

ABSTRACT

of the habilitation thesis entitled

Researches on the operating regimes of electrical transmission and distribution networks analysis and optimization

author: Assoc. prof. PhD eng. Adrian Pană

The habilitation thesis reveals the capacities and didactic and research performances of the candidate Assoc.prof. PhD eng. **Adrian Pană**, who currently holds a teaching position as a university associate professor in the payroll of the Electrical Power Engineering Department within the Polytechnic University of Timișoara, developed after the public defense of the PhD thesis, to date.

Both the didactic component of the candidate and its research activities took place in two closely related areas, namely the electrical transport and distribution networks and the power quality, fields of major importance belonging to an integrating domain, which is generic named *electrical power engineering*.

In almost 20 years of uninterrupted **didactic activity** within the same department, the candidate has developed his capacities and didactic performances, performing all kinds of activities: seminar, laboratory, project, course, guidance in the elaboration of diploma and dissertation works etc., climbing the hierarchical scale of teaching functions. He contributed to the development of didactic works, being the main author of two university textbooks and two tutors for applied works.

The presentation of the capacities and performances obtained in the candidate's **research activity** occupies most of the habilitation thesis content. Thus, in the introduction chapter the author briefly presents the main topics covered and the results obtained over the 20 years, with reference to the list of bibliographic references. As can be expected from the title of the habilitation thesis, these topics are dedicated to the analysis and optimization of the operating regimes of the electrical transmission and distribution networks, most of them being part of the thematic area of the power quality field.

The introduction overview is followed by an extensive exposure of the most important results of the candidate's research work, obtained on the research topics defined as representative. They were grouped into **four thematic areas of major importance**, as follows:

1. ***Transfiguration of electrical distribution networks.*** The author presents some original methods of arborescent distribution networks equalization, which he proposes as efficient tools for optimizing the normal operating regime by minimizing the losses of active power and energy (technological self-consumption) respectively by optimizing the voltages rms values in the consuming nodes;
2. ***Balancing the loads of three-phase electrical distribution networks by unbalanced reactive cross-compensation.*** The most important original achievement of the author in this thematic direction is the mathematical demonstration of the energy mechanism of balancing the unbalanced active loads through unbalanced reactive compensation. According to these, a three-phase compensator containing only passive reactive circuit elements, in delta connection, causes a redistribution of the active powers between the phases, so that such a compensator can be sized to achieve the perfect balancing of an unbalanced load. Also, a major contribution of the author is the elaboration of the mathematical model of sizing and operation of an unbalanced capacitive compensator. This compensator, besides the function of improving the load power factor (by compensating the inductive reactive components of the positive sequence currents), fulfills the load balancing function (by totally or partially compensation of the negative and zero sequence components). The author has strong arguments in favor of implementing the *Adaptive Balancing Capacitive Compensator (ABCC)* equipment as a version of reactive power compensator built as a *Static VAR Compensator (SVC)*. It is also mentioned that the author was the director of a research grant, won by national competition, for the financing of industrial research activities, aiming precisely at building an experimental model for an ABCC type compensator. The main results obtained through this project were: the filing of a patent application, currently in the advanced validation phase, respectively the building of a

functional experimental model of ABCC, based on the mathematical model perfected by the research team coordinated by PhD eng. Adrian Pană.

