Universidade Federal de Minas Gerais
Escola de Engenharia
Curso de Graduação em Engenharia de Controle e Automação

EHDA closed loop control system based on real time non-visual spray mode classification

Relatório 2 de Atividades PFC 1

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December 1, 2022

1 Summary

Electrohydrodynamic Atomization (EHDA), also known as Electrospray (ES), is a way to disintegrate a liquid into droplets by exposing it to a strong electric field. EHDA surveys have contributed as an important tool for the development of water technology (thermal desalination and metal recovery), material sciences (nanofibers and nano spheres fabrication, metal recovery, selective membranes, and batteries), and biomedical application (droplet encapsulation). Besides that, the project is merged with the Energy Transition strategy and Innovation Agenda Agriculture, Water, and Food, Key Enabling Technologies (KETs). Although, there are EHDA applications in industry, stabilizing the cone-jet spray mode is done empirically and based on mean current measurements.

The electric current flowing transported by the spray reveals characteristic shapes for different spray modes. Those shapes cannot simply be summarized by its mean value. In figure one we can see an example of cone-jet mode electrospray.

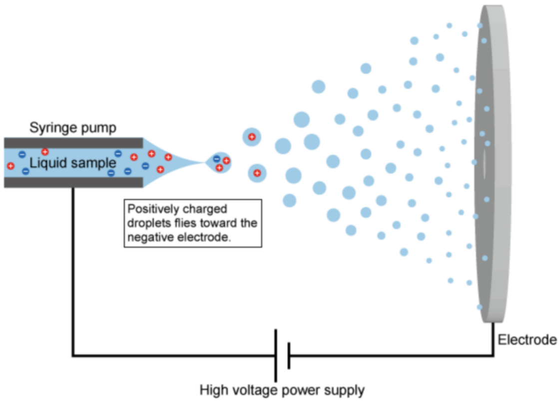

Figure 1: EHDA

Signal processing techniques can allow a non-visual classification of the spray mode based on the electric current shape. The spray process imposes noise and random sequences on the measured signal making its classification not a trivial task.

Industrial applications demand automated stabilization of a spray mode. This can be achieved by a closed-loop control system. Automated classification of the spray mode is a crucial part of a control system same as the development of an appropriate control algorithm. Signal processing implementations of previous projects of the NHL Stenden Water Technology group are showing good classification results. Further research is necessary to improve the classification accuracy and research and implementation of a suitable classification algorithm. Because of that, the work will be done by the Water Technology Group at NHL Stenden University of Applied Sciences and in combination with Dutch companies to match analysis possibilities with knowledge and infrastructure availability.

