

AIIC Lab研究成果報告

報告人: 郭永超 (Yeong-Chau Kuo)

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專長: AI-Driven IC Design, EDA Design

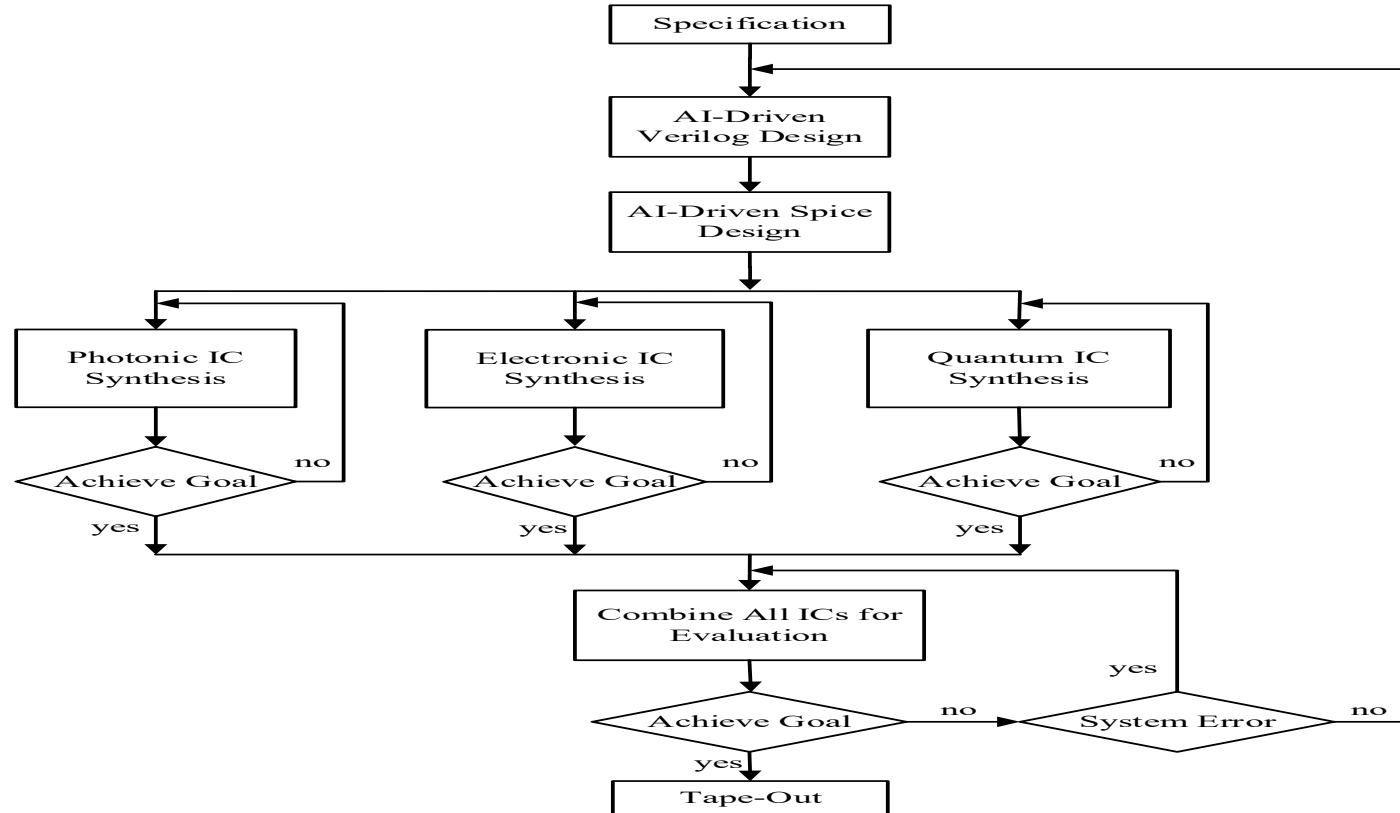
經歷: IC設計公司研發顧問, 電機技師,

國家晶片中心晶片製作審查委員,

太陽光電發電系統設置審查委員

◎非常感謝郭泰豪教授(成大電機系)技術指導與協助

AI-Driven IC Design



- This research proposes an EDA tool for synthesizing photonic quantum integrated circuit and system to shorten time-to-market design time.
- The proposed EDA tool can be applied in the fields of photonic quantum IC design.
- Energy harvesting IC can be used in space AI servers to provide sufficient power.

