Automatic Transformer Design Tool Selection in the Online-CADCOM Platform

Katerina Kostova[1], Galia Marinova[2]

[12] Technical University of Sofia, Blvrd. " St.Kliment Ohridski", № 8, 1000 Sofia, Bulgaria
kmkostova@tu-sofia.bg, gim@tu-sofia.bg

Abstract. The paper deals with the extension of the Online-CADCOM platform by incorporating knowledge for transformer design online tools. Calculators like goodcalculators, alfatransformer, jcalc, farnell bulgaria, maddox, 3phaseassociates, voltage-disturbance, omnicalculator, forumelectrical and modules in online platforms like PowerEsim and Magnetic Part Editor (Cadence) are tested, and their Characterization passports are developed, then added as electronic content. Compulsory and optional criteria for automatic selection of the online transformer design tools are defined and added to the Knowledge-base of Online CADCOM platform. Special attention is given to the capacity of the tools to generate the SPICE model parameters of the transformer designed which allows the implementation, simulation and test in electronic circuits. The Expert tool supporting decision-making methods such as multicriteria decision-making (MCDA) and multi-attribute utility theory (MAUT) is implemented to select online transformer design tools to satisfy a given specification. Illustrative examples are presented. The study extends the capabilities of the platform Online-CADCOM by assisting engineers and designers with the automatic selection of appropriate online transformer design tools.

Keywords: Decision-Making Models, MCDA, MAUT, Online-CADCOM Platform, Transformer Design, Transformer SPICE Model

1 Introduction

The Online-CADCOM platform [1],[2],[3],[4] is a complete cloud-based resource dedicated to the development of engineers, teachers, or even amateurs interested in designing communication circuits and systems. A notable feature of the platform is the capacity to make design tool suggestions using the customers' specifications which brings about efficiency in the entire design process. Users are provided with two significant panels: one which is behavioral and the other topological with both architectural designs following the Y-model of Daniel Gajski. Recently the possibilities for printed circuit board design [6] and passive elements design tool selection [7] were added. The automatic selection of tools in the Online CADCOM platform implements 2 methods: 1) a model developed that emphasizes multicriteria decision-making (MCDM) and multi-attribute utility theory (MAUT) [1], [2] and 2) A multicriteria decision model based on PROMETHEE I – method [4]. The current

paper is focused on the de velopment of automatic transformer design tool selection. The transformers play a key function in electrical circuits, specifically regarding power distribution, signal isolation and impedance matching. However, due to the intricacies involved in sensitizing oneself to the nuances present in transformer designs, utilizing any of the tools available demands due course of considering several aspects like core material, winding type, power loss, and operating efficiency. At the same time, this variation of the types of transformers including step-up, step-down, isolation, and auto transformer requires the use of specialized tools.
Online tools and platforms for transformer design are considered and analyzed. Criteria for tool selection are defined based on the main categories of tools and on the transformers features. The criteria are classified as compulsory and optional with different weight coefficients. The automatic selection of transformer design tools will help projects especially in the fields of power electronics, audio, and communication systems, where transformers are basic elements.
This integration of the transformer design tools selection will be achieved with the help of the platform's Expert tool, which recommends the best alternative to the users based on their contributions and the requirements of the project.

The outline of the paper is as follows: In section 2 are defined the criteria for selecting transformer design tools, in section 3 are presented the online tools and platforms studied, section 4 presents examples and section 5 concludes the paper.

2 Criteria for Transformer Design Tool Selection

Transformers play a vital role in applications such as power distribution, signal isolation, and impedance matching, making the availability of reliable and accurate transformer design tools crucial for engineers and designers. Given the complexity of transformer design, which involves calculating electrical and physical parameters like voltage, current, impedance, and winding turns, selecting the appropriate tools requires a careful and structured approach.
Following the methodology for selection criteria definition proposed in [1],[7], compulsory criteria with weigh coefficient 1 and optional criteria with weigh coefficients 0.5 and 0.33 are determined for the transformer design tools. The criteria are based on the types of tools available and the main features of the transformers.

2.1 Compulsory criteria for transformer design tools

The compulsory criteria (with weigh coefficient 1) for transformer design tools are defined based on the types of tools available and the number of phases and the transformer types and topologies.
The review of transformer design tools show that they are of 2 types:

- Transformer calculators oriented to the selection and potential ordering of a transformer for predefined application (calculating transformer current, primary and secondary full load currents, transformer rating or size)

- Transformer design and simulation modules offering topological design, modeling and simulation of the transformer.