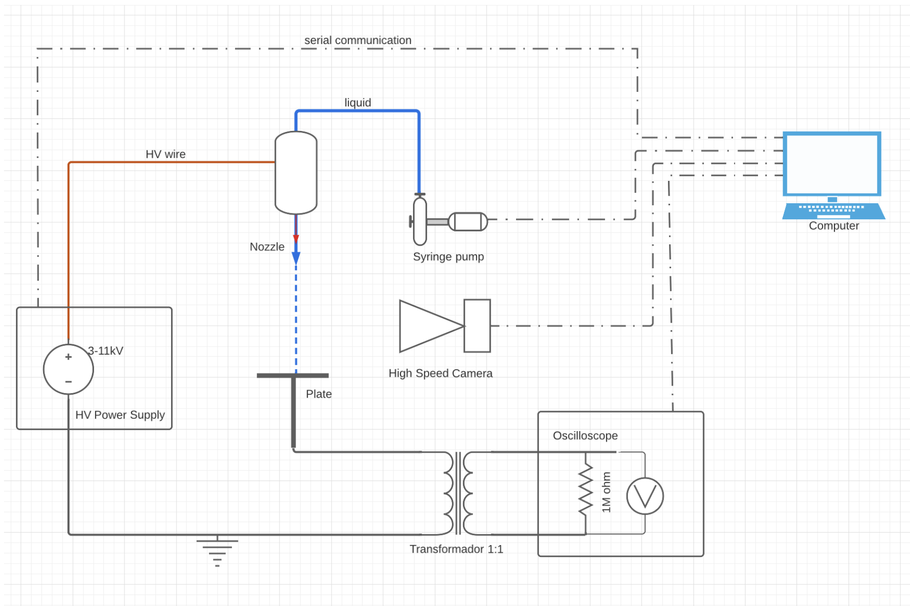

Figure 2: System Architecture

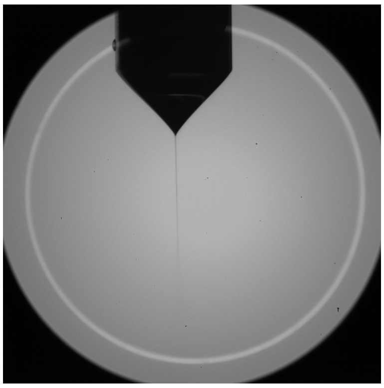

Figure 3: cone jet mode

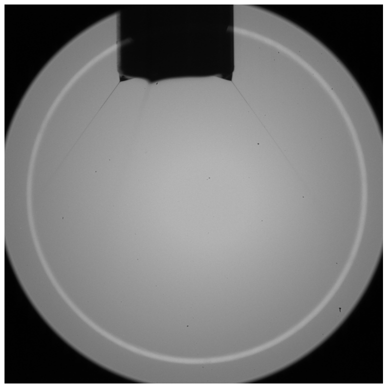

Figure 4: multi jet mode

2 Development

3.1 Peripherals integration

Doing experiments we discovered that the frequency of the pump machine internal motors was creating an interference in the flowrate. Therefore compromising the stabilization in cone jet mode. A solution for that was to increase the flowrate wich smooths this pumping noise. For that was also necessary to increase the nozzle diameter to balance with all other variables from the experiment.