Latest Publication

- P. C. Huang, Y. C. Kuo*, Y. C. Liu, and T. H. Kuo, "An Analog Optimum Torque Control IC for a 200W Wind Energy Harvesting System," IEEE Trans. Circuits Syst. II: Exp. Briefs, Vol. 66, Iss. 11, pp. 1790-1794, Nov. 2019.
- Y. C. Kuo*, Y. M. Huang, and L. J. Liu, "Integrated Circuit and System Design for Renewable Energy Inverters," International Journal of Electrical Power & Energy Systems, Vol. 64, pp. 50-57, Jan. 2015.
- Y. C. Kuo*, Y. J. Luo, and L. J. Liu, "Synthesizable Integrated Circuit and System Design for Solar Chargers," IEEE Transactions on Power Electronics, Vol. 28, Iss. 9, pp. 4260-4266, Sep. 2013.
- Y. C. Kuo*, W. H. Tung, and L. J. Liu, "Smart Integrated Circuit and System Design for Renewable Energy Harvesters," IEEE Journal of Photovoltaics, Vol. 3, Iss. 1, pp. 401-406, Jan. 2013.
- Y. C. Kuo*, Y. J. Luo, and L. J. Liu, "Synthesis Design of Digital Solar Energy Harvesting Integrated Circuits and Systems," IET Optoelectronics, Vol. 6, Iss. 6, pp. 282-289, Dec. 2012.
- Y. C. Kuo*, C. H. Liu, and L. J. Liu, "Synthesisable Solar-Harvesting Integrated Circuit and System," IET Renewable Power Generation, Vol. 6, Iss. 6, pp. 408-413, Nov. 2012.
- P. C. Huang, W. C. Liu, Y. C. Liu, Y. C. Kuo*, and T. H. Kuo, "An Analog Optimum Torque Control IC for a 200W Wind Energy Conversion System with Over 99% MPPT Accuracy, 1.7% THDi and 0.99 Power Factor," 2014 IEEE Custom Integrated Circuits Conference (CICC), San Jose, California, USA, 2014/9/15-2014/9/17.

