

## Development of Mechanical Casing Structure of SWAD (Signal Warning Detector)

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**Abstract:** There are several safety procedures while conducting maintenance and repairing on the highway. Unfortunately, there has an accident among workers and vehicles. This application of Signal Warning Detector is invention to help to reduce the incidents that involves the maintenance worker and vehicles at the highway. This system detects using sensor, whenever vehicles near the construction site within 100 meters and giving signal to alert the workers and the vehicles. Some problem has been stated according to the previous design of the casing that is not suitable for the environment and the situation at the highway that is exposed to the heat and rain. Improvement has been done by reconstruct the design and changing the material that use at the casing of the transmitter and the receiver from ABS (Acrylonitrile Butadiene Styrene) to Cast nylon 6 for transmitter and Polyoxymethylene Copolymer for the receiver. Using the Solidworks simulation to get the analysis result of the strength and rigidity of the design. From the result, the new design with new material giving better improvement from the previous design and it is suitable to use at the highway.

**Keywords:** Casing, Signal Warning Detector, Transmitter, Receiver, Simulation Analysis

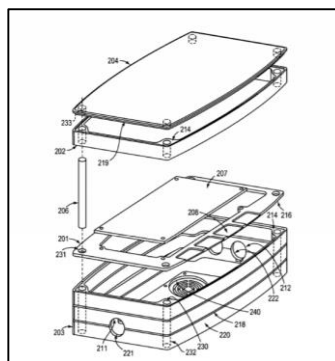
### 1. Introduction

Nowadays, road accidents are common nowadays. Not only minor injuries, but also serious injuries and found dead at the scene. Driver behavior plays a central role in road safety risk, but it is often difficult to measure in real-world driving situations. Based on the research, factors such as inexperience, lack of skill, and risk-taking behaviors have been associated with the collisions of young drivers. In contrast, visual, cognitive, and mobility impairment have been associated with the collisions of older drivers[1]. Maintenance is described as work to repair, rebuild, or upgrade all aspects of buildings or infrastructure, to maintain the efficiency of buildings and their utilities, including the environment, and to maintain the building's usefulness and importance. Basically, maintenance at the highway can be categories to 3 different works, such as routine works, periodic works and special works[2].

The application of Signal Warning Detector (SWAD) may be help on construction that happened at the highway and can help to reduce accident and injury that involving maintenance workers and vehicles on the highway. While conducting the maintenance, the system will warn by using a detector that can detect cars as far as 100 meters through 3 ways such as sound, vibration and visual. After the problem has been stated, the application of Signal Warning Detector (SWAD) has been developed to reduce the incident, but other issue is the design and the structure. The design may be good enough in term of design, but there a few things that to point out such as neat, easily install, toughness in material and mechanical structure. Other than that, the design needs some improvement in term of structure, and suitable shape design.

### 1.1 Casing invention

Designing a housing for motherboard is needed to cover the programming board from dust and water to avoid malfunction of the system. By implementing the design phase, the product must be designed to making an improvement in term of specification, and requirement. Based on the [3] designing the previous product may be easier to making an improvement using 3D software. Housing is designed first based on functional requirements, with the system being statically indeterminate. A modal analysis is carried out. The natural frequency of the arrangement is the most important thing to consider while optimizing the design [4].



**Figure 1: Circuit board enclosure[5]**

Based on the figure above, the invention is to provides housing system of circuit board by a stackable concept. Between the base and top units, spacers and carriers are alternately stacked, and each circuit board is mounted to a carrier. Each carrier has a side portion with recessed vents that extends from one side, and each carrier and spacer define an opening. To cool the circuit boards, air flows through the vents, over each circuit board, and through the carrier's openings.

