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Original scientific paper

Electric Machines Winding Applications – DC Machine GeoGebra Winding Application

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Abstract: Understanding the winding configurations of electric machines is essential for students of electrical engineering, yet it remains one of the most complex and abstract areas of study. At the beginning of this paper, a brief overview of existing software solutions for electric machine winding design is provided, along with a summary of previously developed educational tools created at the Faculty of Technical Sciences Čačak. These earlier software tools, focused on both DC and AC machine windings, laid the foundation for the creation of more advanced and interactive learning resources. Building on this foundation, and leveraging the experience gained through the development of more than 50 GeoGebra applications at the Faculty, this paper presents a new interactive GeoGebra-based application specifically developed to support the teaching and learning of electric machine windings, with a focus on DC machine armatures. The developed application enables users to define winding parameters, calculate winding steps, generate winding tables, visualize developed winding diagrams, and simulate commutator and brush placement across eight different winding types. These features are designed with a strong emphasis on educational value, offering an intuitive and didactic workflow that serves as an effective teaching aid in mastering topics related to electrical machines. The new tool introduces interactivity, parameter validation, and animation—providing students with a hands-on experience that enhances both comprehension and retention, while also improving the effectiveness of both classroom and distance learning in electrical machines education.

Keywords: Electrical machines winding, Winding visualization, GeoGebra, DC machines, Electrical engineering education, Interactive learning tools.

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Colour versions of the one or more of the figures in this paper are available online at https://sjee.ftn.kg.ac.rs

1 Introduction

The design and construction of electric machine windings remain among the most abstract and challenging topics for electrical engineering students. Winding types—such as lap and wave, one- and two-layer, simplex and multiplex—require understanding complex spatial structures and rules for current distribution and commutation. These concepts are often introduced using static or hand-drawn diagrams, which cannot fully convey the geometric and topological aspects of real windings. Advances in educational software have enabled interactive learning, allowing abstract phenomena to be visualized dynamically. GeoGebra, widely used in mathematics, is gaining popularity in engineering education due to its intuitive interface, dynamic geometry capabilities, and ease of customization. Previous studies have confirmed its effectiveness in visualizing machine characteristics like torque-speed curves, phasor diagrams, voltage regulation, magnetic field distributions, and winding processes [1 – 3].

At the Faculty of Technical Sciences in Čačak, over 240 GeoGebra-based applications have been developed to support courses in electrical machines and drives. Categorized by machine type and function, these publicly accessible tools have been successfully integrated into both traditional and remote teaching formats [4]. Evaluations show increased student engagement and improved exam performance when interactive tools are used [5].

This paper builds on that platform by introducing a new class of GeoGebra applications focused specifically on electric machine winding design. A comprehensive DC machine winding tool is presented, enabling users to define key parameters, generate winding tables, draw developed diagrams, and visualize brush positions. It supports multiple winding types, including lap and wave, right- and left-handed, one- and two-layer configurations. Built-in validation rejects invalid parameter sets, while real-time feedback and animations foster intuitive understanding of winding logic [3].

The paper first reviews existing winding visualization tools and earlier developments from the Faculty of Technical Sciences in Čačak. It then presents the newly developed GeoGebra application for DC machine windings. The aim is to outline its methodology, implementation, and educational value, emphasizing its role in enhancing conceptual clarity and learning outcomes in electrical machines.

2 Related Work and Other Software Solutions in the Field

The winding of electrical machines has been studied for more than a century, and the underlying theory is well established in both classical [6, 7] and contemporary [8, 9] literature. Moreover, the need for visual tools to support the understanding of electric machine windings was growing since first simulation software were introduced. Traditional software tools such as FEMM, JMAG, Motor-CAD, and SPEED have been widely used for simulation and optimization of electrical machines, but they are primarily intended for professional use in design and industrial development contexts. Their complexity, high cost, and steep learning curves make them less suitable for undergraduate education or for use in conceptual introductory courses on electrical machines.

On the other hand, there are several simpler software tools that assist in understanding the operating principles of electric machines as well as the formation of windings in both DC and AC machines. For illustration purposes, here are highlighted only a few of these tools—specifically those that most intuitively convey the underlying concepts.

– **BobiSoft**® (Fig. 1) is a specialized software tool developed for the design and comparative analysis of three-phase windings in low-voltage induction motors. It enables the simultaneous design and evaluation of two different windings, facilitating quick and easy comparison. The software can automatically generate and print detailed reports that include key winding parameters, numerical and graphical schemes, MMF waveforms, core-loss test data, and client/service information [10].

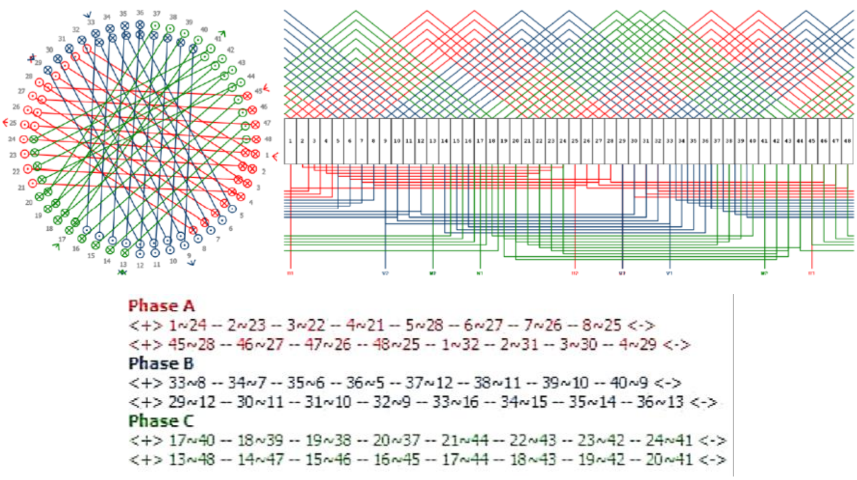


Fig. 1 – *Winding diagrams in BobiSoft® software.*

– **MotorAnalysis** (Fig. 2) is a free professional software package widely used for the design, analysis, and optimization of electric machines**,** developed by Motor Design Ltd. It is particularly popular in industry and academia due to its user-friendly interface**,** high accuracy, and fast simulation capabilities. MotorAnalysis supports wide range of electrical machines including induction machines (IM), permanent magnet synchronous machines (PMSM), brushless DC (BLDC) machines, linear machines, switched reluctance machines (SRM), etc. [11, 12]. It works as a MALTAB-based application or as a standalone program allowing visualisation of both stator and rotor winding distribution.

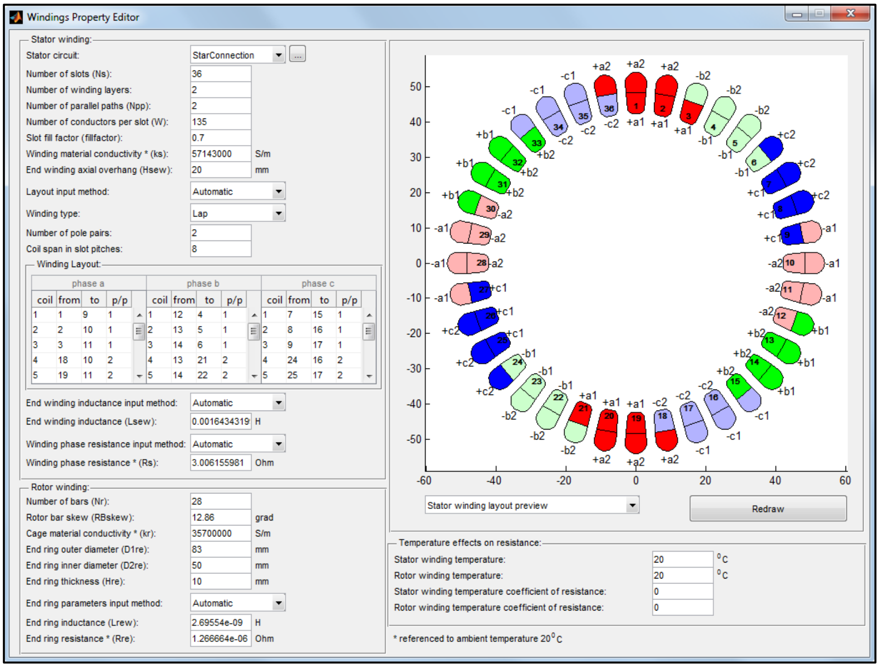


Fig. 2 – *Winding Editor window in MotorAnalysis software.*

– **JMAG** (Fig. 3) is advanced simulation software designed for the analysis, design, and optimization of electric devices, with a particular focus on electric motors. It offers high-precision finite element analysis (FEA) for evaluating electromagnetic, thermal, and structural performance. It wide range of machine types and enables accurate prediction of characteristics such as torque, losses, magnetic flux distribution, and temperature rise [13].

