# 52. IWK

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## FACULTY OF COMPUTER SCIENCE AND AUTOMATION

## COMPUTER SCIENCE MEETS AUTOMATION

## VOLUME I

Session 1 - Systems Engineering and Intelligent Systems

Session 2 - Advances in Control Theory and Control Engineering

Session 3 - Optimisation and Management of Complex Systems and Networked Systems

Session 4 - Intelligent Vehicles and Mobile Systems

Session 5 - Robotics and Motion Systems

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## Preface

Dear Participants,

Confronted with the ever-increasing complexity of technical processes and the growing demands on their efficiency, security and flexibility, the scientific world needs to establish new methods of engineering design and new methods of systems operation. The factors likely to affect the design of the smart systems of the future will doubtless include the following:

- As computational costs decrease, it will be possible to apply more complex algorithms, even in real time. These algorithms will take into account system nonlinearities or provide online optimisation of the system's performance.
- New fields of application will be addressed. Interest is now being expressed, beyond that in "classical" technical systems and processes, in environmental systems or medical and bioengineering applications.
- The boundaries between software and hardware design are being eroded. New design methods will include co-design of software and hardware and even of sensor and actuator components.
- Automation will not only replace human operators but will assist, support and supervise humans so that their work is safe and even more effective.
- Networked systems or swarms will be crucial, requiring improvement of the communication within them and study of how their behaviour can be made globally consistent.
- The issues of security and safety, not only during the operation of systems but also in the course of their design, will continue to increase in importance.

The title "Computer Science meets Automation", borne by the 52nd International Scientific Colloquium (IWK) at the Technische Universität Ilmenau, Germany, expresses the desire of scientists and engineers to rise to these challenges, cooperating closely on innovative methods in the two disciplines of computer science and automation.

The IWK has a long tradition going back as far as 1953. In the years before 1989, a major function of the colloquium was to bring together scientists from both sides of the Iron Curtain. Naturally, bonds were also deepened between the countries from the East. Today, the objective of the colloquium is still to bring researchers together. They come from the eastern and western member states of the European Union, and, indeed, from all over the world. All who wish to share their ideas on the points where "Computer Science meets Automation" are addressed by this colloquium at the Technische Universität Ilmenau.

All the University's Faculties have joined forces to ensure that nothing is left out. Control engineering, information science, cybernetics, communication technology and systems engineering – for all of these and their applications (ranging from biological systems to heavy engineering), the issues are being covered.

Together with all the organizers I should like to thank you for your contributions to the conference, ensuring, as they do, a most interesting colloquium programme of an interdisciplinary nature.
I am looking forward to an inspiring colloquium. It promises to be a fine platform for you to present your research, to address new concepts and to meet colleagues in Ilmenau.

Professor Peter Scharff
Rector, TU Ilmenau

Professor Christoph Ament
Head of Organisation

# Table of Contents

## C O N T E N T S

## Paper submitted after copy deadline

## 2 Advances in Control Theory and Control Engineering

K. Bayramkulov / V. Astakhov

# The method of the boundary equations in problems of computing static and stationary fields on the topological graph

## ADVANCES IN CONTROL THEORY AND CONTROL ENGINEERING

There is a number of technical problems in which it is necessary to provide control of electrotechnical systems. The purpose of the given work is construction of methods of a numerical finding of parameters of such systems.

The problem of computing a plane stationary magnetic field in the presence of magnetizable bodies has been considered. The opportunity of application of the method of boundary equations on the graph of electric circuits in this example has been watched.

The initial boundary problem is following:

$$\begin{aligned} &\mathrm{rot}\overline{H} = \begin{cases} \overline{\delta} \ \text{ on } S_k, \\ 0 \ \text{ on } S \setminus S_k, \end{cases} \quad \overline{\delta} = \overline{e}_z \delta; \\ &\mathrm{div}\overline{B} = 0; \ \overline{B} = \mu\overline{H}; \ \ \mu = \mu^{\pm} \text{ on } S^{\pm}; \\ &B_n^+ = B_n^-, \ \ H_\Gamma^+ = H_\Gamma^- \ \text{на } \Gamma; \\ &\left|\overline{B}(M)\right| \xrightarrow[M\to\infty]{} 0 \end{aligned} \tag{1}$$

($S_k$ is the sections of the coil). In our statement the condition of solenoidalness an induction $\overline{B}$ of the magnetic field including in (1), can be satisfied representation $\overline{B} = \left[\mathrm{grad}\varphi\ \overline{e}_z\right]$.

