An Ambient RF Energy Harvester With Integrated Power Management Unit
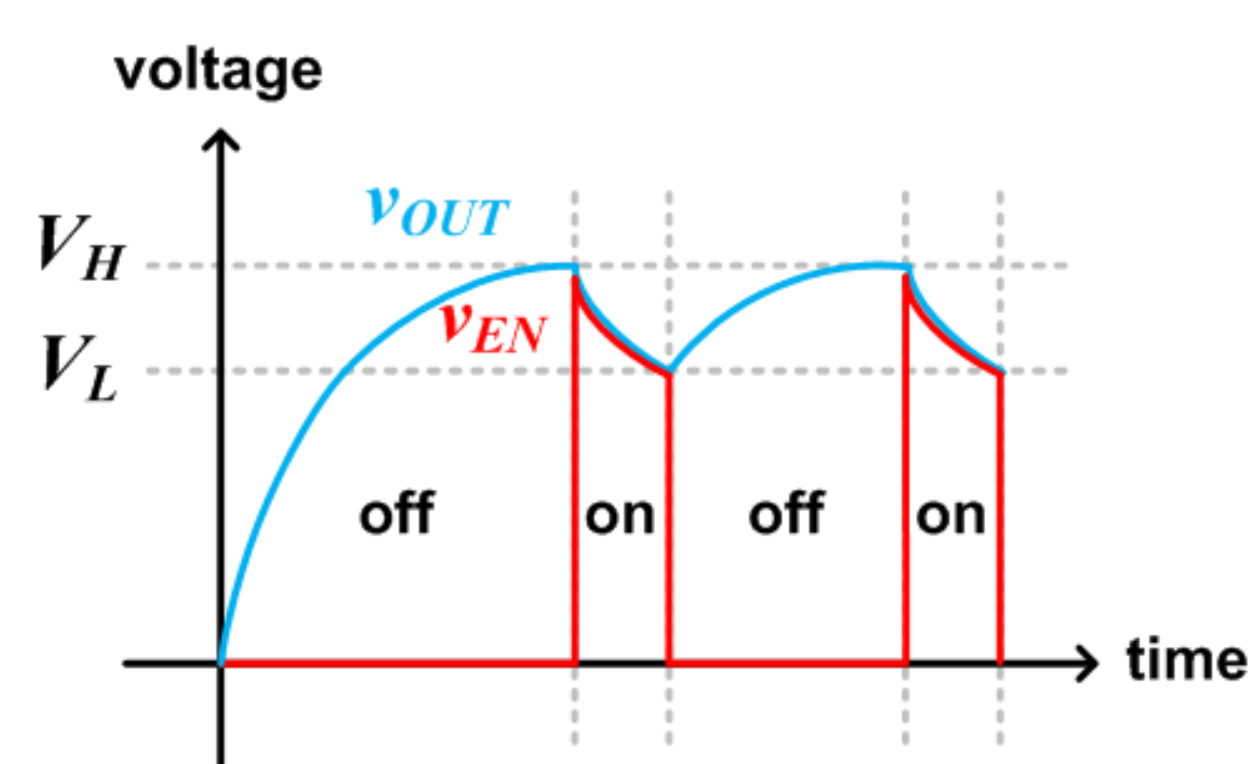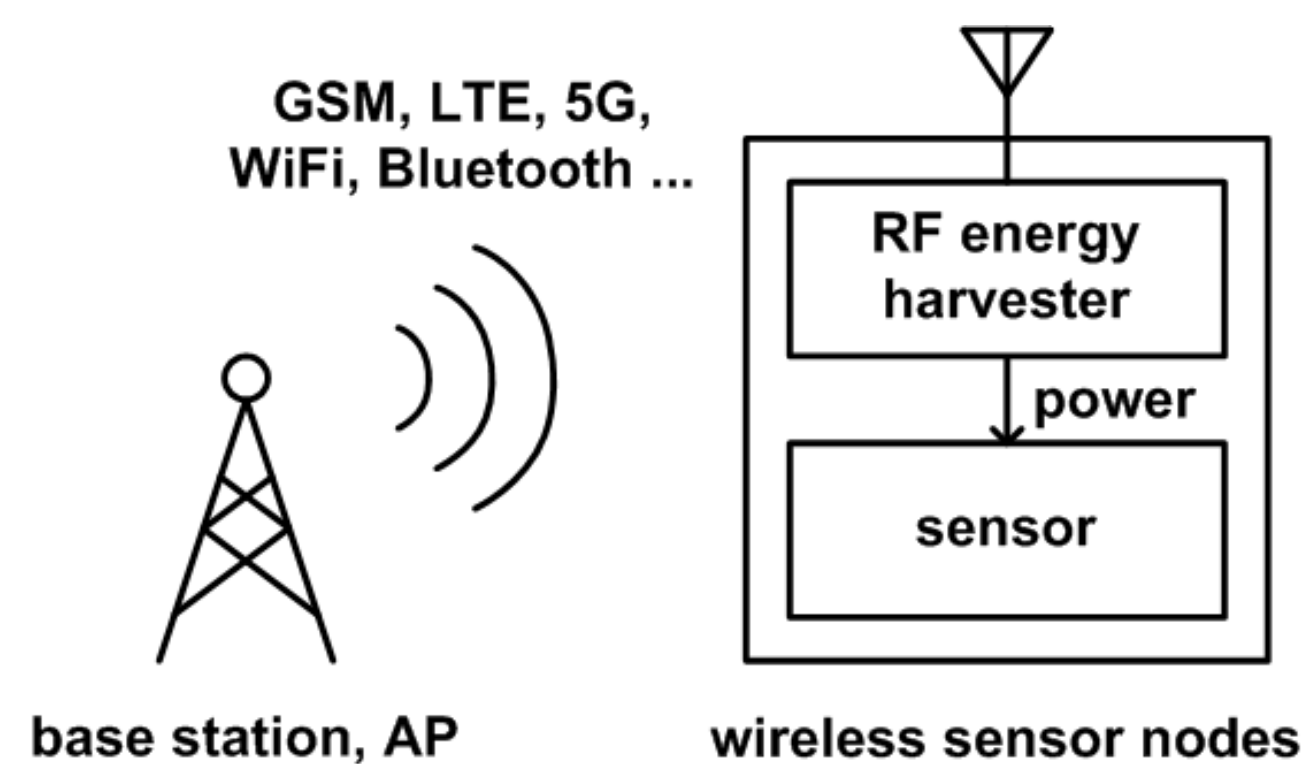
Yoomi Park, Hyeonsoo Seung and Sangjin Byun
Department of Electronics and Electrical Engineering, Dongguk University

