Universitatea *Transilvania* din Braşov

HABILITATION THESIS

SUMMARY

Electronics and Information Technologies in the Development of Support Elements for the Protection of Life and Environment

Domain: Electronics, Telecommunications and Information Technology

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As a subject of this habilitation thesis we chose the brief description of some of the applications made in more than 30 years of work in the research and didactic activity that envisaged life or environmental protection. Human and environmental protection are generous ideas, which are worth guiding the activity of a researcher and being passed on to university students by a faculty.

The most important applications, which target human or environmental protection and which are set out hereunder are :

1. a system of measuring the radon concentration in the air, which contains a measuring device, plus data transmission and centralisation – laid down in chapter 1 ;
2. short-circuit, over-voltage, over-current and ground current leakage protection devices, plus data transmission and centralisation – laid down in chapter 2 ;
3. the analysis of the electromagnetic shielding efficiency for materials, with an aim to mitigate the interferences and the effect on people – laid down in chapter 3 ;
4. educational initiatives, aimed to further the awareness of the environment-related problems and protection amongst university students – laid down in chapter 4.

Chapter 1 Applications for measuring the radon concentration and data transmission

Radon is one of the most important carcinogenic factors worldwide. The carcinogenic impact of radon is proven both by the trials undergone within mining workers and by the studies regarding the exposure to residential radon. 22 major studies on the impact of residential radon upon the appearance of lung cancer have been made in the past 25 years, the main conclusion being that the risk of developing lung cancer due to radon increases by 16 % on 100 Bq/m^3 (Darby et al., 2006).

Within the CEEX research project (CEEX, 2006), the group coordinated by the author had the task of measuring the radon concentration in the Braşov area and in its outskirts, as well as the task of suggesting a device for measuring the radon concentration in the air. They thus designed a measuring device and method with a transducer complete with a ionisation chamber and a data transmission system. The data transmission system sends the measured concentration of radon to a server by several methods : transmission over the telephone line and over the Internet by GPRS (GPRS, General Packet Radio Service). The measuring device was patented (Purghel, Morariu et al, 2012) and the outcomes were published in an ISI magazine – impact factor : 0.529 (Ogruțan, Romanca et al, 2010), in the proceedings of an ISI conference (Morariu, Ogrutan et al, 2008) and of an IEEE conference (Ogruțan and Suciu, 2012). During the tests of the ionisation chamber one found out that the uncertainty in measuring the radon concentration increased in the presence of the electromagnetic fields, these findings being published in an ISI journal – impact factor : 0.745 (Ogruțan, Suciu et al, 2013) and set out at an ISI conference (Aciu, Ogruțan et al, 2014). The (Suciu, Ogruțan et al, 2008) work tackles with the problem of materials for the protection against radon penetration.

The measuring device was designed in such a way as its sizes was reduced and the dependence of the measuring uncertainty subject to the electromagnetic field may fall into a tolerance acceptable for the radon measuring devices. The CEEX project involved designing, executing and testing a module with a microcontroller, which may take over the analogical or digital signals from the transducer and transmit them to the server by means of a wireless module. Two methods were taken into account for designing a device of measuring the radon concentration : the measurement by integration and the measurement by impulse counting. The project included

the creation of a software programme that could receive data from several measuring devices, save them in a database, enable the elaboration of statistics and graphs and generate an alarm when a maximum limit value of the radon concentration is exceeded. The database contains both the measured values and the geographical coordinates of the measuring point and the alarm will show both the concentration and the geographical position of the point where the excess came up. In order to test the functionality of the device, the data measured were compared to the values measured by a standard detector. The block scheme of the system is provided in Figure 1.

