# Rapid Prototyping and Simulation of Modified Electrical Junction Box

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***Abstract*— The developmental-descriptive research paper focuses on prototyping and simulating a physical model of a Modified Electrical Junction Box (MEJB) using rapid prototyping procedure. The Fused Deposition Modeling (FDM) method, commonly known as 3D printing was used for this purpose using a Polylactic Acid (PLA) filament which is a biodegradable plastic. The 3D printed physical model of the modified Junction Box was simulated in actual use. A mock up circuit wiring panel was created where a conventional junction box was installed side by side with the modified electrical junction box. 5 participants composing of experienced Industrial Technology students were asked to use both the conventional and the MEJB one after the other. Each were timed to determine how much time is spent performing circuit wiring using the conventional box and how much time is spent using the MEJB. After each execution, the wiring is checked to see if there are errors committed. The object of the test is to determine whether significant difference exist between time spent installing wires using the conventional junction box and time spent using MEJB through simulation. T-test was used for the analysis of data. The result of the test revealed that the time spent using the MEJB is significantly shorter than when using the conventional junction box. It was also observed that 2 out of 5 participants committed errors in wire connections while none of the students commit errors when they used the MEJB. The advantageous features of the modified Junction Box over its predecessor were also identified.**

***Keywords*— Junction Box, Electrical Wiring, House Wiring, Circuit Wiring.**

## I. Introduction

Rapid Prototyping [6] deals with various aspects of joining materials to form parts of the products using readily available equipment and mediums. This is a very significant breakthrough in product development process particularly in the academe where there is scarcity of materials and fabrication processes in converting product concepts into its tangible form that can be tested for simulation. What the local academic institutions commonly have for their disposals is the digital simulation which is also an accepted and accurate process for testing the functionality of the product using simulation software. But the fact is that not all both in the academe and in the community, from whom product acceptability is expected to be elicited, are keeping track with the trends in technology and innovations in product development. Digital simulation is still far from being familiar. There is still a need for consumers and product evaluators to see and test the product to see how it actually works. Additive Manufacturing (AM) [4] is a technique of using computers to convert a 3D CAD data into a physical product that can be tested and simulated. This is also referred to as Layer by Layer Manufacturing (LLM). Both methods use a technique of creating a three-dimensional object by placing melted or powdered material starting at a first thin layer as if an ink plotter drops ink to cover the mass areas of a print, as the modeling progresses, another layer of material is added on top of the preceding layer. This process of adding layers continues until the 3D object is made. This is different from the traditional modeling for manufacture known as injection molding. Injection molding [7] though is one of the most important stages in the mass production of plastic products. This is way very expensive and is only practical for mass production of product that is ready for commercialization.

This paper is focused on the prototyped Modified Electrical Junction Box (MEJB) using the Fused Deposition Modeling method. Fused deposition modeling is a 3D modeling method where a thermoplastic material is extruded as a half molten filament and is deposited in layers over layers to form a physical prototype of a product [3]. The MEJB is designed to answer for the drawbacks examined in the existing electrical junction box now being used in the construction industry.

## II. The Present Junction Boxes

The typical electrical junction box in the market which is being used in construction industry particularly for residential use is made of a plastic or metal box usually shaped into a rectangular, square, or octagonal for different purposes. The octagonal shaped junction box is used for lighting circuit which is provided primarily with four holes at the sides for receiving pairs of wire for the lighting load, switch wires, and two for source wires. A junction box is an enclosure either made of plastic or metal that protects the connections (junction) of two or more wires. This protection prevents the occurrence of accidents like fire caused by short circuit. The junction box eradicates the need to frequently go back to the main service panel for maintenance [5].

The drawbacks of the existing junction box:

The typical electrical junction box in the market which is being used in construction industry has some limitations:

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1. It takes an electrical professional to handle the connections.
2. Wire grouping must be checked and rechecked before allowing the current to run through the wires.
3. The regular tasks of splicing, and insulating takes quite a time.
4. A layman attempting to do the house wiring must have a thorough knowledge before attempting to do it by himself.