Latest Patent and Honor

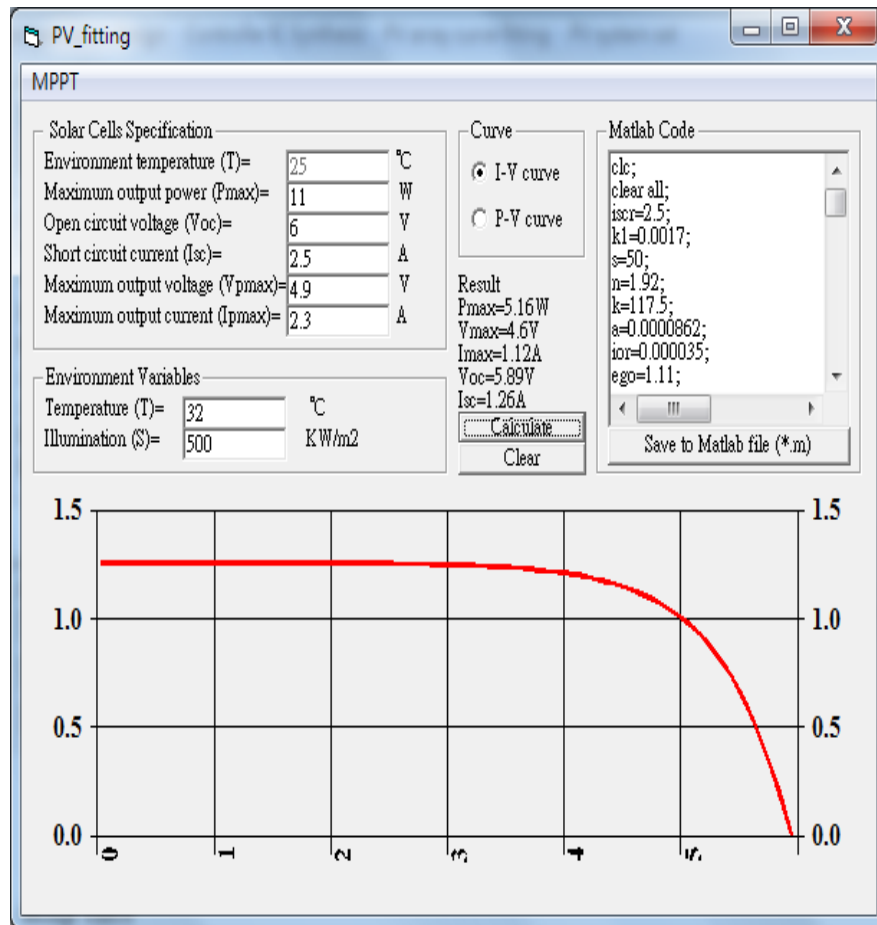
Patent

- JM Liu, YC Kuo, and TH Kuo, Analog Variable-Frequency Controller and Switching Converter Therewith, Invention patent, USA, Patent. No.: US 7923975 B2, 2011.
- Y. C. Kuo*, W. C. Liu, and T. H. Kuo, “Analog Controller for Inverter,” Invention patent, USA, US 8,842,456 B2, Sep. 23, 2014.
- 劉家銘、郭永超、郭泰豪,類比式可變頻率控制器,發明專利,臺灣,發明第I396373號.
- 郭永超、李貞慶、郭泰豪、黃鵬彰,類比式最大功率追蹤控制方法,發明專利,臺灣,發明第I381263號.
- 郭永超*、郭泰豪,換流器之類比控制器,發明專利,臺灣,發明第I444807號, 2014/7/11.

Honor

- 2026年智慧創新大賞晉級總決賽
- 2018年無人機及智慧製造自造者競賽優等
- 2018年金融科技創新競賽佳作
- 2015年龍騰微笑創業競賽晉級總決賽
- 2014年全國大專校院智慧電子系統(IE)設計競賽優等獎
- 2011年旺宏金矽獎設計組優勝獎
- 2010年旺宏金矽獎設計組評審團銅獎與指導教授獎
- 2010年立錡盃電源IC設計暨系統應用競賽佳作獎
- 2009年Discovery Channel採訪報導太陽能充電IC研究成果
- 2009年立錡盃電源IC設計暨系統應用競賽佳作獎
- 2009年奇景盃IC佈局設計競賽佳作獎

Spec. of System Synthesis



Circuit Choose

Specification

Vin=	15	V
Vout=	5	V
Rout=	1	ohm
fsw=	300k	Hz
L=	5u	H
C=	300u	F
RC=	30m	ohm
RL=	0	ohm

System param

VM=	3	V
H=	1	

Compensator specification

fc= 50k Hz
(0.1*fsw~0.2*fsw)

PM= 50 degree
(45~70 is better)

Calculate

Result

fc= 50000
fo= 4170.55
fesrz= 17683.9
GDC= 5
Aco= 10.17
P= -99.94
Boost= 59.94
Q= 2.73
Type= 2

Compensator device value

R1	10	Ohm	C1	108.2n	F
R2	109.57	Ohm	C2	8.41n	F
R3	N/A	Ohm	C3	N/A	F

☒ K controller
☐ PID controller

Circuit view

Spec. of IC Synthesis

Controller IC synthesis

This synthesis using 0.35um 5V process

Parameter

NMOS

UnCox: 80 nA/V

Vtn: 0.787 V

lambda: 0.0098 1/V

cgg: 2.1f F

cdd: 2.2f F

PMOS

UpCox: 25 nA/V

Vtp: 1.003 V

lambda: 0.0408 1/V

cgg: 2f F

cdd: 2.2f F

Confirm

Original WL ratio

WL1=15.79

WL2=15.79

WL3=3.12

WL4=3.12

WL5=12.8

WL6=80.42

WL7=39.27

WL8=6.4

WL9=6.4

WL10=6.4

WL11=6.4

WL12=7.42

WL13=6.4

WL14=0.26

Av=85.86

Pwd=364.16u

ICMR=2.07~3.52

Oswing=0.45~4.5

*Two-stage operational amplifier

LIB nm0355v1 TT

LIB nm0355v1 TT_5V

OPTION POST

(GLOBAL vdd! gnd!

