

## Errantry report (2015/2/15 – 2015/3/1)

Department of Electrical Engineering and Information Systems

Ph.D. course 2nd year

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I visited five universities in the US from Feb. 15th to Mar. 1st to have presentations at

1. Massachusetts Institute of Technology
2. University of Michigan
3. University of California Los Angeles
4. Stanford University
5. University of California Berkeley

with the title of “Low power and quick start-up crystal oscillator design for IoT application”, and attended ISSCC (International Solid-State Circuits Conference) which is most prestigious conference for solid-state circuit designs held in San Francisco from Feb. 22nd to 26th.

In the presentation at each university, I presented the crystal oscillator designs for a quick start-up and low power operation presented in Symposium on VLSI Circuits 2013 and 2014 for 30-60 minutes. The initial energy in the quartz crystal should be increased to reduce the start-up time. In the presentation, the basic idea and the effect of the chirp modulated noise injection technique were shown to increase the initial energy, and the digitally controlled negative resistance generator with a quick start-up and low power operation is also presented. We had a lot of discussions about the effect of damping resistor, the relationship between the modulated coefficient and the start-up time, the frequency deviation by the chirp modulated noise injection and the negative resistance boost, the tread-off between the start-up time and the implemented area, the modeling technique for the quartz crystal, the design margin with PVT variations, the measurement method for ultra-low power circuits, the linear and low power analog buffer design for large signal operation, the setting of the time step in transient simulation with high-Q resonator, and so on. It is difficult to ask and study these topics in journal papers and conferences; therefore, this visit and the presentation were quite valuable opportunity to learn the complicated and practical knowledge. After that, we visited and discussed at a measurement room and a student room for our researches and the dairy life in the graduate school.

Finally, I would like to express the gratitude for my supervisors (Prof. Sakura and Prof. Takamiya), MERIT project. The assistances are very helpful to get the very valuable opportunity in this tour.