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## Photovoltaic Powered T-Shirt Folding Machine

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### Abstract

Easy T-Shirt Folding Machine is an automatic motor controlled t-shirt folding machine powered by a photovoltaic system. The aim of this project is to fold t-shirts merely by pressing a button. The folding machine is fully automatic where one has to place the t-shirt on the folding tray and press the button. It will then fold the t-shirt by itself. This system uses four DC motors to control the motion of the folding part. Usually, a person uses conventional method to fold the clothes which by hand folding. Many problems usually faced by working women who is unable to manage time for house hold chores. The purpose of this project is to introduce an easy and fully automatic t-shirt folding machine. In this propose system, a DC motor are attached to the folding motion and rotates according to a program which uses microcontroller. The microcontroller controls the overall motion of the folding. The overall system is powered by a photovoltaic system. Result shows that by using this system, the time for folding clothes by human can be cut down in half compared to conventional method.

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*Keywords:* Photovoltaic; T-Shirt; DC Motor; Microcontroller

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### 1. Introduction

People nowadays have been living with tight schedule in their daily life. Household chorus despite gender discrepancy has been a burden for many. Among the entire chorus that are time and energy consuming is the part where laundries are concern. This work is a burden for many and sometimes tiring depending on

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the amount of clothing and number of people in a house. Clothes such as shirts, pants and undergarments are the usual and if multiplied by the number of person in a family, will consume a lot of time and energy. This is a predicament for an average person that needs to be resolved. The process flow of a laundry usually are, washing, drying and folding thus an idea of a machine that can fold clothes are presented in here, among many categories of clothing, the T-shirt is chosen as a test focus and the project is conducted based on the T-shirt folding flow based on Fig 1 below.

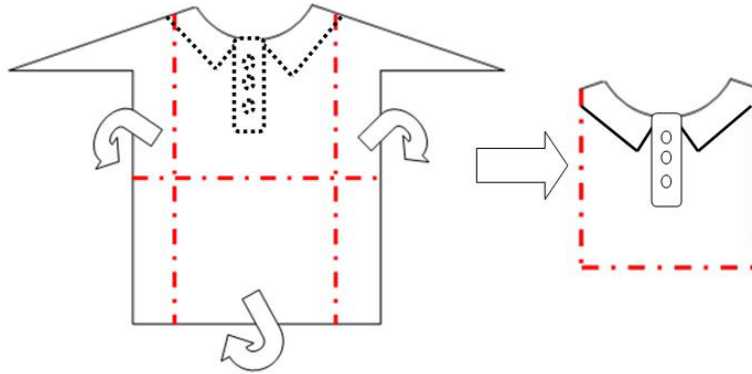


Fig. 1. T-shirt folding Method

Figure 1 shows the idea on how the t-shirt folding machine will fold the t-shirt; the picture on the left shows the shirt is placed front to back (shows as the dotted line of the collar and buttons). The red dotted lines are the parts where the machine will fold the t-shirt and lastly becoming the one near the right. This idea is presented as an aid for people to speed up the folding process and proceeding with other chorus. This machine intends to aid those with tons of shirts are involved such as in the laundry service, hotels, hospitals and many more places that is associated with ample of clothing. This machine promises to deliver folded t-shirt with precise folding scale and speed up time as well as being unguided. In order to achieve the objective of the project, there are several scopes that have been outlined. The scope of this project includes using the usage of MIDE-51 to program microcontroller AT89C51, build hardware for the system, and interface the hardware to a dc motor. 3 dc-motors are used to control the motion of the folding material. The EAGLE 6.0.6 software is used to design the circuit and run the simulation. This project only focuses on folding t-shirts as the test focus.

## 2. Apparatus

### 2.1. DC Motor

Electric motors are the workhorse for industry, all the mechanical movement is caused by an AC or DC motor. Motor normally consist six basic parts known as rotor, commutator, brush, axle, field magnet and finally some sort of DC power supply [1]. Since DC gear motors are used in this project, a brief explanation is given. The DC motor basically consists of two permanent magnets and also two windings. The brushes and the commutator power the coil. Magnetic polarity of the electromagnet will change. And also the winded direction of the two magnet windings will be reversed [1]. So it will make one electromagnet to be north and another will be south. The basic of a DC motor can be seen in the Figure 2.

