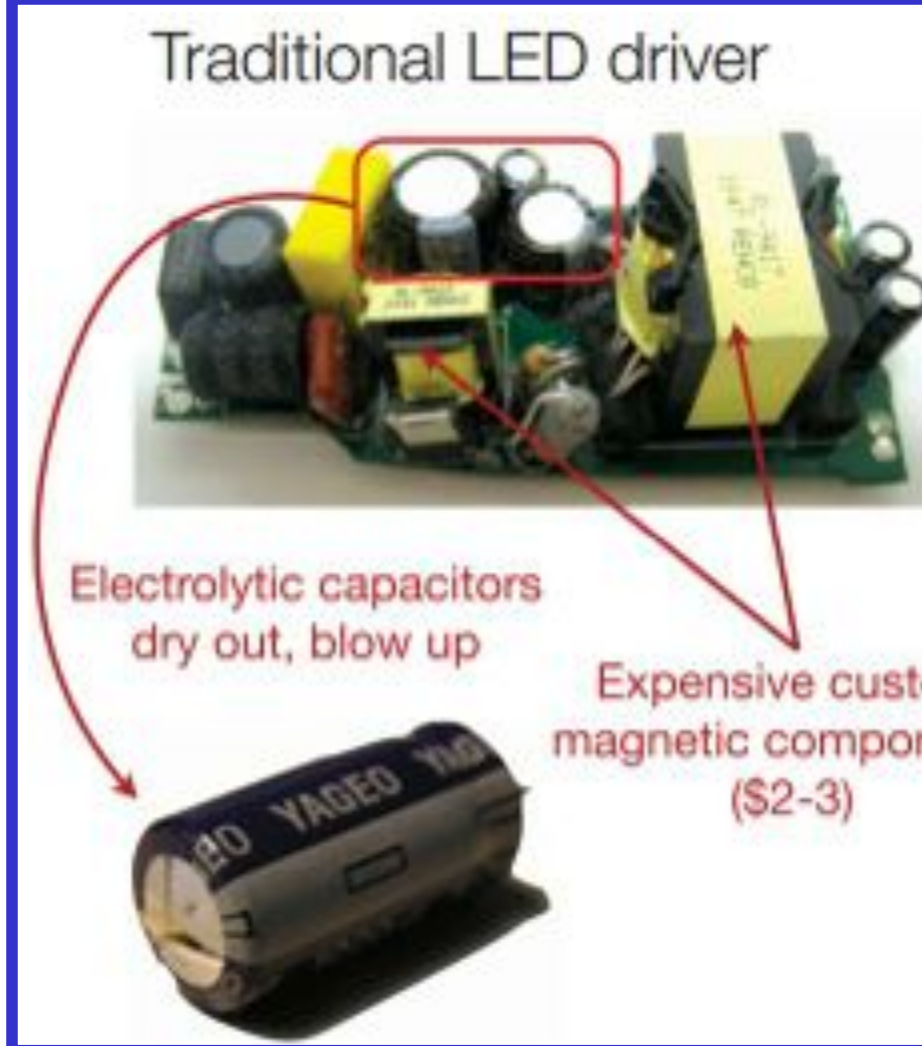


# Off-line transformerless LED driver with power-factor correction and galvanic isolation using high energy density thin-film Metacapacitors

