Integrating EHDA in autonomous drones for enhanced greenhouse crop protection

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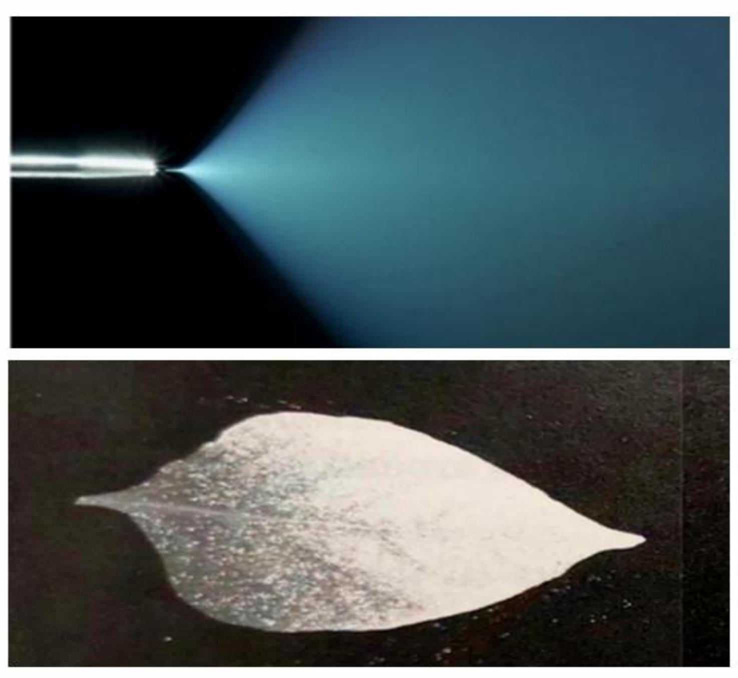
Introduction

The Dutch greenhouse strategy foresees stricter rules regarding pesticide application for the coming years. Recognizing this urgent need, growers need to find innovative solutions to keep protection at lower pesticide application volumes. The RAAK-MKB Smart Greenhouse project proposes the use of autonomous drones equipped with computer vision tools and EHDA systems. Such drones can identify plages and apply small amounts of pesticides with great precision.

Figure 1. Drone flying inside a greenhouse. Photo: PATS Indoor Drone Solutions

Electrohydrodynamic Atomization (EHDA) is a technique that uses strong electric fields to break-up a liquid into tiny and charged droplets.[1] Among the several advantages offered by EHDA in the spraying of pesticides, the fact that generated droplets have a surface charge enhancing leaf coverage is the main benefit[2]. Therefore, small volumes of pesticides can be sprayed with EHDA and still achieve a good deposition on the leaves.



(a)

(b)

Figure 2. (a) Photograph of EHDA plume pattern; Source: Battelle Memorial Institute. **(b)** Droplet deposition on a leaf with EHDA as spraying technique. Source: [2]

Objectives

In this project the implementation of a miniaturized EHDA system to be embedded in autonomous drones will be designed, tested and validated.

The essential requirements of the EHDA module are:

- **Small**: dimensions smaller than 20 x 15 x 15 cm
- **Light**: maximum weight of 1 kg
- **Remote controlled** by the drone flight controller
- The liquid must be atomized in the **cone-jet mode**

Methods

Figure 3 shows a block diagram for the designed module. We need to miniaturize a High Voltage Module to produce the high voltage and miniaturize the Pump for the liquid supply at a stable flow rate.