The numbers of phases considered are one phase and three phases.
The types of transformers considered in the tools studied are:

- Step-up
- Step-down
- Isolation
- Dry type
- Pad Mounted
- Xubstation
- Pole Mounted
- Buck/Boost

The topologies of the transformers are:

- Flyback Xformer
- Forward Reset
- Forward Xformer
- Active Clamp
- CCM PFC Choke
- DCM PFC Choke
- Half-Bridge Xformer
- Full-Bridge Xformer
- Push Pull Xformer
- HF Power Inductor
- Buck-Boost Choke
- Boost Choke (step-up)
- Buck Choke (step down)
- Input Choke
- Output Choke
- CM Choke
- Current Xformer
- DC Inductor (Single winding)

2.2 Optional criteria for transformer design tools

The optional criteria with weigh coefficient 0.5 for transformer tool design are:

- The core shapes usually considered are: E, Toroid, U
- Calculation of the transformer impedance (%Z) which affects the voltage regulation and fault levels.
- Secondary transformer voltage calculation
- Secondary fault current calculation to assess the short-circuit capacity and protection requirements.
- Voltage drop calculator
- Turns ratio.
- Transformer simulation (Core losses, DC copper losses, AC copper losses)
- Portability of the transformer designed (capacity to insert it in a design)
- Generation of Spice model of the transformer

The optional criteria with weigh coefficient 0.33 for transformer tool design are:

- Generation of Bill of materials for the transformer
- Generation of documentation for the transformer designed
- Physical image
- 3D image
- Cost estimation
- Option to order the transformer selected/designed
- Calculation and design theory and formulas provided
- Feedback
- References provided

By incorporating these compulsory and optional criteria, the Expert tool within the Online-CADCOM platform can provide more tailored recommendations for transformer design tools, ensuring that users can select the best tool for their specific design needs. Whether the user is focusing on basic transformer calculations or more complex design considerations like impedance and fault current, these criteria will ensure that the chosen tool meets both essential and advanced design requirements.

3 Online/Downloadable Transformer Design Tools and Modules

This section presents a study of various online and downloadable tools that are widely used for transformer design. Each of these tools offers a unique set of features designed to meet the specific needs of different transformer types and use cases, ranging from basic calculators to more advanced design and simulation platforms. Nine tools focused on transformer calculation are studied:

- Goodcalculators [8];
- Alfatransformer [9];.
- Jcalc [10];
- Farnell Bulgaria [11];
- Maddox [12];
- 3phaseassociates [13];
- Voltage-Disturbance [14];
- Omnicalculator [15];
- Forumelectrica [16]l.

Two modules focused on transformer design and simulation are studied:

- Transformer Design module (TDM) [18] in PowerEsim [17] and
- Magnetic Parts Editor (MPE) (former Transformer Designer) module in PSpice [19].

Each of these platforms is evaluated based on its ability to perform core transformer calculations and design..
The user experience is also considered, with particular attention to tools that offer intuitive interfaces, comprehensive documentation, and cross-platform accessibility. Web-based tools provide ease of access from any device, while downloadable software often offers more advanced and customizable features for professional users. Tools that can integrate with other platforms, such as SPICE simulators or PCB design software, are especially valuable for more complex design workflows.
The classification of these tools is based on the set of compulsory and optional criteria defined in section 2.
The Tables 1, 2 and 3 represent the classification of the tools for transformers design for compulsory criteria, optional criteria with weigh coefficients 0.5 and 0.3 respectively. This classification provides a structured approach to selecting the right tools, enabling engineers to make more informed decisions and ultimately improve the efficiency and accuracy of their transformer designs.

Table 1. Classification of the transformer design tools for compulsory criteria

Compulsory criteria	Options	Tools
Type of tools	Transformer calculator (current calculator)	Goodcalculators;Alfatransformer;.Jcalc; Farnell Bulgaria; Maddox; 3phaseassociates, voltage-disturbance, Omnicalculator;Forumelectrica (*)
	Module for transformer design and simulation	TDM, MPE
Number of phases	Single	(*),TDM, MPE
	Three	Goodcalculators;Alfatransformer;.Jcalc;Farnell Bulgaria; Maddox; 3phaseassociates, voltage-disturbance, Forumelectrica, TDM, MPE
Type of transformer	Step-up	MPE
	Step-down	Goodcalculators; Farnell Bulgaria;
	Isolation	Alfatransformer;
	Dry type	Maddox; Alfatransformer;
	Pad Mounted	Maddox; Alfatransformer;
	Substation	Maddox; Alfatransformer;
	Pole Mounted	Maddox; Alfatransformer;
	Buck/Boost	Alfatransformer;
Transformer topology	Flyback Xformer	TDM, MPE
	Forward Reset	TDM, MPE
	Forward Xformer	TDM, MPE
	Active Clamp, CCM PFC Choke, DCM PFC Choke, Half-Bridge Xformer, Full-Bridge Xformer, Push Pull Xformer, HF Power Inductor, Input Choke, Output Choke, CM Choke,Current Xformer	TDM
	Buck-Boost Choke	TDM, Alfatransformer;
	Boost Choke (step-up)	TDM
	Buck Choke (step down)	TDM, Goodcalculators; Farnell Bulgaria;
	DC Inductor (Single winding)	MPE

