DEVELOPMENT OF A KNOWLEDGE-BASED SYSTEM FOR POWER ELECTRONICS DESIGN

By

BOUKETIR OMRANE

Thesis Submitted to the School of Graduate Studies, Universiti Putra Malaysia, in Fulfilment of the Requirements for the Degree of Doctor of Philosophy

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To my big and small families

Abstract of thesis presented to the Senate of Universiti Putra Malaysia in fulfilment of the requirements for the degree of Doctor of Philosophy

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Chairman: Associate Professor Norman Mariun, PhD

Faculty: Engineering

Various simulation packages are being widely used to design and simulate electrical and electronic circuits. These simulators require the user to be proficient in designing the circuits and need deep training to be familiar with. Moreover, the design is based on trial and error, till the user reaches the required outputs. Despite their long use, the existing general-purpose simulation packages are still time-consuming when they are used to design power converters especially for inexperienced designers. This is because of the ad-hoc nature of the design task. An approach to overcome the drawbacks of these packages and augment their functionality is to incorporate knowledge-based techniques along with these packages.

In the present work an approach to automate the design process of power converters is introduced, explained, and implemented. The presented approach integrates object-oriented paradigm within expert system techniques to develop a

user-friendly tool; **p**ower **e**lectronic converters **d**esign **a**id **s**ystem (PEDAS). Benefiting from the class builder provided in Visual Basic programming language, various class modules with their properties and methods were implemented to constitute the inference engine and represent the knowledge base. Two types of knowledge were investigated; application-based knowledge which was implemented using fourteen (14) classes and subclasses and type based knowledge which was represented by one class having eleven (11) methods. Each topology was represented by either one subclass for the first type or one method for the second type. Additionally, the tool offers an automatic selection of switching devices for a specific converter topology. The selection process is conducted within a switching devices database built for this purpose. Further, this database can be seen as an independent unit where many functions such as searching for or adding, removing devices are provided. In using this tool, the designer has firstly to choose the appropriate application of his/her converter among a given list of applications. Then he/she has to pursue interaction process to input his/her requirements and answer some questions needed for facts insertion in order to come out with the most appropriate topology that meets the entered specifications. The topology suggested for the user is formed in a schematic file accepted by the Pspice simulation package. The topology is then displayed within *Schematic* environment containing all the circuit parameters including the best (optimum) switching devices and the control circuit. The switching devices are stored in database module accessed by the inference engine to select the optimum switch for a certain topology. General description of the system is presented, its architecture and interaction between its various modules is

dealt with in details. Finally, the issue of validating the developed tool is accomplished through many design examples, both software and hardware.

The developed system still can be improved, mainly in expanding its knowledge base in its two parts; converter topologies and switching devices.

Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia sebagai memenuhi keperluan untuk ijazah Doktor Falsafah

PEMBANGUNAN SEBUAH SISTEM UNTUK REKABENTUK ELEKTRONIK KUASA BERASASKAN PENGETAHUAN

Oleh

BOUKETIR OMRANE

April 2005

Pengerusi: Profesor Madya Norman Mariun, PhD

Fakulti: Kejuruteraan

Pelbagai pakej penyelakuan sedang digunakan secara meluas untuk merekabentuk dan menyelaku litar elektrik dan elektronik. Penyelaku ini memerlukan pengguna mahir dalam merekabentuk litar dan memerlukan latihan mendalam untuk membiasakannya. Tambahan pula, rekabentuk tersebut berasaskan kepada cuba dan gagal, sehingga pengguna mencapai keluaran yang diperlukan. Selain penggunaannya yang sudah lama, pakej-pakej penyelakuan bertujuan umum yang sedia ada masih lagi memakan masa yang panjang apabila pakej-pakej tersebut digunakan untuk merekabentuk penukar kuasa terutama bagi perekabentuk baru. Ini kerana persekitaran "ad-hoc" bagi tugasan rekabentuk. Walau bagaimanapun, suatu pendekatan untuk mengatasi kelemahan pakej-pakej ini dan memperbanyakkan fungsinya adalah dengan menggabungkan teknik-teknik asas pengetahuan bersama pakej-pakej ini.

