EnerHarv 2024

PSMA International Workshop | 26-28 June, 2024 | Perugia, Italy

COMMERCIAL SPONSORS

EnerHarv 2024 Workshop:

System level considerations enable energy harvesting component optimisation

Dr. Maeve Duffy, Associate Professor

Power Electronics Research Centre,

University of Galway

maeve.duffy@universityofgalway.ie

Friday, June 28, 2024

ORGANIZER PSMA HOST A.D. 1308 unipg

MEDIA SPONSORS

TECHNICAL SPONSORS

OVERVIEW

Electromagnetic generator system design

- Coil optimisation
- Impact of diode characteristics
- Impact of load impedance

IRISH RESEARCH COUNCIL
An Chomhairle um Thaighde in Éirinn

Dye sensitized solar cell (DSSC) system design

- Cell structure optimization
- Combined DSSC – DC/DC converter optimisation
- Energy storage considerations

IRISH RESEARCH COUNCIL
An Chomhairle um Thaighde in Éirinn

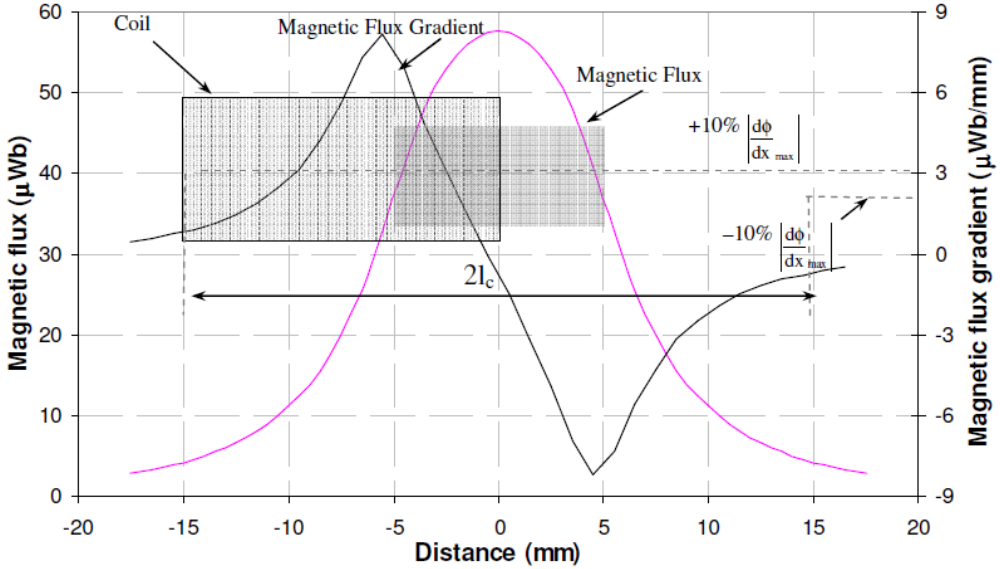
SOLARPRINT

EnerHarv 2024

PSMA

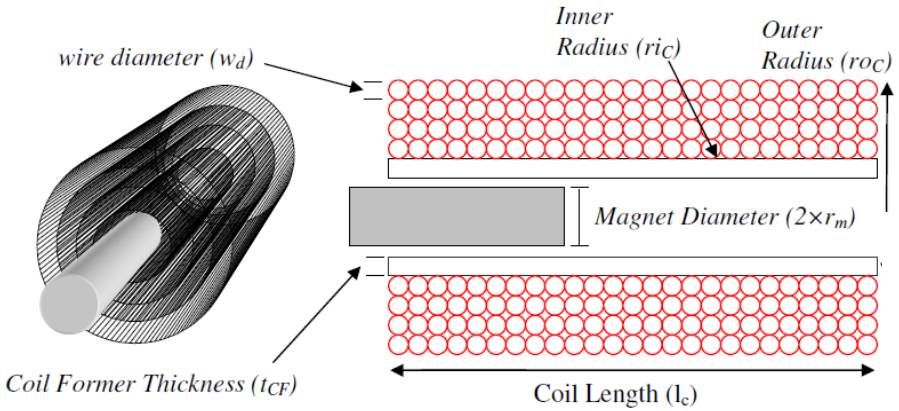
Ollscoil na Gaillimhe
University of Galway