### 1.2 SolidWorks Software

According to the SolidWorks conceptual design by Dassault System, Solidworks simplified the process of conceptual design and easy to operate it. In advance, SolidWorks is a CAD/CAE/CAM/PDM desktop system, and the first 3D mechanical CAD software in Windows developed by the SolidWorks company. The power of ability of this software is it can process and much more detail than other software which is the inside out of the design can be seem using cross section from integrated model. Solidworks is the software of choice for many industries. According to the Innova Systems, every industry faces a unique set of challenges in today's increasingly competitive marketplace. SOLIDWORKS offers solutions that can help with the toughest of engineering tasks. Even for the

government (The Ministry of Defense) use Solidworks to design strategic defense equipment, arms, vehicles and vessels and the researchers can access the latest in engineering technology, while communicating with other researchers and industrial users worldwide.

### 1.3 Simulation Analysis

Simulation Analysis is a procedure in which infinite simulations are carried out to obtain the potential effects and probabilities for every action option. SOLIDWORKS Simulation is a virtual test system that analyses the concept, assesses its performance, and makes choices to enhance the output of the product. There are few simulations packages design on the Solidworks to analysis. Different simulation has different function. The standard basically used for structural, motion, and fatigue analysis. Based on the previous research , this analysis is the simulation of the effect that loads, or physical structure are applied. The estimation of the deflection and the stress produce can be determined by this analysis[6].

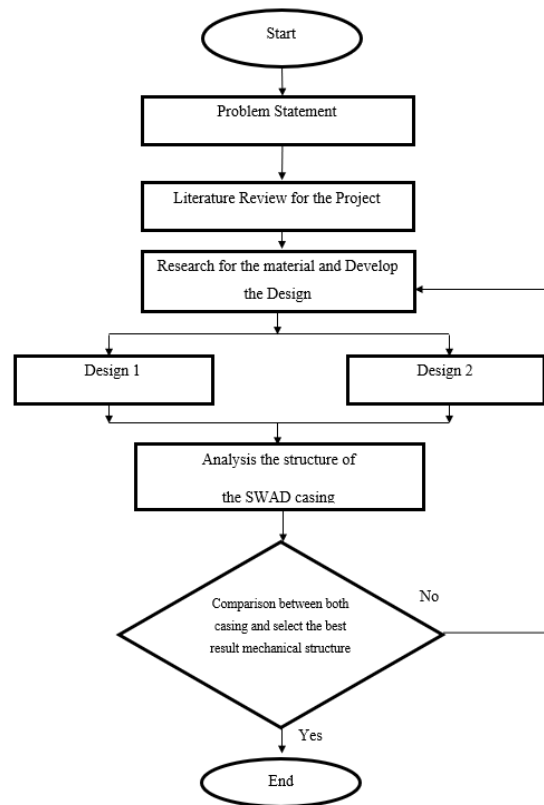
In addition, static analysis is conducted where additional displacements, such as differential support settlements, are subject to the system. A static analysis was performed to calculate the effect of steady loading conditions on a structure. However, time-varying loads that can be approximated as static equivalent loads can be included in a static analysis (such as the static equivalent wind load). Static analysis determines the displacements, stresses, strains, and forces caused by loads that do not cause significant inertia and damping effects in structures or components[4]. The response of the system involves inner forces and internal pressures used in the design process. In static analysis, there are 3 types of function must be determined, such as stress, strain, and displacement. In general, first, the uncertain displacements are derived from the equilibrium equations of an active system using a finite-element-based structural analysis system, and then the external and internal forces and stresses are determined from the global equilibrium equations of the structure. However, the prescribed displacements have limitations for a structure exposed to external displacements because of limited knowledge or measuring errors that change the reaction of the structure.

## 2. Materials and Methods

This methodology of this research is designed to achieve the objective of the research based on the scope of work. the elaboration of method uses to design, simulate, and improve the performance and design of Signal Warning Detector (SWAD) for highway maintenance. The previous design of this project was changed and redesign to improve of the structure stronger in term of forces, heat, and stress. The improvement is made with existing design of the structure, material, and the shape.

