

Doctoral Thesis Review

Author: **Kinan Wannous**

Supervisor: **doc. Ing. Petr Toman, Ph.D.**

Thesis title: **DISTANCE PROTECTION DESIGN USING DIGITAL INPUT DATA**

Reviewer: **doc. Ing. Zdeněk Müller, Ph.D.**
Department of Electrical Power Engineering
CTU in Prague, FEE

The presented dissertation thesis is focused on one of the most current topics in the field of smart power systems – protection systems. The thesis work reflects the current trend towards a comprehensive transition of the entire measuring chain from analog to digital circuits, which eliminates the negative properties of current and voltage loops and allows more efficient distribution of signals to all necessary places in digital form.

The first chapters present the current state of knowledge in the distance protection field - available measuring methods and principles, comparison of their properties and implementation options. The introductory part is smoothly followed by a chapter outlining the author's motivation, setting out the objectives of the work and the methodology of the solution.

The core of the work consists of chapters six to eight.

In the sixth chapter, the author focuses on analysis of IEC 61850-9-2LE measured values using neural networks. Above mentioned IEC standard is described at first. Author analyses influence of time synchronization over a process bus and provides timing analysis of sampled values. IEC based information system is presented. Results are presented on base case studies and measured using testing set Omicron CMC256 – 2x distance protection – communication analysis software. Final section of chapter six contain information based on machine learning. The chapter no. 7 contain application of developed methods described in previous chapters on real measured data. The analysis is done using Matlab package. A graphical user interface (GUI) was created using a GUI Matlab package. The developed tool does not require additional hardware (Matlab running computer with ethernet port is sufficient). This allows to implement the distance protection function, additional protection functions and of course "traditional calculations" – RMS, harmonic distortion, FFT analysis and more...

Conclusions are stated in chapter eight.

The contribution of this dissertation in:

- Development of improved protection algorithm in Matlab environment including IEC 61850 data caption,
- Results obtained using machine learning tools,
- Current transformer saturation and harmonics impact on relay operation.

Part of the work is also an overview of the author's publishing activities. The core of the work was published in journal and conference articles.

I evaluate the author's approach to this issue as very well founded. Ing. Wannous created a valuable work, especially chapters six to eight point to real applications. All aims of the dissertation mentioned in chap. 3 author fulfilled.

Comments:

- Misprints could be minimized (Autp Reclosing p. XV, Extensive Markup Language p. XVI, XML etc..., m-th p. XVII,)
- Figures in PDF version are not readable (p. 18, p 19, p. 23, p. 41, p. 43, p. 51 etc.)
- References does not have consistent form ([26, 27] vs. [50][51]).
- Units are missing or wrong (table on p. XVII, Fig. 4.2, Tab. 4.1,
- What is the source of Fig. 2.2? Reference is missing.
- Time derivative Eq. 2.1 is inconsistent with other equations. Initial constraint is missing.
- Fig. 2.8. - Packet length is unclear.
- Equation 4.2. is not explained.
- Equation 4.4 – what does “k” states?
- Eq. 5.1 and 5.2. – iterator is missing.
- Sentence “Fast fourier transform (FFT) is a faster version of the discrete fourier transform (DFT)” does not have good sense.
- What does state “n” in connection with FIR filter (p. 33)?
- Eq. 5.8. – brackets are missing.
- Fig. 5.4. and 5.5. – can you clarify step change in frequency?
- Fig. 5.13 – units are unclear.
- Ref. to figure 15.13. on page 42, figure is missing, the same on p. 58.
- Page 46 – intervals are really 278 μ s and 102ms?
- Can you clarify “*the best validation was in epoch 23*” (p. 47)?
- Tab. 6.1 is unclear. What does it state?
- Fig. 6.16 – in description discrete model is stated, the figure is not discrete.
- Description of Eq. 7.1. to 7.3. contain completely different variables.

Questions:

- Neural networks were used during data processing. Please describe your model (the description is missing in the thesis). Did you tried it repeatedly with the same results? Did you tried different datasets?
- Does developed software (chapter 7) have any possibility to export data and export/import settings?
- In the contributions chapter (p. 80) is written “*We selected seven important parameters that have the most impact on the distribution line. These parameters are line length,*

line resistance, line conductor, overall outer, and zone1,2.” Please describe these seven parameters.

After studying the work, I can state that the topic of the dissertation is very current and its solution is beneficial, I very positively evaluate the practical proposal in chap. 7. The aims of the dissertation are in my opinion fulfilled. The work is beneficial for the field of smart grids and provides a concept with a high potential for real use. The methodology of the work shows the good theoretical foundations of the author and his ability to apply this knowledge in practice.

The author of the dissertation thus contributed with an innovative approach to the development of power grids, and his outputs can be used in the anticipated advent of smart grids.

The dissertation fully meets the requirements for doctoral dissertations in accordance with §47 of the Act on Higher Education Institutions no. 111/98 Sb. and therefore his

I recommend

to be submitted for defense.

Prague, May 20th 2020

doc. Ing. Zdeněk Müller, Ph.D.