The problem (1) can be approximately transformed to the boundary problem for $\varphi$ on the graph of Kirchhoff electric circuit (KEC). This graph may be construct by the method of power balance. The problem on graph KEC looks as:

$$\Delta\varphi(q) = \begin{cases} J, \ q \in \boldsymbol{M}_J, \\ 0, q \notin \boldsymbol{M}_J \cup \boldsymbol{M}_\Gamma, \\ i_q(r-R), q \in \boldsymbol{M}_\Gamma, \end{cases} \quad \varphi(q) \xrightarrow[q\to\infty]{} 0 \tag{2}$$

$\boldsymbol{M}_q$ is the set of nodes connected by edges with $M_q$, $J = \dfrac{\mu^+ i}{W}$, $i$ is the full current of the coil, $2W$ is the number of ineradicable nodes included in set $\boldsymbol{M}_J$ (belonging to section of the coil), $\boldsymbol{M}_\Gamma$ is the set of boundary nodes (in which converge edges with different resistance). The problem (2) has been reduced to the boundary matrix equation. The following representation has been used for this purpose

$$\varphi(p) = -\sum_{\boldsymbol{M}} R(p,q)\Delta\varphi(q) \tag{3}$$

($\boldsymbol{M}$ is the set of all nodes the graph) by the fundamental solution $R(p,q)$ of Laplase equation on infinite graph (the finding $R(p,q)$ makes a separate problem).

After technically simple transformations the matrix equation gets a form

$$I = \lambda A I + B \tag{4}$$

$I = \{i_p\}_{p=1}^{m}$ is the boundary currents, $\lambda = \dfrac{r-R}{r+R}$, $B = \{b_p\}_{p=1}^{m}$, $A = \{a_{pq}\}_{p,q=1}^{m}$.

The research of the equation (4) in class of bounded functions with zero average values on $\boldsymbol{M}_\Gamma$ has shown its correctness. Let's note, that equality (3) will give the answer of a problem (2) if preliminary solve the equation (4) and, thus, define boundary currents. The software package for the numerical realization of the developed theory has been created. Examples of the calculations executed by the considered method are illustrated on fig. 1.

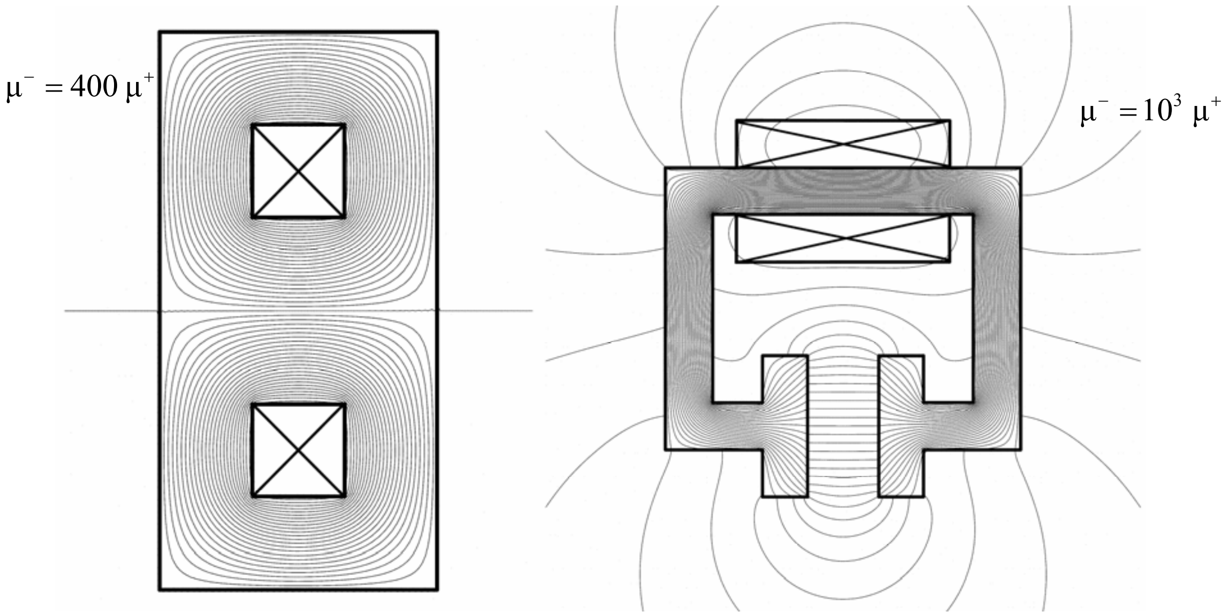


Fig.1


**References:**

[1] Bayramkulov K.N.-A. Astakhov V.I. Computing of a magnetic field by the method of the boundary equations on the graph of an electric circuit //Works of the Southern Scientific Centre of RAS. -- 2007. Vol.2 P. 72-79.



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