MASTER INTERNSHIP POSITION

Distributed amplifier improvements: flatness in bandwidth, tunability and new architectures

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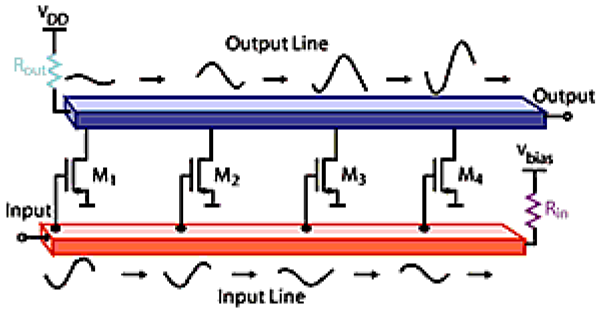
Objectives:

The objectives of this master internship concern the design and layout of innovative and tunable distributed amplifiers of extremely large bandwidth and high gain in silicon technology, for which performing design should pave the way towards state-of-the-art results.

Context for mmW distributed amplifiers and high-Zc slow-wave transmission lines:

According to Cisco´s Global Mobile Data Traffic Forecast Update 2016-2021, the annual Global IP traffic reached $1.2 \cdot 10^{21}$ bytes in 2016, and will reach $3.3 \cdot 10^{21}$ bytes in 2021. To address this issue, millimeter-wave systems (30-300 GHz) are required and so highly performing circuits at such frequencies. Especially, 5G working groups plan to aggregate a large number of physical channels to highly increase the effective data rate of mobile devices. The need for low cost wideband wireline systems developed in bulk technologies is exploding to support the demand in term of cost and bit rate.

When dealing with very high frequencies, distributed approach for active circuits is a good solution. By distributing the amplifying blocks along a transmission line, due to the additive property of distribution, high gain, over 20dB, may be reached while keeping transconductors small enough to reach considerable working frequencies as high as 100 GHz. This research area becomes a strategic field for the achievement of the 5G, especially on silicon. Traditionally, distributed circuits were dedicated to high cost wireline applications and designed using III-V expensive technologies. The high performance of recent commercial CMOS technologies now allows designing distributed circuits at low cost and could be a solution for the next generation of communication systems. In practice, a travelling wave distributed amplifier is presented below. It is based on two propagation lines and several transistors which act as amplifiers. The signal is amplified at each section of the input line and combined in the output line leading to the so-called additive property of distribution.



For accurate distribution over the in- and out- transmission lines whilst keeping a high gain, the transmission lines have to fulfill two requirements: being high-impedance and showing design flexibility. The high-Zc transmission line is a solution and the team involved in this work at the RFIC-Lab already designed and layouted a distributed amplifier in 2018. The drawbacks are the following:

- Surface on the die of almost 1 mm^2
- About 17 dB of gain with + or – 1.5 dB in a large bandwidth of 10-120 GHz. That is to say that half the power can be transmitted only depending on the frequency. Distributed Amplifiers (DA) are suffering from a lack of flatness in their wide bandwidth.
- No gain tunability

<u>Description of the Research Work</u>:

On the basis of the design that has been sent to fabrication in June 2018, integrated into a standard B55-type STMicroelectronics technology, the student will propose a new architecture in order to save room on the die. In practice, the student will first have to impregnate about previous results (state of the art over the several solutions usually implemented to compensate for the phase velocity mismatch, interest for high-Zc). Then he will improve the bandwidth flatness by means of techniques inspired from filtering design (by tapering both transmission lines and actives). Finally, he will propose some solutions for smart tuning. The technology may differ from the B55.

The design of distributed circuits needs the development of skills in the field of passive circuits design (transmission lines, matching, electric and magnetic fields mapping, …) and also in active devices design (amplifiers, and integration considerations, biasing, decoupling, …). Of course, this study will be based on the expertise developed in the laboratory in the field of active millimeter-wave circuits and all the backgrounds that exists in the literature concerning distribution of the amplification.

<u>Skills</u>: Cadence, Matlab, HFSS, HF design, Active circuits, Passive circuits

<u>Perspectives</u>: This internship will be continued by a PHD work in the field of distributed circuits (Amplifier, VCO, …)

<u>Salary:</u> In the framework of the IDEX project for equipment; legal minimum about 530 €/month over February 2019 till June 2019. **To be discussed**.