DOI: http://dx.doi.org/10.26483/ijarcs.v15i5.7132

Volume 15, No. 5, September-October 2024

ISSN No. 0976-5697

International Journal of Advanced Research in Computer Science

RESEARCH PAPER

Available Online at www.ijarcs.info

DEVELOPMENT OF ARDUINO-BASED ELECTRONIC COMPONENT TESTING DEVICE

Rexcel Entienza
College of Engineering, Architecture and Fine Arts
Batangas State University, Philippines

Jeffrey Sarmiento
College of Engineering, Architecture and Fine Arts
Batangas State University, Philippines

Mark Angelo T. Mercado
Department of Computer Engineering
National University, Philippines

Abstract: As advancements in electronics continued, the limitations of traditional component testers became increasingly evident. Most available testers were designed to evaluate a single component type, resulting in a circuit testing process that was often cumbersome and time-consuming. This inefficiency posed challenges to both learning and innovation in educational and professional environments. To address the growing demand for more efficient and versatile testing tools, the development of a multi-component tester became crucial. The proposed project aimed to create an integrated electronic components tester capable of evaluating a wide range of components, including integrated circuits (ICs), resistors, transistors, and capacitors. This all-in-one device was designed to streamline the testing process, improving the user experience in electronics laboratories and supporting professionals in the fields of electronics repair and development.

Keywords: electronic components, circuit testing, integrated circuits, multi-component tester, electronic innovation

I. INTRODUCTION

An electronic component is defined as a basic element in electronics that has leads (terminals) which enable it to be connected to other components to form functional devices depending on the intended application. Components are divided into passive components and active components. Active components use as a direct source of energy while passive components only rely on the available power.

Electronic components are a vital part of the manufacturing process of electronic goods. The quality of components used in manufacturing process can determine your future and growth in the market. Quality components ultimately enhance the quality of the product as well as its durability.

In Batangas State University – Alangilan Campus, students under computer courses use electronic components almost in every laboratory experiments. Electronic Component is an essential thing to finish every single activity according to (Haleem et al., 2022). In line with that, these kinds of materials should be maintained and checked regularly to ensure its good performance and condition. And this is what Bat-Su needs, an electronic components tester that will give solutions to every student's problem and will also give benefits to the student assistants of the laboratory and the Bat-Su Laboratory itself.

According to; currently the head of the Laboratory Department, Bat-Su Engineering Laboratory has no specific way of maintaining the electronic components available. Bat-Su Laboratory doesn't have enough testing devices to maintain all of the electronic components specially the integrated circuits (IC's). Due to lack of testing devices, it is difficult for them to categorize the condition of components. It is also difficult to label integrated circuits accordingly and sorting then moving all of it to its respective places. Another problem is that not all of the student assistants of Bat-Su Laboratory has knowledge on handling and testing electronic components. Existing testing devices in the laboratory are hard to use when the user don't have enough knowledge to operate and use it properly.

Defective electronic components can lead to many disadvantages referring to (Maurice et al., 2021); it can lead to an accident when a damaged component was use. Some possible accidents to occur are short circuits, tendency for the electronic components to burn and the tendency that the students will suffer electric shock. It can affect the whole project and laboratory experiments of the students in a way that it is so time consuming for students to test each component before using it just to ensure its condition.

The above mentioned problems lead the proponent on the idea on making an electronic components tester. In order to address these problems, the proponents will present a method on creating an Arduino-based electronic components tester to test specific TTL IC's (7432, 7411, 7404, 7486, 7410, 7427, 7408), BJT transistor, electrolytic capacitor, fixed resistors that will serve as an additional testing device, reduce time on testing electronic components, gives solution to student assistants problem (user-friendly), prevent possible small accidents to occur and provide a useful and more beneficial device for the Bat-Su Laboratory by applying the Arduino technology.

II. LITERATURE REVIEW

2.1 Factors that can affect electronic components reliability

According to (Kulkarni et al., 2020). An example of the first case is that a damp PCB will impair the operation of the circuit on it and, if severe enough, will halt it altogether. On the other hand, high salinity will gradually corrode the mating surfaces of a connector until eventually the electrical path is broken and failure results. The practical difference between the two cases is that the first can be detected during system commissioning whereas the latter appears only later, in the form of low reliability. All the ambient conditions mentioned exist, to some degree, in the onshore environment, so the components considered are already protected from them to some extent. Resistors, capacitors, diodes, transistors, ICs and hybrid circuits are protected by their packaging, and connectors are constructed from materials which resist corrosion (e g, gold). The problem is to establish the degree to which the standard packaging and materials are suitable to protect the components from the more severe environment they will experience offshore.

2.2 Testing Electronic Components

According to (Kui et al., 2020). During your design phase, thinking about the testability of your component should be an important focus. Using a ― Design for Test ‖ methodology, can influence design and make sure meet test requirements early on. Something like setting additional test points and using push-down resistors on inputs and outputs. During the process, have visibility to the whole production process (not just testing) and be able to calculate costs of testing and also assess potential risks.

According to (Palmieri et al., 2022). Besides testing capacitors, transistors and resistors individually, the passive component test devices are also able to measure assorted electronic components composed of them. Individual components include wound components and communication and power filters; Composites include switches, connectors, lead wires, conductive, dielectric material, magnetic material and semiconductor components. The tests not only analyze the characteristics of these components but also optimize the entire application process including the inspection of auto manufacturing and incoming/outgoing material, quality verification and RD analysis in order to meet the low cost/high efficiency requirements. The circuit is a low cost Electronic Sensor & Component Tester which is powered by a 9V, 300mA Battery. It does not include any Integrated Circuit(IC), Sensor or Digital Display. This circuit can be used to test any faulty components. Unlike a Digital Multi- meter it will not display the values of the component. It can also be used to test the polarity of certain forward biased or reversed bias components.

