教育部補助大專校院延攬國際頂尖人才
年度績效報告

學校名稱及聘任系所：國立臺灣大學電機系	學門領域： 工 學
學者姓名：金藝璘	□玉山學者　■玉山青年學者

Yushan Fellow Program Performance Report

Assessment of effectiveness of tangible work (The implementation results can be presented cumulatively, including the annual performance report of the second year, which can include the results of the first year and the second year)

Main points of assessment	The anticipated goals	Concrete work achievements or results	Supporting documents
1. Chief content of the Yushan (Young) Fellows' research work and overview of full research process.	This work aims to: 1. conduct high-impact research on power electronics and control with contributions to mitigating climate change by enabling clean solar energy 2. train students to be independent thinkers and researchers with practical skills 3. present research findings on research topics at local and international conferences while receiving constructive feedback from the academic community 4. disseminate research conclusions through peer-reviewed high-impact journals that reach a large audience. **Progress** For awards, since 2021, one education award has been received, specifically focusing on innovative flipped learning and video lecture teaching methods. The award was received at the IEEE Energy Conversion Congress	**Awards**: 1. IEEE PELS: 2022 Award for Achievements in Power Electronics Education. "For pioneering educational videos and online learning in power electronics" 2. MIT Technology Review: 2020 Innovator Under 35. Honored as an innovator under the age of 35 for the Asia Pacific by the MIT Technology Review. **Research Projects:** 1. Power Converter and Control Development for Modular High Power-Density Photovoltaic Systems. Grant: MOST 109-2218-E-002-011-MY3. August 1, 2020, to July 31, 2023. 2,915,000 NTD for 3 years. 2. High-Efficiency Nanosatellite Power System Development using GaN Devices and Controls Assessment. Grant: MOST 109-2221-E-002 -097-. August 1, 2020, to July 31, 2021. 945,000 NTD for 1 year. 3. SIMPLIS PFC Boost Converter Stimulation: Theoretical and Simulation Analysis. Funder: SIMPLIS Technologies Inc. September 1, 2020, to August 31, 2021. 300,000 NTD for one year. **Recent Published Journal Papers:** 1. S.-Y. Chiu and K. A. Kim, "System Analysis and Design for Multiconverter Electrical Power Systems in Nanosatellites," in IEEE Journal on	Appendix No. Quantitative Assessment: 1 Opinion Survey: 2 Awards: 3-4 Recent Journal Papers: 5-9

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	& Exposition (ECCE) 2022, a flagship international conference in the power electronics field. For research projects, since 2021, one 3-year research grant from MOST (now NSTC) has been carried out and the findings are being prepared for dissemination through conference and journal publications. Two additional research grants have been submitted to the NSTC for future projects, and another project funded by a prominent company in Taiwan is in preparation. For published journal articles, from 2022, five peer-reviewed journal articles have been published. Three of the articles (1-3) were related to my main research topic of power electronics for photovoltaics and two were collaboration papers: one on high-power density converter development (4) and the other on considerations for electric vehicles with solar photovoltaic panels (5). In addition, two manuscripts are in preparation and will be submitted in 2023, so more journal papers are expected in the coming year. For conference papers, from 2022,	Miniaturization for Air and Space Systems, vol. 4, no. 1, pp. 41-53, March 2023. 2. Katherine A. Kim, F. Selin Bagci, and Kristen L. Dorsey. Design considerations for photovoltaic energy harvesting in wearable devices. Scientific Reports, vol. 12, pp. 1-12, 28 Oct. 2022, art. no. 18143. 3. F. Selin Bagci, Katherine A. Kim, Yu-Chen Liu and Yi-Hua Liu. Evaluation of Power Maximization and Curtailment Control Methods for Converters in Wearable Photovoltaic Energy Harvesting Applications. IEEE Open Journal of Power Electronics, vol. 3, pp. 508-520, Aug. 2022. 4. Yu-Chen Liu, Chen Chen, Yu-Chen Chung, Meng-Chi Tsai, and Katherine A. Kim. Integrated magnetics optimization process for an interleaved three-phase buck converter at 500 kHz. IET Power Electronics, pp. 1-11, 10 June 2022. 5. Saksham Consul, Krishna Veer Singh, Hari Om Bansal and Katherine A. Kim . Intelligent switching mechanism for power distribution in photovoltaic-fed battery electric vehicles. Environment, Development and Sustainability, pp. 1-20, 18 May 2022 **Previously-Reported Published Journal Papers:** 6. Mina Kim, Sangkyu Kwak, Katherine A. Kim and Jee-Hoon Jung, “Enhanced Computation Performance of Photovoltaic Models for Power Hardware-in-the-loop Simulation,” IEEE Transactions on Industrial Electronics, vol. 68, no. 8, pp. 6952-6961, Aug. 2021. 7. Hoejeong Jeong, Seungbin Park, Jeehoon Jung, Taewon Kim, A-Rong Kim, and Katherine A. Kim. Segmented Differential Power Processing Converter Unit and Control Algorithm for Photovoltaic	

