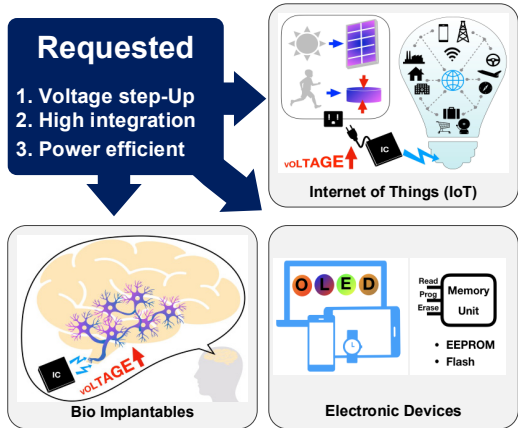


# An 83mA 96.8% Peak Efficiency On-Chip 3-Level Boost Converter with Full-Range Auto-Capacitor-Calibrating Pulse Frequency Modulation (ACC-PFM)



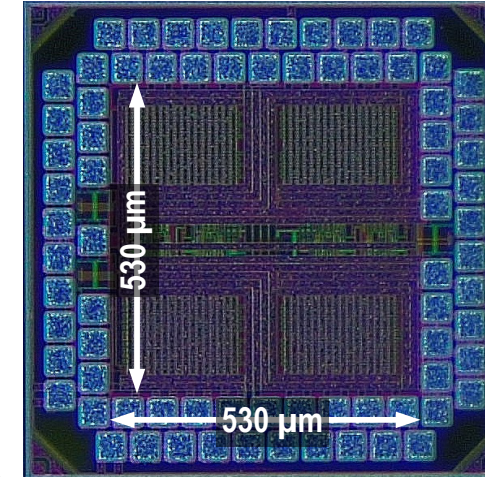
## Motivation and Applications



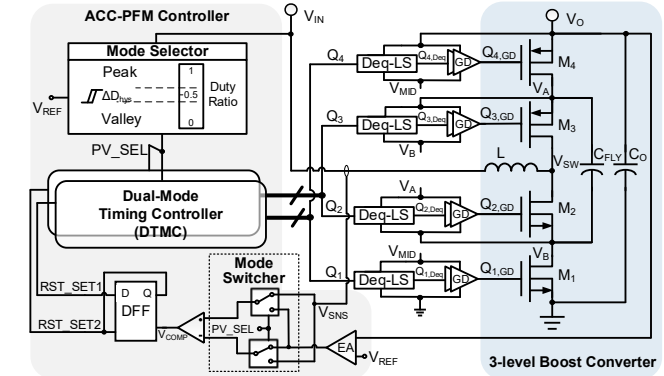
High voltages are demanded to

- Generate efficacious stimulations for bio-implantable devices
- Interface between low-voltage energy harvesters and batteries for wireless sensor network (WSN)
- Program memories for high operational speeds
- Drive LED strings efficiently

## Chip Implementation

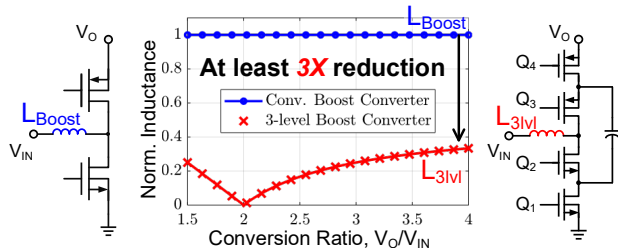


- TSMC 65nm CMOS process
- 2.5V devices for 5.0V operation



## Challenges and Solutions

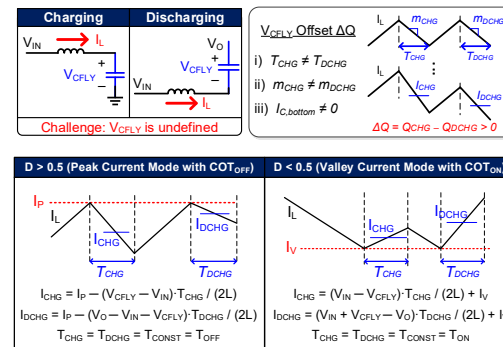
Topology: 3-level Boost Converter



Hybrid SC converters merge the advantages of the conventional switched capacitor (SC) and switched inductor converters (e.g. Boost converter)

- Achieve high power density
- Mitigate charge sharing loss in SC converter
- Retain the ability to employ low voltage

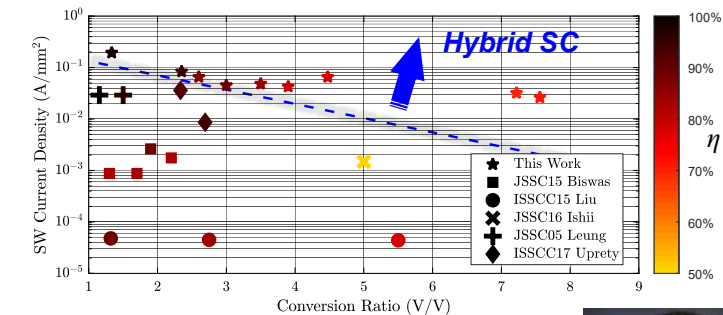
Control: ACC-PFM



- ACC-PFM is an integrated controller solution for both  $V_{OUT}$  regulation and capacitor balancing

## Measurement Results

Peak Efficiency	96.8%
Input Voltage	0.3 – 3V
Output Voltage	2.4 – 5V
Peak Output Current	83 mA
Peak Switch Current Density	300 mA/mm <sup>2</sup>
Switching Freq.	0.5M – 45MHz



Excellent performance for wide-range voltage and load variation required in step-up applications, compared to prior arts.

### References:

Wen-Chuen Liu, Pei Han Ng, Robert C.N. Pilawa-Podgurski, "An 83mA 96.8% Peak Efficiency 3-Level Boost Converter with Full-Range Auto-Capacitor-Calibrating Pulse Frequency Modulation", *IEEE Custom Integrated Circuits Conf. (CICC)*, 2019.

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