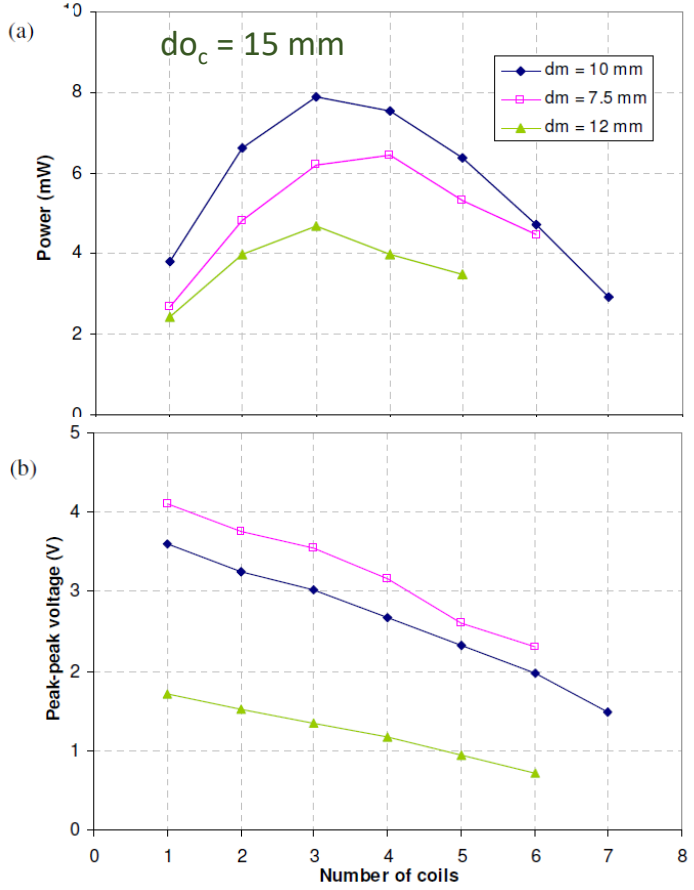
Electromagnetic generator design: sliding magnet [1]



- Optimum coil length for a given magnet
  - Equal to the extent of the magnetic flux gradient

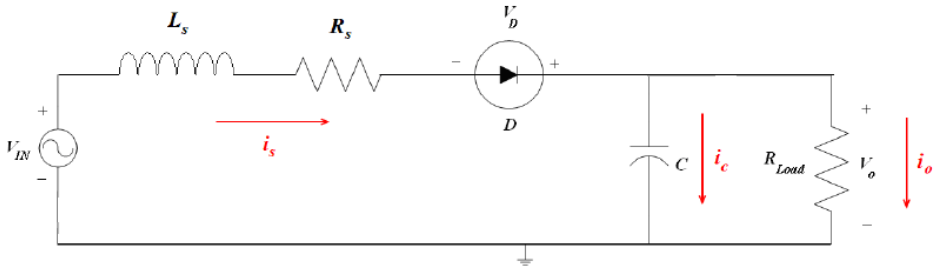
Electromagnetic generator design: optimisation

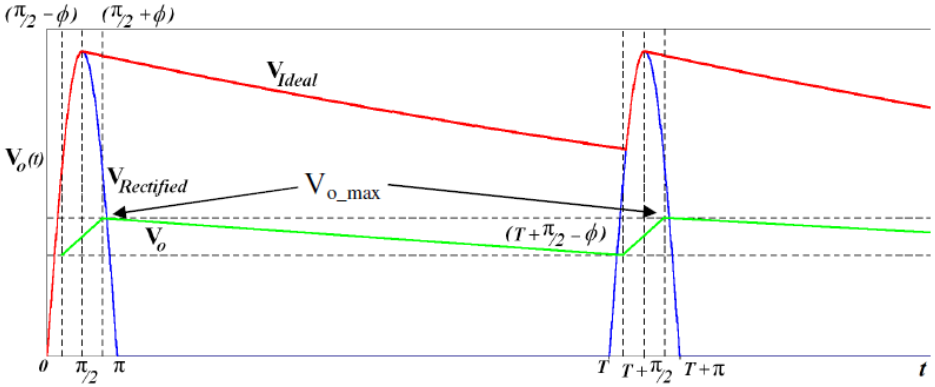




- Optimum magnet, d_m : coil diameter, do_c, within a given space
- Optimum number and combination of coils