Dalam kerja kali ini suatu pendekatan untuk menjalankan sendiri proses rekabentuk penukar kuasa diperkenalkan, diterangkan, dan dilaksanakan. Pendekatan kali ini menggabungkan paradigma berorientasikan objek di dalam

teknik sistem mahir bagi membangunkan perkakasan mesra pengguna; sistem bantuan rekabentuk elektronik kuasa (SBREK). Mendapat faedah daripada pembangun kelas yang disediakan dalam bahasa pengaturcaraan Visual Basic, pelbagai modul kelas dengan ciri dan kaedahnya telah dilaksanakan untuk membentuk enjin kesimpulan dan mewakili asas pengetahuan. Dua jenis pengetahuan telah diselidik, penggunaan berasaskan pengetahuan yang dilaksanakan menggunakan empat belas (14) kelas dan subkelas dan jenis berasaskan pengetahuan yang diwakili oleh satu kelas yang mempunyai sebelas (11) kaedah. Setiap topologi diwakili oleh sama ada satu subkelas untuk jenis pertama atau satu kaedah untuk jenis kedua. Tambahan lagi, perkakasan tersebut menawarkan pemilihan automatik peranti pensuisan untuk untuk topologi penukar spesifik. Proses pemilihan dikendalikan di dalam pangkalan data peranti pensuisan yang dibina untuk tujuan ini. Tambahan pula, pangkalan data boleh dilihat sebagai unit bebas di mana banyak fungsi seperti mencari atau menambah, memindah peranti disediakan. Dalam menggunakan perkakasan ini, perekabentuk perlu pertamanya memilih penggunaan bersesuaian penukarnya antara senarai penggunaan yang diberi. Kemudian, beliau perlu mengikuti proses interaksi kepada keperluan masukannya dan menjawab beberapa soalan yang diperlukan untuk masukan fakta untuk mengeluarkan topologi paling bersesuaian yang memenuhi spesifikasi yang dimasukkan. Topologi yang dicadangkan untuk pengguna dibentuk dalam fail skematik yang diterima oleh pakej penyelakuan Pspice. Topologi ini kemudian dipaparkan dalam persekitaran Schematic yang mengandungi semua parameter litar termasuk peranti pensuisan dan litar kawalan yang terbaik. Topologi ini membentuk asas pengetahuan sistem yang diwakilkan

sebagai objek. Peranti pensuisan disimpan dalam modul pangkalan data yang dicapai oleh enjin kesimpulan untuk memilih suis yang terbaik bagi topologi tertentu. Gambaran umum sistem dipersembahkan, senibinanya dan interkasi antara modulnya diperjelaskan dengan terperinci. Akhirnya, isu memperakui perkakasan yang dibangunkan disempurnakan melalui banyak contoh rekabentuk, merangkumi perisian dan perkakasan. Sistem yang dibangunkan masih boleh diperbaiki, terutamanya dalam memperkembangkan asas pengetahuannya dalam dua bahagian; topologi penukar dan peranti pensuisan.

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I certify that an Examination Committee met on 1 April 2005 to conduct the final examination of Bouketir Omrane on his Doctor of Philosophy thesis entitled "Development of a Knowledge-Based System for Power Electronics Design" in accordance with Universiti Pertanian Malaysia (Higher Degree) Act 1980 and Universiti Pertanian Malaysia (Higher Degree) Regulations 1981. The Committee recommends that the candidate be awarded the relevant degree. Members of the Examination Committee are as follows:

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This thesis submitted to the Senate of Universiti Putra Malaysia and has been accepted as fulfilment of the requirements for the degree of Doctor of Philosophy. The members of the Supervisory Committee are as follows:

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DECLARATION

I hereby declare that the thesis is based on my original work except for quotations and citations which have been duly acknowledged. I also declare that it has not been previously or concurrently submitted for any other degree at UPM or other institutions.

BOUKETIR OMRANE

Date:

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