Table 2. Classification of the transformer design tools for optional criteria 0.5

Optional criteria 0.5	Options	Tools
Core shapes	E	TDM, MPE
	Toroid	TDM, MPE
	U	TDM, MPE
Transformer impedance calculation	(%Z)	3phaseassociates;Voltage-Disturbance;
Secondary transformer voltage calculation		Goodcalculators, Jcalc, Farnell Bulgaria, 3phaseassociates, Voltage-Disturbance, Omnicalculator, Forumelectrical
Voltage drop calculator		Voltage-Disturbance
Secondary fault current calculation		3phaseassociates, Voltage-Disturbance
Turns ratio		Goodcalculators, Jcalc, Farnell Bulgaria,3phaseassociates, Forumelectrical
Transformer simulation	Core, DC copper, AC copper losses	TDM, Voltage-Disturbance
	Efficiency	MPE
Portability of the transformer designed	capacity to insert it in a design	TDM, MPE
Generation of Spice model		MPE

Table 3. Classification of the transformer design tools for optional criteria 0.33

Optional criteria 0.33	Tools
Generation of Bill of materials Generation of documentation Physical image, 3D image	TDM
Cost estimation	TDM, Farnell Bulgaria
Option to order	TDM. Maddox; Alfatransformer;
Design theory and formulas	Alfatransformer; Jcalc, Farnell Bulgaria, Omnicalculator, Forumelectrica
Feedback	TDM, Goodcalculators, Alfatransformer, Jcalc, Farnell Bulgaria, Maddox, 3phaseassociates, Voltage-Disturbance, Omnicalculator, Forumelectrical
References provided	TDM, Goodcalculators, Alfatransformer, Jcalc, Farnell Bulgaria, Maddox, 3phaseassociates, Voltage-Disturbance, Omnicalculator, Forumelectrical

4 Example for transformer tool selection

An example of the selection of online/downloadable tools for the transformer is given below, implementing the classification of the tools in the Tables1, 2, and 3.

Firstly the following specifications are selected which the tools required to have:

- Voltage calculator
- Three-phase transformer;
- Transformer Impedance (% Z)*;
- Secondary Transformer Voltage;
- Secondary Fault Current (Amps);
- Price;

The process commences by outlining criteria that need to be satisfied. Viable options are identified through set theory principles. The compulsory criteria are with weigh coefficient 1 and the decision-making consists in the product of the values [1].

The tools that satisfy the compulsory criteria are: Goodcalculators; Alfatransformer;.Jcalc; Farnell Bulgaria; Maddox; 3phaseassociates, Voltage-Disturbance, Forumelectrica.

The assessment uses a Decision Matrix (DM) to evaluate and prioritize options based on predefined criteria. In conjunction with this, the Multi-Attribute Utility Theory (MAUT) is employed to calculate a combined value representing the overall usefulness of each option by considering multiple attributes. MAUT standardizes the performance values of different alternatives to align with the decision maker's preferences. This involves creating a utility function for each criterion, indicating how desirable each option is relative to that criterion. The total utility of an option is then calculated by summing the utilities of all criteria, with each criterion weighted according to its importance. [2] The weight coefficients are integrated into the MAUT model to rank the available options. The Decision Matrix is a table stored in a database that organizes the decision-making process. Each row represents an option, while columns reflect the values for various criteria, helping to streamline and quantify decision-making. These mathematical models provide a structured and systematic approach to selecting the most suitable tool for the design task based on specific criteria.

Table 4 evaluates 9 tools based on the optional criteria specified. A "1" is assigned to a tool if it offers the requested feature, and a "0" if it does not. To determine the overall score for each tool (alternative Ok), the function F(Ok) is calculated by summing the values in the cells, each multiplied by the respective weight coefficient.

