52. IWK

Internationales Wissenschaftliches Kolloquium
International Scientific Colloquium

PROCCEDINGS | 10 - 13 September 2007

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

TECHNISCHE UNIVERSITÄT
ILMENAU

Bibliografische Information der Deutschen Bibliothek
Die Deutsche Bibliothek verzeichnet diese Publikation in der deutschen Nationalbiografie; detaillierte bibliografische Daten sind im Internet über **http://dnb.ddb.de** abrufbar.

ISBN 978-3-939473-17-6

Impressum

Herausgeber:	Der Rektor der Technischen Universität Ilmenau Univ.-Prof. Dr. rer. nat. habil. Peter Scharff
Redaktion:	Referat Marketing und Studentische Angelegenheiten Kongressorganisation Andrea Schneider Tel.: +49 3677 69-2520 Fax: +49 3677 69-1743 e-mail: kongressorganisation@tu-ilmenau.de
Redaktionsschluss:	Juli 2007
Verlag:	Technische Universität Ilmenau/Universitätsbibliothek Universitätsverlag Ilmenau Postfach 10 05 65 98684 Ilmenau www.tu-ilmenau.de/universitaetsverlag
Herstellung und Auslieferung:	Verlagshaus Monsenstein und Vannerdat OHG Am Hawerkamp 31 48155 Münster www.mv-verlag.de
Layout Cover:	www.cey-x.de
Bezugsmöglichkeiten:	Universitätsbibliothek der TU Ilmenau Tel.: +49 3677 69-4615 Fax: +49 3677 69-4602

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

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J. C. Ferreira / P. B. Maia / A. Lucia / A. I. Zapaniotis

Virtual Prototyping of an Innovative Urban Vehicle

ABSTRACT

The manuscript outlines the original solutions adopted to design and powering an original three-wheel lightweight hybrid electric vehicle (HEV) operating for medium and short distance drives in urban environments that has zero CO_2 emissions and has a silent performance. This vehicle is legislated as a tricycle and it can carry three people, i.e., two passengers and one driver. The electrical HEV motorization is carry out by an axial-flux permanent magnet machine (AFPM) with a single toroidal stator being placed between two permanent-magnet (PM) rotor discs. The electrical supply is realized by a fuel-cell-battery core.

INTRODUCTION

Considerable efforts have been expended to develop hybrid electric vehicles (HEVs) as replacements for high-emission cars, buses, and trucks powered by conventional gasoline or diesel engines [1]. The main objective of this work is to describe a virtual prototype of a HEV by the use of a suitable simulation model. This is an important step in the development of the HEVs due to the following two reasons:

(i) a good virtual prototype allows for proof testing before hardware is assembled, which means likely reduction in the manufacturing cost and time, and
(ii) new design possibilities can be explored; e.g., study of tradeoffs between sizes of components in the HEV is feasible.

A virtual prototype of a hybrid electric vehicle (HEV) is created within the virtual test bed (VTB) environment, which has been developed for modeling, simulation, analysis and virtual prototyping of large-scale multi-technical dynamic systems.

Some attention is also commited on the electric system, which is composed of:

(i) a fuel cell system as a prime power source,
(ii) battery and super capacitor banks as energy storage devices for high and

(ii) intense power demands,
(iii) DC-to-DC power converters to control the flow of power,
(iv) a three-phase inverter-fed permanent magnet synchronous motor as a drive,
(v) and a common DC bus.

VIRTUAL PROTOTYPING OF THE URBAN VEHICLE

In the last two years a research project was carried out to modell and construct the prototype of three-wheel HEV. This is a lightweight vehicle intended for use in urban mobility with mission tasks such as 50 km/h cruising speed and 80 km range of autonomy. The propulsion system is arranged with a 10.0 kW prototype of slotless AFPM being totally enclosed in the tweem rear wheels of the vehicle and fed from a fuell-cell-battery. The HEV urban vehicle is legislated as a tricycle and it can carry three persons, two passengers and one driver. The energy is generated from an electric motor, alimented from a fuel-cell-battery core.

The casing body dimensions of the HEV urban vehicle to accommodate the three persons and the electrical motorization are shown in Figure 1.