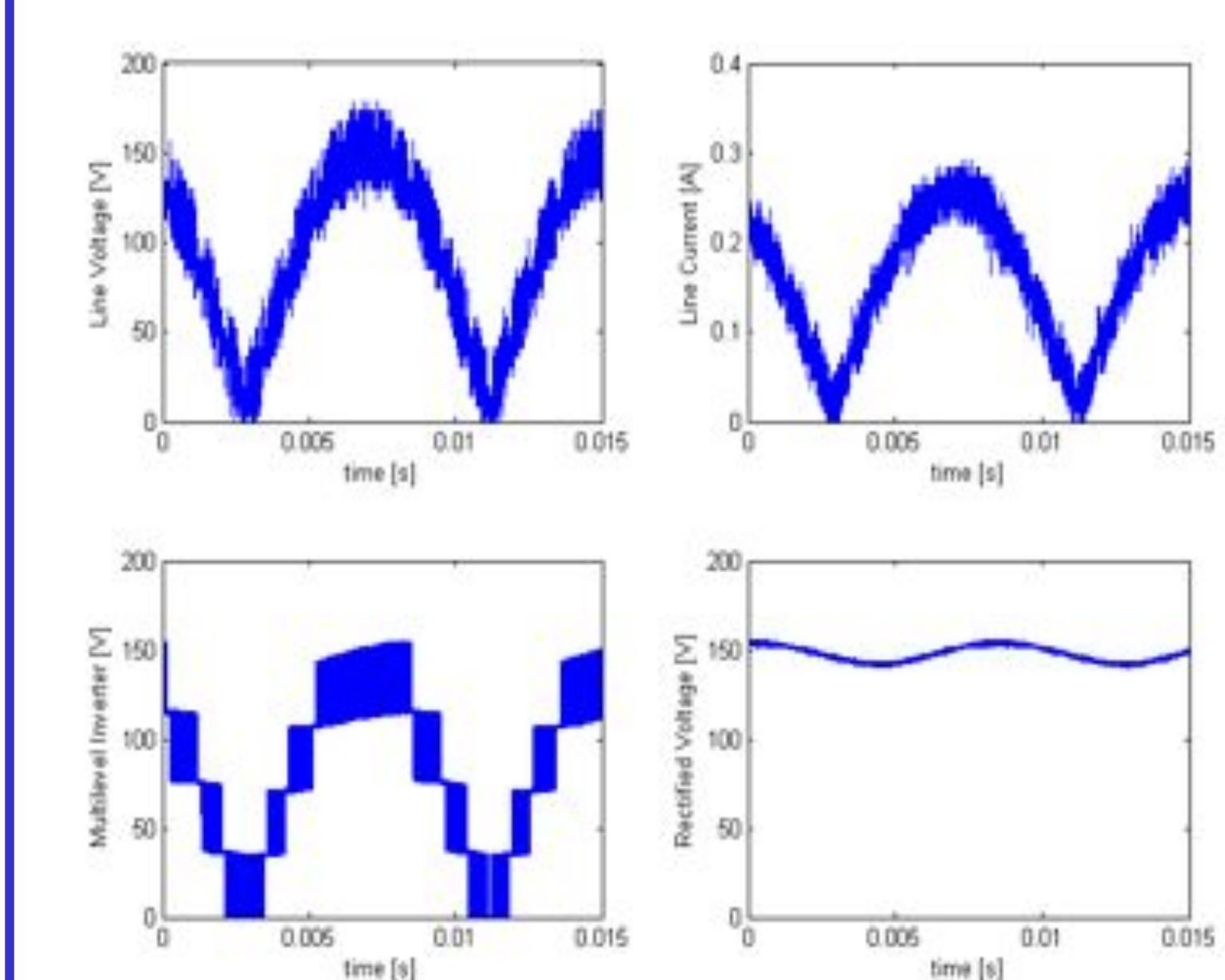
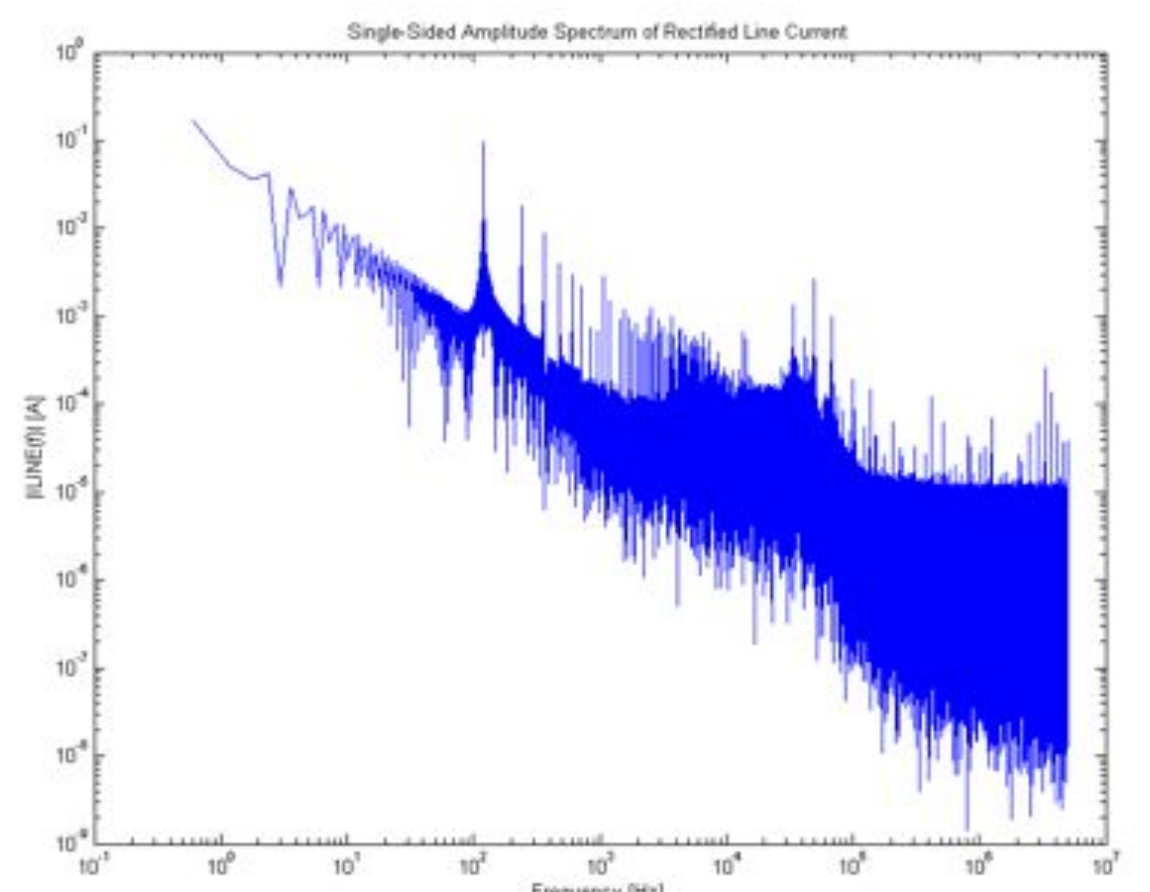