– **Siemens Simcenter SPEED** (Simulation Program for Electrical Engineering Design, (Fig. 4) is a software tool developed by Siemens Digital Industries Software for the design and performance evaluation of electric machines with strong visualization and reporting tools. It is primarily used in the early stages of motor development to enable fast analytical modelling and preliminary design before moving to detailed finite element analysis (FEA). It is widely used in industry and academia for designing high-efficiency electric machines, especially rotating machines such as PMSM, IM, SRM, BLDC. The software offers unique capabilities for analysing and optimizing winding layouts, including the ability to evaluate different balanced winding configurations [14].

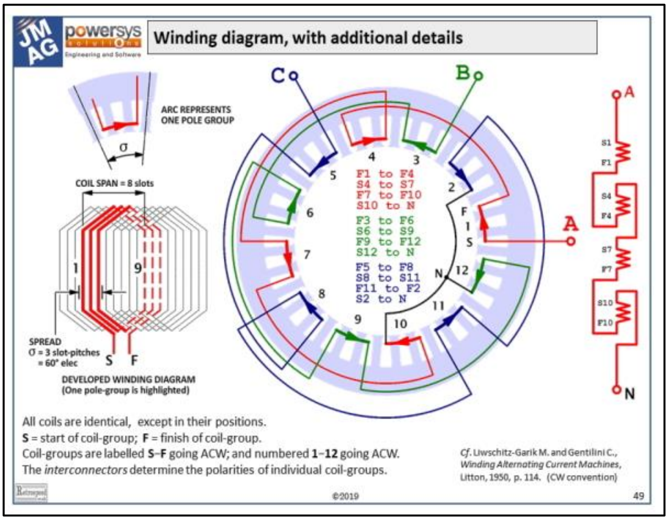


Fig. 3 – *Winding diagrams in JMAG software.*

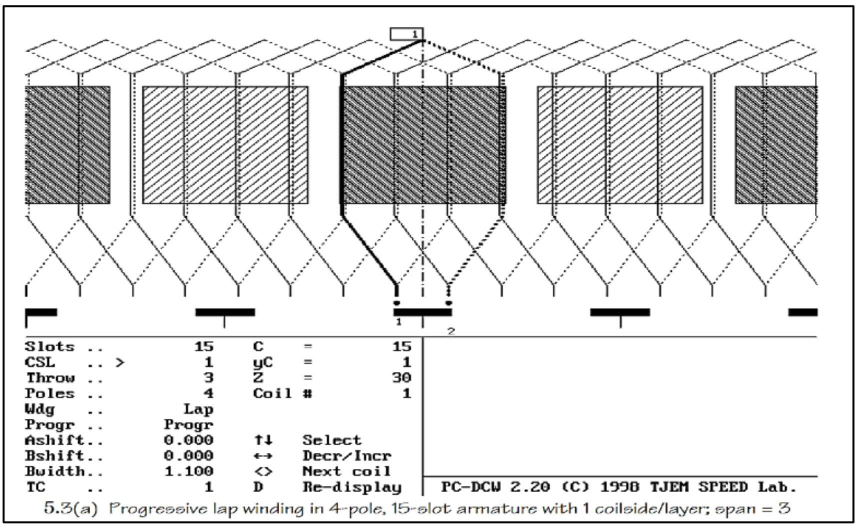
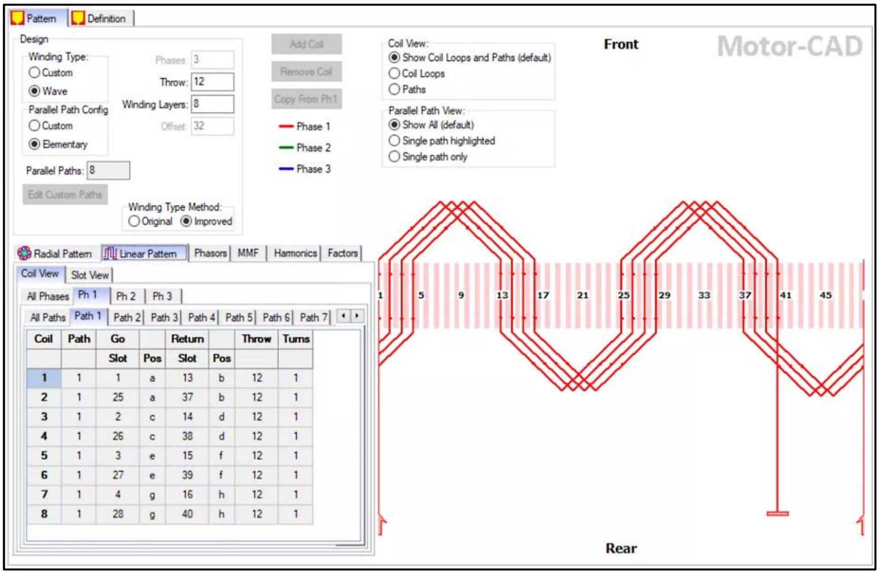


Fig. 4 – *Winding diagrams a Lap, Two-layer armature winding generated in the SPEED software.*

– **Ansys Motor-CAD** (Fig. 5) is a specialized software tool for the multi-physics simulation of electric machines. It enables fast and accurate design across electromagnetic, thermal, and mechanical domains, making it ideal for developing high-efficiency, high-performance electric machines from concept through optimization. Motor-CAD is widely used in the automotive, aerospace, industrial automation, and research sectors. While not specifically designed as a machine winding design tool, it provides important capabilities related to windings within electric machine performance analysis and allows users to define and configure a wide variety of winding types. It also enables visualization of coil distribution in stator slots. The software automatically checks for valid winding configurations and calculates resulting winding factors, which influence machine torque and back-EMF [15].



Coil	Path	Go Slot	Go Pos	Return Slot	Return Pos	Throw	Turns
1	1	1	a	13	b	12	1
2	1	25	a	37	b	12	1
3	1	2	c	14	d	12	1
4	1	26	c	38	d	12	1
5	1	3	e	15	f	12	1
6	1	27	e	39	f	12	1
7	1	4	g	16	h	12	1
8	1	28	g	40	h	12	1

Fig. 5 – *Winding diagrams in Ansys Motor-CAD software.*

A large number of web pages promoting freely available software tools for calculating motor winding parameters can also be found online. One such example is available at [16], although the detailed program it refers to applies only to alternating current motors. Most of these software tools are useful for quick calculations and visualization, and can be helpful in understanding the winding process of electric machines.

2.1 GeoGebra applications

In recent years, programs developed using the GeoGebra software package have been increasingly utilized for educational purposes. GeoGebra has proven to be user-friendly and effective for creating various visual animations that can be described mathematically, particularly in the intuitive visualization of complex physical phenomena and systems. Additionally, a dedicated GeoGebra database has been established within the platform, currently containing 245 categorized applications in the field of electrical machines, with the number continuously growing [17].

On the website of the Laboratory for Electrical Machines, Drives, and Automation at the Faculty of Technical Sciences in Čačak, all GeoGebra applications related to electrical machines and drives are collected and categorized, as shown in **Table 1** [4]. Among the applications listed in **Table 1**, only one focuses on visualizing the developed winding scheme of a DC machine armature (Fig. 6), but it does not allow for the adjustment of winding parameters. This application was created as a demonstration of current direction in the windings and commutation during the transition from one pole to another, and is intended primarily to support the understanding of the commutation process [18].

Table 1
Classification of GeoGebra applications in electrical machines by application area.

Category	Number
Basic	28
Magnetic circuit	10
Transformers	12
Electromechanical energy conversion	3
General part of electrical machines	33
DC machines	24
Asynchronous machines	28
Synchronous machines	47
Special electrical machines	11
General theory of electrical machines	16
Electrical drives	24
Automation	3
Electromagnetism	6
SUM:	**245**

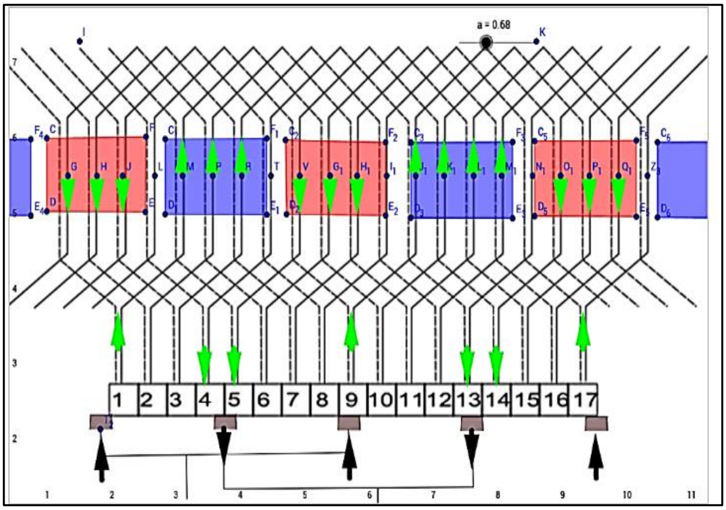


Fig. 6 – *GeoGebra application related to the developed winding scheme of a DC motor armature.*

3 Electrical Machines Winding Software Created at FTN Čačak – Early Work Back in 1993

At the Faculty of Technical Sciences in Čačak, the development of educational computer software has a tradition spanning over thirty years [19]. One notable example is a program created in 1993 by Professor Dr Slavoljub Janda, designed to demonstrate the winding of a DC motor armature [20]. This early software proved to be an effective learning tool, particularly valuable for students in mastering the principles of electric machine windings. It was widely used as a support resource for solving homework assignments and preparing for the written portion of exams, which consistently included at least one task related to DC or AC machine windings.

