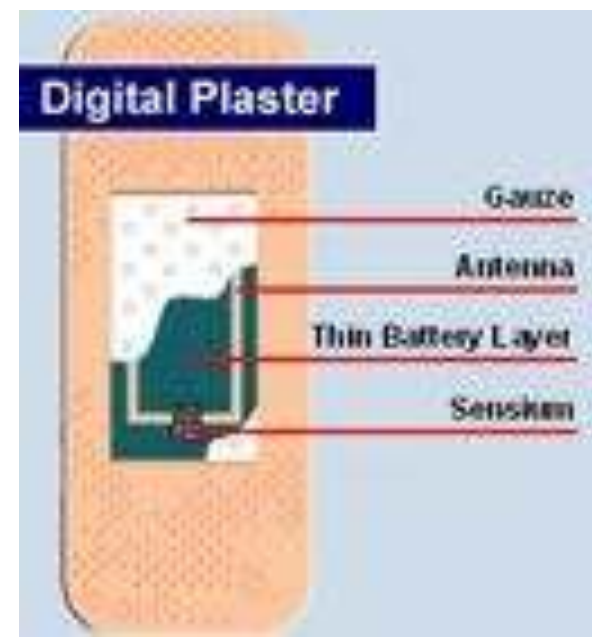


Motivation

Battery-less sensors



Health monitoring



Hand-held Devices

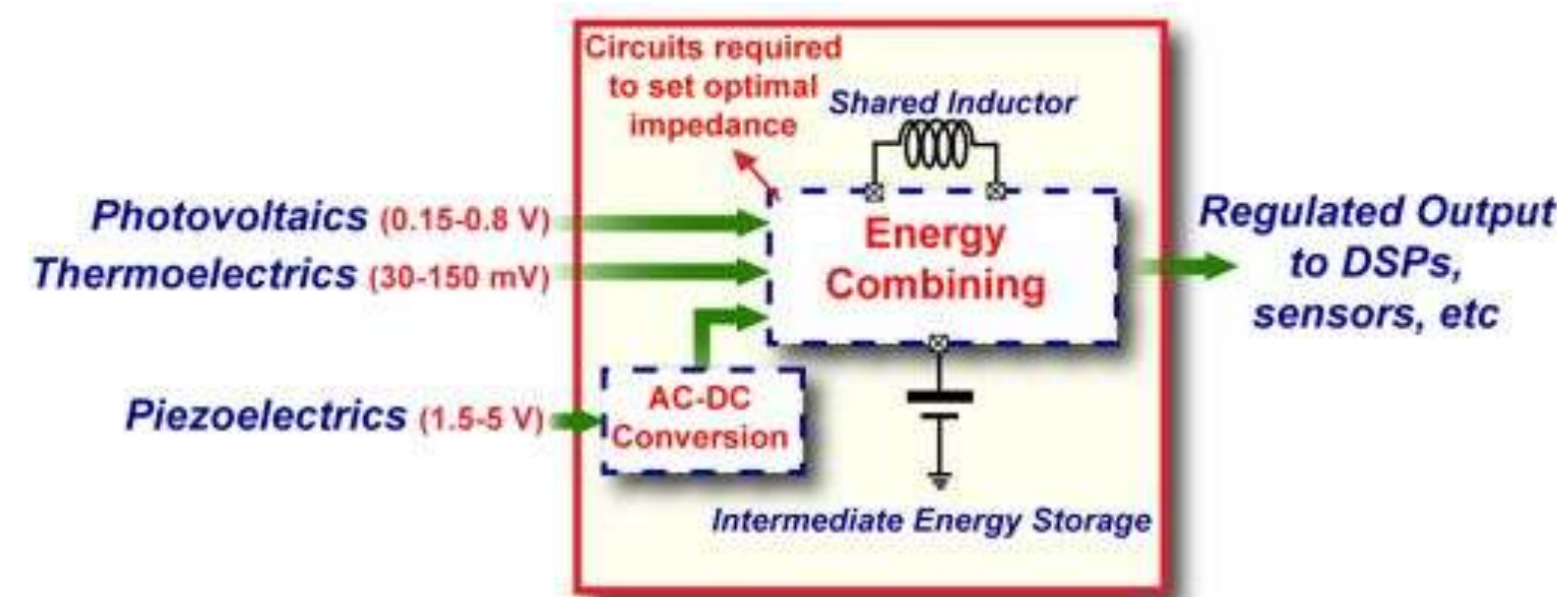


Toumaz Band-Aid