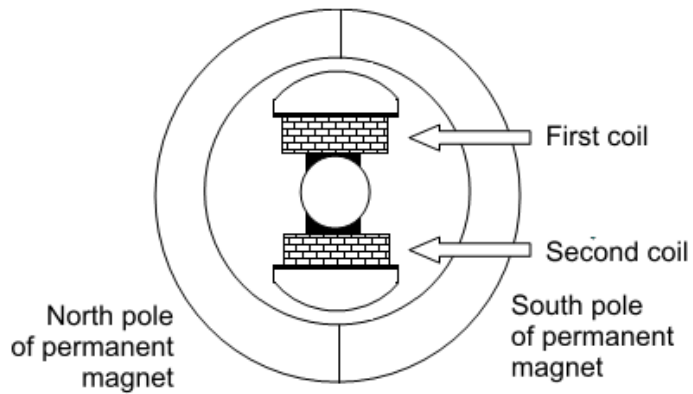


Fig. 2. Basic of DC Motor

In this project a 200rpm 12V DC gear motor has been used to lift up the folding material. The difference between normal DC motor and DC gear motor is, DC gear motor can hold a position without drifting. DC gear motor can rotate and return accurately to the wanted position according to the program that has been added in the microcontroller [2]. Since the motor shaft only cannot lift up the folding material, a steel rod is welded on the shaft of the motor as shown in Figure 3. On the top of the steel rod, a T shape PVC is joined with it and connected with the folding material as shown in Figure 4. This is to strengthen the polystyrene with the motor.



Fig. 3. DC Motor welded together with the shaft

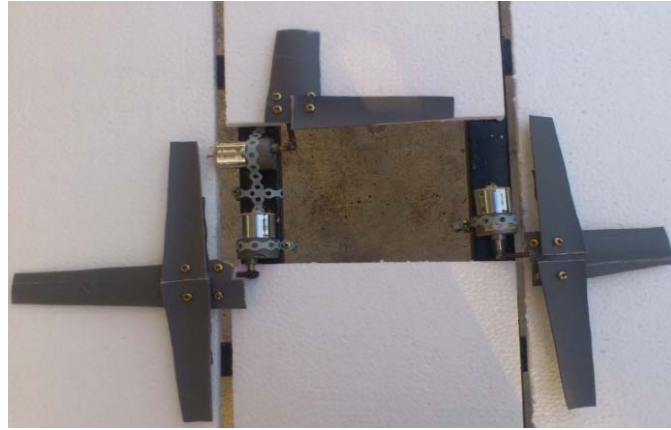


Fig. 4. Base for the DC Motor Placement

## 2.2. Relay as switching purpose for DC Motor

Relay is a component that operates like a switch. Most of the relay has electromagnets which will able to mechanically operate a switching mechanism. Relays are used where it is necessary to control a circuit by a low-power signal (with complete electrical isolation between control and controlled circuits), or where several circuits must be controlled by one signal. In the earlier days, relays were used in the telegraph circuits where it will repeat the signal from one circuit to another. Relays are also used in earlier computers to perform logical operation. Most relays are manufactured to operate quickly. In a low-voltage application this reduces noise; in a high voltage or current application it reduces arcing. Figure 5 below shows a relay component that is used as switching for the DC motor's rotation aid.



Fig. 5. Relay

## 2.3 Microcontroller

A microcontroller or  $\mu\text{C}$  is considered as a small computer on a single IC circuit which contains a processor, memory, and programmable input/output peripherals. Program memory neither is in the form of NOR are flashes or OTP ROM also often included on chip, as well as a typically small amount of RAM. Microcontrollers are designed for embedded applications, in contrast to the microprocessors used in personal computers or other general purpose applications. By reducing the size and cost compared to a design that uses a separate microprocessor, memory, and input/output devices, microcontrollers make it economical to digitally control even more devices and processes. Mixed signal microcontrollers are common, integrating analog components needed to control non-digital electronic systems.

## 2.4 Folding Tray

The folding tray that is used for the prototype model is a polystyrene sheet shown in Figure 6 [3]. The reason to use polystyrene is because of its light weight feature which will not burden the DC motor. Polystyrene sheet also has rough surface so it will really hold on to the t-shirt and not let it fall as it is being folded. This material is actually connected with the DC motor to lift up the t-shirt.