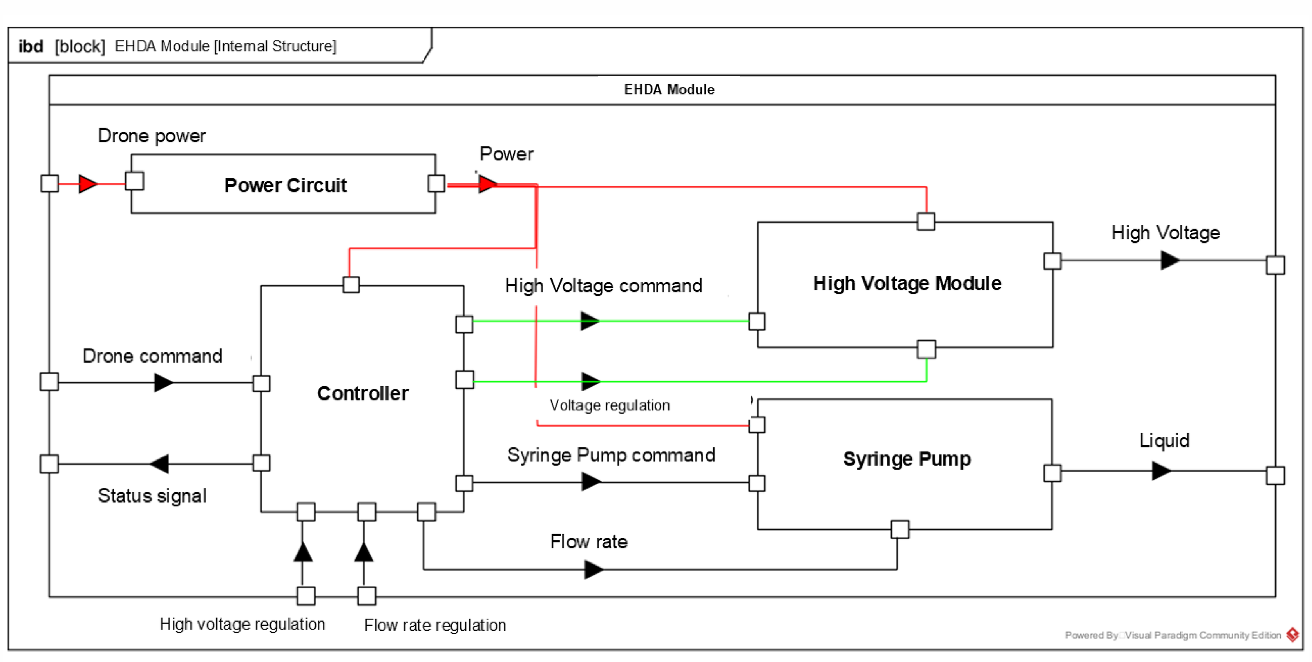


Figure 3. Internal block diagram for the designed module.

Verification Methods

To verify the requirements of the developed system, we can use the setup shown on Figure 4. The oscilloscope measures the waveform of i_{GND}, which can be used with the method suggested by [3] to verify if we are operating in the cone-jet mode.

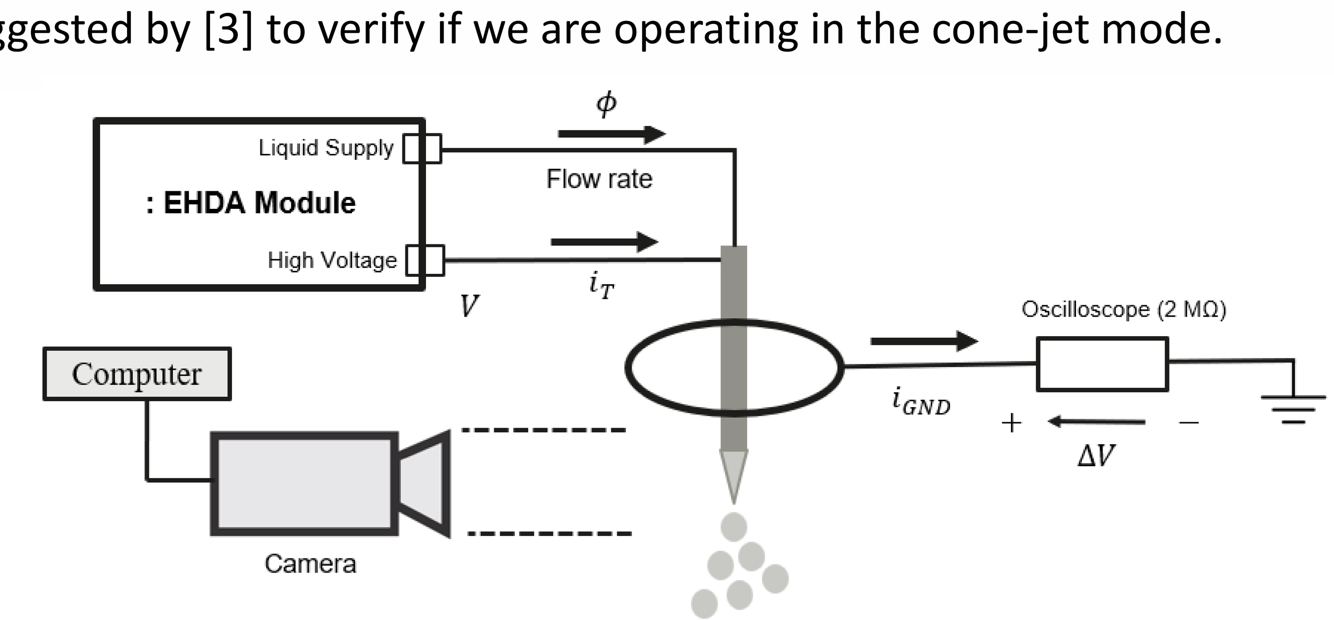


Figure 4. Setup for the verification of the designed EHDA module.