Samsung Blue Earth

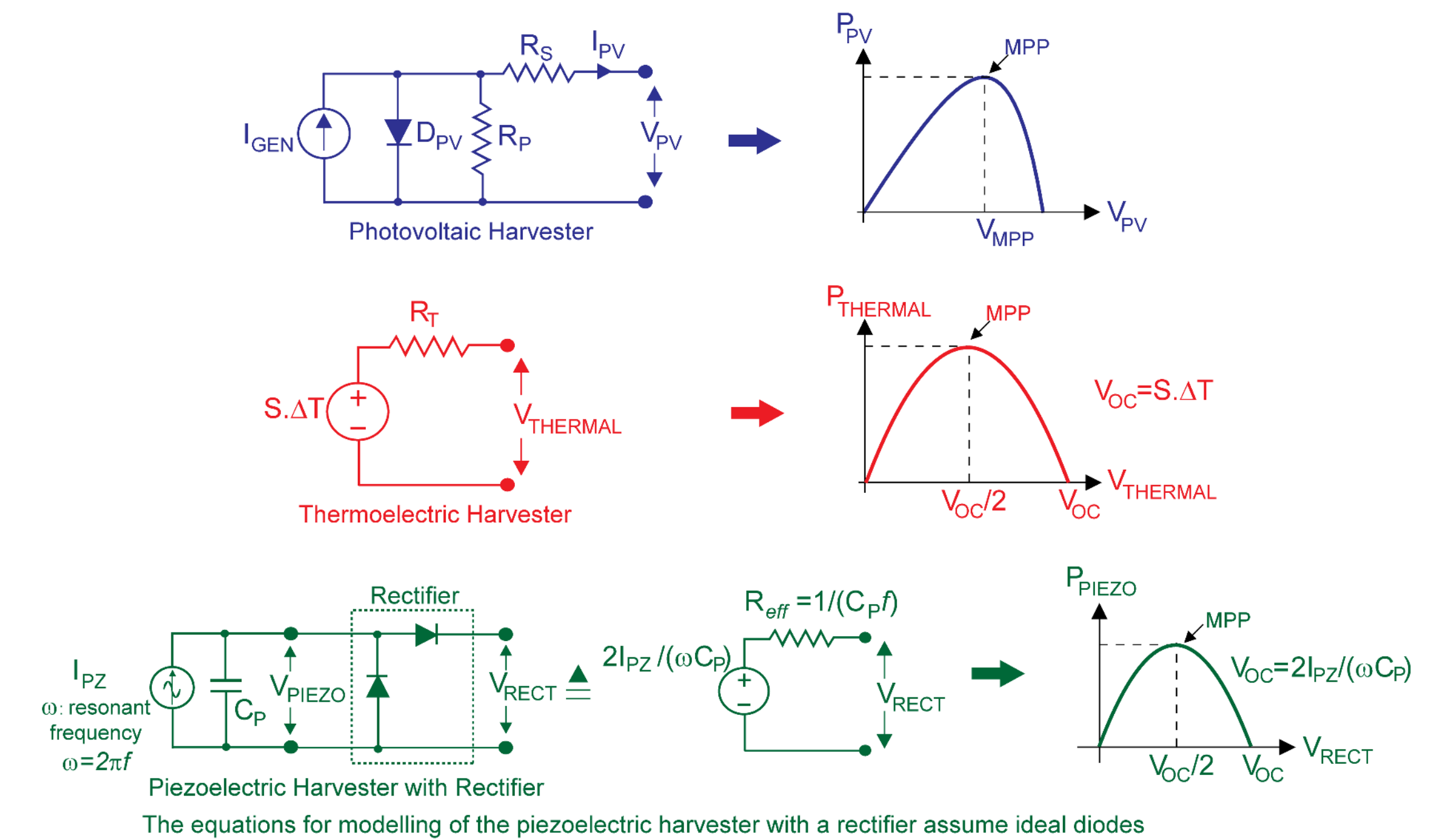
- Battery-less operation in sensors and health monitoring systems
- Extend battery life in hand-held portable devices

