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A Single-Inductor Triple-Output Buck-Boost Converter with Output Ripple Control for Wearable Devices

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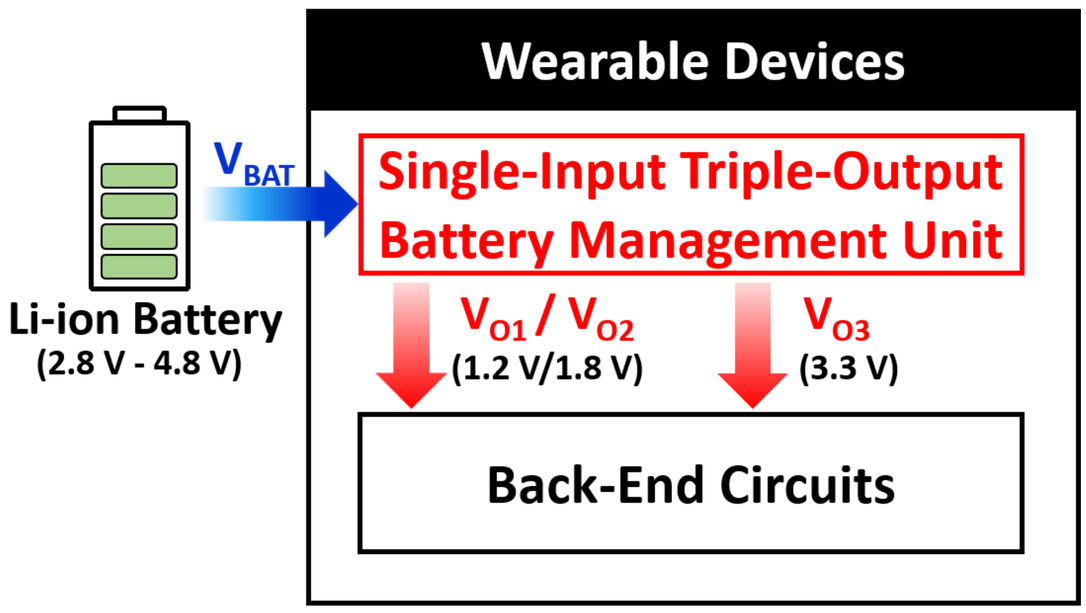
Introduction

- A single-input triple-output (SITO) battery management unit regulates triple output voltages for different back-end circuits.
- Target input voltage: V_{BAT}= 2.8V - 4.8V
- Target output voltage: V_{O1}= 1.2V, V_{O2}= 1.8V, V_{O3}= 3.3V



