An Automatic Paper Separator

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Executive Summary

The purpose of this report is to offer detailed descriptions of our team's design—automatic paper separator—for those who are intrigued by our design. This report is comprised of seven parts including introduction, background, criteria, design, evaluation, recommendations, and conclusions. Additionally, the manual for construction is attached in the appendices as a Do-It-Yourself project.

In our daily life, many tasks involve a large amount of paper to deal with. However, people have to waste much time to separate paper manually. Although some existing devices such as collating machines are capable of separating paper automatically, they are subject to some disadvantages including being too large. In order to address the issue of dealing with paper, our team built an automatic paper separator.

In order to be a successful design, a device has to meet two fundamental criteria—functionality and accuracy; a device is able to separate over 100 sheets of paper automatically and keeps the error index within 5%. Furthermore, for the purpose of improving our device, we add more criteria—buildability, and robustness. In other words, a device should be buildable by hobbyists, and work in different conditions.

After taking these criteria into consideration, our team constructed the automatic paper separator. Our device consists of three parts—paper feeding system, paper separating system, and joint system. The feeding system feeds one sheet of paper each time into the paper separating system. Meanwhile, the paper separating system rotates the paper tray 90 degrees when the sheets of paper reach the expected number for one portion. Additionally, these two parts are controlled by the joint system consisting of an Arduino board, light sensors, and drive board.

We tested our design by each criterion after construction. We tested whether our prototype meets the criteria for buildability, functionality, robustness and accuracy. We got the following results. First, our device is capable of separating 132 sheets of paper one time. Second, the maximum of error index is 4.83%. Third, hobbyists can build our device by the manual provided by us. Finally, it can work in different light and voltage conditions, while it does not work effectively when humidity is high. Consequently, our design satisfies the criteria of buildability, functionality, and accuracy, but fails to meet all the demands of robustness. Although our design has some shortcomings, it also has a potential to be applied in schools and print shops widely. People can use our device to separate paper automatically instead of wasting time to separate it manually.

Recommendations are provided for those who are interested in our design and would like to work on it. The low-cost materials are expected to be used instead of plexiglass and the Arduino board. Also, we recommend that future teams should reduce the noise and volume of our device further.

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1 INTRODUCTION

With the popularization of printers, we often deal with a large amount of paper to separate. It is common that paper needs to be separated into several portions in schools and print shops. This work is boring and time-consuming. Therefore, there exists a pressing need for a machine capable of separating paper automatically. Although we have found that there are similar products such as collating machines in the market, they are considered too large and inconvenient for daily use. Consequently, we decided to create an automatic paper separator to address this problem.

Our team, Massive Dynamics, built an automatic paper separator successfully. The device consists of three systems. One is the paper feeding system, which feeds paper to the separating system. Another is the paper separating system, which is able to separate paper by rotating 90 degrees each time. Also, the joint system connects those two systems and contains the electric circuit to control them. With these three systems working together, our device is able to separate paper successfully. Additionally, our device has the similar volume compared with family printers. It is convenient for people to use our device in schools and print shops and it is capable of saving the precious time.

The purpose of this report is to give detailed information of our design for people who are interested in it. We offer background information followed by criteria we set for our design. Meanwhile, the detailed descriptions of final design and evaluation are shown in the following sections. Finally, we list our recommendations for future teams and give our conclusions.

2 BACKGROUND

In this section, we first provide the descriptions of the collator. Then we show the conclusion of our investigations about the printers in the print shops in SJTU. Finally, similar products are briefly introduced.

2.1 Description of Collator

A collator is positioned as office use, which is good at sorting documents. It can arrange paper in order and some collators even have the function of copying paper. (“What is a Collator,” n.d., para. 1) It is a very useful device because it can really liberate our two hands and let the boring work done by the machine automatically. IBM once developed a kind of collator to help the U.S. Social Security Board to deal with a massive bookkeeping project. People described that “Collators were a new super-fast way to merge data sets or spot duplicate cards.” (McMillan, 2012) The British Museum once introduced a kind of collator to check whether different copies or impression of books w ere in order or not. It learned the case of the Folger Library which contains 79 copies of

the First Folio of Shakespeare assembled in order with the help of the collator. (Departm ent of Printed Books, 1957)

2.2 Products in the Market

There is a similar product in the market called the collating machine. The collating machine is able to separate more than ten sheets of paper with different contents into one portion. Furthermore, some kinds of collating machines can staple one portion of sheets of paper together at the same time. However, most of the collating machines have the height of an adult and cost more than several hundred thousand RMB. Hence, they are designed for professional printing plants, not for ordinary users (see Appendix A).

2.3 Conditions in SJTU

We investigated most of the print shops in SJTU. There are only two models of printers (see Appendix B). One is the family-used laser printer and the other is the office-used multifunction printer which is able to copy and can print in high speed. However, these two kinds of printers do not have the function of separating paper. If there is a large amount of paper to sort, people have to spend great efforts and time separating them manually.

3 CRITERIA

This section will detail our criteria we set up for our design. There are four criteria: buildability, functionality, robustness, and accuracy.

- *Buildability*

  The design should be buildable by hobbyists and anyone who is interested. More specifically, all the materials and components in a design should be accessible to everyone. No advanced techniques or methods should be needed to assemble the prototype. With the instructions given, anyone should be able to replicate the same prototype. This criterion is necessary because we are doing a DIY project.

- *Functionality*

  The design should be able to separate sheets of paper effectively. The sheets of paper processed by the design should be arranged by portions and should be easy to be taken apart without any further labor. Moreover, this criterion also requires the design to be able to handle more than 100 sheets of paper because according to our survey, more than 65% people feel it annoying to separate less than 200 sheets of paper by hand (see Appendix C).

- *Robustness*

  The design should be able to work in different conditions. In the real world, a

design is used in various environments, where some variables, such as the voltage, the humidity, and the light condition, are constantly changing. A successful design should withstand these changes and retain its functionality. This criterion is necessary because users expect our design to work in different environment.

- *Accuracy*

  The design should be accurate. The accuracy is indicated by the error index, which is calculated by the percentage of the number of portions which have the wrong number of sheets of paper in the total number of portions. People will not use a design if they have to spend considerable extra time dealing with the inaccurate outcome. Because it's almost impossible to be 100% accurate, the design should keep the error index lower than 5% if it is dealing with no more than two hundred sheets of paper. We think this percentage is acceptable because even the printers have errors sometimes.

4 DESIGN

4.1 Design Overview

Our team's design Automatic Paper Separator enables users to separate paper into desired portions by placing paper in the machine and input the requirement. The phrase "separate paper" means to take in one large pile of hundreds of sheets of paper and divide them into small portions perpendicular to each other. This makes it easier for the paper to be taken apart with specific number of sheets per portion. Users can input the number of sheets of paper in each portion so that they can later distribute paper more conveniently.

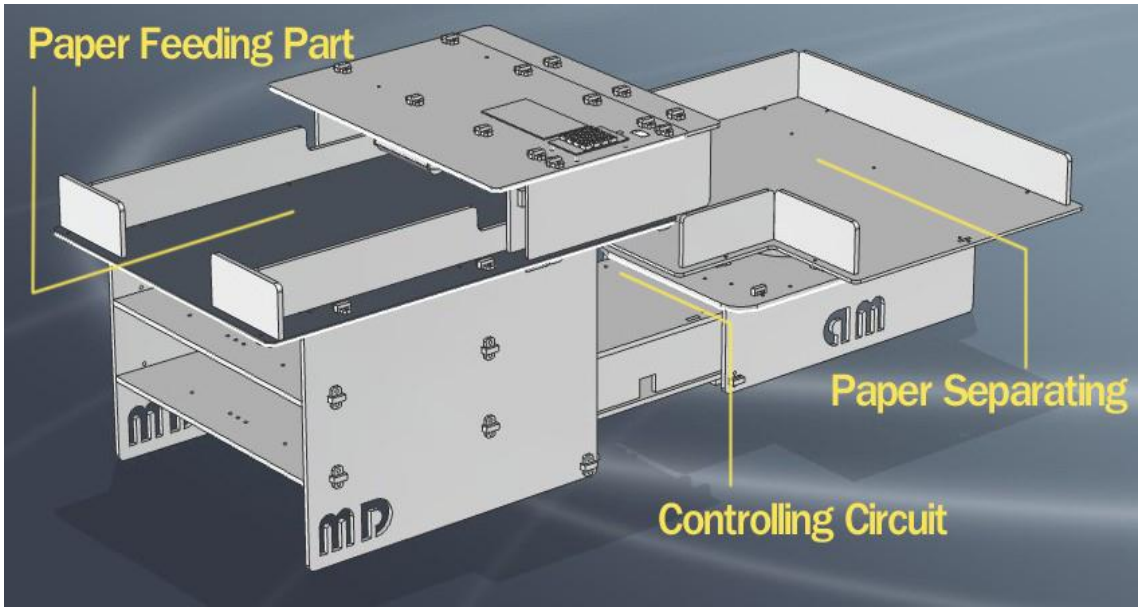

Figure 4-1: 3D Design Model

To realize the function of separating paper, the Automatic Paper Separator is designed to

have three major systems (see Figure 4-1 and Figure 4-2). We designed and manufactured each part of the Automatic Paper Separator and developed the program on our own so that hobbyists would be able to build this machine with our guidance. This section will give out detailed explanations in terms of mechanical structure, specifications for the circuit, program algorithm, and material.

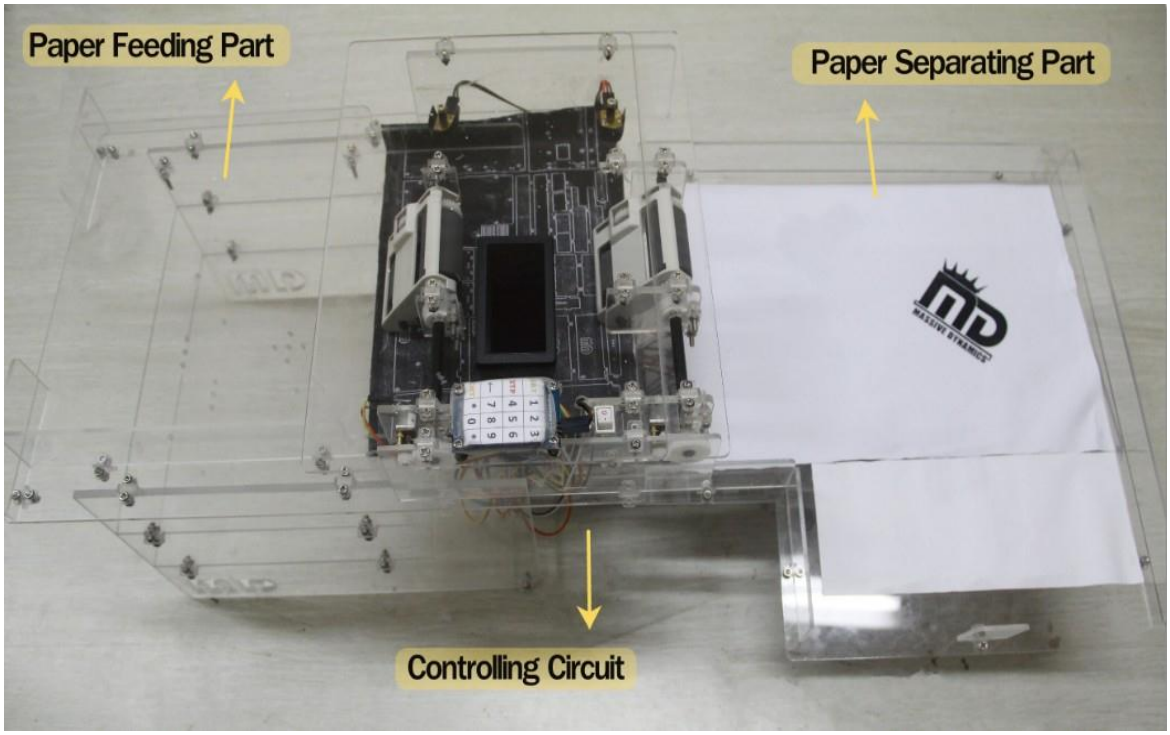

Figure 4-2: Picture of the Final Design

4.2 Mechanical Design

This section will introduce the mechanical structure of the automatic paper separator. The Automatic Paper Separator is a machine that contains three mechanical systems which are controlled by an Arduino board. The paper feeding system can take in paper one by one and report the number of sheets of paper taken to the Arduino board. Also, the user input-output subsystem is placed on the top of the paper feeding system. The paper separating system can rotate the paper tray 90 degrees each time to put each portion of paper in a different direction. The joint system can protect the central control circuit and fix the distance between the paper feeding system and the paper separating system. Combining the three systems, the machine has maximum length 718 mm, maximum width 340 mm, and maximum height 260 mm (see Appendix D).

4.2.1 Paper Feeding System

The paper feeding system contains two motors, two light sensors, two rubber rollers, one matrix keyboard, one LCD screen, one power switch, one plexiglass paper track, and one supporting plexiglass shelf. It has maximum length 378 mm, maximum width 280 mm, and maximum height 260 mm (see Figure 4-3).

The top of the paper feeding system is the user control subsystem. It is made up of one matrix keyboard with 16 buttons, one LCD screen which can display four numbers and a power switch. Ten buttons of the matrix keyboard are used for decimal number input. Four more buttons are used as function keys for Start, Stop, Backspace and Continue. The other two buttons are left blank for future use.

The center of the paper feeding system is the feeding structure which is composed of one rubber roller connected with a motor by gears. The rubber roller has a special structure which allows portions of paper with different thickness to be taken in. On the other hand, the contact area between the rubber roller and the paper to be separated can be regarded as a horizontal line with 25 mm in length. This size of contact allows the machine to take in paper without wrinkling it. The first feeding structure is placed 45mm above the center of paper and the second feeding structure is placed 122 mm behind and 3 mm lower than the first rubber roller. This design is to insure that the paper feeding system can take in single paper or stapled paper one by one and increase the capacity of this design.

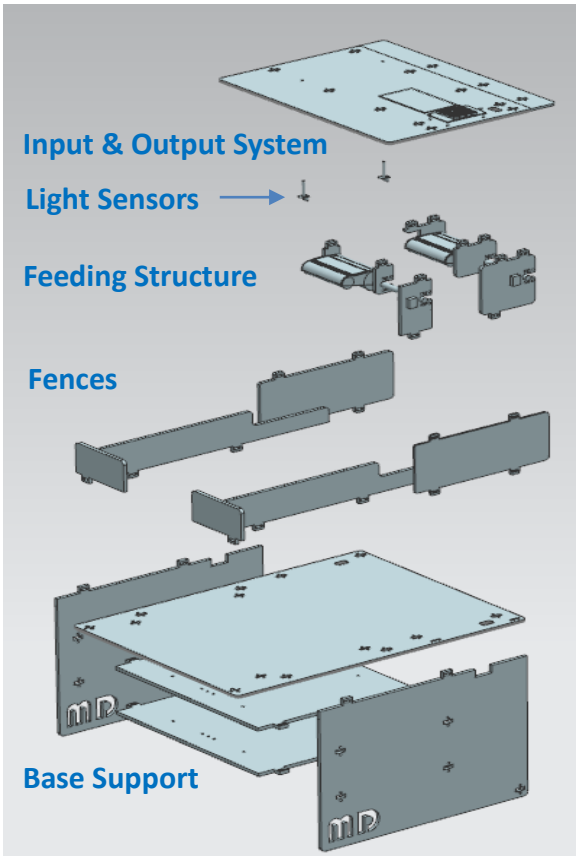

Figure 4-3: Paper Feeding System

The bottom of the paper feeding system is entirely made of 4.3-mm plexiglass, nuts, and bolts. This part supports the plexiglass track of paper, and is designed to have two shelves for users to place their things. These two shelves also increase the robustness of the supporting part.

The process of feeding one sheet of paper contains two steps. After pressing the Start button, the first feeding structure begins to take in paper. When the light sensor placed beside the second feeding structure detects the paper, the second one begins to rotate and meanwhile the first feeding structure puts up to stop taking extra paper until the second one has complete the paper feeding. The former two steps complete a whole loop of feeding one sheet of paper. As the loop goes on, the light sensors will gather information about whether each step of paper feeding is finished and count the number of sheets of paper that has been taken in. The two light sensors can also monitor whether the paper gets stuck or not and give feedback to the control circuit

4.2.2 Paper Separating System

The paper separating system is mainly composed of one big motor, two light sensors, one plexiglass tray and one supporting plexiglass platform. It has maximum length 340 mm, maximum width 340 mm, and maximum height 175 mm (see Figure 4-4).

The top of the paper separating system is a plexiglass tray with 307 mm inner length and 220 mm inner width. The size of the plexiglass tray is designed to be 10 mm bigger than the size of A4 paper. This allows the separating system to take in paper under different voltage which affects the accuracy of the motor for the separating system.

The center of the paper separating system is one big motor and two light sensors. The motor rotates 90 degrees each time to place the paper tray in a perpendicular direction for paper separating. As the direct current motor cannot accurately control the angle of its rotation, the two light sensors are used for feedback control and initialization.

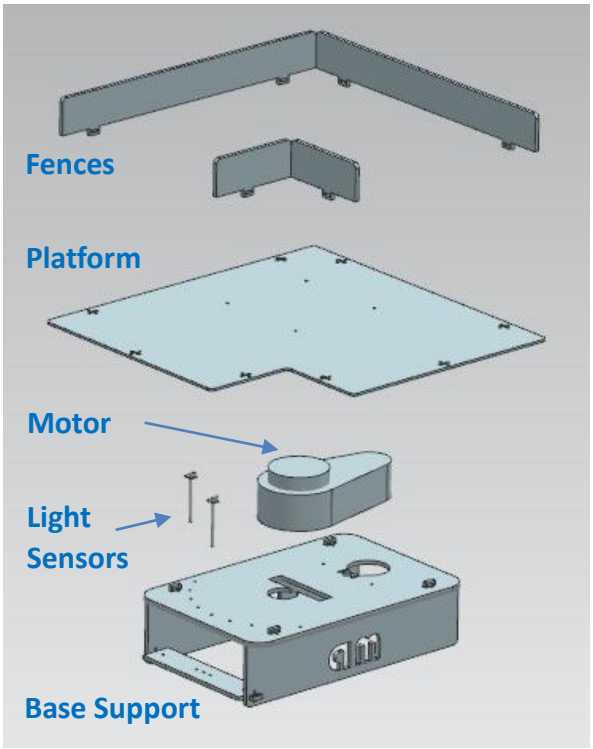

Figure 4-4: Paper Separating System

The bottom part of the paper separating system is a plexiglass platform used to horizontally support the big motor and sensors. It has maximum length 270 mm, maximum width 135 mm, and maximum height 73 mm.

4.2.3 Joint System

The joint system is a plexiglass box made by 4.3-mm plexiglass. It has maximum length 222 mm, maximum width 142 mm, and maximum height 50 mm. The box is designed to offer protection for the central control circuits. Three circuit boards are fixed in the box. Another function of this system is to connect the paper feeding system and the paper separating system with fixed distance. Ten nuts and bolts are used to fix two ends of the joint system onto the paper feeding system and paper separating system respectively (see Figure 4-5).

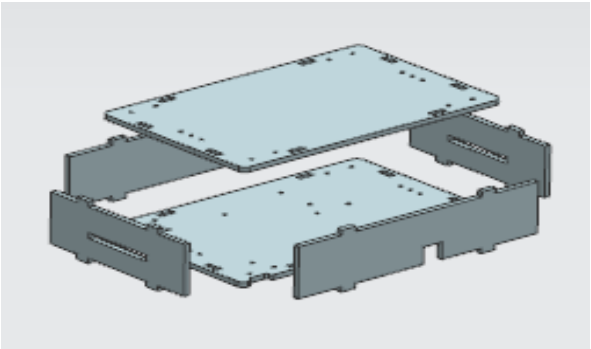

Figure 4-5: Joint System

4.3 Circuit Design

This section will introduce the electric circuit of the mechanical structure (see Appendix E). The circuit has four sensors, three motors, one driver board, one sensor board, one keyboard, one LCD screen, one buzzer, one Arduino board, and the wires. See Figure 4-6 for details. Note that the keyboard, the buzzer, and the LCD screen are not shown in Figure 4-6.