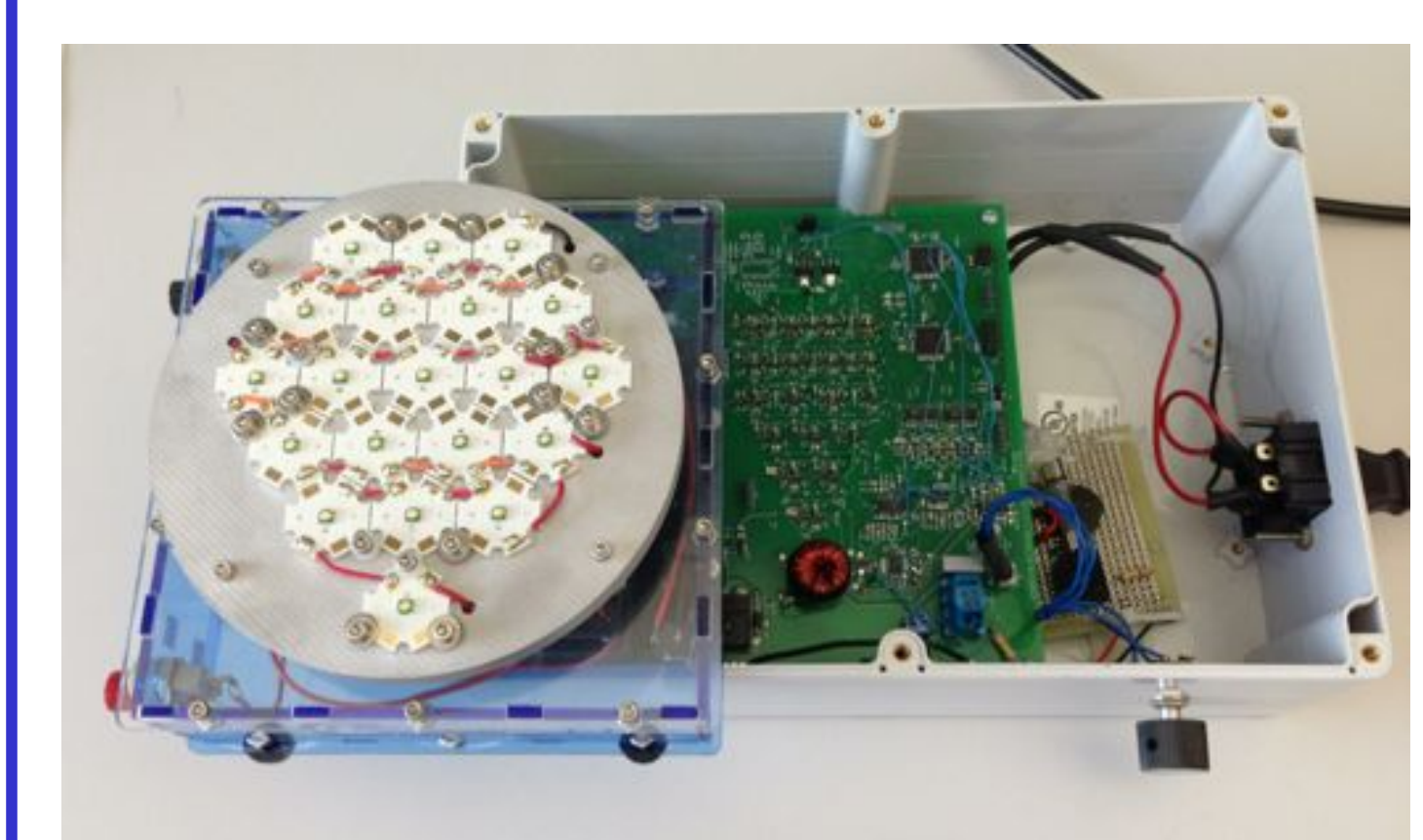
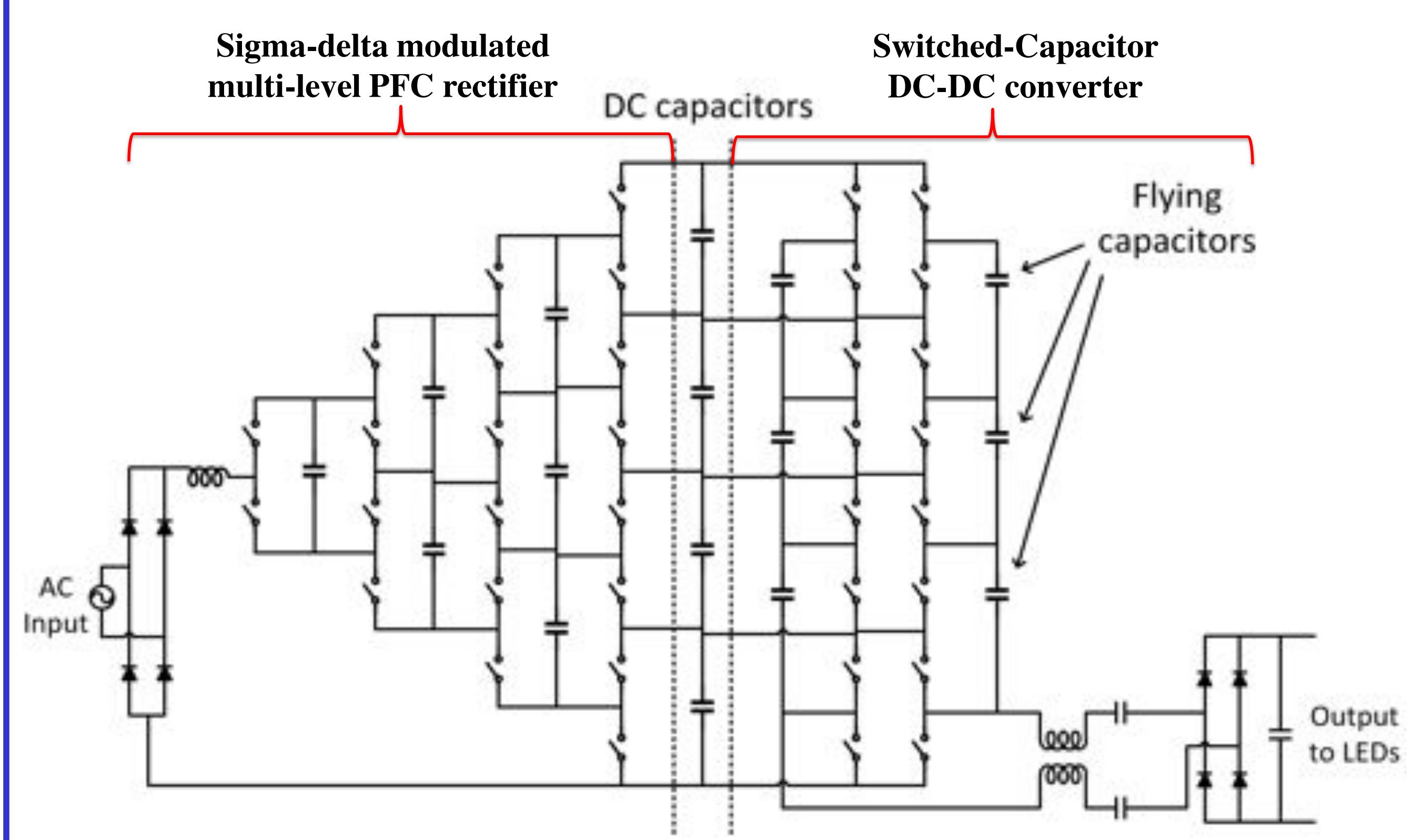
Chengrui Le(1), Daniel Gerber(2), Peter Kinget(1), Seth Sanders(1), Columbia University(1), University of California, Berkeley(2)



