**UNIVERSITI PUTRA MALAYSIA**

# DEVELOPMENT OF POWER ELECTRONIC CIRCUITS DATABASE FOR KNOWLEDGE-BASED SYSTEM

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**DEVELOPMENT OF POWER ELECTRONIC CIRCUITS DATABASE FOR KNOWLEDGE-BASED SYSTEM**

**By**

**AHMAD DIB YOUSEF ZAHRAN**

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بسم الله الرحمن الرحيم

قَالُوا سُبْحَانَكَ لَا عِلْمَ لَنَا إِلَّا مَا عَلَّمْتَنَا إِنَّكَ أَنتَ الْعَلِيمُ الْحَكِيمُ ﴿٣٢﴾

***Surat Al-Baqara.***

***To my parents, brothers and sisters***

Abstract of thesis presented to the Senate of Universiti Putra Malaysia in fulfilment of the requirements for the degree of Master of Science.

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**March 2000**

**Chairman:** **Norman Mariun, Ph.D.**

**Faculty:** **Engineering**

The development of design automation tools for a power electronic circuit has received a great deal of attention in the last two decades. To provide an optimum solution for each power electronics application demands the selection of the most appropriate power electronic devices, power circuit and control philosophy. For a certain applications, it must be decided which power circuit topology and which power semiconductor with which control strategy is best suited for it. Their design and fabrication require extensive knowledge and sophistication, that must be continually updates as the technologies improve. Considerable engineering effort and knowledge are required to take a power circuit from a laboratory prototype to a finished product. Other than being an expert in areas as diverse as thermal design, circuit and system packaging, circuit protection, and safety and electromagnetic interference regulations.

With such a highly demanding expertise required of power electronic circuits' designers and with such rapid advancements in the field of circuit topology and semiconductor devices it is difficult for designers to come up with an optimum circuit and the right device within a short time. These difficulties can be solved using a design-aided system with high accuracy and flexibility in a short time.

In this study the developed system is named PEDAS (Power electronic Design Aid System). The system is characterized as an intermediate object-oriented system that allows the user to deal with different software packages through an attractive interface. The aim of this research is to develop a database circuits library. The implementation includes generation of formatted files to be used as input streams with the design packages, writing an interface program for each kind of these software, and managing the data flow timing and dependency among them. In this thesis the circuit topology data base development based on PSPICE is presented with examples of converters and inverters circuits.

The database circuits library was designed and used successfully by some of the researchers of the electrical engineering department in the Control and Automation System Center.

Abstrak tesis yang dikemukakan Senat Universiti Putra Malysia sebagai memenuhi keperluan untuk ijazah Master Sains

**PEMBANGUNAN PANGKALAN DATA LITAR ELEKTRONIK KUASA UNTUK SISTEM PAKAR BERASAS PENGETAHUAN**

Oleh

**AHMAD DIB ZAHRAN**

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Pembangunan rekabentuk peralatan automasi untuk litar elektronik kuasa diberi perhatian dalam dekad ini. Untuk memberikan penyelesaian optima untuk setiap permintaan aplikasi memerlukan pemilihan yang bersesuaian peranti elektronik kuasa, litar kuasa dan falsafah kawalan. Bagi aplikasi tertentu, adalah penting memastikan topologi litar kuasa, semikonduktor kuasa serta strategi kawalan yang bersesuaian dengan aplikasi tesebut. Rekabentuk dan fabrikasi memerlukan pengetahuan meluas dan sofistikated yang produk mesti dikemaskinikan mengikut kemajuan teknologi. Litar kuasa bermula dari prototaip dimakmal hingga akhir. Selain daripada kepakaran dalam teknologi pelbagai disiplin, jurutera elektronik kuasa mesti pakar dalam pelbagai bidang rekabentuk thermal, litar dan sistem pembungkusan, perlindung litar dan keselamatan serta peraturan gangguan elektromagnetik. Pengetahuan dan usaha yang banyak diperlukan bagi pembangunan.

Dengan permintaan kepakaran tinggi yang diperlukan untuk perekabentuk litar elektronik kuasa dan kemajuan yang pesat bidang topologi litar dan peranti-peranti

semikonduktor, adalah agak mustahil untuk perekabentuk mencapai litar optima dan peranti bersesuaian dalam masa yang singkat. Masalah ini boleh diatas dengan menggunakan sistem bantuan rekabentuk yang mempunyai kejituan yang tinggi serta fleksible dan menggunakan masa yang singkat.

Dalam kajian ini, sistem yang dibangunkan digelar PEDAS dicirikan sebagai sistem pengantara berorientasi objek, yang menyambungkan pengguna dengan pakej-]pakej perisian yang tertentu. Sasaran penyelidikan ini adalah untuk membangunankan librari litar pangkalan data. Perlakasanaan sistem ini termasuk, membina fail terformat yang digunakan sebagai 'stream' masukan, menulis antaramuka program untuk setiap perisian dan mengurus aliran data pemasaan. Dalam tesis ini, pembangunan pangkalan data topologi litar berasaskan kepada PSPICE yang diwakilkan dengan contoh-contoh penukar dan penyongsang.

