**CZECH TECHNICAL UNIVERSITY IN PRAGUE**
**Faculty of electrical engineering**
**Department of electrical power engineering**
Technická 2, 166 27 Prague 6, Czech Republic

# Bachelor thesis opponent's review

**Master thesis:** Impedance-meter for quantification of ethanol content in liquid solutions
**Author:** Arkady Vainshtein
**Thesis supervisor:** **Doc. Ing. Mattia Butta, Ph.D**
**Thesis opponent:** **Dott. Ing. Giuseppe Foti, Ph.D.**

| | Rating (1 – 5) (1 = best; 5 = worst): |
|---|---|
| 1. Fulfillment of assignment requirements: | 1 |
| 2. Systematic solutions of individual tasks: | 1 |
| 3. Ability to apply knowledge and to use literature: | 1 |
| 4. Thesis formal and language level: | 1 |
| 5. Thesis readability and structuring: | 1 |
| 6. Thesis professional level: | 1 |
| 7. Conclusions and their formulation: | 2 |
| **8. Final mark evaluation (A, B, C, D, E, F):** | A |
| **verbal:** | |

**Brief summary evaluation of the thesis** (compulsory):

This bachelor thesis is focused on the design, implementation and test of an impedance measurement device based on the IC AD5933 and the MCU ESP32. The system is used for the quantitative determination of ethanol concentration in different liquid solutions.
The overall quality of the work is excellent. The manuscript is well-written and pleasant to read. The problems are clearly explained and thoroughly addressed. The candidate details each step of the process of problem resolution as well as the unavoidable mistakes. The work demonstrates that the candidate applies critical thinking when solving engineering problems and has acquired several skills by addressing a broad range of tasks and problems, from the design and implementation of hardware, firmware and software for data acquisition and processing, till data analysis and interpretation. I therefore recommend the highest mark.

**Questions:**

1. In section 2.3, Fig. 2.11 shows the sensitivity of the Imaginary part of impedance vs the Phase Bias at 10 kHz and 100 kHz calculated using the iterative process outlined in page 13.

Could the candidate explain why a simple analytic (trigonometric) function would not suffice to shift the phase in such a way to project all the information over either the real or imaginary part?

2. Impedance measurements for liquid samples are sensitive to temperature changes. This work addresses this very important aspect. In section 4.2, page 47 it is explained the method used to compensate such effect by using a 2D matrix with temperature-dependent sets of coefficients in combination with a bisectional method. Could the candidate explain why a fitting function for the Imaginary part vs temperature data would not work? This could avoid the rounding to the nearest half-degree.
3. The effect of DC polarization on impedance reading is properly addressed (pag. 22, section 3.2.2). However, in general, parasitic effects might develop at the metal/liquid interface at medium-low frequencies when measuring impedance in liquid samples. In such cases an Analog Front End (AFE) circuit is typically employed to make the measurement immune to such effects. Did the candidate considered such problem? How would he mitigate/address it?
4. Just a comment: as shown in Figures 2.2 to 2.6, the addition of ethanol into the solution results in an increase of the impedance at all frequencies. It would have been interesting to provide a simple qualitative explanation of the physics behind such behavior.

Date: 05/06/2023 Signature:

Notes:

1) The total thesis evaluation needn't be determined by the partial evaluations average.
2) The total evaluation (item 8) should be from the following scale:

| excellent | very good | good | satisfactory | sufficient | insufficient |
|---|---|---|---|---|---|
| A | B | C | D | E | F |