**Traditional LED driver**  
This LED driver design can meet specifications for efficiency and harmonic distortion without the need for bulky transformers and life-time limiting electrolytic capacitors. In addition, there are plans to use a high power density flexible thin-film capacitor technology known as the Metacapacitor.

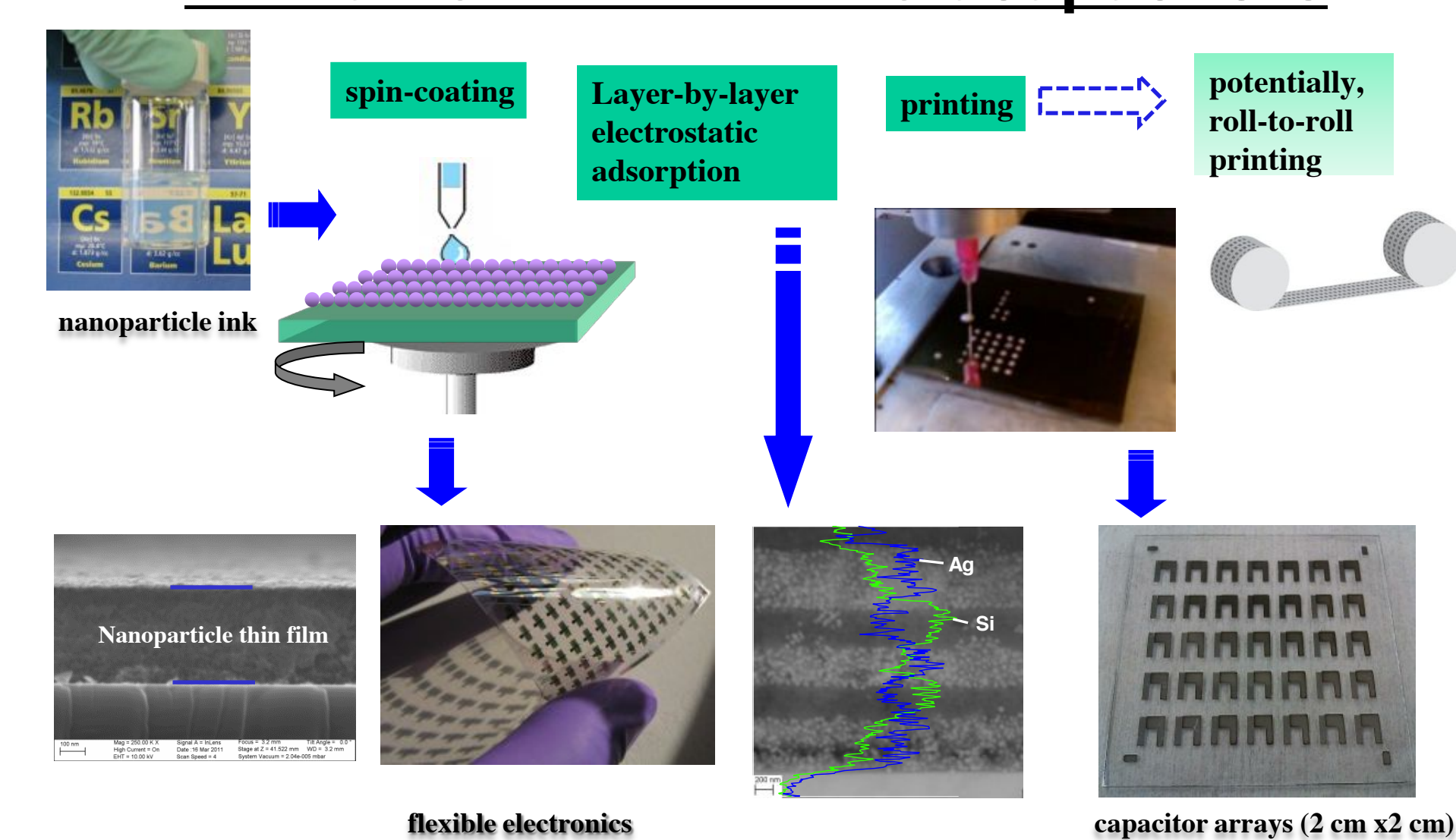
- Sigma-delta control for multi-level power factor correction input module
- Switched capacitor 4-to-1 DC-DC converter
- Capacitive galvanic isolation via resonant circuit
- Load current regulation
- Dimming capability