2.3 Working principles of Transistors

According to (Maftunzada, 2022). Transistor is a component which is sensitive to measure. The performance of electronic components is more and more influenced by what happens to electrons at the boundaries of materials, since the likelihood of an electron being close to an interface increases as size decreases. Transistors are the basic building blocks of microchips, and are found in everything from computers, to smartphones and amplifiers. Their function fundamentally depends on how electrons flow near or at the interfaces between their metallic, insulating and semiconductor materials. Transistors today can be as small as 10 nanometers wide, and they're getting smaller. If you have a smartphone in your pocket, it most probably has more than a billion transistors within.

2.4 Common cause of electronic components failure

According to (Zhang et al., 2019). The perfect storm is brewing in the automotive electronics supply chain. Industry professionals are seeing lead times on "passives" — electronic components such as resistors, capacitors, inductors and integrated circuits — stretch out to one year or more in some cases. The issue is can be classified in various ways, such as by time or cause. Failures can be caused by excess temperature, excess current or voltage, ionizing radiation, mechanical shock, stress or impact, and many other causes. In semiconductor devices, problems in the device package may cause failures due to contamination, mechanical stress of the device, or open or short circuits.

According to (Zhao et al., 2023). The failure occurs soon after starting to use the product, and the failure rate drops gradually over time. One of the factor is the latent internal causes that existed in the product from the start, second is external stressors such as heat and humidity applied from the usage environment (external causes), and also degradation with time. The main cause is thought to be latent defects. Regular testing electronic components are essential for preventing it from being damaged. After the initial failure period eases, a period starts during which failure can occur by chance. These failures are usually caused by unpredictable events such as lightening and dropping the product. This means that such failure occurs at a nearly constant failure rate that is unrelated to how much time has passed. The goal is to reduce accidental defects in the production process and fluctuations in environmental stressors during use to approach a zero failure rate.

2.5 Accuracy, Precision and Resolution of Electronic Components

According to (Zivkovic et al., 2019). Quantities can't be determined with absolute certainty. Measurement tools and systems have always some tolerance and disturbances that will introduce a degree of uncertainty. In addition, also the distinctiveness is a limiting factor.

The following terminology are often used in relation to the measurement uncertainty:

- Accuracy: The error between the real and measured value.
- Precision: The random spread of measured values around the average measured values.
- Resolution: The smallest to be distinguished magnitude from the measured value.

2.6 Functions and Uses of Arduino

According to (Kondaveeti et al., 2021). Arduino is more portable than any other electronic prototyping platform for design. A user does not need to use it in the confines of a lab where special computers or other components are needed. The Arduino is a singular unit and connects with USB, the most common standard for connecting devices which makes it accessible outside a lab environment. The Arduino's board design evolves because of an active community of users who support both the history and future of the product. The Arduino microcontroller advances in its hardware design, software examples and popularity because user's document and share code and designs. Open source platforms such as the Arduino microcontroller builds upon the creativity of an entire group of people rather than the small team from which it originated. Arduino is licensed with a share-alike creative commons license. With this license, users of the Arduino are able and encouraged to share designs, reuse, and remix these designs to adapt the Arduino for their work.

2.7 Different Applications of Arduino

According to Pedro Antonio Garcia-Tudela & Jose-Antonio Marin-Marin. Computational Thinking, Programming and Robotics in Educational Contexts. Arduino microcontroller application was found to be supportive in a laser lab class where students learn about general lab control and data acquisition techniques in addition to their laser work. Scanning, coincident counting within detection window, etc. are useful examples. Less critical applications such as FM detection with Arduino microcontrollers are popular in hobby electronics and usually attract the attention of students readily in an introductory session. A frequency counter tutorial has been published as well. An application of Arduino microcontroller in field operation is currently being developed with Brookhaven National Lab to strengthen our engineering technology curriculum. Ultrahigh Energy Cosmic Ray detection using RF technology has been an important tool in cosmology. Arduino microcontroller would add decision capability to improve the detection scheme. Extension to the use of Arduino microcontroller in atmospheric disturbance studies is also possible since terrestrial gamma ray flash, etc. also would carry RF signatures. Such data would supplement those events collected by satellite.

According to (Taufiq et al., 2020). Projects based on integrating already available resources were accepted in to improve system integration skills. In same authors reported that the main microprocessors course learning objective is to ―create‖. Hence; the assessment scheme was updated with a deliverable document distinguishing the students' contribution from used resources. Authors reported the improvement of the students' system design capabilities. In most previous works, Arduino was programmed using its C-like language; thus only providing high-level knowledge. The single exception was for Arduino, in which Assembly was used during the final stage of the course using studio but not necessarily for Arduino. Assembly usage in was for the PIC microcontroller during the course. However, Arduino was always programmed using C in the project. This still offers both low-level and high-level knowledge as in. Both approaches address ―the lack of low-level knowledge‖ concern raised. As for the effect on students' performance, the percentage of students successfully passing the course has increased, after using Arduino, from 61% to 92% in module I and from 66% to 93% in module II. A study conducted over three consecutive semesters revealed that 94% of students selected Arduino for their course projects. Out of these students, 59% continued to use Arduino in their capstone courses resulting in an improved performance. The cooperative learning methodology, with the use of Arduino, resulted in improving the academic success of students with 93.5% scoring above 85%. One cited advantage is the reduction in project development time allowing for post evaluation, and increasing code complexity. Same advantage was highlighted, as using Arduino allowed students to develop fully functioning systems with the appropriate documentation in less time. The concern highlighted about timers was also identified. The concern was addressed by changing the course delivery method to use Studio towards the end of the course in order to program Arduino in low-level. An important advantage reported is the need for little lab space. As students can buy their own Arduino platforms at an affordable price, there becomes no need to purchase and install dedicated laboratory equipment for the course. Finally, one major advantage identified in most of these works is the ease of learning and using the Arduino platform (Accessibility Ease of interfacing external chips, Ease of use and Support material). With the availability of numerous online forums and groups, tutorials, and previously implemented projects, it becomes easier for students to learn such a platform in less time.