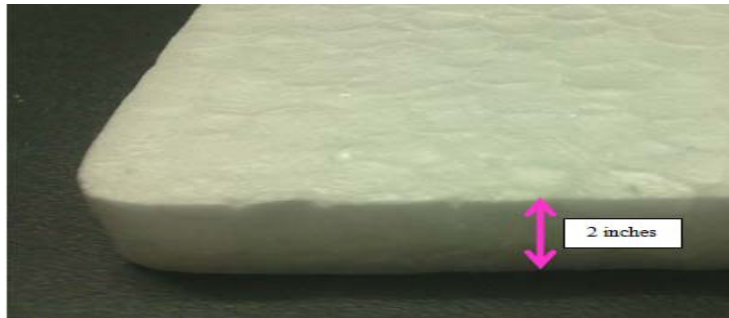


Fig. 6. Polystyrene sheet

## 2.5 12 Vdc Solar power Supply

As of most system, a supply voltage of 12V dc is used to operate the folding machine. In this project, since the motor accepts a maximum voltage of 12V DC, a 12Vdc solar power supply is used. A brief circuit construction is shown in Figure 7.

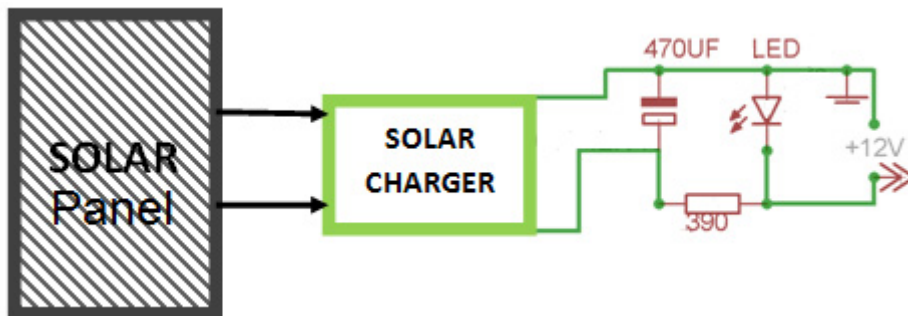


Fig. 7. Solar power supply for running the folding machine

## 2.6 Metal Frame

For this project a metal frame is designed to place the folder and also hold the DC motor. The stand is 2 feet high from the ground. This design can vary based on user's preference. It is design as horizontal as shown in Figure 8.

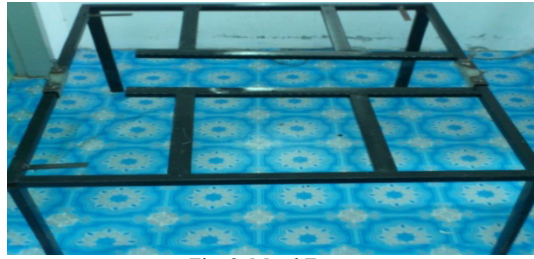


Fig. 8. Metal Frame

### 3 Project Development

Figure 9 shows the project phase that is planned accordingly. The system will be divided with two common parts which consists of hardware and software. The software designed in this early level is only for testing purpose. In hardware part, consideration from many aspects is very important in terms of size, electrical characteristic, purpose, and rating of current, voltage and power. After completing these two important parts, and before integrating both of them, several testing must be conducted on each component that used. After confirming the circuit is perfectly functioning, simple program will be burned into the microcontroller. All ports are tested and verified.