## Full Design with PFC and Step-Down Modules



Efficiency (no GD/GD)	90.4%/89.5%
Power Factor	> 0.99
# LEDs	12
Line voltage	74.8 Vrms
Line current	120 mA rms
Line power	8.98 W
LED voltage	35.3 V
LED current	0.23 A
LED power	8.11 W
Gate drive power	87 mW
SD clock	500 kHz
CP clock	262 kHz

## Printable Thin-Film Metacapacitors



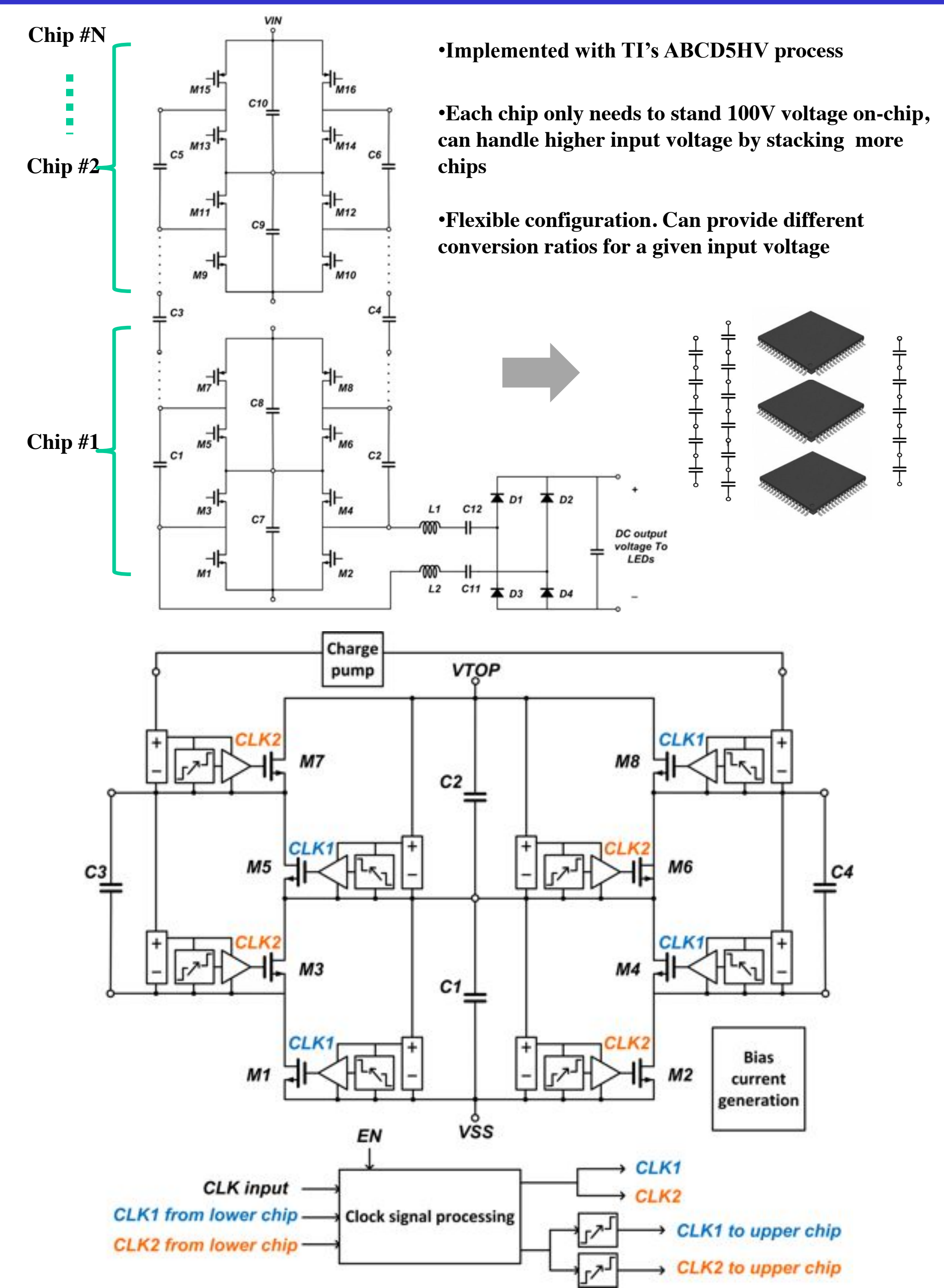
Eli S. Leland<sup>1</sup>, Barry Van Tassel<sup>1</sup>, Paul Chando<sup>1</sup>, Xiaohua Liu<sup>1</sup>, Andrew Byro<sup>1</sup>, Shyuan Yang<sup>2</sup>, Limin Huang<sup>1</sup>, Shuangyi Liu<sup>1</sup>, Olivia Niitsoo<sup>1</sup>, Brian Tull<sup>2</sup>, Alexander Couzis<sup>1</sup>, Dan Steingart<sup>1</sup>, Ioannis Kymissis<sup>2</sup>, Steve O'Brien<sup>1</sup>, 1 - City College of New York, 2 - Columbia University

