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THE DEVELOPMENT OF SMART AUTO-FEED PAPER SHREDDER

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Abstract

Paper is an important material where it is used for many purposes worldwide. Due to this, the amount of paper waste also increases. This paper presents an innovation derived from conventional paper shredders. The main objective is to effectively dispose used paper. Currently, users need to wait and shred the unwanted paper manually and this consumes a lot of valuable time. Putting this critical problem into concern, an innovative product with upgrades on the way of disposing unwanted paper is proposed. The process of paper shredding is upgraded, taking into consideration the analysis on how people dispose unwanted papers. This project is divided into two parts which are software and hardware developments. The main process involved in this project is cutting paper into chad, typically in strips or fine particles. The development of this shredder involved using two infrared (IR) sensors. The first sensor is used to detect the existance of paper. If paper exists, the motor will turn on, driving a roller. The roller will grab the paper and bring them to the blade for shredding process. In the meantime, there is another IR sensor in a dustbin which is used to detect the storage being either full or not. If full, the shredder will stop the shredding process until the user clears the dustbin. In a nutshell, the way of disposing unwanted paper should not be a problem as this shredder will dispose them automatically and effectively. The benefits of this shredder are the reduction of labor and time resulting in cost reduction in paper shredding operation.

Keywords: infrared (IR) sensor, chad, nutshell, shredder

1.0 INTRODUCTION

Paper is an important material used daily for many purposes worldwide. The global production of paper and cardboard stood at approximately 407 million metric tons in 2014, (John, 2016). This has led to the increase in the volume of paper waste. Thus, this paper aims to carry out an innovative design of paper shredder. The main objective of this project is to dispose used paper effectively.

Shredders come in different sizes and prices. The general small shredder is an electrically powered device, but there are some which are manually powered such as special scissors with multiple blade pairs and hand-cranked rotary shredders. Instead of crumbling papers and throwing them into bins, shredding paper into strips are better for easy recycling. Beside that, some shredders used by commercial shredding services are built into a shredding truck costing hundreds of thousands of dollars, able to shred millions of documents per hour (Garry, 2017).

There are a lot of manual and automatic paper shredder products produced. Most people still use manual feed paper shredders instead of using automatic feed paper shredders. One of the reasons is that the automatic feed paper shredder's price is too expensive compared to manual shredders. Using a manual feed paper shredder, the user needs to focus on putting the paper inside it one by one leading to a lot of work, time, and energy. However, all the problems exist can be overcome using automatic shredders.

2.0 LITERATURE REVIEW

A paper shredder is a mechanical device used to cut paper into Chad, typically in strips or fine particles. Based on previous studies, there are several projects related to automatic paper feeders regarding to the design and development of shredder machine focussing on chopping coconut leaves (Kumar & Kumar, 2015).

Siddiqui et. al (2017) provided a detailed study of various parts of shredder machine such as stand (frame), transmission system, and cutting system which are manufactured and designed separately. The first part deals with the study of cutting system of a shredding machine, i.e. types of blades, different profiles, its dimensions, its alignment, and the advantages and disadvantages of different types of blades. The second part includes problem definition, objectives, procedure of design with the detailed design of each component of the cutting and transmission system, i.e. designing a blade and making certain modifications in it and the frame.

Despite inventing a lot of shredder machines, a few researchers have outlined some relationships in the development shredder machines (Adepo & Obanoyen, 2017). In fact, a shredder machine design is affected by many factors such as the speed and tension of belt and the transmitted power. All these factors have significant effects in the development of a shredder machine. For example, the speed of belt depends on the mass of load (item to be shredded). Beside that, to produce a good shredder machine, some important parts such as the cutting blade, spur gear, and motor must be considered.

The gearbox and motor are the most important in an efficient paper shredding. A gear or a cogwheel is a rotating machine part having cut teeth or cogs, which meshes with another toothed part to transmit torque, (Simon Huang, 2009). The automation of the process using motor reduces process time compared to manual shredder which uses manual labour. The new design has reduced the automation time for operation to a great extent compared to previous shredder machines.