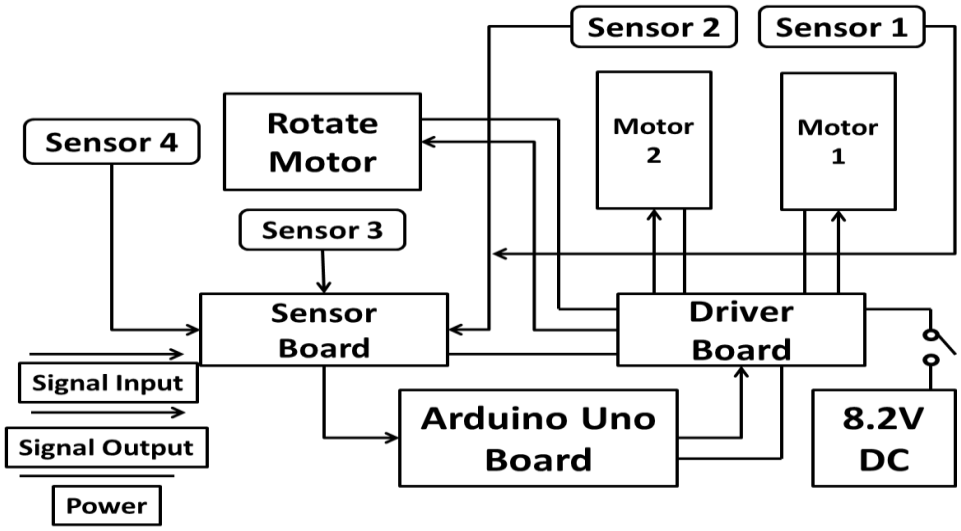

Figure 4-6: Electronic Subsystem Diagram

Our electronic circuit is organized by signal input, signal output, and power. The first part detects and transmits the light signals to the Arduino board. The second part gives signals to control the motors, the buzzer, and the LCD screen, whereas the third part supplies power to the whole circuit (see Figure 4-7).

- *Signal Input*
  The signal input is from the four sensors and the keyboard to the Arduino board. Each sensor has one pin to give the information it receives to the sensor board, which then transforms these signals from analog to digital for the Arduino board to process (LOW for white and HIGH for black). The sensor board has four signal wires connected to the Arduino board to give the signals. The signal pin of the keyboard is directly connected to the Arduino board.

- *Signal Output*
  The signal output is from the Arduino board to the motors, the screen and the buzzer. Three pins on the Arduino board are directly connected to the LCD screen to determine what to display on the screen. And another eight pins (two for each motor and two for the buzzer) are connected to the driver board to control the motors and the buzzer. And the driver board has corresponding eight wires to the motors and the buzzer.

- *Power Distribution*
  8.2-8.4V DC power is first given to the driver board, which then distributes it to other components. The driver board supplies 5V power to the Arduino board and the LCD screen, 3.3V to the sensor board and the matrix keyboard, and 8.3V to the buzzer and the motors. Except motors and the buzzer, other components also require a ground wire.

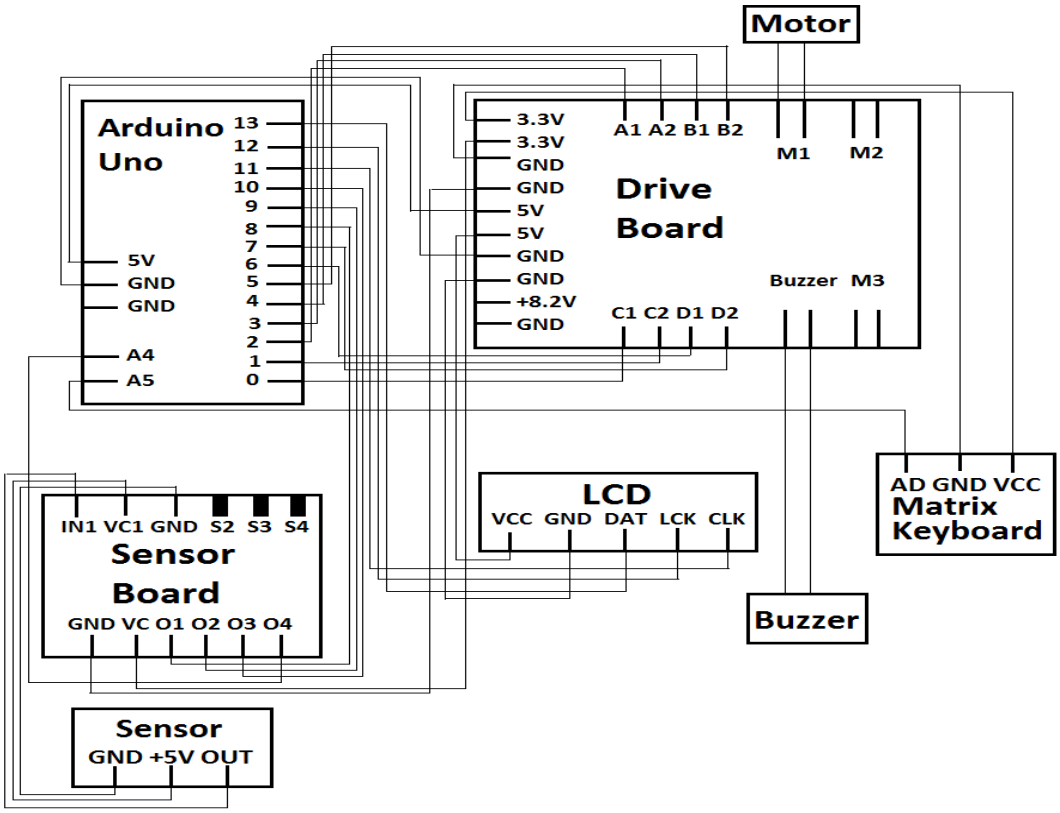

Figure 4-7: Circuit Diagram

4.4 Algorithm Design

This section will introduce the overall algorithm our team designed and implemented in order to accomplish all the functions described in the design overview section. The programming language we used is C. The program serves as an overall control for different subsystems. The algorithm is also designed to be able to cope with different kinds of situations such as wrong user input or stuck paper. Figure 4-8 is an abbreviated flow chart, which describes the main procedure of our program. The detailed description of the algorithm, as well as the full version of the code with comments, can be found in Appendix F.

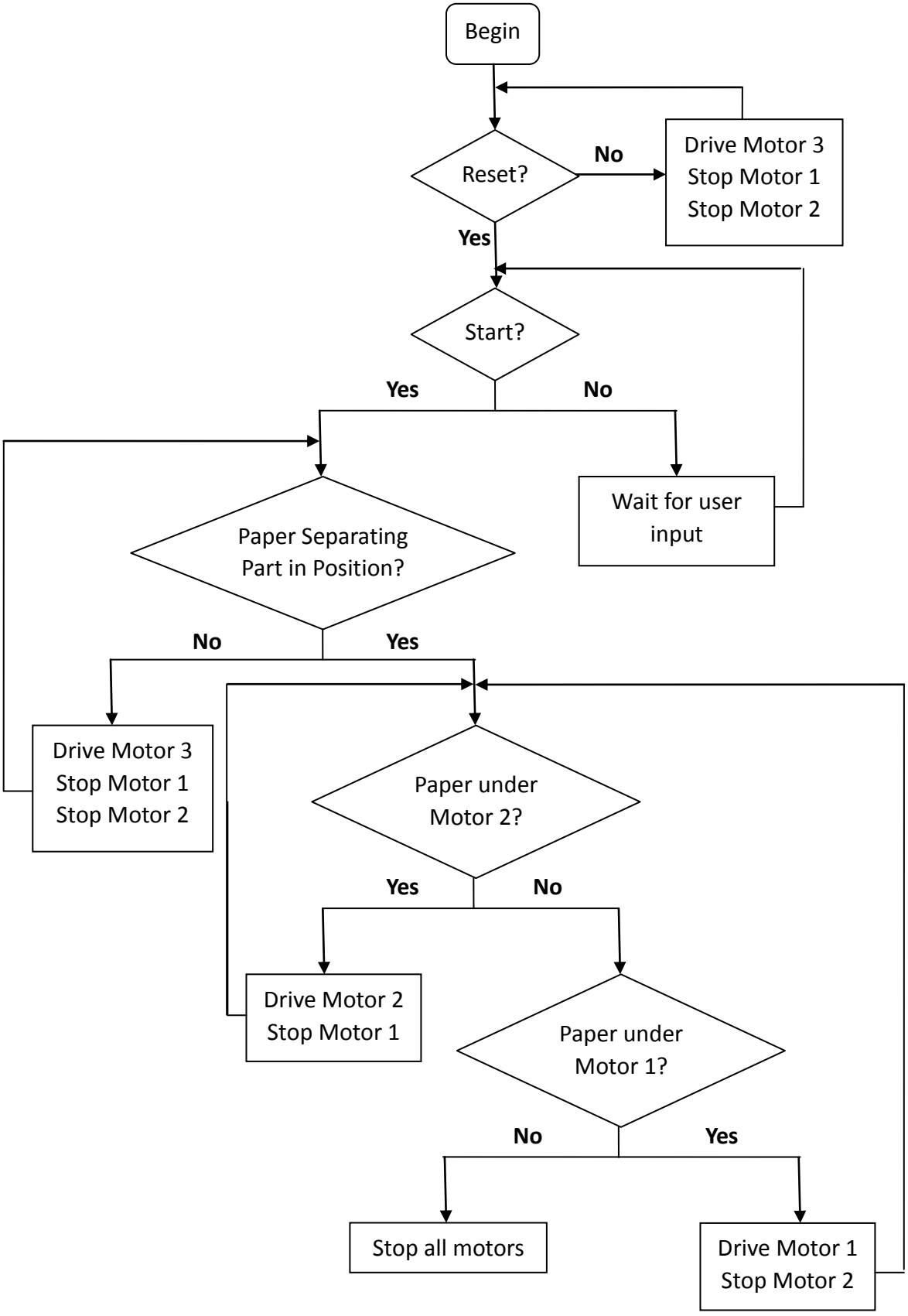

Figure 4-8: Flow Chart

4.5 Materials

To meet the requirements of robustness and accuracy, plexiglass is mainly used for the mechanical structure. The maximum impulse strength of the plexiglass is 16kg/cm^3 and the maximum tensile strength of the plexiglass is 61kg/cm^3, which meets the robustness requirement of mechanical structure. The density of the plexiglass is 1.95kg/dm^3, which makes the machine relatively light. The material can be processed by laser cutting machine, as its melting point is 105℃.

Besides plexiglass, some other materials are needed. For example, rubber rollers for paper feeding, circuit boards for central control, and so on. For detailed information about the numbers of necessary materials, access for getting them and cost of these materials, please refer to Appendix G, Appendix H, and Appendix I.

5 EVALUATION

5.1 Buildability

As a DIY project, the design should be buildable by hobbyists and anyone who is interested. Instead of running extra tests for buildability, our team wrote a step-by-step assembling manual (see Appendix J). This manual clearly has explained how to build an automatic paper separator, which will enable hobbyists to build the design without much difficulty. Therefore, the design meets the criterion for buildability.

5.2 Functionality Test

We must ensure that our design can realize the basic function, separating paper effectively. In this test, we checked if our prototype could separate at least one hundred sheets of paper. We put a stack of paper into our prototype and operated it. The result showed that after four minutes and eleven seconds, the total number of 132 sheets of paper was separated, which successfully met our criterion (see Appendix K.1).

5.3 Robustness Test

- *Light Condition Test*

  We must ensure that different light conditions, especially the natural light, will not affect the normal use of our design because we use light sensors to control the paper feeding and separating. We let our prototype separate paper at 12:51p.m. and 17:28 p.m. Also, since it was not so dark outside, we closed the curtains and tested again at 17:30. The result showed that our prototype worked well both in bright and dark conditions, proving that our prototype was robust enough (see Appendix K.2).

- *Voltage Condition Test*

  The purpose of this test is to ensure that our design is robust and is workable in a range of voltage. Since we used a voltage transmitter to offer the power to our prototype, we were able to change the voltage. We changed the voltage and checked if our prototype could still work properly. During the test, we found that the best working voltage was around 8.4 V because we got the proper velocities of paper feeding and rotating. If the voltage was below 7.4V, the power was not enough for our prototype to work. If it was above 9.4V, the platform of the paper separating system would rotate so fast that it would over rotate and result in the failure of separating paper properly. The test showed that our design was able to work in the range of 2 volts, so it was robust enough (see Appendix K.3).

- *Humidity Condition Test*

  The purpose of this test is to check whether our design can work well both in dry and wet conditions. In different days, we measured the air humidity using a hygrometer. Then, we put the same number of sheets of paper into our prototype, checked whether it could work accurately, and recorded the error index. Unfortunately, all the error indexes recorded were over 5% when humidity conditions were 76% and 89%. Paper would get stuck in high-humidity condition. Therefore, our design needs improvement for this problem (see Appendix K.4).

5.4 Accuracy Test

Since sometimes our prototype might feed two sheets of paper at one time, we tested the accuracy of it (see Appendix K.5). We let our prototype separate different number of sheets of paper. Since the LCD screen of the paper feeding system would automatically show the number of times that paper passed through, the exact number of sheets of paper we put in minus the number counted by our device was the number of times our device fed two sheets of paper at one time. For each number of sheets of paper we tested three times and recorded the result (see Figure 5-1 and Figure 5-2).

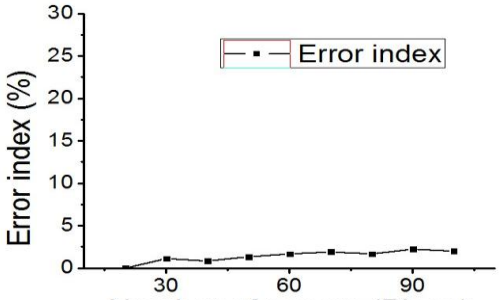

Figure 5-1: Accuracy Test Result (Part)

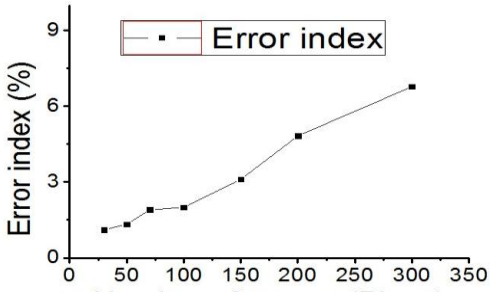

Figure 5-2: Accuracy Test Result (Full)

As the graphs showed, if no more than 100 sheets of paper were put in, our device was able to separate paper accurately and the percentage of error was no more than 2%, proving that our design could work fairly well within the capacity. However, if we separated more than 150 sheets of paper, the percentage of error would increase linearly. We also tested the accuracy of 200 sheets of paper and the result was 95.17%, which just met our criterion.

5.5 Conclusion

In conclusion, our design can separate paper effectively and accurately, and it is robust for different light and voltage conditions. However, it is not robust enough because it cannot handle humidity condition quite well. Also, though we have not run specific test for buildability, we have successfully built it by ourselves (see Appendix J), so we think that our design meets this criterion.

6 RECOMMENDATIONS

Although our design meets the criteria, functionality, accuracy, and buildability, there still exist some constraints. Therefore, we offer future teams the following recommendations for improvement.

- *Shrink the Volume*

  Though our final design is much smaller than present collators in the market, it is still subject to relatively large volume. It has maximum length 718 mm, maximum width 340 mm, and maximum height 260 mm. The large size of our design, in our point of view, takes much space, which may prevent our design from being widely used in schools and print shops. Therefore, we strongly recommend that future teams can reduce our design's volume to make it more practical and useful.

- *Reduce the Cost*

  Our final design uses the Arduino board and plexiglass which are more expensive compared with other SCMs and plastics, respectively. Thus, the cost of our design is relatively high and reaches 409.8 RMB. If the future team can use cheaper SCM and plastic instead of an Arduino board and plexiglass, hopefully, the cost will be reduced to 250 RMB. Accordingly, we recommend future teams to reduce the cost.

- *Reduce the Noise*

  When we tested our prototype, the problem identified by us was that our prototype made much noise due to the rotation of the rubber rollers and motors. Staying in such environment with noise, people will feel uncomfortable and agitated, which is considered as one of the shortcomings of our design. Consequently, we commend that future teams can reduce the noise.

7 CONCLUSIONS

Our team designed the automatic paper separator successfully to help people deal with the problem of separating paper. Our design is able to separate paper automatically and accurately. Instead of wasting much time to separate paper manually, people are able to use our design to tackle this task. Also, we add some functions such as separating both single sheet of paper and stapled paper for our target users—schools and print shops.

Furthermore, our design meets all the criteria—functionality, accuracy, and buildability. It is capable of separating over 100 sheets of paper in different light and voltage conditions and informing people of the error when paper is stuck. Also, it is buildable by hobbyists, as a DIY design. However, our design fails to meet all the demands of the criterion of robustness. In other words, our design can only separate neat paper in low-humidity conditions. Though there are some disadvantages in our design, it still has a great potential to be widely applied in schools and print shops.

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Appendix A Existing Relevant Products and Patents

Digital Collator 10 Stations (See Figure A-1.)
Stations: 10
Speed: 3000 sheets per hour (A4 paper)
2400 sheets per hour (A3 paper)
Paper size: A3-A5
Paper quality: 40-210 GSM
Station capacity: 250 sheets (80GSM)
Stacking capacity: 600 sheets (80GSM)
Station device: Cross collating
Error display: Paper double-feed, paper jam, out of paper, no paper, delivery tray full, paper miss-feed, back door open
Power: AC220V, 180W
Net weight: 73kg
Gross weight: 93kg
Measurement: 1270*710*970mm

Figure A-1: Digital Collator 10 Stations

http://www.alibaba.com/product-gs/531783620/Professional_supplier_Digital_Collator_10_Station.html

Offset Printing and Collating Machine (See Figure A-2.)
Max paper size: 470*365mm
Max printing size: 454*345mm
Min paper size: 90*140mm

Paper thickness: 32-157g/m^2
Ink roller: 100 pieces, 2 form roller
Water roller: 4 pieces, 1 form roller
Print speed: 2000-6000 sheet/hour
Collating speed: 2000-5500 set/hour
Motor power: 1.5kw/220V air pump: 1.5kw/380v*2units
Machine size: 2400(L)*1150(W)*2000(H)
Weight: 1400kg

Figure A-2: Offset Printing and Collating Machine

http://www.alibaba.com/product-gs/539079977/offset_printing_machine_and_collating_machine.html

G460B Collating Machine (See Figure A-3.)

Table A-1: Data of G460B Collating Machine

Model	G460B/8	G460B/12	G460B/16	G460B/20	G460B/24
No. of station	8	12	16	20	24
Book size(a)	135*196 mm				
Book size(b)	230*460 mm				
In line speed (Max.)	6000pcs/hour				
Stand-alone speed	4800pcs/hour				
Power required	7.5 kw	9.7 kw	11.9 kw	14.1 kw	16.3 kw
Machine weight	3,000 kg	3,500 kg	4,000 kg	4,500 kg	5,000 kg
Length of machine	10,736 mm	13,022 mm	15,308 mm	17,594 mm	19,886 mm

Figure A-3: G460B Collating Machine

http://www.alibaba.com/product-gs/565045867/G460B_collating_machine.html?s=p

Relevant Patents

United States Patent [19]

Luperti et al.

[11] **Patent Number: 4,640,506**

[45] **Date of Patent: Feb. 3, 1987**

[54] **REVERSE COLLATING MACHINE**

[75] Inventors: **Harry E. Luperti**, Wilton; **Robert Irvine**, Riverside; **Anthony Luvara**, Stamford, all of Conn.

[73] Assignee: **Pitney Bowes Inc.**, Stamford, Conn.

[21] Appl. No.: **791,889**

[22] Filed: **Oct. 28, 1985**

[51] **Int. Cl.**[4] **B65H 31/36**

[52] **U.S. Cl.** **271/212**; 271/245; 414/92

[58] **Field of Search** 271/212, 245, 246, 3.1, 271/216, 202, 203, 270; 414/92; 148/462, 423; 83/88

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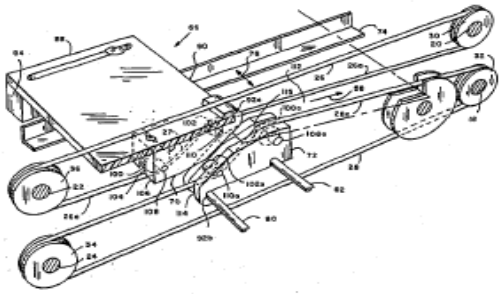
Primary Examiner—D. C. Butler
Assistant Examiner—John A. Carroll
Attorney, Agent, or Firm—Lawrence E. Sklar; Melvin J. Scolnick; David E. Pitchenik

[57] **ABSTRACT**

An improvement in a collating machine for stacking sheets of paper being fed seriatim thereto from a singulating feeder in the same order as the sheets appear in the singulating feeder. The collating machine includes a belt for transporting the sheets of paper, a ramp for lifting a succeeding sheet of paper over and onto a preceding, stopped sheet of paper, and a stopping device for stopping each sheet of paper after the sheet has been lifted by the ramp. The improvement includes a removable stacking device for stacking the sheets of paper in the reverse order as the sheets appear in the singulating feeder.