INTRODUCTION
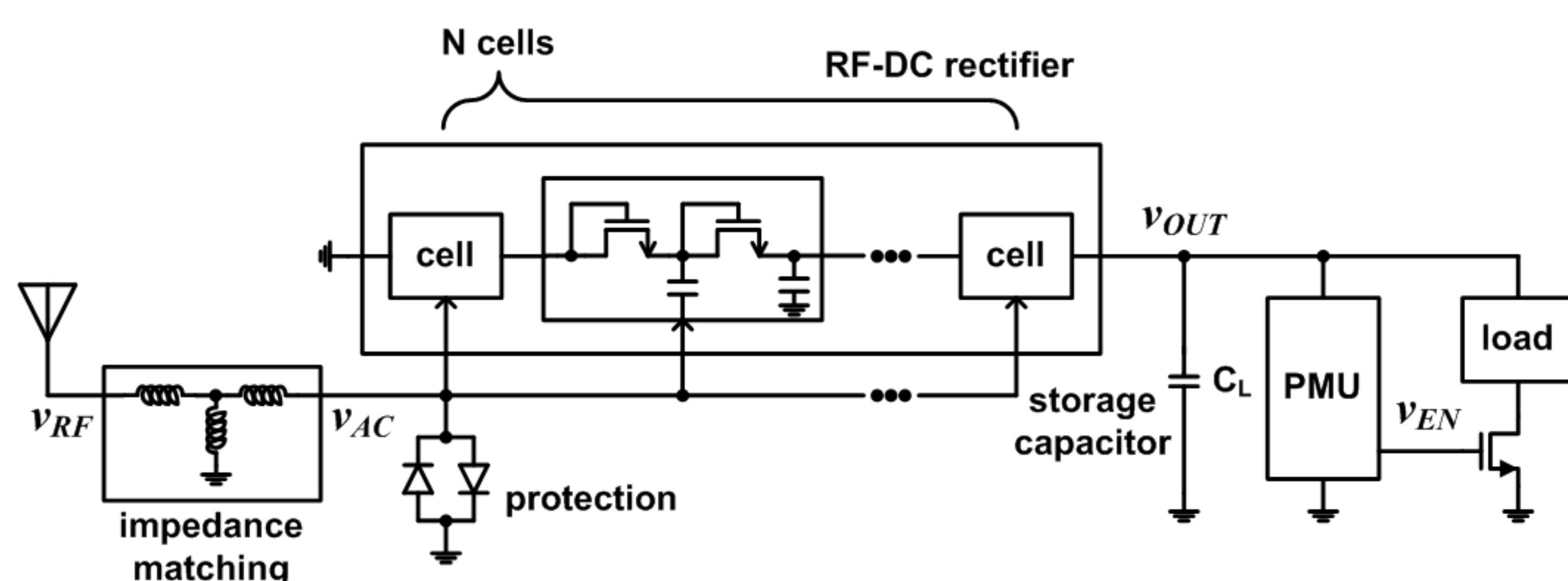
Ambient RF Energy Harvester

Duty-Cycled Operation

- For ambient RF energy harvesters, the available power from ambient RF signals is typically lower than the power required for sensing and data transmission
- Thus, it should supply power to the load in duty cycle to harvest enough energy
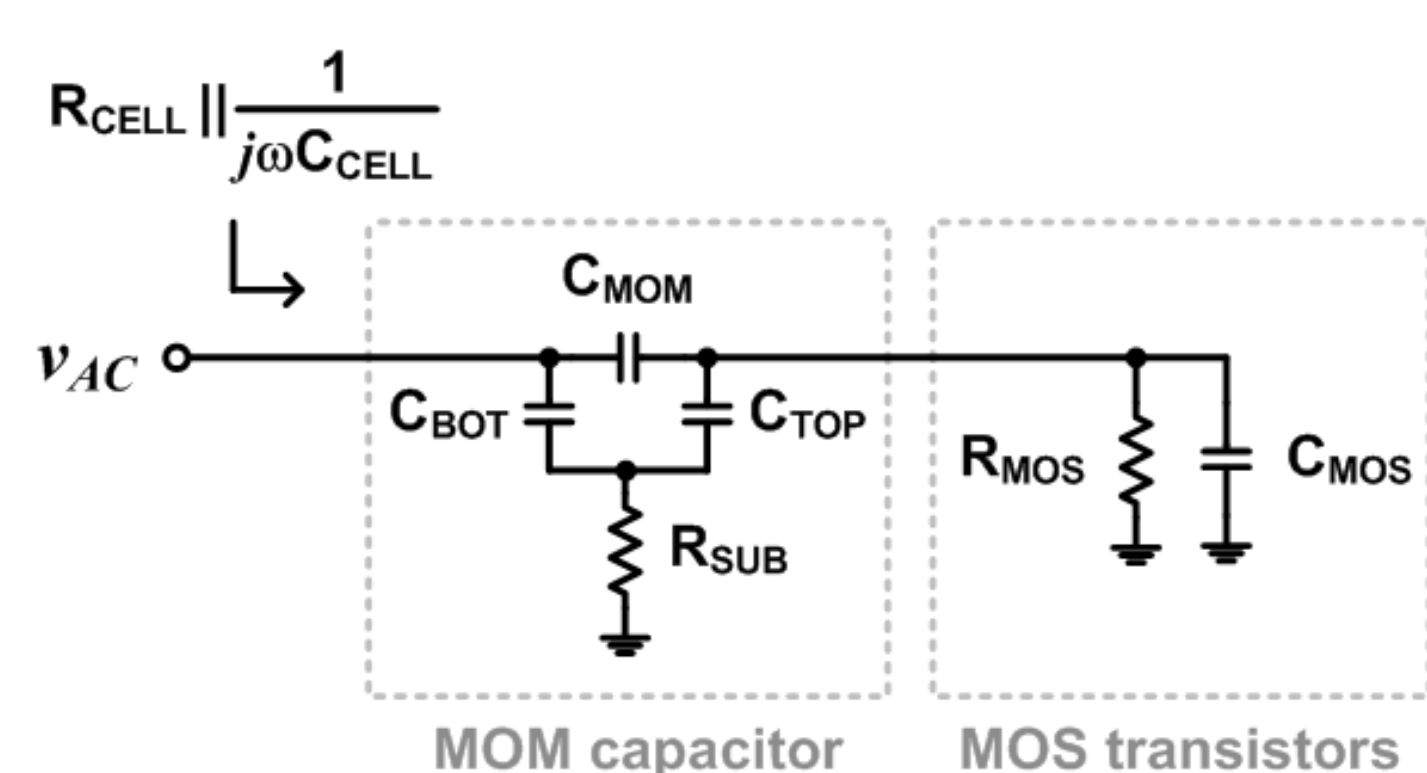
IMPLEMENTATION