Multi-Input Energy Harvesting

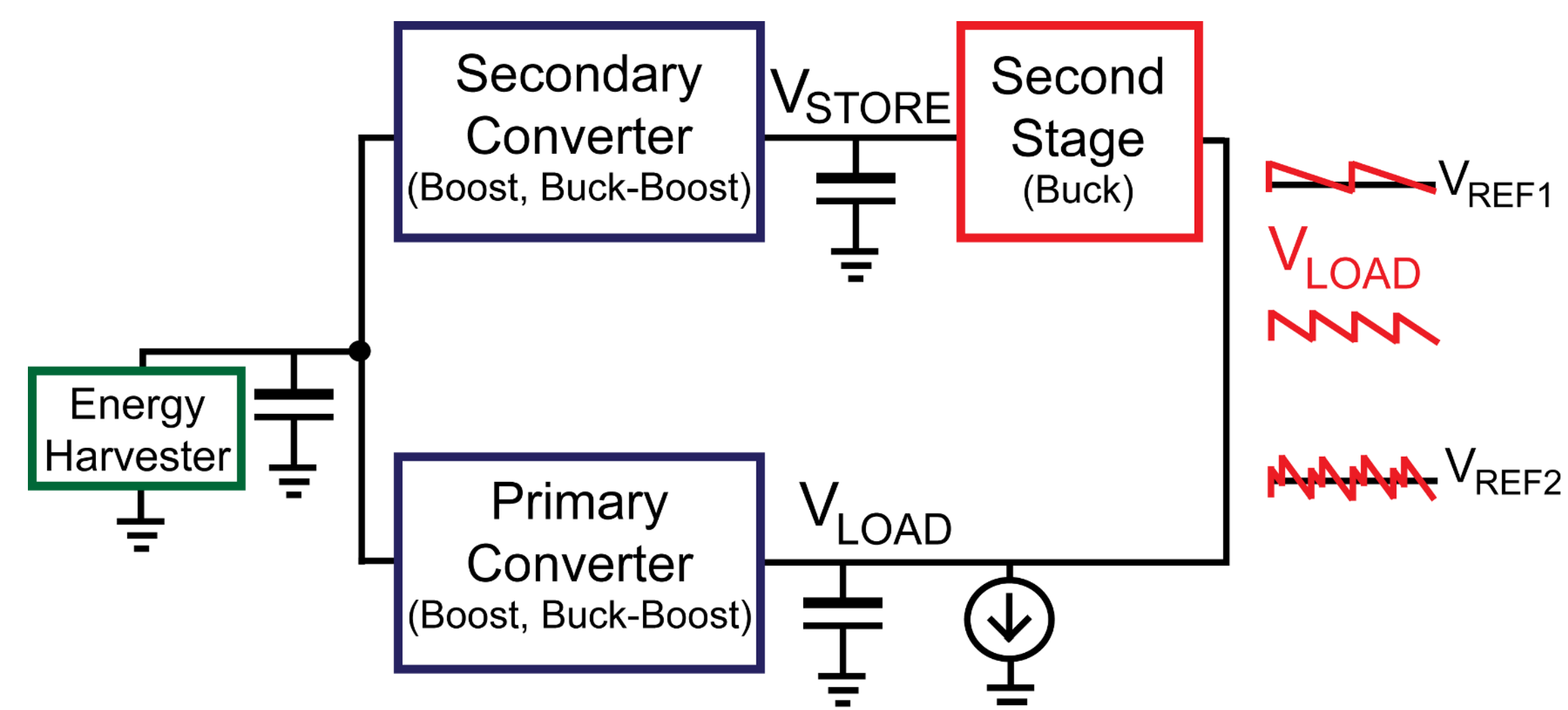


- Source impedances of 5Ω to 100's of kΩ for various harvesters
- Voltage range of 20mV to 5V for various harvesters
- High end to end efficiency