System Architecture

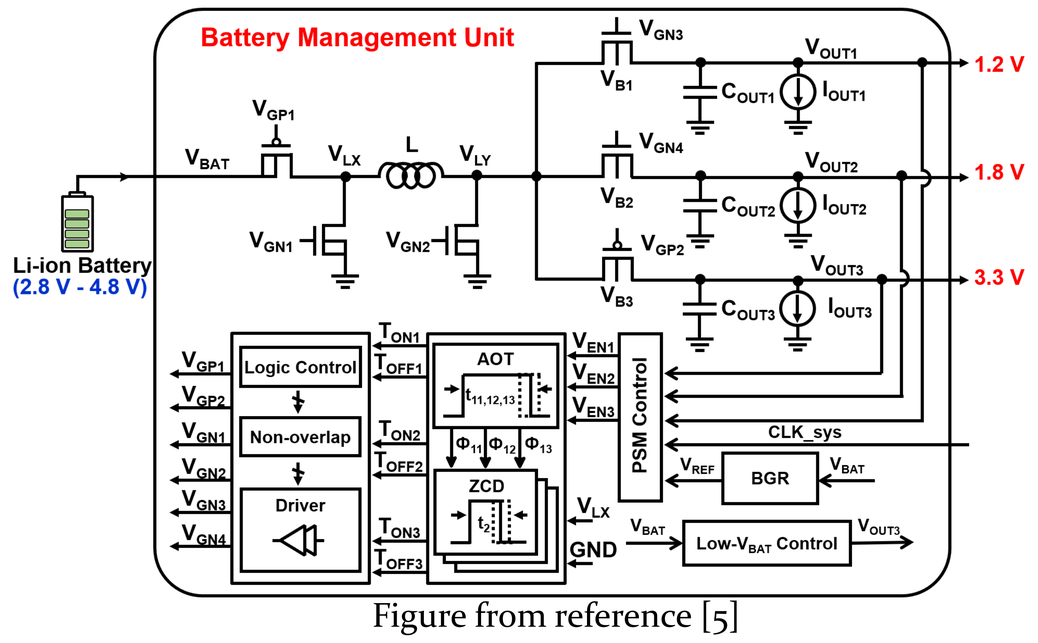


Figure from reference [5]

- The proposed SITO battery management unit provides three different regulated outputs using a shared off-chip inductor and three off-chip capacitors.
- The PSM controller decides which output channel needs to be powered according to the output voltage level.

Characteristics

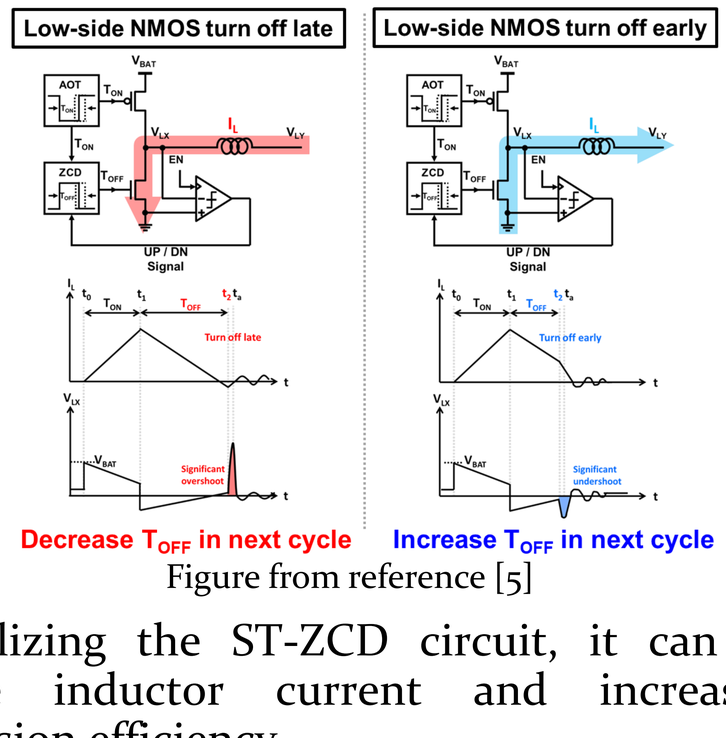


Figure from reference [5]

- By utilizing the ST-ZCD circuit, it can minimize reverse inductor current and increase power conversion efficiency.

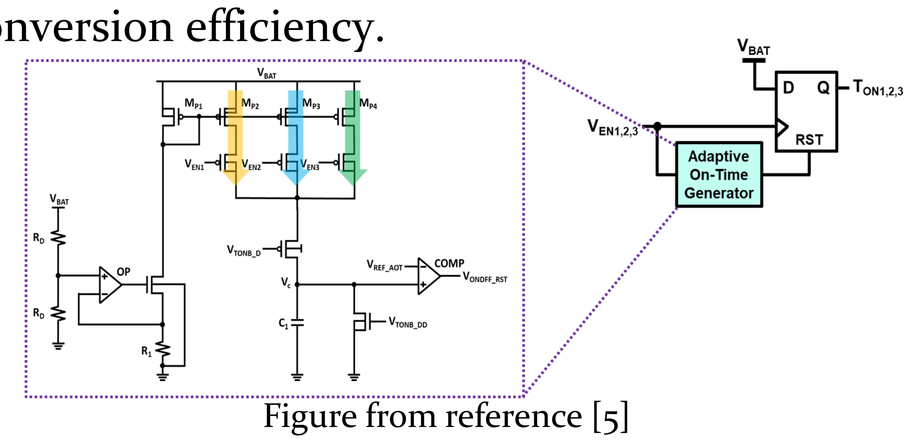
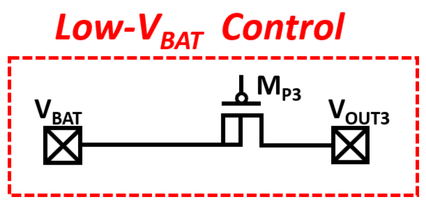


Figure from reference [5]

- AOT generator is used to maintain output power range and output ripple with different V_{BAT}.