Architecture of the Ambient RF Energy Harvester

- Impedance matching network with high quality factor (> 70)
- RF-DC rectifier composed of N rectifier cells for high input sensitivity (> −40dBm)
- Power management unit operating with ultra low power consumption (< 1nW)

RF-DC Rectifier

MOM capacitor   MOS transistors
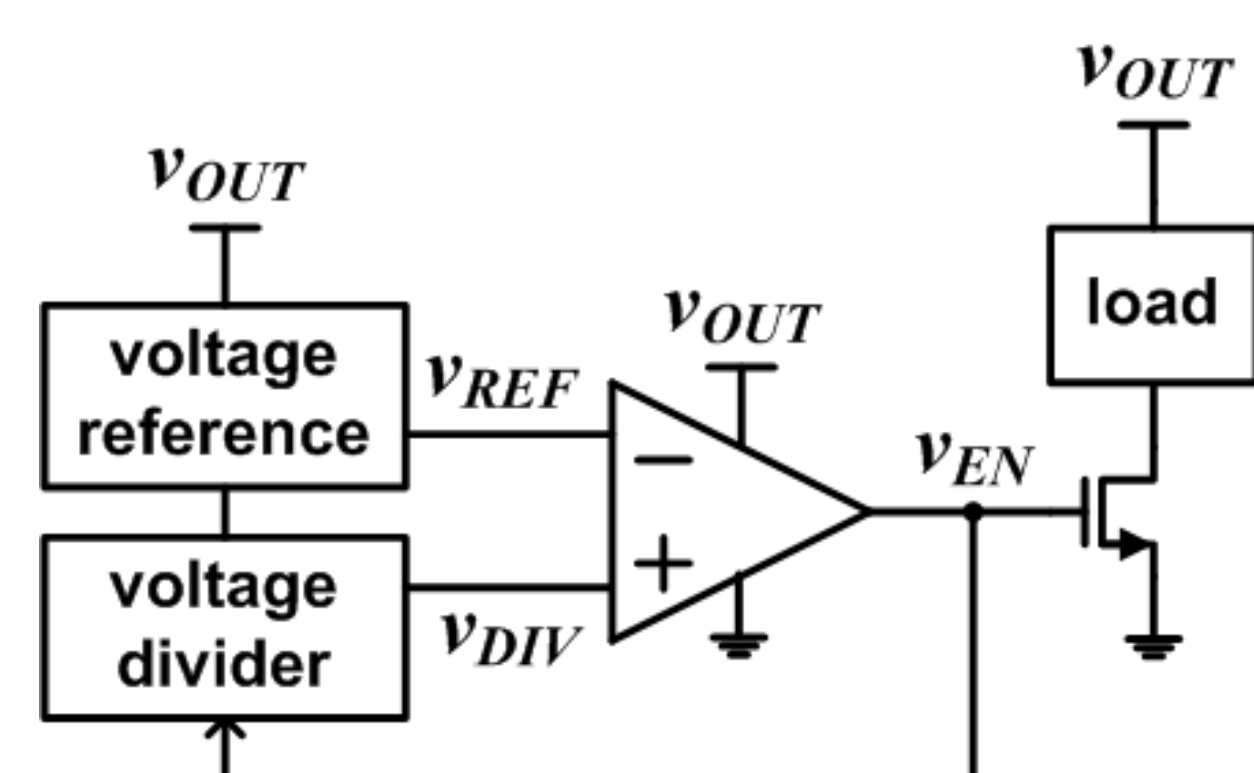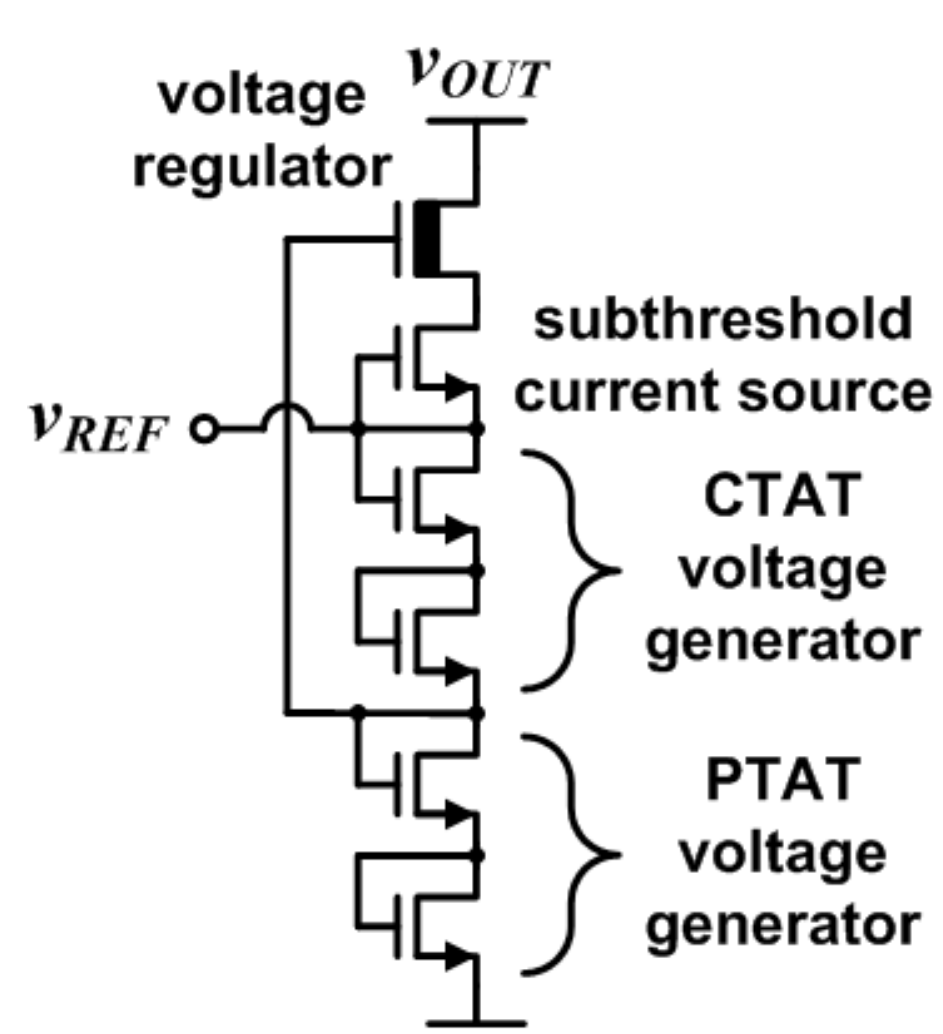
$$R_{CELL} \approx R_{MOS} || R_{SUB}(1 + Q^2)$$
$$\text{where } Q = \frac{1}{\omega(C_{TOP}+C_{BOT})R_{SUB}}$$
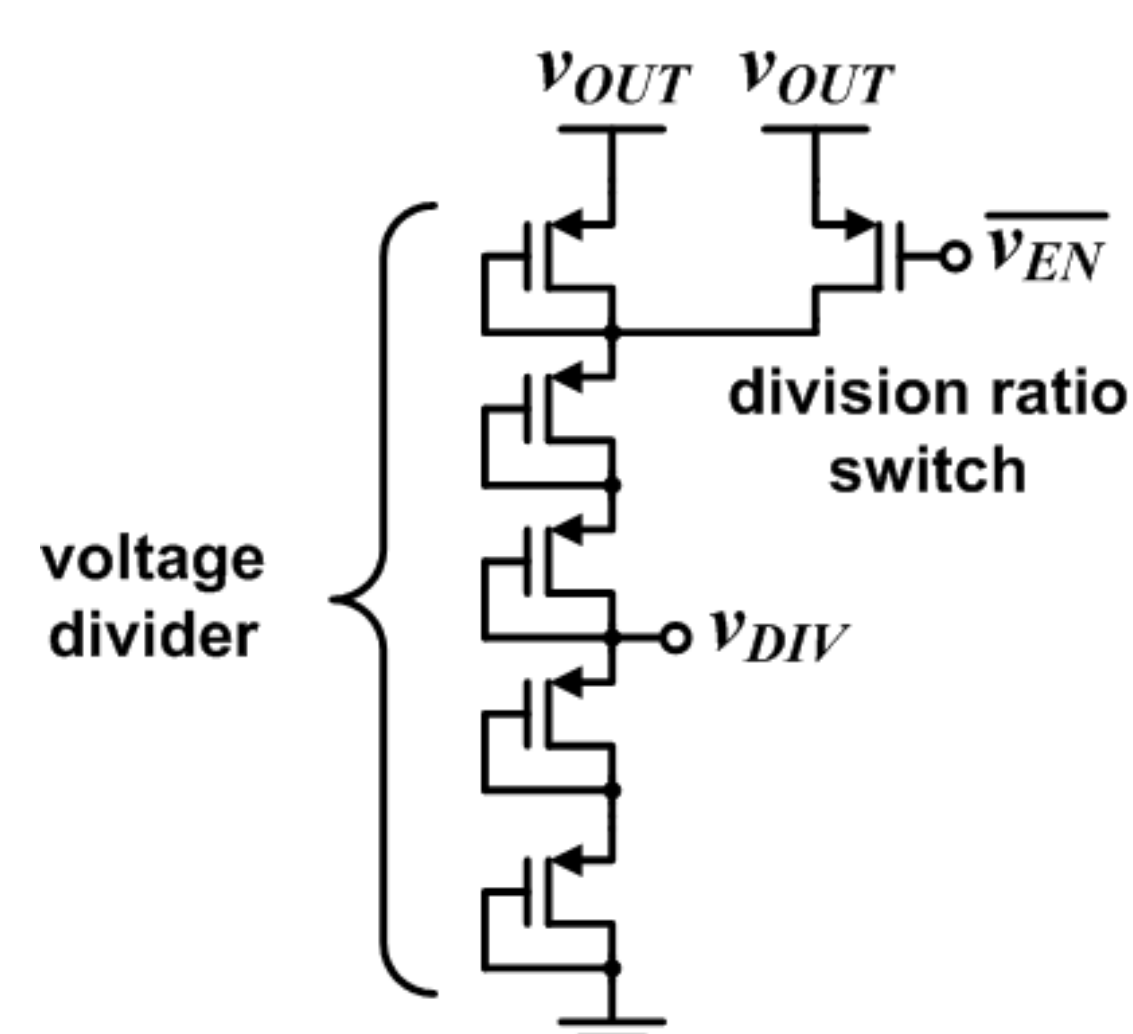
Power Management Unit

