

INFORMATION ON DOCTORAL THESIS

1. Full name : Hoang Bao Anh 2. Sex: Female
3. Date of birth: 04/08/1995 4. Place of birth: Ha noi
5. Admission decision number: 1200/QĐ-CTSV Dated 29/12/2020
6. Changes in academic process:
(List the forms of change and corresponding times)
7. Official thesis title: Development of a Wireless LC Sensor Integrated with a Microfluidic System toward Biomedical Diagnostics
8. Major: Electronics Engineering 9. Code: 9520203
10. Supervisors: Assoc. Prof. Bui Thanh Tung
(Full name, academic title and degree)
11. Summary of the **new findings** of the thesis:
12. Practical applicability, if any:

This dissertation focuses on the research and development of a microfluidic system integrated with an Inductor-Capacitor (LC) resonant sensor, designed for the effective analysis of various solutions, with a primary goal of enabling label-free biomedical analysis and diagnostics.

The dissertation developed a mathematical model for the LC sensor and conducted experimental studies on specific subjects, including: Sodium Chloride (NaCl) solution, serving as an electrolyte, to evaluate the fundamental performance of the designed sensor structures, verify the operating principle based on changes in conductivity and permittivity; Proteins, as biomarkers, to assess the capability for protein detection and quantification.

The dissertation employed a multi-faceted approach, encompassing theoretical research, literature review, computational design and simulation, and experimental fabrication with validation measurements. The theoretical foundation was built upon the principles of capacitive sensing, wireless passive LC resonant structures, and contactless conductivity detection. The experimental fabrication process involved a flexible combination of 3D printing technology (to create positive molds), soft lithography (using PDMS and subsequently PMMA for the microfluidic channels), and Printed Circuit Board (PCB) technology (to fabricate the planar microelectrodes and inductors). Numerical simulations were performed using COMSOL Multiphysics software, employing Radio Frequency (RF) and Electrostatics modules to analyze, predict behavior, and optimize the sensor design prior to fabrication. Finally, the experimental measurement setup was established with a Vector Network Analyzer (VNA) to measure the S11 reflection coefficient and determine the resonance frequency, a syringe pump for fluid delivery, and custom control software for automated data acquisition and analysis.

The dissertation has delivered several new results and contributions, including:

- Proposing a microfluidic system integrated with a co-planar LC resonant sensor capable of operating in solution environments and meeting the requirements for label-free analysis of biological samples.
- Developing and refining an analytical model that describes the sensor system's operating principle, thereby clarifying the interaction mechanism between the sample and the resonant circuit.
- Conducting fabrication, measurement, and experimental evaluation of the sensor, which validated the model's correctness and the system's operational effectiveness for specific biological samples.

The research findings of this dissertation hold scientific significance, contributing to the understanding of electromagnetic field interactions with microfluidics, providing valuable data for future studies, and laying the groundwork for the development of compact, rapid, and low-cost Point-of-Care Testing (POCT) devices for biomedical diagnostics, chemical analysis, and environmental monitoring. The developed sensor technology has demonstrated good sensitivity, repeatability, and accuracy, along with capabilities for miniaturization, label-free analysis, and wireless/contactless detection, meeting the critical demands of modern applications.

13. Further research directions, if any: Research and development focus on improving both the performance and practical application of the system.

- Improving the quality factor (Q-factor) of the resonator to increase detection sensitivity and reduce noise, thereby improving measurement accuracy.
- Research and development of sensors to analyze intracellular variations will facilitate more complex biological diagnostic applications.
- Optimizing the manufacturing process to reduce costs and improve mass production capabilities, helping to transfer technology from the laboratory to the commercial scale and meet the needs of biomedical testing in clinical practice.

14. Thesis-related publications:

- **Hoang Bao Anh**, Nguyen Canh Viet, Tran Thi Thuy Ha, Pham Van Thanh, Do Trung Kien, Chu Duc Trinh, Bui Thanh Tung, Do Quang Loc, A Wireless Passive Conductivity Detector for Fluidic Conductivity Analyzation in Microchannel, JST: Engineering and Technology for Sustainable Development, vol. 1, no. 2, pp. 89–94, April, doi: 10.51316/jst.149.etsd.2021.1.2.15.
- **Bao-Anh Hoang**, Hang Tran Thanh, Ha Nguyen Thi Ngoc, Thao Pham Ngoc, Kien Do Trung, Ngoc-Thanh Le, Tran-Thuy Nguyen, Trinh Chu Duc, Tung Thanh Bui, Loc Do Quang, A Wireless Passive Capacitively Coupled Contactless Conductivity Detection (WPC4D) for Microfluidic Flow Monitoring, 2021 IEEE Sensors, Sydney, Australia, 2021, pp. 1-4, doi: 10.1109/SENSORS47087.2021.9639815.
- **Bao-Anh Hoang**, Van-Anh Bui, Kien Do Trung, Hang Bui Thu, Trinh Chu Duc, Tung Thanh Bui & Loc Do Quang (2023) Development of a wireless passive capacitively coupled contactless conductivity detection (WPC4D) for fluidic flow detection utilizing 3D printing and PCB technologies, Instrumentation Science & Technology, 51:6, 591-609, DOI: 10.1080/10739149.2023.2182791 (Q3)
- Nhu Cuong Nguyen, **Bao Anh Hoang**, Trung Kien Do, Thanh Tung Bui, Duc Trinh Chu, Quang Loc Do, Development of a PCB-based passive capacitive sensor for

- fluidic flow detection, Vietnam Journal of Science, Technology and Engineering, 65(3), 8-13. [https://doi.org/10.31276/VJSTE.65\(3\).08-13](https://doi.org/10.31276/VJSTE.65(3).08-13).
- L. Do Quang and **Hoang Bao Anh**, “Development of a passive wireless sensor for fluidic detection and characterization utilizing the PCB-based coplanar electrode (PCE) configuration”, JMST, vol. 96, no. 96, pp. 116–123, Jun. 2024.
 - Bao-Anh Hoang, Thi Bich Ngoc Nguyen, Thuy Ha Tran Thi, Phu Nguyen Van, Tung Thanh Bui, Tuan Vu Quoc, "PCB-Based Wireless Biomicrofluidic Device for Biochemical Detection toward Point-of-Care Applications," 2024 International Conference on Intelligent Cybernetics Technology & Applications (ICICyTA), Bali, Indonesia, 2024, pp. 814-818, doi: 10.1109/ICICyTA64807.2024.10913224.
 - **Bao Anh Hoang**, Tuan Vu Quoc, Bui Thu Hang, Nhung Le Thi Hong, Hieu Luong Trung, Phu Nguyen Van, Thanh Pham Van, Kien Do Trung, Loc Do Quang, Tung Thanh Bui, A Non-Contact Lab-on-PCB Platform for Label-Free Protein Detection via Resonance Frequency Bandwidth (đang submit tạp chí Sensors and Actuators A: Physical).