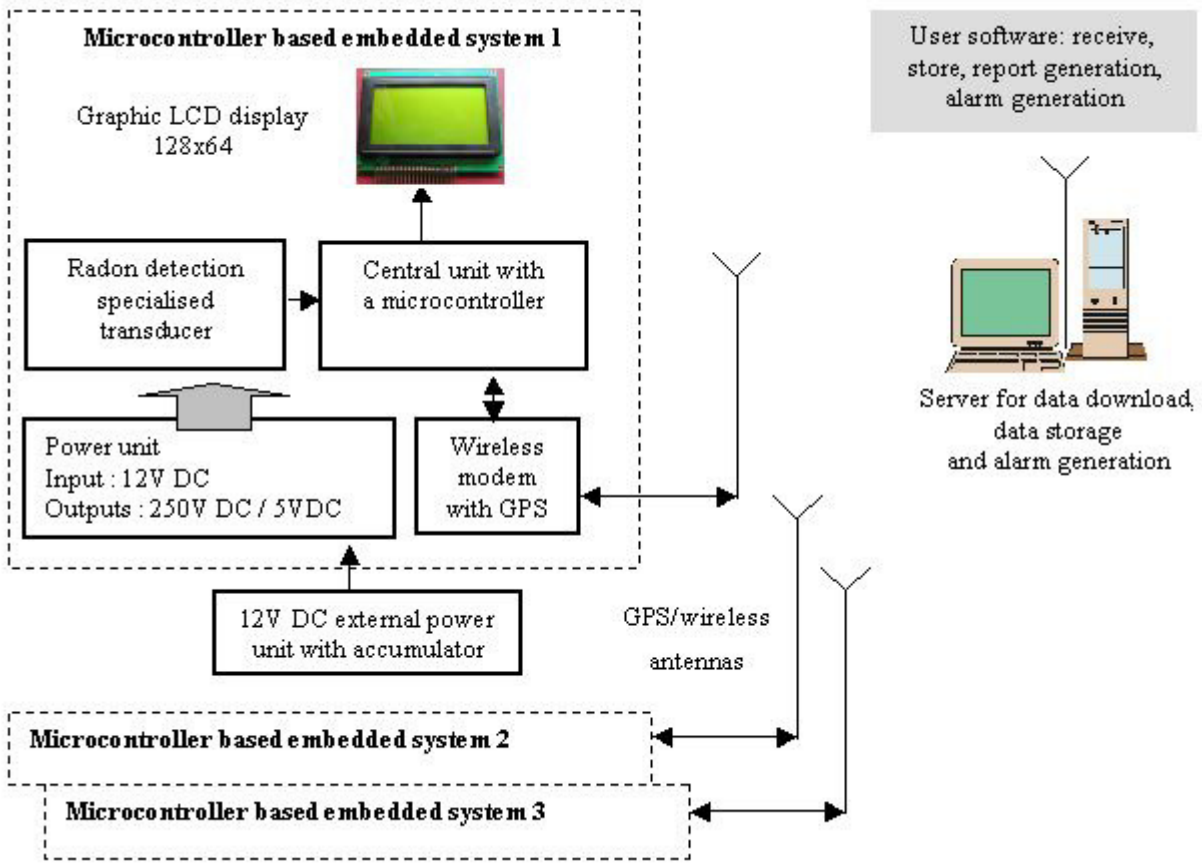

Figure 1. The block scheme of the Real Time and Multiple Location Radon Monitoring System

Chapter 2. Applications for protection in the power supply network

Physical security of energy infrastructure against risks, including supply interruption, is an essential factor for predictability. Increasing security and competitiveness of electrical power supply systems within the context of an energy mix which is more enduring, more efficient and more diverse, requires sustained innovation within the strategic European planning of technologies in the energy sector. The study (Kobes *et al.*, 2009) carried out for the benefit of the European Community was intended to investigate the fires occurring in power systems based on models of fire initiation and growth, in order to provide effective protections. The study provides a classification of fires depending on their causes, although within this project only electrical causes are of importance. E.g., in the Netherlands 31 % of the fires have electrical causes. IEC (International Electrotechnical Commission) states : "1st step to a Smart City : reliable access to electricity" (IEC, 2016).

Several attempts were made to replace the conventional protection devices by their electronic counterparts, one of the first ones being patented by the authors of this proposal (Munteanu *et al.*, 1989), a transistor device for short-circuit protection. One of the features of this device was

automatic reconnection. A group of researchers were granted in 2008 a patent proposing an electronic overcurrent and overvoltage protection device based on a microcontroller circuit (Ogruțan, Munteanu *et al.*, 2008), followed by a protection method, in (Ogruțan, Munteanu *et al.*, 2010). A research contract between the Braşov 'Transilvania' University and SC Electrica Distribuție Transilvania Sud SA, (Research Project, 2009) identified the problems regarding power supply security at the electrical power distributor. Following this contract, in 2001 a patent application was filed (Ogruțan, Aciu et al, 2011).