3. ***Evaluation of impedance unbalance in three-phase electrical networks and their effects.*** This thematic direction was initiated because of the demands of the field specialists, who have repeatedly observed a phenomenon apparently paradoxical, which is visible on the untransposed overhead lines, operating in no-load conditions. This phenomenon consist in delivering, by such a line, of relatively high values of active power on one or two phases. It was explained by the author in a series of papers using a mathematical modeling in phase components, through the asymmetry of the equivalent natural capacitances of the line, resulted from the geometrical unbalance, which causes a redistribution of the active powers between the phases of the line. The correctness of the mathematical model was confirmed by experimental determinations and the obtained results constitute an important original contribution of the author to the modeling of the phenomena from the electrical transport and distribution real installations.
4. ***Evaluation of harmonic impedances in harmonic polluted electrical networks and their effects:***
 - 4.1. *Using the harmonic impedance of the network in the study of capacitive shunt compensation in the presence of non-sinusoidal regime.* One of the most important applications involving a correct evaluation of the equivalent harmonic impedance seen in a consumer bus of an electrical network operating under non-sinusoidal conditions, is the anticipation of a parallel resonance in the case of the installation of a capacitor bank for capacitive shunt compensation. The author presents in an original manner, with a pronounced didactic character, the mathematical model and the numerical results of some case studies related to it, for the correct sizing of compensating-filtering devices.
 - 4.2. *Analytical and numerical determination of the harmonic impedance seen in the buses of an electrical distribution network.* Evaluating harmonic impedances in real networks is an issue as important as complex and difficult. An important category of methods falls into the category of analytical methods. The author carried out research in this field, the most important results being the application in case studies of the mathematical models for two of the analytical methods: the method of the nodal harmonic admittances matrix and the state variable matrix method. Of these, the latter can be considered as an unconventional method, the use of which is commonly known as belonging to the study of automated systems domain. Its application for determining series and parallel resonance frequencies from an AC electrical network is an original approach, and the correctness of the obtained results is validated by comparison with the results obtained by the classical method of the nodal harmonic admittances matrix.
 - 4.3. *Analytical and numerical determination of harmonic impedance seen in the sections of a three-phase electrical line.* The correctness of the results obtained by applying the analytical methods depends on the correctness of the harmonic modeling of the loads and of the network's elements. One of the problems with an original solution proposed by the author is the modeling of long electric lines, which have a different characteristic than the other elements, consisting in the uniform distribution along the line of the equivalent longitudinal and shunt impedances. The author presents in a series of papers the results of applying an original method for calculating the harmonic impedance seen in any section of a long electric line, based on the calculation of the input impedances of the equivalent quadripoles formed on both sides of the respective section.
 - 4.4. *Experimental determination of the harmonic impedance seen in the buses of an electrical distribution network.* Another major difficulty, in addition to the one mentioned above, which makes very difficult to apply an analytical method for estimating the harmonic impedance of a network, is the very large number of components and loads. This is why researchers' efforts have been geared towards finding determination methods, which use data that are measured in the real network. The author has also approached this topic in his research, to which he made original contributions by proposing a method that result as a combination of the variation method and a procedure of measured data selection. The method has been implemented in a virtual instrument built with National Instruments technology, which has been applied in real conditions and whose results are very promising.

Another component of the author's research activity is the participation in solving over 20 research grants won in national competitions, research contracts or consultancy with energy companies or training grants, out of which **six** he was the project director. According to the current classification of the total of these works, **7** are research/consultancy contracts with a value of at least 2000 € (out of which **3** was the project director) and **6** are national grants/projects won by competition (out of which **2** the author was project director).

The results of the candidate's research activity have been brought to the attention of national and international academic and scientific community, through articles published in journals or conferences proceedings. For the period covered by the habilitation thesis, the candidate has published **81** articles, out of which **36** articles he is the first author or main author. The distribution by category of publications of these papers is as follows:

- **4** in journals ISI (*Institute for Scientific Information*) indexed;
- **2** in journals indexed in other international data bases (BDI);
- **16** in journals not indexed in BDI;
- **19** to international conferences ISI indexed;
- **5** to international conferences indexed in other BDI;
- **21** to international conferences not indexed in BDI;
- **14** to national conferences not indexed in BDI.

The candidate is also the main author of two treaties, two monographies and two chapters in specialized books, the latter two being published in foreign publishing houses.

The habilitation thesis includes a final chapter in which the author sets the future directions of action and development of academic, scientific and professional careers in his field of expertise. In the didactic field, the candidate intends to continue his current mode of action, in order to permanently update the content of the courses and the applicative activities, respectively an interactive way of working with the students, where the main place has the experiment to be performed, as possible in real installations. Scientific activity will be based, as before, on a team of seniors, from academics and industry, which are knowledge holders, but also of young people which have creative energy. The current research directions will continue, and of course new directions will be initiated, in accordance with the directions and requirements of the economic environment, to which the research activity must be necessarily connected.