### 2.1 Overall Flowchart

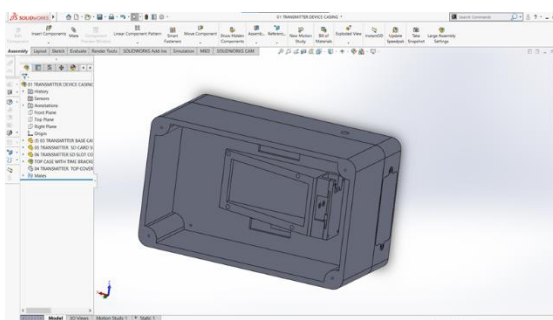
Flow chart is a chart that separate all the steps of doing project in sequential order. This chart is the progress from the start, discussing the problem statement until the finish of the project. this is to make sure there are no technical problem will be done.



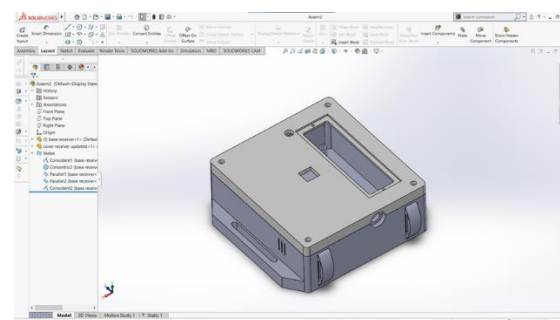
**Figure 2: The methodology of Flowchart**

## 2.2 SolidWorks Design

In this analysis, Solidworks Software is used as a design drawing tool. The existing project plan becomes a reference for designing a new design for change and evaluating the project layout. Essentially, there are 2 types of designs have been designed to analyses the structure of the model. In this project, the structure factor and scale would need to be taken into consideration to suggest improved outcomes relative to the previous project. The first design was a square or more to rectangular shape and the other one was a square to rectangular shape also with an aero dynamic air flow to breaks away the air and becomes turbulent.



**Figure 3: Drawing of transmitter casing using Solidworks**



**Figure 4: Drawing of Receiver casing using Solidworks**

## 2.3 Material Selection

After researching the suitable material for this project, reviewing the material properties for this project must be in careful. Usually, the best choice of material to satisfy such functional engineering

specifications implies that a balance be achieved between competing standards[7]. Besides tensile strength, the weight and melting point must be considered. Some are there are using abs plastic as material for existing product, but the properties might be hard, rigid, but when it comes to temperature resistant, it is only at 70 °C (160 °F) and it is poor UV (ultraviolet radiation) resistance.

## 2.4 Simulation

In this project, the simulation will be demonstrating the stress, heat, and mechanism of the design. Animation, fundamental motion, and motion processing are three types of motion simulation that will be used. Other than SolidWorks Motion to simulate the motion for assembly models, Finite Element Analysis (FEA) software or Lisa 7 software also can simulate the stress, motion, air flow and more. This purpose of simulation is to make sure that all the components are stable, no deformations occur during interactions and ready to be published. This analysis is the simulation of the effect that loads, or physical structure are applied. The estimation of the deflection and the stress produce can be determined by this analysis. In addition, static analysis is conducted where additional displacements, such as differential support settlements, are subject to the system.

### 2.4.1 Stress (Maximum Von Mises)

Stress analysis also known as Von Mises are used to determine the yield strength of structure. In Solidworks, the yield strength can be determined by identify the material. Von Mises creates a requirement that if, under basic stress, the material stress under the load is equal to or greater than the yield limit of the same material that can be readily experimentally calculated, then the material would yield.

### 2.4.2 Strain

Strain is a deformation or change in shape and scales of structure under applied forces. When forces are applied at certain area, the structure of object will change the shape as matter depend on the load. As the particles of which the substance is composed are slightly shifted from their normal location, the deformation expressed by strain occurs in the material. This analysis includes the structure including strength, load limits, and performance.

### 2.4.3 Displacement

Displacement method of analysis also known as stiffness matrix method in the FEA. First force of displacement relations is determined, and equations are subsequently written to satisfy the structure's equilibrium conditions. The other forces are determined after evaluating the unknown displacements, satisfying the conditions of compatibility and relations of force displacement. The method of displacement is commonly used in modern structural analysis. The maximum deflection and the maximum stresses are generally small compared to the structure determined statically.