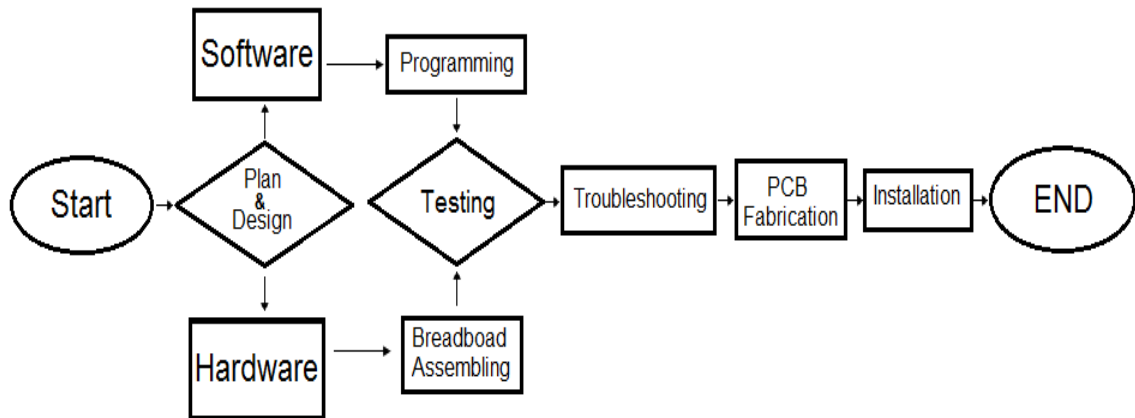


Fig. 9. Flow Chart of Project Development

#### 3.4 Process flow

Process of this easy t-shirt folding machine will start once the push button is pressed. When the push button is pressed, motor B will rotate anticlock wise. Once it reached the time set in the program, it will stop. Then motor B will return to the original position by rotating clockwise. The sequence of the motor will be same for motor A, C and motor D. This process is simplified in Figure 10 below.

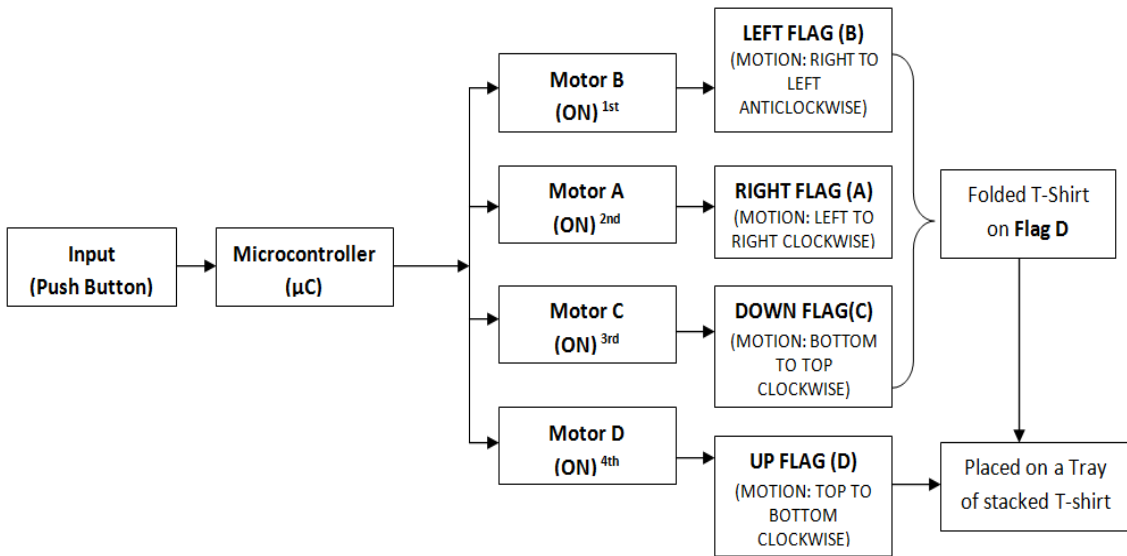


Fig 10. Process Flow of T-Shirt Folding Machine

The folding motion of this machine is controlled by the motor which is attached with the folding material listed as Motor A, B, C and D as shown in Figure 11. Motor B is the first motor to rotate where it will make the B flag of the polystyrene to rotate to the left. Then follows by motor A will lift up and make flag A to rotate from left to right. Then followed by motor C from bottom to top to finish up the folding mechanism and finally motor D will move from top to bottom to slide the folded t-shirt on a tray that will stacked the folded t-shirt. This motion continues until the shirts are finish.

