Cornell's Wooram Lee Receives SSCS Predoctoral Fellowship for 2010–2011

Wooram Lee, a student of Ehsan Afshari at Cornell University, was awarded the 2010–2011 IEEE Solid-State Circuits Society (SSCS) Predoctoral Fellowship. According to John Corcoran, chair of the Society's fellowship committee, "Wooram Lee has a diverse set of publications in a number of different journals, and one of his recent articles received a Best Paper Award. In addition, he has an outstanding academic record and has already designed and tested four chips. The combination of his breadth and depth make it clear that he has high potential for achievement."

Lee published a paper in the September 2010 issue of *IEEE Journal of Solid-State Circuits* from his research on the first passive CMOS frequency divider based on parametric oscillation in a CMOS process, operating at 20 GHz with very low phase noise.

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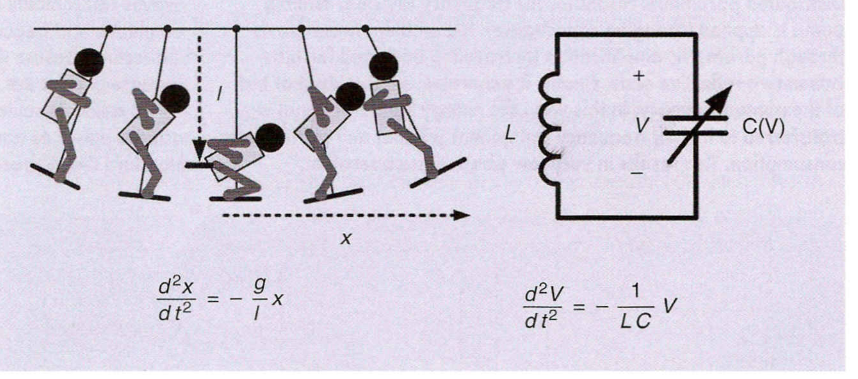


Parametric amplification in a swing and an LC resonator. What is a parametric amplification? Imagine a swing. There are two methods for pumping energy into the system: 1) Having someone push the swing. In that case, the frequency of pushing has to be the same as the swing frequency. 2)Moving the center of mass (changing *l*) periodically. In this case, the frequency of shift of the center of mass has to be exactly the swing frequency. Furthermore, the phase of this shift is critical (hence the amplification is phase sensitive). As shown in the governing equations of a swing and an LC tank, they are exactly the same if *x* and *l* are switched with *V* and *C*. Therefore, we easily show that the voltage can be amplified by changing the capacitance.

DISCOVERY OF RF DESIGN AS AN ENGINEERING "BUFFET"

How I Became Interested in Electrical Engineering

When I was in elementary school, I played with a transistor radio kit. I began by assembling and soldering components on the PCB, following the manual without understanding its operating principles. I had my own soldering machine and a multimeter that my father bought me as birthday gifts. (Unfortunately, I burned out the multimeter because I tried to measure the voltage of an outlet without adjusting the voltage range.)

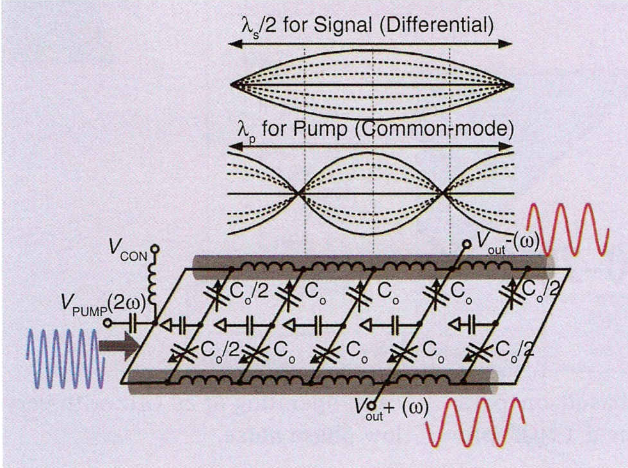
After I entered high school, I was fascinated by the beauty of physics. It was a great joy for me to take different steps toward solving a physics problem: observing an interesting phenomenon, setting a model and equations, and translating the solution back to the physical meaning. Nevertheless, I decided to major in electrical engineering at the university because physics seemed far away from real-world problems, and I found the same kind of joy in electrical engineering as I had in physics.

For me, RF analog circuit design is a perfect area. In the stage of theory development, I can feel like I am a scientist. In the schematic drawing and simulation stage, I perform with an engineering sense. In the layout stage, I become an artist: good RF circuit designs look beautiful due to their symmetry. When I get my chip back after fabrication, I can enjoy an experiment. The whole process is like a buffet that has all the tastes I can feel as a scientist and an engineer.