v_{EN} goes high when $v_{DIV} > v_{REF}$ and voltage divider makes hysteresis

Voltage Reference

Temperature variation is compensated by using different types of transistors
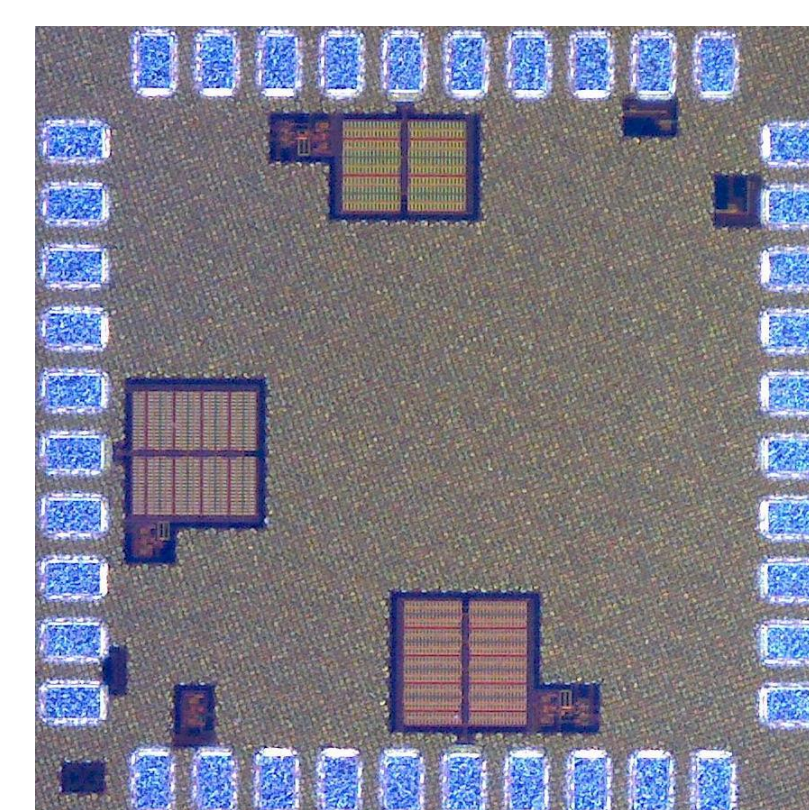
Voltage Divider