Electromagnetic generator design: AC/DC considerations





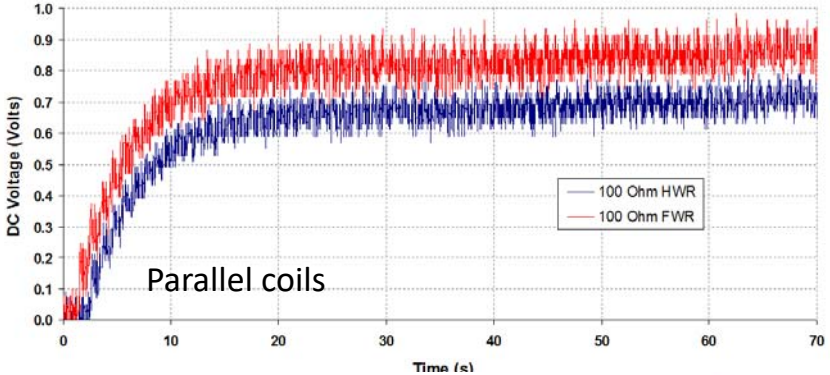
- Choice of diode
  - Lowest V_{FWD} not the only factor
  - Reverse leakage current has significant contribution

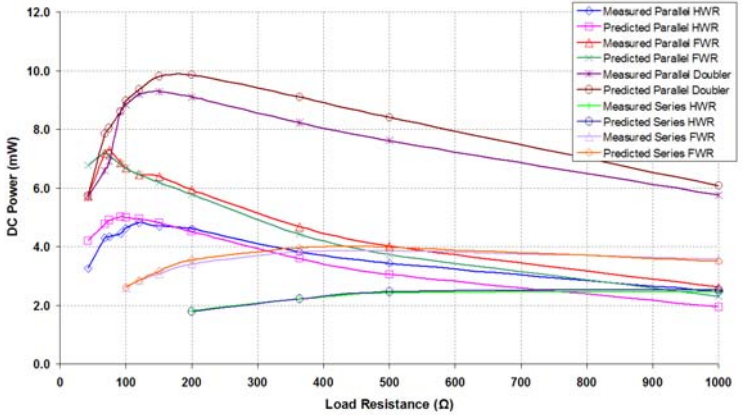
Diode Type	Reverse Current Typ - Max:	Reverse Voltage (V)	Forward Current (mA)	Forward Voltage mV (I_F = 0.1mA - 1000mA)
PMEG201 0EH	15 – 40 µA at 10 V	20	0.1- 1000 0.1 -1000	Typ: 90 – 420 Max: 130 – 500
PMEG102 0EH	1.2 – 3 mA at 10 V	10	2000	Typ: 100 – 350 Max: 130 – 460

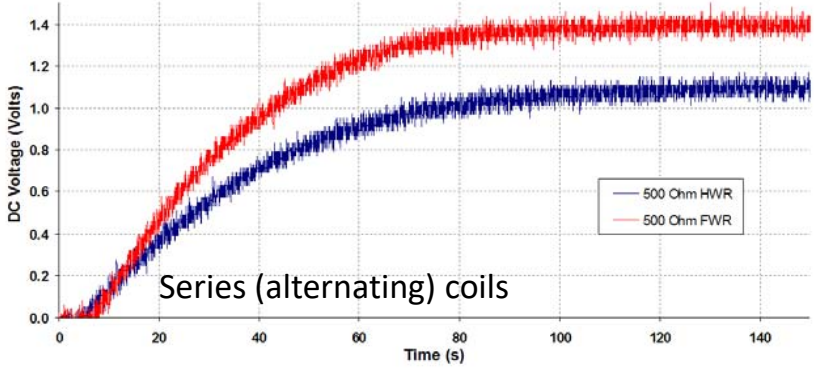
Electromagnetic generator design: rectified DC output