5 Claims, 12 Drawing Figures



US005499806A

United States Patent [19]

Bourg

[11] **Patent Number: 5,499,806**

[45] **Date of Patent: Mar. 19, 1996**

[54] **COLLATING MACHINE**

[76] Inventor: **Christian-P. Bourg**, Rue de Blanmont 5, 1435 Hevillers, Belgium

[21] Appl. No.: **220,533**

[22] Filed: **Mar. 29, 1994**

[30] **Foreign Application Priority Data**

Apr. 7, 1993 [FR] France 93 04122

[51] **Int. Cl.**[6] **B65H 3/44**; B65H 5/26

[52] **U.S. Cl.** **271/9.11**; 271/9.13; 271/12; 271/94; 271/98; 271/105; 271/31

[58] **Field of Search** 271/9, 11, 12, 271/94, 96, 98, 104, 105, 30.1, 31, 9.11, 9.13; 270/58

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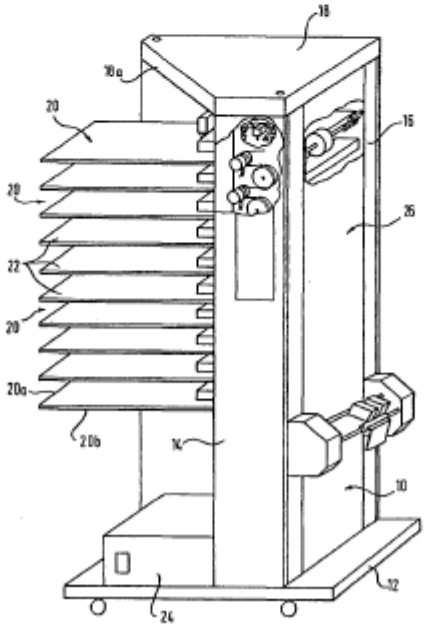
Primary Examiner—H. Grant Skaggs
Attorney, Agent, or Firm—Sixbey, Friedman, Leedom & Ferguson; Gerald J. Ferguson, Jr.; Tim L. Brackett, Jr.

[57] **ABSTRACT**

The collating machine comprises a frame (**10**), a plurality of superposed trays (**20**) in the frame in order to be loaded with stacks of paper (**28**), each tray (**20**) being fitted with an individual sheet ejection device and a transfer device, and a vertical conveyor (**26**) adjacent to the transfer devices of the trays (**20**) to receive, by the intermediary of the transfer devices, sheets ejected from their trays and to move the same to a collating station. The ejection device comprises several endless perforated tapes (**34**) carried on two spaced bend rolls (**36** and **38**) and a vacuum chamber (**46**) surrounded by the tapes (**34**) and having apertures, for the passage of air, distributed in its lower wall which is adjacent to the internal surface of the lower run (**34***a*) of the tape (**34**). The opposite surface of the lower run of the tape (**34**) is positioned opposite to the top sheet (**28***a*) in the stack in parallelism to the latter and at a distance which is maintained essentially constant by a moving plate (**22**) carrying the stack (**28**). FIG. 2.

7 Claims, 2 Drawing Sheets



US005083769A

United States Patent [19]

Young, Jr.

[11] Patent Number: 5,083,769

[45] Date of Patent: Jan. 28, 1992

[54] **DUAL COLLATING MACHINE**

[75] Inventor: **John J. Young, Jr.**, Danbury, Conn.

[73] Assignee: **Pitney Bowes Inc.**, Stamford, Conn.

[21] Appl. No.: **519,199**

[22] Filed: **May 4, 1990**

[51] **Int. Cl.**[5] **B65H 29/00**

[52] **U.S. Cl.** **271/280**; 271/303; 271/265; 271/288; 271/198; 414/790.7; 414/791.1; 270/58

[58] **Field of Search** 270/58; 414/791.1, 790.7; 198/447; 271/9, 265, 266, 270, 301, 302, 303, 304, 198, 202, 288, 280, 212

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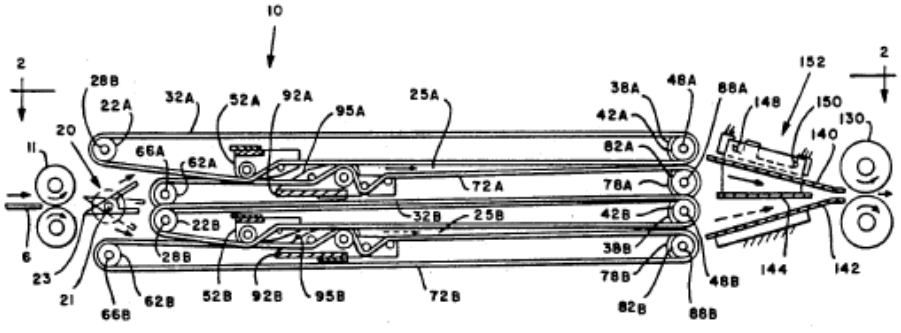
1445913	8/1976	United Kingdom	271/303

Primary Examiner—H. Grant Skaggs
Attorney, Agent, or Firm—Charles R. Malandra, Jr.; David E. Pitchenik; Melvin J. Scolnick

[57] **ABSTRACT**

A system embodying the present invention includes first structure having a first area for stacking at least one sheet to form a first collation, second structure having a second stacking area adjacent to the first stacking structure for stacking at least one sheet to form a second collation, and diverting structure arranged in a sheet path between the feeder and the first and second stacking structure for diverting the sheets fed by the feeder. The diverting structure having first and second operative positions for respectively diverting the sheets to the first stacking structure and to the second stacking structure. The system further provides control structure operatively coupled to the diverting structure for actuating the diverting structure to one of its operative positions and sensor structure operatively connected to the control structure for sensing when a sheet is conveyed to the diverting structure.

15 Claims, 5 Drawing Sheets



Appendix B Two Printers in Print Shops of SJTU

After we investigated several print shops in SJTU, we found that there are only two models of printers. One is the laser printer and the other is the multifunction printer. The following pictures were taken by us in one of the print shops in SJTU (see Figure B-1 and Figure B-2).

Figure B-1: Laser Printer

Figure B-2: Multifunction Printer

Appendix C Survey Analysis

In order to get useful information for our design, we have done some online investigations. We used six questions to get necessary information in terms of peoples' feeling about separating paper and their opinion of our design. The duration of the survey is from June 23, 2012 until July 23, 2012.

By effective using of human resources, we received 785 responses from different people including teachers and students. The following survey analysis shows the result of the survey (see Figure C-1 to Figure C-6).

1. Have you ever experienced separating paper?

A. Yes
B. No

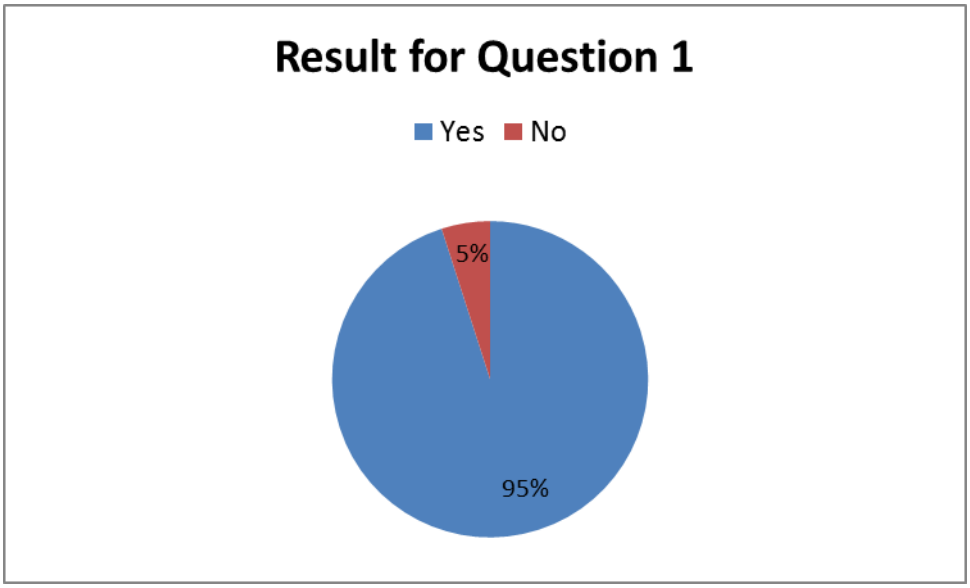


Figure C-1: Result for Question 1

2. How much paper do you often separate in one time?

A. 0-100
B. 100-200
C. 200-300
D. 300-400
E. More than 400

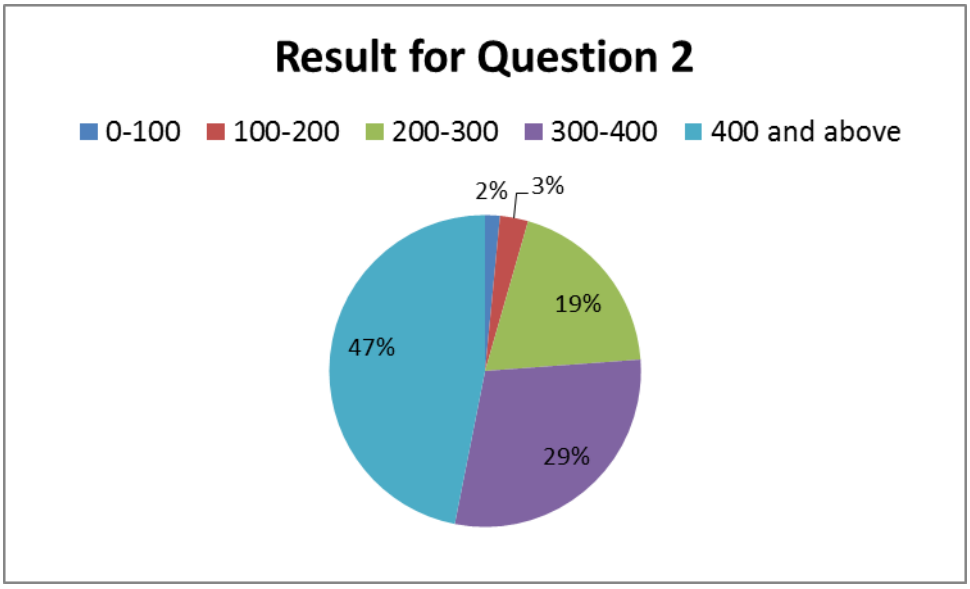


Figure C-2: Result for Question 2

3. How much time does it take you to separate 400 sheets of paper?

A. 0-2 minutes
B. 2-5 minutes
C. 5-10 minutes
D. More than 10 minutes

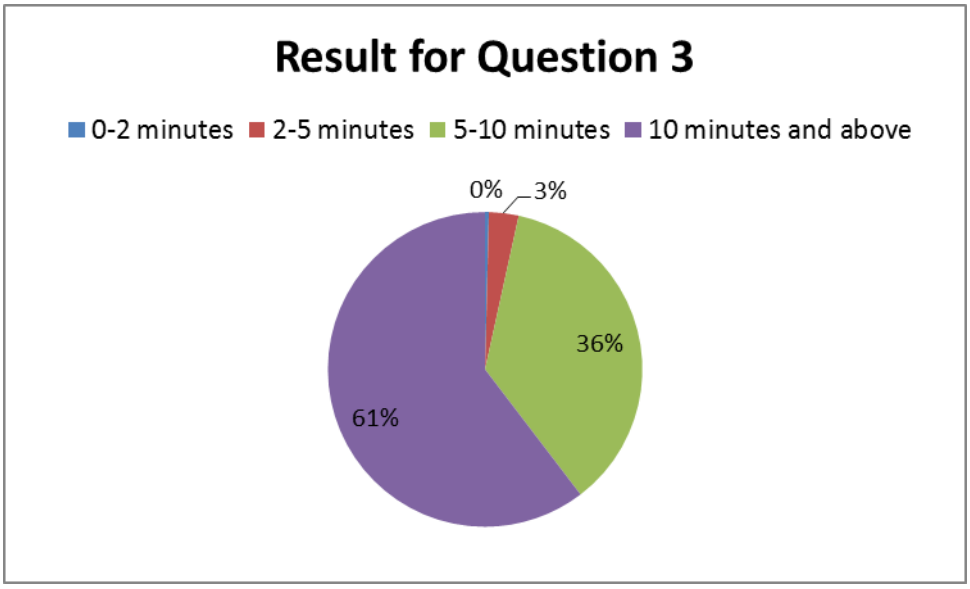


Figure C-3: Result for Question 3

4. If you are going to separate paper, what is the amount will make you annoying?

A. More than 10 sheets
B. More than 20 sheets
C. More than 50 sheets
D. More than 100 sheets

E. More than 200 sheets

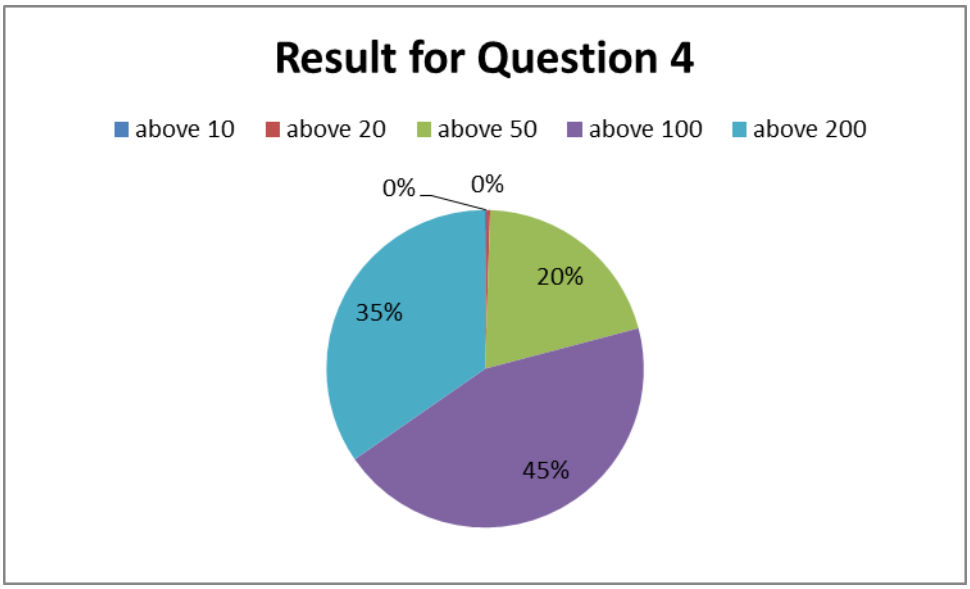


Figure C-4: Result for Question 4

5. If there is a paper separator, are you willing to use it?

A. Yes

B. No

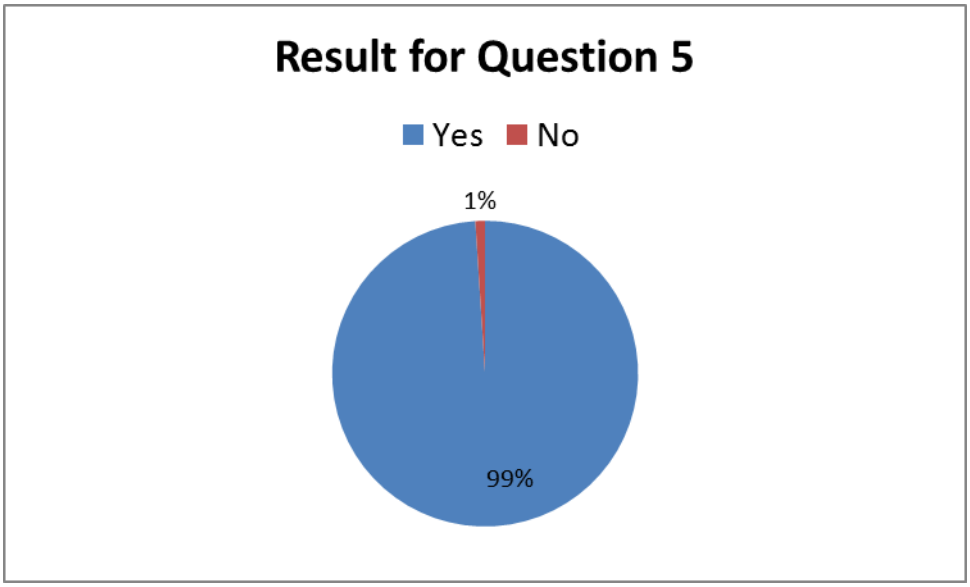


Figure C-5: Result for Question 5

6. What is the price do you think is suitable for that machine?

A. 0-50 CNY

B. 50-100 CNY

C. 100-200 CNY

D. More than 200 CNY

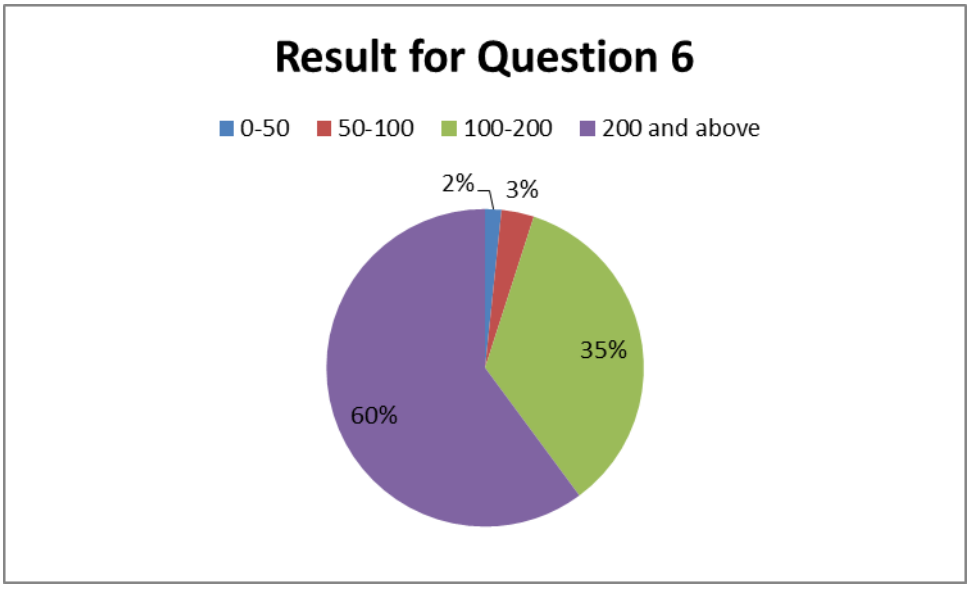


Figure C-6: Result for Question 6

As we can see from the result above, almost all of the people investigated have the experience of separating paper. More than 65% of the people investigated feel annoyed if they are asked to separate less than 200 sheets of paper. More importantly, 98.98% of the people investigated give us a positive response on whether they are willing to use a device to help them do the job of separating paper.

Based on the survey, we conclude that people will get annoyed when they are asked to separate large amount of paper. They are willing to use a device to help them separate paper.

Appendix D CAD Diagrams

Appendix D.1 Specifications

To build an Automatic Paper Separator, processing plexiglass is necessary. This part gives out the detailed dimension of different parts of the automatic paper separator. By drawing these parts according to the dimension in a CAD software and use laser cutting machine to process the plexiglass according to the notes, hobbyist should be able to manufacture the necessary components by themselves.

This appendix is divided into four sections according to different part of the design. The first section mainly gives out specifications and common parts of the design. The detailed information about the joint part including bolt and wire arranging structure is given in this section (see Figure D-1 and Figure D-2). All the holes for nuts and bolts used in this design are M3 bolts. The plexiglass used in this design has the thickness either 4.3mm or 2.7mm. Joint part structures are simplified with giving the thickness of the plexiglass in the later sections instead of drawing all the detailed dimensions. Hobbyist can refer to Figure D-1 in the joint structure for detailed information when having difficulty in drawing the later sections. See notes below each graph for detailed information.