2.8 Reliability of Electronic Components

According to (Samokhin et al., 2019). The increasing demand for electronic components has been driven by a number of application categories, including communications, medical services, signage, and general illumination. The construction of Electronic components is somewhat similar to microelectronics, but there are functional requirements, materials, and interfaces in Electronic components that make their failure modes and mechanisms unique. This paper presents a comprehensive review for industry and academic research on electronic components failure mechanisms and reliability to help electronic components developers and end-product manufacturers focus resources in an effective manner. The focus is on the reliability of Electronic components at the die and package levels. The reliability information provided by the electronic components manufacturers is not at a mature enough stage to be useful to most consumers and end-product manufacturers. The diodes and the rectifiers are bipolar components with non-linear constants which have a different behaviour, depending on the polarization of the applied voltage. The rectifier diodes for general purposes (namely without avalanche breakdown) are improper for high transient reverse voltages. The small irregularities of the barrier layer may lead to a local breakdown, which may produce a local overheating (hot spot) leading to chip deterioration. Despite of the important costs for reliability assurance, new defects arise all the time, leading to perturbations in the operation of the equipment. Since the majority of stress tests don't supply information about the long time behaviour (failure rate or other comparable reliability indicators can not be calculated), the only possible manner to obtain reliability data is the trial operation under the most appropriate conditions for the foreseen utilisation. With this end in view, the user has only the information that in his equipment, in similar loading conditions and coming from the same manufacture moment, the component will have results similar to those obtained from tests. To complete the information, one may say that the trustworthiest data can be obtained only by the equipment operation itself. The completion of laboratory reliability data with failure rate data obtained by testing at the user, in various and arbitrary established conditions (failure rates being in a more or less marked relationship with the operational failure rates) must be only a momentary solution. Consequently it is necessary to concentrate the activity of a reliability laboratory on short duration tests, and not to obtain failure rates from long duration tests.

III. DESIGN OF THE STUDY

This chapter presents a comprehensive analysis and design required in every system development. This includes method that divides complex projects into smaller, more easily managed segments or phase such as the project design, project development, operational and testing, and evaluation procedure.

3.1 Research Design

In this phase, the proponent will conduct research investigation about the most effective method to be used to design a system that will make solutions to the current issues confronting the electronic component testing.

The proponent will conduct several research investigations into a most efficient way of testing electronic components and maintaining its good condition. These are the aspects to be considered in the study. Using available multi-tester, the proponents will practice the present system and the old way of testing electronic components that led to inaccurate results and time consuming method. So far, there is no available integrated circuit (IC) tester in the BatSu engineering laboratory so there is no way to test the condition of the integrated circuits. Electronic components should be maintained and ensure its good condition. The proponents will systematically develop the Arduino-Based Electronic Components Tester to eliminate the problems of students and as a device for maintaining electronic components in the engineering laboratory. Figure 1 shows the V-shaped Model which is a step by step process used by the proponents as a guide in the development of the system.

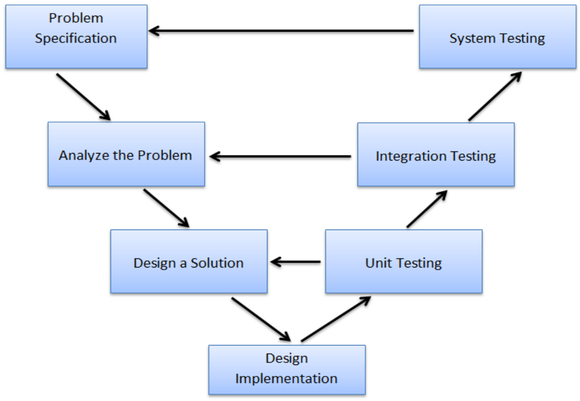

Figure 1. V-Shaped Model

In this approach, the overall process of system development is divided into different phases. Each phase must be completed before the next phase begins. V-shape model focuses on a fairly typical waterfall method that follows strict, step-by-step stages. While initial stages are broad design stages, progress proceeds down through and more granular stages, leading into implementation and coding, and finally back through all testing stages prior to completion of the project.

The V-Shaped life cycle is a sequential path of execution of processes. Before the next phase begins, the current phase must be completed first. Testing is emphasized in this model more than other model. The testing procedures were developed earlier before any coding is done, during each of the phases preceding implementation. The test plan focuses on meeting the functionality specified in requirements gathering. (Lalband and Kavitha, 2019).

3.2 Data Gathering

Electronic components from time to time needs to be maintained; resistors, transistors and capacitors should be measured accurately every time and integrated circuits should be categorized easily even without a label. These processes consumed more time and needs a lot of effort.