## 3. Results and Discussion


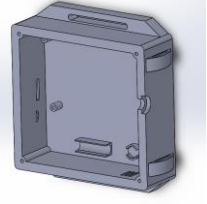
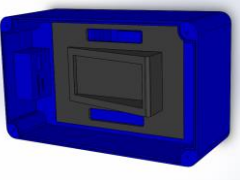
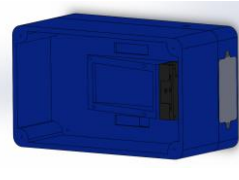
This project has been successfully implemented using simulation analysis under the Solidworks operation of the casing of receiver and transmitter and it achieves the scope of the target. Based on this project scope, it is to study the simulation analysis the stress, strain, and displacement on that model. Furthermore, it was focused on the original design and the modification on the casing. At the end of this chapter, the results were compared between different design of casing to determine the mechanical structure characteristic.

### 3.2 Discussions

The design of the previous project has been identified in term of the shape, structure, and concept. All these terms must be improved to satisfy the requirements such as safety, strength, and serviceability. The requirements are important to get a better design of danger signal detector system to make a new way to upgrade the level of safety for the maintenance worker during maintenance work at the highway or any site.

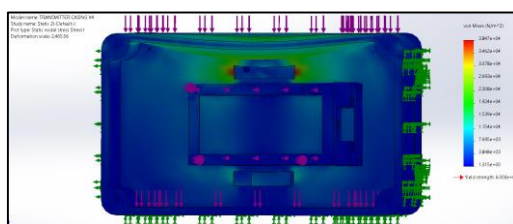
The shape of the receiver casing before is quite large compared to typical Malaysian elbow size and disturbing users' comfort because the device and the vibrator are connected to the worker's wrist. Then it has been improved by adjusting the size that are compatible to attached at the wrist and the adding a port hole to put the belt to make it tighter and sturdier. Based on the past design transmitter casing, it has lack of ports stand to put all the component and case difficult to arrange the wiring and the board while install the SWAD. The improvement has been made by adding more port stand and layer of the casing.

**Table 1: Explanation of new concept of design**

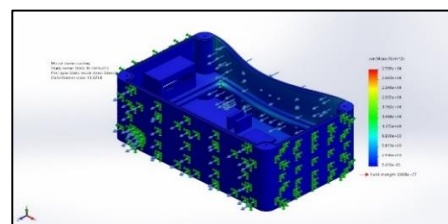
	Previous	Present	Explanation
Receiver casing			The concept of placing the component inside the base. Creating the transparent view larger and adding grip hole at top of casing.
Transmitter casing			Redesign the concept of adding layer of casing. Lower layer to insert the component and connect to upper layer (uRad). Changing the place of USB port to lower layer.

### 3.3 Simulation analysis Result

To analyze the stress, strain and displacement of the design, suitable loads, or forces to be determined same as actual load of weight to get the best results compare to the previous project. For the transmitter casing, the forces that applied is 0.102 (1 N) inside the casing as forces of the component and forces acting downwards as weight of casing. Besides, receiver casing also needs to be considered acting forces is applied and it is about to 0.100kg (0.98 N).