The original program was written in the QBASIC programming language and distributed as a standalone executable (*.exe) file. For over fifteen years, it served its educational purpose reliably. However, with the advent of newer operating systems and the gradual discontinuation of support for DOS command-line execution, the usability of such programs became severely limited. Running them required DOS emulators, which introduced additional setup steps and complexity for students.

This situation remained unchanged until 2016, when efforts were made to adapt the programs to run on modern Windows systems. Although these modifications restored functionality, the operating system would still display persistent security warnings, flagging the executables as potentially unsafe due to the risk of malware—an issue common to legacy file formats. Consequently, despite their educational value, these programs faced growing challenges in practical usability and accessibility. Nevertheless, the previously developed software still provides valuable support in teaching and helps students better understand the winding process.

3.1 DC machines winding

The process of creating a winding diagram for a DC machine involves determining the number of slots, poles, and conductors, followed by assigning the appropriate coil connections based on the winding type (e.g., lap or wave). Each coil is placed between two slots, ensuring correct polarity and direction of current flow to achieve the desired magnetic field distribution and back electromotive force. The layout must also take into account the commutator segment connections to ensure proper commutation. Finally, the developed winding diagram is drawn in an unfolded (2D) view of the armature, clearly showing the slot-to-slot coil connections and current directions. Using the developed applications which ensure winging process criteria, the user can generate a clear winding diagram based on the previously defined parameters.

Figs. 7 – 10 show developed winding diagrams of a DC machine for various combinations of lap/wave winding, one/two-layer winding, simplex/multiplex winding, and left/right winding option, as well as different numbers of slots *Z*, poles p', back pitch *y1* and front pitch *y2*.

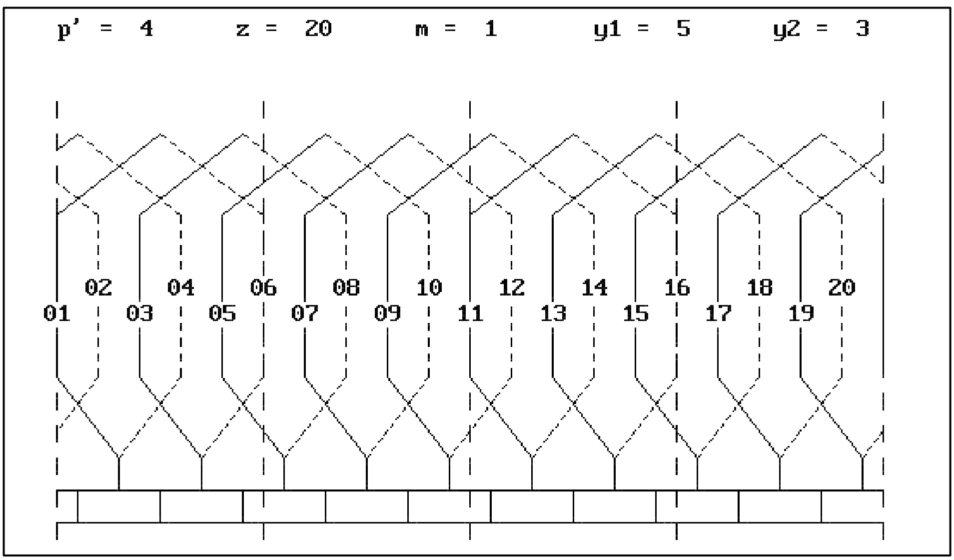


Fig. 7 – *Lap*, *One-layer*, *Simplex* (*m* = 1), *Right winding.*

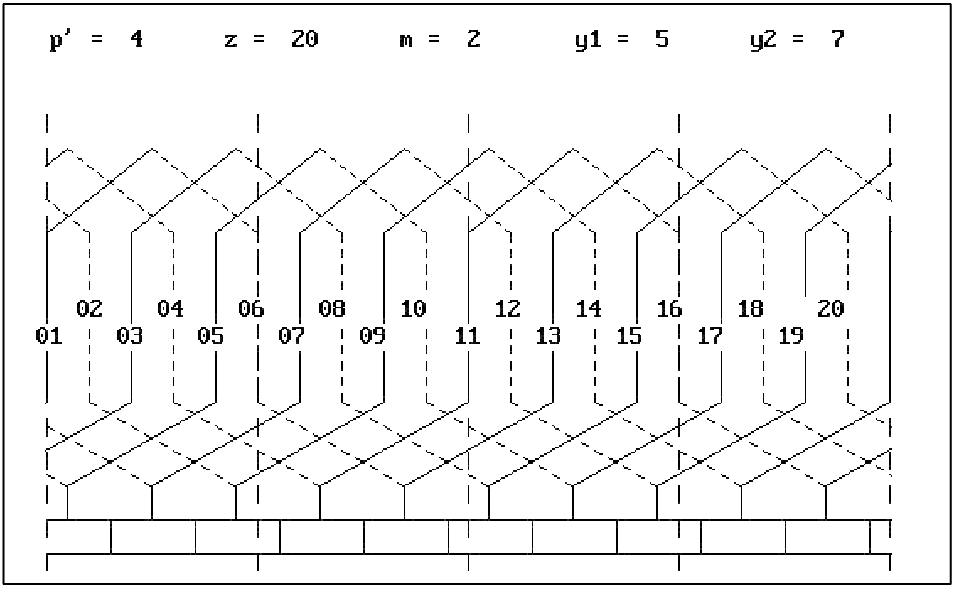


Fig. 8 – *Wave, One-layer, Multiplex* (*m* = 2), *Right winding.*

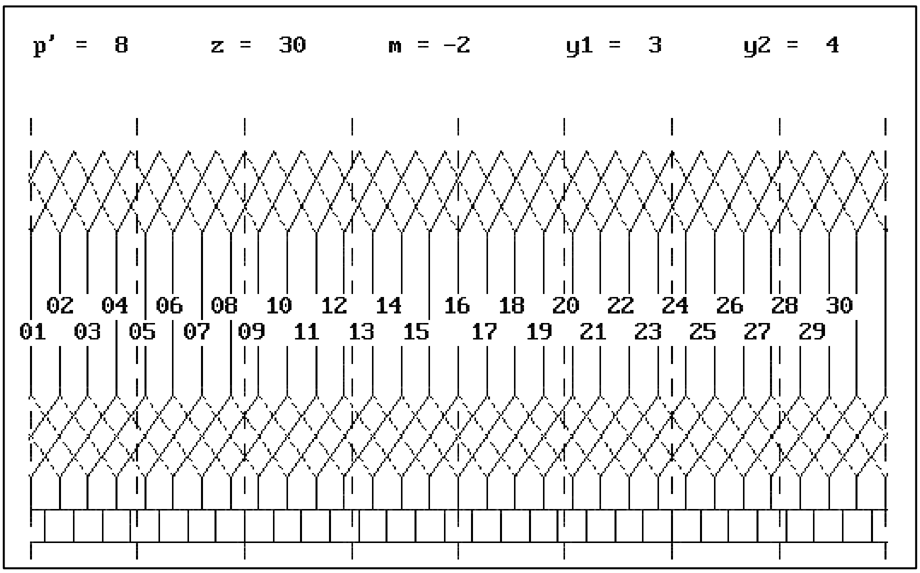


Fig. 9 – *Lap, Two-layer, Multiplex* (*m* = –2), *Left winding.*

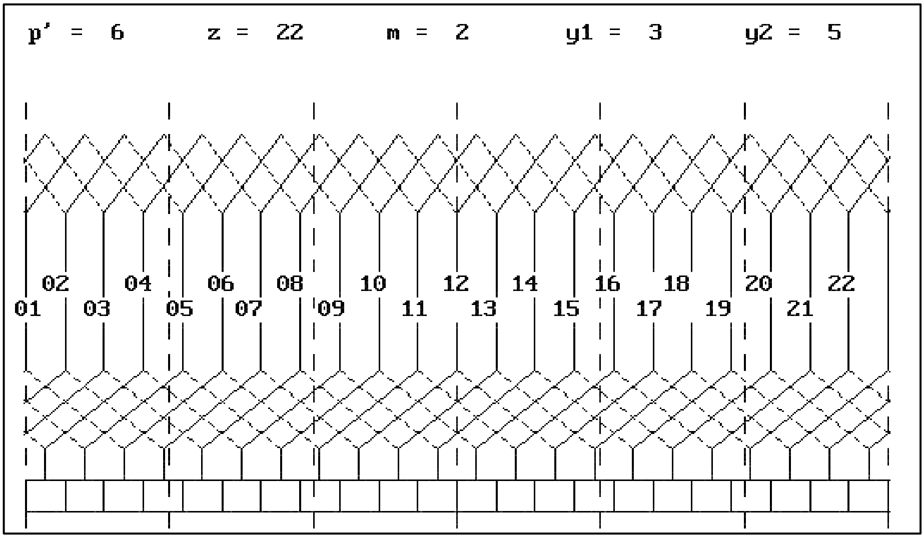


Fig. 10 – *Wave, Two-layer, Multiplex* (*m* = 2), *Right winding.*

In the same manner, applications for winding alternating current machines were also developed in the QBASIC programming language, as described in the following chapter.