In the current system the tester are responsible for displaying the measured value of components. Multi-tester available at the BatSu laboratory cannot be easily calibrated and cannot test neither integrated circuits nor determine its series number or label. Improper testing and handling of components can also affect the results in an ordinary multi-tester.

The proponent come up with an idea to develop a system that could be used as an alternative method on improving the electronic components testing procedures. The proponents will focus on maintaining the electronic components. In addition, the proponents will implement the Arduino technology as the controlling unit of the tester.

3.3 Analyze the Problem

Since the problem has been identified, analyzation of it will be conducted to provide solutions to the stated problem. The proponent studied the requirements for the stated problems such as inputs, the process to be taken and the expected output of the study.

The problems identified in this study are the existing and present testers which displays lack of information about the electronic components, absence of integrated circuit tester in engineering laboratory of BatSu, lack of device for the maintenance of good condition of electric components, time consuming and not a user friendly kind of existing testers and how can the Arduino-based technology improve the process of testing electronic components. These problems define as vital factors that affect the ability of Electronic Component Tester to identify the condition of electronic components and how long it takes to test all of the basic components. The comparison between the traditional and existing tester system and the arduino based system will be carefully observed.

In line with this, as a formulated way on resolving the issue. The proponent rely on modern technology so it came up on using Arduino-based technology as a possible way to properly test the component by using Arduino as the main control unit, in which, identifies the condition of electronic component.

3.4 Design and Metholodogy

Preparing the system design is the next thing to do after analyzing the problem. System design helps in specifying both hardware and software requirements and also helps in defining overall system architecture. This phase examines the software and hardware requirements gained from analyzing the problem, and produce a specification for how each requirement is implemented.

The proponent created the design of the Hardware and System Block Diagram of the study as shown in Figure 4 and 5 which the major components of the system are represented by blocks and connected by lines. The lines show interactions of the components and how the system should be built. The diagram determines the hardware and software structure of the system to meet its requirements.

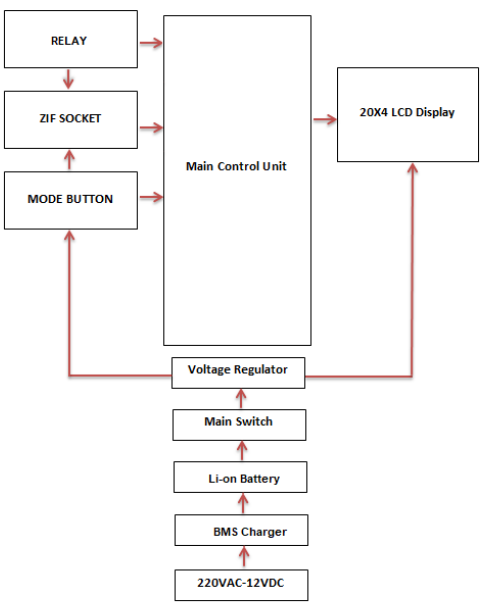

Figure 2. System Block Diagram

To understand the relationship between the hardware components to be used in the whole system each module must be analyzed first. The last part will be the troubleshooting for simple errors, testing connectivity and finally integration of all hardware modules.

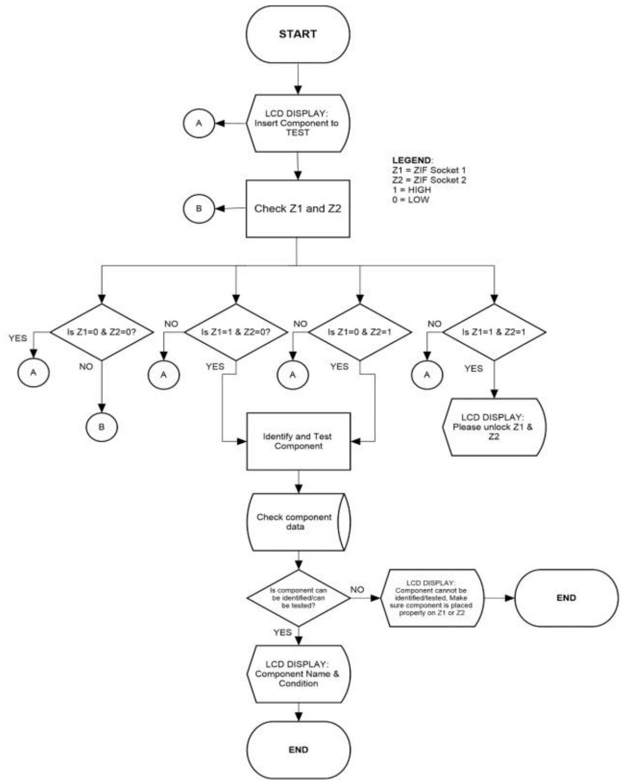

Figure 3. Hardware System Flow Chart

In order to understand the system, flow chart was displayed below showing the graphical flow of the process with the use of arrows and symbols.

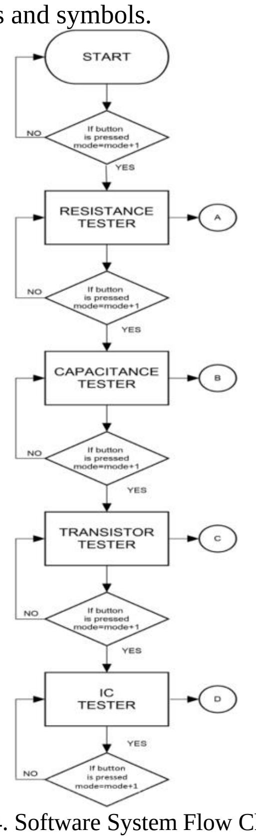

Figure 4. Software System Flow Chart

As the user turn on the tester, the tester will ask the user to select mode of testing. Once the user presses the mode button, it will change its mode of testing from resistor testing, capacitor testing, transistor testing and integrated circuit testing respectively. On each mode the LCD will display ―Please insert … ― followed by the right component to place according to the current mode.

