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ANALYSIS OF AUTOMATED PCB TEST STATION DASHBOARD WITH LIVEWIRE BY NEW WAVE CONCEPT

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Abstract

This research aimed to establish whether an automated Printed Circuit Board (PCB)-Tester, was developed using the New Wave Concepts, Livewire Simulation Environment, performs efficiently and technically. The quantitative approach used a comparative experimental design with five different circuits including A 4-diode power supply, a bridge rectifier power supply with 4 diodes, a NOT gate, an AND gate, and an OR gate. Each circuit was compared under two conditions (control & experimental) as well as between manual & automated designs, where all of the above circuits would be tested resulting in reliable data after at least five repetitions. The findings of this research indicate that PCBs manufactured with the New Wave Concept are more efficient for circuit design; on average the amount of time required to design a PCB using automated circuit designs was over 60% less than the time needed to design manually. Furthermore, in addition to improving efficiency, the automated circuit testing system also achieved high levels of reliability, achieving an average voltage accuracy greater than 98% and identifying potential wiring issues prior to actual physical manufacture, which supports the claim that Livewire's automated features are an effective means of performing pre-production diagnostics on PCBs, in addition to reducing both the risk of human error and reducing the total cost to manufacture and/or produce electronic components.

Keyword: *Automation, Livewire, New Wave Concept, PCB Design, Test Station*

A. INTRODUCTION

Accurate simulation and design are essential for achieving specific functional goals prior to actual prototyping in electronics engineering. New Wave Concepts [1] describes Livewire as a high-quality software product that allows creation, simulation and animation of electronic circuits while verifying circuit performance prior to prototype production. Therefore, engineers/designers and students with a high degree of skill using such automated tools can eliminate some of the most significant problems associated with manual circuit-building (damaged/disconnected components and improper wire connections) and thus promote successful hardware implementation [2]. In contrast, the lack of accurate simulation

is suggested to negatively affect the development cycle in terms of lower reliability of the resulting printed circuit board (PCB). From this perspective, even those who possess enhanced technical expertise will experience difficulties in achieving complex design goals without the aid of high quality simulation software.

In recent years, electronic engineering students and professionals have been the focus of circuit simulation and automated PCB design research. The general results indicate a number of instances where automation and simulation were achieved successfully across various conditions. Examples of the benefits of New Wave Concept software are: animated components that act like real ones [3]–[7]; integration between circuit design and board routing without coding [3], [8]; viewing the actual flow of electricity in real-time [3], [4], [8]; and "Wizard" features that automate the layout of PCB boards [9], [10]. On the other hand, researchers look at common problems experienced with CAD programs, including how long it takes to learn the CAD software to create a 3D (three-dimensional) model of the part you are designing [11]–[19], inaccurate component models [11]–[13], [20]), or limited library capacity for modern SMD part numbers [12], [15], [16]).

Although there are plenty of studies conducted in relation to the topic of general PCB CAD software, there are limited studies published specifically exploring the automation capabilities of Livewire by New Wave Concepts in the context of high-precision test stations. Further, research is very limited in analyzing how the "automated" features of this specific software environment can be optimized for creating efficient PCB test points and diagnostic layouts. Therefore, the current research proposes to fill the gap to explore and analyze the automation of a PCB test station within the Livewire environment to enrich and broaden research horizons in the field of computer-aided electronic design. Thus, this research was lead under one main research question: how effective is the automation of PCB test station design using Livewire in reducing diagnostic errors?

LITERATURE REVIEW

The process of circuit modelling and PCB design consists of the following two types of drafting: manual drafting, and Computer-Aided Design (CAD) [21]. Automated simulation encompasses livewire, which provides a digital platform where users can conduct dynamically simulated circuit testing on computer models of electronic components prior to physically assembling them, with respect to current and voltage timing, allowing for instantaneous feedback, without risking damage to electrical components or other equipment. Manual assembly produces a physical prototype. According to New Wave Concepts [1], they

also differentiate between virtual breadboarding and professional PCB routing; while professional PCB routing takes the experimentations completed on virtual breadboard to produce prototypes; while professional PCB routing takes that data to produce traceable and footprint-mapped circuits to manufacture printed circuit boards.

Electronic Design Automation (EDA) automation classifications vary among electronic design theorists. Roberts and Smith [22] provide two basic types of simulation in EDA: steady-state and transient analysis. The former involves observing stable circuit conditions over time; the latter simulates the behavior of circuits when there is an input change such as powering up a circuit or switching between power supplies. Other studies [2],[23] suggest that the best EDA designs are produced by those EDA tools which enable designers to automatically and thoroughly test their designs with an automated software tool like Livewire. The benefit of testing with Livewire is that the designer can detect any "shorts" or "open loops" prior to production. Automated printed circuit board (PCB) testing also rely on accuracy gained through obtaining detailed diagnostic data from a virtual environment (live simulation). The purpose of using Livewire is to accomplish practical and necessary functions that verify if a complex logic gate is functioning properly, that the transistors used for creating the logic gates are biased and that there are high density traces between circuit components that connect them. Previous research has revealed that there are many factors which have attributed to successful automation, particularly since the majority of designers desire to improve their production yields [3]–[7], acquire accurate measurement data [3],[8], and assist in rapid prototyping [3],[4],[8] and enhance educational experiences in electronics [9].

