The 11th SEMBA (5370)

Energy Harvesting Interface for Soil Energy Harvesting with Maximum Power Point Tracking

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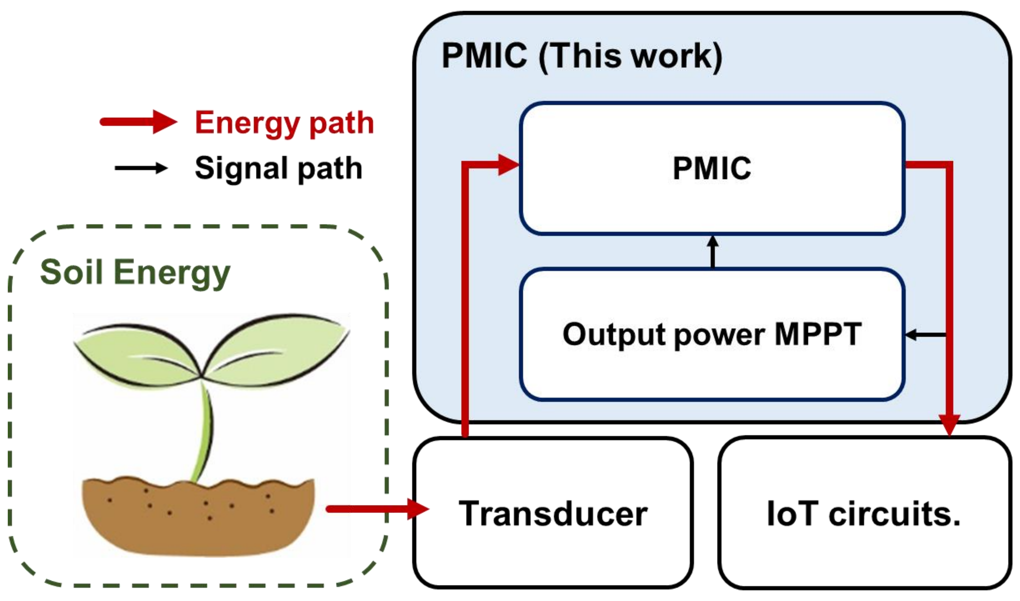
Introduction

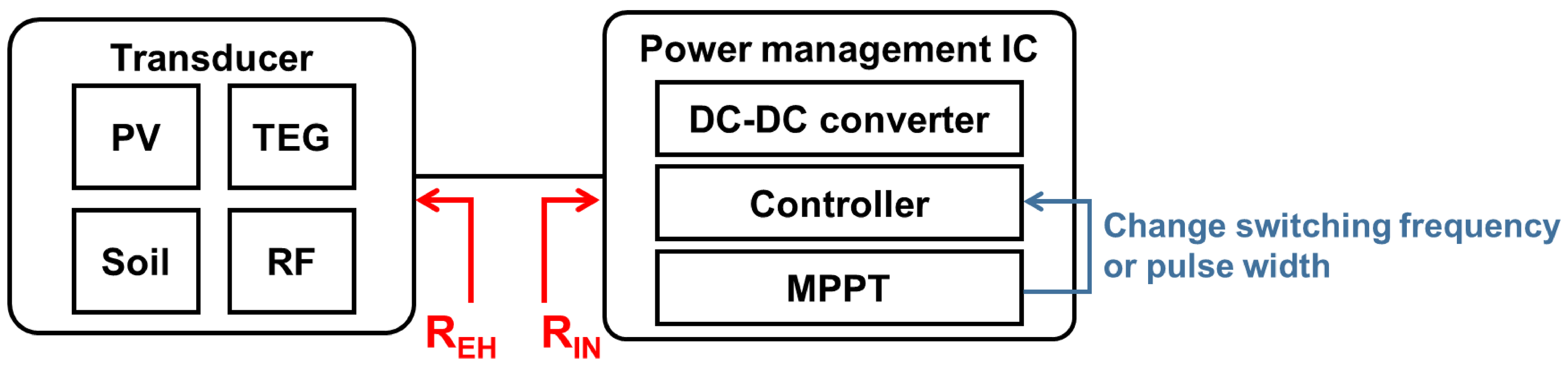
❑ The proposed power management IC

- Soil energy as input power
- Collect soil energy and convert it to the target DC voltage for IoT application.
- Input voltage range is 0.3V to 0.6V.
- Output voltage range is 1.6V to 1.8V.
- Output power maximum power point tracking (MPPT)