Voltage division ratio is changed by using the load enable signal
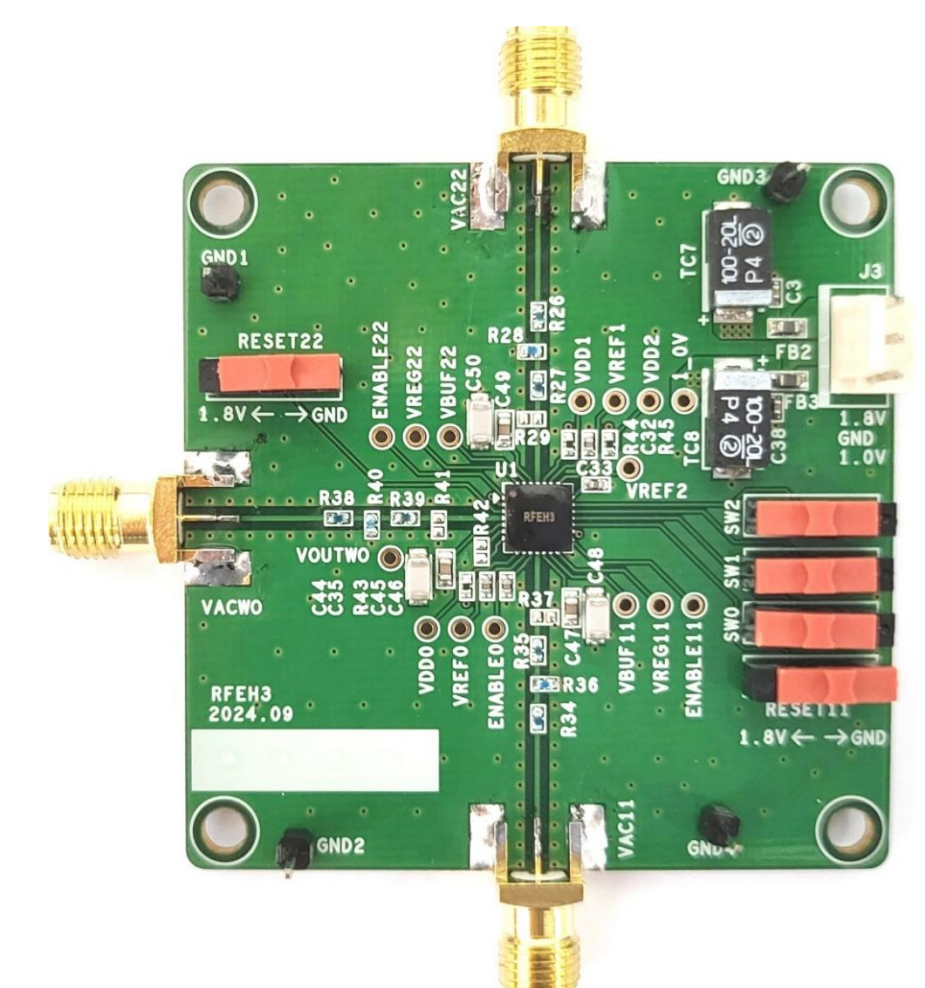
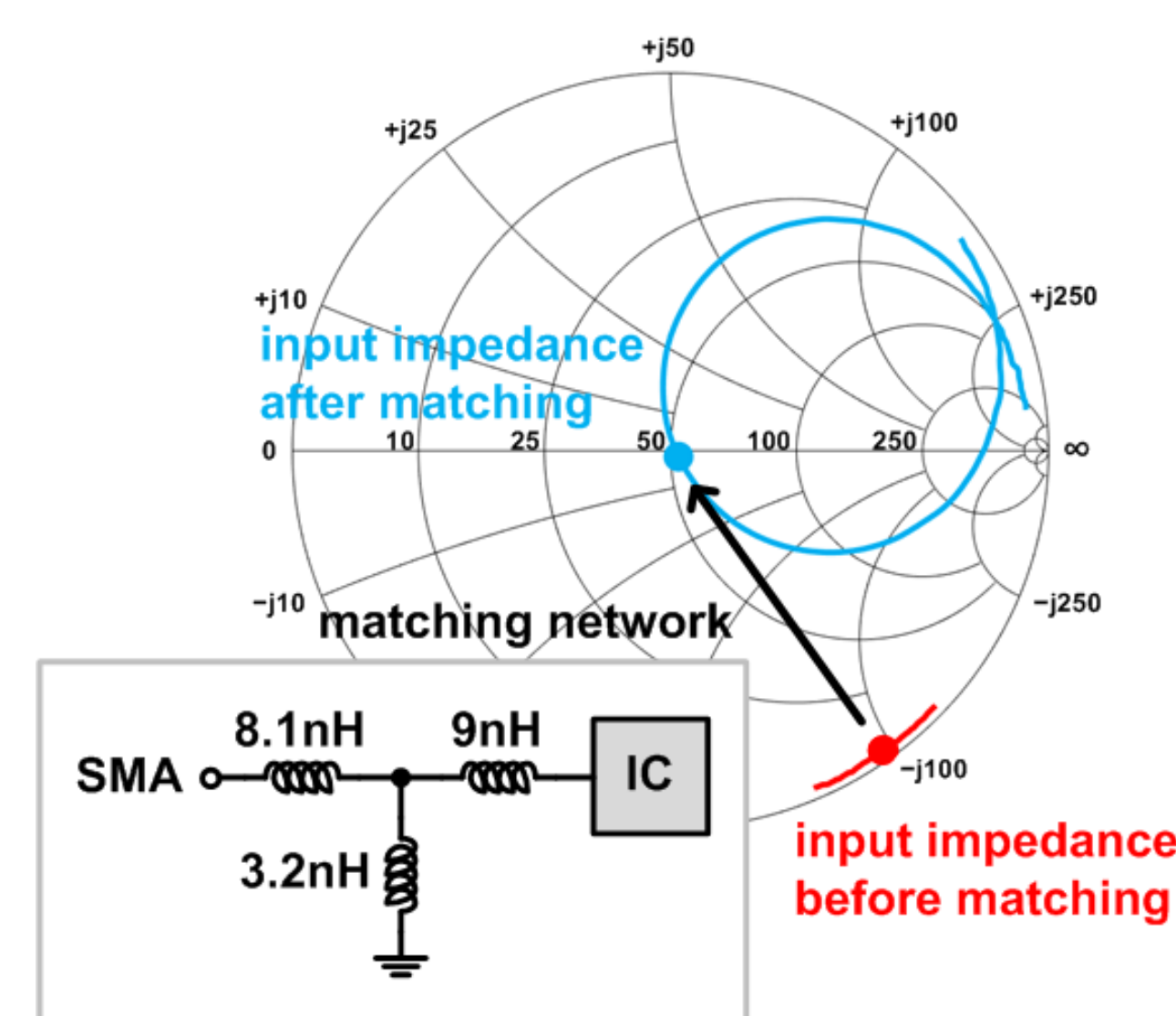## MEASUREMENT