Harvester Electrical Models



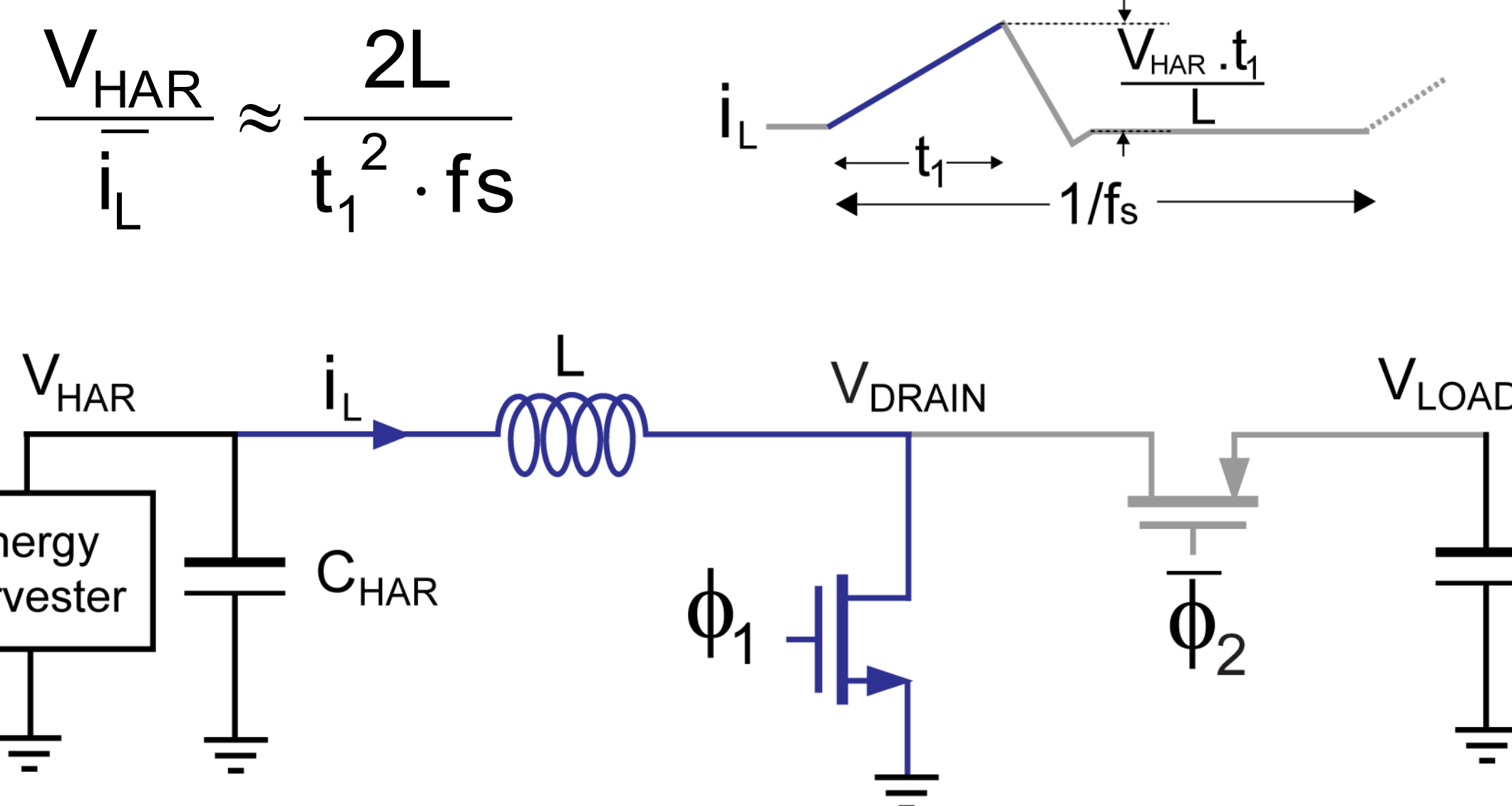
Dual Path Architecture