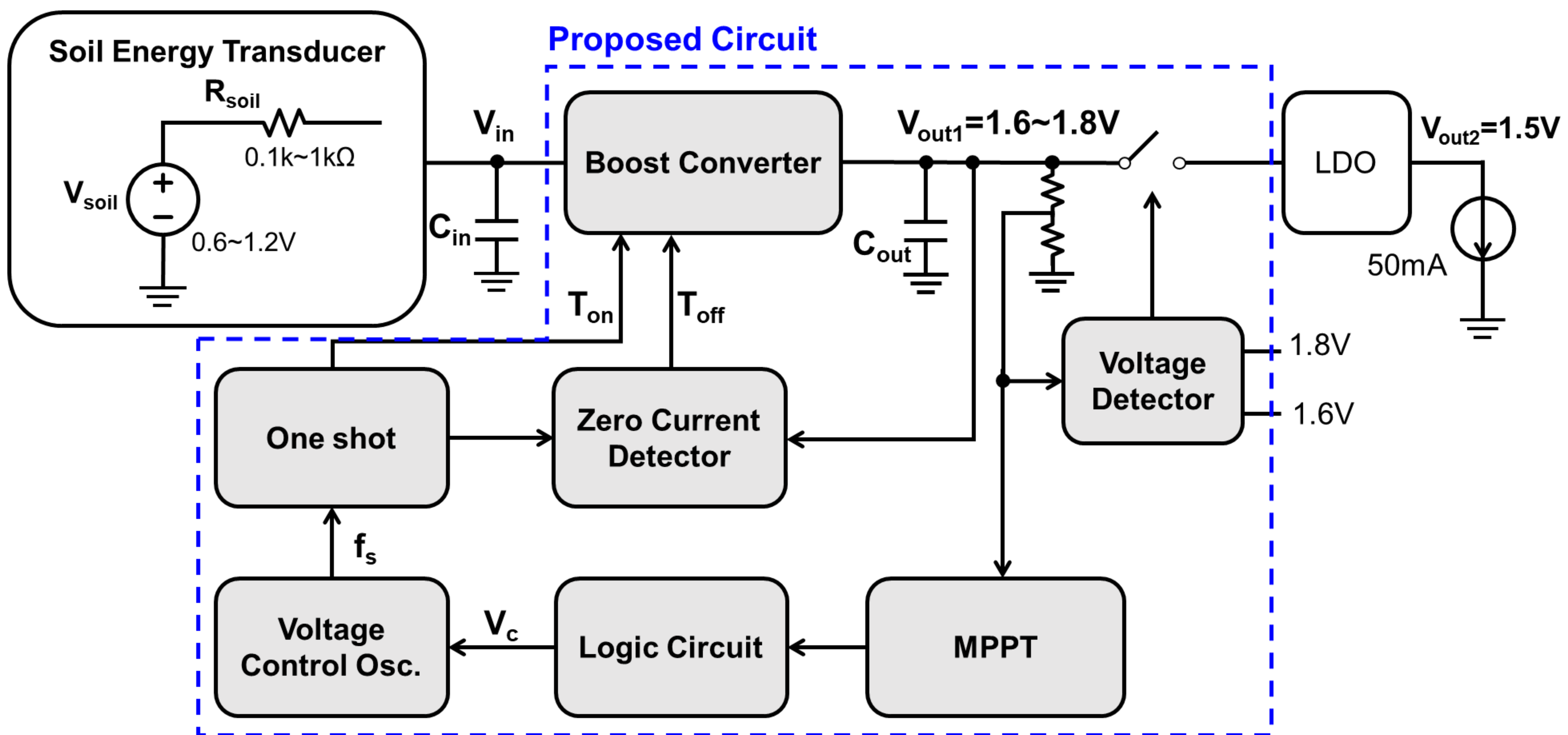
❑ The concepts of traditional MPPT

- The energy harvesting system is low input power and wide-range condition of environment.
- If the system reaches impedance matching(R_{EH}=R_{IN}), it can get maximum power from transducer.
- Track the power from the transducer.
- Dynamically adjust the PMIC to get maximum input power.