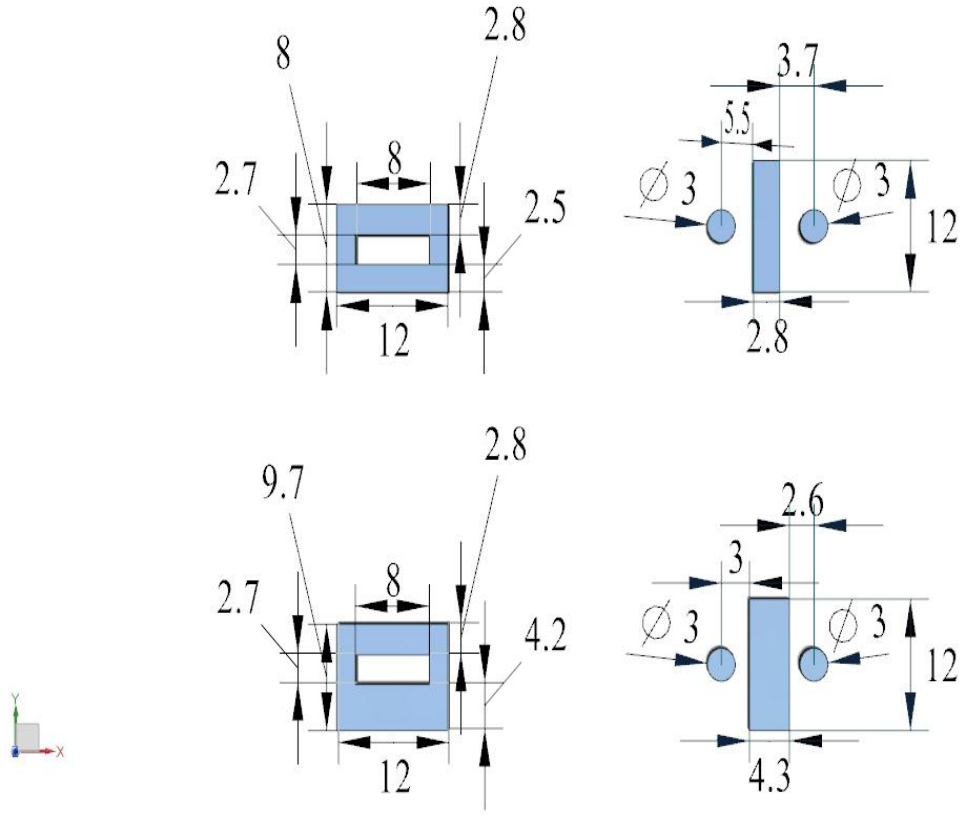


Figure D-1: Joint Part Structure

Notes: These structures serve as reference for the following parts.

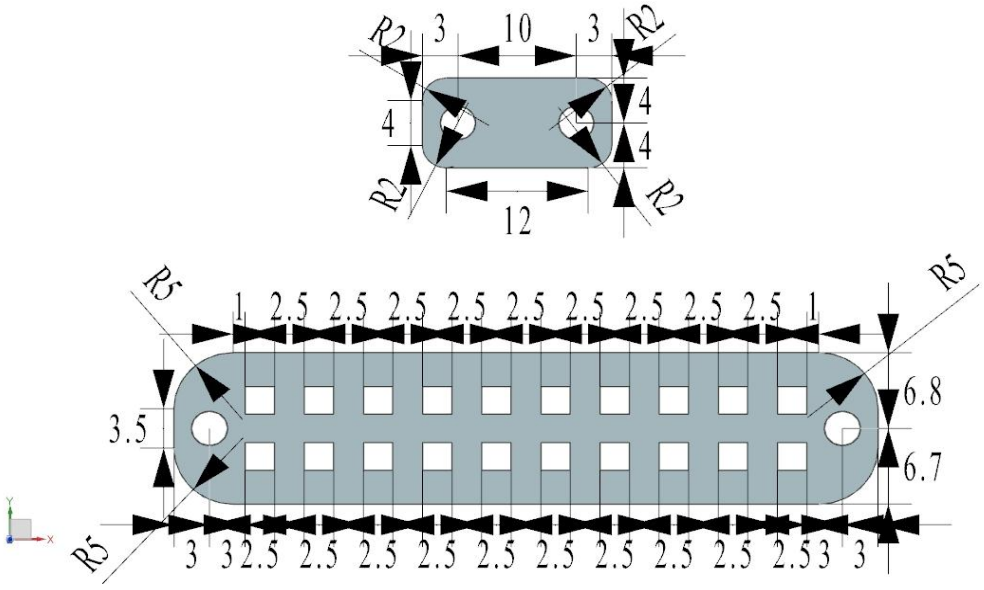


Figure D-2: Plastic Bolt & Wire Arranging Structure

Notes:
Plastic Bolt: Quantity: 50; Thickness: 2.7mm;
Wire Arranging Structure: Quantity: 4; Thickness 4.3mm

Appendix D.2 Paper Feeding System

This section gives detailed dimensions for parts of the paper feeding system (see Figure D-3 to Figure D-16).

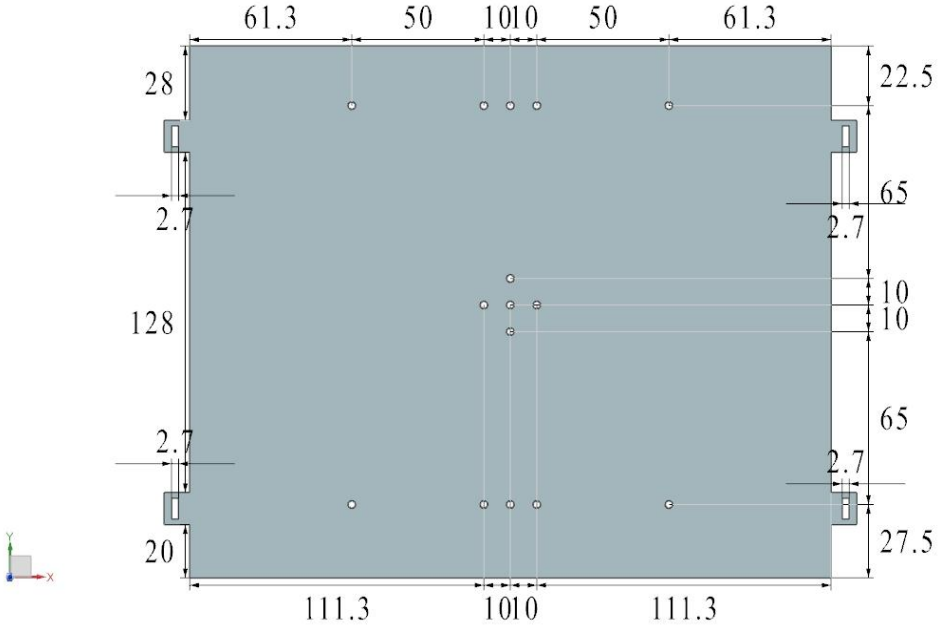


Figure D-3: Drawer

Notes: Quantity: 2; Thickness: 4.3mm; Joint Part Structure: 4.2mm.

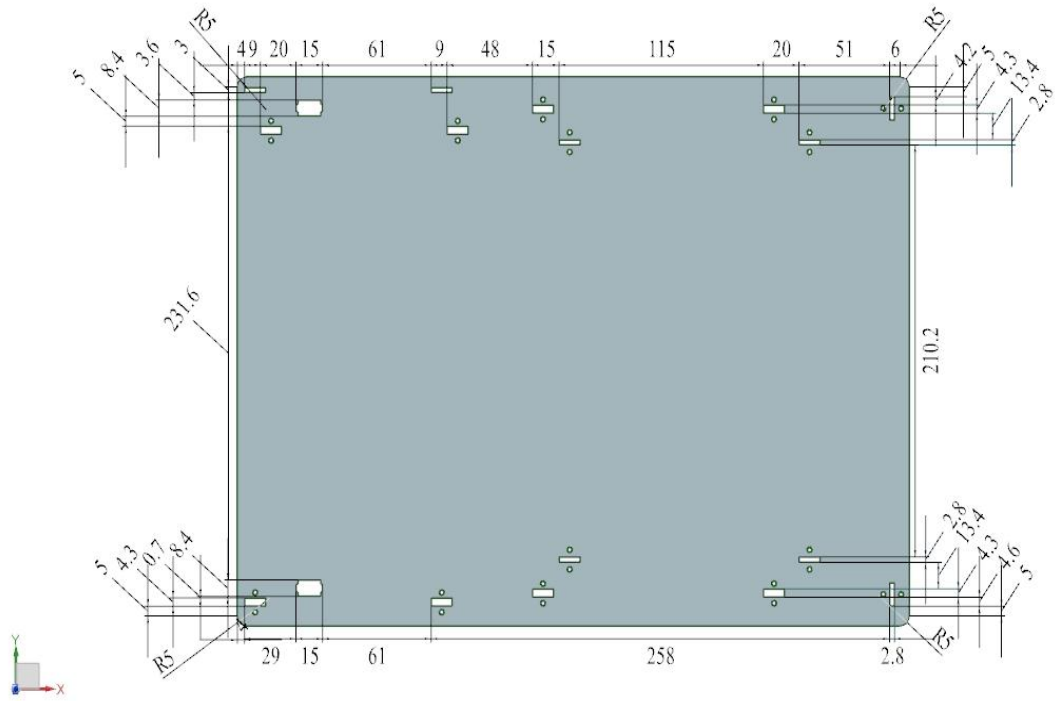


Figure D-4: Paper Track Base

Notes: Quantity: 1; Thickness: 2.7mm; Joint Part Structure: 4.3mm & 2.7 mm.

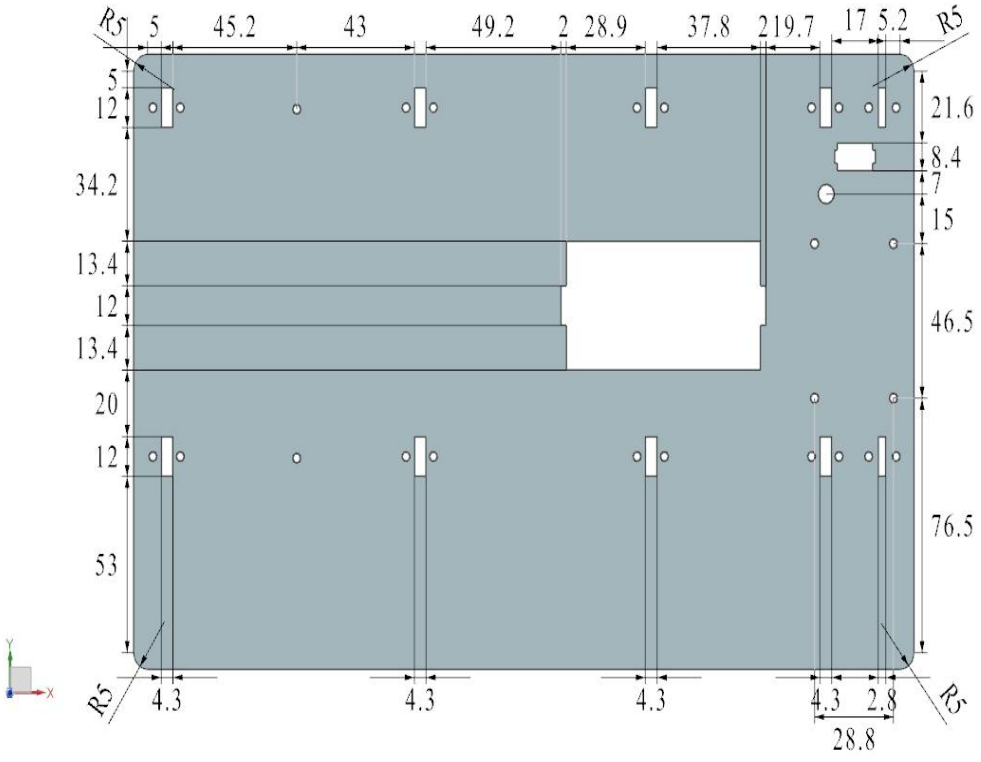


Figure D-5: Input & Output System

Notes: Quantity: 1; Thickness: 2.7mm; Joint Part Structure: 4.3mm & 2.7 mm.

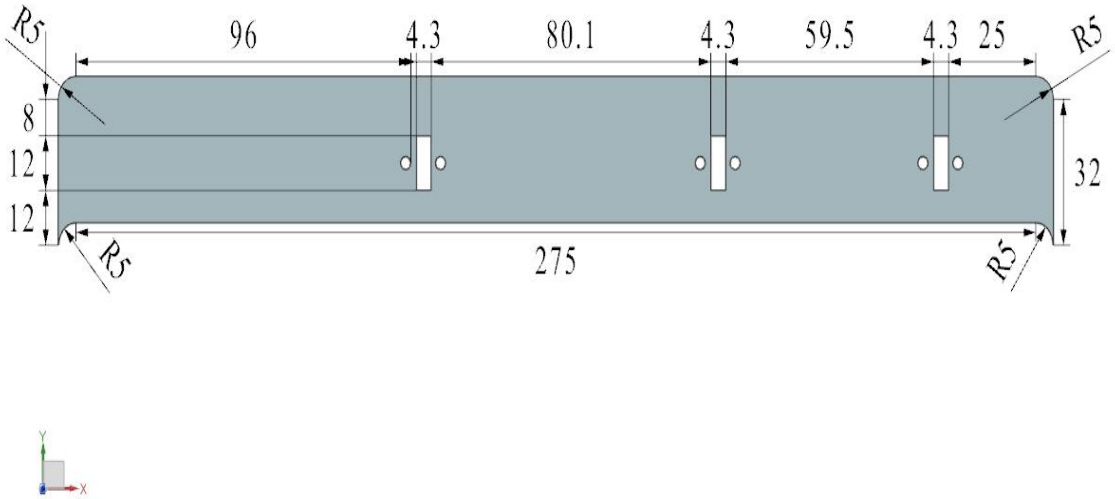


Figure D-6: Paper Feeding Part Cover

Notes: Quantity: 1; Thickness: 2.7mm; Joint Part Structure: 4.3mm & 2.7 mm.

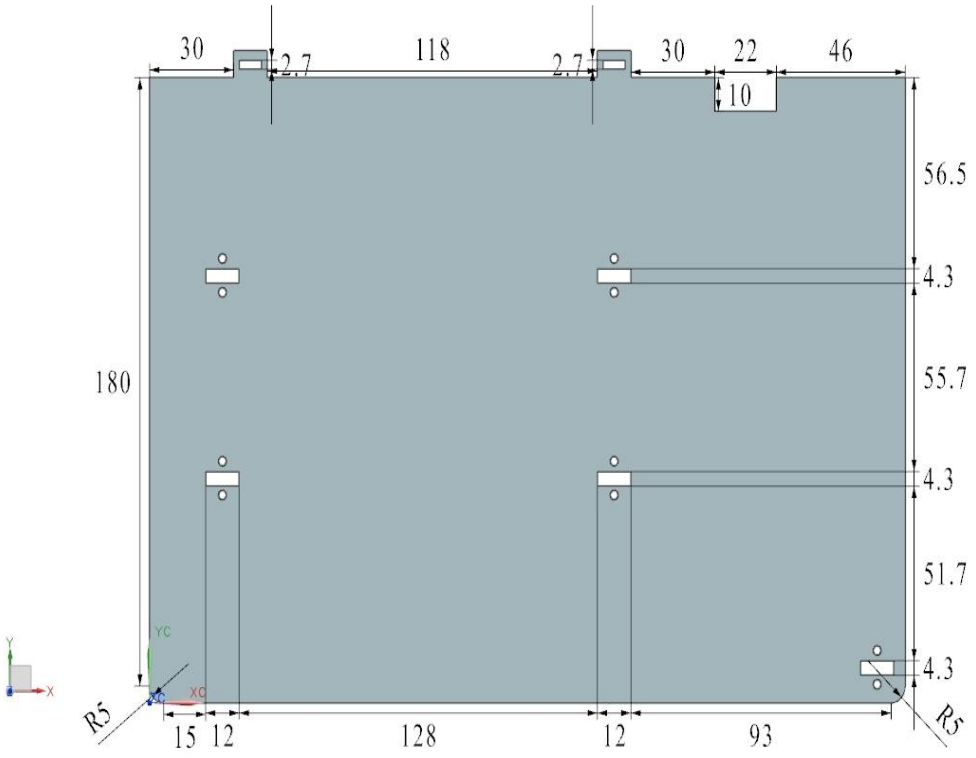


Figure D-7: Paper Feeding Part Support

Notes: Quantity: 2; Thickness: 4.3mm; Joint Part Structure: 4.3mm & 4.2 mm.

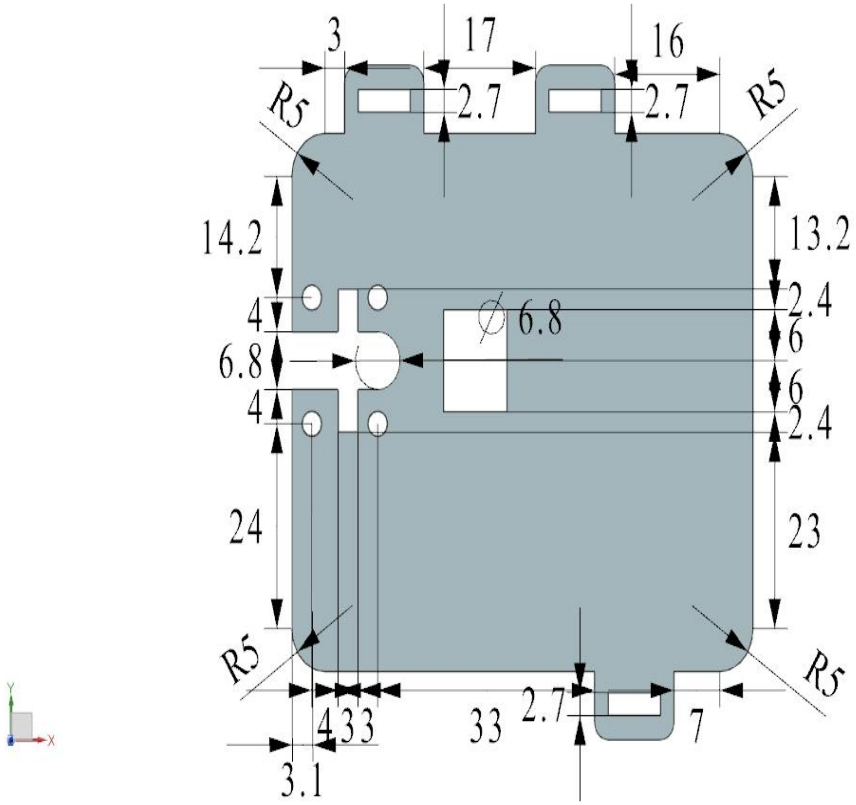


Figure D-8: Paper Feeding Structure

Notes: Quantity: 1; Thickness: 4.3mm; Joint Part Structure: 2.5mm.

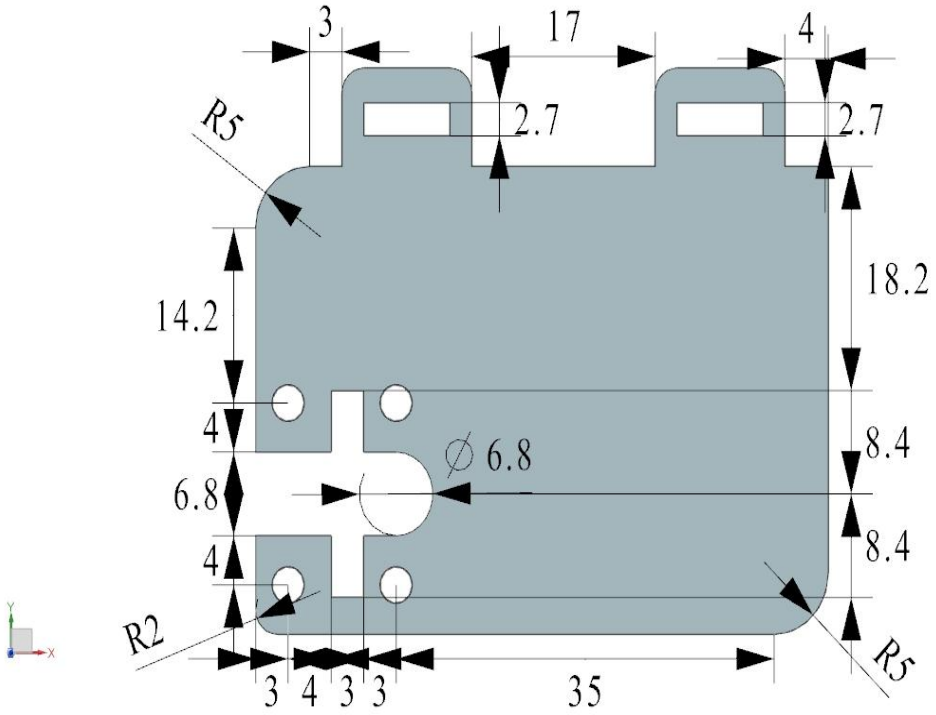


Figure D-9: Paper Feeding Structure

Notes: Quantity: 1; Thickness: 4.3mm; Joint Part Structure: 2.5mm.

