

Research Assessment Exercise 2020

Impact Overview Statement

University: City University of Hong Kong

Unit of Assessment (UoA): 12 - Electrical & Electronic Engineering

Total number of eligible staff of the university in the UoA: 41

(1) Context

At CityU, the Department of Electrical Engineering (EE) hosts faculty specializing in a wide range of areas that are highly relevant to the industry including antenna design, machine learning, biomedical systems, control and optimization, photonics and nanotechnology, power electronics, as well as networking and wireless communications. CityU EE faculty recently obtained top awards such as: 3 IEEE Society Awards (on antennas, computational electromagnetics, and cybernetics), 1 State Natural Science Award of China (Second Prize), as well as 1 Ho-Leung-Ho-Lee Prize for Scientific and Technological Progress of China. Highlights of the achievements in research impacts are as follows.

- **132 U.S. patents were filed, including 80 that have already been granted**, in the past 6 years.
- **Antenna technology for 5G, 6G, and beyond** was advanced at millimeter-wave and terahertz bands through the State Key Laboratory of Terahertz and Millimeter Waves in CityU EE.
- **Emerging power electronics technologies** for energy saving and battery assessment in solar-powered lampposts were commended by the Development Bureau of the HK Government.
- **The world's first standard for wireless charging, *Qi Standard***, was developed based on a suite of patents from CityU EE. The standard is adopted by millions of devices such as iPhones.

(2) Approach to impact

CityU EE aspires to be the leader for high-impact research with emphasis on readiness for industrial and marketable applications. To foster industrial links, CityU EE has been active in organizing the Emerging Technologies Forum Series with the Knowledge Transfer Office of the university. Typically, each workshop had about a hundred attendees from the industry. In the past 6 years, the forum series covered important topics including the state-of-the-art 5G technologies, artificial intelligence, battery technology, and Internet of Things (IoT); attracting collaborations from industrial partners like **NVIDIA (HK) AI Tech Center, GP Batteries, SmarTone Mobile Communications, and Chow Tai Fook Jewellery**. As a platform for industrial collaborations in HK as well as the greater China, the State Key Laboratory of Terahertz and Millimeter Waves is supported by the Ministry of Science and Technology of China. It has always been attracting much recognition in the region and around the world. The laboratory acts as a hub for experts to exchange ideas and share the state-of-the-art equipment, while facilitating engagement and collaboration with the industry. Similarly, the Centre for Smart Energy Conversion and Utilization Research was founded to support research and development in the domain of power electronics. Recently, CityU EE launched a joint lab scheme for industrial collaboration with **HK Government's Electrical and Mechanical Services Department (EMSD), HK Applied Science and Technology Research Institute (ASTRI), HK Electronic Industries Association, HK Productivity Council, and Automotive Platforms and Application Systems R&D Centre. Deloitte, PCCW, Sengital, DBS Bank**, and some other companies have also supported undergraduate design projects and internships. In order to meet the needs of industry, CityU EE has been regularly organizing group visits for faculty and students to different regional companies, including **Huawei, BYD, and Tencent** in Shenzhen, China. In order to foster a culture of industrial involvement, CityU EE has organized sharing sessions among faculty members to raise the quality and quantity of successful industry-related grant applications involving local and non-local companies.

(3) Strategy and plans

Over the 6-year assessment period, CityU EE has been awarded a number of industry-related research grants amounting to about [REDACTED] from sources including Innovation and Technology Commission

(ITC) of the government for fostering research with industries (38%), licensing revenues for research (26%), contract research from local industries and donations (8%), as well as research with industries in Mainland China (28%). **These grants helped establish entrepreneurial resources** that promote innovation, creativity, and knowledge transfer into the industrial sector – including knowledge-based commercial activities. Funding was received via different organizations such as: [REDACTED] Co. Ltd. on antenna-in-package technologies, complex networks theory, photonic metro network topology and characteristics modeling, and modeling and dynamical analysis of information network topologies; [REDACTED] on special antennas for navigation communication chips; [REDACTED] Co. Ltd. and [REDACTED] Co. Ltd. with ITC in collaboration for the development of a 60-GHz RFIC transceiver for short-range instant massive data sharing; [REDACTED] Ltd., [REDACTED] Ltd., [REDACTED] Ltd., and [REDACTED] Ltd. for the development of power electronics and smart battery management systems for distributed energy resources; [REDACTED] Ltd. on fast and robust fingerprint-based video copy detection systems; and [REDACTED] Co. Ltd. on mobile, parallel, and scalable platform for multi-user EEG recording and analysis. Additionally, consultancies or services were provided to NGOs such as Direction Association for the Handicapped, Chiropractic Doctors' Association of HK, and HK Blind Union.

On intellectual properties, **CityU EE filed 132 U.S. patents, including 80 that have already been granted**, in the past 6 years, covering the areas of antennas, power electronics, lighting, motion sensing, and RFIDs. There were 98 active licenses with a suite of wireless charging licenses that generated a record-high revenue of [REDACTED]. The technologies developed at CityU have been adopted by such companies as [REDACTED]

[REDACTED] CityU EE has conferred the Ph.D. degree to 196 individuals in the past 6 years and is currently training 165 on-going Ph.D. students, subject to various types of quota allocated to the university. It currently provides education to 233 taught-master's students and about 1000 undergraduate students. CityU EE prepares the students to become future professionals and leaders who will further impact the society, as exemplified by a start-up company – [REDACTED] Ltd., which was founded by recent graduates. The above involvements with the government and industry provide excellent opportunities for generating further research impacts.

CityU EE aspires to be a global leader with long-term breakthroughs in millimeter-waves and THz applications, high-performance photonic and biomedical devices, efficient power and energy, high-speed communications and networking, bioinformatics and big data, IoT; and deep learning; targeting to create lasting solutions to society challenges. CityU EE will focus on professional education and research excellence on rigorous science and technology, while extending ground-breaking findings to serve industry and our society by bringing together students, faculty and global collaborators in a multidisciplinary research environment that supports open-ended thinking in science, engineering, and entrepreneurship. With help from all EE faculty, the UoA will continue to actively recruit top scholars around the world to enhance our global leadership.

(4) Relationship to case studies

Arising from the outstanding research in CityU EE, three individual impact case studies are selected for RAE 2020: The first case on **high-performance antennas for wireless communications** illustrates the impact of CityU EE's antenna research on the base station industry and the BeiDou Navigation Satellite System in China. The second case on **emerging technologies for energy conversion** illustrates the impact, leveraged through collaboration with the government, of applying machine intelligence and power electronics research to achieve significant energy saving. The third case on the **world's first industrial standard on wireless charging** illustrates the impact of CityU EE's wireless transformer research on the global industry. The *Qi Standard* is now widely adopted in millions of mobile devices by popular smartphone brands such as Apple, Samsung, Huawei, and Xiaomi. These individual cases strongly demonstrate the technological, societal, and environmental impacts of the research at CityU EE.