Master's Thesis

Coil Array Inductive Power Transfer System for Autonomous Underwater Vehicle

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January 8, 2021

A Master's Thesis
submitted to Graduate School of Information Science,
Nara Institute of Science and Technology
in partial fulfillment of the requirements for the degree of
Doctor of ENGINEERING

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Abstract

For a long time, providing a stable, safe, and efficient power supply for underwater electromechanical equipment has always been a concern in deep-sea exploration. Compared with the complicated docking mechanism, potential safety hazards, and expensive price of traditional wet-mate connectors, wireless power transmission (WPT) technology can transmit energy without any electrical contact between the power supply and the electrical equipment, which provides an effective solution to the aforementioned drawbacks of wired charging. There are many uncontrollable factors in the seawater working environment. Therefore, this topic takes the equivalent circuit and magnetic field distribution as the theoretical basis to study the energy transmission characteristics of underwater WPT and proposes corresponding improvements and solutions to the current problems and deficiencies. Especially for the unstable output voltage of the receiver and excessive magnetic flux density at the internal of AUV.

Keywords:

Autonomous underwater vehicle, inductive power transfer, underwater wireless power transfer, undersea

*Master's Thesis, Graduate School of Science and Technology, Nara Institute of Science and Technology, January 8, 2021.

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1 Introduction

1.1 Background and research purpose

In the foreseeable future, the electrification of ocean systems, renewable ocean power sources and ocean energy networks will be necessary, which could help accelerate the growth and deployment of ocean renewable energy and ways to explore and understand the ocean [1]. To realize electrification in the ocean requires good water resistance, durability and long-distance remoteness. For the waterproofness of the equipment, we can use high-performance waterproof and pressure-resistant materials. The durability of electrical equipment requires low-consumption AUV and high-energy batteries or continuous energy supply for the equipment. Long-distance maneuverability needs to solve the problem of long-distance underwater communication. We can use xx to reach xxkm underwater long-distance distance. Certain attributes of ocean energy, such as its high energy density, make it attractive as a grid-connected energy, or it may make it an isolated and remote ocean energy, thereby providing power solutions for the sustainable development of ocean space, which is attractive. The rapid development of distributed ocean energy applications (such as underwater sensor networks, ocean sensors and monitoring technologies, ocean automatic network buoys, and deep sea and tsunami buoys) is advantageous. In particular, it can power an autonomous underwater vehicle (AUV) whose service life is limited by its battery power.

1.2 Wireless power transfer technologies

Far field power transfer

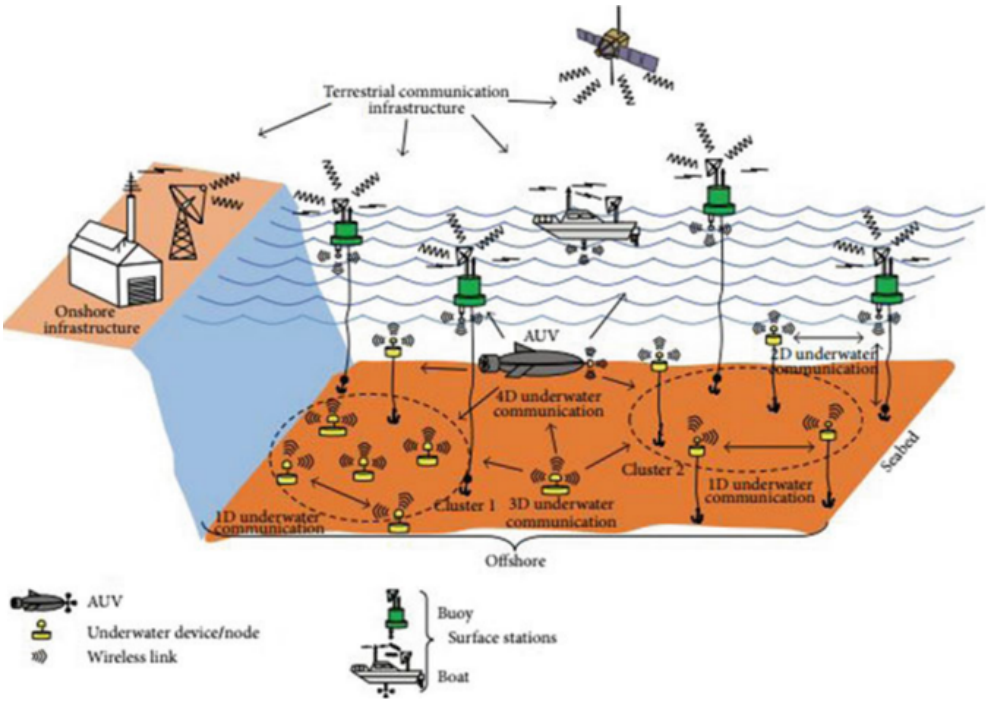
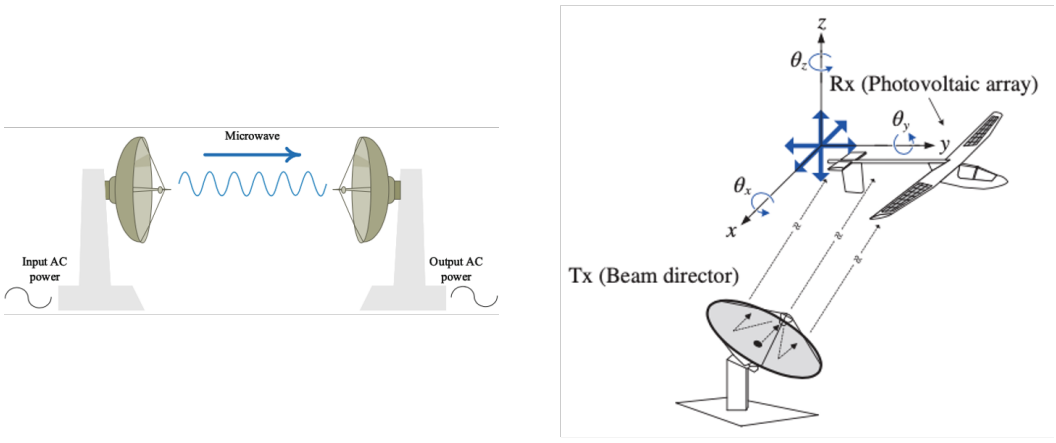