Results

The developed system weighs less than 600 grams and fits in a 20 x 8 x 15 cm box enclosure. As shown on the plot in Figure 5, the system operates in the cone-jet mode 300ms after the command signal to activate the spray.

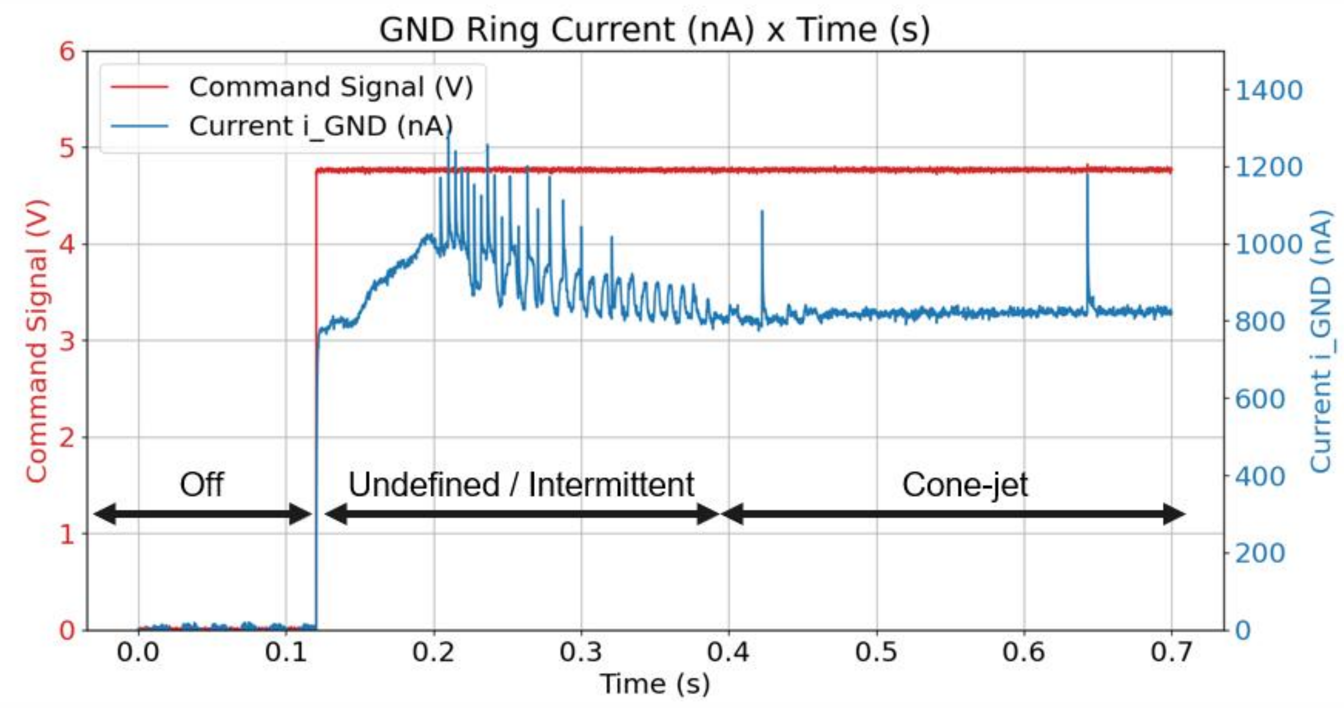


Figure 5. Waveform of i_{GND} when the command signal from the drone is received. The classification is based on [3].

The high voltage produced on the output is stable for both charge and discharge dynamics as shown on Figure 6.