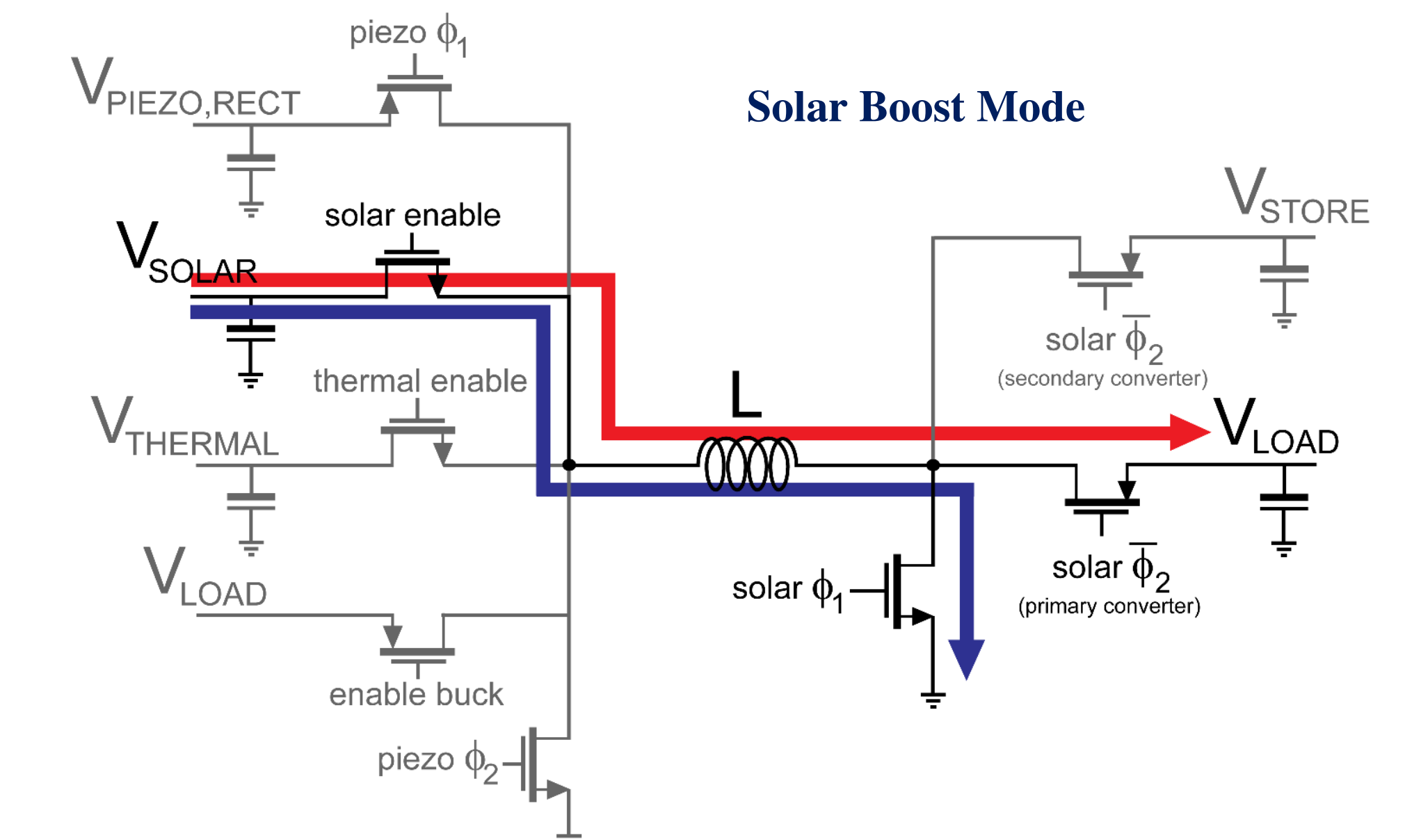
Peak Efficiency improvement of 13% and 5 to 6% in average case