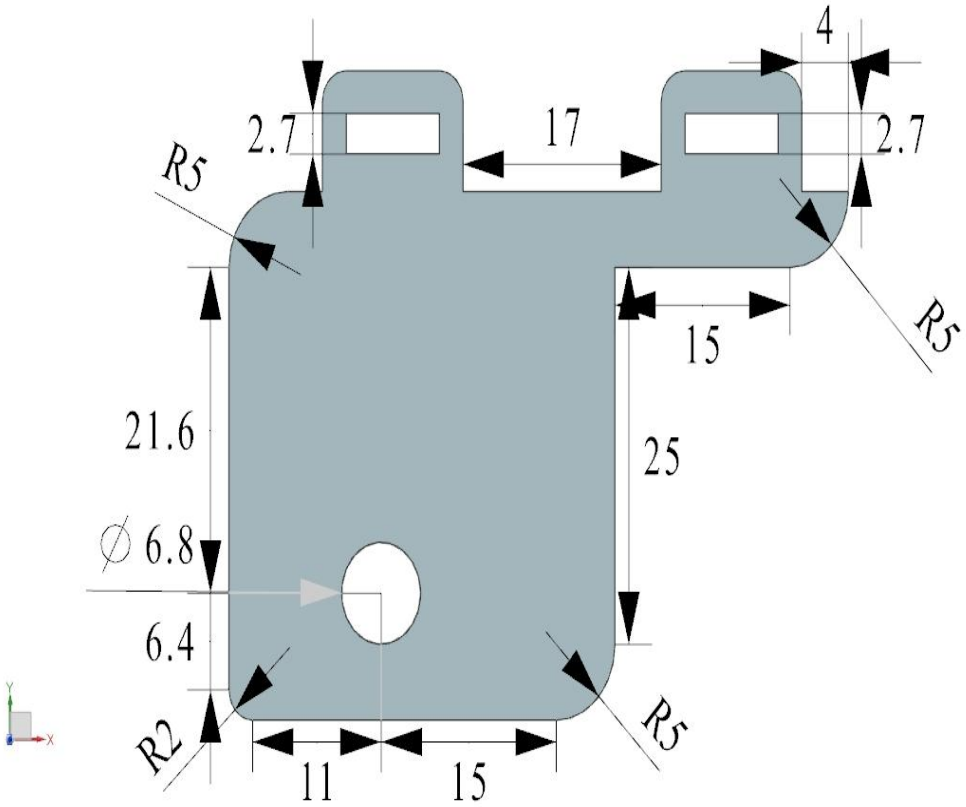


Figure D-10: Paper Feeding Structure

Notes: Quantity: 1; Thickness: 4.3mm; Joint Part Structure: 2.5mm.

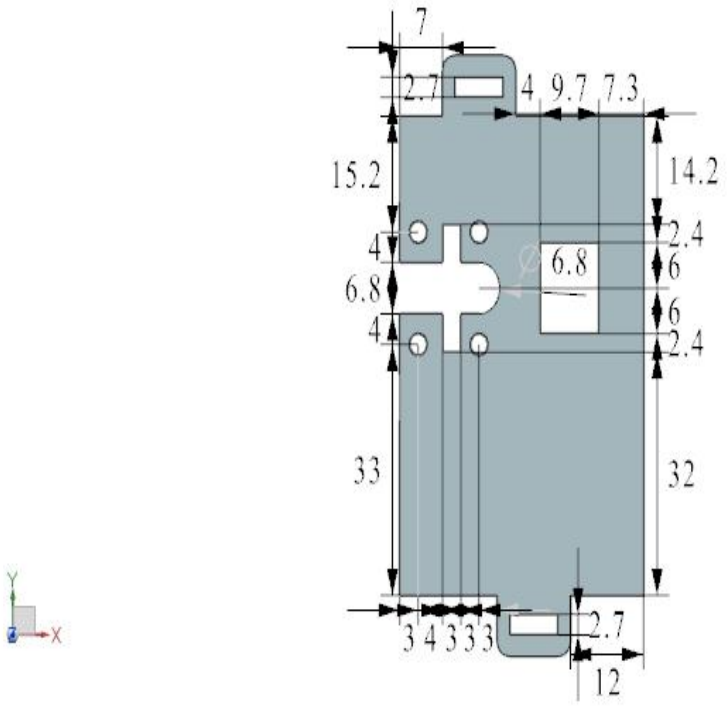


Figure D-11: Paper Feeding Structure

Notes: Quantity: 1; Thickness: 4.3mm; Joint Part Structure: 2.5mm.

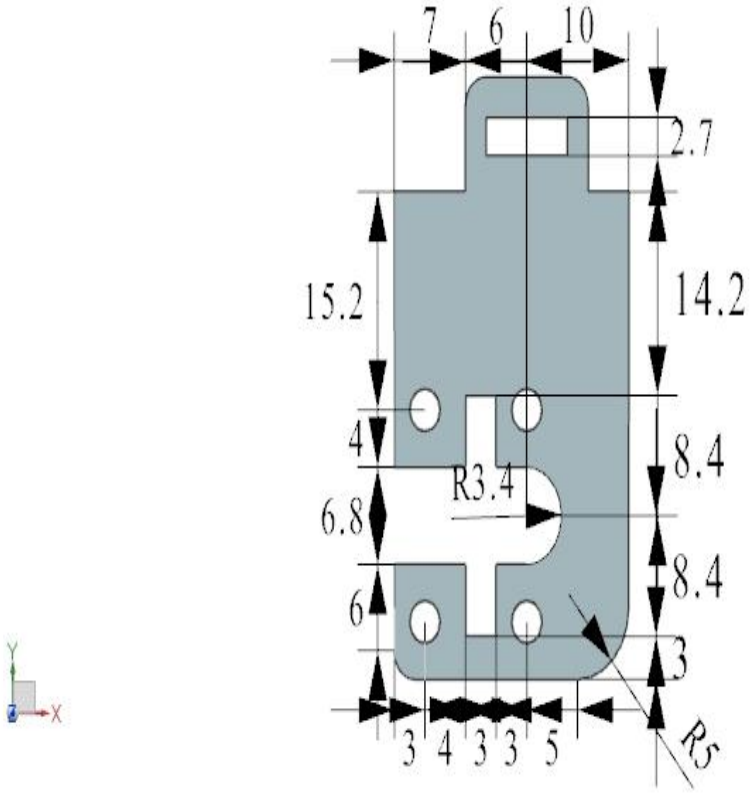


Figure D-12: Paper Feeding Structure

Notes: Quantity: 1; Thickness: 4.3mm; Joint Part Structure: 2.5mm.

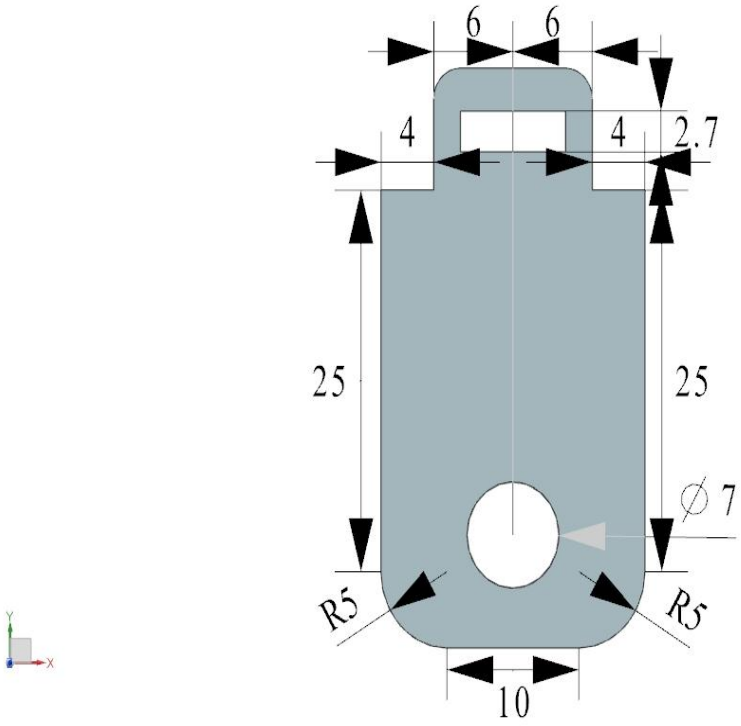


Figure D-13: Paper Feeding Structure

Notes: Quantity: 1; Thickness: 4.3mm; Joint Part Structure: 2.5mm.

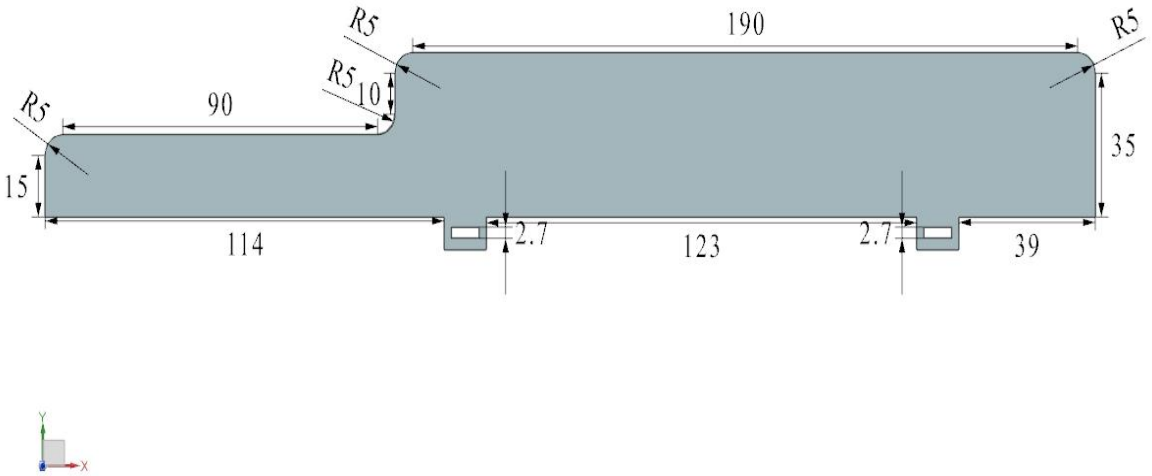


Figure D-14: Paper Track Fence 1

Notes: Quantity: 2; Thickness: 2.7mm; Joint Part Structure: 2.5mm.

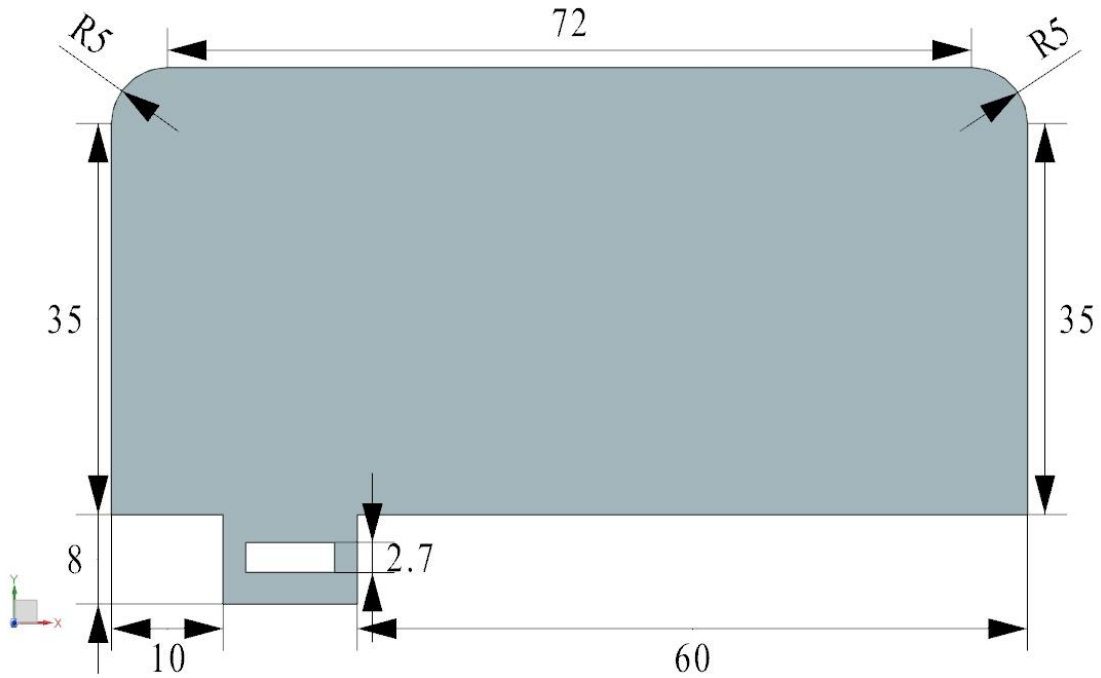


Figure D-15: Paper Track Fence 2

Notes: Quantity: 2; Thickness: 2.7mm; Joint Part Structure: 2.5mm.

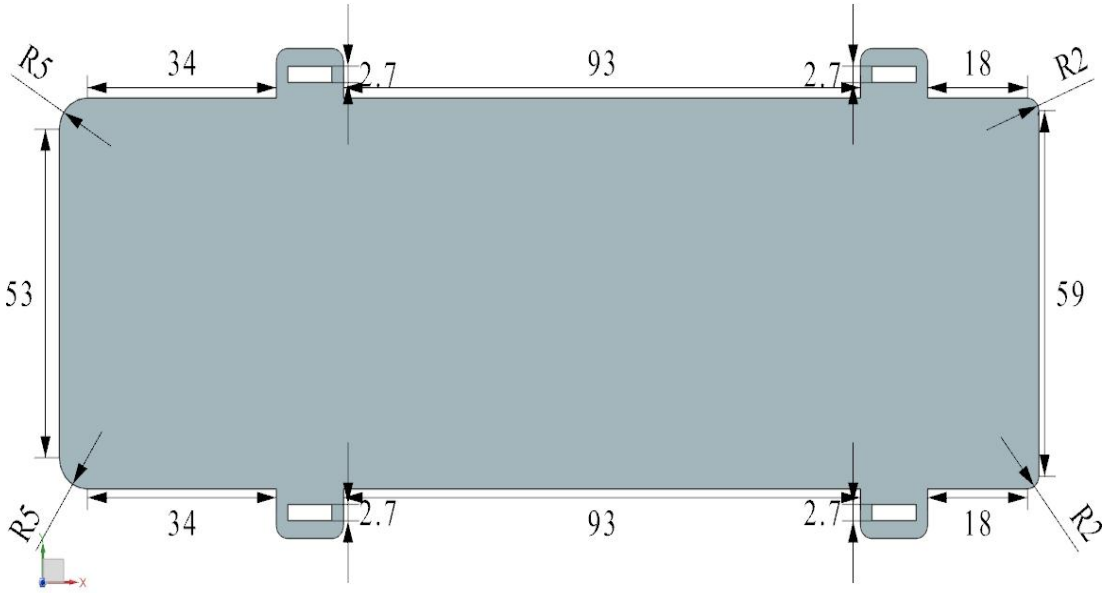


Figure D-16: Paper Feeding Part Fence

Notes: Quantity: 1; Thickness: 2.7mm; Joint Part Structure: 2.5mm.
Quantity: 1; Thickness: 4.3mm; Joint Part Structure: 2.5mm.

Appendix D.3 Paper Separating System

This section gives detailed dimensions for parts of the paper separating system (see Figure D-17 to Figure D-21).

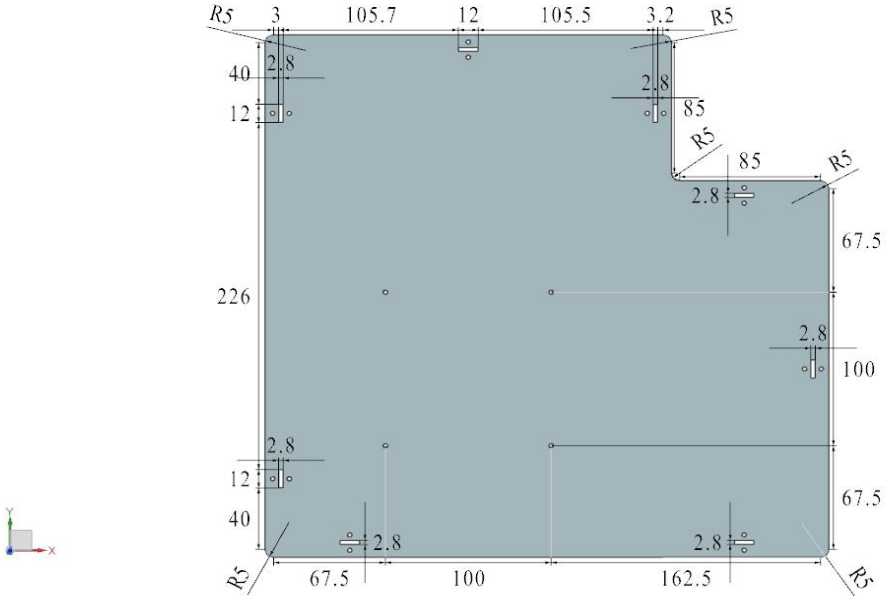


Figure D-17: Paper Platform

Notes: Quantity: 1; Thickness: 2.7mm; Joint Part Structure: 2.7mm & 4.3mm.

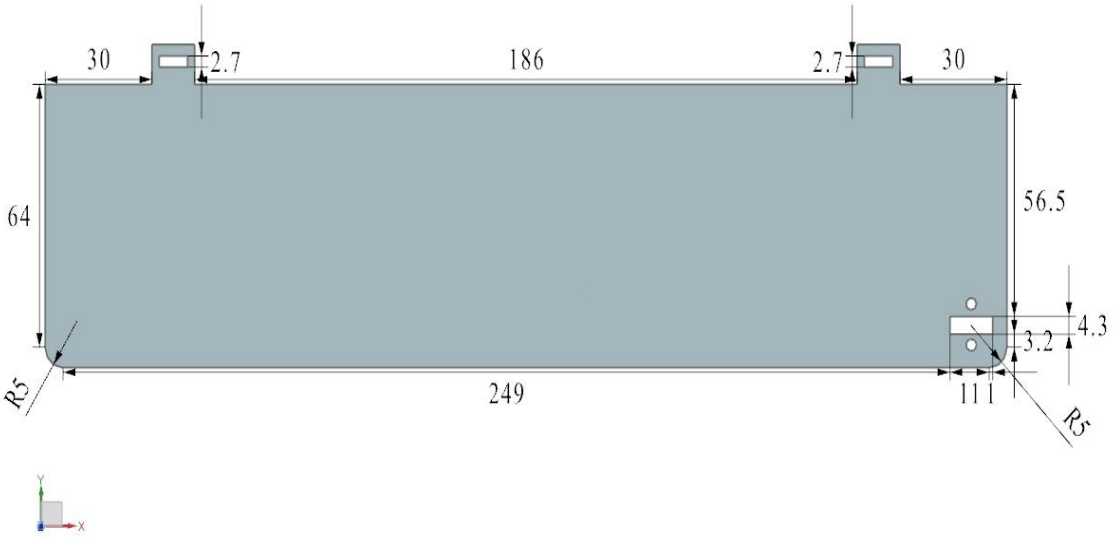


Figure D-18: Paper Separating Part Support

Notes: Quantity: 2; Thickness: 4.3mm; Joint Part Structure: 4.2mm & 4.3mm.