**Figure 5: Simulation analysis of new design transmitter casing**



**Figure 6: Simulation analysis of previous design transmitter casing**

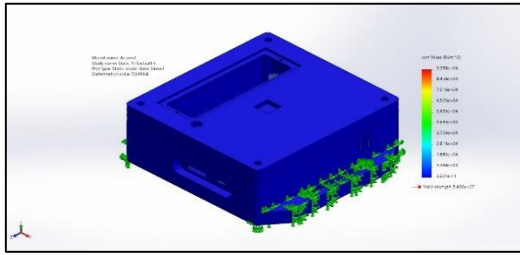


Figure 7: Simulation analysis of new design receiver casing

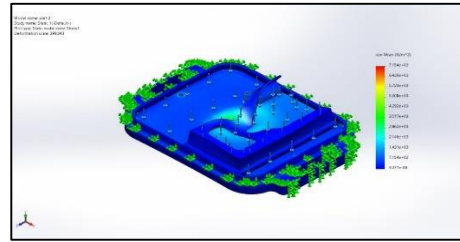
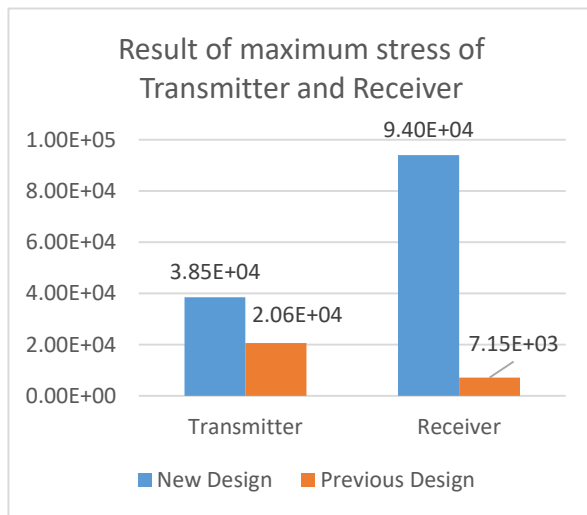


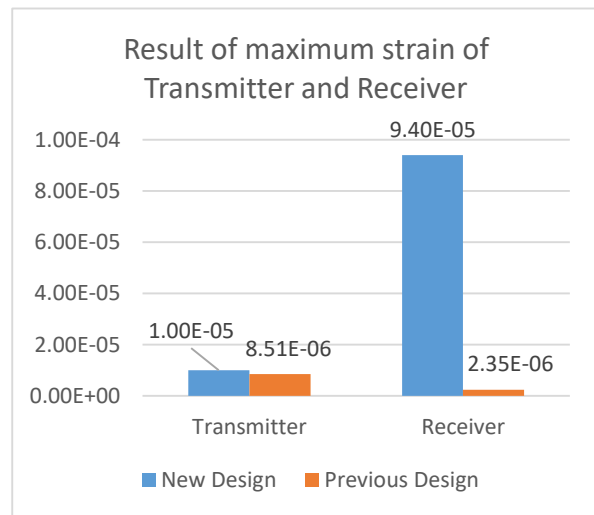
Figure 8: Simulation analysis of previous design receiver casing

Table 2: Maximum and minimum value of stress, strain and displacement for both design transmitter and receiver

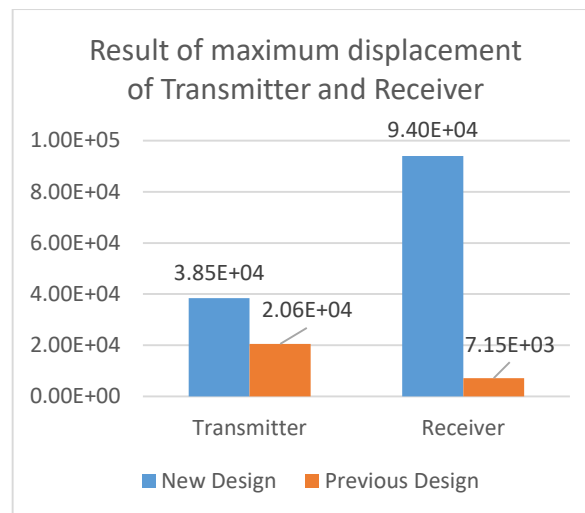
Casing	Type of design	Maximum Value			Minimum Value		
		Stress (N/m <sup>2</sup> )	Strain	Displacement (mm)	Stress (N/m <sup>2</sup> )	Strain	Displacement (mm)
Transmitter	New Design	3.846 x10 <sup>4</sup>	1.003 x10 <sup>-5</sup>	1.831 x10 <sup>-3</sup>	9.042 x10 <sup>-1</sup>	8.01 x10 <sup>-10</sup>	0
	Previous Design	2.0556 x10 <sup>4</sup>	8.509 x10 <sup>-6</sup>	1.767 x10 <sup>-3</sup>	3.541 x10 <sup>-5</sup>	1.048 x10 <sup>-14</sup>	0
Receiver	New Design	9.398 x10 <sup>4</sup>	2.646 x10 <sup>-5</sup>	2.272 x10 <sup>-4</sup>	3.301 x10 <sup>-11</sup>	3.852 x10 <sup>-14</sup>	0
	Previous Design	7.154 x10 <sup>3</sup>	2.353 x10 <sup>-6</sup>	2.901 x10 <sup>-5</sup>	9.377 x10 <sup>-8</sup>	2.857 x10 <sup>-12</sup>	0