SUBCKT OP vin+ vin- vout vdd! gnd!

*Current bias*****

Rb net5 gnd! 1K

M13 net10 net10 gnd! gnd! Nch5 W=6.5u L=1u M=1

M12 net8 net10 net5 gnd! Nch5 W=7.5u L=1u M=1

M11 net18 net18 net10 gnd! Nch5 W=6.5u L=1u M=1

M10 net36 net18 net8 gnd! Nch5 W=6.5u L=1u M=1

M9 net18 net36 vdd! vdd! Pch5 W=6.5u L=1u M=1

M8 net36 net36 vdd! vdd! Pch5 W=6.5u L=1u M=1

*Differential pair*****

M1 net2 vin- net1 vdd! PCH5 W=8u L=1u M=2

M2 net3 vin+ net1 vdd! PCH5 W=8u L=1u M=2

M3 net2 net2 gnd! gnd! NCH5 W=5u L=1u M=1

M4 net3 net2 gnd! gnd! NCH5 W=5u L=1u M=1

M5 net1 net36 vdd! vdd! PCH5 W=6.5u L=1u M=2

Specification-Two-Stage OP

Specification

Low-frequency gain: 60 dB

Unity-gain frequency: 10x Hz

Slew Rate: > 10 V/us

Load impedance: 5p F

Power dissipation: < 2m W

Phase margin: < 45 °

Load list file: Tuning

Calculate W/L: Generate test files

Message window

Two-Stage OP

Term	Target	Simulation
Av	>60dB	75.17dB
Phase Margin	>45°	54.75 °
ICMR	0V-5V	0.06V-4.45V
CMRR	>60 dB	73.52dB
PSRR	>60 dB	76.88dB
Slew Rate	10 V/us	28.75 V/us
Unit-gain frequency	10 MHz	36.92 MHz
Output swing	>3V	0.075V-5V
Offset	>1V	53.31mV
Pwr dissipation	<2mW	0.9mW