System Architecture

❑ Block diagram of proposed system



- Soil energy transducer models as a series of voltage source and resistance.
- Boost converter boosts the input voltage to higher DC voltage.
- MPPT tracks the power of V_{out1} and modifies the system frequency(f_s).
- Zero current detector (ZCD) avoids the reverse inductor current in low-power operation.

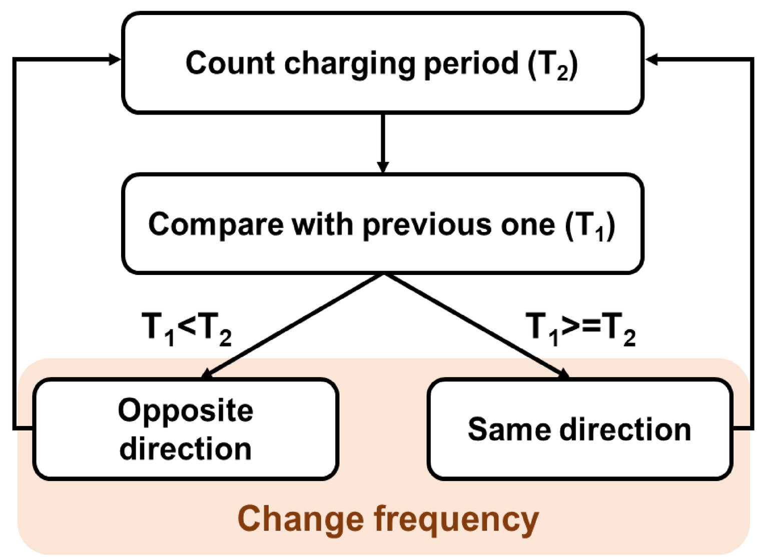
Proposed MPPT

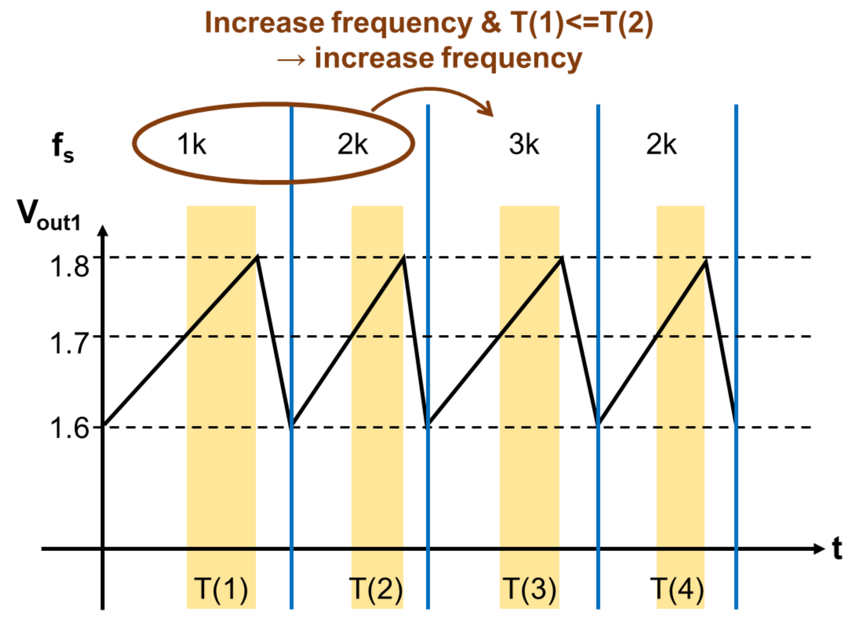
❑ Track output power

- Count the period of V_{out1} charged from 1.7V to 1.8V.
- The power loss in PMIC is concerned in MPPT.