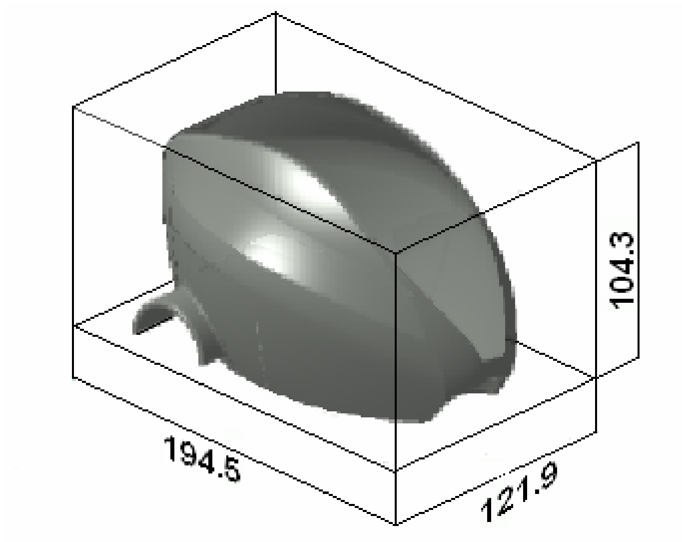

Figure 1: Dimensions of the casing body of the HEV urban vehicle.

The objective of geometric models is to show the form and the design of the product. In these cases the prototype is either designed in great detail comprising a manipulation model, either it is roughly designed representing a conceptual form of the product under design.

The casing body of the three-wheel lightweight electric vehicle was been designed in CAD Solid-Works^{TM} and studied through Virtual Prototyping (VP). The results are exposed in Figure 2.

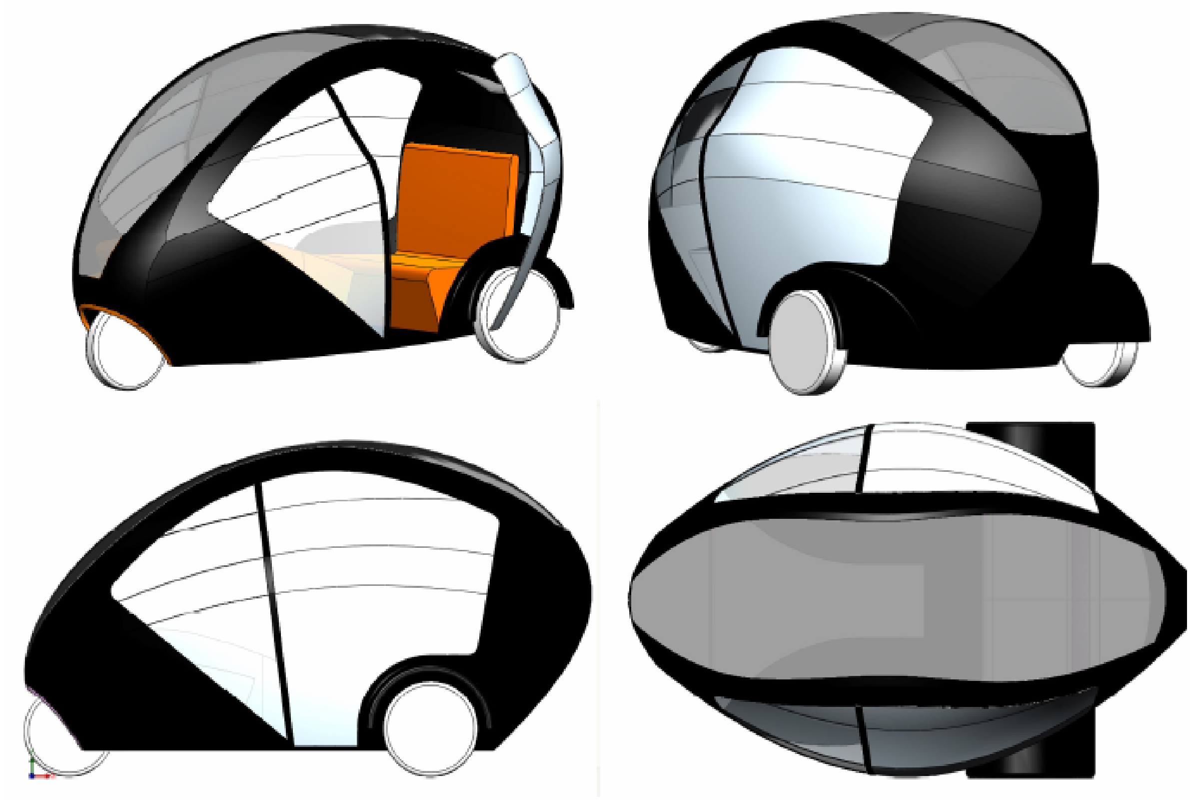

Figure 2: VP of the three-wheel lightweight electric vehicle draft in Solid-Works^{TM}.