## III. The Developed Innovation:

The modified junction box has the following features:

1. A modified junction box that allows a non-professional to perform the basic lighting circuit wiring.
2. Wire splicing and insulating is not necessary.
3. Any person with little knowledge can use the junction box using the provided cues for wire connections.
4. Cues are provided for the user.

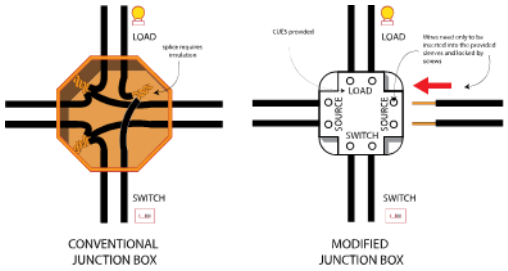


Fig. 1 Comparison between conventional and modified junction box.

## IV. Objectives Of The Study

The study generally aimed to design, prototype, and test the Modified Electrical Junction (MEJB) Box.

Specifically, this study aimed to:

1. design the modified electrical junction box (MEJB) using 3D CAD applications.
2. construct the prototype of the MEJB through the use of Fuse Deposition Modeling (FDM)process.
3. through simulation, determine whether significant difference exist between time spent installing wires using the conventional junction box and time spent using MEJB.
4. account the frequency of errors committed using the conventional junction box and the MEJB.

## V. Materials And Methods

### A. *Research Design*

The developmental research approach was used in the conduct of the present study involving the production of the 3D physical prototype model of the modified electrical junction box. A descriptive method was also adopted in quantitatively describing the observed functionality of the modified junction box in terms of time spent using the conventional junction box against the modified junction box.

### B. *Materials*

The production of the physical prototype made use of the Rapid Prototyping (RP) concept as described by Gibson [6] and making use of the Fuse Deposition Modeling (FDM) method utilizing the Makerbot model Z18 3D printer. PolyLactic Acid (PLA) filament was used and loaded on the Makerbot Z18. PLA is a biodegradable plastic suited for prototyping small objects or products for testing purposes. Conductive sheets were used in making the prearranged connections inside the junction box. Stove bolts with nuts were used for locking mechanisms.

### C. *Workflow*

The modified electrical junction box was designed using 3D CAD application. This way, the product can be virtually simulated. Formative evaluation and successive improvements in the design were made. The 3D CAD files were exported into STL file which is the file type readable by FDM 3D printer application driver [1]. The STL file was loaded to the 3D printer driver software application. The MakerBot Desktop was used. From there, the model was analyzed, sliced, brought into appropriate settings, and finally printed. Figure 2 shows the first design of the product. Though tested to work fine but evaluated as not complying for mass product through injection molds.

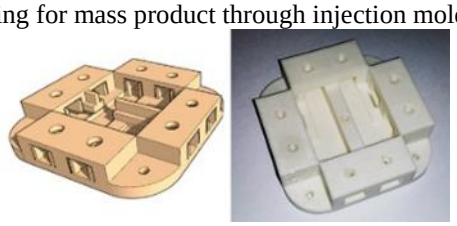

Fig. 2 3D CAD model and the 3D printed first design of the modified junction

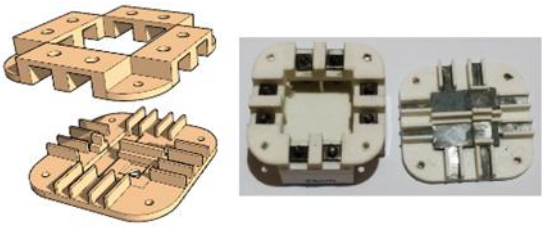

Fig. 3 3D CAD model and 3D printed second design of the junction box

Figure 3, shows the second design. This was made of two removable parts that snugly fits each other. This is more appropriate for mass production through injection mold. The terminals and the locking screws are more accessible during assembly of terminals. Figure 4 shows the two parts assembled. Finally, figure 5 shows the junction box with the cover installed to protect the locking screws from accidental connections.

Fig. 4 Two-parts main assembly of the modified junction box

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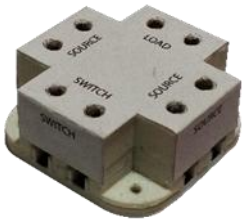


Fig. 5 External appearance of the modified junction box with printed cues.