Die Photo

Samsung 28nm 1P11M CMOS
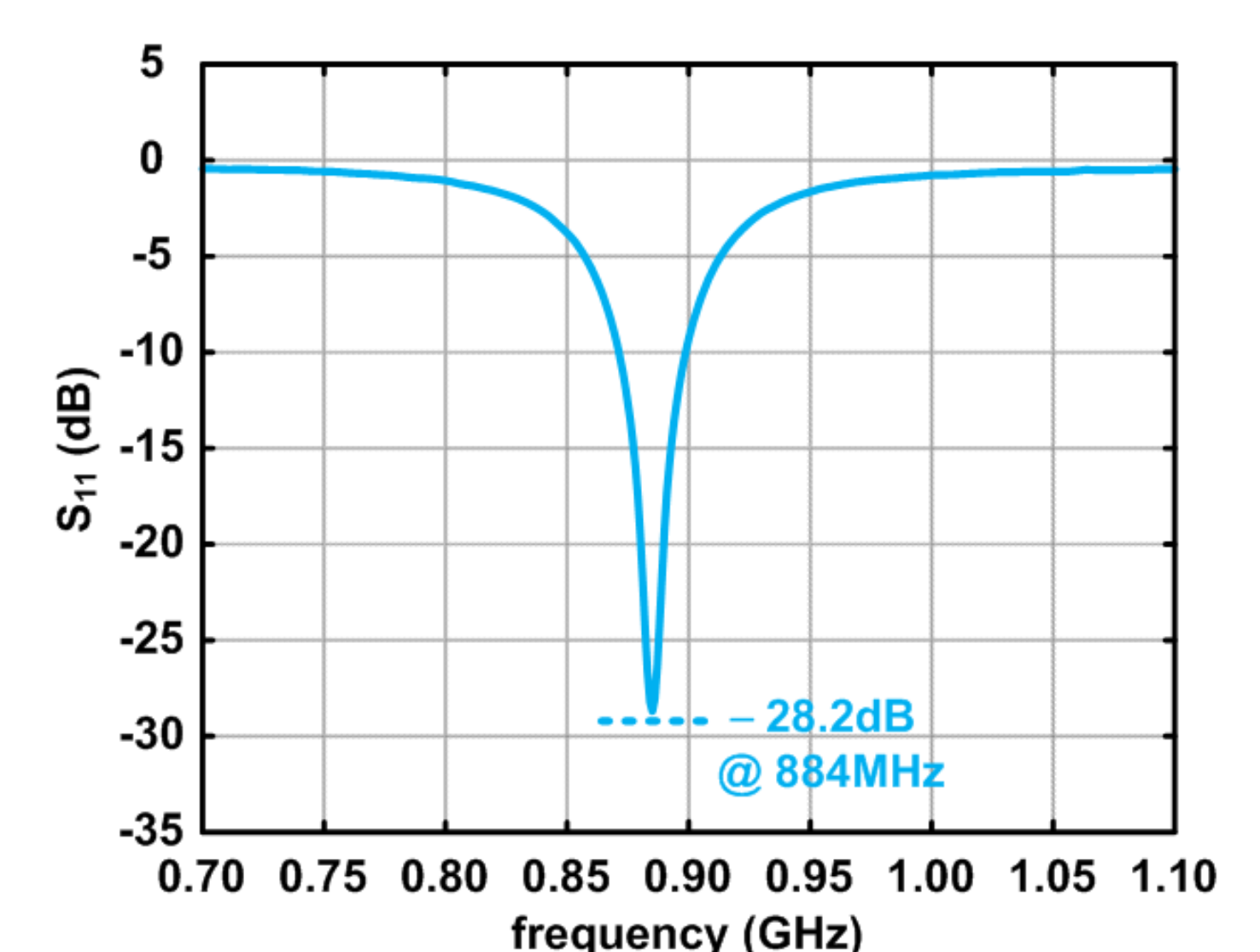Active area: 217um x 203um