Main points of assessment	The anticipated goals	Concrete work achievements or results	Supporting documents
	only one paper has been published at an international IEEE conferences held in Taiwan. However, three conference papers have already been accepted for publication in 2023 at international IEEE Conferences in the US and South Korea. For Keynotes, a talk was delivered as the second Keynote talk at the IEEE PELS Design Methodologies Conference 2022, held in Bath, UK. The talk on "Can Online Engineering Lectures Be Fun? A Perspective on Developing Educational Videos" was given virtually.	Systems. IEEE Trans. Power Electronics, vol. 36, no. 7, pp. 7797-7809, July 2021. 8. Yu-Chen Liu, Chen Chen, Kai-De Chen, Yong-Long Syu, De-Jia Lu, Katherine A. Kim, and Huang-Jen Chiu. Design and Implementation of a Planar Transformer with Fractional Turns for High Power Density LLC Resonant Converters. IEEE Trans. Power Electronics, vol. 36, no. 5, pp. 5191-5203, May 2021. 9. Yu-Chen Liu, Yong-Long Syu, Nguyen Anh Dung, Chen-Chen, Kai-De Chen and Katherine A. Kim, "High Switching Frequency TCM Digital Control for Bidirectional Interleaved Buck Converters Without Phase Error for Battery Charging," in IEEE Journal of Emerging and Selected Topics in Power Electronics, vol. 8, no. 3, pp. 2111-2123, Sept. 2020. 10. Yu-Chen Liu, Kai-De Chen, Chen Chen, Yong-Long Syu, Guan-Wei Lin, Katherine A. Kim and Huang-Jen Chiu, "Quarter-Turn Transformer Design and Optimization for High Power Density 1-MHz LLC Resonant Converter," IEEE Transactions on Industrial Electronics, vol. 67, no. 2, pp. 1580-1591, Feb. 2020. **Published Conference Papers:** 1. Taiwei Chen and Katherine A. Kim. Nanosatellite Power System with A Variable DC Bus Voltage for Improved System Efficiency. IET International Conference on Engineering Technologies and Applications (IET-ICETA), pages 1–2, Oct. 2022. 2. Shang-You Chiu, Katherine A. Kim, and Yu-Chen Liu, "Analysis of Nanosatellite Impedance Interaction and Stability Based on System Operation Mode," in Proc. International Future Energy	

Main points of assessment	The anticipated goals	Concrete work achievements or results	Supporting documents
		Electronics Conferences, Nov. 2021, pp. 1-6. 3. Yu-Ting Yang, Katherine A. Kim, and Jonghoon Kim, “Bidirectional CLLC Resonant Converter Design for Photovoltaic Microinverters with Li-Ion Batteries,” in Proc. International Future Energy Electronics Conferences, Nov. 2021, pp. 1-6. 4. Guan-Ru Li, Katherine A. Kim, Aishworya Roy, and Thomas G. Wilson, “Examining Power Factor Correction Boost Converter Feedback Control Using SIMPLIS,” in Proc. International Future Energy Electronics Conferences, Nov. 2021, pp. 1-6. 5. Chi Jui Lo and Katherine A. Kim, “System Control and Reset Algorithm for Differential Power Processing Converters in a Photovoltaic Microinverter,” in Proc. IEEE Workshop on Control and Modeling for Power Electronics, Nov. 2021, pp. 1-8. 6. F. Selin Bagci and Katherine A. Kim, “Performance Comparison of Burst-Mode MPPT and Perturb and Observe MPPT Algorithms for Photovoltaic Energy Harvesting Applications,” in Proc. IEEE Energy Conversion Congress Exposition (ECCE), Vancouver, BC, Canada, Oct. 2021. 7. Yu-Chen Liu, Meng-Chi Tsai, Ying-Jiun Chen, Katherine A. Kim, Chen Chen, and Nguyen Anh Dung, “Design and Implementation of a Stepped Air-Gap Inductor for Buck Converters,” in Proc. IEEE Applied Power Electronics Conference, June 2021, pp. 1-6. 8. Yu-Chen Liu, Chen Chen, Kai-De Chen, Yong-Long Syu, Wen-Hao Xue, Yun-Yan Chen, Katherine A. Kim, and Huang-Jen Chiu, "Design and development of a fractional-turn transformer for high power density LLC resonant converters," IEEE Applied Power Electronics Conference and	

