

A B S T R A C T

The habilitation thesis entitled "*Modern electronics applications to increase the energy efficiency of industrial consumers*" presents the main professional, scientific and didactic concerns, that I have carried out since the PhD thesis completion on 23.01.2003 until now.

During the mentioned period I performed relevant activities for my career, namely: within the RWE Solutions Ltd Germany, at R&D department in the position of *prototype development engineer* (2003-2004), at the University of Petrosani, Department of Automation, *as lecturer* (2004-2007) and since 2007 at the "1 Decembrie 1918" University of Alba Iulia, Department of Exact Sciences and Engineering, within the Electronics team *as lecturer, associate professor and since 2016 full professor*.

The present proposal is a summary of my work in the last 14 years, which has resulted in the publication of over 70 scientific contributions, out of which 45 indexed in international databases (IDB) and participation in over 25 grants or RDI contracts with industrial companies. During this time, 3 articles were published in journals like *Energetica*, *RailwayPro* and *Acta Electrotehnica* and 27 are ISI indexed, having a summed up impact factor of 6.75 points.

The activity within the scientific community has been capitalized through the publication of 4 books by recognized publishers, one of which in Germany. Other 7 didactic materials (problem collections, course support and laboratory practice materials) complete my didactical expertise.

The proposed habilitation thesis is structured in four sections, namely:

1. Electronics applications in power generation
2. Implementation of advanced electronic devices for the electrical energy conversion
3. Optimizing energy consumption using modern electronic technologies
4. Virtual educational platforms for teaching/self learning applied electronics.
5. Future directions in the professional development.

The first section of this thesis presents the main contributions derived from both the PhD thesis that I proposed and from the experimentally validated control method from the postdoctoral research, namely the integration of advanced semiconductor devices (Shottky + Power MOSFET diodes) into the rotor of the squirrel cage asynchronous machine, with the goal to make a fine shaft torque adjustment and attenuating electrical and torsional oscillations. Depending on the application, the proposed induction machine can operate as an electrical drive or a power generator. Having access to the prototype developed during the elaboration of the PhD thesis also after obtaining the Dr.-Ing.-title, I continued the research concerning the implementation of the embedded structure inside the mechatronics system.

The activity with hardware connotation is reflected in the papers B2, B5, B7, C2, C5, C12, C16 and the one regarding the particularities of the proposed embedded system in B3, B6, C6, C7, C14. The applications and operating methods of the 8 and 16-bit microcontroller systems used to implement the autonomous control solution were published in B4, B10, B13 and C3, C4, C8, C11 and C18 respectively. Regarding the topics of electricity harness and generation, I focused my activity in 2008-2012 on designing, commissioning and operating of evaluation systems (monitoring and transmission) for the regional solar and wind energy potential. The measurement systems consist of sensors network, data logger buffer, modem and GPRS transmission module of

captured data. Three such real-time wind energy monitoring systems have been installed in the Alba region with the support of contracts with the German company *International Wind Concept GmbH* in Hamburg and another for solar energy in partnership with *EcoVolt Romania SRL*. This data-acquisition system able to deliver a 86 m high wind profile was unique in Transylvania on that date, as the Romanian Aeronautical Authority had advised it. The others were put into operation on a telecommunication relay, belonging to *ORANGE Romania SA*, on a utility pillar in Pianu, in the Alba county and on the student's hostel no.4 at "1 Decembrie 1918" University of Alba Iulia.

These innovative investigations and related data have led to the first regional study "*Masterplan and Green Energy Map*". The results of the research carried out in the contracts D9, D13, D15 and published in articles B15, B16, B19, B20, B21, B36 and C10, C22, C23 are also summarized in the first section of this report.

The second section describes the researchs concerning the conversion of electrical energy using power electronics. The research in this field started during my job in the development laboratory by *RWE Solution/Germany* under the D2, D3 and D4 contracts. The carried out investigations allowed me, with the time gap imposed by my funding, to publish the papers B1, B13, B18 and C19, C25.

