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Automatic Design of Analog Filter Using Genetic Algorithm

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Introduction

Background

Specifications for the analog circuit have increased rapidly in recent years

However

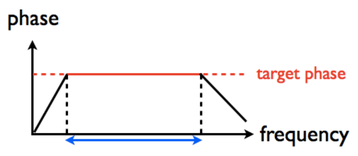
The more complicated the circuit configuration becomes, the more difficult it gets for an engineer to design

Automatic design by the computer is demanded

This method can be expected to design complex circuits quickly

Research Goal

Output of any phase can be achieved for the analog filter working in any frequency band



Using genetic algorithm

We have developed

Automatic design algorithm & software for analog filters

Genetic Algorithm

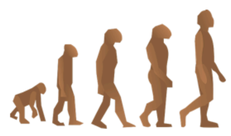
Genetic Algorithm

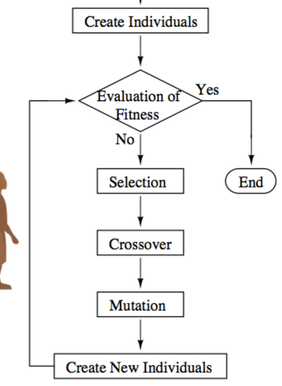
A superior gene survives, while an inferior gene is been weeded out in the process of biological evolution

Expressed in Algorithm

Genetic Algorithm

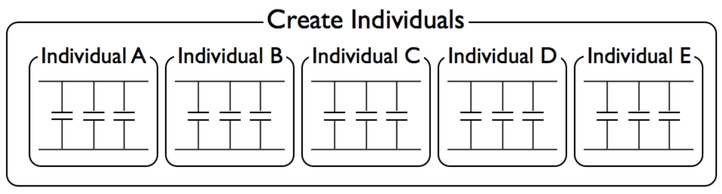
- Create Individuals
- Evaluation of Fitness
- Selection
- Crossover
- Mutation
- Create New Individuals





Flowchart of genetic algorithm

Create Individuals & Selection



Selection

Example of fitness proportional selection

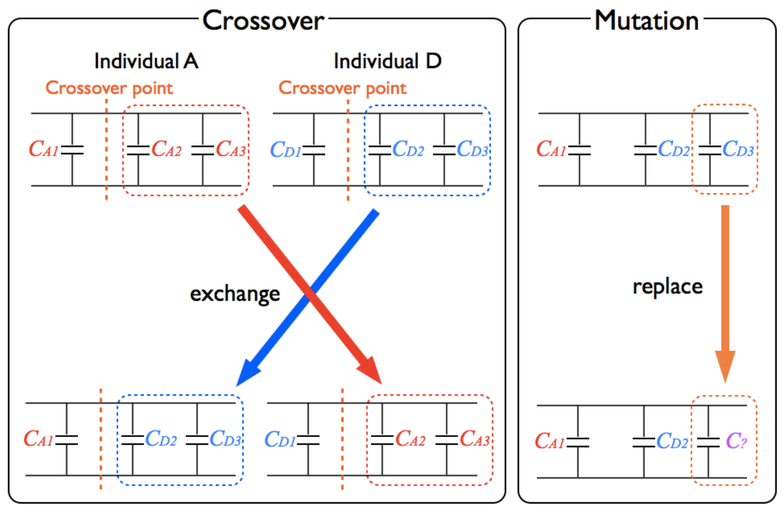
Individual	Individual A	Individual B	Individual C	Individual D	Individual E
Fitness	0.6	0.3	0.1	0.5	0.2