3.2 Experiment 1

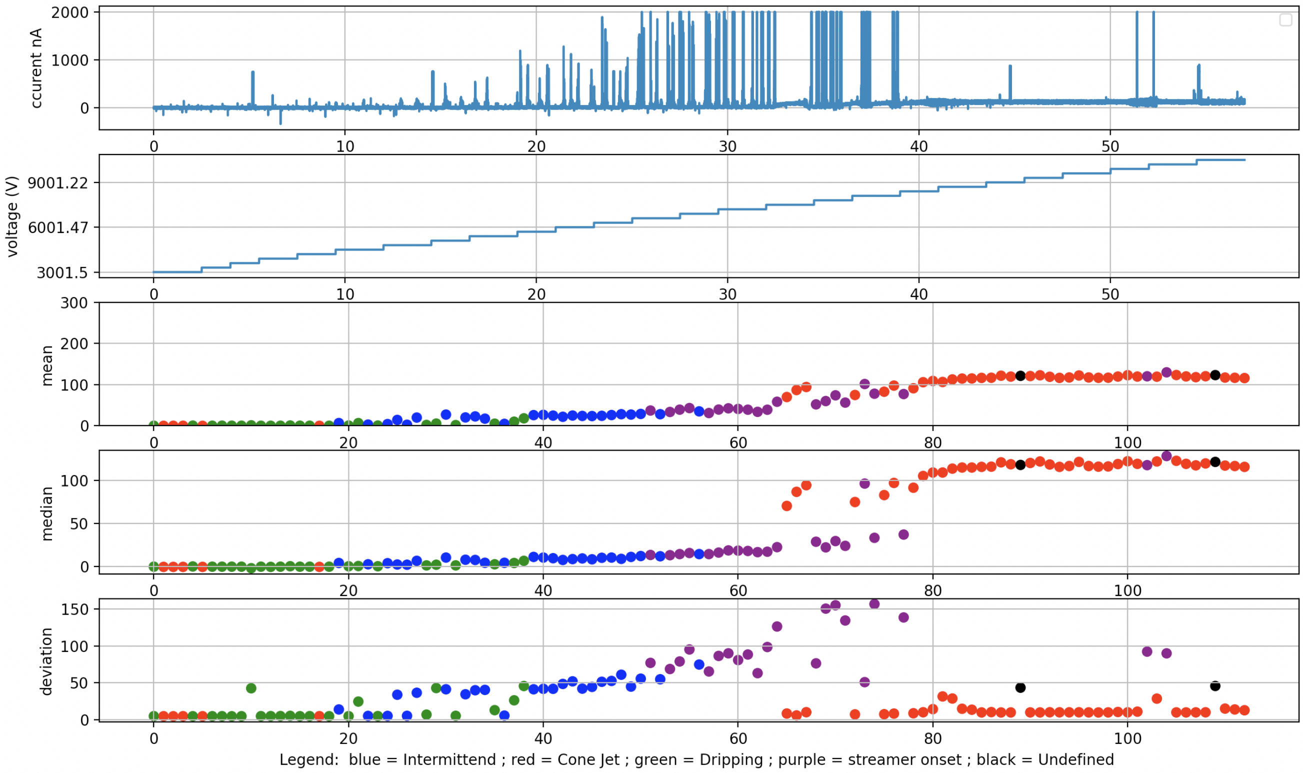

Figure 5: Data acquired in the experiment 1 - liquid: Water AND alcohol

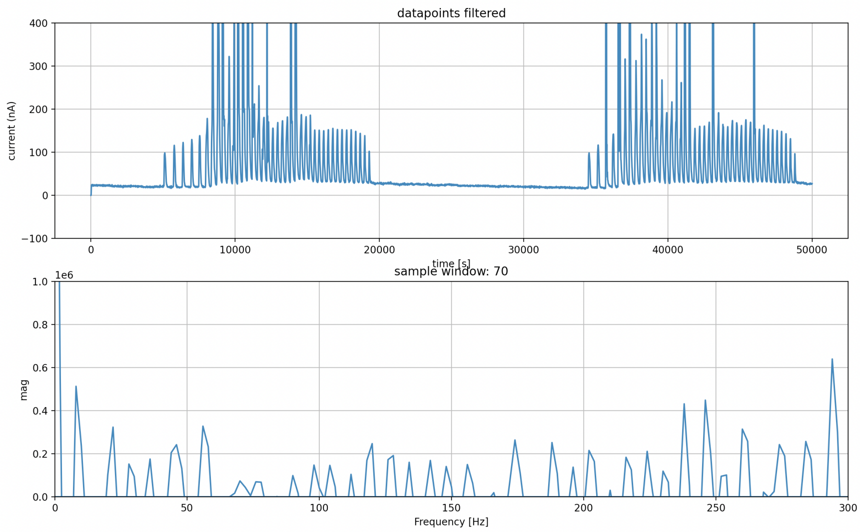

Figure 6: Dripping sample

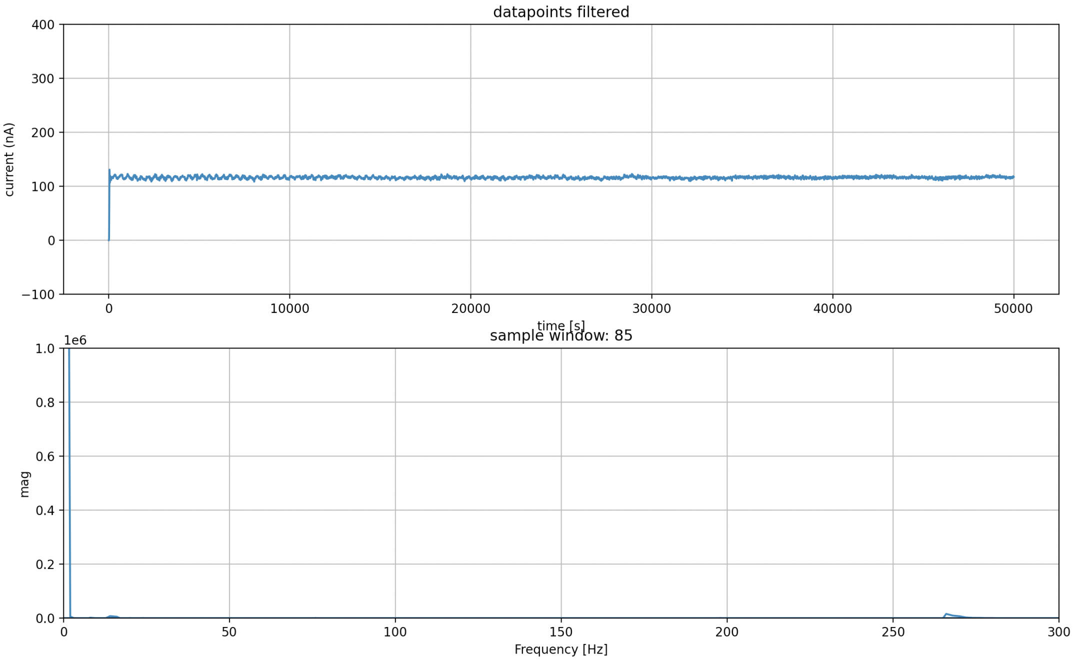

Figure 7: Cone jet sample

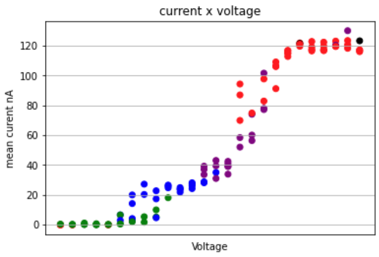

Figure 8: mean current X voltage

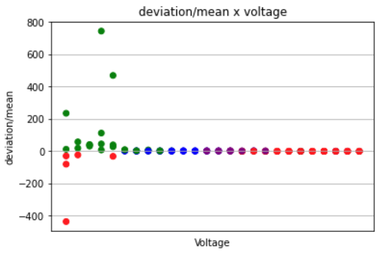

Figure 9: deviation/mean