3.2 AC machines winding

The developed application for visualizing AC machine windings includes two independent modules that enable users to generate both a winding table and a developed (unfolded) winding diagram for alternating current (AC) machines. It supports eight different winding configurations, covering parallel (lap) or series (wave) windings, short-pitch or full-pitch windings, and single-layer or double-layer windings [21]. The original version of the program was developed in 1993 and was later modified and adapted for the Windows operating system in 2016.

Before starting to generate the winding diagram, the application requires the following input parameters:

– The number of stator slots – Z;

– The number of poles of the machine – p';

– The pitch shortening factor (if the winding is short-pitched; this is not entered for full-pitch windings);

– The winding speed, which can be adjusted interactively using the (+) and (–) buttons.

Winding table drawing procedure is consisted of following steps. The program first displays the slot numbers, arranged into *p'* columns and *m* rows, where *m* represents the number of slots per pole and per phase. The slots are grouped into three sets, corresponding to the three phases of the winding. For each group of slots that belong to the same pole and phase, the current direction is marked. Coil groups are then connected with arrows that indicate the correct connection sequence.

Developed winding diagram drawing procedure is as follows. The diagram begins by displaying and labelling all stator slots. Neutral planes (symmetry axes between poles) are marked. The winding process is then animated at the selected speed, following the exact sequence previously defined in the winding table. Each of the phases from the winding table is marked with a different colour, and the winding process for the corresponding phase is shown using the same colour. Upon completion of winding each phase, the start and end points of the winding are labelled. Simultaneously, the direction of current flow in each part of the wound section is indicated at the bottom of the screen as well as at the active part of the conductor in the slot.

Figs. 11 – 14 present example diagrams for both Lap (parallel) and Wave (series) windings. The first example shows a winding table and winding diagram for short-pitch winding, while the second illustrates the same for a full-pitch winding.

