PhD defense

by

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"Advanced Self-Charging Magnetic Grasping System with EMI Mitigation from Electric Sparks for Drones on High-Voltage Power Lines"

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POPULAR SCIENTIFIC ABSTRACT

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Advanced Self-Charging Magnetic Grasping System with EMI Mitigation from Electric Sparks for Drones on High-Voltage Power Lines

The electricity power demand has recently experienced a significant increase due to the rise in the number of AI data centers and the electrification of transport. Any disruption in the electrical system can result in substantial economic losses. Given that a significant portion of Europe's power line infrastructure is nearly 70 years old, regular inspection and maintenance are crucial to ensure reliability and prevent potential wildfires. Drones have become increasingly popular for inspection tasks due to their ease of deployment, cost-effectiveness, and safety compared to traditional methods like cranes and helicopters. However, due to the limitation in the drone's flight time, it is time-consuming to inspect millions of kilometers of power lines on a regular basis. In order to overcome this problem, harvesting energy from electromagnetic fields around the power cables to recharge the drone is a promising solution. When the battery is low, the drone can land on the cable and harvest energy to charge the battery.

In this PhD dissertation, a magnetic energy harvesting unit is developed which consists of a magnetic core and a charging circuit. A detailed guideline for selecting a suitable magnetic core in high-current application is introduced based on multiple factors. A new charging technique is also presented to enhance the harvested power from the power line by nearly 60% compared to the state-of-the-art studies. In order to help the drone attach to the cable, a passive magnetic grasping system is developed without using external actuators. A Magnetic Manipulating Circuit is designed to control the magnetic force of this gripper and charge the battery simultaneously. The grasping system with the charging function was tested on a drone with a 300A/50Hz power line. Multiple autonomous flying/charging cycles were performed in **2.5 hours** without landing on the ground.

Due to the voltage difference between the drone and the high-voltage cable, electric sparks can strike the drone as it approaches the cable, potentially damaging electronic circuits. In order to design a lightweight shield for the drone, an electrical model is proposed to predict the level of spark currents in different power line voltages, distances, and drone capacitance. The output of this model can be imported into simulation tools for the shielding optimization process. Additionally, numerous experiments with 100kV-AC power line were conducted to investigate the effects of sparks on drone components, and a mitigation method was proposed to reduce the noise to the low level where the shield can be removed. Finally, multiple flights with up to **500kV-AC** were performed to test the drone performances in different sizes and shielding techniques.