Main points of assessment	The anticipated goals	Concrete work achievements or results	Supporting documents
		Exposition (APEC), 2021, pp. 335-342. 9. F. Selin Bagci and Katherine A. Kim, “Burst-Mode Maximum Power Point Tracking Algorithm for Low-Power Photovoltaic Energy Harvesting Applications,” in Proc. IEEE Energy Conversion Congress Exposition Asia, Singapore, May 2021, pp. 1-6. 10. F. Selin Bagci, Katherine A. Kim, Ting-Yu Lin, and Yu-Chen Liu, “Power Profile Measurement and System Design Analysis for a Wearable Photovoltaic Application,” in Proc. International Power Electronics and Motion Control Conference – ECCE Asia, Nanjing, China, Dec. 2020, pp. 1469-1474. 11. Yu-Chen Liu, Chen Chen, Yu-Chen Chung, Meng-Chi Tsai, and Katherine A. Kim, “Integrated Magnetics Design for an Interleaved Three-Phase Buck Converter,” in Proc. IEEE Energy Conversion Congress Exposition (ECCE), Detroit, Mi, USA, Oct. 2020, pp. 4533-4538. **Keynote Talks** 1. “Can Online Engineering Lectures Be Fun? A Perspective on Developing Educational Videos” Design Methodologies Conference 2022, September 2, 2022.	
2. The link between Yushan (Young) Fellows' future research topics and the university's development and the anticipated benefits (including Higher Education SPROUT Project): (1)Fellows' research plan and goals (2)The link between scholars' research content and the university's development	Since joining the EECS of NTU in 2019, my research has focused on renewable power and smart grid technologies through power electronics and control. I have carried out both MOST/NSTC and international industry projects that mutually benefit NTU and the students working on the projects by cultivating high-level R&D talents.	**Awards:** ● National Taiwan University Excellent Teaching Award 2022. For 2021-2022 academic school year. ● National Taiwan University Excellent Teaching Award 2021. For 2020-2021 academic school year. Courses Taught: ● 2021-2023 Spring: 2004 Electronic Circuits, National Taiwan University (NTU) First-year	

Main points of assessment	The anticipated goals	Concrete work achievements or results	Supporting documents
(3)Specific work performance or achievements, please include the mid-term progress report of the particular research plan (4)Anticipated goals (including qualitative or quantitative working performance or results) ※ If there is a quantitative work achievements, please fill out "Quantitative Assessment Form"	As both a scholar and educator, I have brought my passion for education to my classroom and research laboratory. All my classes and lab meetings are conducted in English, and I hold each student to high expectations. This prepares the students for the industry which is increasingly demanding high levels of English proficiency. My goal is to prepare my students for rigorous, international environments where they are motivated to make a positive impact through their careers. I was honored to receive the NTU excellent teaching award for the 2020-2021 and 2021-2022 academic school year and will continue to improve my teaching.	undergraduate required course. ● 2019-2022 Fall: 4010 Introduction to Power Electronics, NTU Senior undergraduate elective course. ● 2022 Fall: Differential Equations, NTU Second-year undergraduate required course.	
3. Support provided by the university and the project's original goals (please specify the type of support or funds provided by the university to assist in research, such as research equipment and funds, research assistant personnel expenses, accommodation, relocation, children's education assistance, etc.)	National Taiwan University has supported through: 1. starting faculty funds and smaller departmental funds that enabled the purchase of equipment and infrastructure needed to conduct research. The Electrical Engineering Department has supported by providing an office, lab space for students, and covering utilities. 2. Research Program Application: The Research and Development Office of the NTU regularly	School-Supported Funds: ● Start-Up Funding for Incoming Faculty: March 20, 2019, to December 31, 2019. 250,000 NTD. ● Graduate Institute of Electrical Engineering: February 1, 2019, to December 31, 2019. 100,000 NTD. ● Electrical Engineering Dept: February 1, 2019, to December 31, 2019. 100,000 NTD. ● SPROUT Project: January 1, 2019, to December 31,	