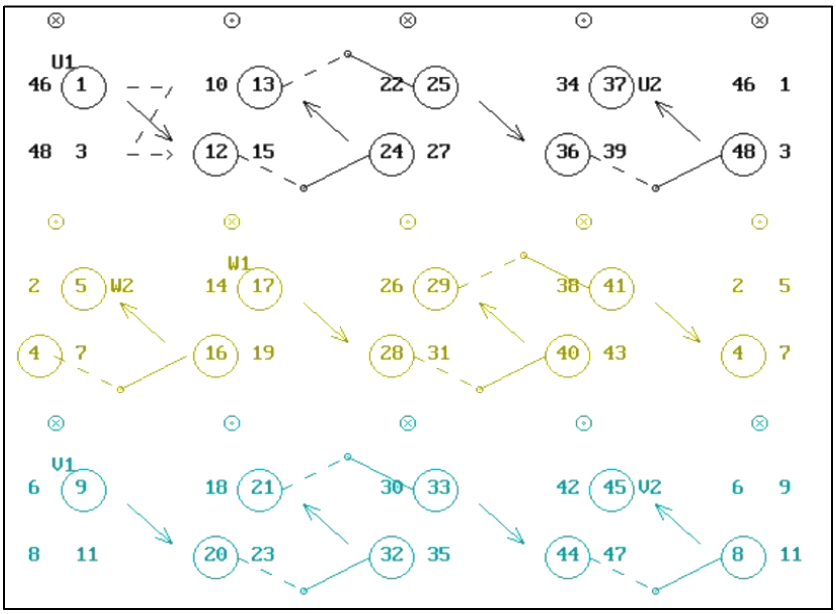


Fig. 11 – *Winding table for lap, two-layer, short-pitch winding.*

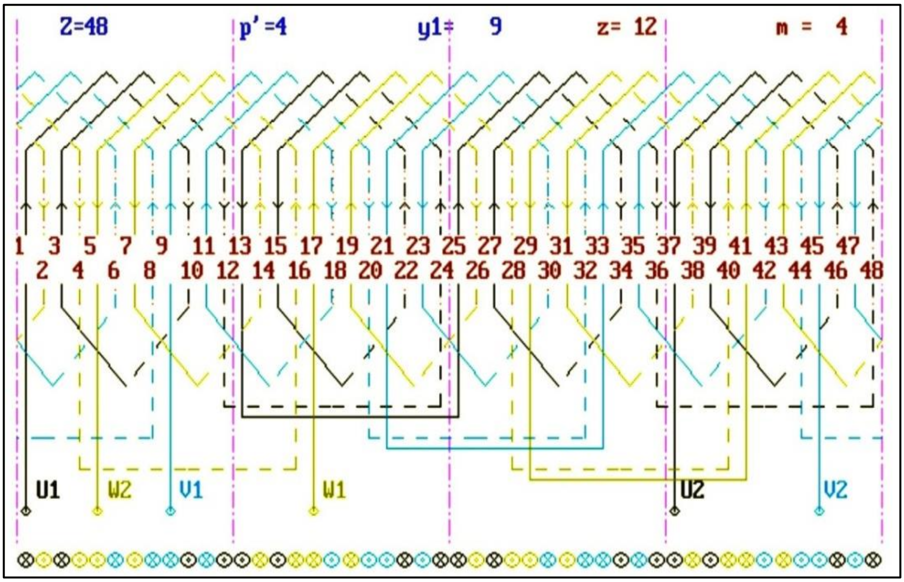


Fig. 12 – *Winding diagram for lap, two-layer, short-pitch winding.*

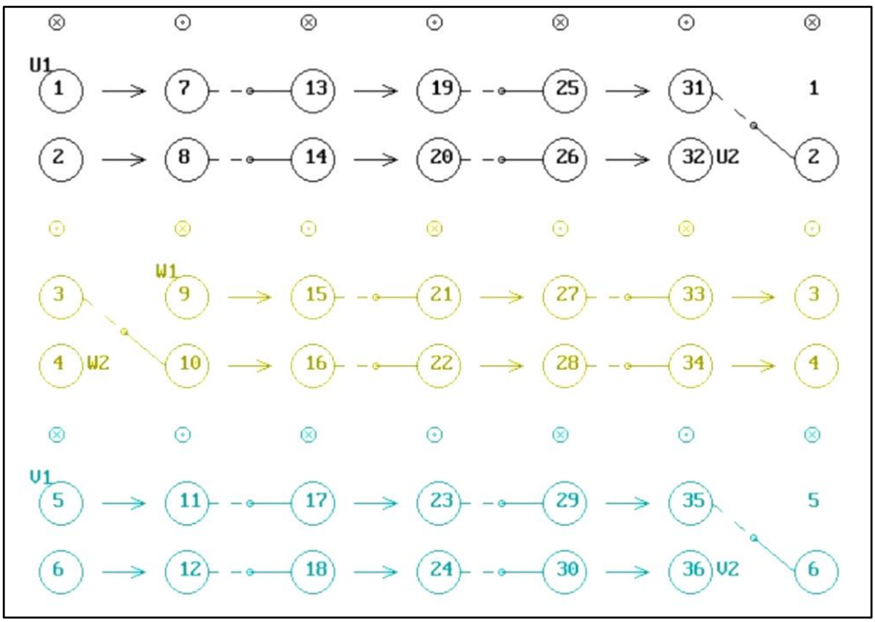


Fig. 13 – *Winding table for wave, one-layer, full-pitch winding.*

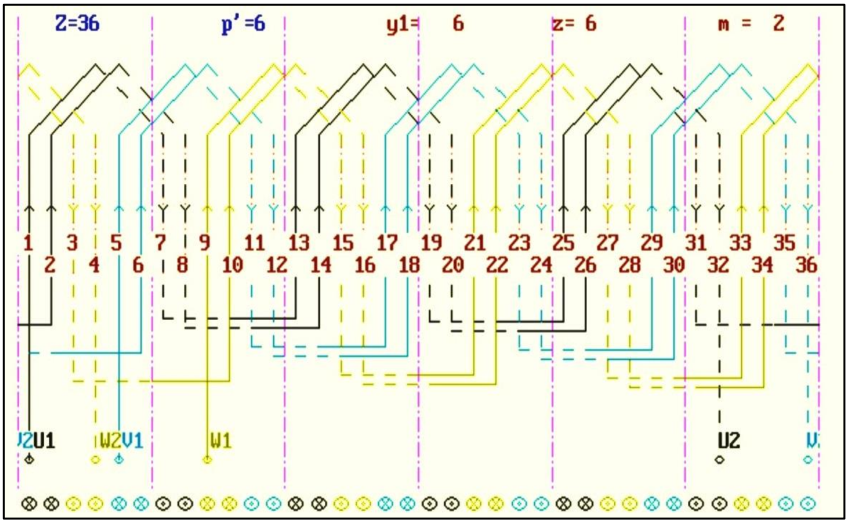


Fig. 14 – *Winding diagram for wave, one-layer, full-pitch winding.*

4 New GeoGebra Application for DC Motor Winding Created at FTS Čačak

In recent years, this development has shifted to modern, cross-platform environments – most notably GeoGebra. A large number of GeoGebra applications have been created within the EMDA Laboratory at the Faculty, covering topics from electromagnetic energy conversion and transformer modelling, to detailed phasor diagrams and steady-state analysis of various machine types. Notably, over 240 categorized GeoGebra applications are currently available online [4], including several that focus on visualization of winding arrangements in AC machines, such as distributed and concentric windings of induction and synchronous machines. These tools provide students with a graphical understanding of phase displacement, coil group structure, and winding factor effects, and support parameter variation via interactive sliders and animated diagrams.

Despite these advances, most existing GeoGebra-based applications related to windings have focused on final visual output—such as showing current direction or illustrating stator winding distributions—without offering step-by-step construction logic or parameter validation. In the case of DC machines, only a few applications prior to this work included options for generating winding tables or brush positioning.

The developed GeoGebra application described in this paper builds upon and extends this foundation. Unlike earlier visualization tools, it incorporates winding logic algorithms, error checking for invalid configurations, interactive table generation, and commutator animation, covering all major steps in the manual winding design procedure. Furthermore, it supports eight different winding types, making it one of the most comprehensive educational tools currently available in the domain of winding design for DC machines. This work complements and deepens previous research in the area of educational visualization tools for electric machines, and addresses an identified gap between simplified schematic visualization and full-featured engineering design software. It also aims to improve the quality of distance education and supports the rapid shift from traditional to distance, adaptive, and flipped learning formats.

To better understand the winding procedure of DC machines, it is necessary to understand the following steps during formation of armature winding: 1) calculation of winding steps; 2) drawing of the winding table; 3) drawing of the developed winding scheme; 4) construction of the schematic diagram of the potential of the closed-loop coil; 5) drawing of the schematic diagram of the commutator bars and 6) positioning of the brushes (position, number, and width). The application that will be presented in this paper provides the answer on how steps 1, 2, 3, and 6 are performed.

The GeoGebra DC Motor Winding Application [23] demonstrates the armature winding process of DC motors through the following steps.

4.1 Determining the winding type

The application allows user to select:

– Lap (Parallel) or Wave (Series) winding type;

– Two-layer or One-layer winding;

– Progressive (Right, $m > 0$) or Retrogressive (Left, $m < 0$) winding;

Also, the basic winding parameters must be entered: number of slots Z, number of pole pairs p, and winding complexity (m=1 for Simplex, m=2 for Duplex winding).

It should be noted that in the application the maximum number of pole pairs p_{max} = 3 and maximum number of slots Z_{max} = 30, are given as a remark and not as a software limitation.

4.2 Calculation of winding steps

Based on the provided input data, the back pitch, front pitch, and resultant pitch are calculated and displayed. For Lap winding, the application allows winding only with valid parameter combinations (e.g., winding with 5 slots and 6 poles is not feasible). Additionally, for Wave winding, the back pitch must be an integer.

In the case of one-layer winding, the number of slots must be even. To simplify the application, only Simplex windings are supported in this configuration. If invalid parameters are entered (i.e., those for which winding cannot be performed) the application displays a warning message explaining the reason, as shown in Fig. 15.

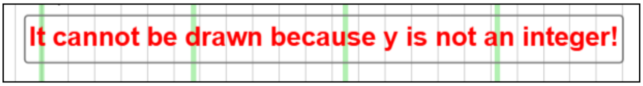


Fig. 15 – *Warning about the impossibility of winding a Wave winding for the given input data.*

Fig. 16 shows an example of described calculation procedure and graphical representation of Lap and Wave DC machine winding. In addition, the graphs clearly show the neutral zones marked with green vertical lines, as well as the machine slots marked with grey lines. Displayed small circles and crosses indicate the direction of the magnetic field under the poles.

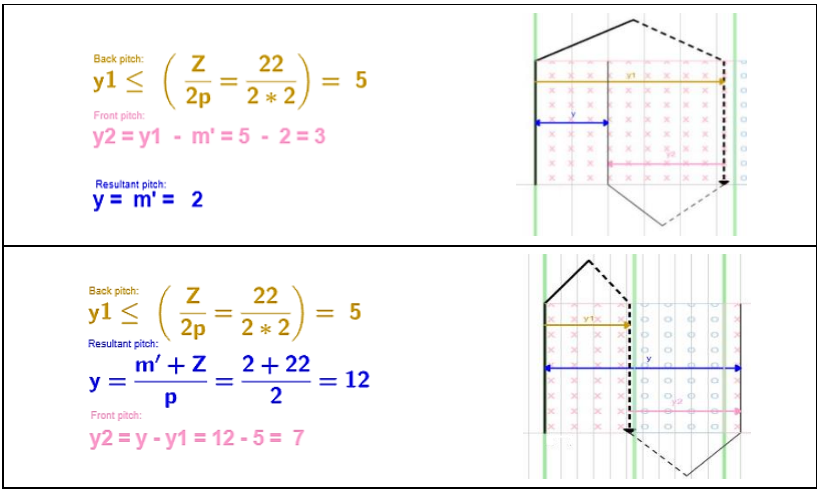


Fig. 16 – *Calculation and graphical display of winding step.*

4.3 Formation of the winding table

On the right side of the application's graphical environment, the winding table is generated – depicted later in Figs. 21–26. If a multiplex winding is selected, the program generates additional columns in the winding table. These columns, marked in blue and red, represent the second and third independent windings. The number of tables depends on the winding type:

– For parallel (Lap) winding, if Z/m is an integer, the number of winding tables is equal to m; otherwise, only one table is generated.

– For series (Wave) winding, the number of separate winding tables is equal to x, where x is the greatest common divisor of the resultant pitch and m.

For Lap winding, the table display follows the conventional format typically used for this type of winding. In the case of Wave winding, a more illustrative approach would involve a table with the number of columns matching the number of poles. However, this would significantly increase the complexity of the application, so it was intentionally avoided.

The winding table is automatically generated by moving the „Show table“ slider. Each table is completed when the initial number reappears in the table (the winding is short-circuited).

4.4 Drawing winding section

By checking the “Start winding” box, the user enables the drawing of winding sections defined in the table, which can then be visualized step-by-step using a slider. Additionally, an animated winding mode can be activated, allowing the user to control the animation speed of the winding sections, as shown in Fig. 17.

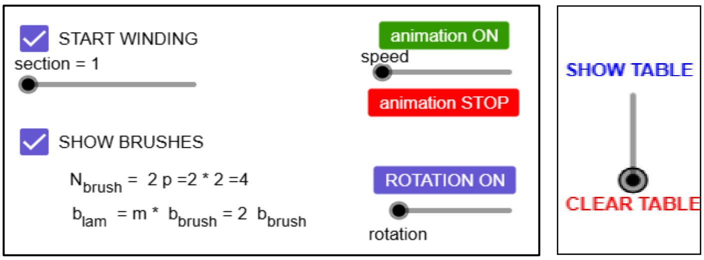


Fig. 17 – *Sliders for table visualization and animation speed adjustment.*

4.5 Show brushes

By checking the “Show brushes” box, the brushes and their positions are displayed on the developed diagram. The number of brushes and their width, relative to the width of the commutator bars, are also shown – see Fig. 18. The number of brushes depends on the type of winding. In parallel winding, the number of brushes corresponds to the number of poles, while in series winding two brushes are sufficient. Brushes polarity colour is made in accordance with usual polarity marking: red – positive, blue – negative.

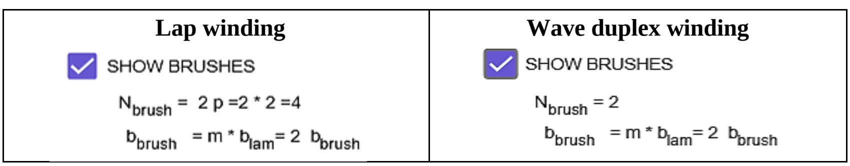


Fig. 18 – *Calculation of brushes number and their width.*

It is important to emphasize that the application only illustrates the procedure of winding formation and does not specify whether it refers to a motor or a generator. Therefore, it is not possible to determine current direction, by using the left or right-hand rule (depending on whether it is a motor or a generator) [24], either the direction of rotation or the direction of the induced EMF [25].

