Master thesis position

Adaptive Distributed Amplifier up to 150 GHz using Machine Learning

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Objectives:

The objectives of this master thesis are to address issues related to amplification for high-data rates such as in-serial links through optical broadband communications. Requirements for amplifiers concern the need for very large bandwidths, above 100 GHz, and gain tunability in order to fit with the minimum necessary power. This ambitious program includes to pursue master thesis with PhD thesis. The work will consist to model, design and layout innovative distributed amplifiers of extremely large bandwidth and high gain in silicon technology. Then a built-in self-test (BIST) for smart tunability and adaptivity will be implemented. Performing design should pave the way towards state-of-the-art results. The master thesis will start with simple theoretical designs and depending on the student appetence it will be oriented towards innovative design or BIST principle.

Context for millimeter-wave distributed amplifiers:

According to Cisco´s Global Mobile Data Traffic Forecast, traffic will reach 282 Exabyte (EB) per month in 2027. This is the traffic if we exclude Fixed Wireless Access (FWA). If we add also FWA, the total mobile data traffic will be 368 Exabyte (EB) per month by the end of 2027. To address this issue, millimeter-wave systems (30-300 GHz) are required and so highly performing circuits at such frequencies. Especially, 6G 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 terms of cost and bit rate. As an example SIMITRANS project is targeting large bandwidth amplification till D-Band, up to 150 GHz.

In parallel, limiting power consumption in communication integrated circuits is a key requirement that goes beyond increasing battery life or reducing the electricity bill. It has been projected that by 2030 more than 25% of the total energy consumption of the planet will be due to communication technologies. In this scenario, reducing the energy consumption of communication systems may have a significant impact on reducing our ecological footprint.

Principle of distributed amplifiers:

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 over 100 GHz. This research area becomes a strategic field for the achievement of the 6G, 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, as shown in Fig. 1, 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. Up to now, drawbacks are the following: surface on the die of almost 1 mm² and no gain tenability.

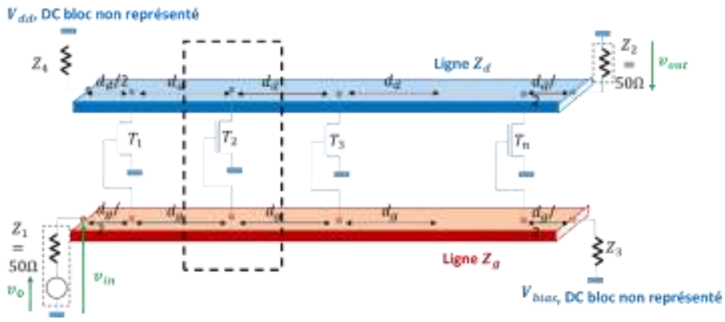

Fig. 1 : Principle of traveling-wave distributed amplifier

Context for BIST:

Self-healing is a technique for improving performance and yield of millimeter-wave integrated circuits against process variation, transistor mismatch, load impedance mismatch, and partial or total transistor failure. This work is widely described and investigated in the literature at the moment, for power amplifiers as an example. In our case, this technique can be used as well in the purpose of adaptive process in order to make the distributed amplifier gain tunable, thus limiting DC consumption. To adjust the performance of the circuit, actuators as well as a feedback loop must be implemented, controlled through a digital algorithm such as machine learning.

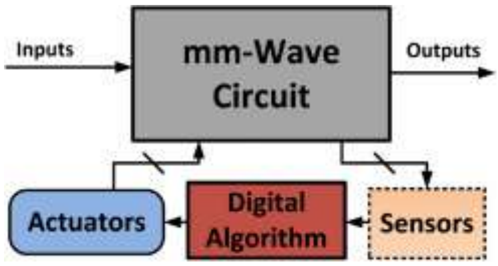

Fig. 2 : Block diagram of a generic mm-wave self-healing system.

Description of the Research Work: On the basis of the standard B55x STMicroelectronics technology, well-suited to millimeter-wave circuits, the student will become familiar with already proposed architectures. Then, he will either investigate design methodology solutions and use them for circuit implementation or find proper solutions for smart tuning, on the basis of already existing or innovative BIST solutions.

Skills: Cadence, Matlab, HFSS, HF design, Active circuits, Passive circuits

Future PhD thesis support: In the framework of CIMITRANS project, TIMA will benefit from a 3-year PhD thesis support. In the framework of SHIFT project, TIMA will benefit from mm² on the die in order to realize millimeter-wave integrated circuits in the B55 technology.

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