Fitness is defined as measure of relative merits

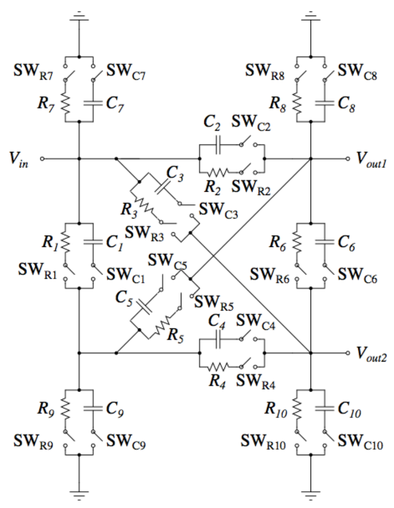
While selecting 2 individuals

Probability of individual A and individual D being selected is the highest

Crossover & Mutation



Circuit Configuration to Apply The Genetic Algorithm



Using switch operation of ON & OFF

variety of circuit configurations

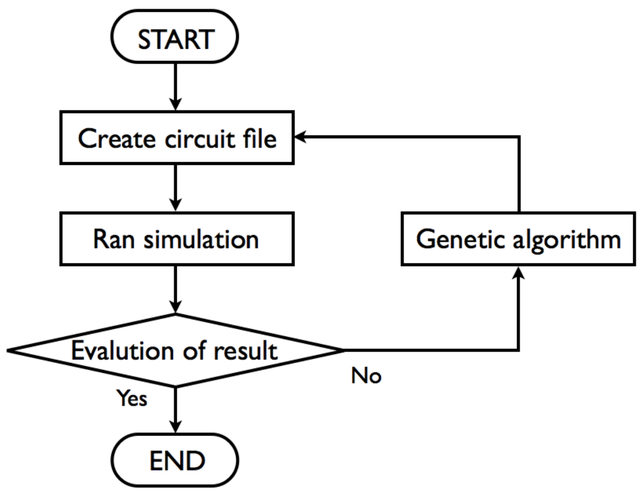
C : Values
R : Values
SW : ON or OFF

Genetic operation

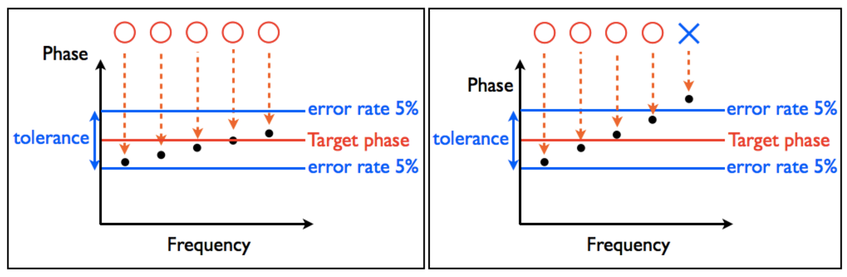
Automatic design

Result of Automatic Design

Flowchart of Automated Design



Evaluation of Result



The error rate is less than 5% for all the points

The condition is satisfy

There is any point indicating an error rate of more than 5%

The condition is not satisfy

Target Specification

Target Specification 1 :
Automatically design an analog filter that generates constant phase of ±π/2[rad] for a frequency band of 100MHz to 300MHz

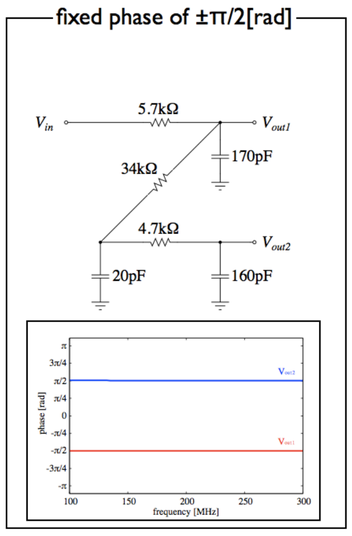
Target Specification 2 :
Automatically design an analog filter that generates constant phase of ±π/6[rad] for a frequency band of 100MHz to 300MHz

Conditions of automated design

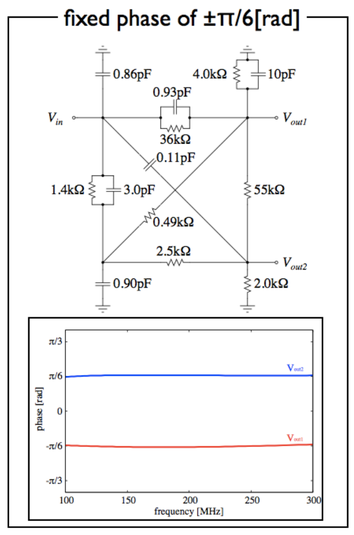
Population	100
Generation	300
Crossover rate	60%
Mutation rate	10%

Result of Automatic Design

fixed phase of ±π/2[rad]



fixed phase of ±π/6[rad]



Summary

Conclusion

- We have proposed an automated design of an analog filter that satisfies target specification

  — Frequency band of 100MHz to 300MHz, the target specification of constant phase has been fulfilled

Utilizing this new designing method

Automatic designing of various kinds of Filter circuit is possible

References

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[3] H. Kobayashi, J. Kang, T. Kitahara, S. Takigami, H. Sakamura, "Explicit Transfer Function of RC Polyphase Filter for Wireless Transceiver Analog Front-End", 2002 IEEE Asia-Pacific Conference on ASICs, pp.137-140, Taipei, Taiwan (Aug. 2002).

[4] N. Mori, *Learning the Genetic Algorithm with Java*, Kyouitsu Shuppan (Nov. 2007).