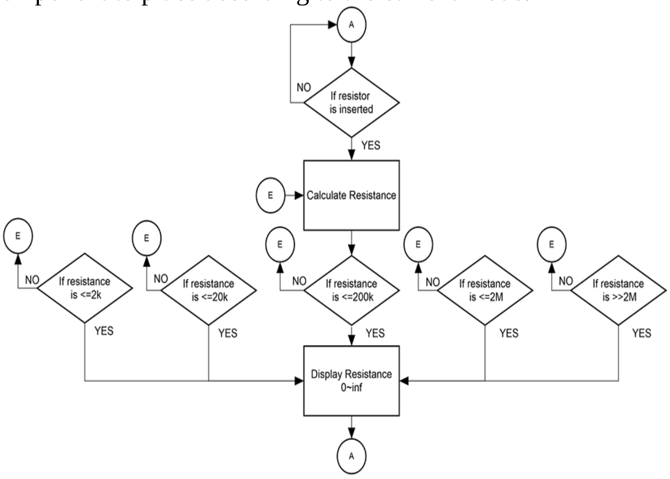

Figure 5. Resistor Testing Flow Chart

Figure 5 shows the flow chart on testing resistors. Once the resistor was inserted, the Arduino Tester will automatically calibrate the way of categorizing the proper resistance of the resistor. It can vary to five values. First is if the resistor is less than or equal to 2K ohms. Second if the resistance is less than or equal to 20K ohms and greater than 2K ohms. Third is when the resistance is less than or equal to 200K ohms and greater than 20K ohms. Fourth is less than or equal to 2M ohms and greater than 20K ohms and last if the resistance is greater than 2M ohms.

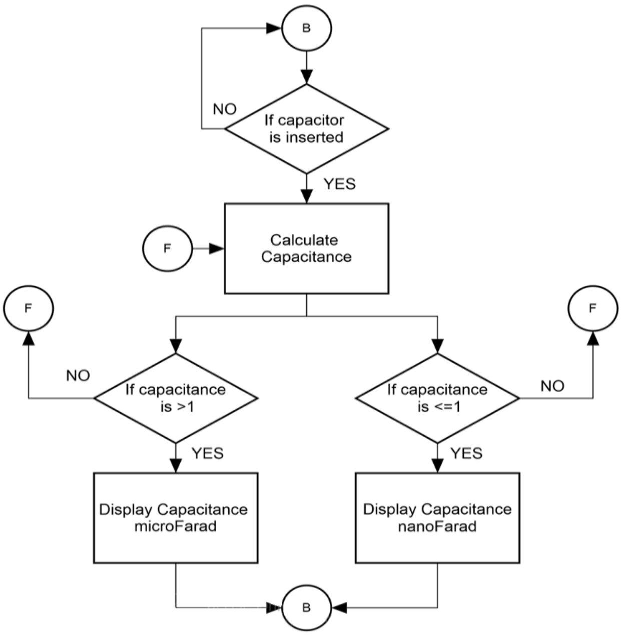

Figure 6. Capacitor Testing Flow Chart

The above figure shows the flow chart on testing capacitors. The system will first check if a capacitor was inserted. If tested true, it will proceed on calculating its capacitance. If the calculated capacitance is greater than one then the label that will display to LCD is in microfarad while when the calculated capacitance is less than or equal to 1 then its label is in terms of nanofarad.

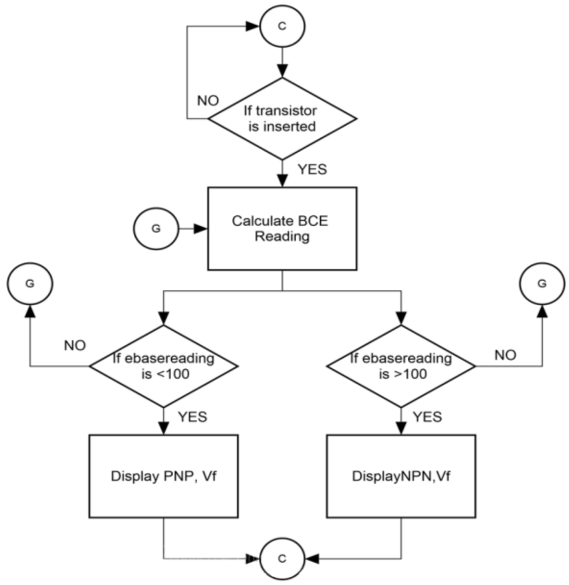

Figure 7. Transistor Testing Flow Chart

On transistor testing the system will calculate the transistor's forward voltage and will identify the transistor type (NPN or PNP). After calculating its base, collector and emitter the system now knows its forward voltage. It's the time now to determine if it's NPN or PNP type transistor. If the ebase reading is less than 100 the system will display that the transistor is PNP. When ebase reading is greater than 100 then it's a NPN type of transistor.