Table 4. Assessment of optional criteria for the specification requested

Optional Criteria	Farnell Bulgaria	Goodcalculators	Maddox	Jcalc	3phaseassociates	Alfatransformer	Voltage-Disturbance	Forumelectrica	Weight coefficient
Transformer Impedance (% Z)*	0	0	0	0	1	0	1	0	0.50
Secondary Transformer Voltage	1	1	0	1	1	0	1	1	0.50
Secondary Fault Current (Amps)	0	0	0	0	1	0	1	0	0.50
Cost estimation	1	0	0	0	0	0	0	0	0.33
F(Ok)	**0.83**	**0.5**	**0**	**0.5**	**1.5**	**0**	**1.5**	**0.5**	**Weight coefficient**

The results for the utility function F(Ok) allow to rank the 8 tools identified earlier as viable options, as follows:

First rank: 3phaseassociates and Voltage-Disturbance, F(Ok)=1.5
Second rank: Farnell Bulgaria, F(Ok)=0.83
Third rank: Goodcalculators, Jcalc, Forumelectrica, F(Ok)=0.5
Fourth rank: Maddox and Alfatransforme F(Ok)=0

5. Conclusion

The paper presented a detailed study of online and downloadable tools and modules for transformer design, evaluating and classifying them utilizing a structured set of compulsory and optional criteria. These tools, by being integrated into the Online-CADCOM platform with their passports, turn it into a highly extended functional platform, offering engineers and designers powerful resources for transformer design. The application of the decision-making models-MCDA and MAUT-allows for the pertinence of advice given by the Expert tool of the platform to needs and project requirements.
These include goodcalculators, alfatransformer, jcalc, Farnell Bulgaria, Maddox, 3phaseassociates, voltage-disturbance, omnicalculator, forumelectrical, Transformer

Design module and magnetic Parts Editor, among others. This has enabled users to make transformer designs for several applications. The knowledge of Online-CADCOM is increased by the findings of the paper.

Acknowledgments. The research in the paper is supported by project 242PD0008-07 within the Research and Development sector of the Technical University of Sofia.

References

1. Rodic B, Marinova G, Chikov O.: Algorithms and Decision Making Methods for Filter Design Tool Selection for a Given Specification in Online-CADCOM Platform, Proc. of the 26th Int. Electrotechnical and Computer Science Conf. ERK'2017, Slovenian IEEE Section, Portoroz, Slovenia, 25-26 September 2017, ISSN 2591-0442 (online), (2017) pp. 247-251.
2. Marinova G., Chikov O., Rodic B.: E-Content and Tool Selection in the Cloud-based Online-CADCOM Platform for Computer-Aided Design in Communications", Proc. of CONTEL'2019, Graz, Austria, 3-5 July 2019, IEEE (2019), pp.1-4, ISBN 978-1-7281-2091-1
3. Chikov O, Marinova G.: Software Implementation of the Computer - Aided Design Platform Online-CADCOM in Cloud Environment Proc. of Papers of ICEST 2017, 28-30 June 2017, Nis, Serbia, (2017) pp.277- 282, ISSN:2603-3259, Issue:1
4. Marinova G., Guliashki, V., Chikov, O., "MCDA Approaches for Automatic Tool Selection in a Cloud-Based Online-CADCOM Platform", 17th International Conference on Telecommunications, ConTEL (2023), pp.1-4
5. Menxhiqi L., Marinova G.: Knowledge base assisting PCB Design tool selection and combination in Online CADCOM platform, IT IS'2023 Book of Proc."Future of Digital Society in the Age of AI and ChatGPT", 14th Int. Conf. on Information Technologies and Information Society, November 2023, Ljubljana, Slovenia, (2023) pp.174-181
6. Kostova K., Marinova G., Knowledge-Base for Passive Elements Tools Selection in the Online CADCOM Platform. Proc. XXXIII International Scientific Conference Electronics - ET2024, Sozopol, Bulgaria, 17-19 September (2024)
7. Transformers, ElectronicTutorials, https://www.electronics-tutorials.ws/category/transformer, [Accessed on 13.10.2024]
8. Goodcalculators, https://goodcalculators.com/transformer-calculator/
9. Alfa transformer, https://www.alfatransformer.com/transformer_calculator.php
10. jCalc, https://www.jcalc.net/transformer-calculator
11. Farnell, https://bg.farnell.com/transformer-turns-calculator
12. Maddox, https://www.maddox.com/resources/kva-calculator
13. 3phaseassociates, https://3phaseassociates.com/transformer-current-calculators/
14. Voltage Disturbante, https://voltage-disturbance.com/engineering-calculators/transformer-calculator/
15. omnicalculator, https://www.omnicalculator.com/physics/ideal-transformer
16. forumelectrical, https://forumelectrical.com/full-load-current-turns-ratio-calculator-for-transformer/
17. PowerEsim - Free SMPS Switching Power Supply, https://poweresim.com/
18. PowerEsim Magnetic Builder, https://poweresim.com/Xformer/Select_Application_Front_Page.jsp?default=T&designator=XF1&pc=18658
19. Aidan Franits, How to Create Transformer SPICE Models, EMA Design Automation, 2024 https://www.ema-eda.com/how-to-page/how-to-create-transformer-spice-models/