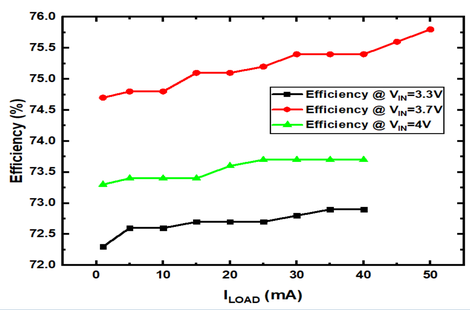
- The low-V_{BAT} control shorts V_{BAT} and V_{OUT3} together to save energy when VBAT is lower than the third output channel (3.3V).

Measurement Results

- Comparison to recently reported works [5]

	JSSC 2011 [1]	TPEL 2016 [2]	ICECS 2018 [3]	TCAS-II 2019 [4]	This Work
Technology	45 nm CMOS	90 nm CMOS	180 nm CMOS	180 nm CMOS	180 nm BCD
Input voltage	2.8V~4.2V	1.8V ~ 4.2V	3.4V~5V	3.2V ~ 4.8V	2.8V ~ 4V
# of output	1	1	2	3	3
Output voltage	0.4V~1.2V	0.9V~1.4V	3V / 2V	2V / 6V / -6V	1.2V / 1.8V / 2.8V~3.3V
Regulated mechanism	PFM+PWM	PFM	PSM	PSM	PSM
Inductance	10uH	4.7uH~10uH	4.7uH	4.7uH	1uH
Output capacitance	2uF	2.2uF~10uF	N/A	10uF	10uF
Output ripple	20mV	20mV	N/A	> 100mV	< 30mV of V_{OUT1} < 30mV of V_{OUT2} < 60mV of V_{OUT3}
Maximum output power	100mW	56mW	65mW	40mW	315mW
Peak efficiency	87.4%	86.2%	93.6%	82.9%	75.8%

- The converter achieves maximum efficiency of 75.8% with an 1μH inductor under V_{BAT}= 3.7V, $I_{LOAD1,2,3}$ = 50mA [5].



Reference

- [1] S. Bandyopadhyay, Y.K. Ramadass, and A.P. Chandrakasan, "20μA to 100mA DC-DC Converter with 2.8 to 4.2V Battery Supply for Portable Applications in 45nm CMOS," in Proc. IEEE Int. Solid-State Circuits Conf. Dig. Tech. Papers (ISSCC), Feb. 2011, pp. 386-387.
- [2] W. Fu, S. T. Tan, M. Radhakrishnan, R. Byrd, and A. A. Fayed, "A DCM-only buck regulator with hysteretic-assisted adaptive minimum-on-time control for low-power microcontrollers," IEEE Trans. Power Electron., vol. 31, no. 1, pp. 418-429, Jan. 2016.
- [3] P.-C. Liao, Y.-L. Chen, and P.-H. Chen, "A Single-Inductor Dual-Output (SIDO) DC-DC Converter for Implantable Medical Devices in 180nm Standard CMOS Process," in Proc. IEEE Int. Conf. Electron., Circuits Syst. (ICECS), Dec. 2018, pp. 601-604.
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- [5] Z.-Y. Hsu, C.-W. Liu, J.-W. Wu, W.-J. Chang, T.-L. Li and P.-H. Chen, " A Single-Inductor Triple-Output Buck-Boost Converter with Output Ripple Control for Wearable Devices", *IEEE International Symposium for Circuits and Systems (ISCAS)*, May. 2022.

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