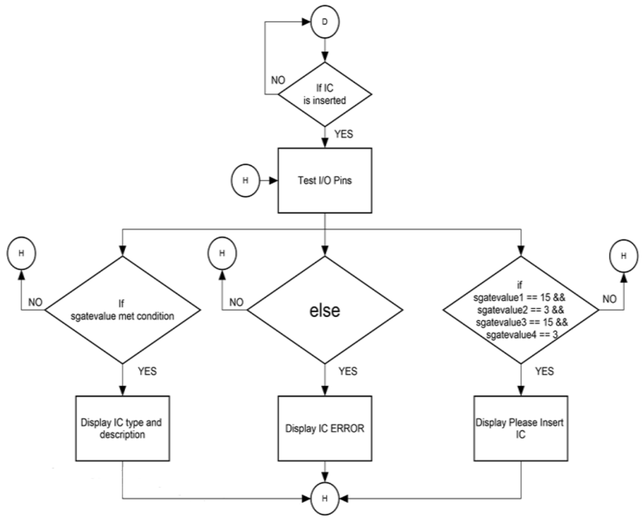

Figure 8. Integrated Circuit Testing Flow Chart

Integrated Circuit testing includes determining if it is defective or not and its series label. The system will first test its I/O pins. After that it will test 3 parameters. If the IC met all sgatevalue condition on the program it will display the IC type and its condition. If all or some of the conditions doesn't meet it will display IC ERROR which means that it is defective. And when the system detected that the component is not properly inserted it will display "Please insert IC".

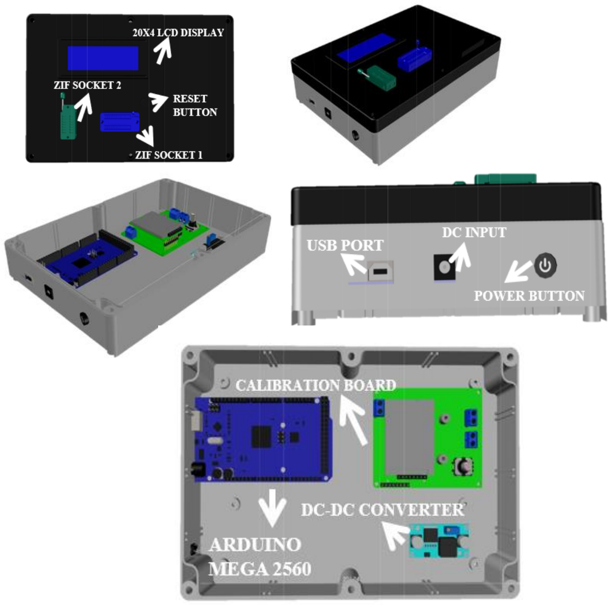

Figure 9. Creative Prototype Design

The image is a set of technical illustrations showing different views and details of the electronic device enclosed in a gray casing. The views include:
A top-down perspective view showing the internal components, such as green and blue circuit boards within the casing.
A close-up on the front face of the device featuring a USB port, a DC input, and a power button.
An angle view of the same casing, giving a slightly elevated perspective that showcases the depth and positioning of the internal components.
An image focusing on the device's display panel, which indicates a 20x4 LCD display along with positions for two ZIF sockets and a reset button.
Another top-down view, but this time focusing on a section labeled as a calibration board, featuring an Arduino controller, a DC-DC converter, and various other electronic components and connectors.

IV. Results and Discussion

This chapter deals with the results and discussions of the project development by the proponents entitled Development of Arduino-based Electronic Component Testing Device. This consists of project description, project structure, project capabilities and limitations and project evaluation.

4.1 Project Structure

Table 1. Basis for Microcontroller Selection

Name	SRAM	ROM	EEPROM	IO Pins	Speed	ADC-Bits	PWM	Min Supply Volts	Timers Counters	SPI	TWI (I2C)	UART	ADC channels	Ext Interrupts
AVR ATmega8	1 KB	8KB	512 B	23	16MHz	10-bit	3	2.7V	3	1	1	1	8	2
AVR ATmega328	2 KB	32KB	1024 B	23	20MHz	10-bit	6	1.8 V	3	2	1	1	8	24
AVR ATmega32	2 KB	32KB	1024 B	32	16MHz	10-bit	4	4.5V	3	1	1	1	8	3
AVR ATmega16	1 KB	16KB	512 B	32	16MHz	10-bit	4	2.7V	3	1	1	1	8	3
AVR ATmega128	4 KB	128KB	4096 B	53	16MHz	10-bit	8	2.7V	4	1	1	2	8	8
AVR ATmega168	1 KB	16KB	512 B	23	20MHz	10-bit	6	1.8V	3	2	1	1	8	24
AVR ATmega328p	2 KB	32KB	1024 B	23	20MHz	10-bit	6	1.8V	3	2	1	1	8	24
AVR ATmega2560	8 KB	256KB	4096 B	86	16MHz	10-bit	16	1.8V	6	5	1	4	16	32
AVR ATmega644	4 KB	64KB	2048 B	32	20MHz	10-bit	6	1.8V	3	3	1	1	8	32
AVR ATmega32u4	3.3 KB	32KB	1024 B	26	16MHz	10-bit	12	2.7V	4	2	1	1	12	13

The system uses several components, not only the characteristics are considered but also its features. The table 3 shows the basis in selection of the microcontroller. The Arduino Mega 2560 was used by the proponents for the reasons that it is open source and has 54 digital input/output pins (of which 15 can be used as PWM outputs), 16 analog inputs, 4 UARTs (hardware serial ports), a 16 MHz crystal oscillator, a USB connection, a power jack, an ICSP header, a reset button, and based on the ATmega2560. It contains everything needed to support the microcontroller; simply connect it to a computer with a USB cable or power it with AC-to-DC adapter or battery to get started. The Mega 2560 board is compatible with most shields designed for Arduino and the former boards Duemilanove or Diecimila.