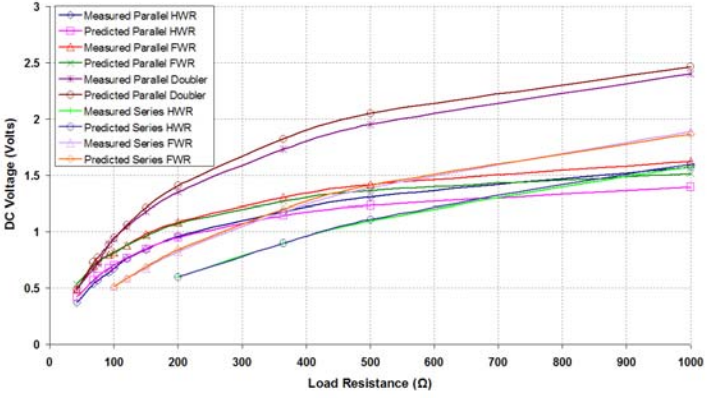
- Higher power achieved with parallel vs. series coils, but at lower voltages

HWR/FWR: Half/Full wave rectifier





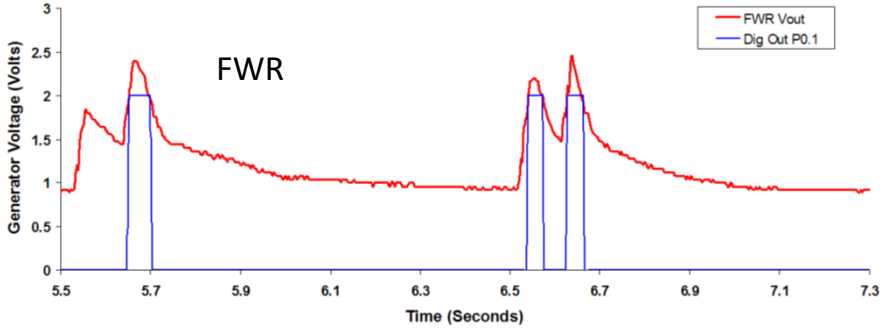


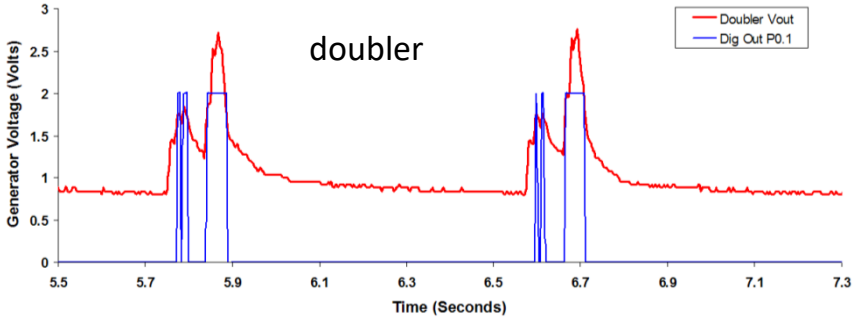


Electromagnetic generator design: pulsed DC output

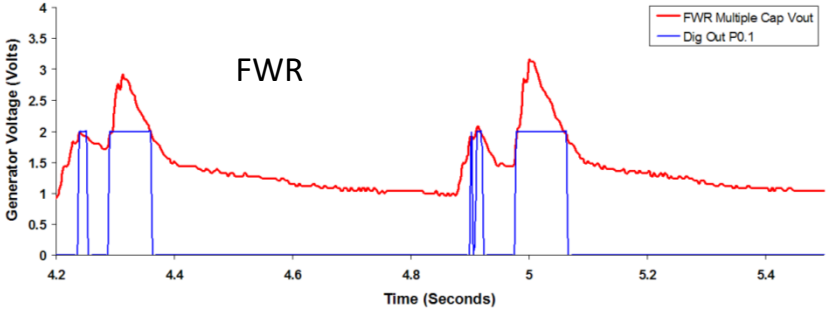
- Higher power and energy achieved with series alternating coils!

