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A Novel Software Introduction for Enhanced Low-Voltage Electrical Installation Design in Buildings: VOLTA

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ABSTRACT

This study introduces a revolutionary version of software for designing and building electrical installations. This software aims to provide optimal solutions within the domain of electrical installations, particularly in building contexts and low-voltage networks. The designed program will be able to generate DXF files with riser and single-line diagrams derived from the designed installation. In addition, a PDF summary of the performed computations will be provided. The suggested software is a significant step forward in the execution of international regulations and adherence to electrical engineers' standards within engineering firms. Furthermore, improvements in the quality of electrical installation execution in buildings and a decrease in the occurrence of rework are expected. This software uses optimization techniques such as a genetic algorithm for load balancing, as well as a particular menu for constructing and calculating capacitor banks, energy labeling calculations, protection coordination, etc. This software was developed with csharp and connected to AutoCAD with .NET capability.

1. INTRODUCTION

Microsoft Visual Studio offered a comprehensive solution for developing Windows application software. As a result, professionals in a variety of fields can learn programming and develop ideas, and sell products. Dr. Mohammad Parhamfar has been working on electrical installation software in Iran since 2010, and he has developed three versions of it. This study introduced the latest version of software developed by a knowledgeable team in Iran.

The efficient and accurate design of electrical installations is paramount for ensuring safety, functionality, and regulatory compliance in modern buildings. Traditionally, this process has been labour-intensive, relying heavily on manual calculations and drafting. However, the advent of specialized software tools has revolutionized the field, offering significant advancements in design optimization, documentation, and adherence to standards [1]. This study provides an overview of the current landscape of electrical installation software, highlighting key features, benefits, and methods. One of the key benefits of using electrical installation software is its ability to automate difficult calculations, including load assessments, voltage drop studies, and short-circuit current evaluations [1]-[2]. These automated techniques reduce human error, resulting in more dependable and safer designs [3]. Furthermore, modern software frequently includes full databases of electrical components and specifications, making accurate material selection and cost estimation possible [4]. Engineers may produce sophisticated graphical representations of electrical layouts, such as single-line diagrams, riser diagrams, and cable routing plans, thanks to the incorporation of Computer-Aided Design (CAD) features inside these software packages (IEC 60364). This graphic depiction improves clarity, enables stakeholder participation, and simplifies the installation process [5]. Furthermore, the ability to generate standardized documents, such as bills of materials and compliance reports, considerably minimizes the administrative load and guarantees compliance with national and international [6]-[7]. Recent literature highlights the growing trend of incorporating Building Information Modelling (BIM) into electrical installation software [8]-[9]. BIM-compatible software enables electrical designs to be seamlessly integrated with architectural and structural models, resulting in early collision identification and increased cross-disciplinary collaboration. This interdisciplinary approach results in more effective project workflows and fewer on-site modifications [10]-[12]. Furthermore, the optimization capabilities provided by modern electrical installation software are increasingly being investigated. Algorithms for appropriate cable sizing, equipment location, and energy efficiency are being incorporated to reduce material costs, lower energy usage, and improve overall electrical installation sustainability [13]. Despite substantial advances, continuing research continues to focus on improving the usability, interoperability, and analytical capabilities of these software tools. Interests include creating more user-friendly interfaces, improving data sharing formats, and using artificial intelligence for automatic design ideas and defect detection [14]-[16]. Finally, electrical installation software has become a vital tool for today's electrical engineers. Its ability to automate calculations, provide accurate documentation, integrate with BIM workflows, and optimize designs greatly improves productivity, accuracy, safety, and regulatory compliance. The rising amount of research continually underscores the benefits of adopting these technologies, emphasizing their critical role in the future of electrical system design.

This work describes a thorough algorithm-based approach to building electrical installation software. In section 2, the methodology and various algorithms are discussed. Section 3 illuminates the developed program by introducing all the abilities. Section 4 investigated software output, and the final section discussed future work and conclusions. Figure 1 shows the roadmap of the work.