In this work, the virtual test bed (VTB) was utilized for virtual prototyping of a HEV. The VTB has two important features [2,3]:

(i) it has the capability of integrating models that have been created in a variety of languages into a single simulation environment; and

(ii) it provides advanced visualization of simulation results, including full-motion animation of mechanical components, and imaginative mappings of computed results onto the system topology.

The first feature of the VTB allows each component of a large-scale multi-technical system to be described in the most appropriate language. On the other hand, the second feature enhances user's comprehension of the simulation results significantly.

FUELL CELL SYSTEM

A simplified block diagram for the electrical part of the HEV [4] is schematized in Figure 1. The components classifications of the fuel cell system are: battery bank, super capacitor bank, boost converter, DC Cuk converter, PMSM, and the PWM inverter.

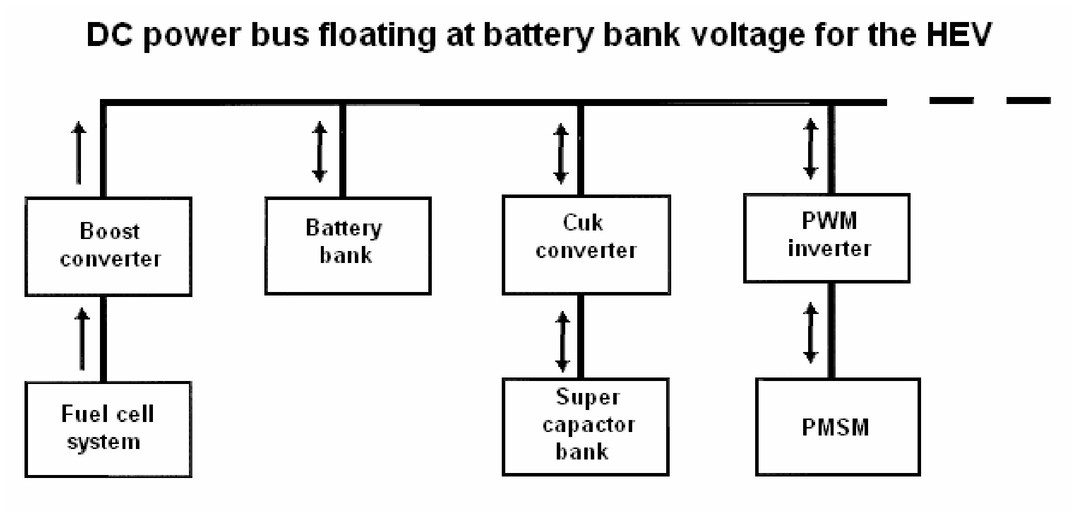

Figure 2: Block diagram for the electrical part of the HEV.

The voltage-current characteristic of a single proton exchange membrane (PEM) hydrogen fuel cell is illustrated in Figure 2. In this figure, V_{fc} (vertical axis) is the voltage at the terminals of the fuel cell, and I_{fc} (horizontal axis) is the current flowing out of the fuel cell. It is seen that there are basically three operation regions. These are:

(i) the low current region in which the voltage decreases exponentially as the current increases,

(ii) the linear region that covers a large portion of the characteristic, and

(iii) the high current region in which there is a sharp drop of the voltage to near-zero [5,6].

Note: the units for V_{fc} and I_{fc} are millivolts and milliamperes, respectively.

For the values of Ifc which remain in the low current and linear regions, Vfc versus Ifc may be expressed by the graph in Figure 3 [7].