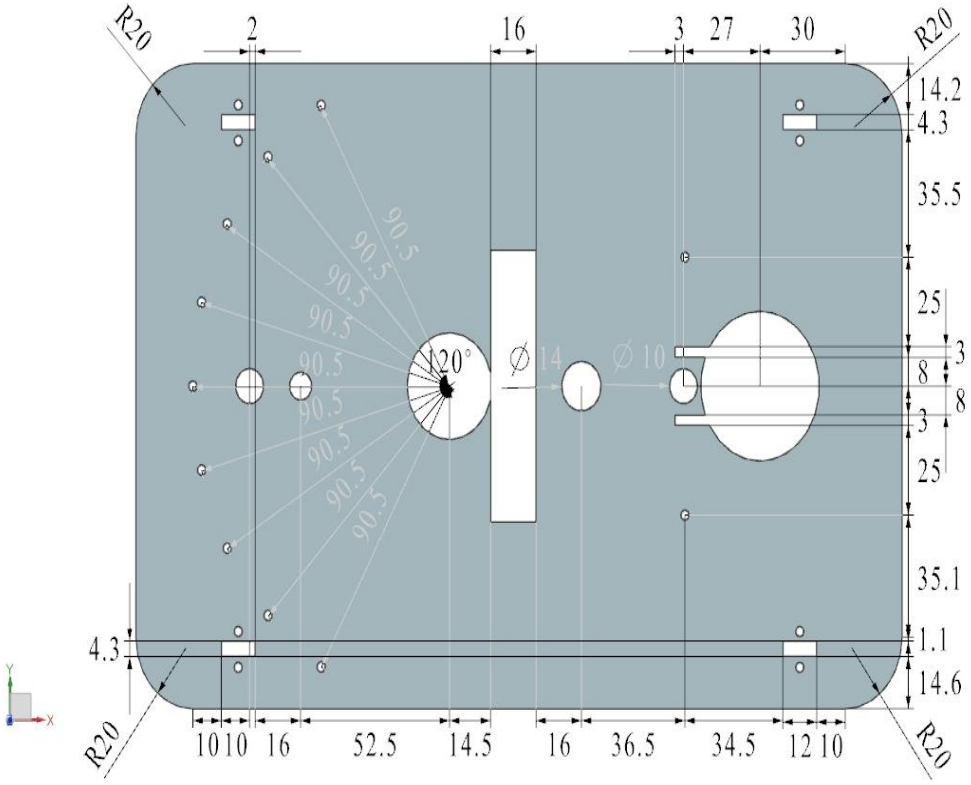


Figure D-19: Paper Separating Part Base

Notes: Quantity: 2; Thickness: 4.3mm; Joint Part Structure: 4.2mm & 4.3mm.

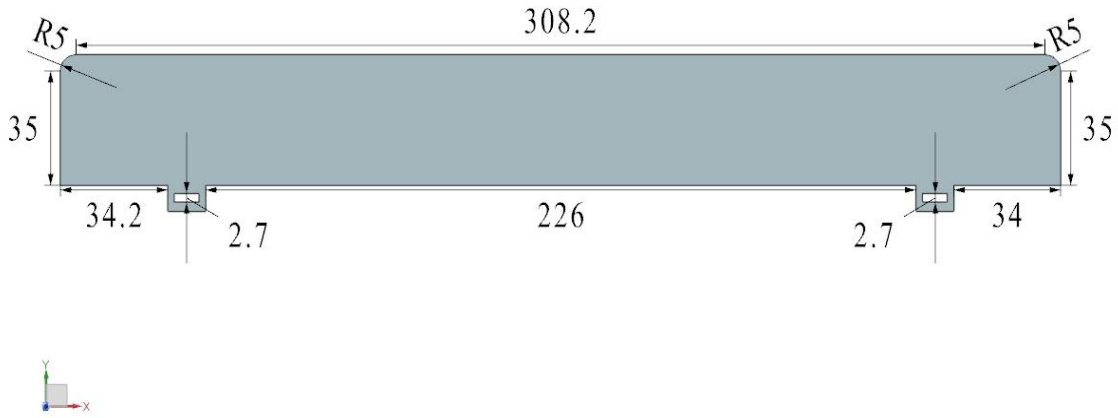


Figure D-20: Paper Platform Fence

Notes: Quantity: 2; Thickness: 2.7mm; Joint Part Structure: 2.5mm.

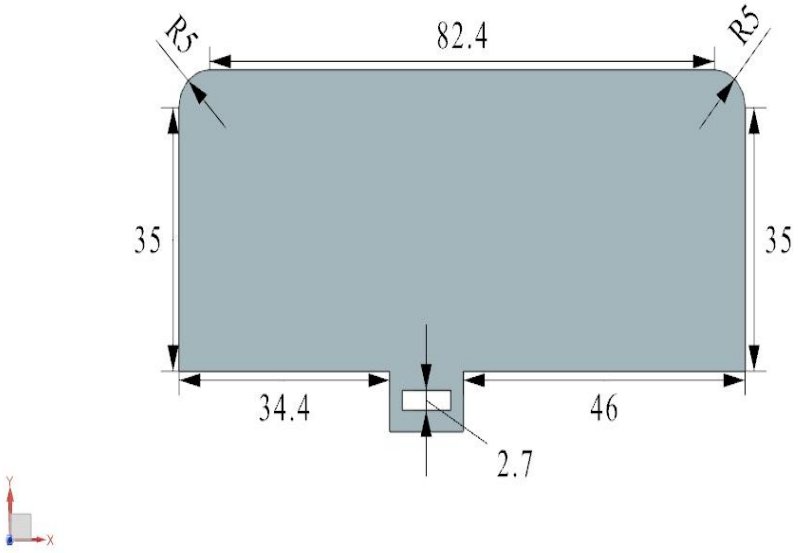


Figure D-21: Paper Platform Fence

Notes: Quantity: 2; Thickness: 2.7mm; Joint Part Structure: 2.5mm.

Appendix D.4 Joint System

This section gives detailed dimensions for parts of the joint system (see Figure D-22 to Figure D-27).

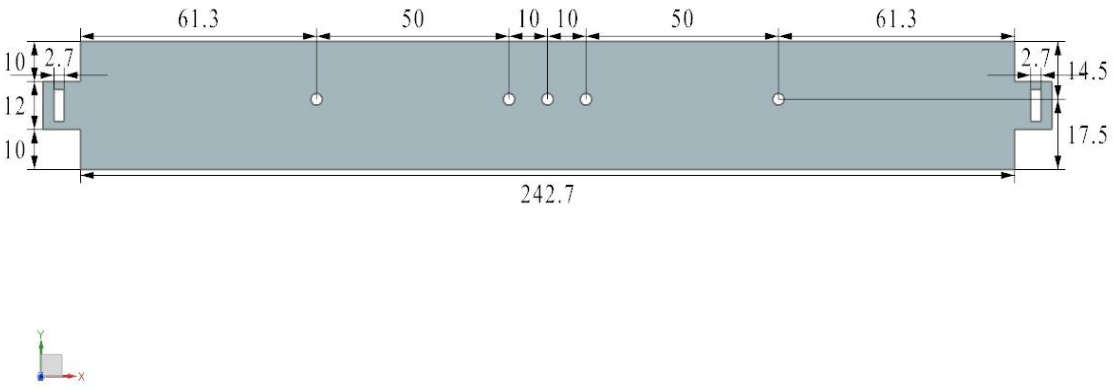


Figure D-22: Joint System Structure

Notes: Quantity: 1; Thickness: 4.3mm; Joint Part Structure: 4.2mm.

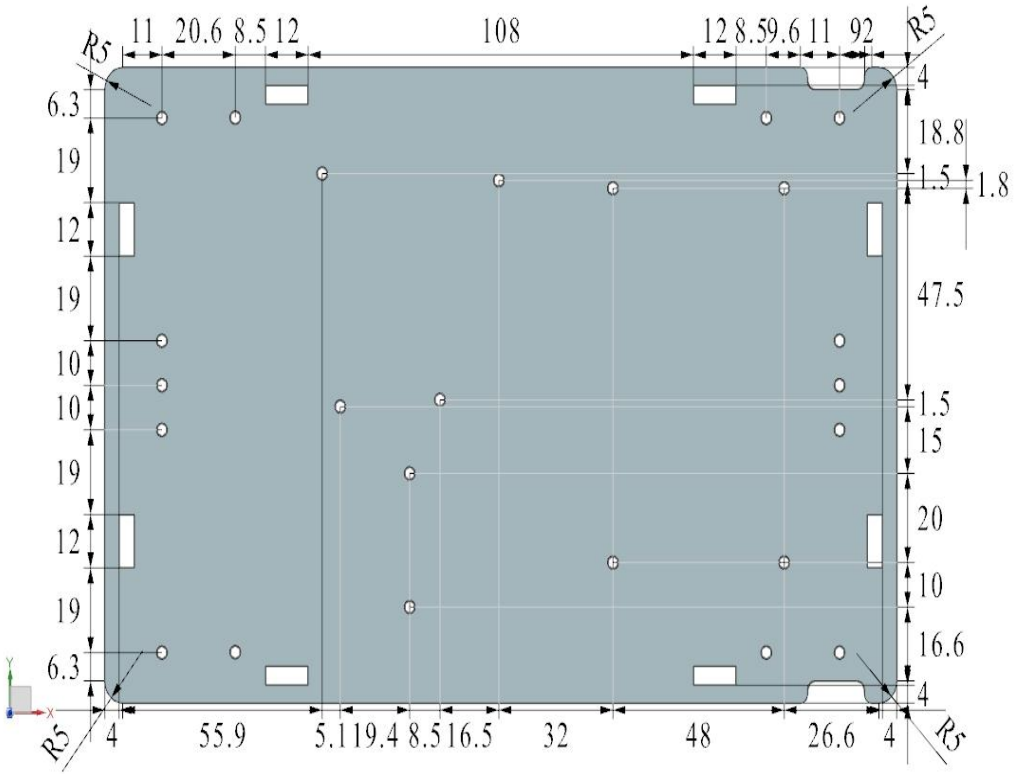


Figure D-23: PCB Box Bottom Part

Notes: Quantity: 1; Thickness: 4.3mm; Joint Part Structure: 4.3mm.

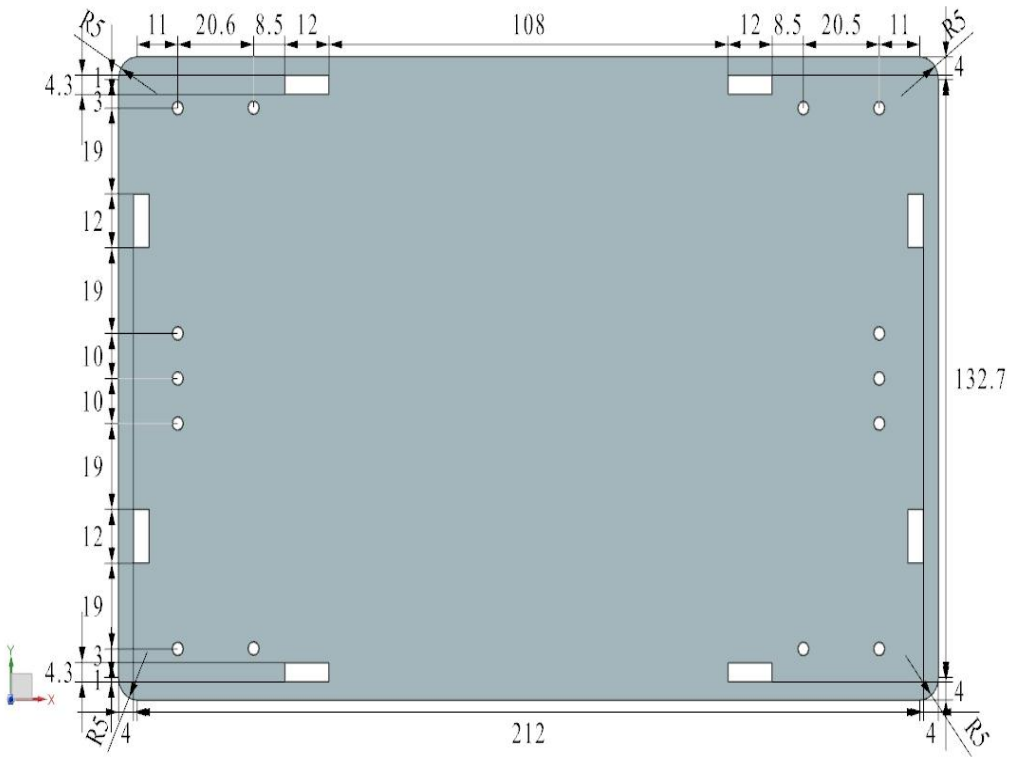


Figure D-24: PCB Box Upper Part

Notes: Quantity: 1; Thickness: 4.3mm; Joint Part Structure: 4.3mm.

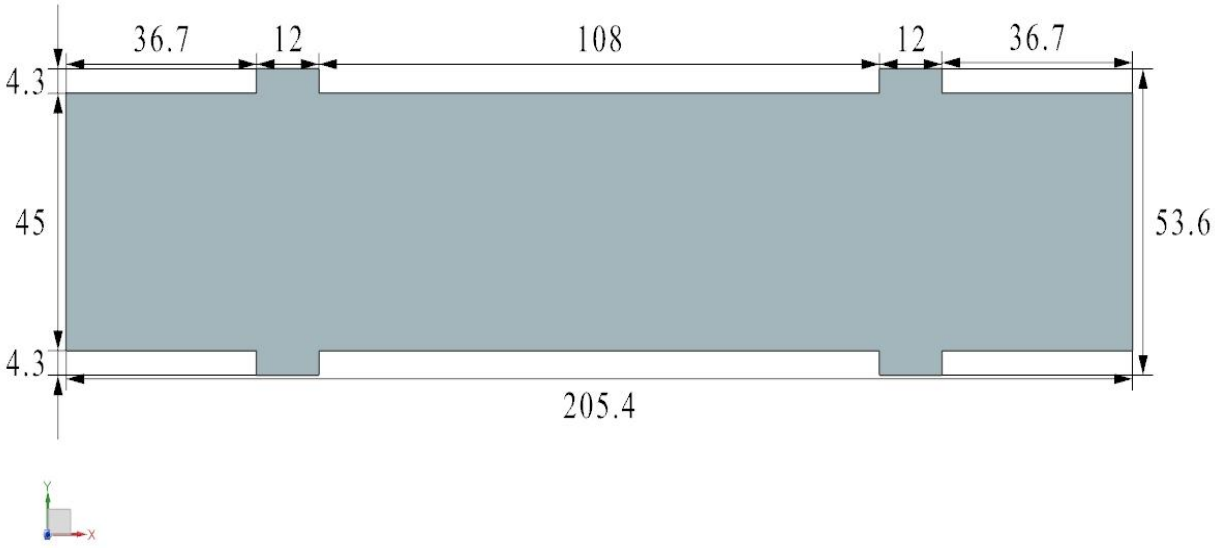


Figure D-25: PCB Box Fence

Notes: Quantity: 2; Thickness: 4.3mm; Joint Part Structure: None.

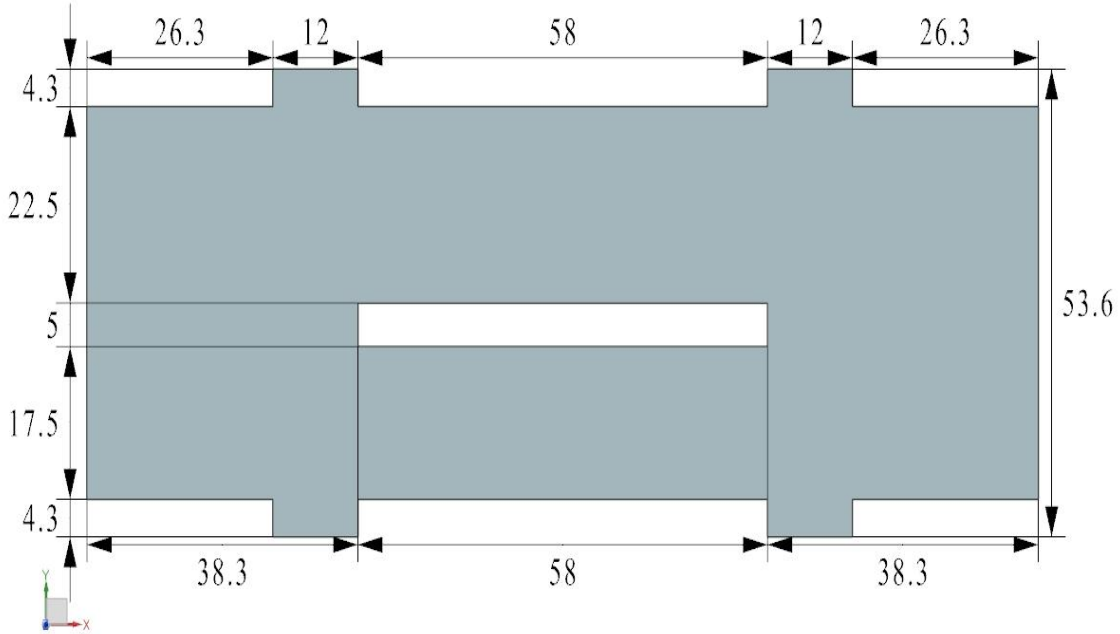


Figure D-26: PCB Box Fence

Notes: Quantity: 2; Thickness: 4.3mm; Joint Part Structure: None.

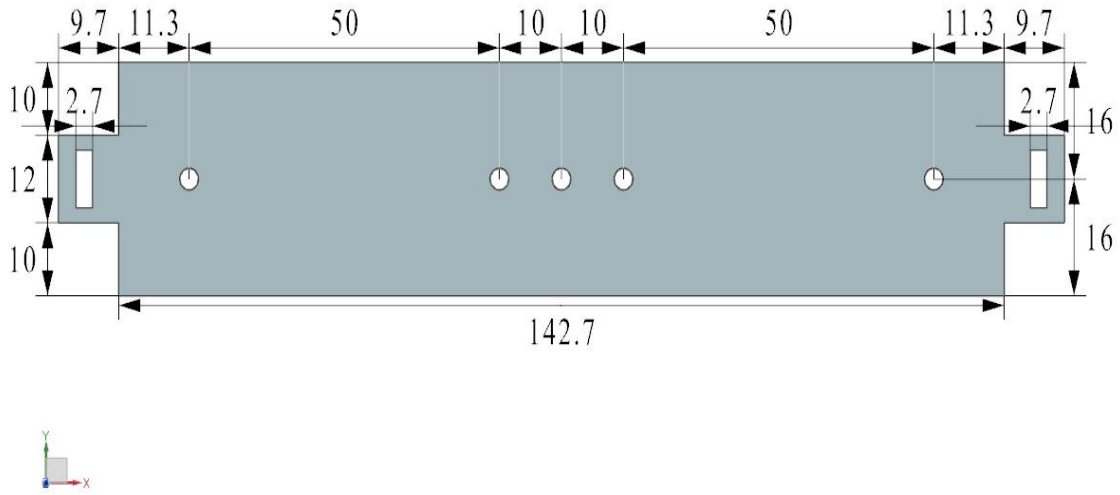


Figure D-27: Joint System Structure

Notes: Quantity: 1; Thickness: 4.3mm; Joint Part Structure: 4.2mm.

Appendix E Wire Connection

This section details the wire connections between different components of our design. Because the circuit structure of our design is quite complicated, we describe the connections by giving names of pins on each component and by connecting these names together (see Figure E-1to Figure E-8).