**Description of the Final Product:**

Unlike the conventional electrical junction box, the modified junction box needs no wire splicing and insulation. The user simply inserts each stripped wire terminal in their respective sleeves and lock the terminal using the provided locking screws.

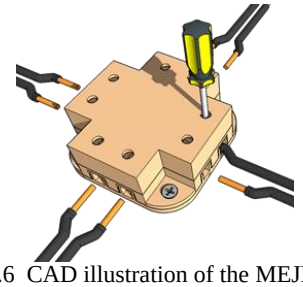

Fig.6 CAD illustration of the MEJB in use

**Participants:**

The participants include 5 third year Industrial Technology students majoring in Electrical Technology who were purposively sampled [2].

**Testing Procedure:**

A circuit wiring panel board was made as mock-up to simulate house wiring installation and for testing the MEJB against the conventional junction box. The conventional junction box was fixed on the panel board, side by side with the MEJB. Wires were installed to simulate lines coming from the lighting load, switch outlet, and live wires. The object of the test is to determine whether significant difference exist between time spent installing wires using the conventional junction box and time spent using MEJB through simulation. T-test was used for the analysis of data. Another object is to account the frequency count of errors committed using the conventional junction box and the MEJB.

TABLE 1SIMULATION RESULT ON PERFORMING CIRCUIT WIRING USING CONVENTIONAL AND MODIFIED JUNCTION BOX

| | Using Conventional JB | | Using MEJB | |
|---|---|---|---|---|
| Participant | Time spent | Remark | Time spent | Remark |
| 1 | 7 | Correct | 4 | Correct |
| 2 | 6 | Incorrect | 4 | Correct |
| 3 | 7 | Correct | 3 | Correct |
| 4 | 7 | Incorrect | 7 | Correct |
| 5 | 3 | Correct | 1.5 | Correct |

A t-Test for Paired Two Sample for Means was used to determine whether significant difference exist between the mean of time spent in installing wires using the conventional junction box and the mean of time spent using modified junction box. The result of t-Test generated a t value of 4.27 and a critical value of 2.13. Thus, time spent using the modified junction box is significantly less than the time spent using the conventional junction box for wiring installation.

It should be noted in Table 1 that incorrect installation occurs twice out of five (40%) cases when using the conventional junction box while no error was committed when using the MEJB.

## VI. RESULTS AND DISCUSSIONS

The design of the modified junction box using 3D CAD application has the following advantages:

1. Virtual Simulation is made possible for sizing and structural assessment.
2. Changing requirement of the design entails no cost
3. Several designs can be assessed prior to physical prototyping.

Producing Prototypes using the Fuse Deposition Modeling (FDM) has the following advantages:

1. Though entailing cost, FDM 3D printing can produce physical model of the product in an instant.
2. Accuracy of the product model in terms of structure and sizes is achieved.
3. The prototype can be tested/ simulated with results that is comparable to expected final product.

Through simulation and testing result, it was found that there is a significant difference in the time incurred in installing circuit wiring using the modified junction box as compared to using the conventional junction box. Thus, circuit wiring is faster and more error -free than using the conventional junction box.

## VII. CONCLUSIONS

Through the results of the study, it can be concluded that the rapid prototyping can be very beneficial in creating models for product development research. Using the physical model of the modified electrical junction box, the product was made ready for physical simulation and test. As the result of tests reveals, the modified junction box can be used by a non- expert as it does not need the activities like wire splicing and insulation. Moreover, using the same, eliminates possible misconnections of wires as the MEJB is provided with cues that guides the user.

## VIII. RECOMMENDATIONS

In the light of the foregoing presentations, the following recommendations are suggested:

1. As any other products, there are still a possibility of rooms for further improvement of the design of the junction box such

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as on the on the design of the connectors where clipping receptors for wire terminals may further increase the speed of installation than the screw locks.

2. In the testing procedures, a need for rerun of the test may be conducted with more participants other than five.

3. Market study may be made including the production cost of the product using the injection mold and calculate the cost per piece in the production for commercialization so that the product can be tested in the market.

## IX. Acknowledgment

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