Main points of assessment	The anticipated goals	Concrete work achievements or results	Supporting documents
	announces various projects that are publicly solicited and assists in applying for research projects. 3. Teaching assistance: The EECS department reduced requirements for one year of employment to teach one less course and also offers an English language teaching credit. General subsidies: NTU provides subsidies related to accommodation, child education, maternity, marriage, & death. These have been beneficial for well-being and peace of mind.	2019. 300,000 NTD. ● Electrical Engineering Dept. Power Group: August 1, 2019, to November 15, 2019. 235,700 NTD ● Electrical Engineering Dept. Power Group: August 1, 2020, to November 15, 2020. 100,000 NTD ● Electrical Engineering Dept. Power Group: August 1, 2021, to November 15, 2021. 100,000 NTD ● . Electrical Engineering Dept. Power Group: August 1, 2022, to November 15, 2022. 100,000 NTD	
4. Yushan Fellows ' team cooperation (please list team members and cooperation methods) (Yushan Young Fellows don't need to fill in this)	Not applicable	Not applicable	Not applicable

Main points of assessment	The anticipated goals	Concrete work achievements or results	Supporting documents
5. Yushan (Young) Fellow should aim to cooperate and exchange foreign academic resources, which should be linked to university development. It's suggested to make good use of these global academic network resources to assist the internationalization of the host university and promote international exchanges and cooperation, including teachers and students exchange activity between universities, international research collaborations, dual degree programs and so on.	In terms of research, I am actively collaborating with a professor in the USA who has expertise in wearables sensors and we have published one journal paper. I also collaborate with a professor in South Korea who has expertise in batteries and modeling; we have published one conference paper and have ongoing work. In terms of other international activities, I volunteer with the IEEE Power Electronics Society (PELS). I am the PELS Constitution and Bylaws Chair (2021-2024) and a voting member of the PELS Administrative Committee. I am also an active member in the PELS Women In Engineering Committee and authored two magazine articles on the status of women in PELS.	**Recently Published Magazine Article:** 1. Katherine A. Kim, Lauren E. Kegley, Stephanie Watts Butler, Christina DiMarino, Marium Rasheed and Radha Sree Krishna Moorthy, "Women in IEEE PELS: Progress and Opportunities" in IEEE Power Electronics Magazine, vol. 9, no. 2, June 2022. **Previously-Reported Magazine Article:** 2. Katherine A. Kim, L. E. Kegley, S. Watts Butler, N. Brandao de Freitas and C. DiMarino, "Women in IEEE PELS: Learning From the Past, Defining the Future [Women in Engineering]," in IEEE Power Electronics Magazine, vol. 8, no. 2, pp. 70-75, June 2021.	Appendix No. Published Magazine Article: 10

3. Information on website (Refer to: https://yushan.moe.gov.tw/TopTalent/EN/Project)

1) Title: Power Electronics and Control to Enable A Clean-Powered Society

2) Description of project results: (explain results' keywords)

As climate change becomes a more urgent global problem, we continue to innovate in power electronic converters to improve solar photovoltaic (PV) power in existing grid-connected systems and expand PV power to non-stationary applications, like wearables. We are developing power electronics and control methods to improve efficiency and resiliency in PV power converter systems. Two primary projects are:
1) PV microinverter design with differential power processing (DPP) converters
2) non-uniform and moving PV power system analysis and development for wearable applications

For the PV microinverter with DPP converters, we have been developing a bidirectional DPP converter for high power density that will be used for a PV microinverter application. Wide bandgap GaN switches are used, operating at high frequencies to increase power density. In addition to the hardware development, improvements have been made to improve the effectiveness of the system control algorithm. Existing system control algorithms for the bidirectional DPP converters in PV systems are slow to converge and cannot quickly respond to sudden changes. A reset algorithm based on PV submodule voltage sensing and PV MPP estimation has been developed for rapid maximum power point operation recovery after transient conditions and for fast convergence to the MPP during system startup. A proposed algorithm has been examined for different types of converter control, including duty cycle perturbation and peak current mode (PCM) control.

