

Automatic Synthesis of Comparator Circuit Using Genetic Algorithm and SPICE Optimizing Function

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1. Research Background

「Engineer of Analog Circuit」

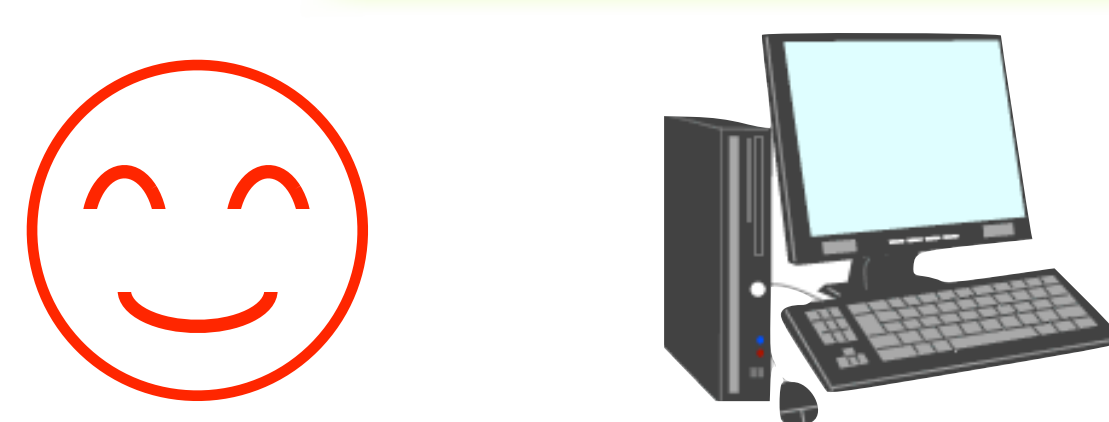


Take time to become a good circuit designer

Time required for designing circuit

- Selection : Proper Circuit Topology
- Determination : Circuit Parameter Values
- Accumulation : Knowledge and Experience

「Automatic Design by Computer」



Compatible

It can be designed in a shorter time than engineer

Time required for designing circuit

- Programming Time
- Execution Time

Industry Demands

- Short Time to Market
- Cost Reduction

2. Research Objective

Comparator circuit is always used for signal comparison.