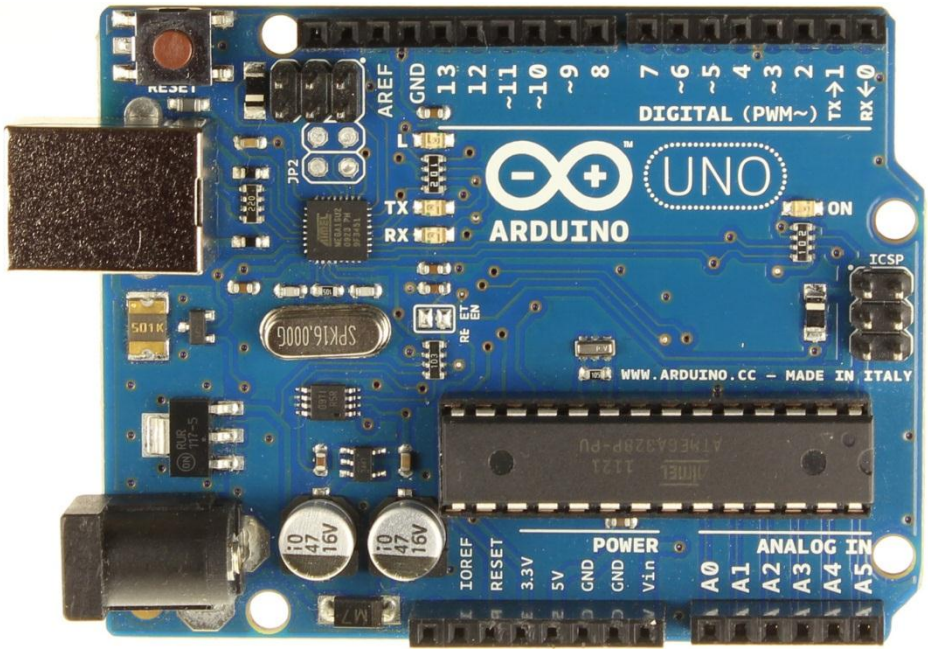


Figure E-1: Arduino Uno Board

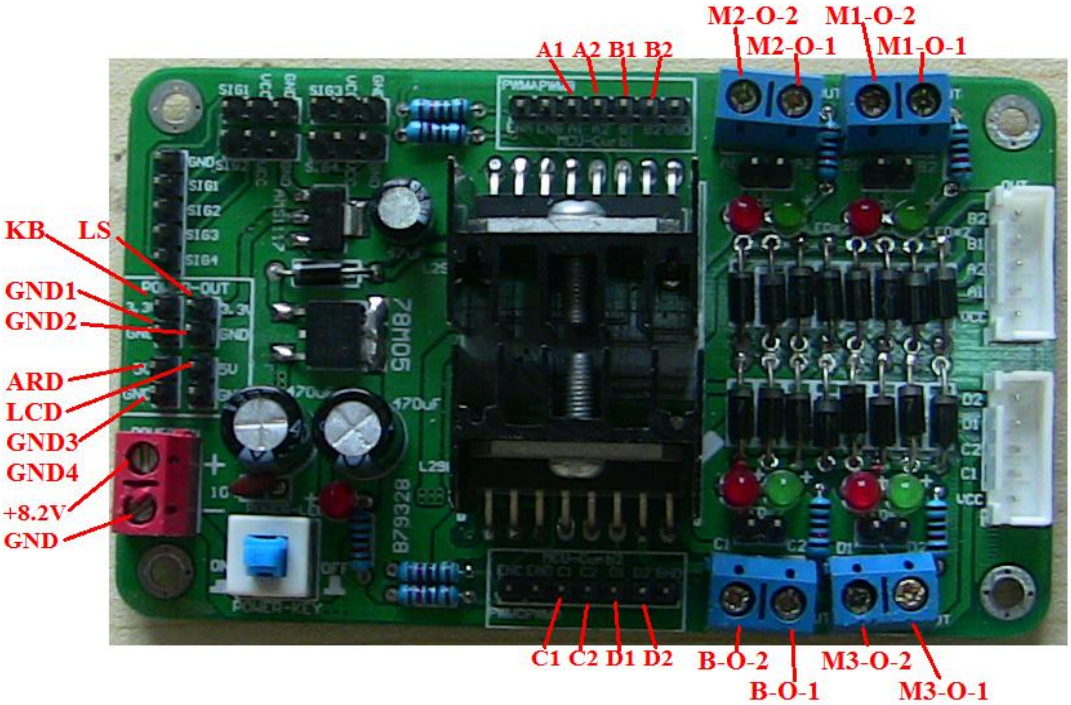


Figure E-2: Drive Board

Figure E-3: Sensor Board & Sensors

Figure E-4: LCD Screen Circuit

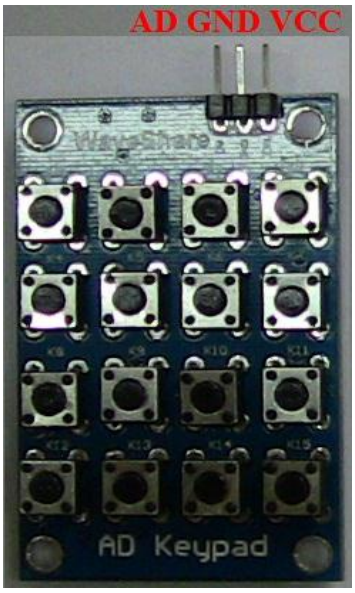


Figure E-5: Matrix Keyboard

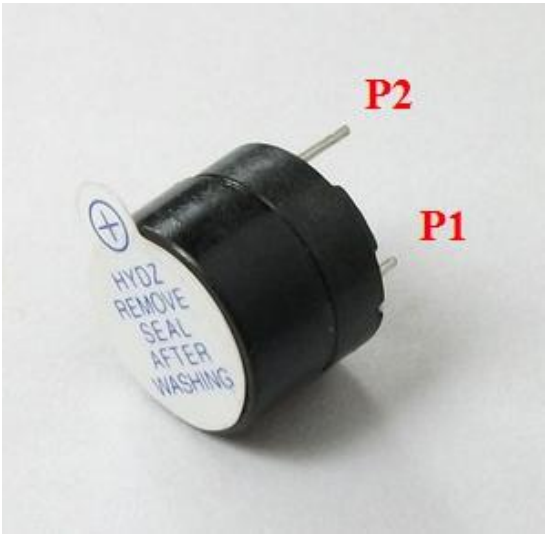


Figure E-6: Buzzer

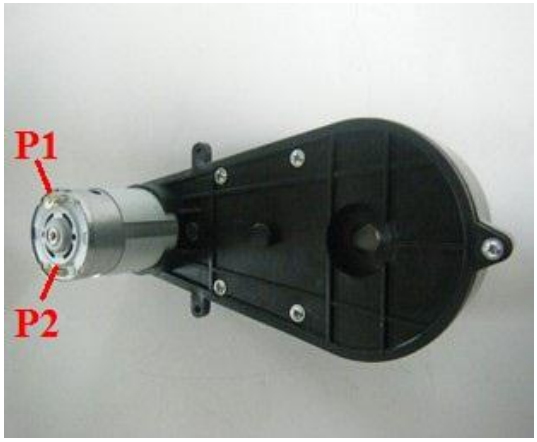


Figure E-7: Paper Separating Part Motor

Figure E-8: Paper Feeding Part Motor

The following part of this section will describe the relationship between these pins. Of course, two pins that are correspondent should be connected with a wire (Dupont lines are recommended).

Between Arduino board and the drive board (the first name on Arduino board and the second on the drive board, the followings are the same):

1. 5V — ARD; GND — GND3
2. 2 – A1; 3 – A2
3. 4 – B1; 5 -- B2
4. 6 – D1; 7 – D2
5. 0 – C1; 1 – C2

Between Arduino board and the sensor board:

1. 8 – O1
2. 9 – O2
3. 10 – O3
4. 4 – O4

Between Arduino board and the LCD screen:

1. 11 – CLK
2. 12 – LCK
3. 13 – DAT

Between Arduino board and the keyboard:

1. 5 – AD

Between drive board and sensor board, keyboard and LCD screen (GND pins are connected correspondingly):

1. LS – VC
2. KB – VCC
3. LCD – VCC

Between drive board and the motors, the buzzer:

1. M1-O-1 – P1; M1-O-2 – P2 (Motor2 and Motor3 are connected analogously)
2. B-O-1 – P1; B-O-2 – P2

Appendix F Programming on the Arduino Uno Board

This section contains the final version of the code that runs on the Arduino board, as well as explanation for the algorithm. We cannot guarantee that this program is bug-free, but it fulfills all the functions we designed in most cases. Some comments are made in the code for those who want to improve our program.

Here are some variables we use to indicate the components of the device and the status of the device. We number the two motors and the two sensors in the paper feeding part with `Motor1`, `Motor2`, and `Sensor1`, `Sensor2`. The motor in the separating part is called `Motor3`, and the two sensors around it are called `Sensor3` and `Sensor4`. `Reset`: if the device is reset; `Start`: if the device starts; `Stp`: if the device stops; `Err`: if there is an error.

Appendix F.1 Preparation Phase

The preparation phase includes the resetting of the paper separating part and the user input. As is mentioned in the mechanical design, we have to make the separating part in the right position to ensure that the paper come out will fall in the device. If one of the `Sensor3` and `Sensor4` detects white, the program keeps rotating the `Motor3`; if not, it then stops `Motor3` and assigns `1` to `Reset` to indicate that the separating part is reset.

The program then loops itself on end to wait for the user input. It uses a variable `Num` to store the number user has inputted. The statement for assignment is `Num=(Num*10+Map[Key])%100;`. Here the `Key` is the number of button which is pressed on the keyboard. The `Map` array is used to convert it to the corresponding number. Note that `Num` is always smaller than 100 because of the designed capacity. How the program deals with input will be covered later in this appendix.

Appendix F.2 Working Phase

Once the user presses the start button, the program assigns `1` to `Start` and gets the motors to work. Again the program loops itself and within each loop, the instructions are given to the four motors based on the colors read by the four sensors. There are four main blocks of codes the program executes according to different status of the sensors and the motors.

The error alarming system is designed in the third block. The program uses the variable `time` to count the time that has passed since the current paper starts to appear under the `Motor2`. If time is greater than `2500`, then there must be an error and the program

assigns `1` to `Err` and `0` to `Start`, therefore entering the stopping phase. `time` is reset to `0` after each sheet of paper comes out.

A number of variables are manipulated in this working phase. The program uses `Cnt1` to count the number of sheets of paper in the current portion, `Cnt2` to count the total number of sheets of paper, `Dir3` to indicate the next rotating direction for `Motor3` (Motor3 has to rotate forward and backward alternatively to separate paper), and `State2` and `State3` to record the working status of `Motor2` and `Motor3`. How the program actually deals with these variables is described in the final code.

Appendix F.3 Stopping phase

Three reasons can cause the program to enter the stopping phase. The first is when user presses the Stop button. The second is when paper gets stuck in the Motor2. The third is when there is no paper in the device. In the stopping phase `Start` is `0` and either `Stp` or `Err` has the value `1`. In the stopping phase the program constantly instructs the three motors to stop to prevent any accidents. Moreover, if `Err` is `1`, the program will activate the buzzer until the user presses the Stop button.

The only way to quit the stopping phase is to press the Continue button. Once the Continue button is pressed, the program assigns `1` to `Start` and `0` to `Stp` and `Err`. Then in the next loop, since `Start` has value `1`, the program again enters the working phase. Note that the status variables (like `Cnt1` and `Cnt2`) are not reset in this phase, therefore the device can work continuously and cumulatively.

Appendix F.4 Matrix Keyboard and LCD Screen

The keyboard input is processed by a PWM (Pulse-width modulation) pin (see Figure F-1). The value `analogRead(pin)` returned is a integer varying from 0 to 1023. As is shown in the Appendix E, the buttons are numbered from `0` to `15`. After some tests, we found that if the power supply to the keyboard is 3.3V, then the i^{th} button corresponds to the value i*42. If no button is pressed, the value is greater than 15*42=630.

0	1	2	3
4	5	6	7
8	9	10	11
12	13	14	15

Figure F-1: Keyboard

The method used for LCD screen output is quite complicated. In short, the program determines the status of each tube (light or dim) by setting one pin to `HIGH` or `LOW`. The screen is used in all three phases. In the preparation phase it first displays “HI” and then the number is inputted; in the second phase it displays the total number of sheets of paper; in the third phase, if `Err` is `1`, the screen will flicker every 0.5 seconds.

Final Code:

```
#define Motor1 2
#define Motor2 4
#define Motor3 6
#define Sensor1 8                                    //Sensor for Motor 1
#define Sensor2 9                                    //Sensor for Motor 2
#define Sensor3 10                                   //Sensor for Motor 3
#define Sensor4 4                                  //Reset Sensor for Motor 3
#define KBI 5                                        //Analog Keyboard Input
#define CLK 11                                              //Three pins to
#define DAT 13                                               //  control the
#define LCK 12                                              //  LCD output.
#define PDir 1                 //Positive Direction of Motor1 and Motor2
#define White LOW                            //Define LOW Input to Be White
int State2=0;      //State of Motor 2,  0:stop; 1:positive; -1:negative
int State3=0;                       //State of Motor 3, 0:stop; 1:rotate;
int Dir3=1;                                 //Initial direction for Motor3
int Cnt1=0;                    //Number of sheets of paper in current portion
int Cnt2=0;                                 //Total Number of sheets of paper
int Num=0;                                  //Store the number user inputted
int PreReset=0;                                     //1:if millius()>500
int Reset=0;                                       //0:reseting; 1:reseted
int Start=0;                                     //0:not started; 1:started
int Stp=0;                                       //0:not stopped; 1:stopped
int Err=0;                                    //1 if error detected in Sensor2
int Map[]={-1,1,2,3,-1,4,5,6,-1,7,8,9,-1,-1,0,-1};
unsigned char NUM[] = {0xfc, 0x60, 0xda, 0xf2, 0x66, 0xb6, 0xbe, 0xe0, 0xfe,
0xf6, 0x6e};
unsigned long time=0;

void Beep()
{
   digitalWrite(0,HIGH);
}

void Silent()
{
   digitalWrite(0,LOW);
}

void SetMotor(int Motor)                  //Initialization of the Motors
{
   pinMode(Motor,OUTPUT);
```

```
    pinMode(Motor+1,OUTPUT);
}

void SetSensor(int Sensor)              //Initialization of the Sensors
{
    pinMode(Sensor,INPUT);
}

int Read(int pin)
{
    return digitalRead(pin);
}

int Read_Sensor4()
{
    int dat=analogRead(Sensor4);
    if (dat > 512) return 1;
    return 0;
}

void Write(int pin, int Mode)
{
    digitalWrite(pin, Mode);
}

void Drive(int Motor, int Dir)    //Drive the Motor in the direction Dir
{
    if (Dir) {
        Write(Motor,LOW);Write(Motor+1,HIGH);
    }
    else {
        Write(Motor,HIGH);Write(Motor+1,LOW);
    }
}

void Drive_PWM(int Motor, int Dir)
{                                                          //PWM controlled
    if (Dir) {
        Write(Motor,HIGH);Write(Motor+1,LOW);
    }
    else {
        Write(Motor,LOW);analogWrite(Motor+1,140);
    }
```

```
}

void Stop(int Motor)
{
   Write(Motor,HIGH);
   Write(Motor+1,HIGH);
}

int Judge()
{
   int State=Read(Sensor2);
   if (State!=White) return 1;
   return 0;
}

void Delay()
{
    delay(500);
}

int KeyRead()            //Keyboard read, return -1 if no button pressed
{
   int data = analogRead(KBI), key1=-1, key2=-1;
   for (int i=0;i<16;i++) {
      if ((data>=((i*42)-10)) && (data<=((i*42)+10))) key1=i;
   }
   if (key1<0) return key1;
   delay(200);          //Delay 200ms to read again to prevent accident
   data = analogRead(KBI);
   for (int i=0;i<16;i++) {
      if ((data>=((i*42)-10)) && (data<=((i*42)+10))) key2=i;
   }
   if ((key2<0) || (key1!=key2)) return -1;
   return key1;
}

void ProcessKey(int Key)
{
    if ((Key==-1) || (Key==13) || (Key==15)) return;    //Invalid Keys
    if(Key==0){                                                    //START
      if ((!Start) && (Num>0)) {
         Start=1;Show(0,0,0);
         Beep();delay(300);Silent();     //Beep when a button pressed
```

```
        }
        return;
    }
    if(Key==4){                                                    //STOP
        if ((Start) && (!Stp)) {
            Stp=1;Err=0;
            Show(Cnt2,0,0);
            Beep();delay(300);Silent();
        }
        return;
    }
    if (Key==8) {                                                  //CANCEL
        if (!Start) {
            Num=0;
            Beep();delay(300);Silent();
        }
        return;
    }
    if (Key==12) {                                                 //CONTINUE
        if ((Start) && (Stp || Err)) {
            Stp=0;Err=0;
            Beep();delay(300);Silent();
        }
        return;
    }
    if (Start) return;           //Numbers only allowed when not started
    Num=(Num*10+Map[Key])%100;
    Beep();delay(300);Silent();
}

void Show(int dat, int HI, int FLK)                //dat:Number to Show
{                       //HI:Whether to show HI; FLK:Whether to Flicker
    if (HI) {
        for (int i=0;i<16;i++) {
            digitalWrite(DAT,LOW);
            digitalWrite(CLK,LOW);
            delay(1);
            digitalWrite(CLK,HIGH);
        }
        for (int i=0;i<8;i++) {
            if (NUM[1] & (1<<i)) digitalWrite(DAT,HIGH);
            else digitalWrite(DAT,LOW);
            digitalWrite(CLK,LOW);
```

```
        delay(1);
        digitalWrite(CLK,HIGH);
    }
    for (int i=0;i<8;i++) {
        if (NUM[10] & (1<<i)) digitalWrite(DAT,HIGH);
        else digitalWrite(DAT,LOW);
        digitalWrite(CLK,LOW);
        delay(1);
        digitalWrite(CLK,HIGH);
    }
    digitalWrite(LCK,LOW);
    delay(1);
    digitalWrite(LCK,HIGH);
}
else {
    for (int i=0;i<8;i++) {
        if (!FLK) {
            if ((NUM[dat%10] & (1<<i))) digitalWrite(DAT,HIGH);
            else digitalWrite(DAT,LOW);
        }
        else {
                //If flicker then the screen lights or dims altogether
            if (FLK==1) digitalWrite(DAT,HIGH);
            else digitalWrite(DAT,LOW);
        }
        digitalWrite(CLK,LOW);
        delay(1);
        digitalWrite(CLK,HIGH);
    }
    for (int i=0;i<8;i++) {
        if (!FLK) {
            if (NUM[(dat/10)%10] & (1<<i)) digitalWrite(DAT,HIGH);
            else digitalWrite(DAT,LOW);
        }
        else {
            if (FLK==1) digitalWrite(DAT,HIGH);
            else digitalWrite(DAT,LOW);
        }
        digitalWrite(CLK,LOW);
        delay(1);
        digitalWrite(CLK,HIGH);
    }
    for (int i=0;i<8;i++) {
```

```
            if (!FLK) {
               if (NUM[(dat/100)%10] & (1<<i)) digitalWrite(DAT,HIGH);
               else digitalWrite(DAT,LOW);
            }
            else {
               if (FLK==1) digitalWrite(DAT,HIGH);
               else digitalWrite(DAT,LOW);
            }
            digitalWrite(CLK,LOW);
            delay(1);
            digitalWrite(CLK,HIGH);
         }
         for (int i=0;i<8;i++) {
            if (!FLK) {
               if (NUM[dat/1000] & (1<<i)) digitalWrite(DAT,HIGH);
               else digitalWrite(DAT,LOW);
            }
            else {
               if (FLK==1) digitalWrite(DAT,HIGH);
               else digitalWrite(DAT,LOW);
            }
            digitalWrite(CLK,LOW);
            delay(1);
            digitalWrite(CLK,HIGH);
         }
         digitalWrite(LCK,LOW);
         delay(1);
         digitalWrite(LCK,HIGH);
      }
}

void Flicker()
         //the screen lights if the time is in the first half of a second
{
   int dat=(millis()%1000)/100;
   if (dat<=5) Show(0,0,1); else Show(0,0,2);
}
void setup()                                          //Initialization
{
   SetMotor(Motor1);
   SetMotor(Motor2);
   SetMotor(Motor3);
   SetSensor(Sensor1);
```

```
    SetSensor(Sensor2);
    SetSensor(Sensor3);
    SetSensor(Sensor4);
    pinMode(0,OUTPUT);
    pinMode(1,OUTPUT);
    pinMode(CLK,OUTPUT);
    pinMode(DAT,OUTPUT);
    pinMode(LCK,OUTPUT);
}
void loop()
{
    if (!PreReset) {                                    //If not Prereset
        Beep();
        Show(0,1,0);
        PreReset=1;
        Drive_PWM(Motor1,1-PDir);Drive_PWM(Motor2,1-PDir);
        Delay()
        Stop(Motor2);
        if ((Read(Sensor3)!=White) && (Read_Sensor4())) {
            Stop(Motor2);State2=0;
            Drive(Motor3,1);
            Delay()
        }
    }
    if (!Reset) {                       //Reset the position before start
        Beep();
        Show(0,1,0);
        Stop(Motor2);State2=0;              //Stop Motor2 while resetting
        if ((Read(Sensor3)!=White) && (Read_Sensor4())){
                                                  //If reseted, then stop
            Stop(Motor3);
            State3=0;
            Reset=1;
        }
        else {                                      //Else keep rotating
            Drive(Motor3,1);
            State3=1;
        }
    }
    if (Reset) {
        if (Err) {Beep();Flicker();}
        else Silent();
        ProcessKey(KeyRead());                       //Detect user input
```

```
        if (!Start) Show(Num,0,0);
        if (Start && (!Stp) && (!Err)) {            //Separation Started
           if (Read(Sensor3)==White) {
                          //If not to the right position, keep rotating
              Stop(Motor1);Stop(Motor2);              //Stops two Motors
              Drive(Motor3,Dir3);State3=1;State2=0;
           }
           else {
              if (State3) {
                              //If to the position but still rotating
                 Stop(Motor3);State3=0;
                 if (Read(Sensor1)!=White) Stp=1;
                                    //If there is no paper, then stop
              }
              if ((!Stp) && ((Read(Sensor1)!=White) && Judge())){
                                                 //If no paper detected
                 Cnt1++;Cnt2++;
                 Show(Cnt2,0,0);
                 Stop(Motor3);Stop(Motor2);State2=0;
                 Stp=1;
                    Beep();Delay()Silent();           //Beep the buzzer
                    Delay()Beep();Delay()             //    three times
                    Silent();Delay()Beep();
                   Delay()Silent();
              }
              else {
                 if (!Judge()) {        //If there paper is under Motor 2
                    if (time!=(-1)) {
                       if ((millis()-time)>2500) {
//If Sensor2 detects white for more than 2500ms, then there is an error
                          Err=1;time=-1;
                          Stop(Motor1);Stop(Motor2);State2=0;
                       }
                    }
                    else {
                       time=millis();
                       Delay()
                             //Delay 500ms to start for better accuracy
                       Drive_PWM(Motor2,PDir);
                           Drive_PWM(Motor1,1-PDir);
                       State2=1;
                    }
                 }
```

```
                else {
                    if (State2==1) {        //If Motor 2 still rotating
                        Cnt1++;Cnt2++;          //Increment the counters
                        Show(Cnt2,0,0);
                        if (Cnt1>=Num) {               //If one portion
                            Cnt1=0;
                            Stop(Motor1);Stop(Motor2);State2=0;
                              Dir3=1-Dir3;
                      //reverse the direction for next rotation
                            Drive(Motor3,Dir3);State3=1;
                            delay(200);
                        }
                        else {                       //Else start Motor1
                            Drive_PWM(Motor2,1-PDir);
                                 delay(50);
                                 Drive_PWM(Motor1,PDir);
                            State2=-1;time=-1;
                            delay(200);
                        }
                    }
                    else {
                        Drive_PWM(Motor2,1-PDir);
                             delay(50);
                             Drive_PWM(Motor1,PDir);      //Start Motor 1
                        State2=-1;time=-1;
                    }
                }
            }
        }
        else {
            if (Start) {    //If started but there is an error or stopped
                  Stop(Motor1);Stop(Motor2);Stop(Motor3);
                  State2=0;State3=0;
            }
            else {
                Stop(Motor2);Stop(Motor3);State2=0;State3=0;
            }
        }
    }
}
```

Appendix G Necessary Materials

This part gives out the detailed information of the necessary components and the number needed for building one Automatic Paper Separator. Note that the material listed below are the minimum requirements, failing to get any of the following material may result in a failure. See Appendix H for detailed information of access to the materials.