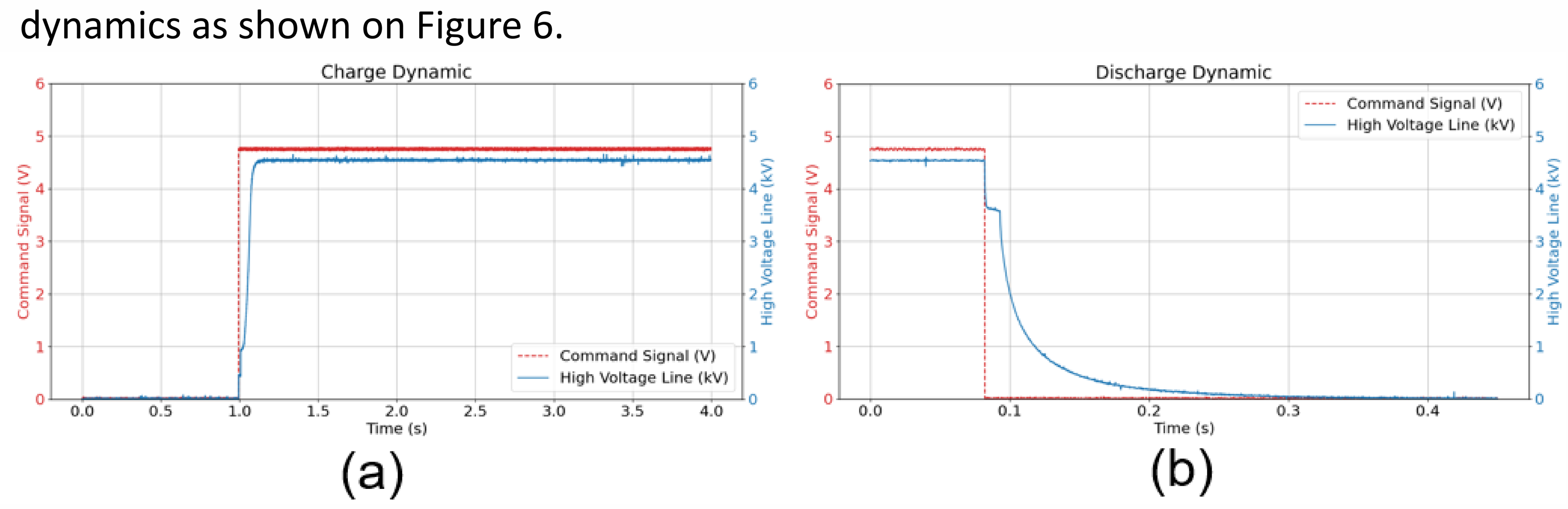


Figure 6. Waveforms of (a) charge and (b) discharge dynamics on the output of the High Voltage Module.

The flow rate generated at the output of the syringe pump – shown on Figure 7 – is stable enough to produce a cone-jet mode and presents a maximum error or 20% with respect to the expected theoretical value for each stepper motor frequency.

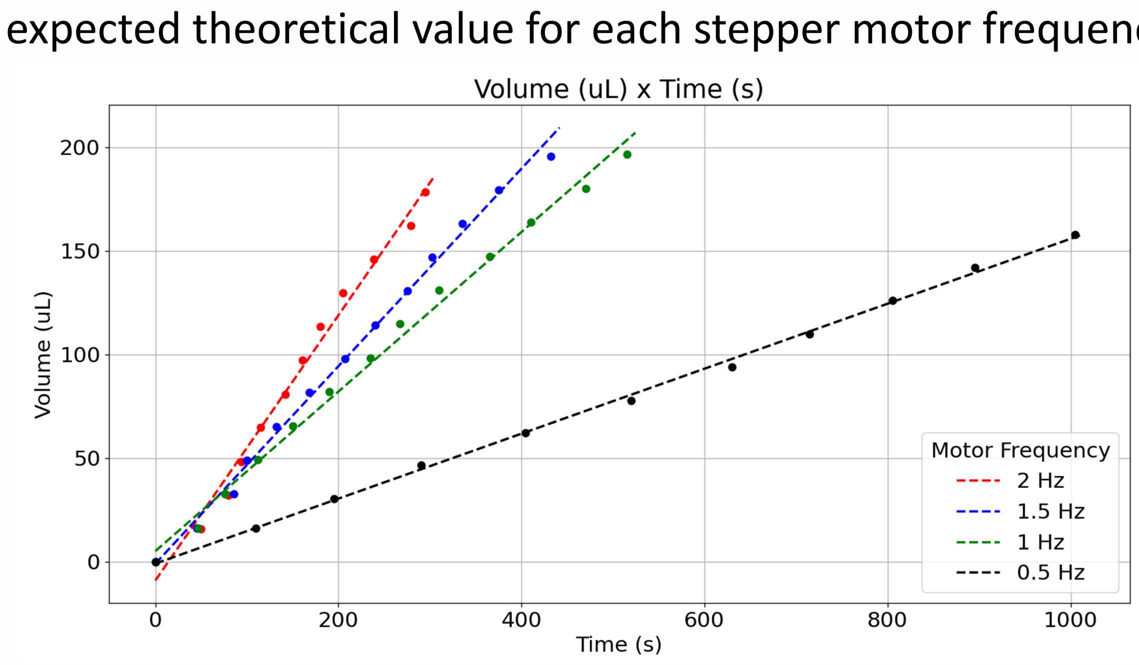


Figure 7. Volume dispensed over time on the developed syringe pump. The angular coefficient of the linear regressions is the experimental flow rate obtained.

Conclusions

- The developed system satisfies the dimension and mass requirements to be drone-embedded
- The liquid can be sprayed with EHDA in the cone-jet mode

References

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