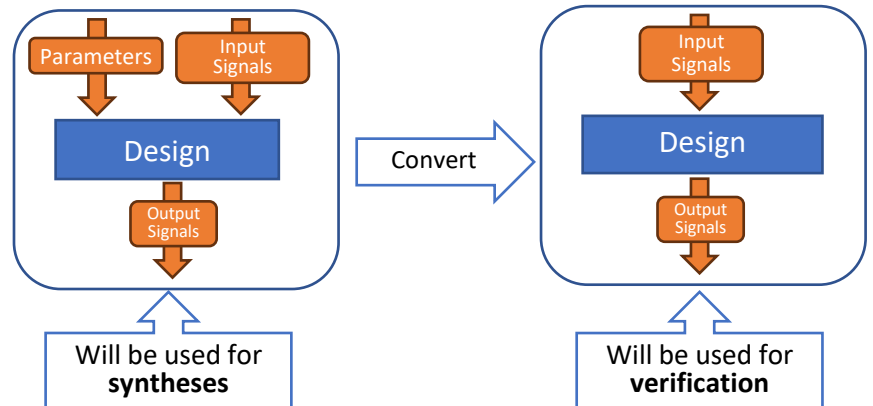
```
module advanced_fifo
#(
    parameter FIFO_DEPTH = 8,
    parameter FIFO_WIDTH = 11,
    parameter NUM_LOOPS = 3,
    parameter logic ADD_MODE = 1
)
```

### Existing solutions:

- Test only specific parameter values – **Can lead to bug escape.**
- Generate a new model for each parameter combination – **Long runtime.**

## Proposed Solution – P2S (Parameters to Signals)

- **Convert** the parameters to stable input signals - **using a script**
- **Use a single formal run** to test all combinations.



## Code Changes

### - Interface changes:

- Replace the parameters with:
  - Input signals.
  - Maximum parameter values.
- Constrain the input signals to have stable legal values.

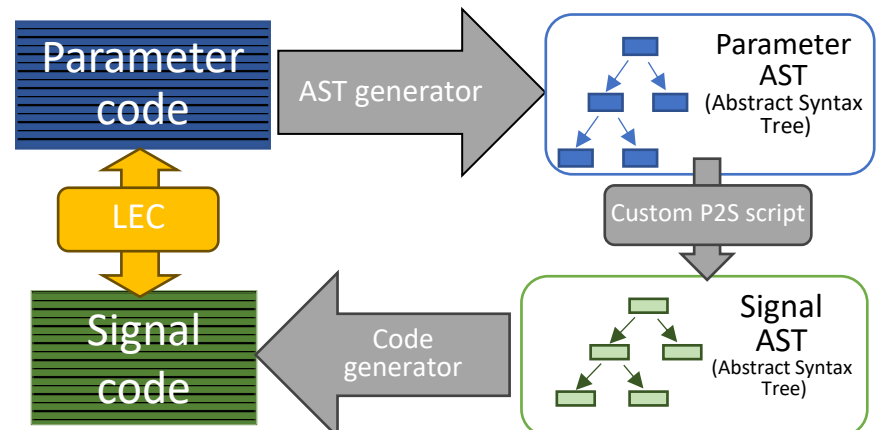
```
module fifo_with_sig_sva
#(
    parameter max_FIFO_DEPTH = 8
)
(
    .
    .
    .
    input [3:0] sig_FIFO_DEPTH
);

ASM_PARAM_FIFO_DEPTH_STABLE: assume property ($stable(sig_FIFO_DEPTH));
ASM_PARAM_FIFO_DEPTH_RANGE: assume property (
    sig_FIFO_DEPTH==2 || sig_FIFO_DEPTH==4 || sig_FIFO_DEPTH==8);
```

### - This impacts internal logic as well.

## Conversion Script & Equivalence Checking

- We used a script to automate the conversion process.
- We verified that both designs have the exact same functionality, by using LEC (Logical Equivalence Checking).



## Runtime Results

- We compared the runtime of our P2S (Parameter-to-Signal) method against the total time required to test all parameter combinations.

| Design example | Number of Permutations | Tool 1 Speedup | Tool 2 Speedup | Tool 3 Speedup |
|----------------|------------------------|----------------|----------------|----------------|
| Advanced FIFO  | 96                     | 258%           | 400%           | 644%           |
| ALU            | 24                     | 675%           | 511%           | 346%           |
| APB XBAR       | 16                     | 357%           | 334%           | 61%            |
| AXI bridge     | 27                     | 304%           | 147%           | 184%           |

## Conclusions

- ✓ We tested 4 different designs with 3 different tools.
- ✓ For almost **all designs**, the **runtime improved**.
- ✓ For most designs, performance improvements **exceeded 300%**.

- You can view an example at:

[https://github.com/MenachemRapp/p2s\\_fifo\\_example](https://github.com/MenachemRapp/p2s_fifo_example)



## Contact Information

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