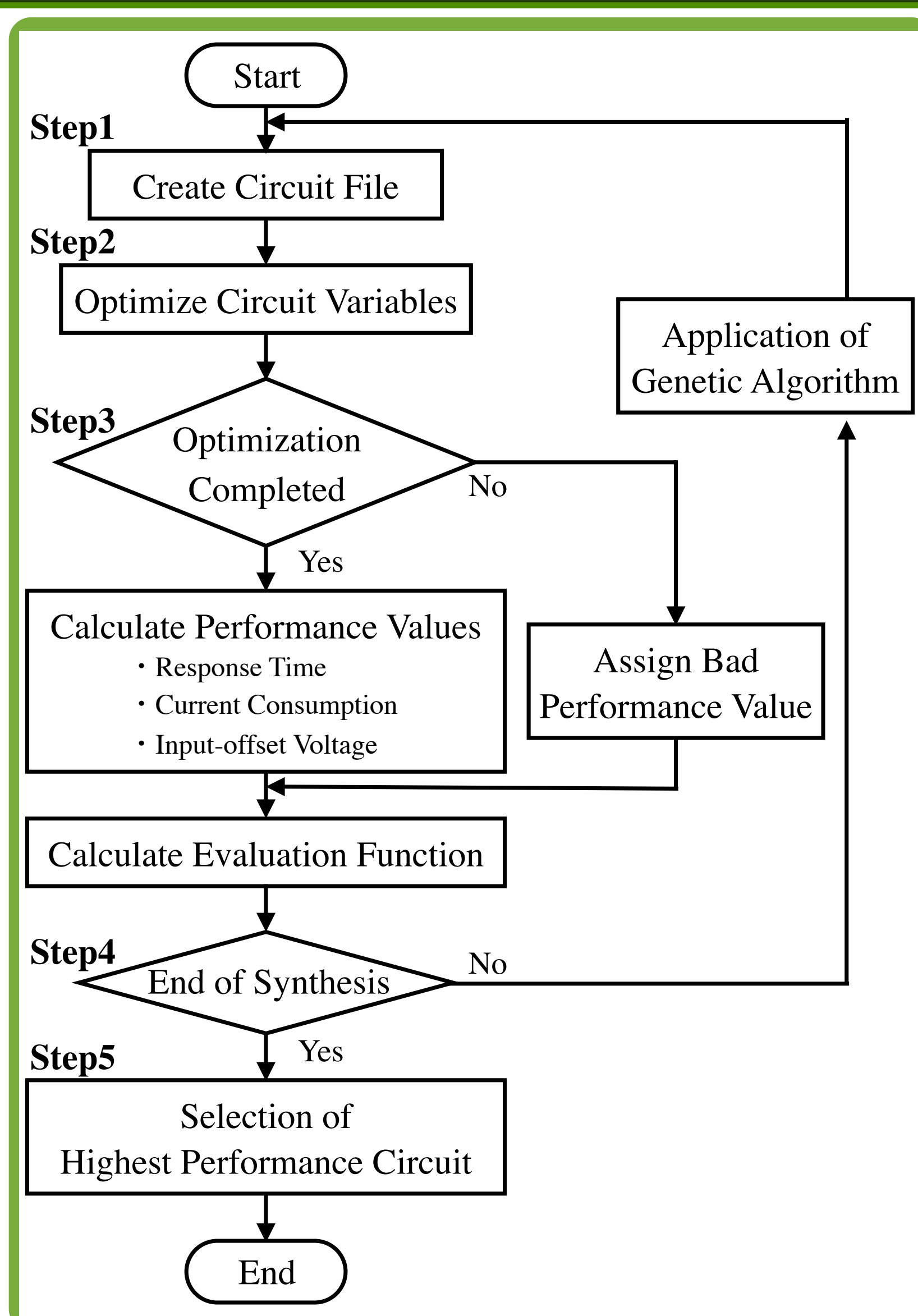
Short Time to Market
Cost Reduction
Merit of automatic synthesis!

Electrical Characteristics of Comparator

- Input-offset voltage
- Input-offset current
- Input bias current
- Current consumption
- CMRR
- PSRR
- Response time