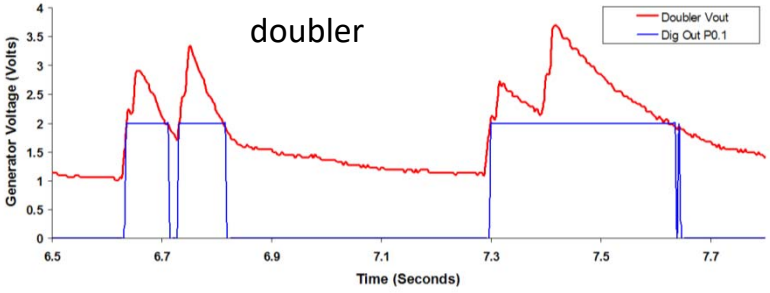
Parallel coils



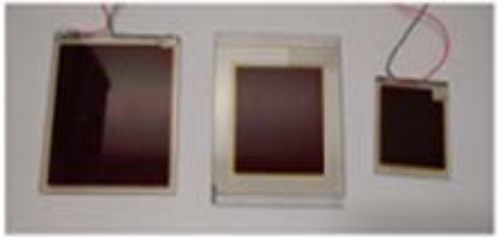


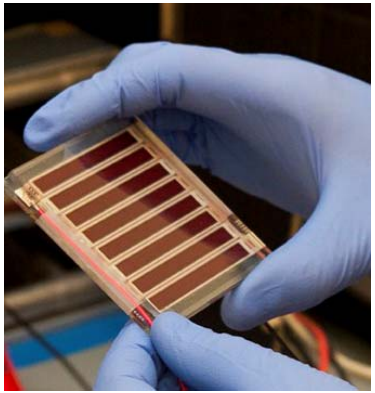
Series (alternating) coils

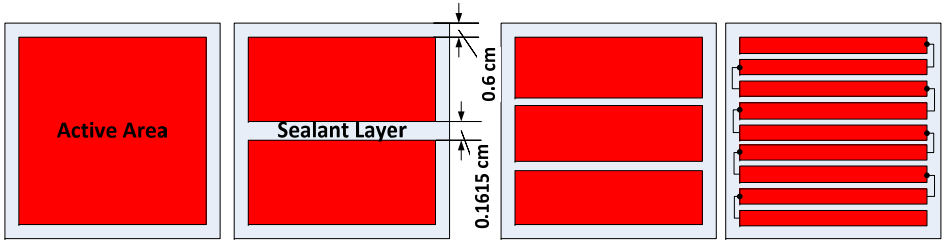




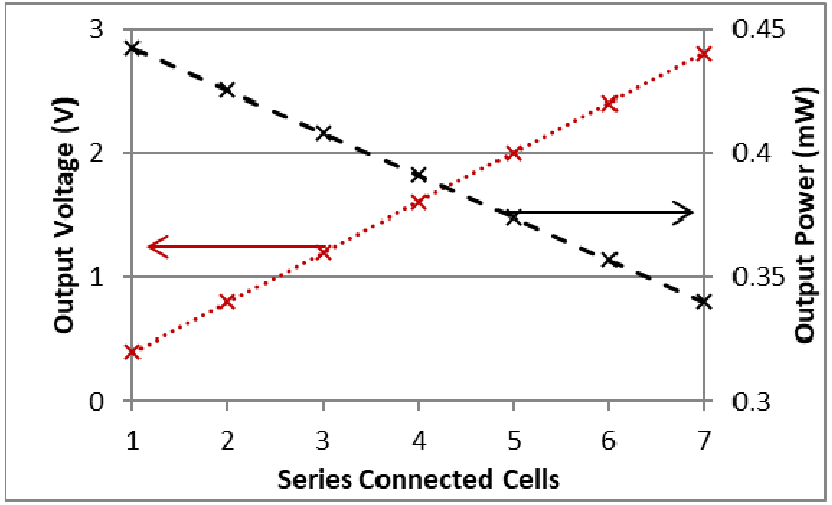
System level DSSC design: cell configuration [2]







- Trade-off between output voltage and power
  - Due to space needed for interconnect



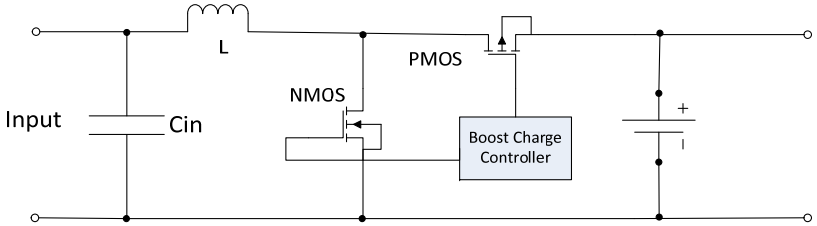
IRISH RESEARCH COUNCIL
An Chomhairle um Thaighde in Éirinn