Figure 2 presents a block diagram of the protection device in relationship with external elements. The diagram clearly displays the microcontroller system, which acquires samples (voltage and load current), and ensures load disconnection if the voltage or current values rise above the admissible levels. If the current values are acquired from both wires of the supply line, the difference can be calculated to find out if there is a ground leakage current. The occurrence of an event will trigger load disconnection using a switch such as relay, triac or another similar device capable of acting as a circuit breaker. The block diagram also presents the bidirectional data transmission path used to transmit the event report to the power distributor and to disconnect the consumer from the distributor.

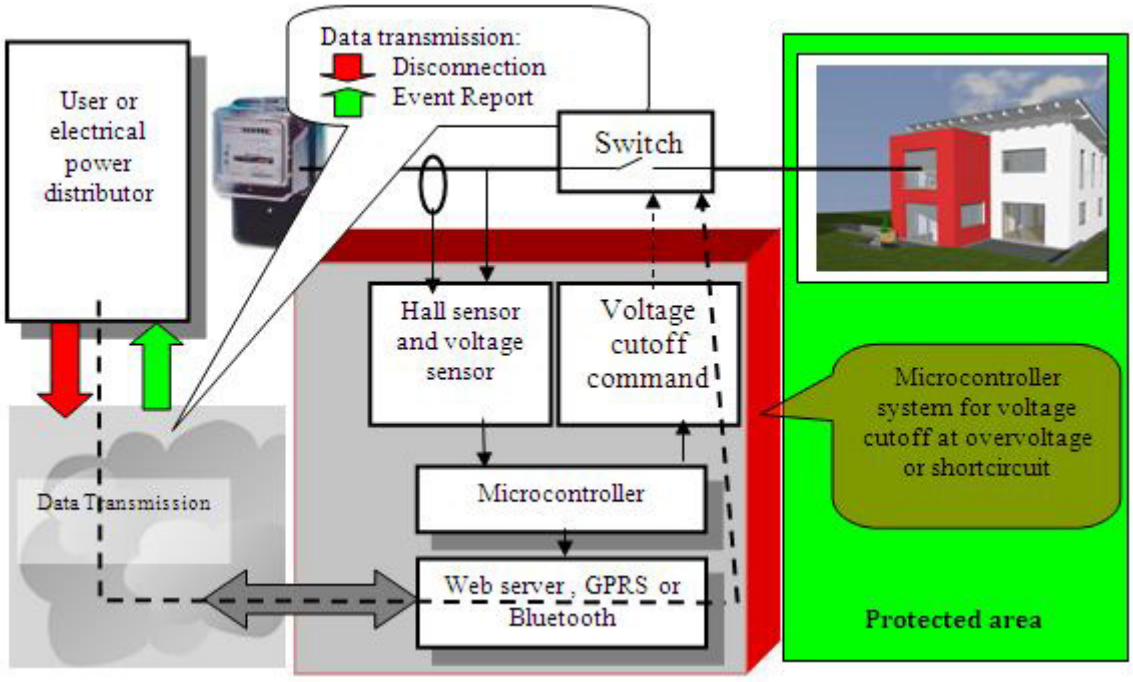

Figure 2. Block diagram of the protection device and data transmission

The main outcome of this project was the development of a functional, test-verified of a hardware and software system in accordance with the European standards, capable of assuring consumer protection against overcurrent, overvoltage, ground leakage currents, as well as the automatic switching of consumers according to a certain schedule. The data generated by these devices were transmitted to a server for storing the information about the system events in a database, which is eventually capable of disconnecting any of the consumers. The messages can be used by the distributor to trace any reported event.

The advantages of the protection device are high speed disconnection and automatic reconnection. One device detects all the events (data fusion) and it ensures the system voltage zero crossing disconnection, which diminishes the generated perturbations and the server can centralise the information in a database, which enables the generation of statistics during periods

of time at different locations. Remote user disconnection is technically possible. The proposed device characteristics are superior to those of the existing devices.

The best data communication solution, agreed by the power supplier, is the use of GPRS. If every protection device is connected locally through the RS232 interface to a GPRS modem, the server can centralise the information in a database, which enables the generation of statistics during periods of time at different locations. User disconnection is also a straightforward operation which does not require the presence of an employee from the supplying company at the client's headquarters.