Test Board

28 pin QFN 5mm x 5mm
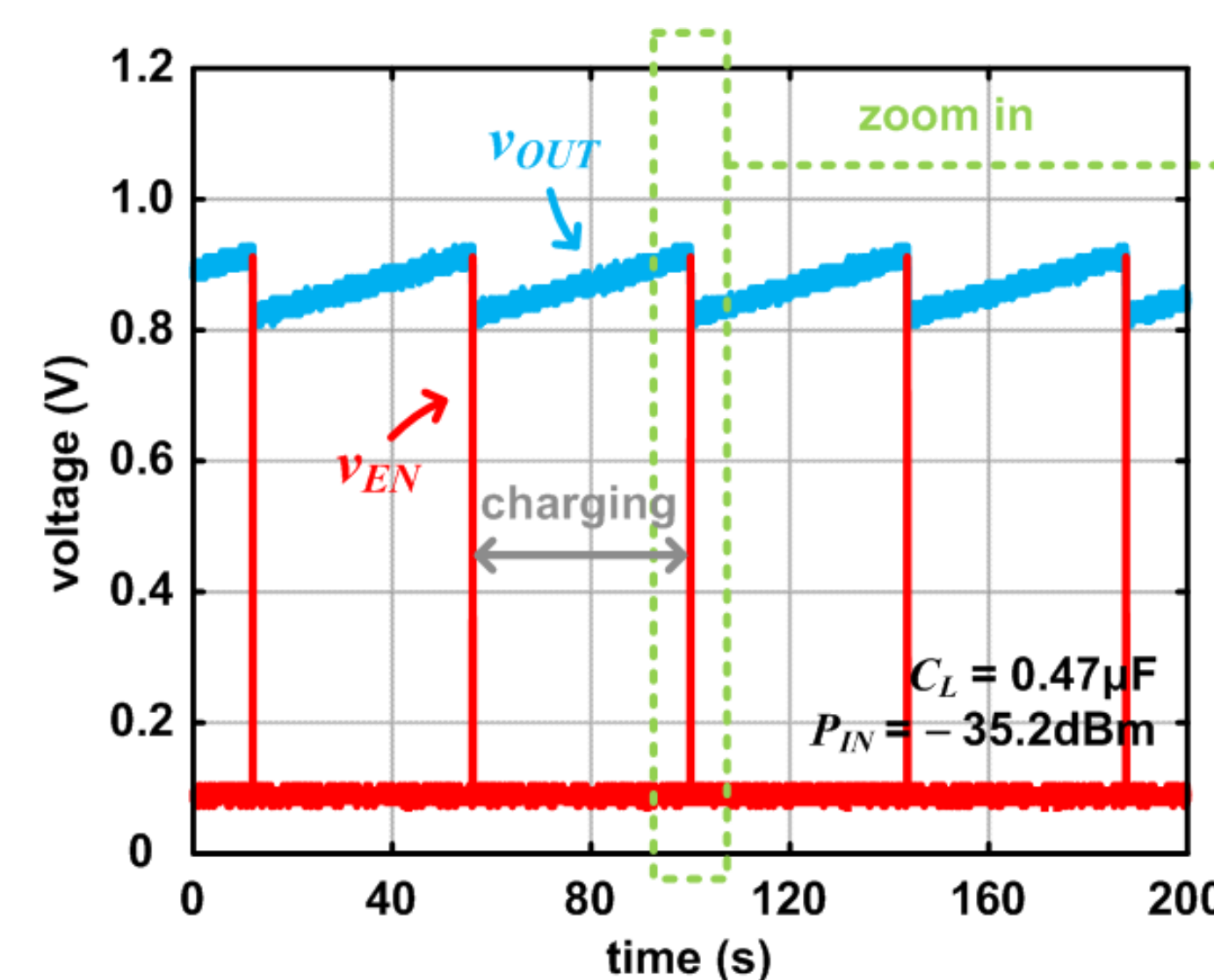4 layer FR4 PCB

Impedance Matching Network
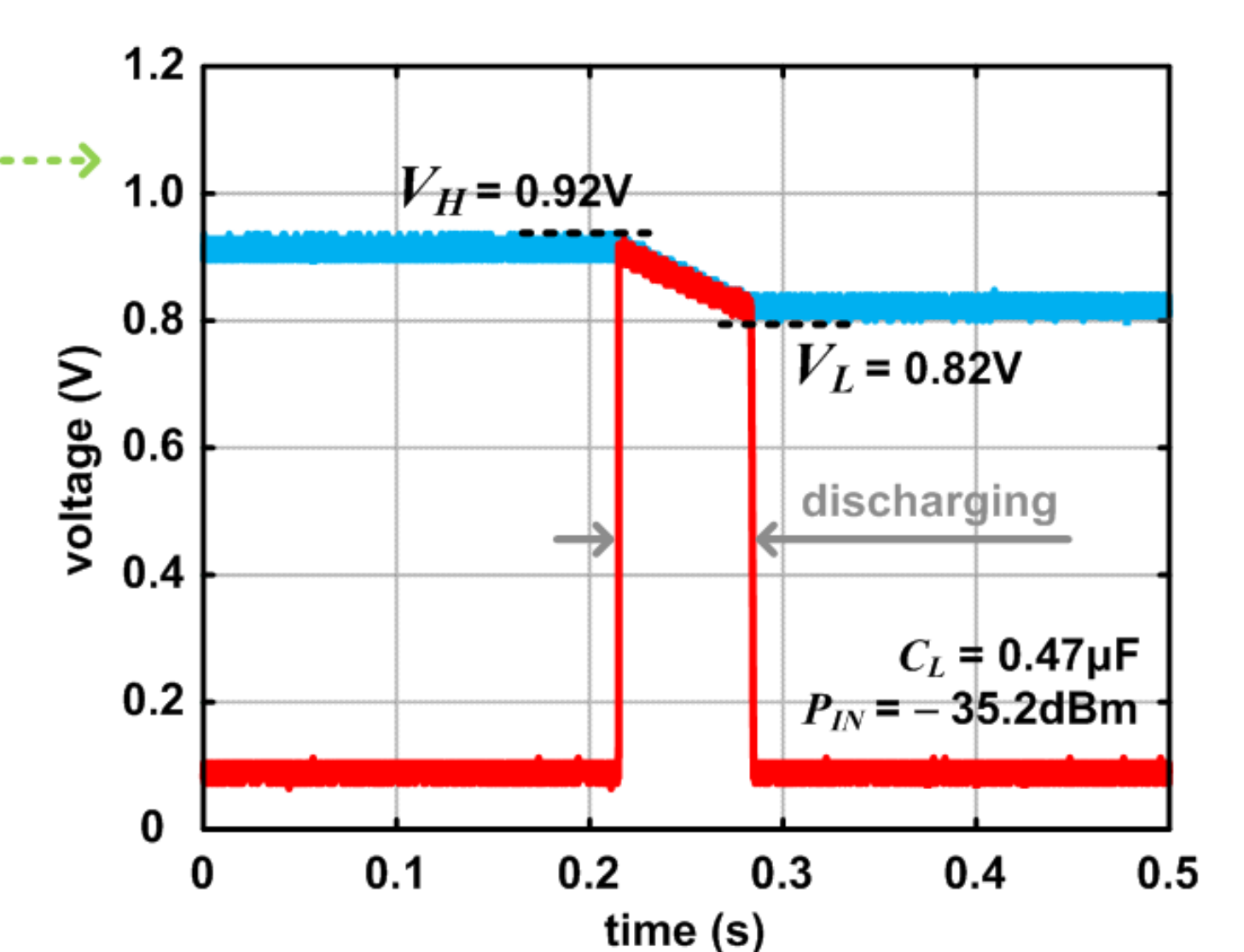

Passive gain = 8.6V/V @ −40dBm

Scattering Parameter

−10dB bandwidth = 27.5MHz

Transient Waveform of the Output Voltage

Charging time = 43.7s

Discharging time = 68.3ms @ 1MΩ

CONCLUSION

Performance Summary

	TMTT 21	TMTT 24	TCASI 24	TCASI 25	JSSC 25	this work
CMOS technology	130nm	28nm	28nm	55nm	65nm	28nm
RF frequency	0.868GHz	0.970GHz	0.884GHz	0.915GHz	2.4GHz	0.884GHz
active die area	0.047mm²	0.025mm²	0.09mm²	0.027mm²	0.7mm²	0.047mm²
self-powered PMU	X	X	X	O	O	O
output DC voltage	1V	1V	1V	1V	1.2V	0.87V
input sensitivity	-31dBm	-36.5dBm	-41.8dBm	-31dBm	-28.5dBm	-40.8dBm

- The ambient RF energy harvester has been fabricated in a 28nm CMOS process
- The self-powered PMU with the low current consumption has been integrated
- The implemented ambient RF energy harvester shows the high input power sensitivity of −40.8dBm for 0.87V while the power management unit is operating