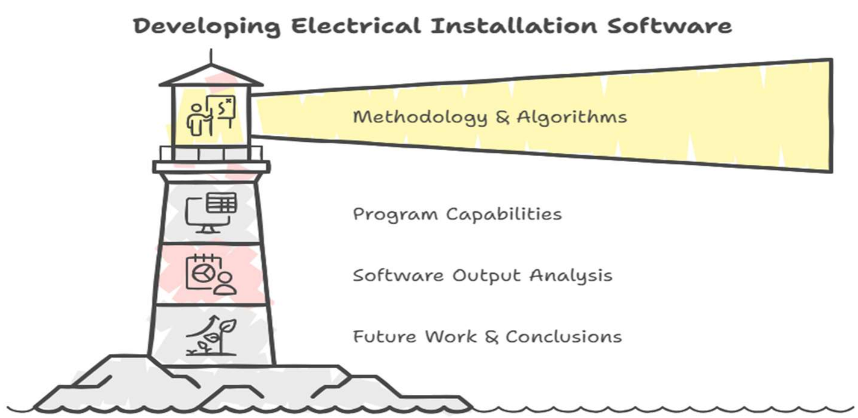

Figure 1. Roadmap of manuscript work.

2. METHODOLOGY

The major component of this software was designed for electrical panel and cable sizing. As a result, the following two methods were investigated. Figures 2 and 3 illustrate cable sizing algorithms. One of the issues in building an electrical panel is load balancing, which is why genetic algorithms are utilized for optimization. In the following, some of the issues are examined.

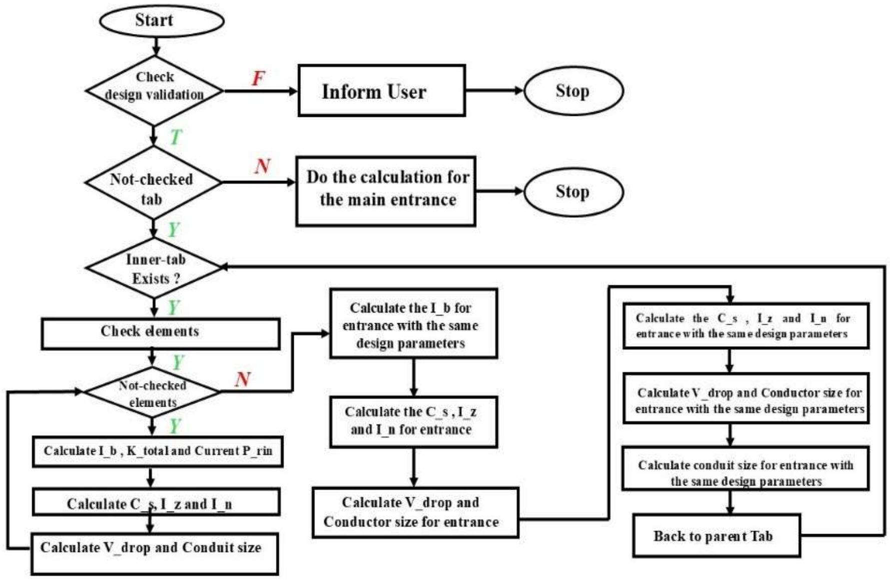

Figure 2. Algorithm for sizing cable.