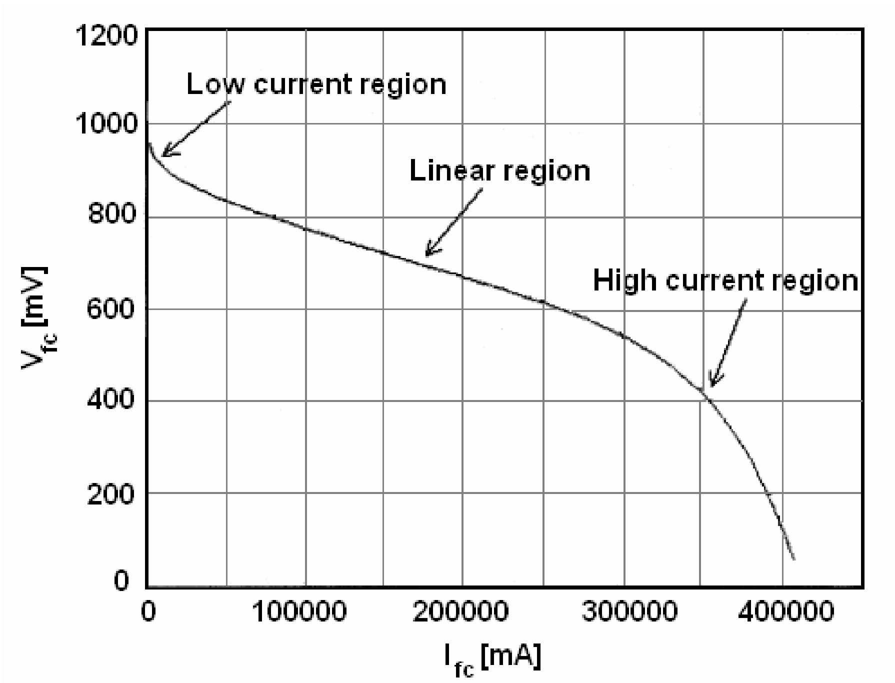

Figure 3: The fuel cell voltage in mV versus fuel cell current in mA.

ELETRICAL MOTORIZATION

The electrical HEV motorization is carry out by axial-flux permanent magnet machine (AFPM) with a single toroidal stator being placed between two permanent-magnet (PM) rotor discs. These systems prove to be the best candidates for such a low-speed high-torque drive application, as they can be designed to achieve the required high torque density without loss of efficiency. In addition, their disc shape is very well suited to housing the motor in a wheel rim as the double PM rotors could be mounted on the wheel side walls and the stator could be mounted centrally on the wheel axle, as shown in Figure 4.

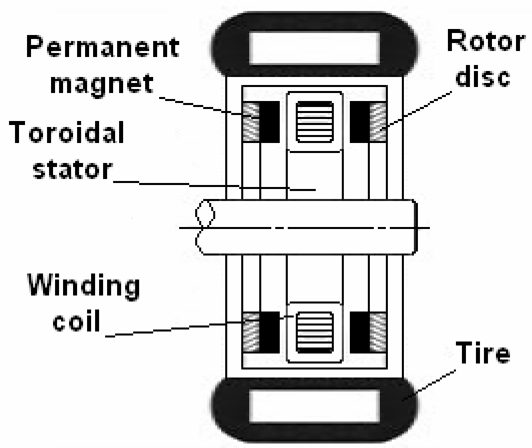

Figure 4: Cross-sectional view of a AFPM being used as wheel direct-drive motor.

In the AFPMs the machine stator, being mounted centrally on the wheel axle, consists of a coils arranged to form a three-phase winding wound in a toroidal fashion. The rotor comprises two mild-steel discs, one on each side of the stator, being mounted on the wheel side walls and carrying axially-polarized magnets.

CONCLUSIONS

A virtual prototype for a three-wheel HEV was developed devoted to urban mobility and numerically verified by simulation results within the urban environment.

One of the unique features of the virtual prototype is that it includes all possible energy devices (fuel cell system, battery bank, and super capacitor bank) for the next generation HEVs.

Further, to be consistent with the real world applications, the nonlinear dynamics, ohmic losses, and voltage/current limits of the components are taken into account.

Acknewlegment:

The authors would like to express its gratitude to Fundação para a Ciência e Tecnologia the support of project POCI/2010.

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Author:
Prof. José Carvalho Ferreira
Eng. P.B. Maia, Eng. A. Lúcia and Eng. A.I. Zapaniotis
IDMEC & In+, Instituto Superior Técnico, TULISBON
Av. Rovisco Pais / 1094-001 Lisboa / Portugal
Phone: +351 (0) 21 8417644
Fax: + 351 (0) 21 841 9058
E-mail: joseferreira@ist.utl.pt