Consequently, this chapter describes the design, adaptation and dimensioning of the power electronic and control components from the power supply unit 28kW / 24V / 2000A, the final stage of 12/48V dc-dc converter and their optimization in terms of electromagnetic compatibility and compliance with European and American domestic and military EMC standards. A special passage from this section is dedicated to the design and revision of the electrical and electronic compliance testing norm for the new developed 28kW GPU (Ground Power Unit), namely "*Test Instruction QW 91.9.179.4897*", presented in the works B1, C17 and F1.

Also in this section there are successively described the scientific achievements resulting from the CNCSIS grants D5, D6 and D7 on increasing the efficiency of electric actuators by advanced methods for losses reducing in the switching mode. The experimental part described in the present thesis focuses on the design and commissioning of the test bench for switching loss measurement, the testing of modern semiconductor devices (see B3, B28, C20) and on impedance analysis of Si and SiC semiconductor junctions in dependance of their control state (see C17, B32). The development of the interface circuit, IGBT MOSFET-driver, that can adjust the transition time in switching mode, reducing the critical overloads and minimizing the protection circuits is also discussed in detail.

Contributions related to the issue of the energy optimizing at the final industrial consumer using modern electronic technologies are reported in *Section 3*. They are derived from the activity performed as a lecturer and consulting engineer authorized by ANRE Bucharest, activity confirmed through over 25 contracts with industrial companies such as CONTINENTAL Automotive Sibiu, Siemens SIMEA Sibiu, BOSCH Rexroth Blaj, UNILEVER Romania Ploiesti, a.o. Innovative technical and scientific contributions, not covered by the confidentiality agreement with the beneficiary, crystallized during D6-D9, D16-D23 studies, were presented in B23, B25, B30, B33 and C21, C27. The activity done as a technical consultant by the introduction of modern lighting solutions in LED technology in Brasov and Alba Iulia is also mentioned in this chapter, respectively in the papers D12, D21, D22, B37, B42. Moreover contributions related to the

optimization of the traction power electronics, B7, B17, B26, C26, possibilities for power factor improving via (super)capacitors stages B23, B38, and the development of energy monitoring units for the usual IT systems (desktop, laptop, peripherals) B39, B42, C21 are included in this section.

The above-mentioned scientific contributions, listed in the attached worksheet, have a good visibility and are quoted in more than 60 scientific papers, including 37 independent citations in ISI-listed lectures or books.

The 4th section is devoted to the educational projects which we have won and implemented within the electronics team of "1 Decembrie 1918" University of Alba Iulia. It describes in detail the proposed objectives and the efforts, performed since 2006, in order to authorize and to accreditate the license and master courses related for the *Applied Electronics* specialization in Alba Iulia. The crucial way was given by the four relevant educational grants funded by European Community, E1, E2, E3 and E4, that I was involved in, whose examples of good practice have led to write the articles B24, B40, B44 and C9. The objectives of the mentioned contracts were to improve the convergence between the university education and the active life in order to develop the working skills under the conditions of using advanced technologies. Also in this chapter there is a review of measurement facilities and interactive training platforms purchased from the approved budget and also of the edited didactic support materials, provided as deliverables in the mentioned projects.

In Section 5, I refer to the experience gained as a member in Steering Committee, chairman or reviewer at the international conference like CAS-International Semiconductors Conference (<http://www.imt.ro/cas>), ISSE-International Spring Seminar of Electronics (<http://isse-eu.net/>), SIITME - International Symposium for Design and Technology in Electronic Packaging (<http://siitme.ro/>), TIE - Interconnection Techniques in Electronics (<http://www.tie.ro/>) and SATEE - Smart Applications & Technologies for Electronic Engineering (<http://www.satee.ro/>), activities that inform me about current achievements in the field of electronic engineering.

Some aspects related as transfer interface and multiplier of technical knowledge to our students, position conferred as professor and IEEE member (Institute of Electrical and Electronics Engineers, www.ieee.org), and VDE member (German Association for Electrical, Electronic & Information Technologies, <https://www.vde.com>) conclude this chapter.

At the end of this thesis, it is listed and detailed the milestones for the future intentions and prospects for the development of both institutional and professional career in the economic and social context of the region.

Alba Iulia, 05.07.2017

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