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Opponent opinion

on dissertation thesis of Tumenbayar Lkhagvatseren, M.Eng.
“Measurement Systems – Connection between Sensors and Embedded System”

Dissertation thesis “Measurement Systems – Connection Between Sensors and Embedded System”, submitted by Tumenbayar Lkhagvatseren, M.Eng., deals with the embedded digital system and sensors using analyzing methods of electromagnetic radiation in indoor scenario, as well as a penetration through a certain building mediums. A lot of experiments of electromagnetic propagation through a construction medium desirable a contemporary state of a reliable wireless communication system for sensors, in the range form 1 to 8 GHz frequency bands, as well as for ultra-low power transmission up to 0.1mW.

The thesis is divided into three main parts. In the first (theoretical) part there are formulated basic principles of the sensors, signal theory and utilization of RF propagation models, as a part of electromagnetic waves fundamentals, and other parts, which interests in communication for sensors. Calls for research are based on latest development in digital signal processing and RF networks for broadcasting. Rather extensive literature and state-of-the-art survey, including key terminology, has been made by the author in the areas of analogue, and digital communication systems. Goals of research were specified at the beginning of thesis. May be it could be better to realize the goals of research after the preview and related problems definition.

In the second (experimental) part of the thesis there are introduced and experimentally presented principles of experimental measurements and their applications in the space systems. There is an also introduced principal measurement of RF signal propagation. Then the measurement of RF signals penetration. The various materials and measurement setups are presented in experiments. The experimental evaluation of the effectiveness is included in the thesis. The results are demonstrated based on percent the parameter of variable overhead. The results are presented in tables and graphs.

In the third scientific and contribution part of the thesis the new model of measurement is introduced. The real laboratory model has been studied by this thesis is applicable both for the research and pedagogical purposes. The experiments of electromagnetic propagation in an indoor scenario and penetration through a construction medium describe the real state of the reliable wireless communication system for sensors, in a range from 1 to 8 GHz frequency bands, and for ultra-low power transmission up to 0.1mW. At the end of the third part and the thesis the results are compared in overview form. The practical point of view it can be predict a reliable wireless communication system for sensors by estimation of signal loss for frequency range of signals.

In the conclusion the author has summarized the increasing demand of the reliable measurement system with the wireless communication system. The particular attention is streamed to sensor system including the sensor technology. The experimental measurement system is designed including the signal conditioning analog and digital as well as the wireless communication system.

The model is based on the analogue signal conditioning, and its converting into digital form, which is prepared to communication system. The results of the modeling and simulation of the sensor signal conditioning and the insertion loss are expected to report at the defense of the dissertation thesis.

The thesis consists of 135 pages including all overhead (content, list of figures, author publication activities, technical appendix, etc.). It is divided into three main parts (please see the text ahead). The aims of the thesis were specified at the beginning of the thesis. The list of references contains 104 items. All the relevant sources (textbooks, technical specifications and reports, scientific papers and articles, www pages etc.) were used to cover the thesis topic and relate the author's contribution. This summary made by me does not meet any doubt on quality, rather on availability of the scientific community feedback and worldwide discussion on results.

The thesis contains all necessary formal parts and the text is comprehensive and written in appropriate scientific level. I have no serious comments on formal quality of the thesis; the references list is arranged in the order alphabetic order.

Question for the discussion:

How does the transmission of measured values verified? Please, explain various experiments.

Summary: Submitted thesis of Tumenbayar Lkhagvatseren, M.Eng. present good contribution for the scientific and technical workers in the area of measurement, research and development. The main contribution I have found in the last part of the thesis, in the design and algorithm development. The contribution was experimentally verified and compared with the state-of-the-art. From the reference list it is evident that the author has very good overview in the thesis topic and the thesis was sufficiently presented.

To conclude, I can confirm that Tumenbayar Lkhagvatseren, M.Eng., by submitting the dissertation thesis, fulfils all needs for independent, systematic and scientific work. He presented new ideas and new solutions that can be included. The aims of the thesis were completed and met their definition. I can recommend, after the successful defense of the thesis before the commission and answering all the questions, confer a degree "doctor philosophiae" (in abbreviation "Ph.D.") in the study program Technical cybernetics.
I recommend the thesis for defense.

Zlin, 10th June 2011



Prof. Ing. Karel Vlček, CSc.

Tumenbayara Lkhagvatserena

**MEASUREMENT SYSTEMS – CONNECTION
BETWEEN SENSORS AND EMBEDDED SYSTEM**

Dissertation thesis usually consists of three dominant parts:

1. **State of the art** is a deep insight into the topics which are intensively investigated by the researchers at present. Problems which have not been sufficiently solved yet are identified to form the goals of the dissertation.
2. **Aims of the dissertation.** The dissertation is usually focused on solving two or three problems covering a narrow research area. The dissertation is requested to deeply analyze the problems. Originality of both the problem and the solution has to be explicitly presented here.
3. **Kernel of the dissertation** brings a detailed description of the original solution of the identified problems. Since the dissertation is written for experts, well-known information is not repeated, and sources of information are referenced.