For PV-powered wearable applications, the work aims to show the feasibility of solar photovoltaic energy as a viable power source for wearables (to power fully or partially the device). One challenge is that wearable applications experience varying light intensities over multiple PV cells that reduce PV power generation in traditional implementations. To properly design the system, this work investigates the effects of the curvature of the panel on its electrical characteristics when worn on the arm. A power converter prototype has also been developed and tested outdoors to measure power generation on various types of usage cases. Experimental tests have verified that sufficient power for low-power health monitoring devices can be harvested.

3) Photos of results (images) and description:

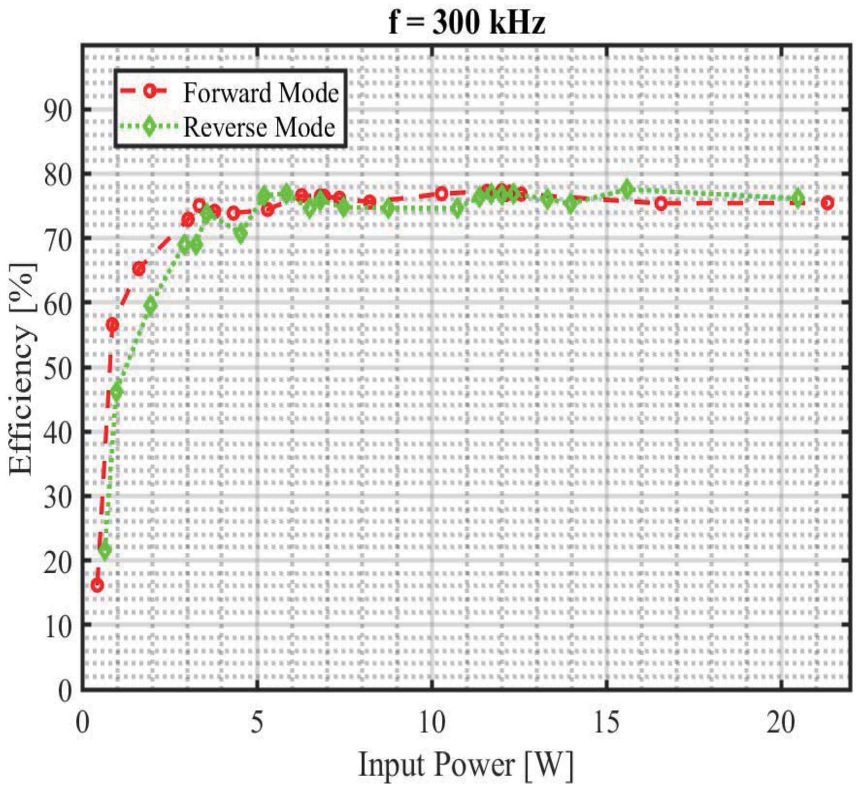

Figure 1. Bidirectional flyback converter efficiency in forward and backward operation.

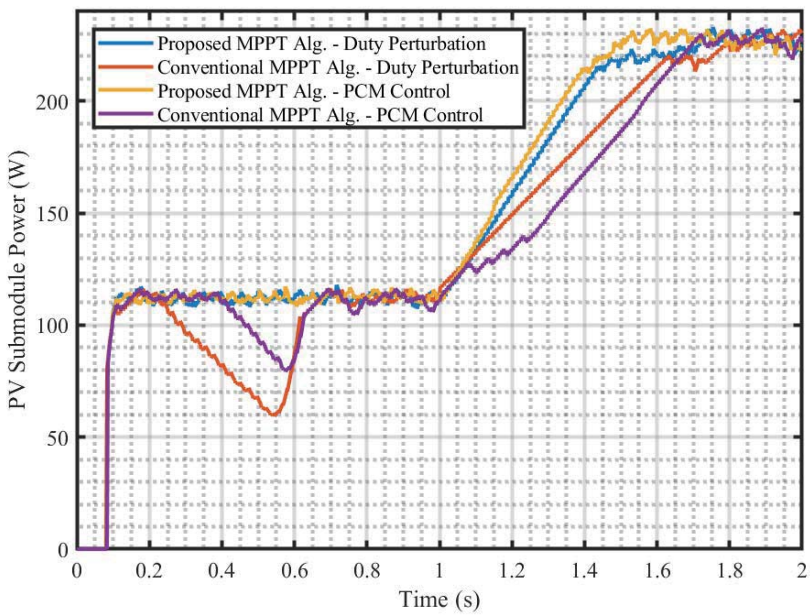

Figure 2. DPP system algorithm comparison of improved MPPT algorithm outperforming the conventional algorithm for both perturbation of the duty cycle and peak current mode control (PCM).