4.6 Start animation

By clicking the "Rotation on" button, the stator magnetic field is animated to move relative to the stationary rotor armature windings. This simulate the relative motion of that occurs in conventional DC machines, where the rotor windings move through the stator magnetic field. Due to limitations of the GeoGebra software where it was very difficult to implement the movement of the winding through the marked stationary field of the inductor, so previously described approach is used to illustrate the relative motion between the armature (rotor) and the inductor (stator) through the animation.

Fig. 19 shows three characteristic positions of a single winding section: when it is in contact with a brush of one polarity, when it is positioned between two brushes, and when it is in contact with a brush of the opposite polarity. Throughout the animation, the magnetic field of the inductor remains fixed in direction, as indicated.

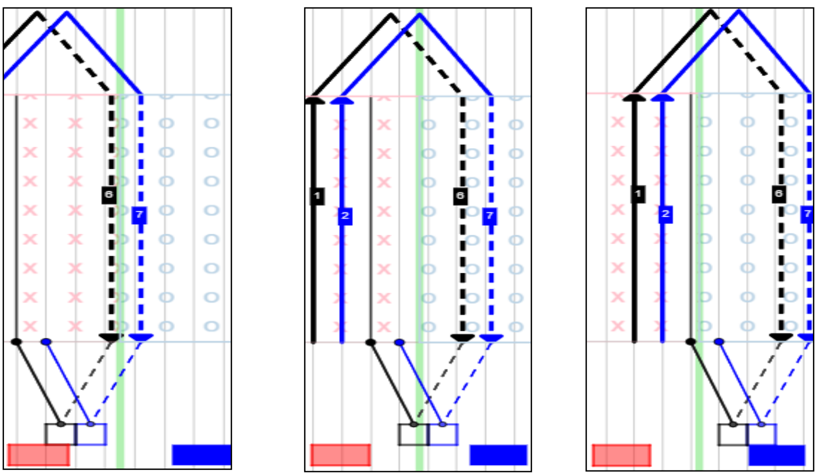


Fig. 19 – *Animation illustrating the relative motion of a pair of independent armature windings with respect to the inductor's magnetic field.*

Above the winding diagram, auxiliary sliders are provided to: zoom the developed winding view, shift the diagram left or right, adjust the height of the side connections, and offset the back section relative to the front section in two-layer windings, as it is depicted in Fig. 20.

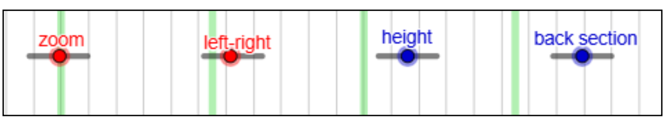


Fig. 20 – *Additional sliders for positioning the developed winding diagram view.*

5 Demonstration of the GeoGebra DC Motor Winding Application

In the developed GeoGebra application, it is possible to define $2^3 = 8$ different winding configurations as combinations of three winding attributes: Lap or Wave, One-layer or Two-layer, and Right or Left. Among these, the figures do not include Wave Single-layer windings (both Left and Right), since the application is limited to displaying only single-layer windings for two-pole machines. Moreover, displaying a Wave winding in such cases is not meaningful, as Lap and Wave windings are identical when the number of pole pairs is equal to one.

In the first example a) in Fig. 21, the most common winding type is illustrated: Lap, Right, Simplex, Two-layer. A two-pole motor with only 4 slots was selected. In this case relatively small slot number is selected to provide clear visualization of the winding layout and connection methods.

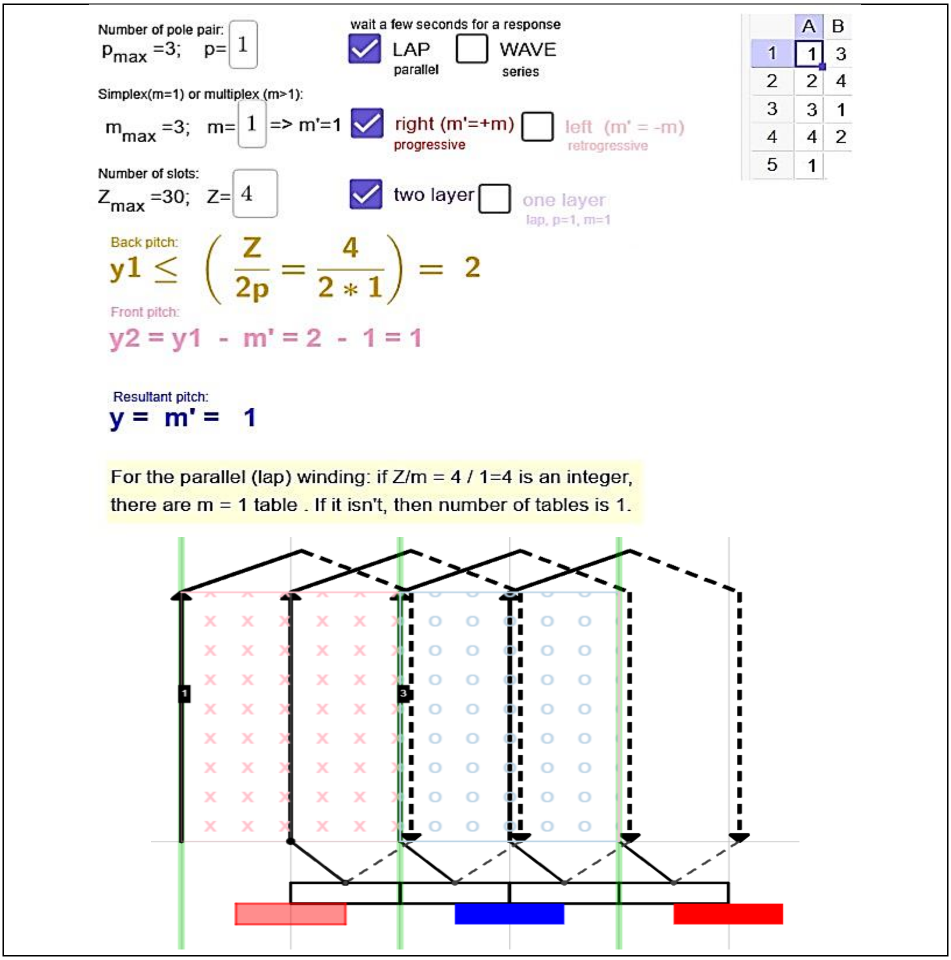


Fig. 21 – *Example (a) Lap, Right, Two-layer, Simplex winding.*

In example b), shown in Fig. 22, a Lap, Two-layer, Triplex, Left winding is presented. It can be observed that with each successive winding section, the winding direction shifts to the left. The figure also highlights the starting points of this winding, which is drawn on the right side of the developed winding diagram. Additionally, the brush width is shown to be three times the width of a single commutator bar, as the brushes must maintain contact with all three independently wound circuits at all times. For this Lap winding configuration, the ratio *Z/m*=21/3=7 is an integer, resulting in *m*=3 separate winding tables. If this condition is not met, the application defaults to a single winding table.