Hysteresis Comparator

Vtrp	110mV
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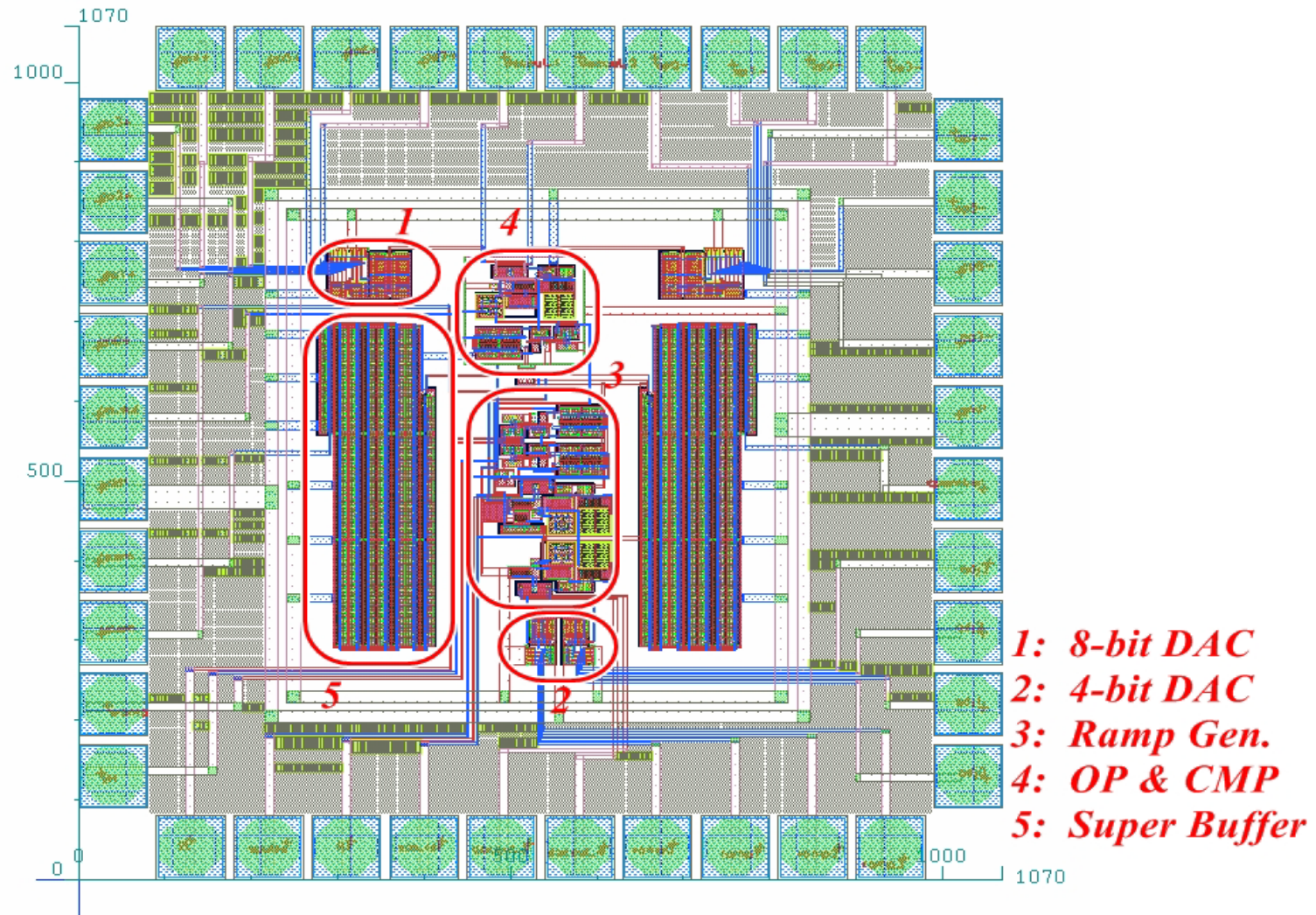
Ramp Generator

Frequency	1kHz~60MHz
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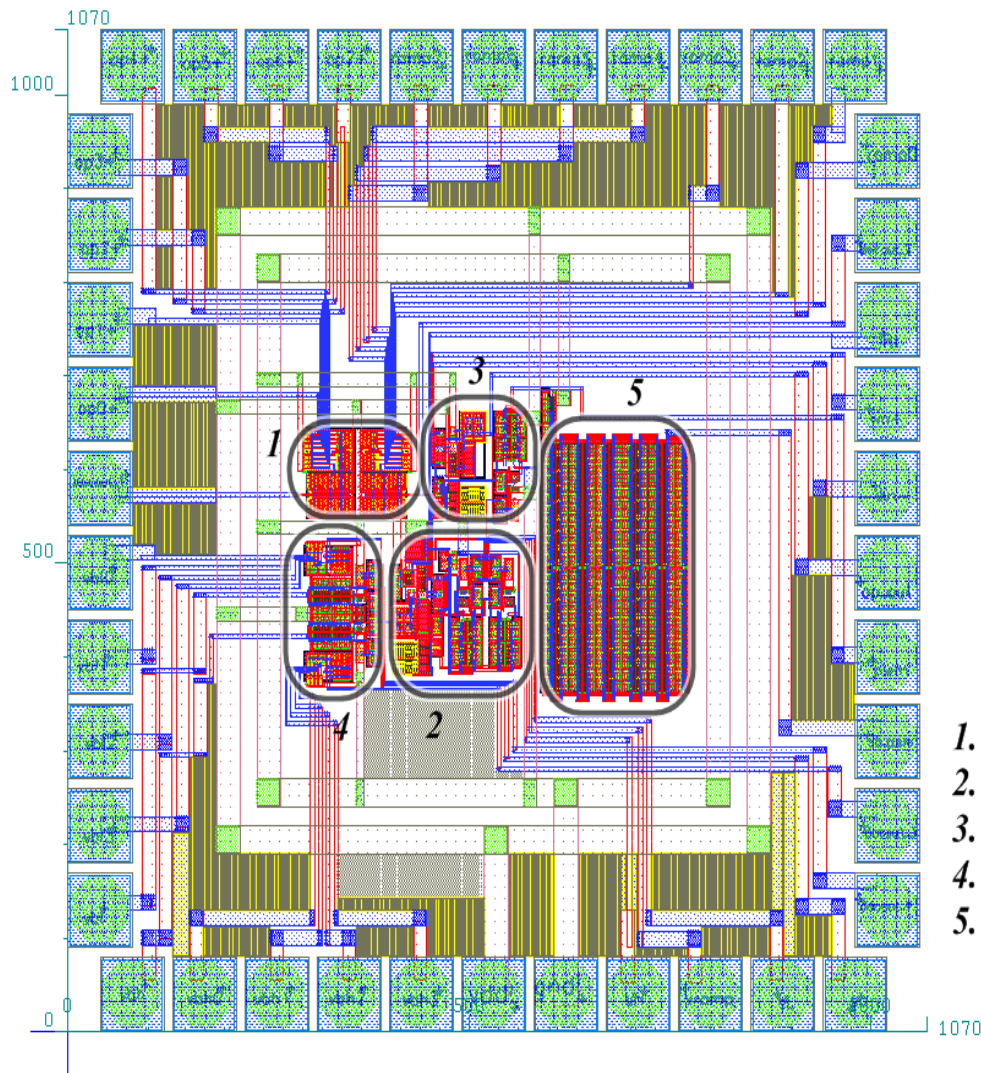
Programmable APWM