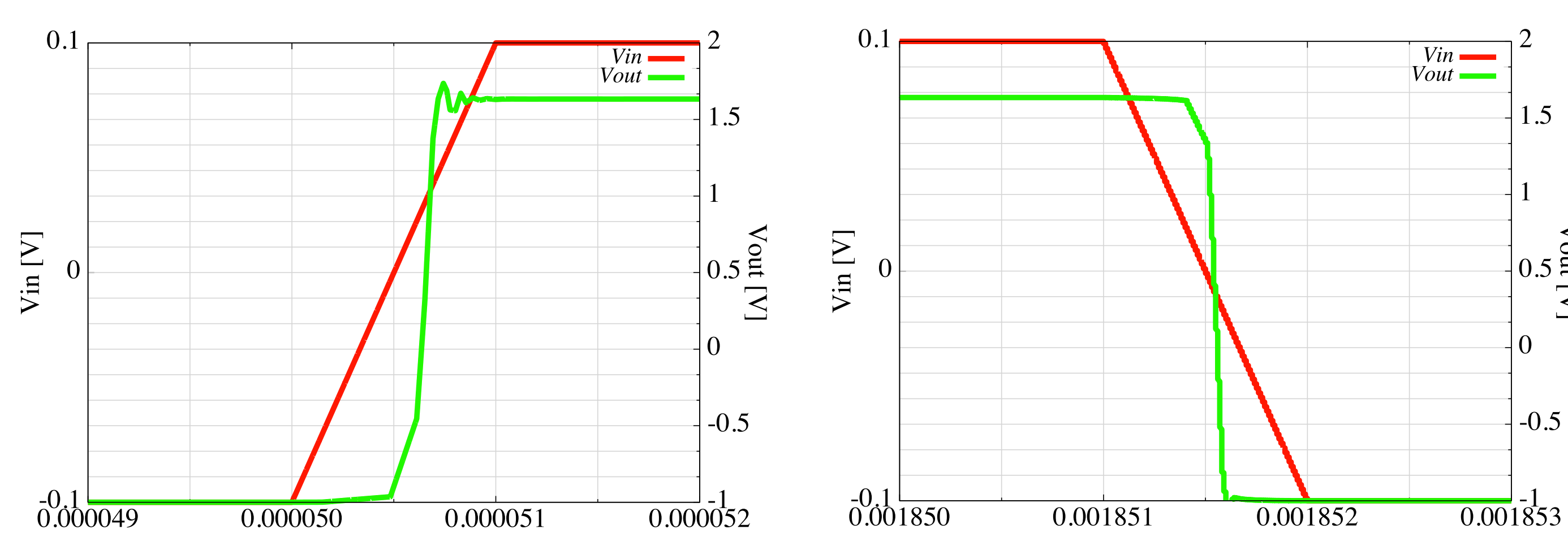
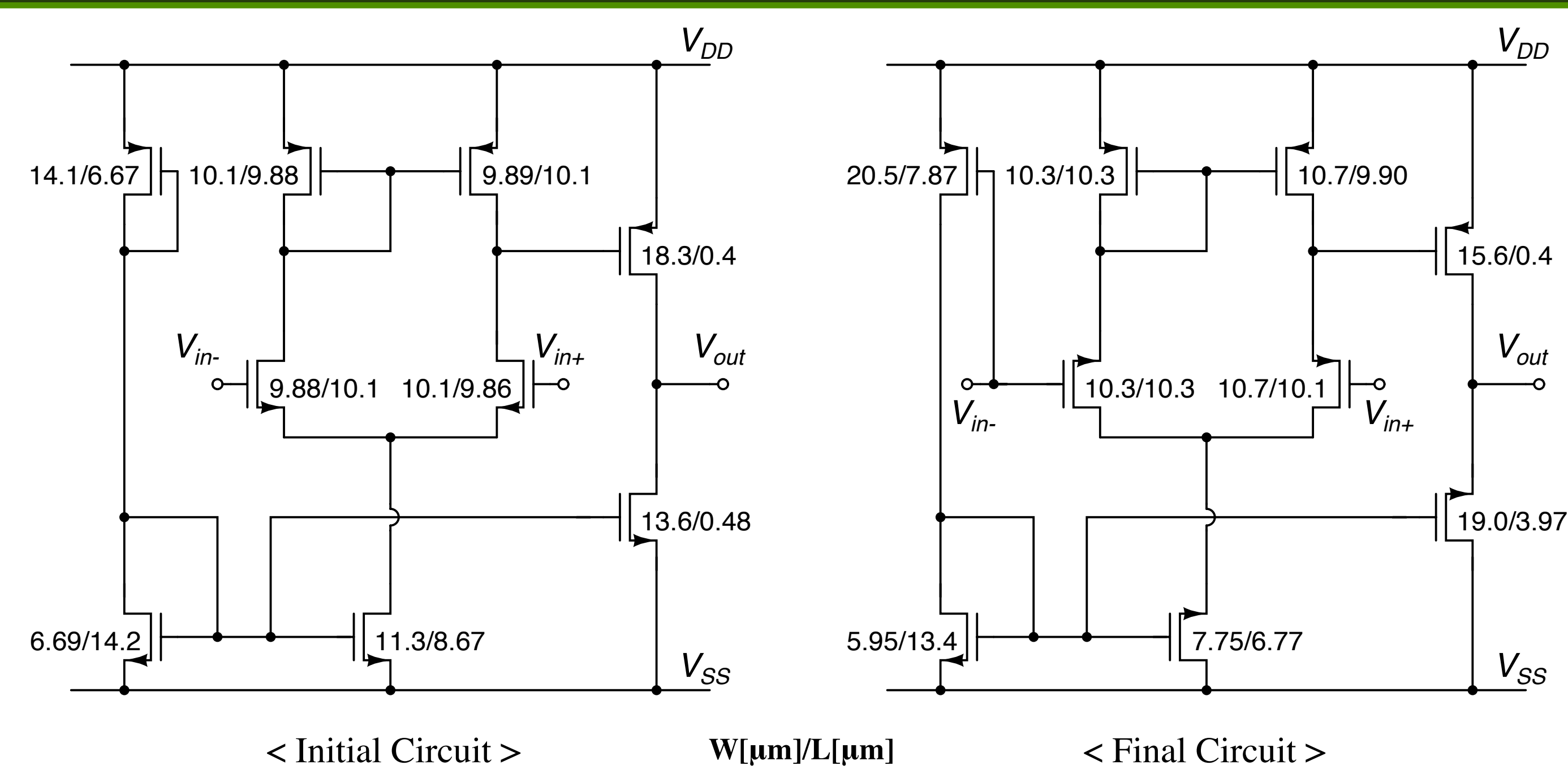
We realize automatic synthesis focusing on 3 characteristics!