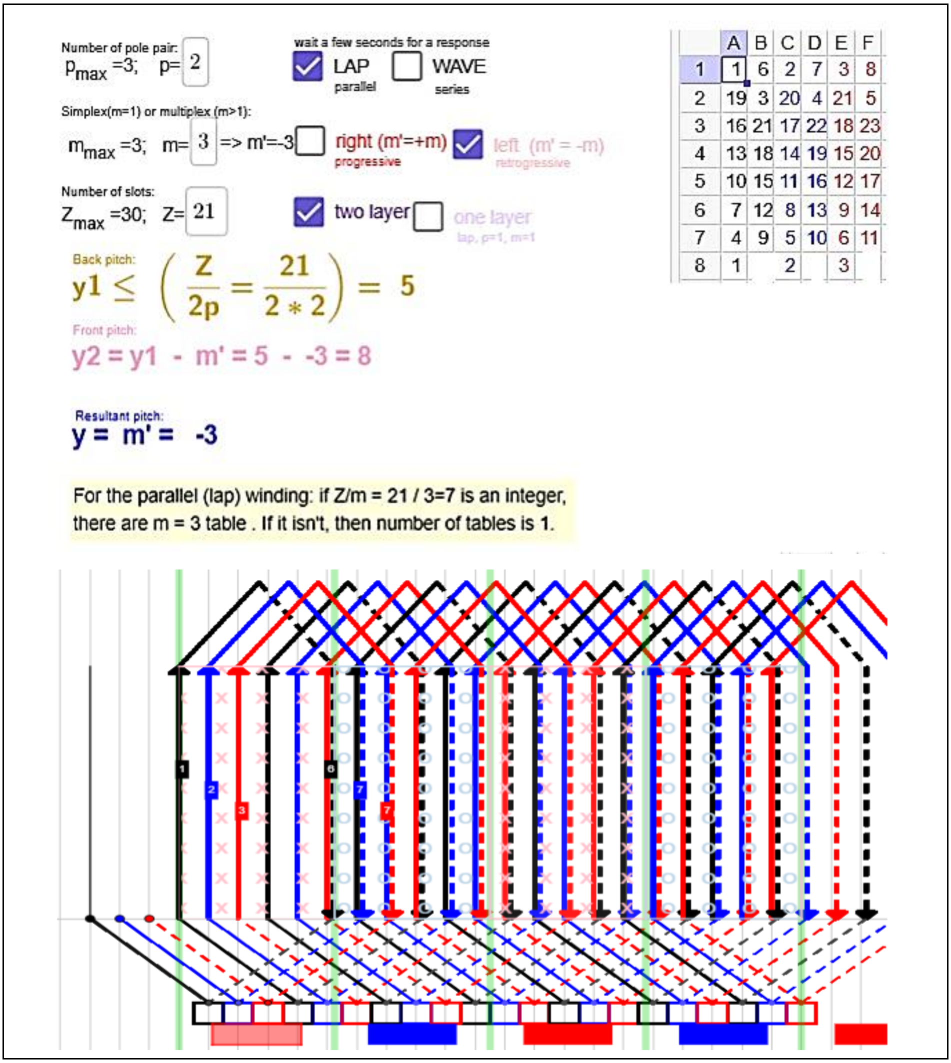


Fig. 22 – *Example (b) Lap, Left, Two-layer, Triplex winding.*

Example c), depicted in Fig. 23 shows a Lap, Right, One-layer winding. In the developed winding diagram, slots 2, 4, 6, and 8 appear empty, as they contain no front winding sides. However, the corresponding back sides of these windings are shown in slots 24, 26, 28, and 30, which represent the same conductors but displayed on the right side of the diagram (note that slots 1 and 23 are the same physical slot). Although the entire winding is not fully drawn, this approach provides a clearer representation of the developed winding layout.

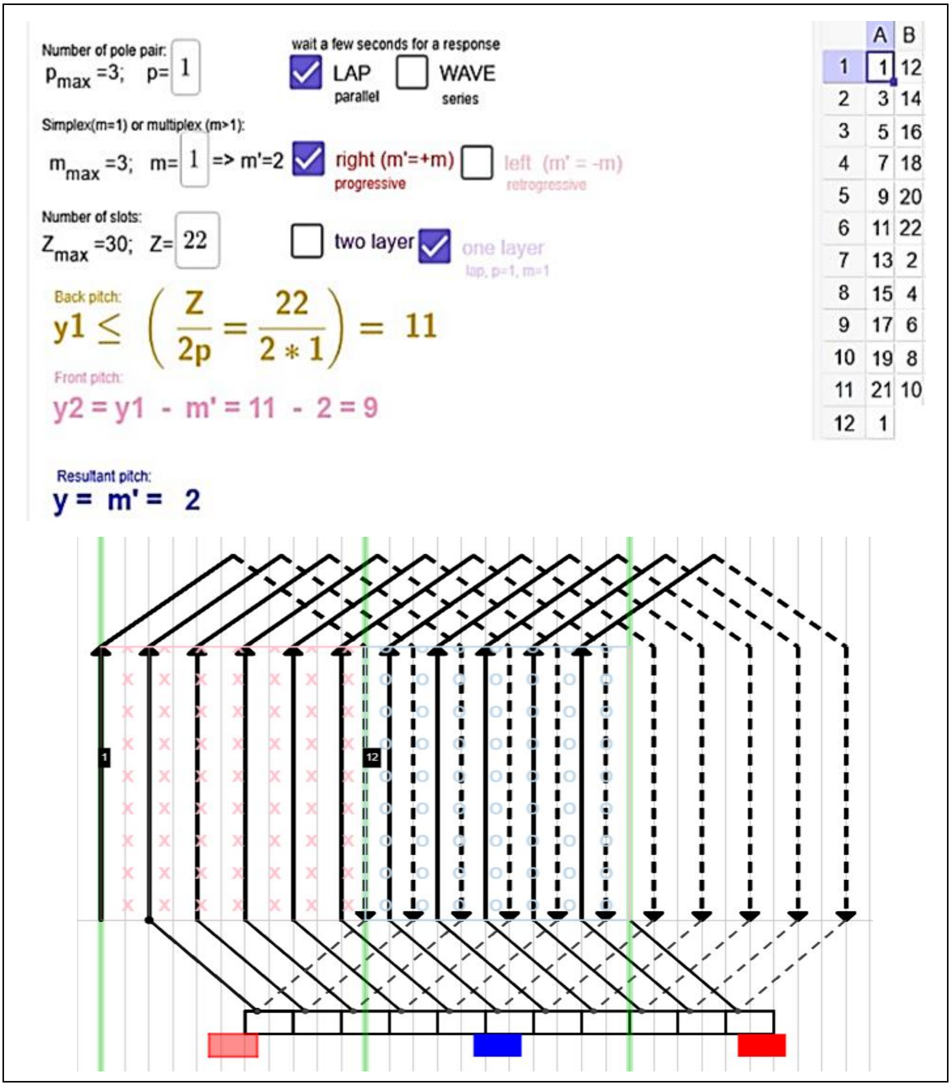


Fig. 23 – *Example (c) Lap, Right, One-layer, Simplex winding.*

Example d) on Fig. 24 shows a Lap, Left, One-layer Two-pole winding with only 8 slots. The resulting winding table is simple with only 5 rows and winding diagram showed below. A small number of slots and the use of a single-layer winding example were chosen in this case for a clear demonstration of the left-hand wave winding method.

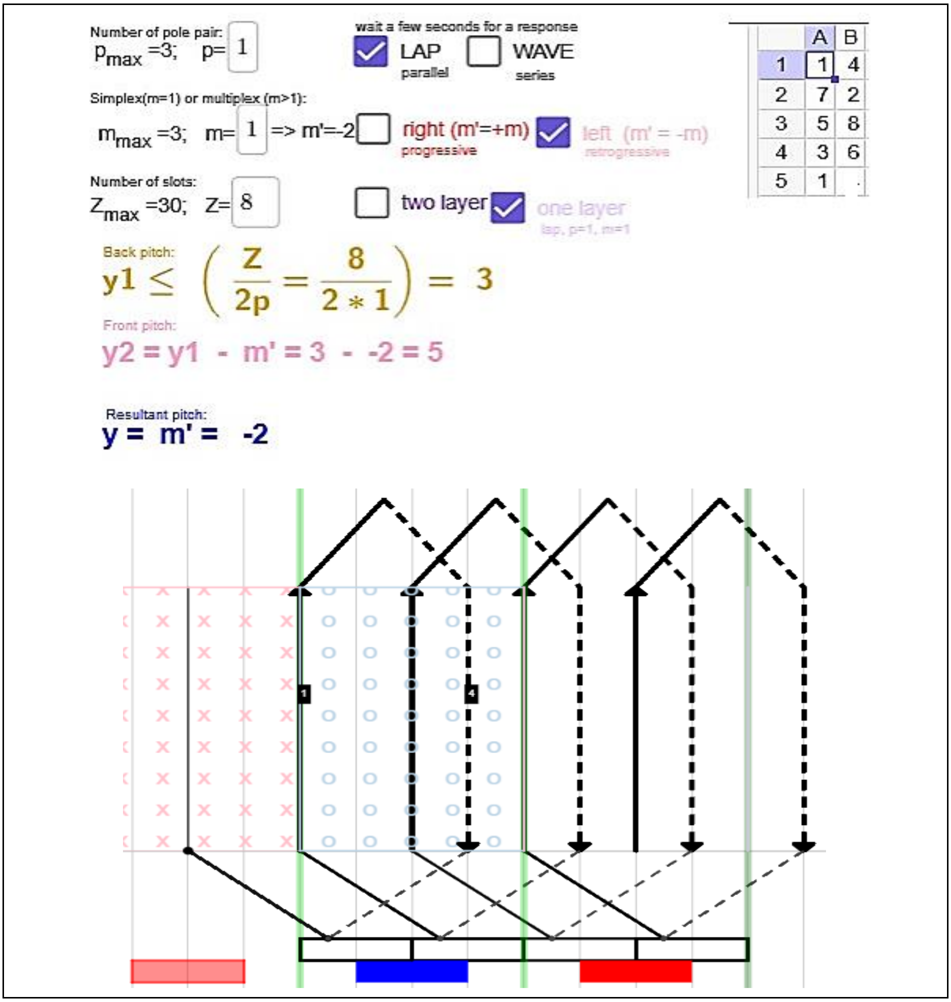


Fig. 24 – *Example (d) Lap, Left, One-layer, Simplex winding.*

A Wave, Right, Two-layer winding is presented in example e) on Fig. 25. Two independent winding tables are required (for Wave winding there are two separate tables because two is the greatest common divisor of y=8 and m=2). The brush width is twice the width of a commutator segment in order to simultaneously short-circuit the commutated winding sections of two independent windings. One winding is drawn in a darker (black) colour, while the other is shown in a lighter (blue) colour.