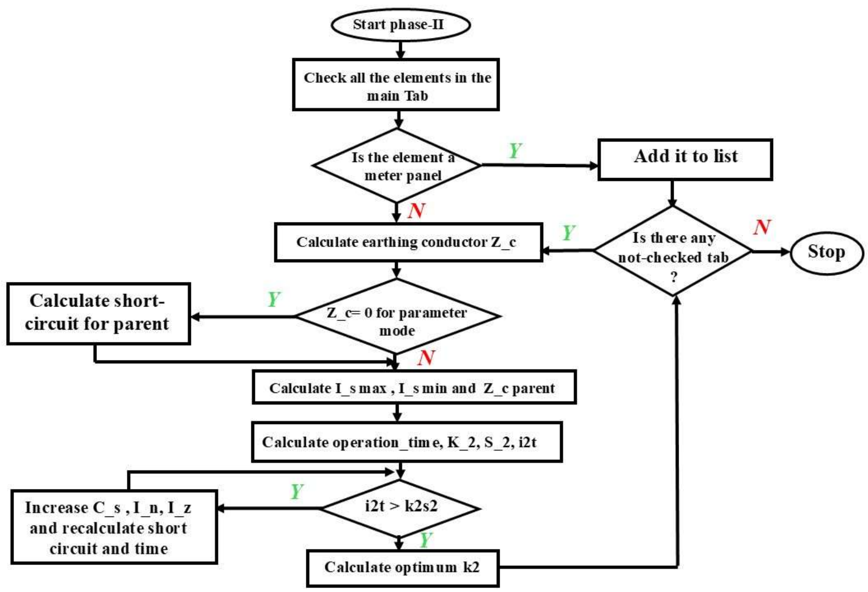

Figure 3. Cable sizing algorithm and influence of short circuit.

2.1 Estimation of simultaneity factor

The Simultaneity factor influences the computation of maximum installation demand and main entrance current rating. Additional information, such as environment and usage parameters, affects the values of the simultaneity factor. The third subsection of the 13th Iranian national building regulations introduces two ways for determining the main branch specification. The first is to apply the simultaneity factor for loads based on accessible tables, while the second is to employ experienced local rules. In this program, we recommend simultaneity factors, which are given in the Schneider Electric Handbook.

2.2 Utilization Coefficient (Ku)

Under typical operating conditions, the load power consumption is occasionally lower than the nominal power rating. This factor must be adjusted to each load, with special emphasis on electric motors, which are rarely used at full load. Ku is also utilized in the program for demand estimations.

2.3 Calculation of cable

Cable estimations in buildings are typically based on current and voltage drop. The proposed software also considers harmonics and short circuit calculations as outlined in the ABB Handbook. Table 1 explains how to calculate correction factors for the third harmonic component. To calculate the cable's, withstand against short circuit, the minimum short circuit is estimated, as shown in equation 1. Table 2 shows the

$$I^2 t \leq K^2 S^2 \tag{1}$$

Table 1. Correction factors for the third harmonic component, $I_N = \frac{I_b}{k_{tot}} * 3 * k_{\text{III}}$.

The impact of the third harmonic component	Reduction factor			
%	Current	Maximum I'_B	Neutral Current	Maximum I'_B
$0 \div 15$	1	$I_b^{'} = \frac{I_b}{k_{tot}}$	-	-
$15 \div 33$	0.86	$I_b^{'} = \frac{I_b}{k_{tot} * 0.86}$	-	-
$33 \div 45$	-	-	0.86	$I_b^{'} = \frac{I_N}{0.86}$
> 45	-	-	1	$I_b^{'} = I_N$

Table 2. Cross-section of different cables.

			Cross section [mm²]							
Cable		k	1.5	2.5	4	6	10	16	25	35
PVC	Cu	115	$2.98 \cdot 10^{-2}$	$8.27 \cdot 10^{-2}$	$2.12 \cdot 10^{-1}$	$4.76 \cdot 10^{-1}$	1.32	3.39	8.27	$1.62 \cdot 10^{1}$
	Al	76	$1.30 \cdot 10^{-2}$	$3.61 \cdot 10^{-2}$	$9.24 \cdot 10^{-2}$	$2.08 \cdot 10^{-1}$	$5.78 \cdot 10^{-1}$	1.48	3.61	7.08
EPR/XLPE	Cu	143	$4.60 \cdot 10^{-2}$	$1.28 \cdot 10^{-1}$	$3.27 \cdot 10^{-1}$	$7.36 \cdot 10^{-1}$	2.04	5.23	$1.28 \cdot 10^{1}$	$2.51 \cdot 10^{1}$
	Al	94	$1.99 \cdot 10^{-2}$	$5.52 \cdot 10^{-2}$	$1.41 \cdot 10^{-1}$	$3.18 \cdot 10^{-1}$	$8.84 \cdot 10^{-1}$	2.26	5.52	$1.08 \cdot 10^{1}$
Rubber	Cu	141	$4.47 \cdot 10^{-2}$	$1.24 \cdot 10^{-1}$	$3.18 \cdot 10^{-1}$	$7.16 \cdot 10^{-1}$	1.99	5.09	$1.24 \cdot 10^{1}$	$2.44 \cdot 10^{1}$
	Al	93	$1.95 \cdot 10^{-2}$	$5.41 \cdot 10^{-2}$	$1.38 \cdot 10^{-1}$	$3.11 \cdot 10^{-1}$	$8.65 \cdot 10^{-1}$	2.21	5.41	$1.06 \cdot 10^{1}$