EnerHarv 2024

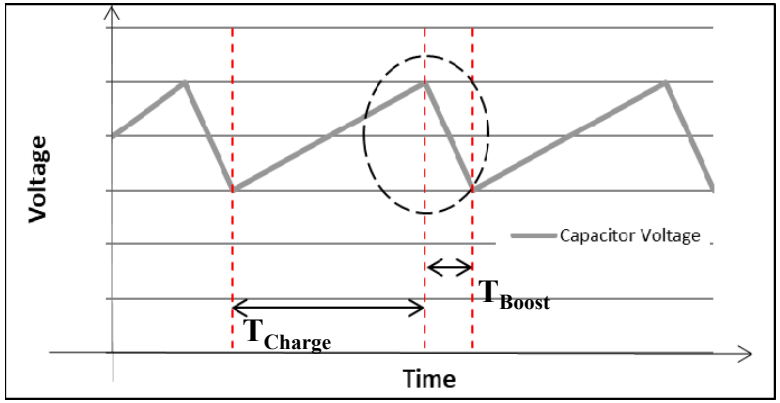
PSMA

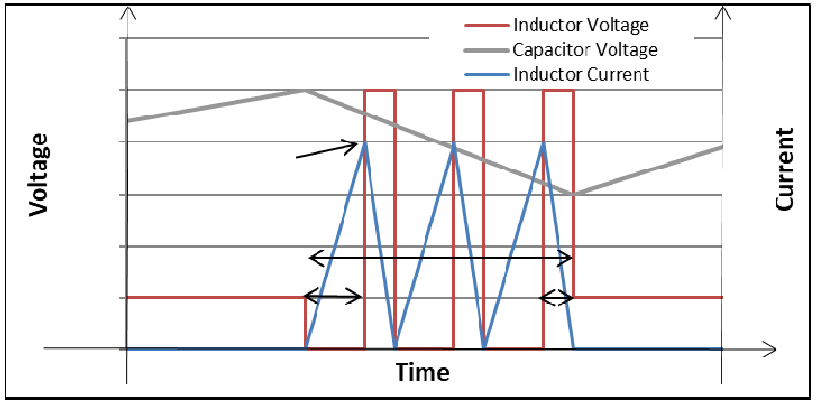
Ollscoil na Gaillimhe
University of Galway

System level DSSC design: boost converter losses

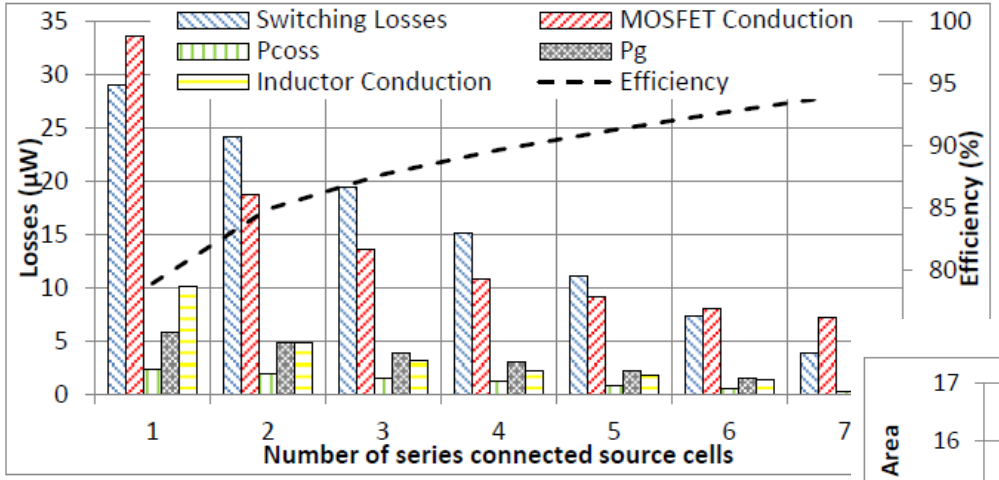


- Converter losses are dependent on input voltage
  - Most losses during discharge of C_{in}
  - EH power supplies storage and load