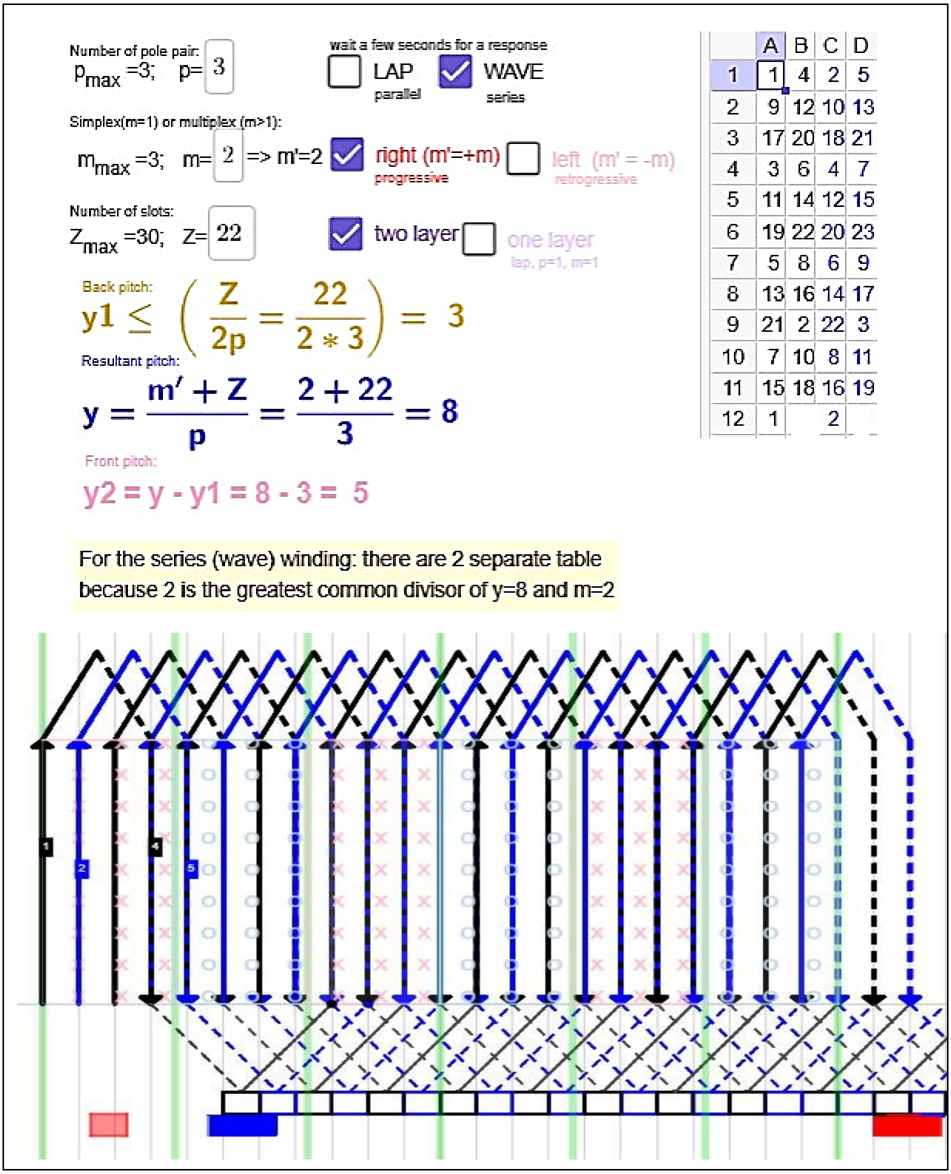


Fig. 25 – *Example (e) Wave, Right, Two-layer, Duplex winding.*

Example f) on Fig. 26 shows Wave, Left, Two-layer winding. Interestingly, this winding requires only one table and one independent winding. The reason is that the greatest common divisor of the pitch y and the m is 1.

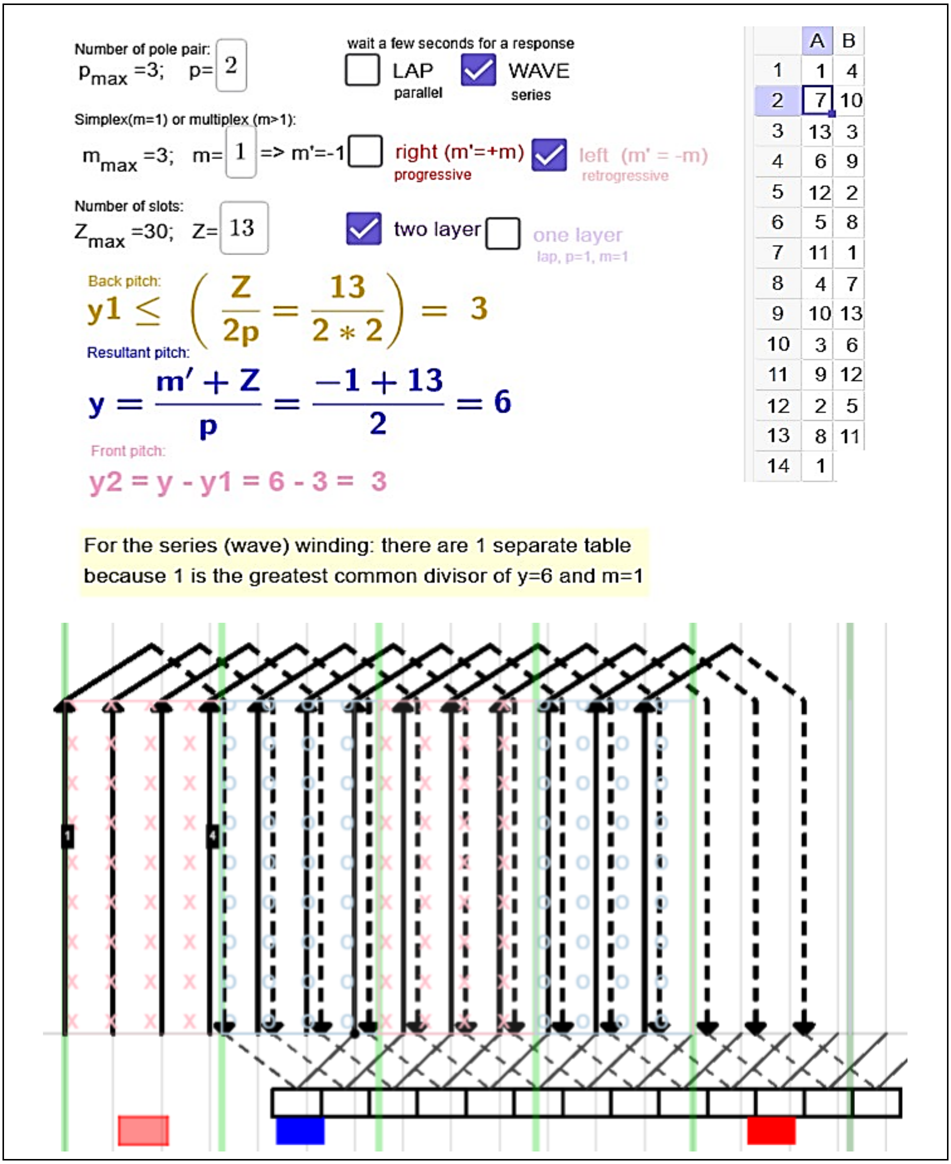


Fig. 26 – *Example (f) Wave, Left, Two-layer, Simplex winding.*

5 Conclusion

The development of software tools for visualizing and analysing electric machine windings has a long tradition at the Faculty of Technical Sciences Čačak. The first applications were created in the early 1990s, primarily for DOS environments, focusing on generating winding tables and unfolded diagrams (winding layouts) for AC machines. These tools were later upgraded in 2016 for the Windows platform, improving usability and adding support for multiple winding configurations. Over time, several specialized software solutions have been developed at the Faculty to support teaching and enhance student understanding in the field of electrical machines and drives. At the beginning paper includes a brief review of existing software tools for winding design in electric machines, outlining their main features and educational limitations.

Building on this foundation, the paper presents a newly developed application for constructing and visualizing DC machine armature windings, implemented in the GeoGebra software environment. The application provides intuitive visualization of the winding process and allows verification of key parameters such as brush positioning, the number of parallel paths, and the type and direction of winding. It supports various configurations, including parallel and series windings, right or left direction, and single or double-layer windings.

Developed as a didactic tool for the Electrical Machines and Drives related courses at the Faculty, this GeoGebra-based solution has proven highly effective in supporting both traditional and remote learning. The simple input of design parameters and dynamic graphic representation significantly improve students grasp of the complex winding structures in DC machines. By offering an interactive and accessible learning experience, the application contributes meaningfully to the educational process and complements the existing set of instructional tools in the domain of electrical machines.

7 Acknowledgment

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