			Cross section [mm²]							
Cable		k	50	70	95	120	150	185	240	300
PVC	Cu	115	$3.31 \cdot 10^{1}$	$6.48 \cdot 10^{1}$	$1.19 \cdot 10^{1}$	$1.90 \cdot 10^{2}$	$2.98 \cdot 10^{2}$	$4.53 \cdot 10^{2}$	$7.62 \cdot 10^{2}$	$1.19 \cdot 10^{3}$
	Al	76	$1.44 \cdot 10^{1}$	$2.83 \cdot 10^{1}$	$5.21 \cdot 10^{1}$	$8.32 \cdot 10^{1}$	$1.30 \cdot 10^{2}$	$1.98 \cdot 10^{2}$	$3.33 \cdot 10^{2}$	$5.20 \cdot 10^{2}$
EPR/XLPE	Cu	143	$5.11 \cdot 10^{1}$	$1.00 \cdot 10^{1}$	$1.85 \cdot 10^{1}$	$2.94 \cdot 10^{2}$	$4.60 \cdot 10^{2}$	$7.00 \cdot 10^{2}$	$1.18 \cdot 10^{3}$	$1.84 \cdot 10^{3}$
	Al	94	$2.21 \cdot 10^{1}$	$4.33 \cdot 10^{1}$	$7.97 \cdot 10^{1}$	$1.27 \cdot 10^{2}$	$1.99 \cdot 10^{2}$	$3.02 \cdot 10^{2}$	$5.09 \cdot 10^{2}$	$7.95 \cdot 10^{2}$
G2	Cu	141	$4.97 \cdot 10^{1}$	$9.74 \cdot 10^{1}$	$1.79 \cdot 10^{1}$	$2.86 \cdot 10^{2}$	$4.47 \cdot 10^{2}$	$6.80 \cdot 10^{2}$	$1.15 \cdot 10^{3}$	$1.79 \cdot 10^{3}$
	Al	93	$2.16 \cdot 10^{1}$	$4.24 \cdot 10^{1}$	$7.81 \cdot 10^{1}$	$1.25 \cdot 10^{2}$	$1.95 \cdot 10^{2}$	$2.96 \cdot 10^{2}$	$4.98 \cdot 10^{2}$	$7.78 \cdot 10^{2}$

Figure 4 demonstrates how to calculate I^2t. After calculating short-circuit current, the cut-off time is computed, and equation 1 will be considered. Figure 3 shows the maximum withstood energy for cables (K^2S^2). Another factor to be considered in cable calculations is starting current, which is calculated by using equation 2.

$$I_b = I_b + \frac{I_{starting}}{3} \quad (2)$$

For Example, the initial values for direct starting currents are as follows (3).