The modelling of the paper shredder also provides some advantages to inventors. There are so many paper shredder products available in the market, and the decision to select the 'right shredder' usually involves a number of criteria as discussed by Zhuang et. al (2017). For example, in organizations, the complexity arises when purchasing a massive amount of shredders of the same type.

3.0 METHODOLOGY

The development of the Smart Auto-Feed Paper Shredder consists of two parts which are software and hardware developments. By using the Proteus 8 simulation software, the circuit and PCB layout were designed. Through the simulation, the errors in the designated circuit can be detected easily, reducing prospect problems to occur during the hardware development. Only one circuit is needed to create an automatic paper shredder and it consists of a relay, a direct current motor, transistor, diode, integrated circuit, variable resistor, resistor, light emitting diode, infrared red sensor, direct current jack, and amplifier. Figure1 illustrates the overall block diagram of the Smart Auto-Feed Paper Shredder. The automatic paper shredder will start working when a bundle of used papers is placed on the platform with the main switch switched on. The roller will automatically grab the paper sheet by sheet towards the blade and shredding process will start. The shredded papers will fall into the basket. When the basket is full, the basket sensor will detect the level of the paper and light up the LED. Automatically, the shredder will stop working to prevent overloading.

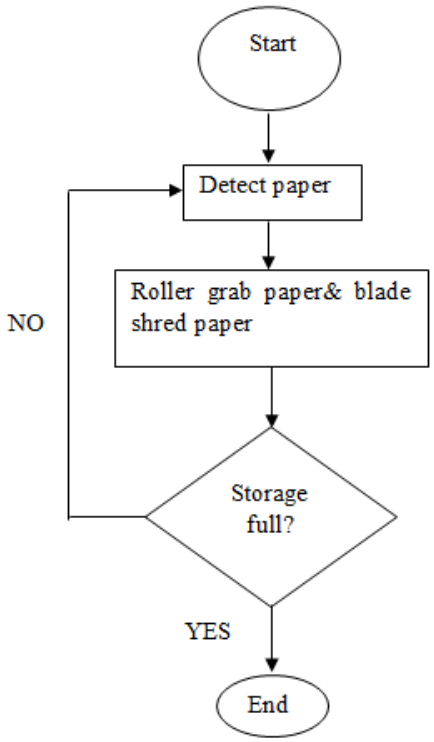

Figure 1. Flowchart of Project Operation

3.1 SOFTWARE DESIGN

This section explains the simulation works involved in this project. Using Proteus 8, the circuit and PCB layout were designed. Through the simulation, possible errors of the designed circuit can be detected easily, preventing prospect problems to occur during the hardware development. Only one circuit is needed to create this automatic paper shredder which consists of a relay, a direct current motor, transistor, diode, integrated circuit, variable resistor, resistor, light emitting diode, infrared red sensor, direct current jack, and amplifier.