The dissertation authored by Mr. Lkhagvatseren breaks these rules:

1. **State of the art** (pages 15 to 16) is a two-page text which defines the measurement as an application-oriented system and introduces a system in package as a potential implementation of such a system. The state of the art, which is conceived such a way, is not able to identify original research topics.
2. **Goals of the dissertation** (page 17) are focused on studying sensors and wireless communication, on proper setting of a measurement system and on measuring wave propagation of a wireless link. In order to meet the requirements put on the dissertation, the aims should concentrate on the development of numerical models of wave propagation, on the methodology of measurements, and on the comparison of simulated and measured data. New propagation models are intensively developed at present (which demonstrates the topicality of the research), and models for some specific conditions are still unavailable (which demonstrates the originality of the research). A proper measurement methodology is consequently required to get the agreement between measured and simulated data.
3. **Theoretical frame** (pages 18 to 57) reviews basic knowledge from the area of sensor technology, signal processing, wireless communication, wave propagation and measurement. According to my opinion, this text does not contain any new contribution, and all the topics are well-covered by basic textbooks of electronics. This part should be removed from the dissertation.
4. **Experimental part** (pages 58 to 95) describes results obtained by the student during the measurement campaigns. From my view point, this is the kernel of the dissertation. Unfortunately, experiments are described very briefly, and results of measurements are not verified (comparisons with simulation data, published results, or independent measurements provided by other laboratories). Hence:

- a. The experiments are not fully reproducible;
 - b. Validity of the presented data cannot be approved;
 - c. Original contribution of the thesis cannot be identified (better accuracy compared to other methods, cheaper instrumentation compared to conventional approaches, etc.).
5. **Discussion of results** (pages 96 to 97) does not bring a real discussion in a fact. In the chapter, contents of the thesis are briefly summarized without any attempt to formulate generalized remarks.

Conclusion. The dissertation thesis

I S R E C O M M E N D E D

to be defended. The defense has to be focused:

1. On the explanation of the original contribution described in the thesis.
2. On the demonstration of the validity of presented results;
3. On the formulation of methodological recommendations related to the implementation of measurement campaigns of wireless links operating in different environments (synthesis and generalization of knowledge obtained for measurements of forces, measurement of propagation and penetration of waves).

Brno, the 16th of June, 2011



Prof. Zbynek Raida

Questions:

1. In Figure 45 (page 81), the measured dependence of the path loss on the distance between the transmitter and the receiver is depicted for different scenarios. What is the explanation for the difference between the ITU-room (green) and measured rooms? What is the explanation of minimum differences among data measured in different rooms?
2. Can you explain basic differences among programs ANSYS, COMSOL Multiphysics and CST Microwave Studio?

Prof. Dr. Ing. Zbyněk Raida

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Expert opinion of doctoral work of Eng. Tumenbayar Lkhagvatseren

Measurement systems – connection between sensors and embedded systems

The presented doctoral work deals with the design of 2 channel wireless sensor and elaborates several aspects of wireless sensor communication.

The work is divided to eight chapters. The first one is an introduction, second denotes the state of the art, the third points out the intentions of the doctoral work, the fourth describes the theory, the fifth covers the practical experiments, in the sixth there is the summary of the results and last two chapters are lists of authors publications and references.

The core work is in chapter 5 with practical experiments, which is further divided into three sections. In the first section 5.1. is description and design of two-axis strain gauge force sensor and wireless communication module. The measurements of input / output characteristics was elaborated in detail, and also the distribution of errors in the measuring chain and overall accuracy was treated precisely. In the section 5.2. is presented path loss measurements in different rooms and their evaluation. In the section 5.3. there were measured penetrations of electromagnetic waves through construction materials, and even through a firemen suit.

It can be stated that all work is concerned with broader issues than just connecting the sensor with embedded systems, as mentioned in the title. The core of the work is more directed at the characteristics of EM field measurements in buildings, which can be taken as certain deflection from the topic. The overall scope of the work is very wide (from the solution of physical phenomena over the area of analog signal processing, digital processing and wireless data communication), that limits the scope for detailed scientific investigation, the results of which would be valid in general.

In formal way, the work is prepared carefully and is well organized. In some tables (Table 17, Table 18) there are missing physical values.

Although in theoretical field has the work rather compilatory character, it usefully summarizes the context of wireless sensors of physical quantities. The contribution of the work can be sought particularly in the practical field. Measurements of attenuation parameters of building materials at frequencies around 2.4 GHz is very useful for future considerations on the applicability of wireless sensors of physical quantities inside the buildings. The work has also general importance for the construction of multi-channel wireless sensors of physical quantities - force sensors, pressure gauges, accelerometers, etc. usable in a variety of applications in industrial and building automation, robotics, automation of vehicles, etc.

I have several questions for the graduant:

1, Could you assess the direct effect of practical knowledges of your work on the applicability of ZigBee in indoor buildings? Does ZigBee system enable an architecture that would facilitate such an application?

2, Why was the examination of firemen suit included to the work? What is "Smart Suit"?

I can say that disertant demonstrated the ability to independent scientific work, his work has practical benefits and, if he answers to my questions, I suggest him to be awarded a Ph.D. title.

Ing. Dalibor Štverka, Ph.D.



Zlín

13.06.2011