Power Dissipation	24.24 mW
Oscillator Frequency	16 MHz
Chip size	0.7 mm x 0.7mm ⁶

IC Tape-out (1/2)

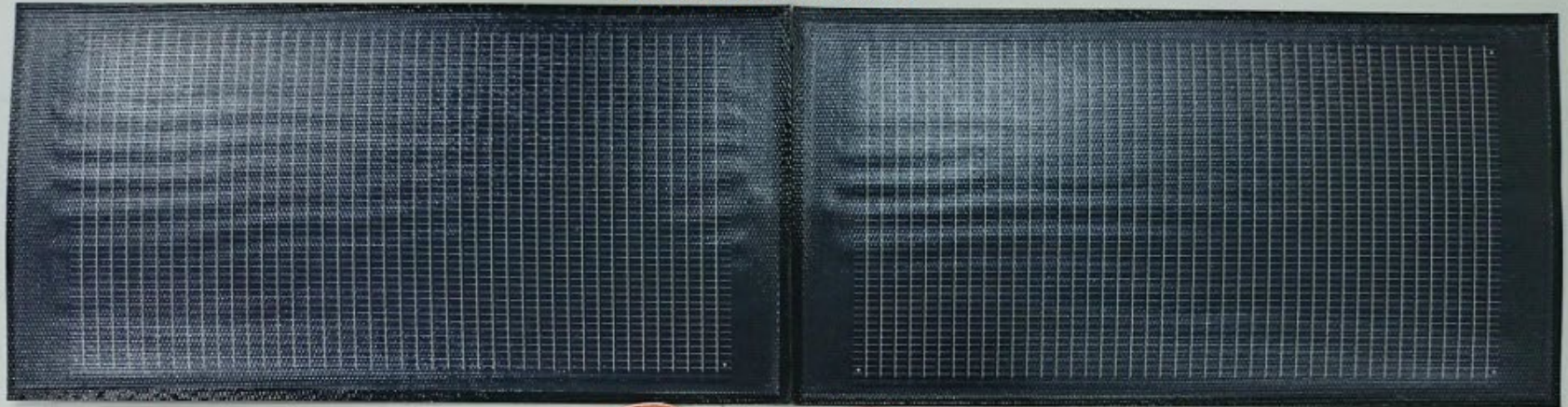


IC Tape-out (2/2)