>Liu, S.; L.; Huang, L.; Li, J.; O'Brien, S., Intrinsic dielectric frequency dependent spectrum of a single domain tetragonal BaTiO<sub>3</sub>, Journal of Applied Physics Issue Number: 112, 2012, 014108, <http://dx.doi.org/10.1063/1.4734004>

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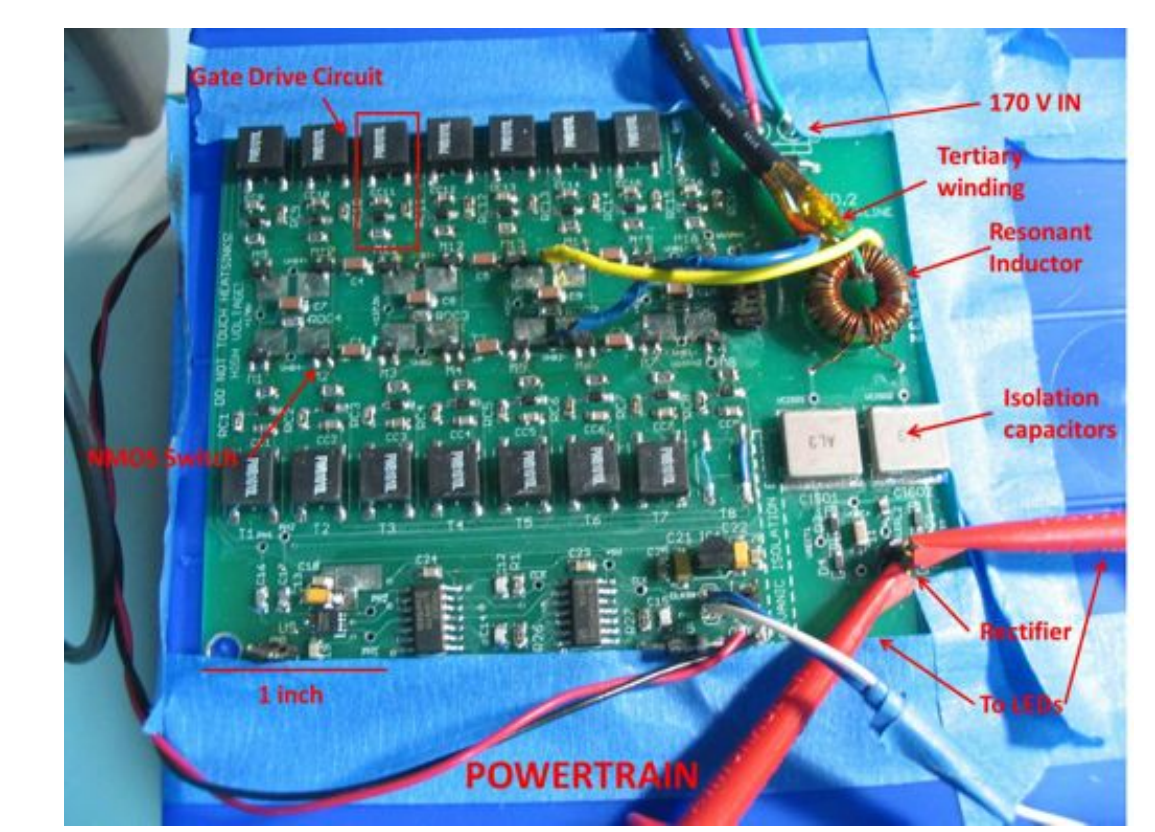
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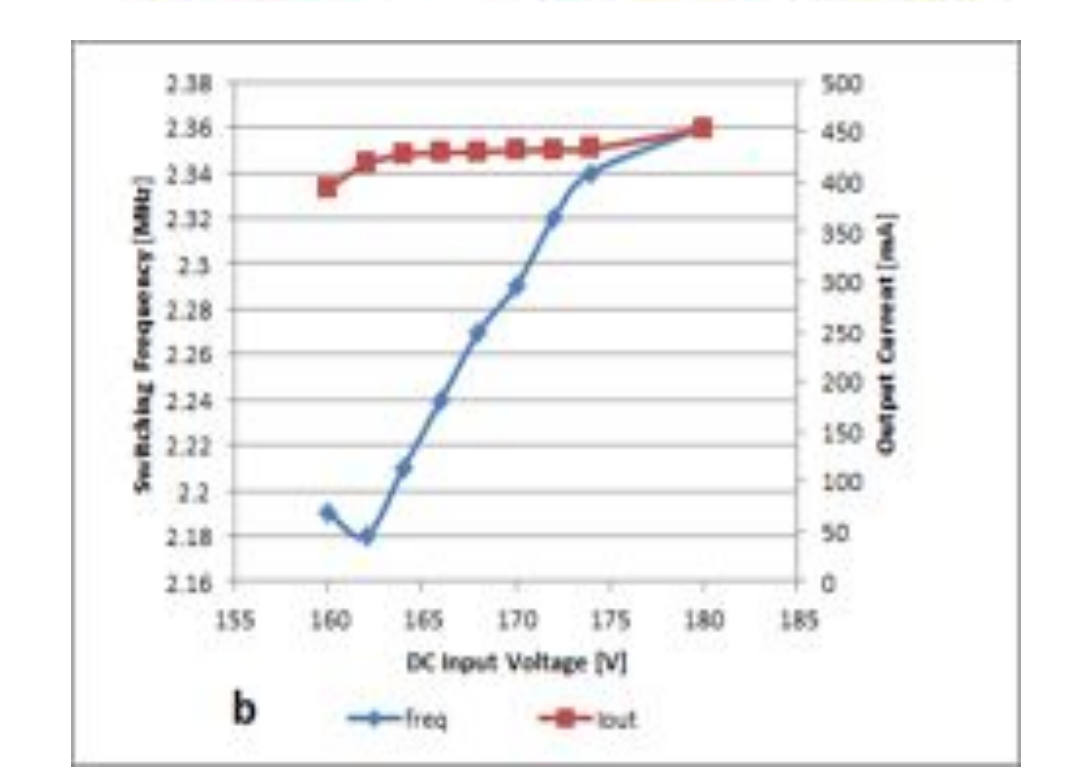
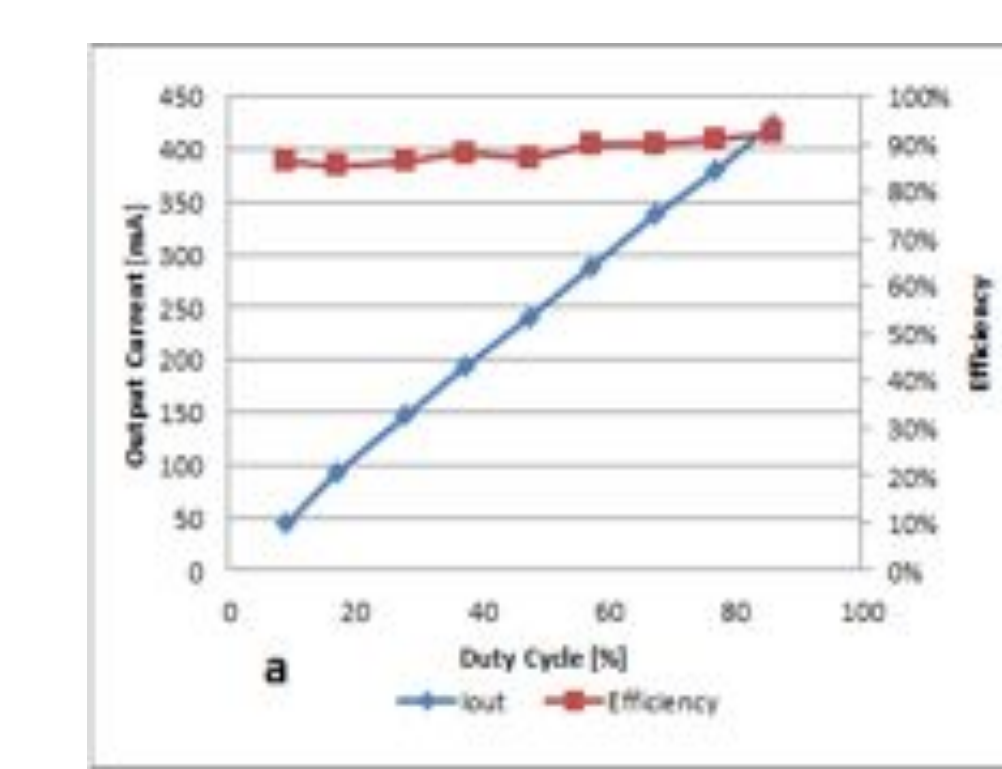