3. Method of Automatic Synthesis



- Step1**
Create circuit file.
HSPICE input file format preparation for variable parameters.
- Step2**
Determines proper values that satisfies the setting condition using HSPICE optimizing function.
- Step3**
< Performance reach the demand (Yes) >
Determines performance values.
< Performance don't reach the demand (No) >
Circuit topology is considered as "bad".
Calculate evaluation function as circuit performance figure.
- Step4**
Increment loop number by 1.
< Loop number is less than the specified value >
Change another topology using GA.
Go to Step 1.
< Loop number is equal to the specified value >
Go to step 5.
- Step5**
Select the highest performance circuit among all of evaluated circuits.

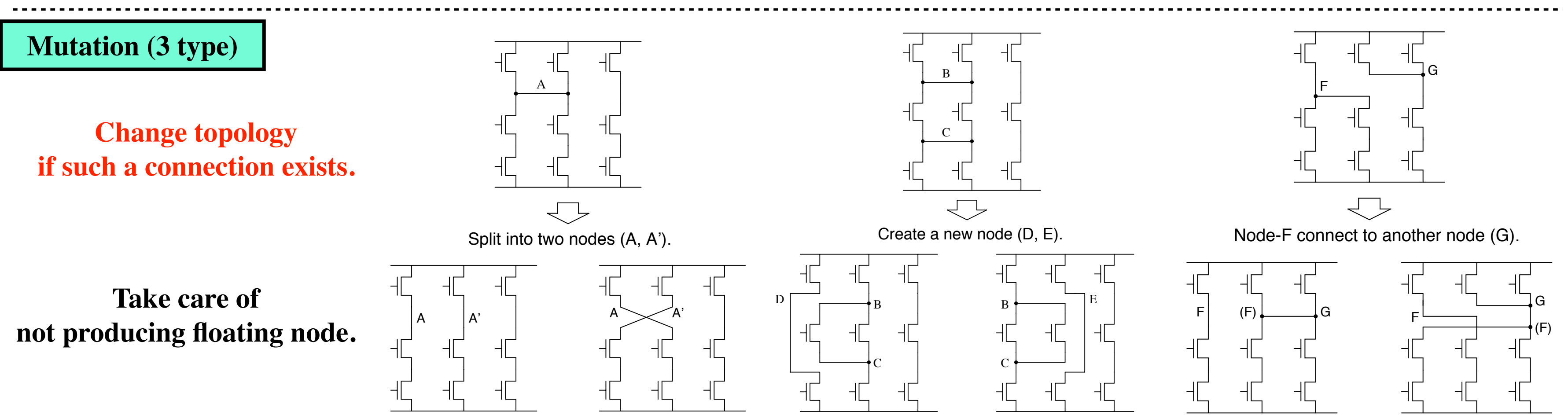
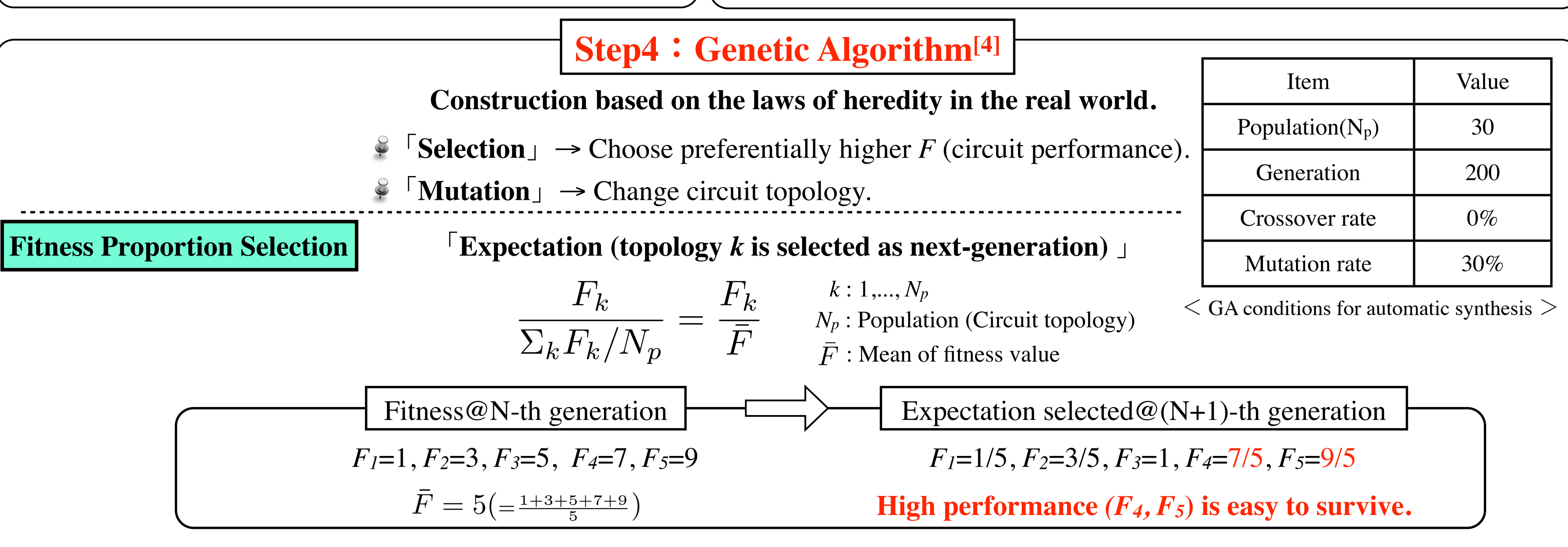
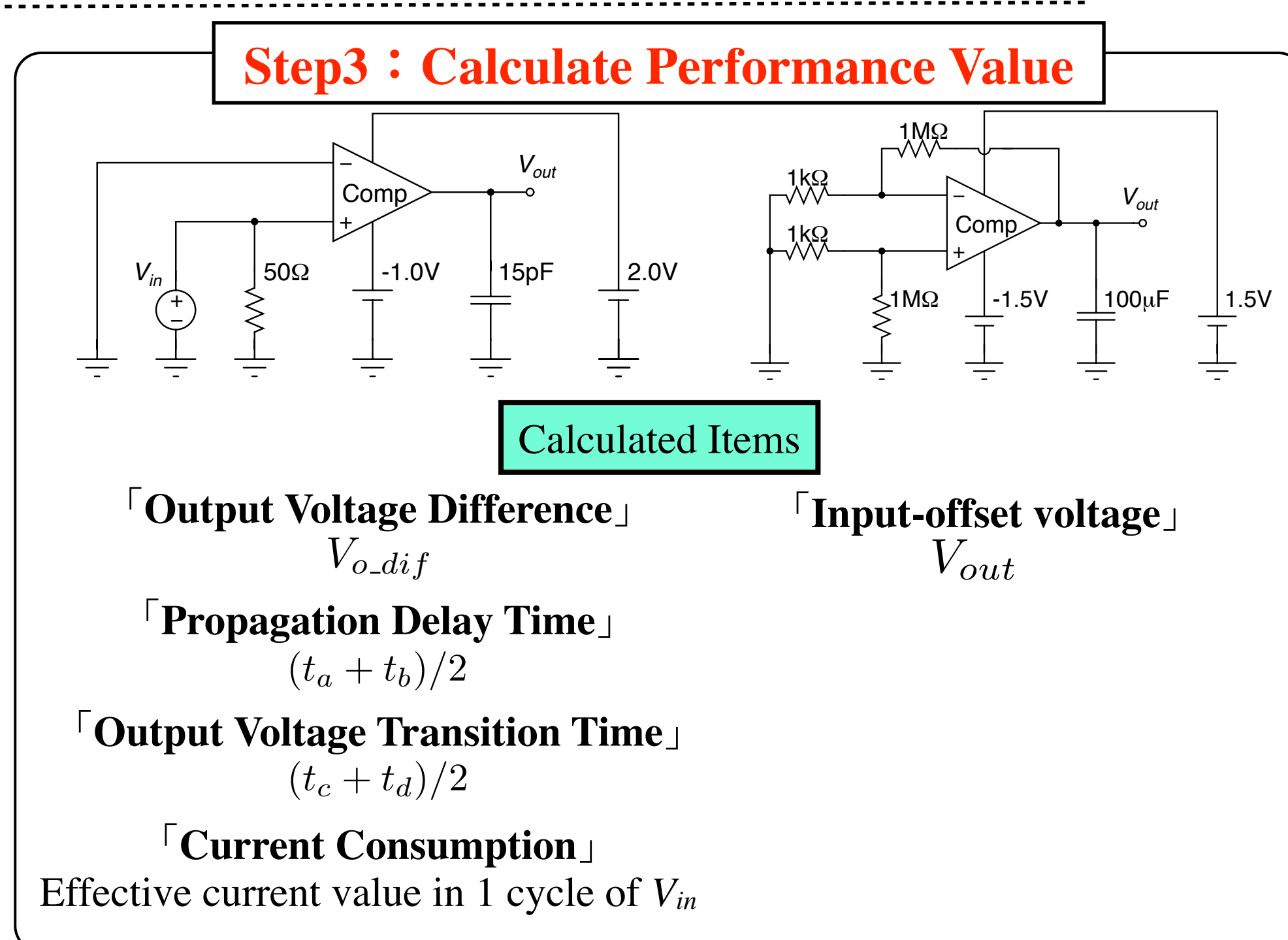
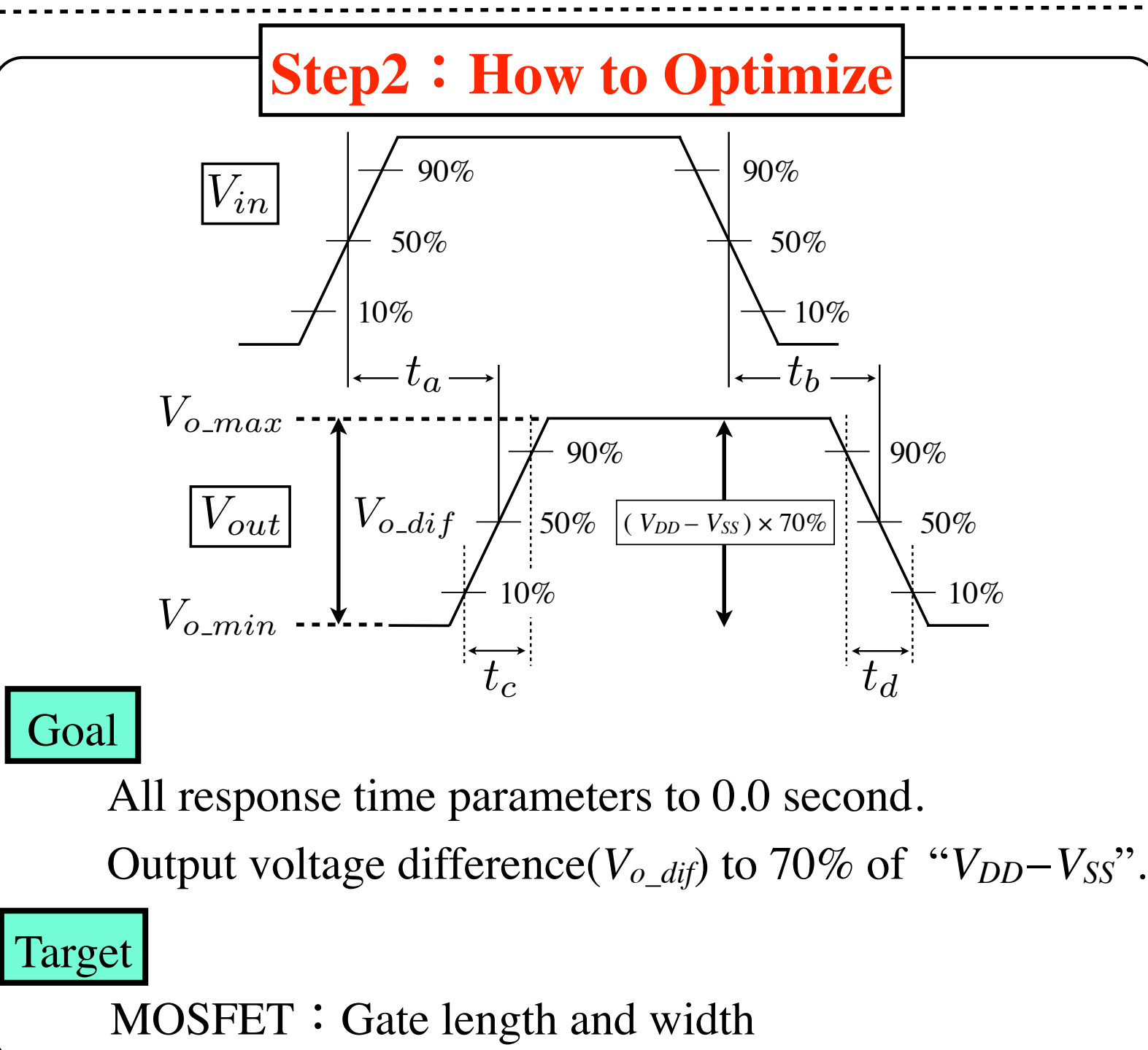
4. Result of Automatic Synthesis