$$Dol\begin{cases} 1\ phase = 7 - 20 \\ 3\ phase = 4 - 7 \end{cases} \quad (3)$$

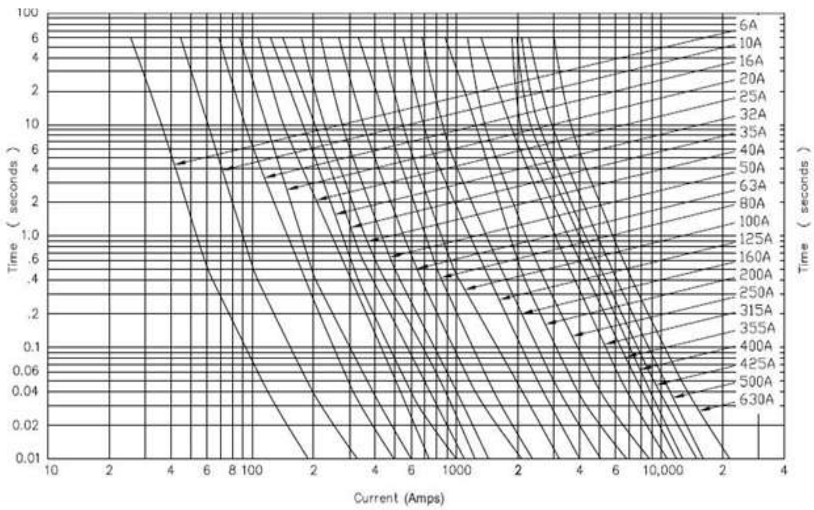

Figure 4. Relation between Time-Current for fuse selection.

2.4 Short-Circuit Calculations

Another issue that is not commonly used in designing low-voltage networks is short-circuiting calculations. According to the ABB Handbook, approximate methods for computing short circuits are sufficient.

Three-phase short circuit, $I_k = \frac{S_k}{\sqrt{3}.U_r}$ (4)

Two-phase short circuit, $I_k = \frac{S_k}{2.U_r}$ (5)

2.5 Description of Electrical Panel Menu

The best part of this software is the electrical panel calculation and design. For this reason, the first software asks for some information such as load information, power factor, maximum voltage drop, length of cable and method of cable installation, and other related data. After that, according to the entry data, the software calculates all of the parameters such as demand, cable sizing, and related protection. And at the last stage, the genetic algorithm is used for load balancing. One of the most important abilities of this software is its connection to AutoCAD and generate an editable map in DXF format. Also, the experts can provide a Calculation notebook and send it to the owner for more information. The advantages of this section in comparison with other software, such as Simaris, are load balancing and editable maps, and independence calculation without any relation with the brand.

3. ABILITIES AND OUTCOME FROM THE VOLTA SOFTWARE

3.1 Abilities of the VOLTA software:

An electrical installation professional must be knowledgeable about a wide range of topics and capable of designing in a variety of sectors. As a result, a suitable tool can assist him in creating an accurate and error-free design. The software team [11] created unique software for electrical specialists in Iran. The entire menu is shown in Figure 5.

2.2 Outcome of the VOLTA software:

The most critical features of the proposed software include a PDF with complete calculations and a DXF file containing single-line and riser designs in AutoCAD. Figures 6 and 7 show some application outcomes. The output of the VOLTA software is also used to design solar power plants [12]. Other products developed by the author have been used to design famous projects in Iran [13,14,15].

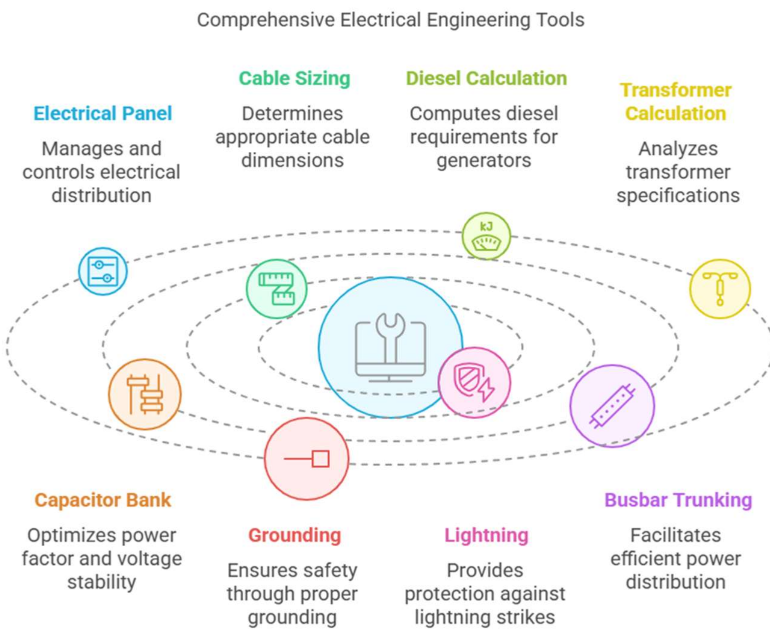

Figure 5. Customized menu of VOLTA software.