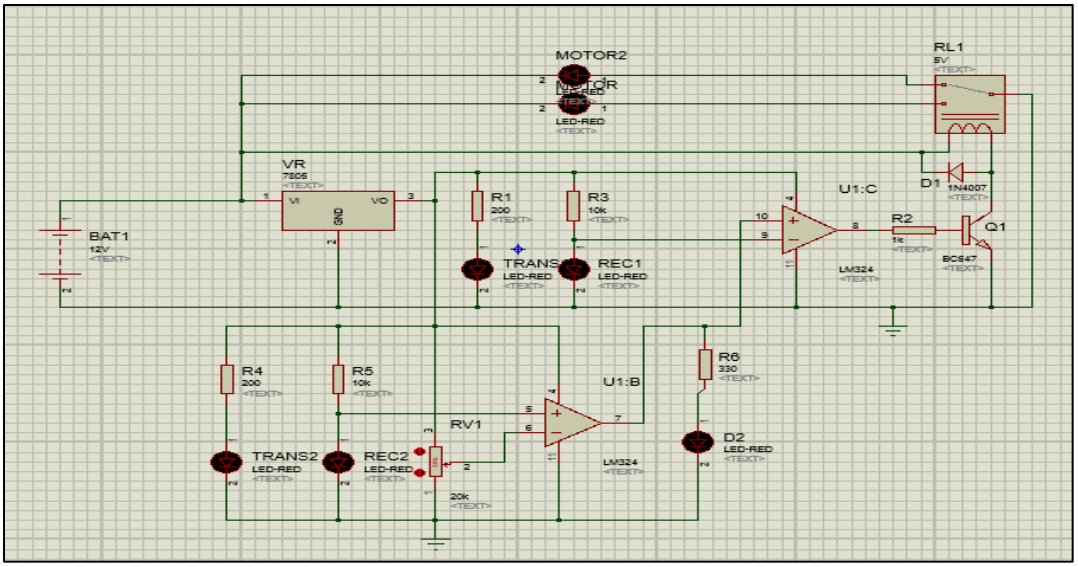

Figure 2. Schematic Circuits for Smart Auto-Feed Paper Shredder

The schematic diagram of Smart Auto-Feed Paper Shredder is shown in Figure 2. Smart Auto-Feed Paper Shredder operates when a stack of paper is placed on the tray and the infrared sensor detects the papers. It can cause the value of resistance to increase together with the value of voltage. Voltage is used as the input for the operational amplifier (OPAMP), U3. If the positive input of op amp higher than the negative input, voltage will be the output. So, there will be current flow in the circuit to activate the relay and the motor will turn on, shredding the paper into the dustbin. In addition, inside the dustbin, there is an infrared sensor which is IR IN to detect the volume of shredded paper to stop the operation of the circuit when the dustbin is almost full. It operates when IR IN detects the paper. The value of resistance of IR IN will increase making the voltage to also increase. That voltage will be the positive input of the operational amplifier which is U1. When the positive input higher than the negative input, voltage will be the output of OPAMP U1. The voltage as output at OPAMP U1 is the input for negative input for OPAMP U3 which has been set to be higher than the input in the positive input at OPAMP U3. If the negative input higher than the positive input, there will be no output at OPAMP U3 and there will be no current flow to activate the relay. So, the motor will stop automatically.

3.2 HARDWARE DESIGN

Figure 3 shows the shematic diagram on the breadboard. The process of troubleshootting is necessary before the implementation on the PCB board. This process involves of the functionality of the direct current motor, relays, timer, infrared (IR) sensor, and so on. The direct motor will function if there is no fault in the connection and the infrared sensor receives supply from the source. If the problem exists, troubleshooting will be done again. After all the troubleshooting was done, the circuit was applied on a printed circuit board (PCB). The soldering technique was used to install the components on the PCB board. The infrared IR sensor, direct current jack, and switch were soldered separately using a jumper in installing the prototype. Before the circuit was applied to the prototype, the circuit was tested to make sure that the IR sensor is functioning as in Figure 4.