< Input & Output Waveform >

< Performance Comparison >

| Evaluation Item | Value Type | Initial Circuit | Final Circuit |
|---|-------------|-----------------|---------------|
| Output voltage difference | Performance | 2.29V | 2.72V |
| | Evaluation | 1.06 | 1.13 |
| Propagation delay time | Performance | 168ns | 73.7ns |
| | Evaluation | 1.0 | 1.36 |
| Output voltage transition time | Performance | 144ns | 272ns |
| | Evaluation | 1.0 | 0.72 |
| Consumption current | Performance | 5.65mA | 1.48mA |
| | Evaluation | 1.0 | 1.58 |
| Input-offset voltage | Performance | 59.6mV | 3.0mV |
| | Evaluation | 1.0 | 2.3 |
| Fitness value (product of all evaluation) | | 1.06 | 4.06 |



5. Summary

「Conclusion」

- Develop automatic synthesis program.
- HSPICE optimizing function determines circuit parameters.
- GA determines the circuit topology.
- Synthesized circuit performance is better than initial circuit.

「Future Work」

- Realize automatic synthesis of comparator from its faulty initial circuit.
- Silicon prototype of synthesized circuit.

「Reference」

[1] K. Jin'no, "An Automated Circuit Design Procedure by Means of Genetic Programming," NOLTA (2005).
[2] N. Unno, S. Takagi and N. Fujii, "Design Automation of Analog Circuits by Combination of Circuit Blocks: Synthesis of OpAmp," IEEJ(2004).
[3] N. Arai, N. Takai, B. S. Kumar and H. Kobayashi, "Automatic Design of Analog Filter Using Genetic Algorithm," AMDE(2012).
[4] D. E. Goldberg and K. Sastry, "Genetic Algorithms: The Design of Innovation, 2nd edition," Springer(2010).
[5] R. J. Baker, "Mixed-Signal Circuit Design, Second-Edition," Wiley(2002).