A special aspect which had to be clarified by using SIMULINK® was the operation of the two-staged protection as described in (Ogruțan, Munteanu *et al.,* 2008) and (Ogruțan, Munteanu *et al.,* 2010). If a triac is used to switch off the load in case of overvoltage, two-staged protection can be provided. These simulations have led to the conclusion that the method described in the patent can be applied with favorable results only for purely resistive loads, even if the concept of a two-staged protection represents an advantage.

Chapter 3. Shaping and assessing the efficiency of the electromagnetic fields shielding

The extension of the wireless communications aroused concern among the population. Another worrying aspect is the increased number of equipment that have wireless communications in each apartment and the enhanced probability of electromagnetic interference appearance.

These recent courses bring forth an increased importance of electromagnetic shielding. The major accomplishment of the author's researches therefore was the research contract with the National Board for Scientific Research in Higher Education - CNCSIS (CNCSIS, 2006). At the beginning of the research, the goal was to comparatively analyse certain methods used for hierarchising the materials from the point of view of their capability of shielding the electromagnetic field. The classical method for the analytical calculation of the shielding efficiency, the method of measurement by TEM cells as an application of the impedances method (Schelkunoff) and the method of the insertion attenuation were studied and analysed. We suggested an original template for assessing the transmission line shielding efficiency based on Schelkunoff's works.

In order to check up the data obtained by the simulation in SPICE and SIMULINK we chose to use a wave guide measurement system with a microwave generator made by means of a Gunn diode, LABVOLT. The system is electromagnetically closed, thus eliminating the influence of the disturbing electromagnetic fields upon the measuring process. The material samples that undergo measurement are laid out in the rectangular wave guide where the microwave field is generated.

Within the experimental measurement process we used samples belonging to the following categories and types of materials :

1. conducting materials (aluminium, copper, brass) ;
2. insulating materials specific to the electronic technology field ;
3. FT-, GR-, FE- and TN-type nanomaterials (created by ICPE CA Bucharest).

Another kind of measurements were carried out by using a system of antennas belonging to ICPE CA Bucharest at the 1GHz frequency. For a material made by nano-technologies (FE300) we simulated the shielding efficiency by parameters determined by calculation and on the simulation graph we overlapped the experimental results obtained by means of the wave guide system and the antenna system. In the end there was a good compliance between the graph simulated by the suggested template and the measured data.

Some other tests took place in the TEM (Transversal ElectroMagnetic) cell. The TEM cell used was a TESCOM one. The TEM TC-5010B mini-cell may be used with an external signal generator, on the DC – 1GHz frequency range. Unlike the wave guide measurements made by using the LABVOLT system or the antenna ones, these measurements can take place on a whole range of frequencies, not only on a certain frequency.

An approach in this field is focused on the construction materials. The author's preoccupations in the reduction of the radon concentration in the air and electromagnetic shielding led to an original idea: the determination of the shielding effect of the nanomaterials with conductive insertions upon the ionising radiation. The materials made at ICPE CA Bucharest were also tested in terms of their behaviour at the decrease of radon penetration.

In 2007 there was a workshop with the outcomes of the research, organised at the Brașov 'Transilvania' University, and in 2008 there was another workshop with an ample attendance, in Predeal, within the International Symposium for Design and Technology of Electronic Packages - 2008 (www.siitme.ro). Several papers were presented at this workshop and the results were debated upon with guests from all the university centres and ICPE CA Bucharest.

The most important published papers are : (Aciu, Ogruțan *et al.,* 2010), (Aciu and Ogruțan, 2012), (Ogrutan, Aciu *et al.,* 2007), (Romanca, Ogrutan *et al.,* 2008) si (Badic, Aciu *et al.,* 2008).

Chapter 4. Accomplishments in the orientation of the didactic activity towards environmental protection

In the didactic activity, the goals were to share the know-how and to shape skills in the field of electronic engineering, telecommunications and information technology by considering environmental and human protection. In 2004, the Faculty of Electrical Engineering & Computer Science put into practice a PBL (Project Based Learning) initiative, starting with the Applied Electronics study programme (where the author is its coordinator) and continuing with the Computers and Telecommunications study programmes, with an aim to stimulate the students' creativity and to enhance their degree of involvement in the school activity. A combination between the classic approach and PBL was applied at the Electromagnetic Compatibility and Interfacing school subjects. Combined approach meant that the course and laboratory activites are traditional and that an elective PBL activity was introduced under the form of a mini-project.