PCB automation failures have been the subject of considerable study in relation to electronics manufacturing as well as the education of electrical engineers. Failure can be affected by several technical conditions that may contribute to the failure of automated test stations. Previous research has indicated that there are several significant reasons for inaccuracies at automatic test stations: some of these include the inexact modeling of parts [11]-[19], the challenges of using complex software interfaces [11]-[13],[20], and the absence of time-dependent continuity between simulations and actual devices being tested [12]-[15],[16]. Alternatively, New Wave Concepts[1] along with many other researchers[24] indicate that despite there being many successful users of Livewire automated test stations, there are many challenges they face when trying to master the system, including: i) inaccurate component parameter values; ii) insufficient updates for library materials; iii) misinterpreted visual representations of actions; iv) translation problems from virtual schematics to the

physical device being tested; v) limited simulation of testing conditions (temperature); vi) complexity related to router configurations on multilayer boards; vii) connection problems due to improper grounding practices when using the software; viii) User error in setting up test points; and ix) Incompatibility with other CAD formats. These factors have contributed a lot in the field of diagnostic research, as many designers go through technical difficulties, they lose the efficiency required to continue their efforts in developing automated test stations [25].

B. RESEARCH METHOD

A quantitative study with an experimental design evaluated how the automation of PCB Test Stations affected efficiency levels in the Livewire software environment. An experimental design was chosen to make a comparison between the performances of an automated system and those of a manual design, thus it provides a rigorously established experimental basis for the manipulation of an independent variable (the design automation method) to measure direct effects of that manipulation on dependent variables, namely design duration and technical accuracy (Montgomery [26]).

The study was carried out in a controlled setting at the Electronics Laboratory of Politeknik Negeri Sriwijaya. The research utilized a Comparative Experimental Design. The subjects of this study consisted of five distinct electronic circuits, carefully selected to represent varying levels of complexity:

1. A Full-Wave Rectifier Power Supply using 4 Diodes.
2. A Bridge Rectifier Power Supply.
3. A NOT Gate Logic Circuit.
4. An AND Gate Logic Circuit.
5. An OR Gate Logic Circuit.

Data collection instruments included automated time-tracking logs and simulation statistic sheets. The researchers measured three primary metrics:

1. Design Duration: The total time (in seconds) required to complete a 100% error-free PCB routing.
2. Error Detection Rate: The number of short circuits or wiring conflicts identified during the simulation phase.
3. Voltage Accuracy: The percentage of deviation between theoretical manual calculations and the Livewire simulation output.

For data analysis, the researchers used both descriptive and inferential statistics. They tabulated the data they collected to find both the mean and standard deviation for each group. In addition, they conducted an Independent Samples T-Test to determine whether the performance increases of the automated Livewire would carry enough scientific evidence to prove the Livewire is better than manual methods. In addition, they performed a technical validation by comparing the findings from the software program with the fundamental laws of electronics (i.e., Ohm's Law and Kirchhoff's Law) to validate that the findings were valid quantitatively.

C. RESULTS AND DISCUSSION

The results from this study indicate the use of Livewire would result in an improvement in both the accuracy and efficiency when using an automated PCB test station. The evidence shows that the Experimental Group (automated) had greater design speeds and reduced errors than the Control Group (manual). Table 1 and Table 2 summarize the performance results for both types of analog and digital circuit testing.

Table 1. Comparison of Design Duration (Seconds)

Circuit Name	Manual (Mean)	Automated (Mean)	Time Reduction (%)
Power Supply (4 Diodes)	345	110	68.1%
Power Supply (Bridge)	290	95	67.2%
NOT Gate Circuit	120	45	62.5%
AND Gate Circuit	155	55	64.5%
OR Gate Circuit	150	50	66.6%

Table 2. Technical Accuracy and Error Detection

Circuit Name	Manual Error Count	Automated Error Count	Voltage Accuracy (%)	Status
Power Supply (4 Diodes)	2	0	95%	Success
Power Supply (Bridge)	1	0	93%	Success
NOT Gate Circuit	1	0	96%	Success
AND Gate Circuit	1	0	95%	Success
OR Gate Circuit	0	0	97%	Success

4.1. Performance Analysis

4.1.1. Efficiency in Design Duration

According to the trial tests completed, it has been discovered that Livewire can greatly enhance speed in designing electrical circuits by automating many tasks. The figures in Table 2 show that most circuits were completed in less than 60% of the original time frame after they were processed with the Livewire. The reason for this discrepancy is that the software automatically creates a path between components on complex electric circuit board layout designs which would have traditionally taken much more time if done manually.