- Implemented with TI's ABCD5HV process
- Each chip only needs to stand 100V voltage on-chip, can handle higher input voltage by stacking more chips
- Flexible configuration. Can provide different conversion ratios for a given input voltage

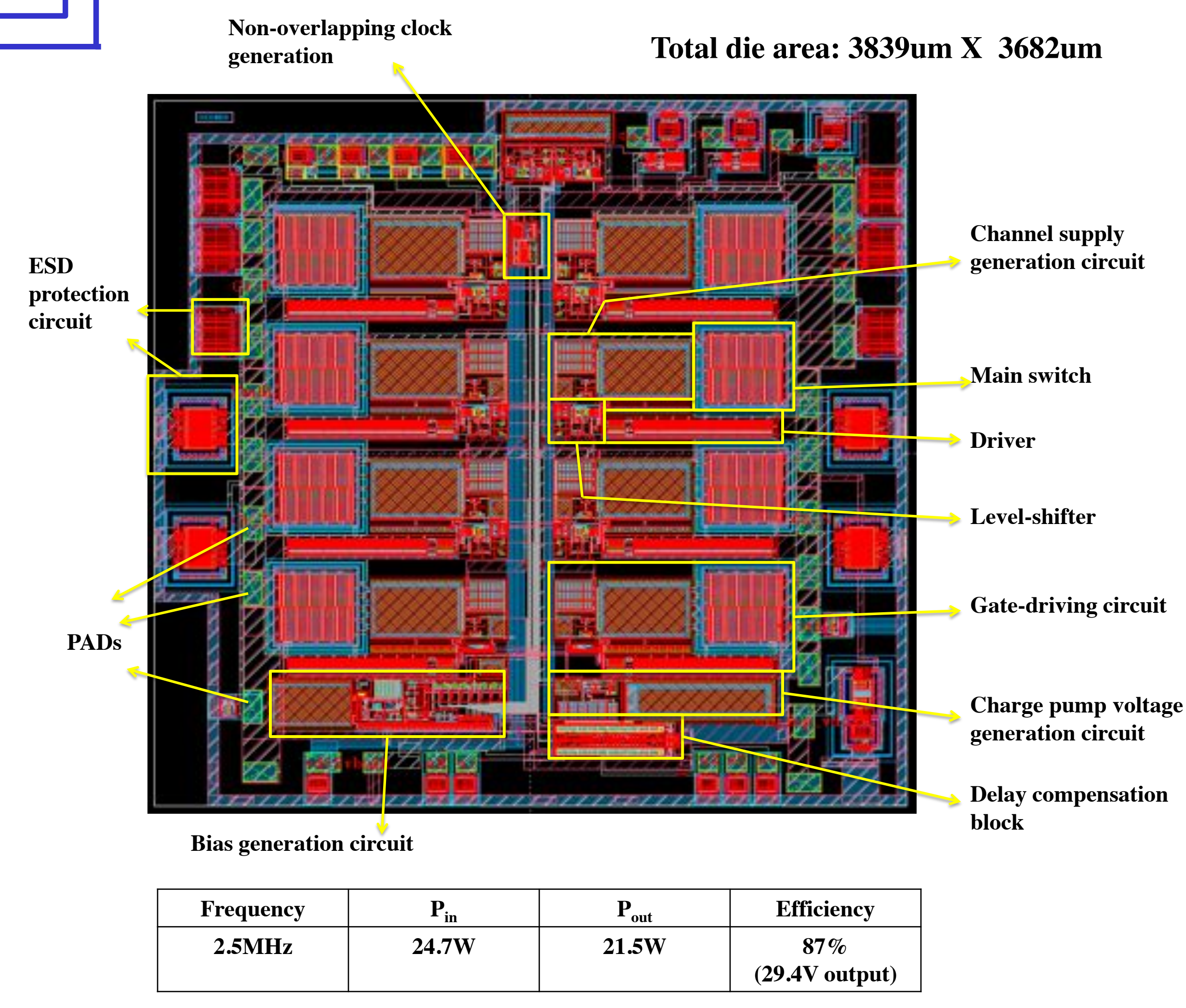
## DC-DC Step-Down Prototype and IC



Regulation loop dynamics [10us/div]. Top: Global ENABLE signal. Middle: STARTUP signal. Bottom: Current through isolation capacitors [400mA/div].



(a) Current regulation and efficiency versus duty cycle  
(b) Switching frequency and current regulation versus input voltage.



Frequency	P <sub>in</sub>	P <sub>out</sub>	Efficiency
2.5MHz	24.7W	21.5W	87% (29.4V output)

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arpa-e ARPA-E ADEPT Metacapacitors. DE-AR000114. Prior and additional support from NSF, DOE and NYSERDA

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