❑ Only digital logic circuit

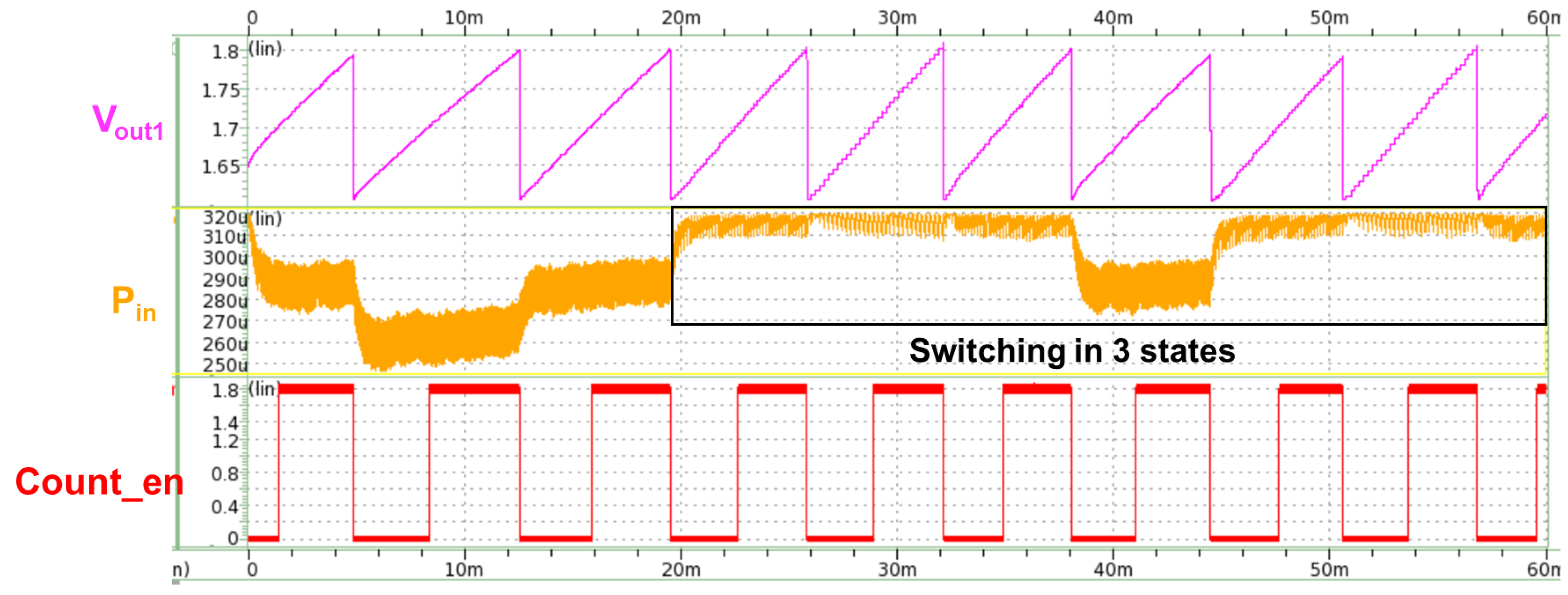
- Low power and easy to implement





Simulation Results

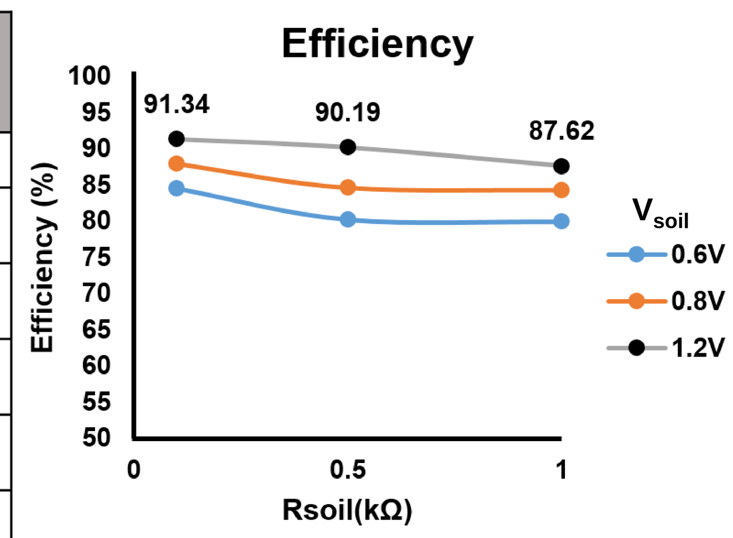
❑ Achieve MPPT waveform



❑ Comparison

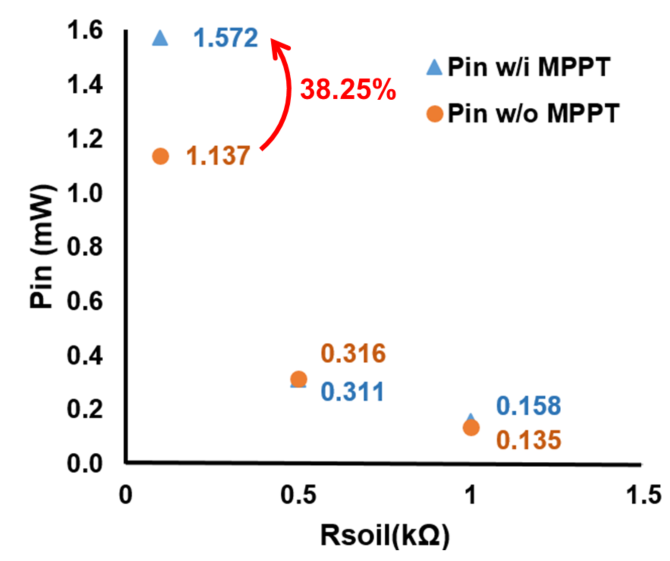
	Sens. J.'19	TPE'13	JSSC'15	This Work
Technology	0.18um	0.35um	0.18um	0.18un
Input Voltage	0.4V-0.5V	0.07V-0.6V	-	0.3V-0.6V
Output Voltage	1.8V	3V-5.8V	1V, 1.8V, 3V	1.6V-1.8V
Converter	Capacitive	Inductive	Inductive	Inductive
Energy Source	Soil	Thermal	Solar	Soil
Peak Efficiency	88%	72%	83%	91.34%
MPPT	2D-MPPT (Capacitor Charge Time)	Open Circuit Voltage	Perturb & Observe	Improved Capacitor Charge Time

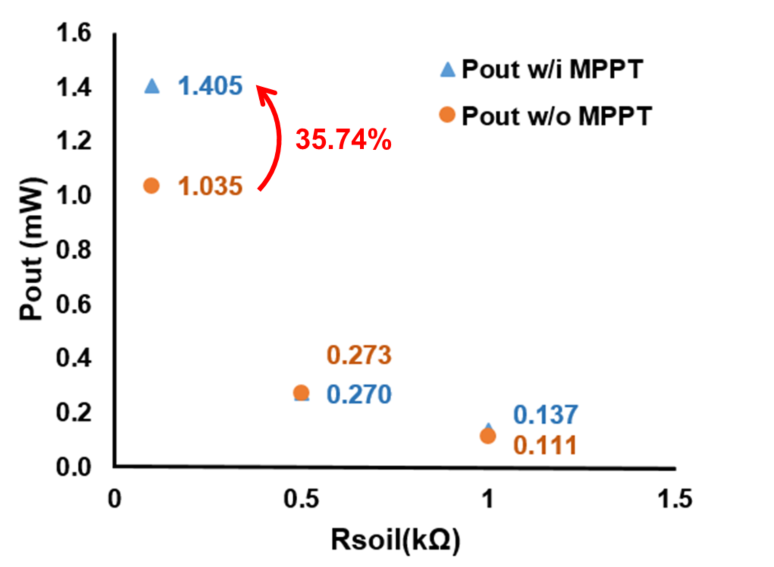
❑ Efficiency



Under different input conditions

❑ Power w/i and w/o MPPT





Reference

❑ I. -C. Ou et al., "Self-Sustaining Soil Electrical Conductance Measurement Using a DC–DC Power Converter," in *IEEE Sensors Journal*, vol. 19, no. 22, pp. 10560-10567, 15 Nov.15, 2019.

❑ J. Kim and C. Kim, "A DC–DC Boost Converter With Variation-Tolerant MPPT Technique and Efficient ZCS Circuit for Thermoelectric Energy Harvesting Applications," in *IEEE Transactions on Power Electronics*, vol. 28, no. 8, pp. 3827-3833, Aug. 2013.

❑ G. Yu, K. W. R. Chew et al., "A 400 nW single-inductor dual-input–tri-output DC–DC buck–boost converter with maximum power point tracking for indoor photovoltaic energy harvesting", *IEEE J. Solid-State Circuits*, vol. 50, no. 11, pp. 2758-2772, Nov. 2015.