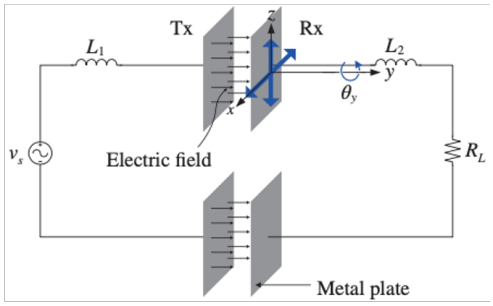
Figure 1.1: Underwater sensor networks architecture [2].



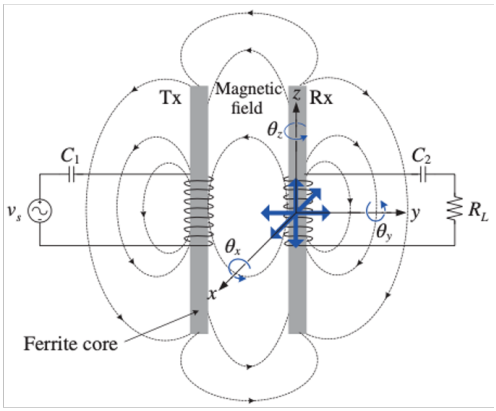
(a) Microwave power transfer [1].

(b) Laser power transfer [3].

Figure 1.2: Far-field wireless power transfer.



(a) Capacitive power transfer [3].



(b) Inductive power transfer [3].

Figure 1.3: Near-field wireless power transfer.

Technology	**Range**	**Frequency**	**Antenna devices**	**Applications**
Microwaves	hm - km	GHz	Parabolic dishes, phased arrays, rectennas	Satellite, Drone aircraft
Optical	dam - km	≥THz	Lasers, photocells, lenses	Drone aircraft, Space elevator
Capacitive	cm - m	kHz – MHz	Metal plate electrodes	Smartcards, Biomedical implant
Inductive	mm - m	Hz – GHz	Tuned wire coils, lumped element resonators	Electric toothbrush, Smartphone, Electric vehicle

Table 1.1: The different wireless power technologies.

1.3 Underwater wireless power transfer

1.4 The main research content of this thesis

1.5 Roadmap

2 Basic principles of WPT

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2.1 Underwater WPT system model

3 Coil array WPT

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3.1 Simulation evaluation

3.2 Coil array WPT in the air

3.3 Coil array WPT under seawater

4 Conclusion

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Acknowledgements

First of all, I would like to thank my supervisor, Professor Minoru Okada. Professor Okada is kind, knowledgeable, and rigorous in scientific attitude. Thank him for giving me an opportunity to study in Japan and let me do wireless power transfer research that I am interested in. He has continued to help me during my three years of study and life. At the same time, I would like to thank Professor Yuichi Hayashi for my research advice and guidance, so that I have a deeper understanding of the weak research environment. With his help, Which greatly improved my research.

Then I would like to thank Associate Professor Takeshi Higashino and Assistant Professor Duong Quang Thang. With their help, they have made me better understand the knowledge of wireless power transfer and wireless communication, and they have helped me overcome the difficulties in professional understanding and helped me complete this topic. Thank them very much. Here, I would also like to thank Assistant Professor Chen Na for her continuous help and encouragement in my studies, so that I have a better understanding of the field of communication.

I would also like to thank the members, staff, and seniors of the Network Systems Laboratory for their companionship in the study and life. We studied together and played together, and established a strong friendship together. Thank you to the international students who have helped me while studying abroad. Thank you for your kindness to me.

Finally, I would like to thank my family for their support of studying abroad, let me choose the knowledge I like, and always provide me with abundant financial support.

Thank you all for your attention!

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