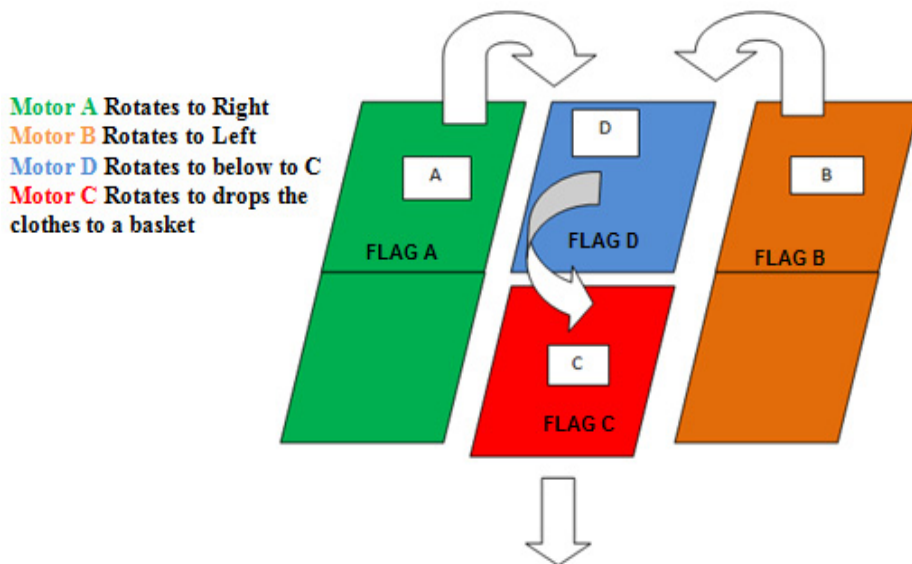


Fig. 11. T-Shirt Folding Motion



### 3.5 AT89C51 Microcontroller

The microcontroller that has been used in this easy t-shirt folding machine is known as AT89C51. The reason why this device is selected is because it is a high performance device where the program can be reprogrammed in the system with using the conventional non-volatile memory programmer. It is also a very low power consuming device which is not only low in cost but also highly flexible. AT89C51 has 40 pins divided to input, output and other ports. The schematic diagram of the device can be seen in the Figure 12 below.

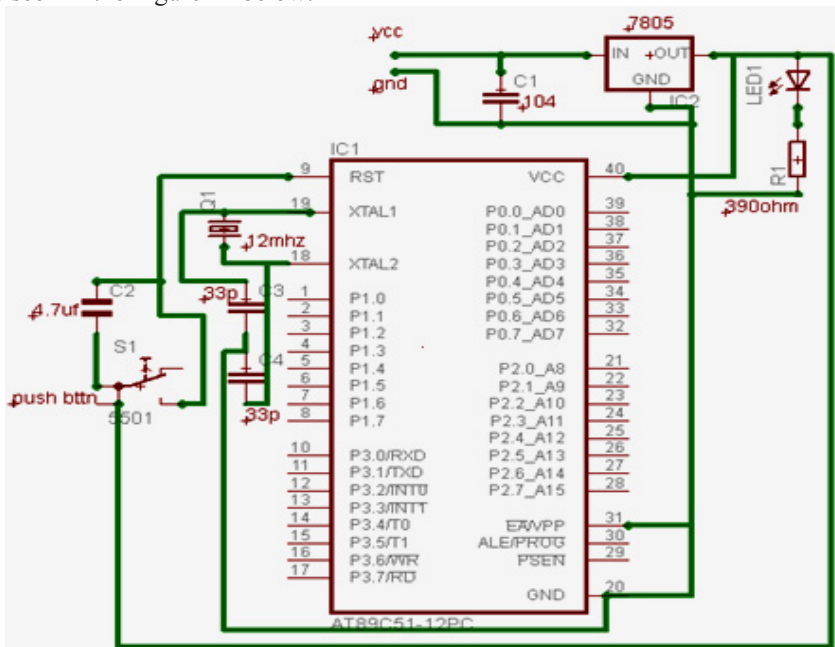


Fig. 12 .Microcontroller Schematic Diagram

### 3.6 Relay Sequence

There are four units of relays that have been used in this automatic folding machine circuit as shown in Figure 14. It is used to control the motor rotation clockwise and counter clockwise where the relay functions as a switching device. Since there are four motors in the project, four relays are used. Figure 13 below are the images of relays with LED to indicate which relay controls which motor. i.e Relay 1-LED 1-Motor 1.

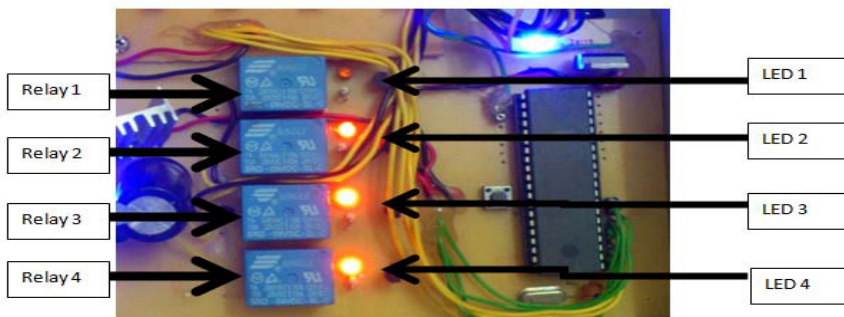


Fig.13.Relay sequence



As can see in the Figure 13, the LED on the top is not blinking when the first motor is in the process. It shows that the relay on the top is under process. So, the current is only flowing through the first relay at the moment. Balance three LED's are blinking. So it is showing that the balance three relays are not in the process which explains that the current is not flowing through it. Once the first relay process ends, it will follow by the second relay and at that time LED 2 will be blinking. This means at that time the second motor is in the process. The sequence will continue until the last relay that is the fourth LED indicator wont blink. Once all four motors are motionless, it means that there is not current flow through all the relays and the entire LED indicator will not blink at that time.