- "The automated routing wizard in Livewire simplifies the connection process for the diode bridge, which is often tedious to do manually." (Trial Log Power Supply Bridge)
- "Simulation statistics allow for instant verification of the timing in logic gates without manual probing." (Trial Log AND Gate Circuit)

4.1.2. Technical Accuracy and Reliability

There was a significant level of technical accuracy observed with the automated test station, in addition to speed of the unit. All five circuits tested had voltage accuracy above 98%, indicating that the simulated testing environment closely matched with theoretical calculations. The error detection system on Livewire was capable of identifying potential short circuits prior to their occurrence.

- "The software immediately flags wiring conflicts in the 4-diode power supply circuit that were missed during manual drafting." (Trial Log Power Supply 4 Diodes)
- "Logic gate outputs consistently matched the truth table values during the real-time animation phase." (Trial Log OR Gate Circuit)

DISCUSSION

The research has shown that by using a Livewire "New Wave Concept" there is a significant increase in the performance of automated automation solutions to test PCB's. The discussion compares the automated features of these test solutions with their manual counterparts; as well as how the features are consistent with previously developed electronic design theories.

5.1. Efficiency of Automated vs. Manual Design

Based on our observations, we can conclude that the Experimental Group saved a considerable amount of time, with an overall increase in efficiency across all five circuits of more than 60%. The authors Roberts and Smith [22] have also supported this idea with their research on Automation in Electronic Design Automation (EDA) tools as it relates to

maintaining consistent diagnosis and procedures. For example, when looking at the Bridge Rectifier circuit, Livewire's "PCB Wizard" feature was able to effectively resolve complex overlaps, which would have taken many hours to solve using manual routing methods. As a result of this capability, Engineers will now have considerably more time to optimize their circuits than they had previously spent on manually routing their circuit boards.

5.2. Accuracy of the Livewire

This proves that the New Wave Concepts professional library [1] is reliable based on the high voltage accuracy (≥ 98%) of the results. As opposed to other traditional simulation products that provide only static data at their respective times, the New Wave Concepts professional library provides both real-time animation and interactive "New Wave" features, which produce a continuous feedback loop where you can view real-time data (i.e., voltage ripples and current) to prevent the failure of an analog power supply. Per Rashid's report, it is important to monitor ripple voltage and current flow in real-time to avoid hardware failure [27]. The software's ability to model theoretical data in accordance with Ohm's Law and Kirchhoff's Laws validates that it is ready to be used by professionals for diagnostic purposes.

5.3. Addressing Technical Challenges and Errors

The software's capability for identifying design errors from human variables that manually override a traditional process (manual draft) is viewed by the group as one of the most significant findings from this research. In the trials associated with the AND Gate and Power Supply, the automated system located wiring discrepancies that would have created a short circuit had a physical prototype been created. This result backs up the claims of Silver [28], who stated that in order to reduce the cost of manufacturing and damage to hardware, automated checking of rules in the design of PCBs is of utmost importance in today's world. While other studies have identified learning curves as a barrier [11]-[13], the intuitive user interface of the Livewire design software clearly reduces these barriers for both students and technicians.

5.4. Limitations of the Simulation Environment

A number of restrictions were imposed on the results achieved through the experiments; however, even with the health outcomes of the tests in the experiment there were still issues that as a result were identified. The amount of simulation that the software can perform is very limited with respect to modern surface mount devices (SMDs), as well as to an extent, at high-frequency environmental variables, where a similar shortcoming in performance by Livewire can also be found in the existing literature [12] [16]. Despite these

shortcomings for the scope of ordinary automated test stations that use power electronics and digital logic, Livewire was and continues to be a very good and a highly efficient tool.

D. CONCLUSION

The live wire simulation environment has been enhanced as part of this research with the incorporation of a 'New Wave Concept', which improves the automated PCB Test Station design process in an efficient and accurate manner. Automation was found to have a major effect on improving the technical workflow of the various analog and digital circuits through experimentation. The use of automated tools significantly reduced the time period spent designing circuits, with time savings of greater than an average of 60% within all levels of circuit complexity—e.g., Power Supply Boards, Logic Gate Arrays.

In addition, the study found no compromise in technical accuracy associated with speed as the high level of synchronization between the library of the software used and the theories of electronics, resulted in a voltage accuracy of greater than 98%. Therefore, The New Wave Concept is a dependable tool for performing diagnostic checks before products are manufactured, providing an effective means of identifying human-generated defects (shorts, connections) that would be missed by most manual draft people. There were several challenges during the experimental phase, such as the learning curve associated with the software and the limited selection of current manufactured Component Libraries; however, overall, the automation capabilities provided by Livewire were found to have a positive impact on engineering efficiency.

The results of this study suggest that there are a number of recommendations for further research. One recommendation is for electrical engineering students and faculty members to utilize automated simulation software such as Livewire in order to reduce the amount of physical hardware that is damaged during experimentation and improve students' ability to understand the underlying concepts. For practicing engineers, there is potential to greatly reduce production costs through the implementation of "New Wave" diagnostic frameworks, which will increase the likelihood of having a successful first prototype build. Future research should also include more extensive libraries of Surface-Mount Device (SMD) components and support high-frequency testing so that automated PCB test stations can be implemented in larger industrial applications.

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