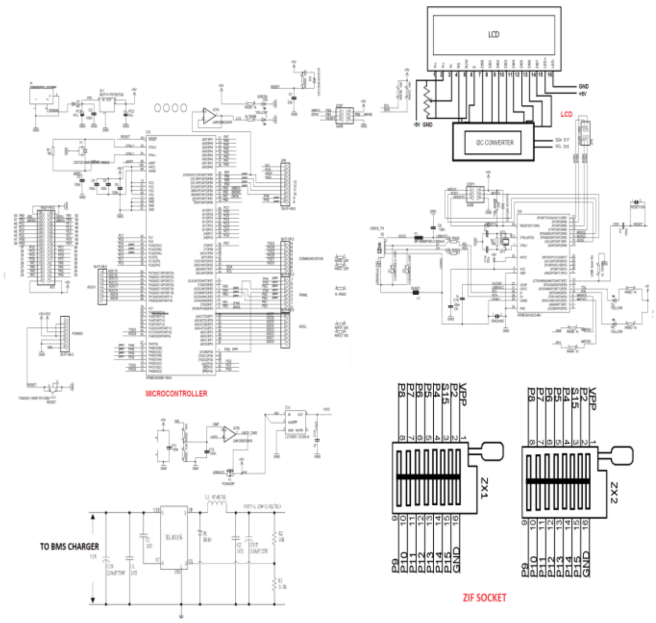

Figure 10. System Schematic Diagram

Figure 10 shows the schematic diagram of whole system. The diagram includes the separated schematic diagram of each component used to build the Arduino Based Electronic Component Tester. The system schematic diagram is composed of schematic diagram of microcontroller, test circuit, mode button, DC-DC voltage regulator, LCD and ZIF Socket.

4.2 Capabilities and Limitations

The Arduino-based Electronic Component Tester has its own capabilities and limitations like any other systems. The system is capable of doing the following functions:

1. It can measure resistance and tolerance of resistors
2. It can measure capacitance of capacitors
3. It can measure the forward voltage and identify the type of transistors
4. It can determine the label, description and condition of integrated circuits.
5. It can display the battery status of the device to the LCD.
6. It can automatically calibrate when testing electronic components.
7. The batteries of this device are rechargeable
8. It can test all types and kinds of resistor, transistor and capacitor.
9. It can be used by the user even when it's charging.

The limitations of the system are the following:

1. The system can't notify the user when wrong component is inserted on the wrong mode of testing
2. The system can't straightly determine the condition of resistors, capacitors and transistors.
3. The system can't test the components when it was inserted on wrong pins.
4. The user can't use any of the slot of ZIF Socket on testing components.
5. Different ZIF Socket slot is used on testing each component.
6. The system can't notify the user if the component is not properly inserted on its respective ZIF Socket slot.
7. The system can only test selected integrated circuits.
8. The system is limited on testing fixed resistors
9. The system is limited on testing electrolytic capacitors
10. The system is limited on testing bipolar junction transistors

4.3 Project Evaluation

In evaluating the system, the proponents used different evaluation methods such as quality requirements definition, evaluation preparation, and evaluation procedure in line with the ISO/ IEC 9126.

In quality requirements definition, the proponents tested the components quality. The proponents list down all the components needed to construct the prototype, the proponents conducted research if all the requirements were available in the market. All components were tested and met their respective hardware specifications.

The next stage is the evaluation preparation. After constructing the prototype, installing the needed program and checking if all parts are properly intact, the proponents tested the system several times and provided scenarios to know if the system performs its desired functionalities and meets its objectives.

The proponents used evaluation instrument to determine the performance of the system. The technical experts used this instrument as proponents evaluated the system in the following criteria and those are the functionality, reliability, usability, efficiency, maintainability and portability. Table 1 shows the system functionality which the set of attribute bear on what the system is supposed to accomplish.

Table 2. System Functionality

Particulars	Weighted mean	Interpretation
Suitability	4.67	Outstanding
Accurateness	4.17	Very Satisfactory
Group Mean	4.42	Very Satisfactory

Functionality is the capability of the system to provide functions which meet stated and implied needs when it is used under specified conditions. The technical experts evaluated the overall system functionality to determine if the system functions properly. It includes the suitability of the system that deals with the performance of the system on performing the task required which is in this case the testing of electronic components and was graded with 4.67 that correspond to outstanding because the system achieved its goal to display all the target output and information about all the tested electronic components. It also includes the accurateness of the system that deals on accurate results in terms of measuring values and was graded 4.17 with that correspond to very satisfactory because the system provides correct information about the electronic components like the resistor's resistance and tolerance value in terms of ohms, the capacitor's capacitance value in terms of farad, the type of transistor and its forward voltage and the series number and condition of the integrated circuits. In general, the system functionality obtained a grade of 4.42 that corresponds to very satisfactory. It signifies that the system meets all the expected output and provides useful functions to the user. However, the system functionality did not obtain the highest rating because the measured value being displayed to the LCD sometimes doesn't get the same value on the second trial of testing.

V. CONCLUSION

The application of latest technologies in traditional processes involves on testing and maintaining electronic components greatly affect the testing results and the development of the system. Technology has a great impact in terms of improving the process that can be adopted on electronic components testing. This helps reduce the effort applied by the users on testing electronic components.