Librari litar pangkalan data ditekabentuk serta digunakan dengan jayanya oleh sebanagian penyeliaik- penyeliaik di jabatan kejuruteraan Elektrik, Kawalan dan pusat sistem automasi.

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I certify that an Examination Committee met on 8 March 2000 to conduct the final examination of Ahmad Dib Yousef Zahran, on his Master of Science thesis entitled "Development of Power Electronic Circuits Database for Knowledge-Based System" 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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**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.

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## LIST OF ABBREVIATIONS

| | |
|---|---|
| $\Delta_{IL}$ | The Net Change in the Inductor Current |
| AC | Alternative Current |
| AEC | Architecture Engineering and Construction |
| AHP | Analytic Hierarchy Process |
| AI | Artificial Intelligence |
| BJT | Bipolar Junction Transistor |
| C | Collector |
| C++ | Advance Programming Language |
| CAD | Computer Aided Design |
| CAE | Computer Aided Engineering |
| CDB | Circuit Data Base |
| D | Duty Ratio |
| DC | Direct Current |
| E | Emitter |
| ERC | Electrical Rules Check |
| f | Switching Frequency (Hz) |
| GTO | Gate Turn-OFF Thyristor |
| I | Current Flow in Ampere |
| $I_C$ | The Average Capacitor Current |
| $I_L$ | Load Current |
| $I_{max}$ | Maximum Value of the Inductor Current |
| $I_{min}$ | Minimum Value of the Inductor Current |

| | |
|---|---|
| KBS | Knowledge Base System |
| $L_{min}$ | Minimum Inductance Required for Continuous Current |
| MCDM | Multiple Criteria Decision-Making |
| MHD | Magneto-Hydrodynamic |
| MOOD | Methodology of Object-Oriented Design |
| MOSFETs | Metal-Oxide Silicon Field Effect Transistor |
| NC | Numerical Control |
| OOP | Object Oriented Programming |
| OPS | Official Production System |
| PC | Personal Computer |
| PECT | Power Electronic Control Tools |
| PEDAS | Power Electronic Design Aid System |
| $P_O$ | Power Delivered to the Load |
| PROBE | Graphical Waveform Analyser |
| $P_S$ | Power Supplied by the Source |
| PSPICE | Simulation Package |
| PWM | Pulse Width Modulation |
| Q | Charge (coulomb) |
| R | General Symbol for the Electrical Resistance (ohm) |
| $R_L$ | Load Resistance |
| rms | Root Mean Square |
| T | Switching Period |
| V | General Symbol for the Voltage Measured in (Volts) |
| $V_L$ | The Average Inductor Voltage |

| | |
|---|---|
| $V_O$ | Output Voltage |
| $V_S$ | The Input Voltage to The Filter |

# CHAPTER I

# INTRODUCTION

Power electronics is an application oriented and interdisciplinary course. It uses power semiconductor devices to perform switching action in order to achieve a desired conversion strategy. The switching slices the voltage and current waveforms into various intervals, whose beginning and end depend on the boundary conditions, which are fixed by the circuit parameters and/or control characteristics. The understanding of the operation of a power electronics circuit requires a clear knowledge of the transient behaviour of current and voltage waveforms for each and every circuit element at every instant of time. However, the power electronics are playing a key role in industrial power control applications.

The development of design automation tools for a power electronic circuit has received a great deal of attention in the last two decades. In recent years, expert system technique has used in the power electronic field for various applications such as modeling, design optimization, device selection, testing, diagnosis and control. There is a requirement for an active, comprehensive, and versatile computer-based intellectual process that incorporate design tools, design knowledge, and device database for power electronics.

This must ideally afford both the development engineer and a non-expert user the opportunity to have total guidance (or assistance) in:

1. Design a power electronics system based on specification of the problem.
2. Exploring the many option and design variations, system interactions, parameter optimizations, and failure-mode mechanisms leading to improved product quality.
3. Selection of the correct device for a given application.

To achieve this goal, it is necessary to enhance the problem-solving capability of existing conventional power electronics Computer Aided Design (CAD) systems.

## The Knowledge-Based Expert System

Expert systems are now being used successfully in many disciplines and practical environments in different parts of the world. The current trends that they will be used in larger numbers and greater varieties of applications. Confronted by the ever-increasing range of academic and commercial products, potential users of expert system technology require systematic and reliable techniques for evaluating expert systems. Also, as the size and complexity of expert systems increase, the task facing the designers and developers to produce quality systems becomes more challenging. This situation is further compounded by the lack of detailed and precise requirement specifications of expert systems especially those which involve a number of human experts specialized in different functions of the expert system. Hence compared with other types of systems, expert systems by nature stand in a special need of rigorous and systematic evaluation of their performance. For potential users, this process can be conducted on a finished product. But for their designers and developers, the evaluation process is a continuous one, which should be carried out throughout the life cycle of the expert systems, which they are building.

