TELECOM ParisTech

# Master Internship Offer 2020

## Title: Machine Learning Aided Analog Mixed Signal Design

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## Context:

The design of analog and Analog Mixed Signal (AMS) Integrated Circuits (IC) is not an easy task. There are difficulties all along the design process. Given the required specifications the designer must first choose an adequate architecture which requires knowledge and experience. The large number of parameters of a given architecture must then be tuned. Tuning these parameters often relies on human experts and their intuition because the relationship between parameters and performance is subtle and uncertain. Optimal tuning requires many simulations which can be very slow for complex circuit. Optimizing both the architecture and the parameters is thus a very complex and time consuming task. This could be even worse by taking the layout process into account.

## Subject positioning and objective:

Machine Learning gained a lot of attraction in the last few years and could be a good candidate to assist AMS IC design. Supervised learning has shown great results for image or language recognition but it might not be adapted for IC design. Supervised learning requires a large dataset in order to work. The slow process of simulation combine with the fact that many AMS IPs are proprietary makes the creation of such a dataset impractical. This method can still be used for simple circuits with less than 10 transistors [1][2].

Reinforced Learning is a type of ML that does not require a dataset. It is based on an agent that takes an action based on a cumulative reward. After each action of the agent a reward is computed based on the observation of the consequences of the taken action. The agent uses this reward to decide its next action. This method is used in [3] for the design of the 3-stage transimpedance amplifier of Figure.1. The graph shows the evolution of the score over time (in hours) compared to other solutions. Random consists of randomly choosing the parameters and BO is based on a Bayesian Optimization called MACE [4]. The score is a figure of merit taking into account the specifications (bandwidth and gain) and the optimization constraint (power, gate area). The solution of the proposed method outperforms the human expert while only requiring around 40 hours. This is a promising technique that needs to be explored.

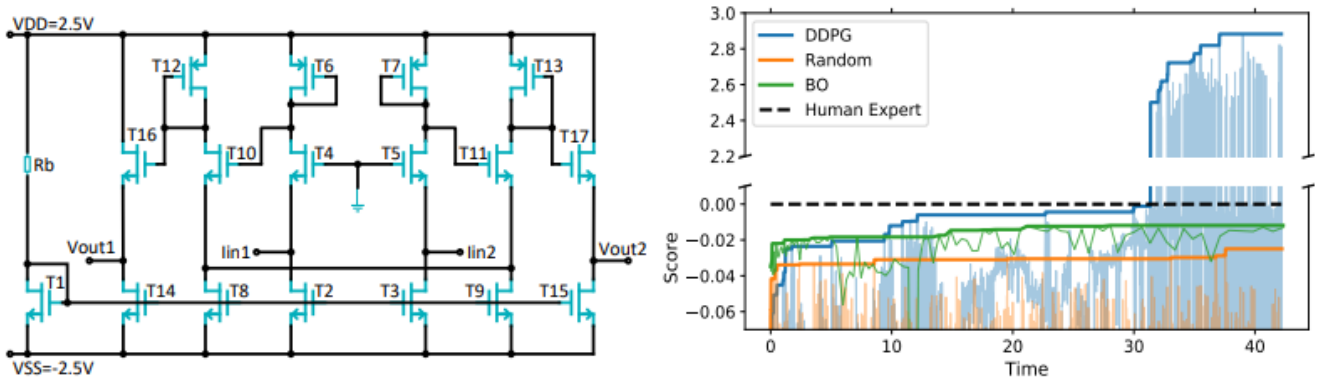


**Figure 1 3-stage transimpedance amplifier and performance over time**

Machine learning methods are not the only ones to assist AMS IC design. Existing solutions include knowledge-based techniques, genetic algorithm-based techniques, equation-based tools, particle swarm intelligence or simulated annealing-based techniques. The objective of this internship is to make a state of the art of the existing methods to assist the design of IC. The most promising technique or a new one proposed by the student will be implemented in order to evaluate it.

This internship could lead to a Ph.D thesis to further study this subject. A possible direction could be the inclusion of architecture exploration in addition to the parameter tuning to create an automatic AMS IC design tool.

## Work Plan (6 months):

The research work plan is the following

- State of the art on recent proposed method (with emphasis on ML) to assist AMS design (2/3 months)
- Implementation of the most promising method for a simple circuit e.g. an amplifier (2/3 months)
- Analysis of the produced work (1 months, report & publication)

[1] Zhenyu Wang, Xiangzhong Luo, and Zheng Gong. 2018. Application of Deep Learning in Analog Circuit Sizing. In Proceedings of the 2018 2nd International Conference on Computer Science and Artificial Intelligence (CSAI '18). Association for Computing Machinery, New York, NY, USA, 571–575.

[2] M. Fukuda, T. Ishii and N. Takai, "OP-AMP sizing by inference of element values using machine learning," 2017 International Symposium on Intelligent Signal Processing and Communication Systems (ISPACS), Xiamen, 2017, pp. 622-627.

[3] Wang, H., Yang, J., Lee, H. S., & Han, S. (2018). Learning to Design Circuits. arXiv preprint arXiv:1812.02734.

[4] Wenlong Lyu, Fan Yang, Changhao Yan, Dian Zhou, and Xuan Zeng. Batch bayesian optimization via multi-objective acquisition ensemble for automated analog circuit design. In International Conference on Machine Learning, pages 3312–3320, 2018.

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