Development of Arduino-Based Electronic Components Testing Device can be used as an alternative method on the traditional way of testing electronic components. It is capable of displaying much more important information. It also uses battery as main source of power.

Arduino technology was the brain of the system. It improved the testing process through the application of automation in terms of automatic calibration feature.

VI. RECOMMENDATION

Upon implementation of Arduino-Based Electronic Components Tester the proponents are now highly recommend the following:

1. The proponents recommended adding other kinds of electronic components to test.
    1.1 To add more type of resistors, capacitors and transistors to test.
    1.2. To add more series of integrated circuits
2. To improve the ZIF Socket by making all of its slot accessible to any components
3. To replace the LCD with larger size that can display much more alpha numeric characters and symbols.
4. To have inventory algorithm in the system that will allow the user to review all the previous testing results.
5. To design a button for each mode of testing.
6. To reduce chassis size to improve appearance and portability.
7. To add a notification message.
    7.1 Notification message when the user improperly inserts the components.
    7.2 Notification message when the user insert wrong component on a wrong selected mode of testing.
8. To improve the battery status display.
9. To improve low battery notification display.

REFERENCES

[1] Haleem, A., Javaid, M., Qadri, M. A., & Suman, R. (2022). Understanding the role of digital technologies in education: A review. Sustainable Operations and Computers, 3, 275–285.

[2] Anuar, A., Hussin, A. F., Majid, M. A., Abidin, A. F. Z., Yusoff, Z. M., Hassan, K. K., Ali, N. M., Harun, M. H., & Rizman, Z. I. (2018). E-TESTER: The development of an electronic board that checks commonly used Arduino-based electronic components and modules. Journal of Fundamental and Applied Sciences, 10(2S), 514–523.

[3] Zhang, K., Cui, Y., Zhao, H., An, S., & Huang, J. (2020). Construction of intelligent testing system for electronic components. *Journal of Physics: Conference Series*, 1693, 012215.

[4] García-Tudela, P. A., & Marín-Marín, J. A. (2023). Use of Arduino in primary education: A systematic review. *Education Sciences*, 13(134).

[5] Băjenescu, T.-M. I. (2021). Reliability and failures of electronic components/systems. *Electrotehnică, Electronică, Automatica (EEA)*, 69(2), 76–82.

[6] Alyahya, D., & Almutairi, N. (2019). The impact of electronic tests on students' performance assessment. *International Education Studies*, 12(5), 109–118.

[7] Lalband, N., & Kavitha, D. (2019). Software engineering for smart healthcare applications. *International Journal of Innovative Technology and Exploring Engineering (IJITEE)*, 8(6S4), 325–331.

[8] Zhao, Z., Fu, H., Tang, R., Zhang, B., Chen, Y., & Jiang, J. (2023). Failure mechanisms in flexible electronics. *International Journal of Smart and Nano Materials*, 14(4), 510–565.

[9] Kulkarni, R., Soltani, M., Wappler, P., Guenther, T., Fritz, K.-P., Groezinger, T., & Zimmermann, A. (2020). Reliability study of electronic components on board-level packages encapsulated by thermoset injection molding. *Journal of Manufacturing and Materials Processing*, 4(1), 26.

[10] Kondaveeti, H. K., Kumaravelu, N. K., Vanambathina, S. D., Mathe, S. E., & Vappangi, S. (2021). A systematic literature review on prototyping with Arduino: Applications, challenges, advantages, and limitations. *Computer Science Review*, 40, 100364.

[11] Maftunzada, S. A. L. (2022). The structure and working principle of a bipolar junction transistor (BJT). *Physical Science International Journal*, 26(11-12), 35-39.

[12] Palmieri, G., Marconi, M., Corinaldi, D., Germani, M., & Callegari, M. (2018). Automated disassembly of electronic components: Feasibility and technical implementation. In *Proceedings of the ASME 2018 International Design Engineering Technical Conferences and Computers and Information in Engineering Conference* (pp. 1-10). Quebec City, Canada.

[13] Samokhin, D. S., Leonova, T. N., Alslman, M., & Vostrilova, A. D. (2019). Clarification of the reliability of electronic components used in the nuclear industry. *IOP Conference Series: Materials Science and Engineering*, 487(1), 012006.

[14] Shmatko, N., & Volkova, G. (2020). Bridging the skill gap in robotics: Global and national environment. *SAGE Open*, 10(3), 1-13.

[15] Maurice, A. A., Dinh, K. N., Charpentier, N. M., Brambilla, A., & Gabriel, J.-C. P. (2021). Dismantling of printed circuit boards enabling electronic components sorting and their subsequent treatment open improved elemental sustainability opportunities. *Sustainability*, 13(18), 10357.

[16] Taufiq, A. J., Kurniawan, I. H., & Nugraha, T. A. Y. (2020). Analysis of Arduino Uno application on control system based on industrial scale. *IOP Conference Series: Materials Science and Engineering*, 771(1), 012015.

[17] Zhang, W., Qi, S., Zhang, H., Pan, C., Wang, W., & Han, D. (2019). Research on failure modes and impact analysis of key electronic components. *IOP Conference Series: Materials Science and Engineering*, 677(1), 052062.

[18] Živković, A. B., Hristov, N. P., Jerković, D. D., Bogdanović, B. S., & Milutinović, J. M. (2019). Automatic measurement of precision and accuracy from the hit pattern of small arms using electronic target system. *IOP Conference Series: Materials Science and Engineering*, 659(1), 012015.