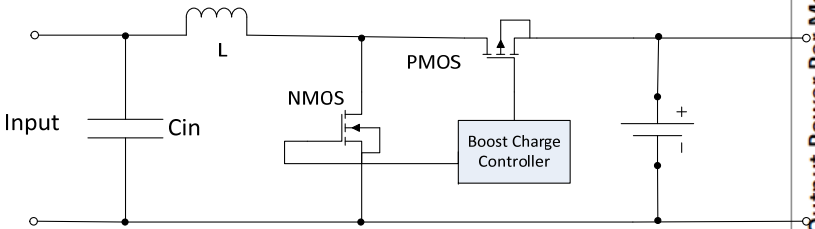


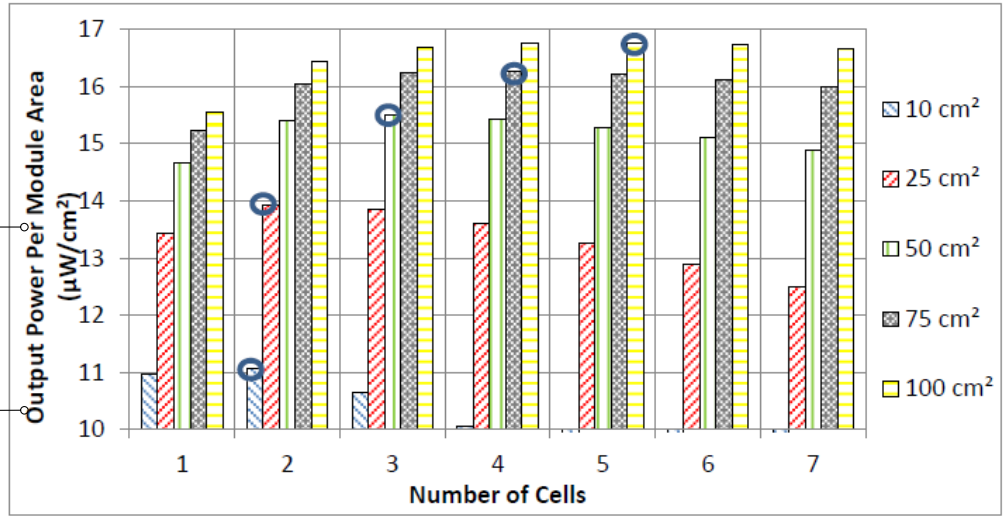


System level DSSC design: boost converter losses



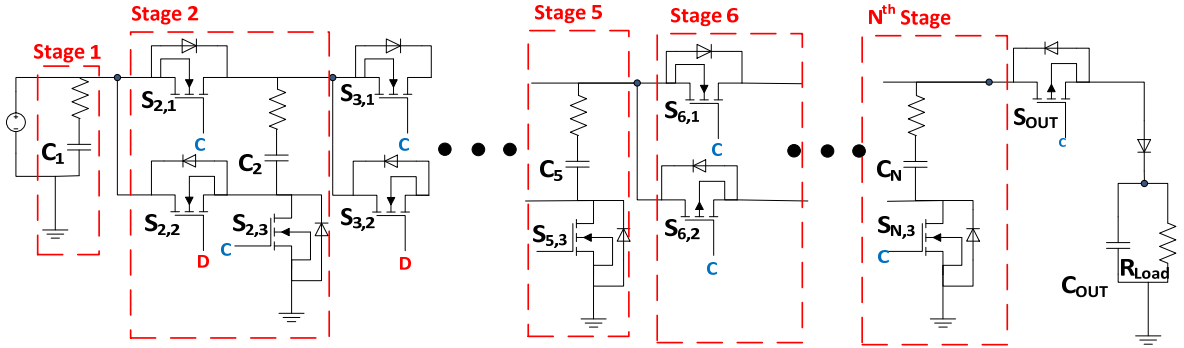
- Combined DSSC and boost converter
  - Optimum number of cells depends on available area