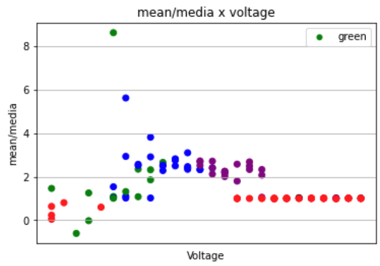

Figure 10: mean/median

3.3 Experiment 2

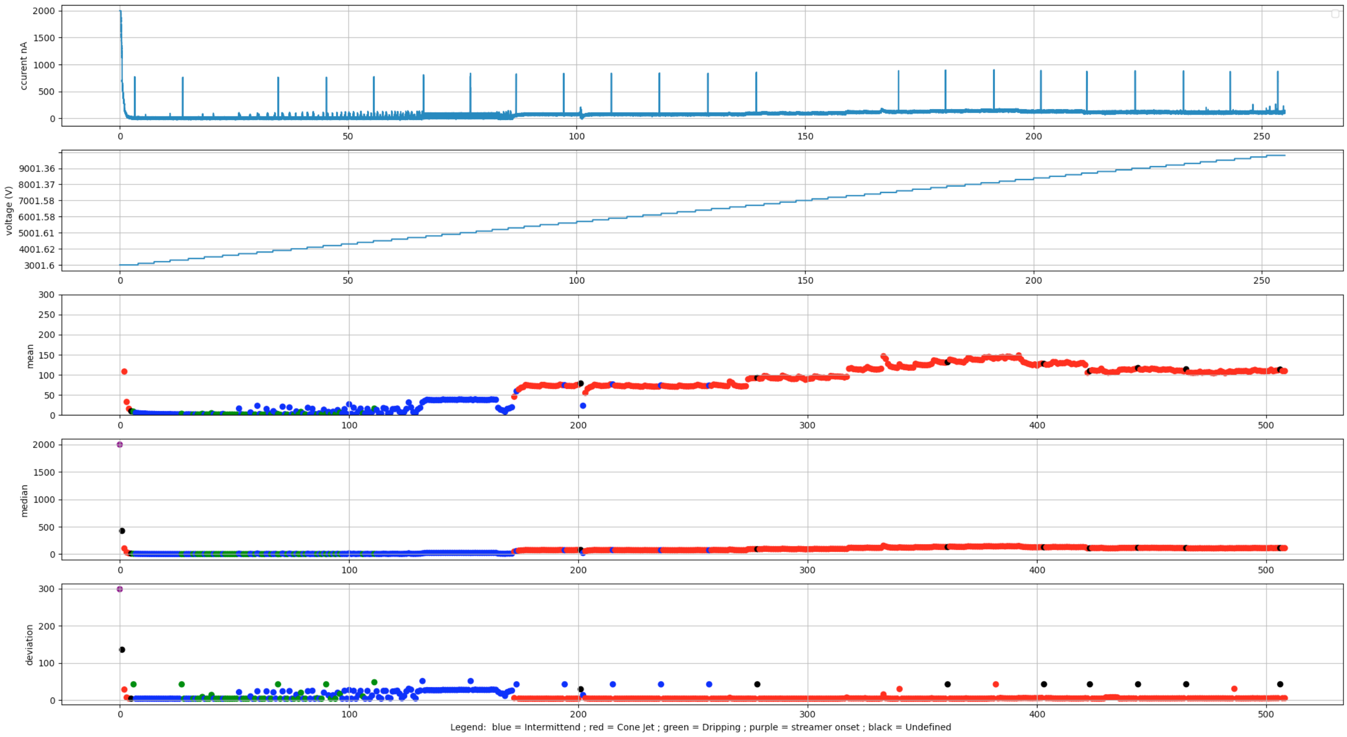

Figure 11: Data acquired in the experiment 2 - pure ethanol

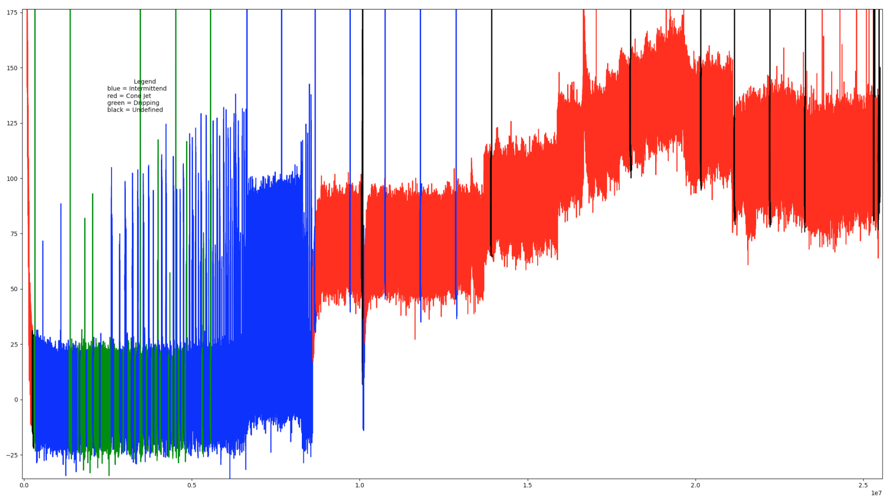

Figure 12: current graph with classification

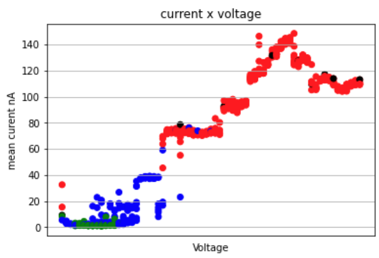

Figure 13: current mean X voltage

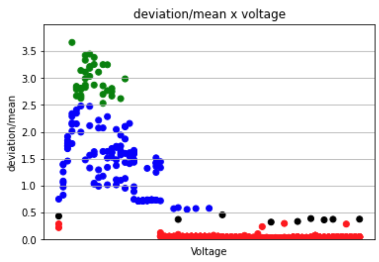

Figure 14: deviation/mean