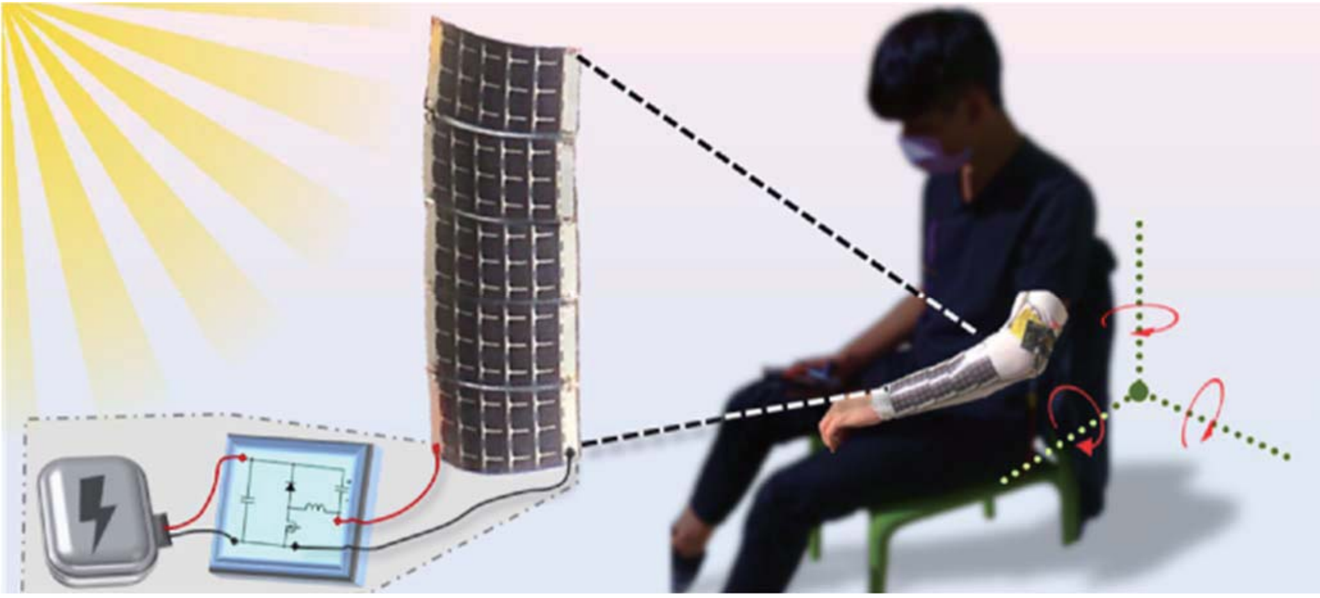

Figure 3. Solar powered health-monitoring sleeve using flexible photovoltaic panels and individual low-power power converter.