**4 Result of T-shirt folder**

*4.4 Comparison between Human and Machine Folding Time*

When human manually fold a shirt, it will take roughly 4 second to complete one t-shirt but with using this easy t-shirt folding machine that time is reduced to just 2 seconds. So Table 1 below shows time to complete 1000 shirts. From the table it shows that by using the easy t-shirt folding machine, the time to fold 1000 pieces of shirt will only take 33 min compare to manually folding the t-shirt which takes up to an hour and 7 min. This clearly shows that the time saved by using the machine is approximately half an hour compare to manually folding 1000 t-shirts.

Table 1. Comparison Of Between Human and Machines Folding Time

	HUMAN	MACHINE
Folding Time (Sec)	4 Sec/ T-Shirts	2 Sec /T-Shirt(min) (Adjustable Timer for Folding Speed)
1000 T-Shirts (Min)	1 Hour 7 Min (67min)	33min

Based on Figure 14, it shows the actually prototype of easy t-shirt folding machine. In top left corner of Figure 14 we can see the flag B starts to rotate and folds the left part of the shirt as the button is pushed and then followed by flag A which folds the right part of the shirt and then finally flag C which lift up the shirt and complete the folding process. In bottom right is the complete folded t-shirt.



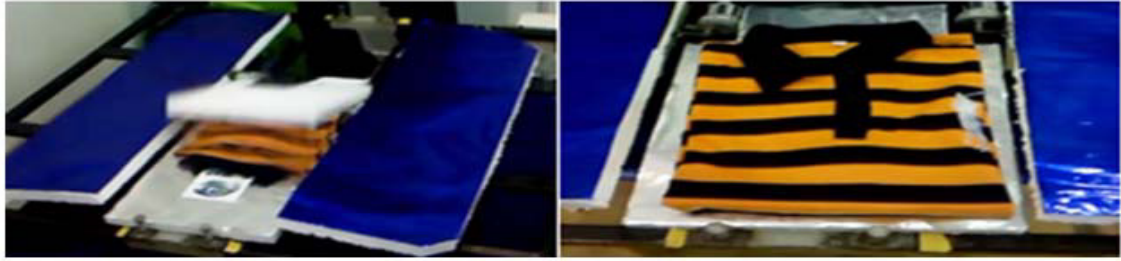


Fig. 14. Folding mechanism of T-Shirt

## 5 Discussion

Initially there are few problems faced when first creating the prototype model of easy t-shirt folding machine. The most difficult part is the selection of the suitable motor. The motor must be powerful enough to lift the folding material. The weight after the shirt is placed on the folding material also must be considered when selecting the motor. The motor also must not be high in price at the same time easy to control by the microcontroller. Problem also occurred when selecting the folding material. The material should not be heavy because motor will face difficulty in lifting it up. The material surface must also be slightly rough so that the shirt won't slip away from it once the wing is turned. So after testing with few materials, finally the polystyrene has been selected as the suitable material because it is very light in weight and also have a rough surface area that can make the shirt stay without falling. Another problem faced is how to attach the folding material with the motors because motor needs something attached on the shaft like a gear system so it can be joined with the polystyrene. So the motor has been welded with a steel rod and then attached with the polystyrene with using a t-shaped flap made of PVC.

## 6 Conclusion

After several attempts on completing this T-Shirt folding project, a novel yet simple project was successfully created. The conventional way of house hold chorus, in terms of folding T-shirts are now done faster and needs less attention or monitoring. This is because this machine is totally automatic and it is proved by a complete cycle of shirt folding by a push of a button. The time spent to fold the t-shirt also has been slash to half since the machine can do the folding in almost half of the time taken by the manual way. This machine can help users to lessen their burden and is highly handy for users with loads of shirts to fold. This project also comes handy to several industries such as the laundries services, hospitals, shirt manufacturers and so on that needs clothes to be folded in a much cheaper way compare to the CNC machine which is expensive and cost a lot.

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