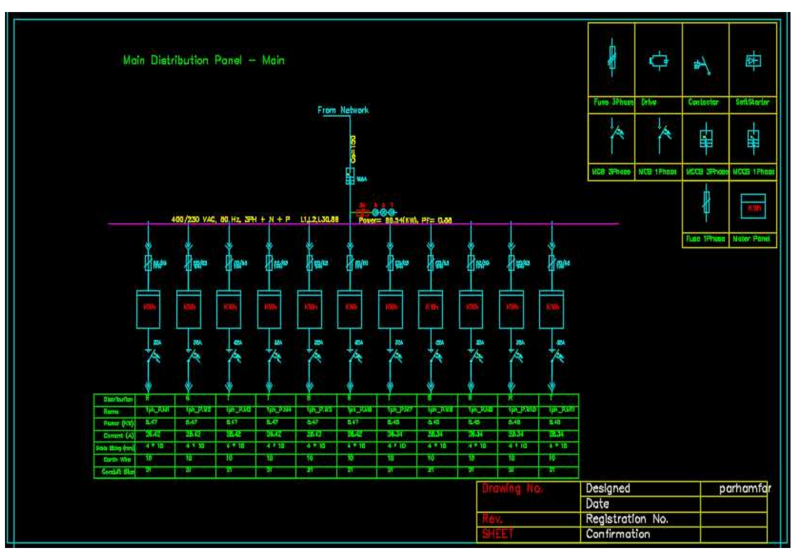

Figure 6. Sample of a single diagram exported in AutoCAD.

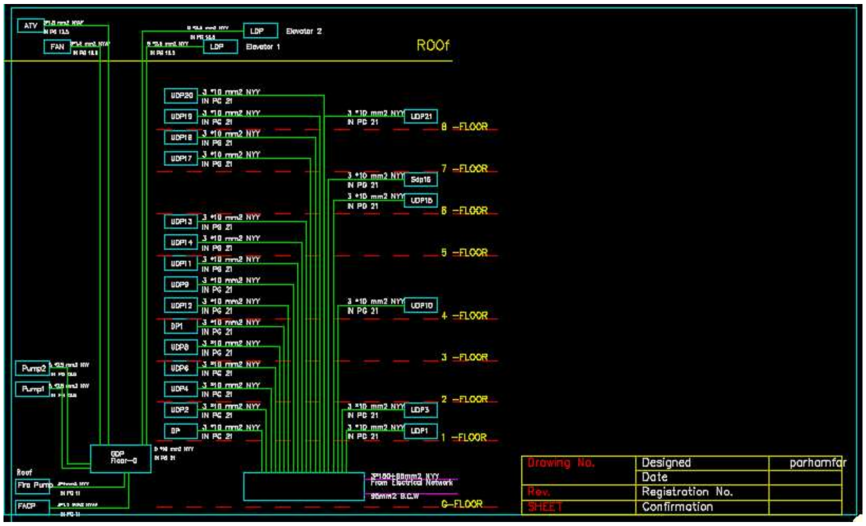

Figure 7. Sample of Riser diagram exported in AutoCAD.

4. CONCLUSION

Nowadays, software plays a vital role in engineering processes. Because of life's obstacles and issues, as well as the vast amount of data, mistakes are common. As a result, engineering applications can assist them in achieving quick and accurate solutions. Each expert technical team can identify a relevant market and use Microsoft Visual Studio and other tools to develop software. This software has found around 500 users due to the prevalence of foreign cracked software and a lack of adequate copyright protection in Iran. For future work, offer a list of materials and calculate the project's costs, import an AutoCAD map, detect the space, and generate the automatic map.

DECLARATIONS

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Author contribution

Mohammad Parhamfar: conceptualization, investigation, supervision, visualization; writing – review & editing.

Data availability interest

The data supporting this study's findings are available from the corresponding author upon reasonable request.

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