The first initiative had a huge success. At the Electromagnetic Compatibility school subject one suggested elective activities and laboratory works, whose goal was to increase the school activity attractiveness and the students' involvement in environmental protection actions. In order to enhance the school subject attractiveness, each year one undergoes laboratory works on the field, when one measures the electrical field values at the 50 Hz frequencies underneath the high voltage lines and at the frequencies allotted to mobile telephony in the proximity of the GSM antenna groups. These outgoings are very much appreciated by students and the preoccupations linked to the protection against the electromagnetic radiations brought in many ideas for the mini-project. The initiative of tackling with the radiations influence on health by organising a course session, laboratory sessions on the field and the activity for the mini-project was generalised and applied every year.

The second initiative tackled with energy savings and energetic efficiency, which are vital to the human kind. The initiative aiming at getting the students familiar with the environmental problems created by the lighting systems was the departing point for certain laboratory works. Within the activities with the students one briefly describes the current lighting solutions and the features envisaged are the energetic efficiency, the operating duration, the electromagnetic

disturbances generated and the dumping risks. The laboratory work outlines the disturbances generated during operating and upon turning on. One suggests the utilisation of a system with microcontroller for the switching on control at the maximum alternation, in order to enable the measurements repeatability and the determination of the maximum level of disturbances. The school activity laid a special stress on discussions with the students and on their individual work, their interest being aroused by the new regulations linked to the energetic efficiency of lighting, adopted in Romania, as well. The students received individual work tasks based on the Project Based Learning concept. At the end of the activity, the students used a rack for testing the disturbances generated by the various types of light bulbs, in order to supplement their knowledge with the engineering elements required by the school subject taught. After the first school year of application one noticed an increase of the students' interest in the school activity, concurrently with the sensitisation towards the environmental problems.

The third initiative was linked to the way of calculating the efficiency of electromagnetic shielding. The simulation of the phenomena, of the circuits and the graphic representation of the results of certain mathematical relations enhances the attractiveness of the school activity. The teaching of the EMC (ElectroMagnetic Compatibility) school subject was thought as to provide the students with practical knowledge of EMC and to reduce the mathematical part as much as possible. This initiative suggested a new manner of teaching the shielding calculation based on simulations. In the school year 2012-2013, the shielding calculation was taught both by analytical calculation and by simulation and the test at the end of the laboratory consisted in solving a problem linked to the calculation of a screen. The students from the Electrotechnics specialisation were asked to solve the problem by analytical calculations and the Applied Electronics students by simulation. The efficiency of the teaching manner is analysed from the standpoint of the students' answers to a questionnaire and of their results at the laboratory test.

The fourth initiative deals with the relationship of the personal computers with the environment, which becomes increasingly important because of the larger number of computers made and of the rapid technological innovation, which shortens the lifetime of a computer. The negative influence of computers upon the environment is seen in the energy consumed for their manufacture and during operating, as well as upon dumping the obsolete computers. The discussions with the students aimed at two methods of mitigating the negative impact of the computers transformation into waste : the former one is to make the users increase the period of utilisation or to reuse the obsolete computers, and the latter one is to use new environmentally friendly materials for manufacturing computers. As a result of the discussions with the students, one identified a few important issues for the relationship between the computer and the environment, which were talked about in detail and constituted the departing point for certain projects. At the beginning of the activity and in the end, the students were asked to take part in an anonymous opinion poll, whose results were analysed.

The most important success of the method applied at the Faculty of Electrical Engineering & Computer Science consists in the outstanding results of the students, who by this method learnt useful things and continued the topic of the mini-project for their graduation thesis. Thus, students M. Scutaru and R. Toev succeeded in publishing, as first authors, a paper much appreciated at the 2008 SIITME (Toev, Scutaru *et al.,* 2008) and at the 2010 ISI OPTIM- rated International Conference (Aciu, Ogruțan *et al.,* 2010). The SIITME paper was granted the Excellent Poster award.

The most important papers published are (Ogruțan, Aciu *et al.,* 2010), (Aciu, Cazan *et al.,* 2015) and (Ogruțan, Sandu *et al.,* 2016).

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