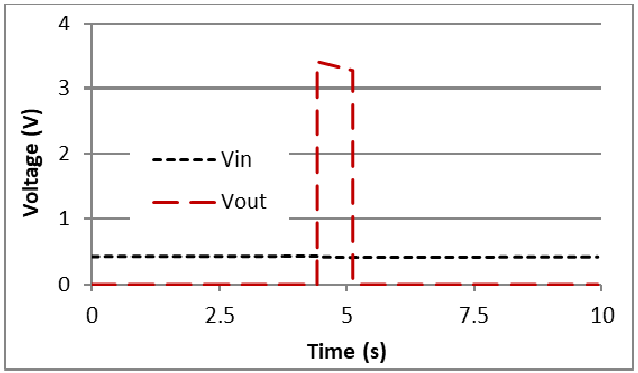




System level DSSC design: switched supercapacitor DC/DC

- Combining energy storage and DC/DC converter functionality

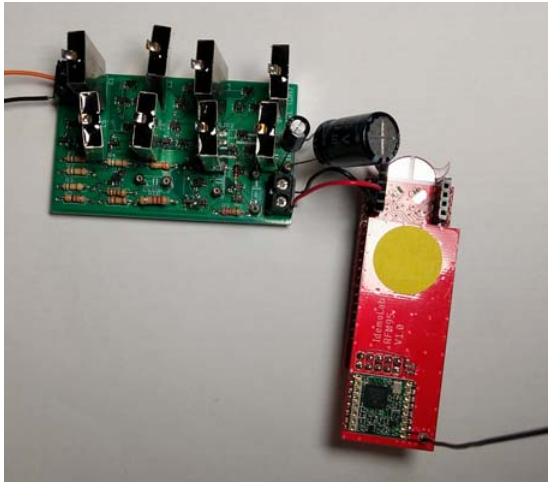


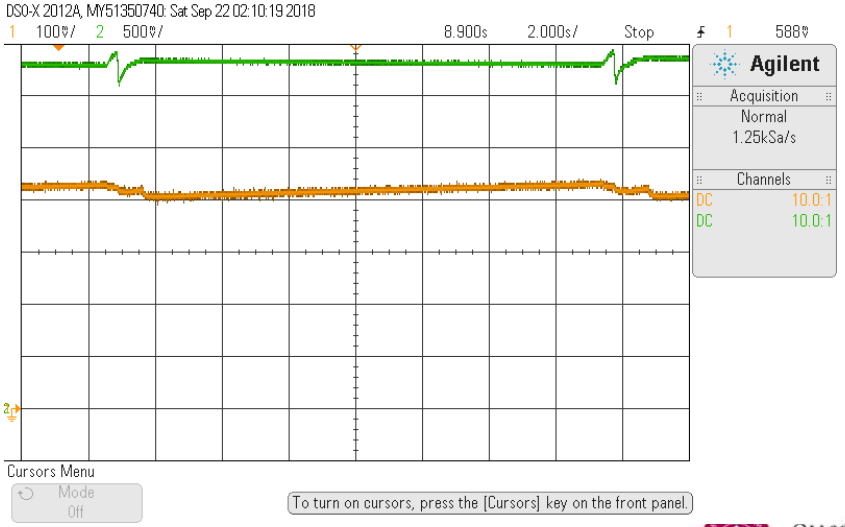


- Optimised design requires close matching to load requirements

System level DSSC design: switched supercapacitor DC/DC

- Demonstator LoRA sensor load
  - 0.4 V DSSC input
  - 0.487 mW input power to operate with switched supercap circuit vs. 0.559 mW for closest EH energy management IC
  - Potential for energy-aware sensor operation, by supplying enable pin with EH voltage





Conclusions

- EH source optimum voltage and power levels do not usually coincide
  - EH source needs to supply load and energy storage
- Choice of all power conversion/energy management components needs careful consideration
- Combined source/power conversion optimization provides significant improvement
  - Earlier consideration of their combination is better!
- Combined source/power conversion/load/storage optimization provides another promising route

Q & A

EnerHarv 2024

PSMA International Workshop | 26-28 June, 2024 | Perugia, Italy

Thanks very much for your time and attention!

Questions/comments???

TECHNICAL SPONSORS

ORGANIZER

HOST

COMMERCIAL SPONSORS

MEDIA SPONSORS

References

- [1] D. Carroll, *Miniaturised Electromagnetic Generators for Portable Applications*, PhD thesis, 2012, available online: https://researchrepository.universityofgalway.ie/entities/publication/876ee2d2-42f2-4f99-9ded-c7c6716bba66
- [2] D. Newell, *Optimised energy management for energy harvesting powered wireless sensors*, PhD thesis, 2019, available online: https://researchrepository.universityofgalway.ie/entities/publication/8315a4fb-060b-4046-a887-31334e20be55