## Power Electronic Design Aid System (PEDAS)

PEDAS system as shown in Figure 1, was developed by a PEDAS research group in the department of Electrical and Electronics Engineering at the University Putra Malaysia. It is an expert system for power electronic circuits that enable the user to get optimal and practical solutions for circuit design problems, given nominal inputs. The system is characterized as an intermediate object-oriented system connecting the user with different expert units, without the assumption of the user familiarity with the internal application of the system components. The user will deal with the system through an interactive windows user interface that implements the concept of a decision support system for data entry in initialization and intermediate phases using messaging and other techniques. PEDAS system concentrates on the design of the power electronic circuits, mainly converters and inverters.

The system consists essentially of several modules interacting with each other; and also consists of interfaces that handle the flow of information between the PEDAS components and external applications such as the simulator package (PSPICE) and the semiconductor power device data library related to the same package. The key components of the PEDAS system comprised of the user interface, semiconductor power device database, information module, and the system interface to PSPICE package. The system modules are User Interface, Inference Engine Module, Circuit Database Module, and Devices Database Module.

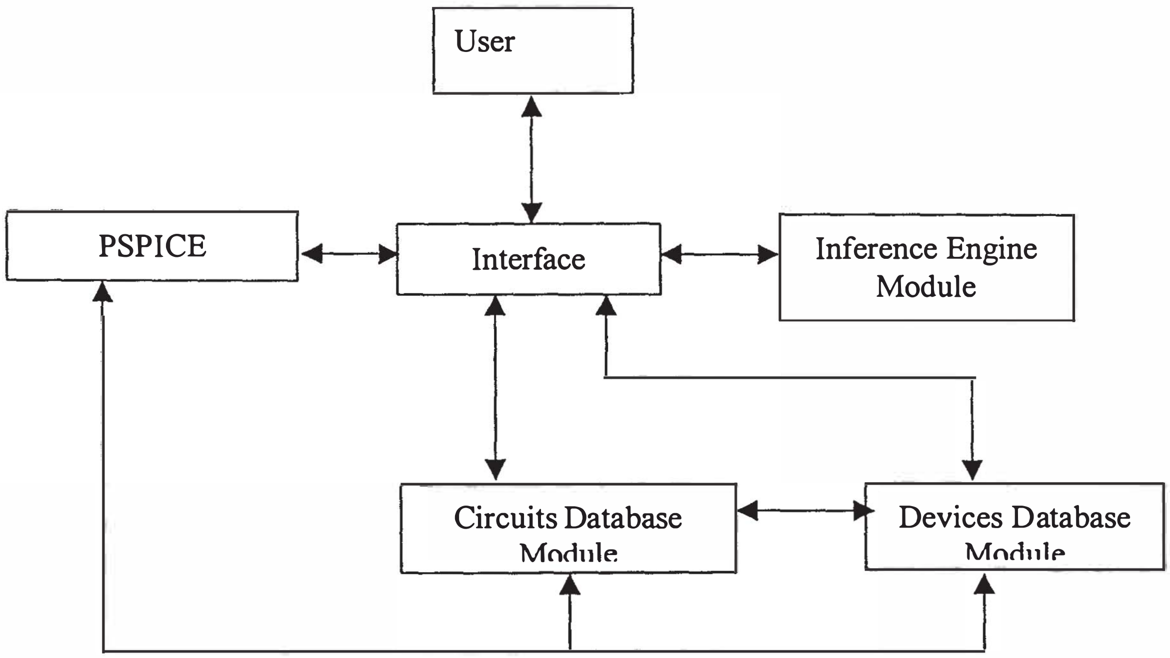


Figure 1: PEDAS System General Architecture

The database system for power semiconductor devices an essential part in building PEDAS system. The user can find a useful information about most of the devices available by accessing their data sheets. The user also can get the PSPSICE model of the selected device and use it in designing and simulating different circuits.

The user interface consists of interactive components designed to facilitate communication between the user and PEDAS system, which has explained the philosophy of good human interface design. The system interface to PSPICE package was designed to integrate the PSPICE tools for design, drawing schematic, simulation and probe facilities.

Circuits Data-Base module, is one of PEDAS system internal modules that has been developed by the author. The implementation includes developing a data base circuits library, generation of formatted files to be used as input streams for the design package, and interface the CDB module with the simulator package, PSPICE.

Inference Engine Module provides the user with the design steps of different circuits that have been designed and tested by other members of the electrical and electronic engineering department. Such as DC/DC Converter for Electric Vehicle, Smart Battery Charger for Electric Vehicle. Development of 6KW Variable Power Supply.

## Research Objectives

The aim of this research work is to develop a circuit database system, which is one of the power electronic design aid system internal modules. To achieve this, the following objectives are accomplished.

1. Developing a data base circuits library
2. Generation of formatted files to be used as input streams for the design package
3. Writing an interface program for the system
4. Interface the circuit database (CDB) module with simulator package PSPICE.

## Tools Selection

It is necessary to choose software developmental tools that support the paradigms useful for implementing the PEDAS functionality requirements. An algorithmic system can normally give only a single answer, which can be assumed to be correct if the input data is correct. In an expert system, it is essential that the user can question the system to determine which rules were crucial to determine an answer, how likely the given answer is to be correct, and perhaps seek a most likely alternative answer. Good user interface is difficult to construct. It often turns out that more effort has to be put into preparing a good input/output interface than