(a)



(b)



(c)

**Figure 9: (a) Graph of Maximum stress of transmitter and receiver, (b) Graph of Maximum strain of transmitter and receiver, (c) Graph of maximum displacement of transmitter and receiver**

Table 2 shows that the maximum stress, strain, and displacement between new design and previous design with different material selected for the transmitter. The value of maximum stress for new design is  $0.03846 \text{ MN/m}^2$ , highest than previous design with value of  $0.02055 \text{ MN/m}^2$ . From the stress result, new concept has more force can be applied than previous design. The maximum strain for new design is  $1.003 \times 10^{-5}$  and is much higher than previous design that is  $8.509 \times 10^{-6}$ . For the displacement, new design has better value of  $0.001831 \text{ mm}$  than previous design that is  $0.001237 \text{ mm}$ . This result is simulated from Solidworks software with different material selection and properties.

Table 2 also shows that the comparison result of maximum stress, strain and displacement between the new design and previous design with different material of polyoxymethylene and ABS for receiver casing. The value of maximum stress for new design is  $93.98 \times 10^3 \text{ N/m}^2$ , higher than previous design that is  $7.154 \times 10^3 \text{ N/m}^2$ . This is because the new design has strong material selection with strong design can held more stress on surface. The maximum strain for new design is  $2.646 \times 10^{-5}$  and has higher strain value than previous design that is  $2.353 \times 10^{-6}$ . While for maximum displacement of new design, which is more than the previous design with  $2.272 \times 10^{-4} \text{ mm}$  and  $2.901 \times 10^{-5} \text{ mm}$ .

On this summary of data analysis, it is important to get the best results and make the improvement of the previous project. The improvement of the design has been done by redesign and rebuild all the parts that involve layer and additional from previous design. From the simulation analysis has been done, both of new design has better result based on new material selection and new casing design. The material that uses for transmitter casing is Cast Nylon 6 and it is suitable to outside use and high tensile, impact strength, and elasticity. The material that used on previous project is not environment friendly and not suitable for outside use because it is poor UV resistance unless protected. Besides that, new receiver casing design has better result compared to previous design because the material that use at new design is polyoxymethylene copolymer that give excellent rigidity, impact toughness and good appearance. To choose which one the best, all these terms need to be considered. For stress result, it is referring to physical contact and impact forces and load to casing.

#### 4. Conclusion

Through this study is to develop the casing structure of transmitter and receiver. The previous design has been analysis and been redesign the structure of the casing to improve the strength and the



strain. Also, the material has been changed from ABS (acrylonitrile butadiene styrene) of both casing to Cast Nylon 6 for transmitter and Polyoxymethylene copolymer for receiver. Changing the material gives lot of impact in term of result analysis such as stress, strain, and displacement.

The next objective was to determine the mechanical structure characteristic by using simulation SolidWorks software. The objective also achieved by running simulation based on the material that been assigned. Based on the result of analysis, the value of maximum stress, strain, and displacement for new design higher than previous design with value of 0.03846 MN/m<sup>2</sup>, 1.003 x10<sup>-5</sup>, and 0.001831 mm. This can be concluded that new design has strong structure characteristic. In term of technical properties of cast nylon, it suitable for the design of transmitter that has upper and lower layer. While for receiver, the value of maximum stress, strain, and displacement for new design higher than previous design with value of 93.98 x10<sup>3</sup> N/m<sup>2</sup>, 2.646 x10<sup>-5</sup>, 2.272x10<sup>-4</sup> mm. The concept of the design has been changed and it give more excellent rigidity and tough from impact and better result than previous material. Lastly, the new design structure with material of cast nylon 6 and polyoxymethylene copolymer give better result of analysis simulation.

## 5. Acknowledgement

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