Maximum Power Transfer

Boost converters with high conversion ratios in DCM

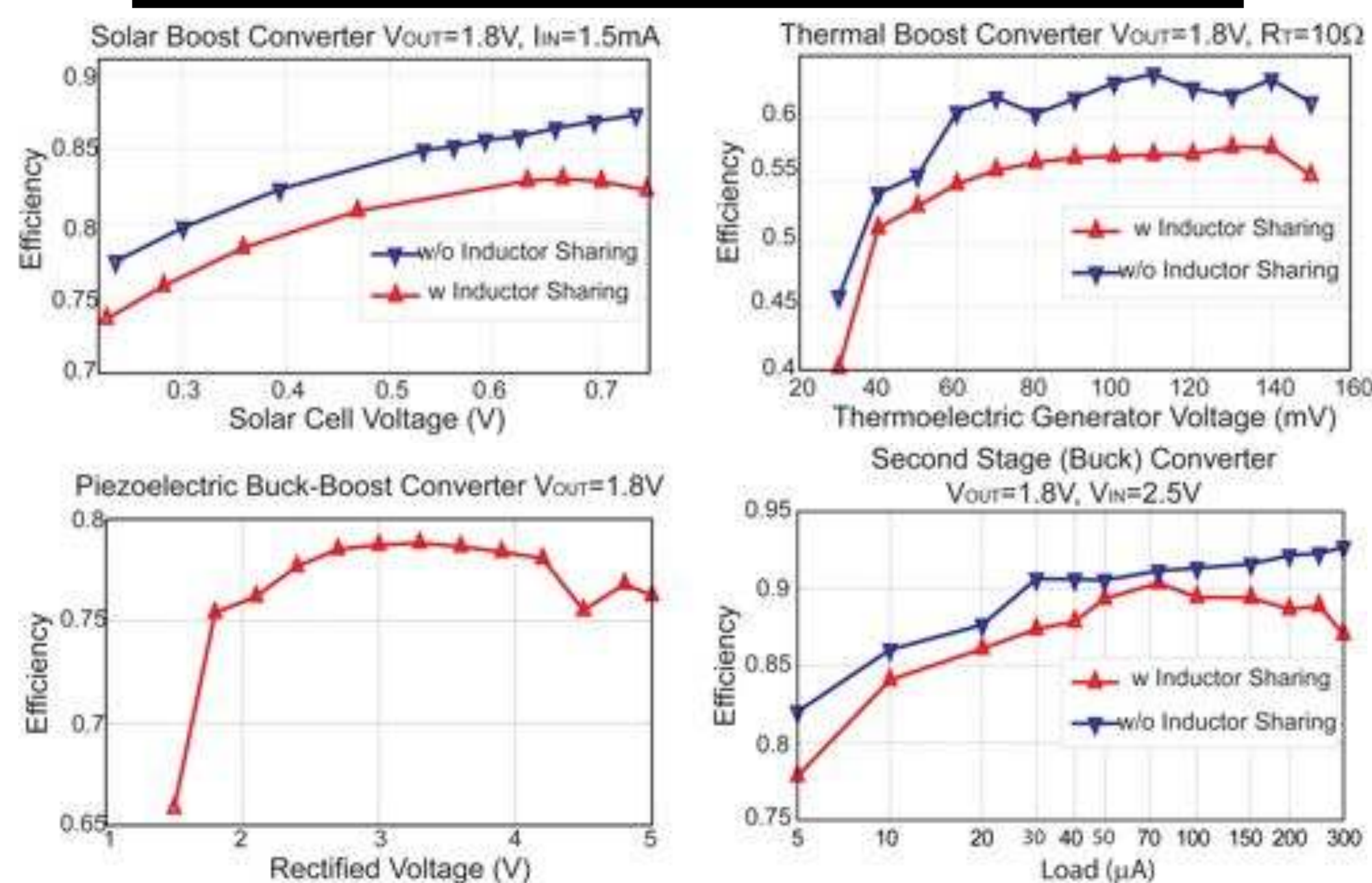


Switch Matrix

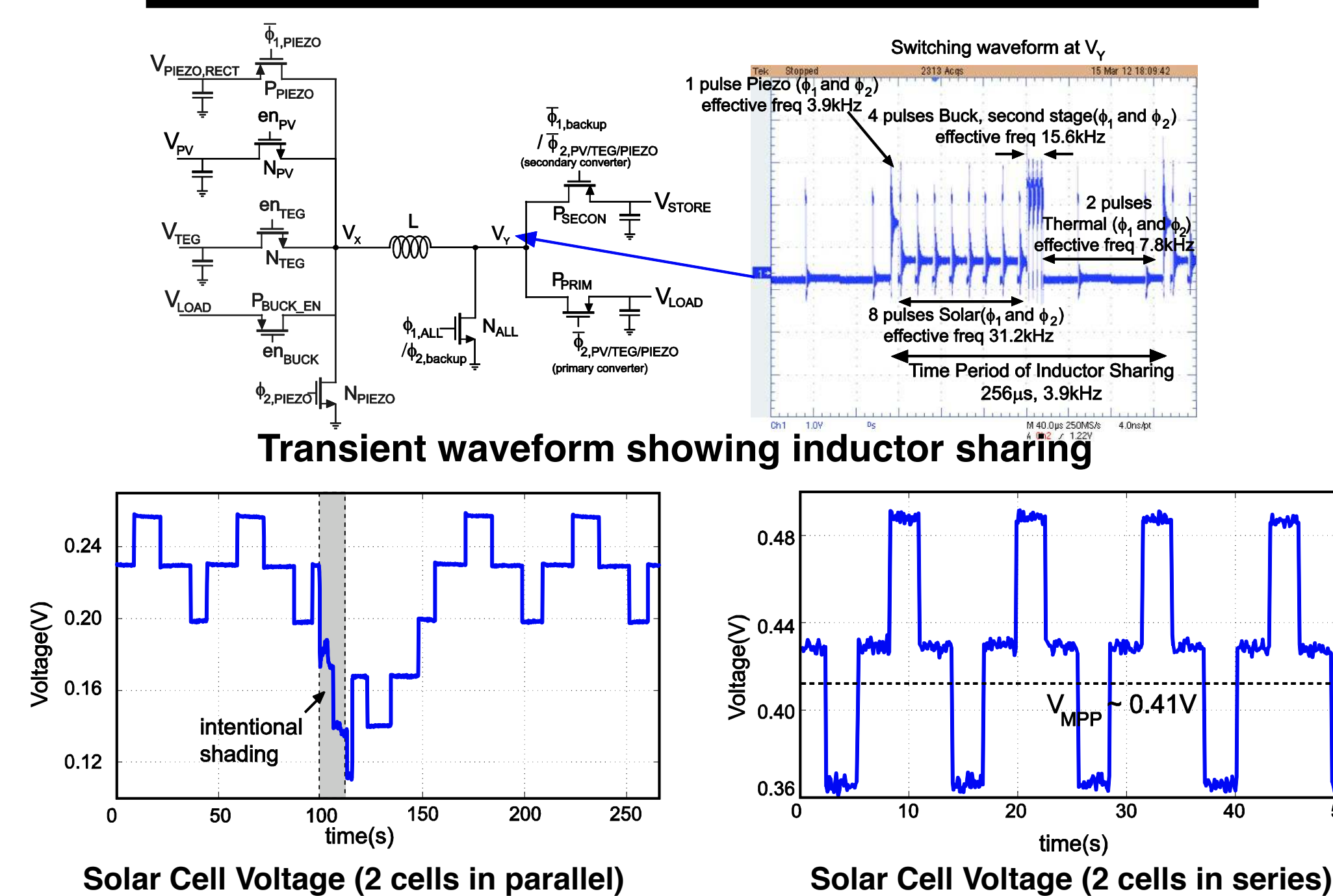


Parallel Converters with single time shared inductor

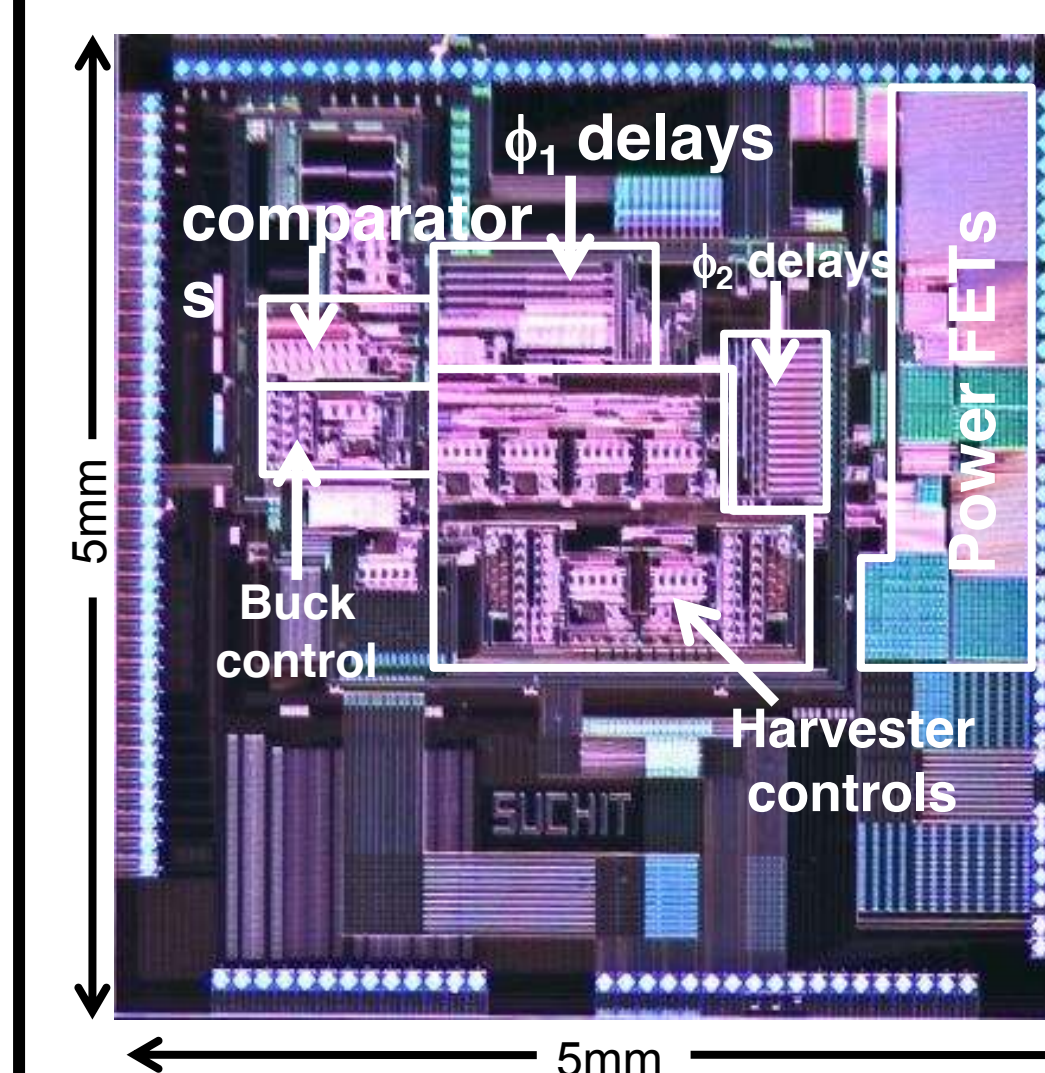
Measured Efficiencies



Transient Measurements



Design Summary



We acknowledge the financial support provided by the Interconnect Focus Center, one of the six research centers funded by the FCRP, a SRC program

Technology	0.35μm (2P4M) CMOS
Input Voltages	20 - 150mV Thermal 0.2 - 0.75V Solar 1.5 - 5V Piezoelectric
Output Voltages	1.8V Regulated 1.8 - 3.3V Storage
Maximum Output Power	1.3mW Thermal 5mW Solar 200μW Piezoelectric
Thermal: Seebeck 50mV/K, ΔT=1.7K	Thermal Boost: 96μW
Solar: 1500lux, 15cm ²	Solar Boost: 262μW
Piezoelectric: PZT 3in ² , 1g	Piezoelectric Buck-Boost: 40μW Total Power: 398μW