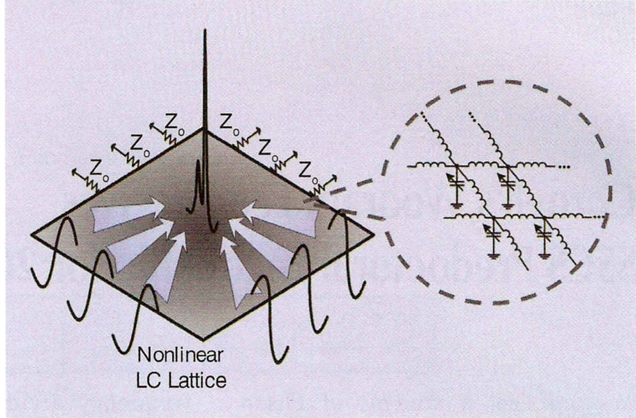
Pursuit of Beauty and Practicality at Interdisciplinary Crossroads

I hope to be a faculty member so I can help young students achieve their goals. Giving them interesting research topics and seeing how they develop them in their own ways will be a great joy to me. Taking a breath with young students in a school will also make me feel younger and refreshed. Academically, I hope to continue straddling the borderline between circuits and different other fields such as physics, biology, and optics. This allows me to enjoy the beauty of the science and the practicality of contributing to the real world at the same time.

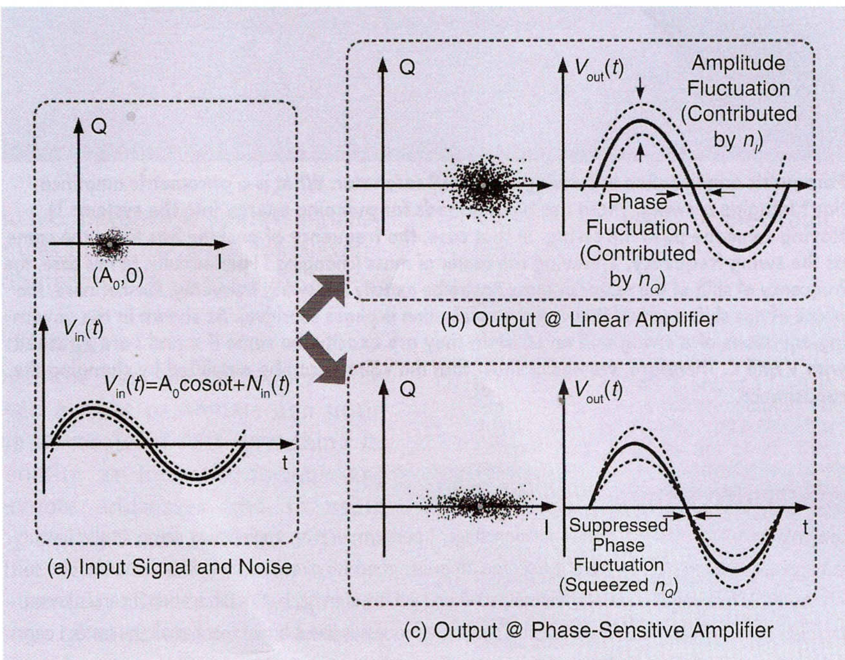
—Wooram Lee



Distributed parametric resonator for frequency division. When a pump is applied (changing capacitance), the ambient noise grows through parametric amplification by traveling back and forth between two reflective ends. Finally, it generates stable output at half of the pump frequency. In this way, the energy from the signal is transferred to its half frequency component without any static power consumption. This results in very low phase noise operation.



Nonlinear 2-D lattice for narrow pulse generation using soliton resonance. We discover that, under certain conditions, two nonlinear waves can combine in a way that an outcoming wave has higher amplitude and frequency than an incoming wave. It's particularly interesting because the medium is completely passive and cannot increase energy. But nonlinearity can localize energy to boost power. This is called as soliton resonance. We have shown that it is possible to achieve pulses as narrow as 1.6 ps with more than 3 V amplitude on standard CMOS process.



Observation of squeezed output noise by phase-sensitive amplification in a time and phase domain compared to linear amplification: (a) input signal, (b) output signal through linear amplification, and (c) output signal through phase-sensitive amplification. Degenerate parametric amplification has an interesting property: phase sensitive gain that results in noise squeezing. The effect of the noise squeezing can be observed in time domain. When noisy input signal is applied to the conventional linear amplifier, the noise is amplified in both directions: amplitude and phase. However, when input is applied to the parametric amplifier, the quadrature noise is suppressed, providing more accurate timing information at the expense of increasing the amplitude noise.

Another paper on a 10-GHz low-noise parametric resonant amplifier, where classical noise squeezing is used for the first time to achieve low-noise amplification in electrical circuits, will appear in the March 2011 issue of *IEEE Transactions on Circuits and Systems I*. A third paper on the nonlinear two-dimensional (2-D)lattice for pico-second pulse generation was published in the July issue of *IEEE Transactions on Microwave Theory and Techniques* as well as in the *Journal of Physics A* in May.

Wooram Lee received the Samsung Graduate Fellowship for 2007–2011 from the Samsung Scholarship Foundation after working as a research engineer specializing in optical transceivers and links at the Electronics and Telecommunications Research Institute (ETRI), Daejeon, Korea, from 2003 to 2007. He received the 2009 IEEE Radar Conference Best Paper Award and the 1996 National Physics Competition Silver Medal. Since 2007, he has been working toward the Ph.D. degree at Cornell University, Ithaca, New York. He received B.Sc. and M.S. degrees in electrical engineering from the Korea Advanced Institute of Science and Technology (KAIST), Daejeon, Korea, in 2001 and 2003, respectively.