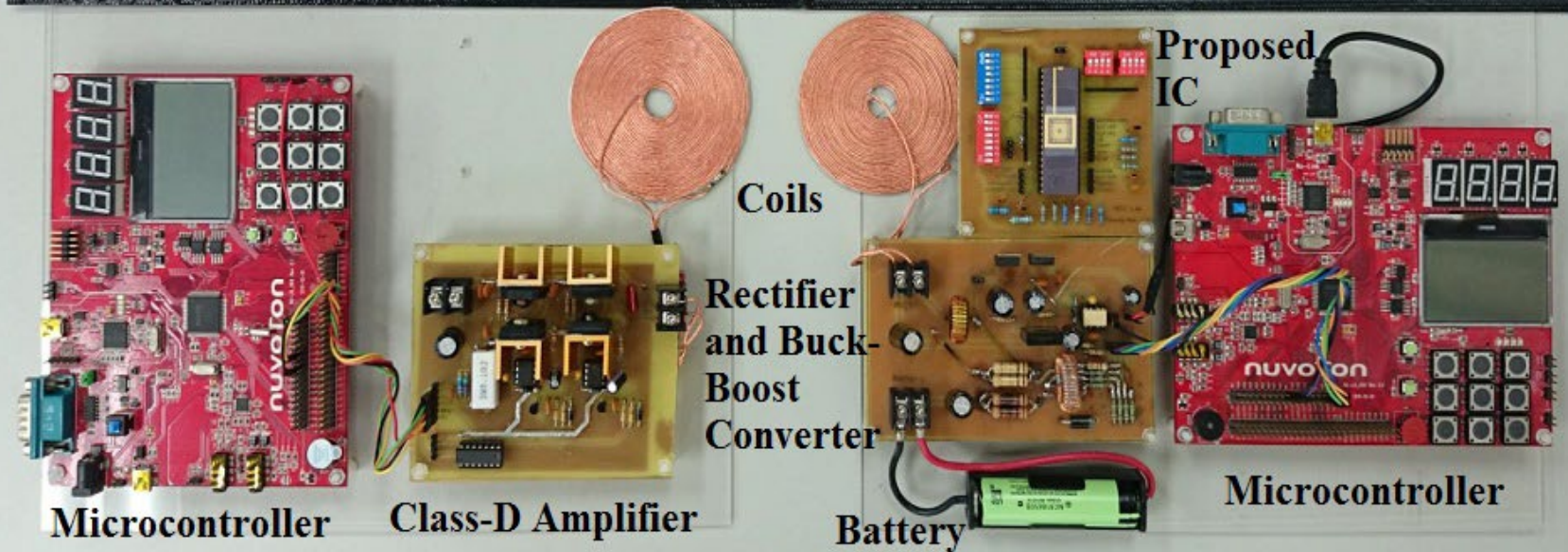


Photonic-Electronic IC

CIGS Solar Panel



Proposed IC



Microcontroller

Class-D Amplifier

Rectifier
and Buck-
Boost
Converter

Battery

Microcontroller

Photonic-Electronic IC for Drones, Robots, and Cars



Reference:

- <https://www.youtube.com/watch?v=KJImQFo7bO4> (AIIC Lab_1)
- <https://youtu.be/-vJfdRQ4IzY> (AIIC Lab_2)
- <https://people.engr.tamu.edu/spalermo/index.html> (Prof. Sam Palermo)
- <https://yuegroup.hkust.edu.hk/> (Prof. Patrick Yue)
- <https://www.tsmc.com/chinese> (TSMC)
- <https://www.nvidia.com/zh-tw/data-center/dgx-cloud/> (Nvidia)
- <https://chipagents.ai/> (ChipAgents)
- <https://agentrys.ai/> (Agentrys)
- <https://www.deepweave.ai/> (Deepweave)
- <https://tenstorrent.com/> (Tenstorrent)
- <https://www.bcanalog.com/> (Blue Cheetah, BAG)
- <https://ayarlabs.com/> (Ayar Labs, BPG)
- <https://lightmatter.co/> (Lightmatter)
- <https://www.xanadu.ai/> (Xanadu, pennylane)
- <https://www.psiquantum.com/> (PsiQuantum, GlobalFoundries)
- <https://www.ionq.com/> (IonQ, Skywater)