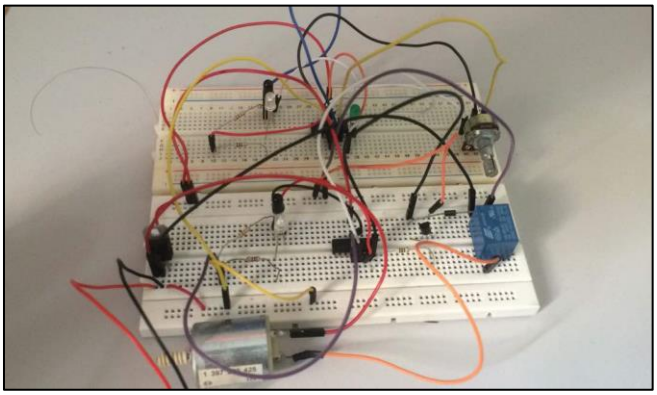

Figure 3. The Schematic Diagram on the Breadboard

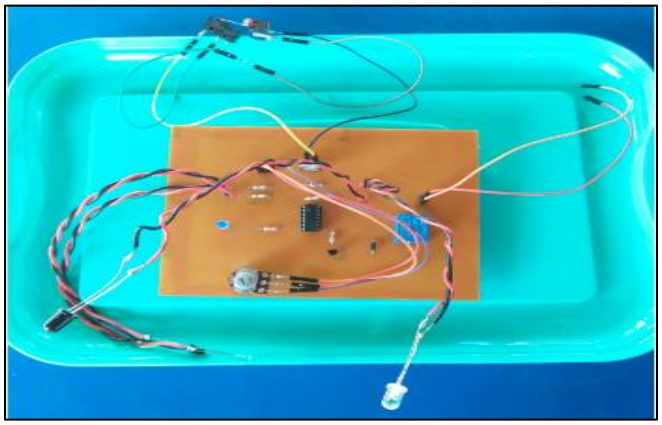

Figure 4. The Complete PCB board

4.0 RESULTS AND DISCUSSIONS

This chapter presents the results obtained from the experimental verification. All the results are discussed and explained. Figure 5 shows the type of IR sensor used in this project to detect paper. This type of IR sensor has two different colors and functions which are black and white representing receiver and transmitter respectively. The prototype consists of a roller that used to be a part of a printer, a blade, a dustbin, and a plastic cupboard. The roller grabs papers and bring them close to the blade. The blade, as in Figure 6, starts shredding a maximum of 3 sheets of paper into strips in one time. The paper strips fell into the dustbin and once the dustbin full, the IR sensor detects the volume of paper strips causing the roller and blade stop moving. The body of prototype is made of plastic cupboard and it supports the shredder.

Figure 5. Infrared (IR) Sensor

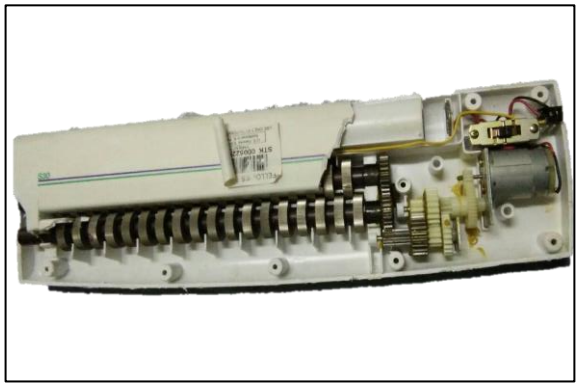

Figure 6. Shredder

Table 1 shows the process of the circuit when it starts and stops working. The circuit will start working when there is a stack of paper placed on the tray and the empty basket is placed at the bottom of the cupboard and the switch is turned on. When the switch is turned on, LED will turn on as well and the roller starts grabbing the paper towards the shredder. The shredded paper will fall into the basket. The LED turns off whenever the basket is full and the circuit stops running as well. The prototype of the Smart Auto Shredder is shown in Figure 7.

Table 1. The Process of The Circuit

Condition	Start	Stop
No paper, no basket/basket not full		YES
Has paper, no basket/basket not full		YES
No paper, has basket, basket not full		YES
Has paper, has basket, basket not full	YES	
Has paper, has basket, basket full		YES

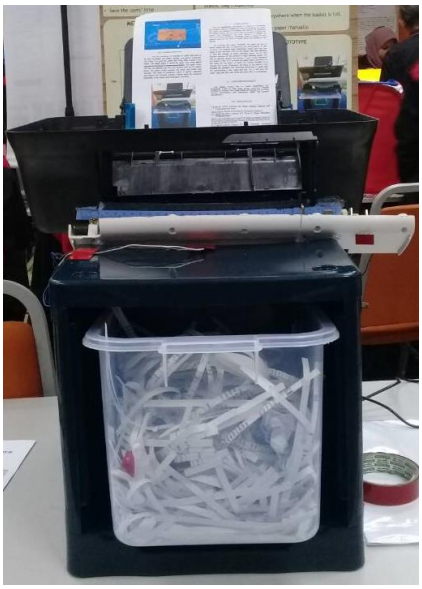

Figure 7. The final product

3.0 CONCLUSION

In conclusion, through this paper shredder, users do not have to worry about the way of disposing the used papers as this shredder will dispose them effectively. Other than that, the blade in this shredder will cut the papers into fine particles to save the storage as more shredded paper can be filled. Special features of this project are the light emitting diode will turn on and the buzzer will produce "beeping" sounds whenever the basket is full. So, the users do not need to check the basket whether it is already full or not. Moreover, users do not need to wait because the shredder will operate effectively to make sure that the surrounding stays clean and tidy.

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