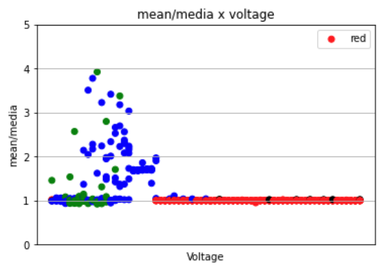

Figure 15: mean/median

3.4 Experiment 3

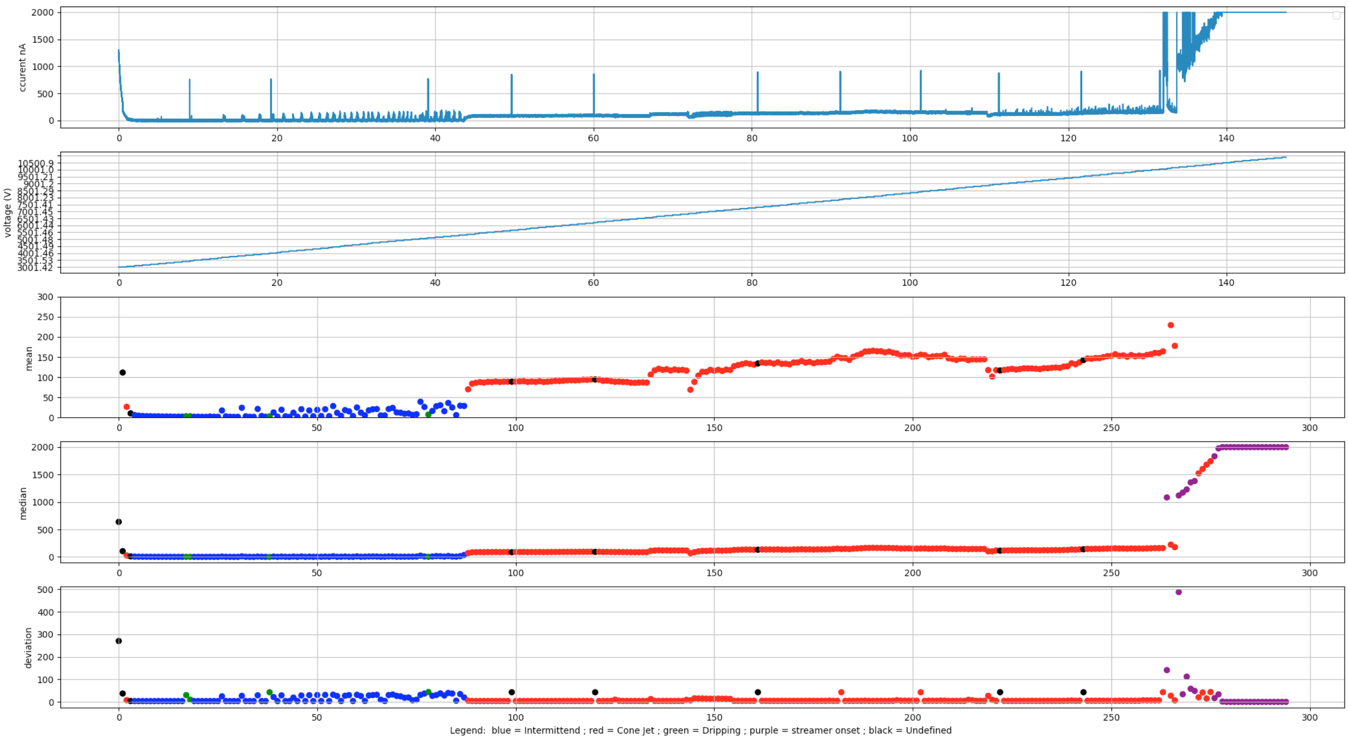

Figure 16: Data acquired in the experiment 3 - pure ethanol

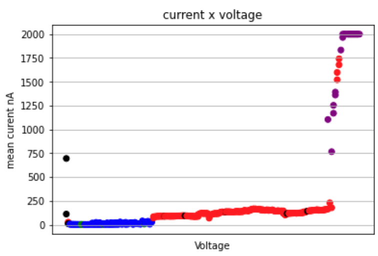

Figure 17: current mean X voltage

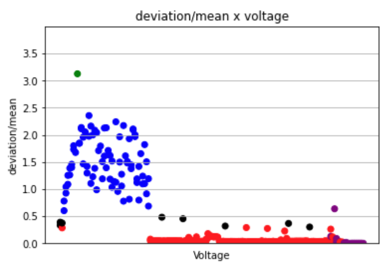

Figure 18: deviation/mean

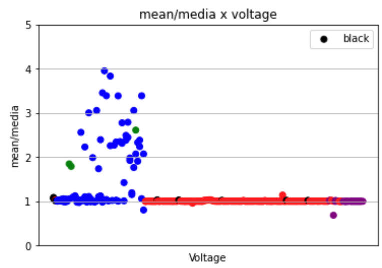

Figure 19: mean/median

3 Conclusion

For further steps the following tasks will be done:

- make experiments with different time windows. This will help to see the time needed for the system to stabilize.
- change power supply and oscilloscope libraries to an updated version wich covers both hardwares.
- correct and upgrade plots to make a better sense of the data.
- Include DHT11 temperature and humidity sensor to the setup.
- Thread sincronization in the main routine.