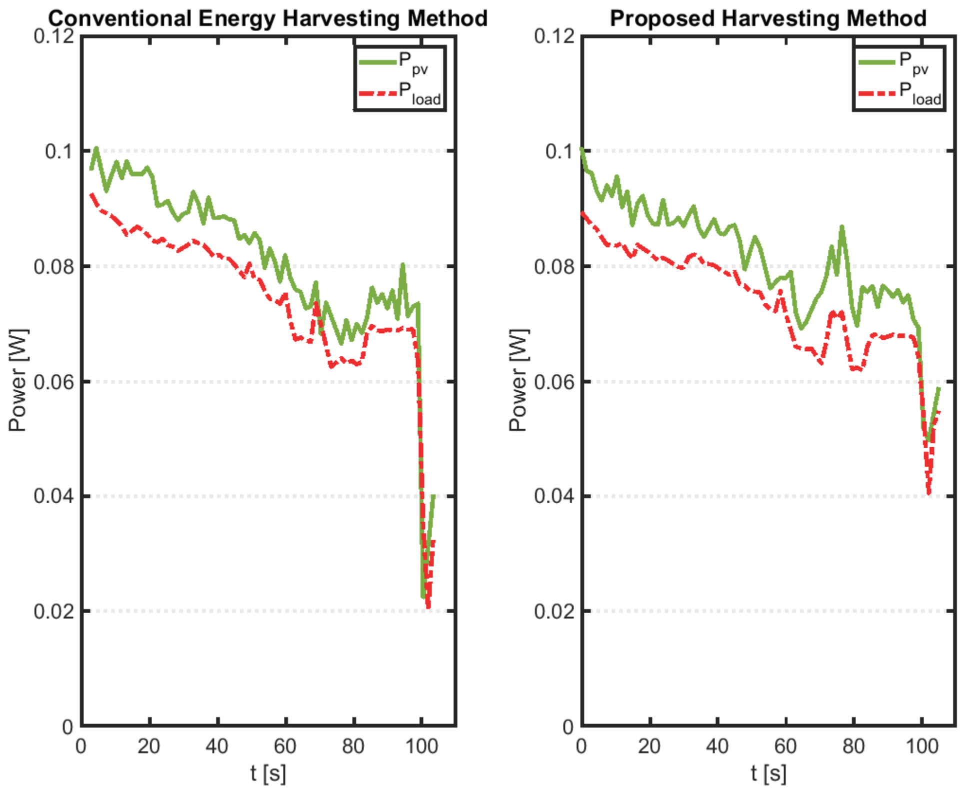

Figure 4. Solar power harvested for a wearable PV application with a conventional control method and a proposed fast-reacting energy harvesting control method.

4) Explanation of results:

For the project on PV microinverter with DPP converters, we have developed a flyback converter operating at 300 kHz and using GaN Switches that is able to handle bidirectional power. Fig. 1 shows the measured efficiency in both the forward and backward directions. It has a higher power density than the previous design and equivalent efficiency. Further improvements to the coupled inductor are expected to further improve performance. Fig. 2 shows the simulation results of the conventional and proposed MPPT algorithm after a sudden light change. Both converter control algorithms directly perturbing the duty ratio and using peak current mode (PCM) control are compared with the conventional and proposed algorithm. Both cases of the proposed MPPT algorithm outperform the conventional algorithm with PCM control showing the best overall performance. Further improvements to the algorithm are being studied and compared.

For the project on PV-powered wearable applications, Fig. 3 shows the concept for the PV-powered health-monitoring sleeve application. Studies of the flexible PV panels found that bending around the forearm reduces output power, but the angle relative to the light source has a more pronounced effect on both output power and voltage characteristics. Among various panel arrangements on the forearm, multiple PV panels of smaller widths provided higher output power while being controlled by a boost converter power stage. Testing verified that the PV sleeve can provide over 100 mW outdoors, which can effectively reduce the battery in wearables. Another topic in this research is the control algorithm to quickly adjust the power converter operation when lighting conditions change. Fig. 4 shows the power captured using a conventional constant-voltage control compared to a control method that we developed that quickly adjusts to the changing conditions to yield more power to the load over the measured time period. Our control method also considers user safety in wearable devices by quickly reacting to overheating conditions.

Appendix 1

Quantitative Assessment Form

Item		Results and concrete work performance	Explanation
1. Manpower training		Doctoral courses:_0______________ Graduate courses:_5______________ Undergraduate courses:_5_________ Doctoral students:_2_____________ persons Master's students:_6_____________ persons Undergraduate students:_3________ persons Others:_0________ persons	
2. Papers and research works	Domestic	Journal papers:_0___________ Academic books and papers in books:_0_____ Conference papers: _4________ Technical reports:_0__________ Others:_0_________	
	Overseas	Journal papers:_10___________ Academic books and papers in books:_0_____ Conference papers: _7________ Technical reports:_0__________ Others:_0_________	
3. Keynote speaker		____1___panels /sessions	
4. Patents （including patents pending）	Domestic	Quantity: _1__________	
	Overseas	Quantity: _0__________	
	☐ N/A		
5. Industry-Academia Cooperation		Number of partnered enterprises :_0______	
		Number of industry-academia research projects: _1____________	
6.Technology licensing		Technology licensing cases: _0_________	
		Total technology licensing royalties （amount）NT$_0____________	
		■ N/A	
7. Others		Research awards: 2 Teaching awards: 3	