For mechanical structure of plexiglass, the dimensions of CAD diagrams are designed for the material listed below. If hobbyists decide to use other material for substitution, the corresponding dimensions of components should be adjusted to meet the change.

For electric circuit design, the change of component that needs electricity to work may result in malfunctioning of the final design, so we suggest hobbyists not change the material related to electricity. If a change like this is necessary, hobbyists should make sure in advance that the new electric components can work well by themselves or contact us through *Vg100massivedynamics@hotmail.com* for further information.

Table G-1: Table of Necessary Materials

Material	Number	Note
Plexiglass	8	20cm*30cm*5mm
	2	40cm*50cm*3mm
Arduino Uno	1	Arduino Uno
Circuit board	1	Able to drive over 3 motors
Rubber roller	2	The component of HP printer
Light sensor	4	3-6V
Display screen	1	Contain four nixie tubes
Matrix keyboard	1	AD Keypad
Nuts & bolts	162	M3,12cm
Buzzer	1	5V
Small motor	2	10cm*12cm, 1.5-6V
Big motor	1	6V

Appendix H Access to Different Materials

For hobbyists who are interested in our design and want to replicate it, this part provides the detailed information about the access of purchasing each component. Note that most components are purchased through Taobao website and the links are given in the table below. If the links exceed the time limit and you still want the original material, please contact us through *Vg100massivedynamics@hotmail.com* for further information.

Table H-1: Access of Necessary Materials

Material	Access
Plexiglass	Stores in Beijing Road, Shanghai
Arduino Uno	Obtained from TAs of Vg100
Motor	Taobao website 1: http://item.taobao.com/item.htm?id=15089588744 Taobao website 2: http://trade.taobao.com/trade/detail/tradeSnap.htm?spm=a1z09.2.9.89&tradeID=146853713747352
Circuit board	Taobao website http://trade.taobao.com/trade/detail/tradeSnap.htm?spm=a1z09.2.9.89&tradeID=146853713747352
Rubber roller	Taobao website http://item.taobao.com/item.htm?spm=a230r.1.10.15&id=4363497011&_u=vkv7b490e1d
Light sensor	Taobao website http://item.taobao.com/item.htm?id=8406382779
Display screen	Taobao website http://item.taobao.com/item.htm?id=10470970486
Matrix keyboard	Taobao website http://detail.tmall.com/item.htm?id=14436780251
Nuts, bolts & wires	Store in Beijing road, Shanghai
Buzzer	Taobao website http://item.taobao.com/item.htm?id=12709588006

Appendix I Table of Cost

For hobbyists who are interested in our design and concern about the cost, this part provides the detailed information about the cost of each component. Additionally, we recommend hobbyists to substitute Arduino Uno and plexiglass by low-cost alternatives for the purpose of reducing the cost. For further information, please contact us through *Vg100massivedynamics@hotmail.com* .

Table I-1: Cost of Necessary Materials

Material	Price (RMB)
Plexiglass	122
Arduino Uno	80
Motor	50
Circuit board	45
Rubber roller	40
Light sensor	25
Display screen	22
Matrix keyboard	15
Nuts, bolts & wires	10
Buzzer	0.8
Total	*409.8*

Appendix J Step-By-Step Assembling Manual

In order to enable hobbyists to build an Automatic Paper Separator easily, this manual uses 3D component diagrams to illustrate the manufacture and assembling of each part step by step. Together with the algorithm and specification part, DIY hobbyists should be able to follow our design and actually build our machine.

Step 1: Install Necessary Computer Program

Mechanical Modeling: Unigraphic or AutoCAD
Programming: Ardunio 1.0.1 for Windows

Step 2: Draw Mechanical Structure

Use CAD diagrams provided by us directly or draw CAD diagrams with the dimensions given in Appendix A.
Make necessary adjustment if the materials are changed.
See Appendix D for detailed instructions.

Step 3: Use Laser Cutting Machine (see Figure J-1) for Manufacture

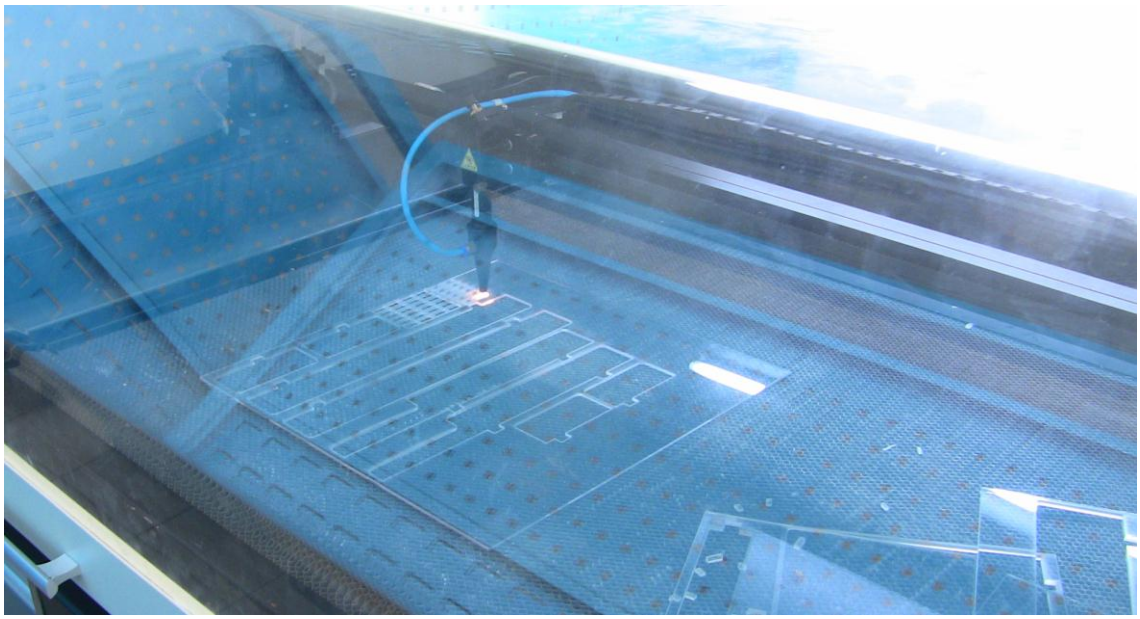


Figure J-1: Laser Cutting Machine

Step 4: Assemble the Paper Feeding Part

Assemble the supporting shelves (see Figure J-2 and Figure J-3).
Assemble the paper feeding structure (see Figure J-4 and Figure J-5).
Combine the user Input & Output system with the paper separating part (see Figure J-6).

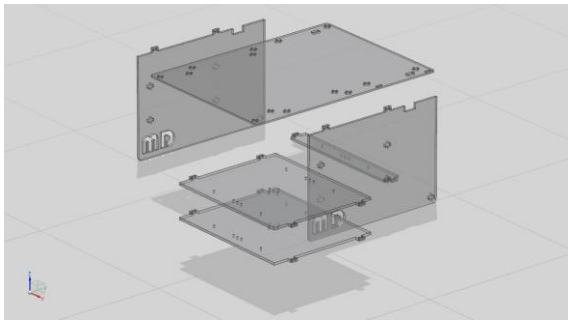


Figure J-2: Supporting Shelves

Figure J-3: Supporting Shelves

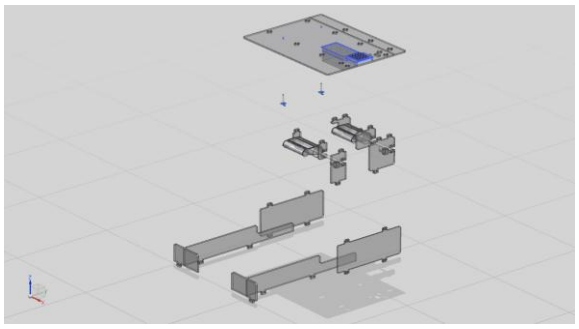


Figure J-4: Paper Feeding Structure

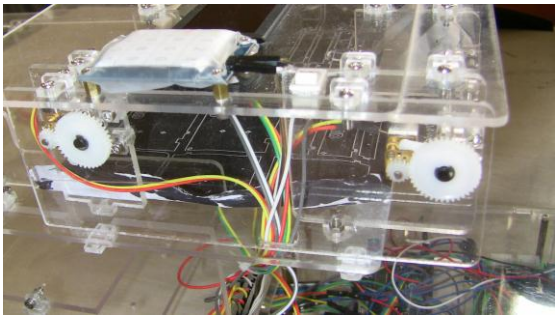


Figure J-5: Paper Feeding Structure

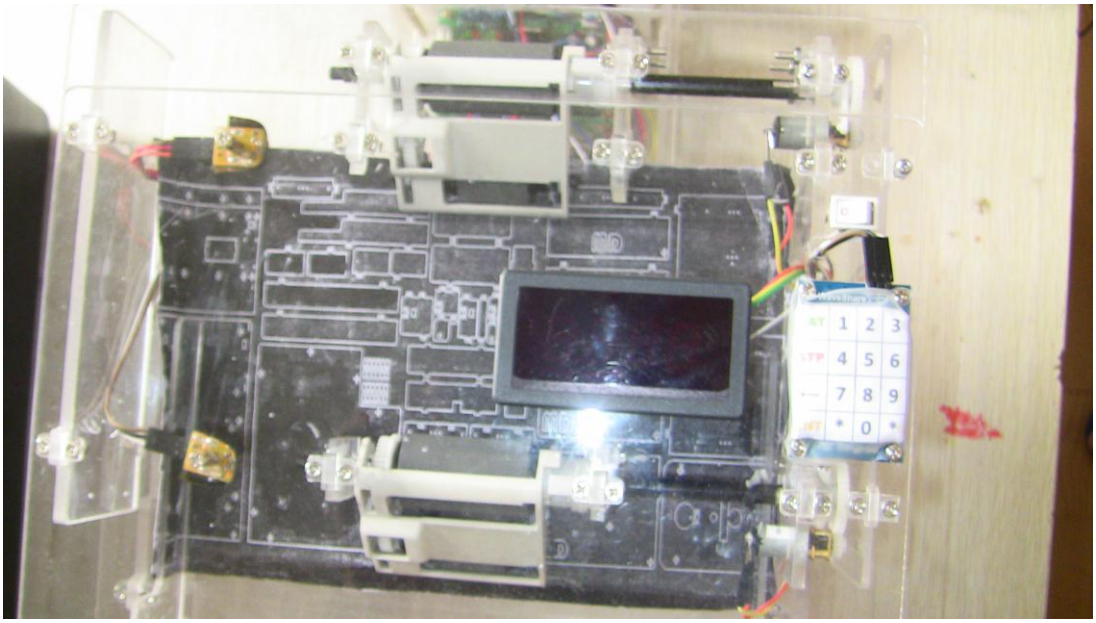


Figure J-6: Paper Feeding Structure

Step 5: Assemble the Paper Separating Part

Assemble the supporting structures (see Figure J-7 and Figure J-8).

Assemble the rotating platform (see Figure J-7 and Figure J-8).

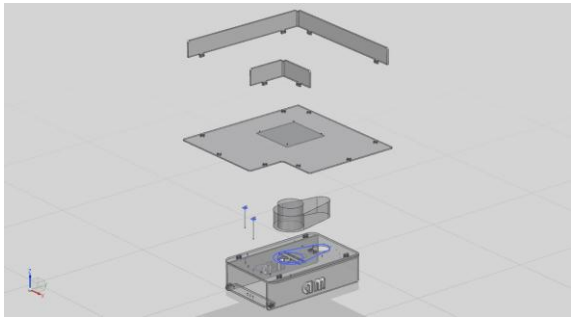


Figure J-7: Paper Separating Part

Figure J-8: Paper Separating Part

Step 6: Connect the Wires of Circuits

Connect the wires (see Figure J-9). See Appendix E for detailed instructions.

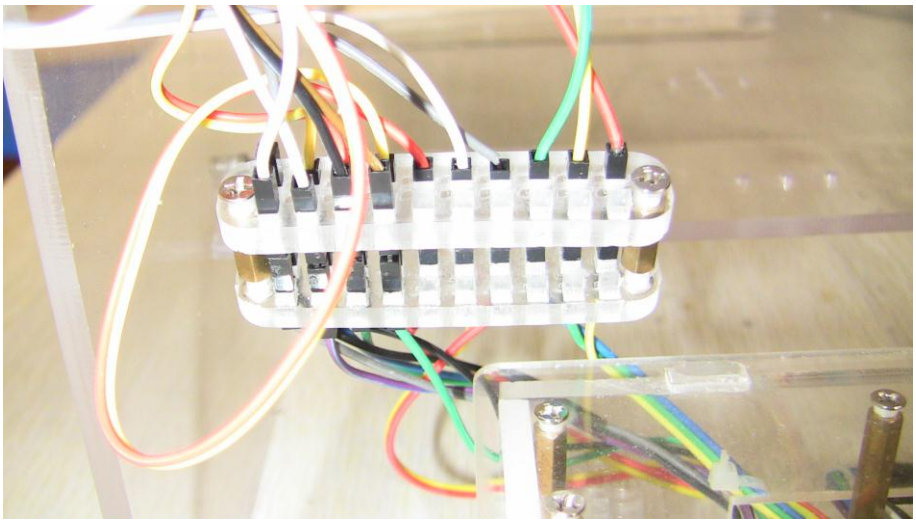


Figure J-9: Wire Arranging Structure

Step 7: Program the Arduino Uno

See Appendix F for detailed information.

Step 8: Fix the Circuit Boards in the Joint System

Fix the PCB circuit boards in the joint part (see Figure J-10 and Figure J-11).

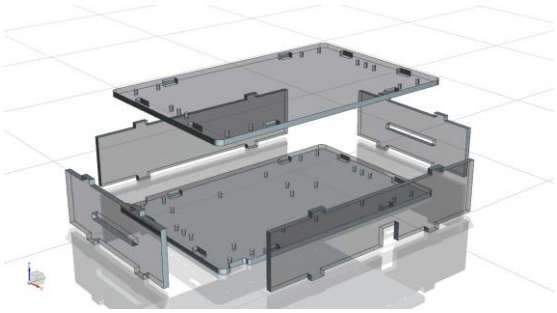


Figure J-10: Joint System

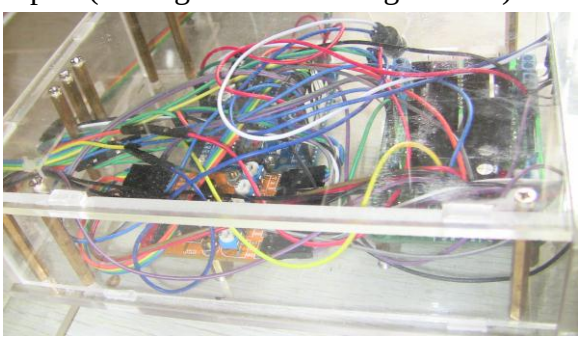


Figure J-11: Joint System

Step 9: Combine Three Main Parts

Connect wires of different parts.
Fix the joint part with the paper feeding part.
Fix the joint part with the paper separating part.
See 4.1 Design Overview for the real picture of the final product.

Step 10: Check Each Component for Safety Concern

Check for short circuit.
Check for unstable connected nuts and bolts.
Run Some Test for Functionality.

Appendix K Tests and Evaluations

Appendix K.1 Functionality Test

The purpose of this test is to find out whether our design is able to handle more than 100 sheets of paper or not. The procedure for this test is as follows:

1. Prepare a stack of paper, which should be a little bit more than 100 sheets.
2. Put the paper into our design.
3. Use our design to separate it.
4. Check if our design is able to separate at least 100 sheets of paper before paper gets stuck or other errors happen.
5. Repeat step 2-4.

The result in this test, also in other tests showed that our design is capable for at least 100 sheets of paper.

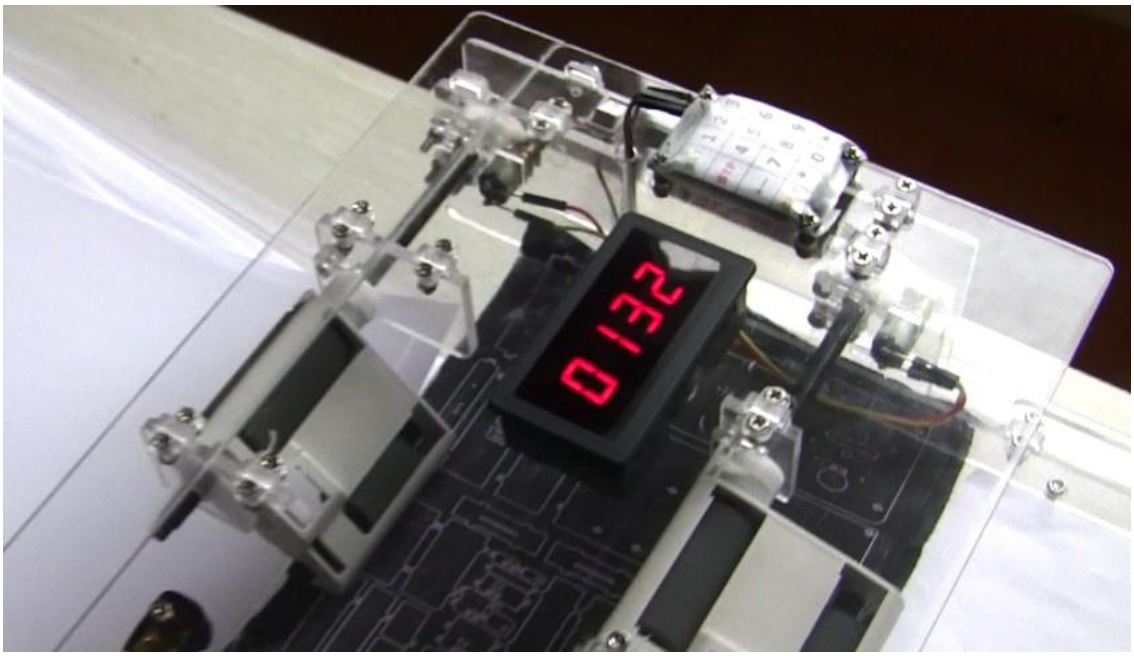


Figure K-1: Number of Sheets of Paper Separated

As the photo (See Figure K-1) shows, our prototype successfully separated 132 sheets of paper.

Appendix K.2 Light Condition Test

The purpose of this test is to ensure that different light conditions will not affect the light sensors in our design. The procedure is as follows:

1. Choose a certain light condition, ranging from bright to dark, indoor to outdoor.
2. Put some paper into our design.
3. Use our design to separate them.
4. Check if our design can work normally.
5. Change the light condition.
6. Repeat step 2-5.

The result showed that our design can work well both in bright and in dark conditions. Here are some photos (see Figure K-2 to Figure K-4) showing that our prototype can work normally in different light conditions.

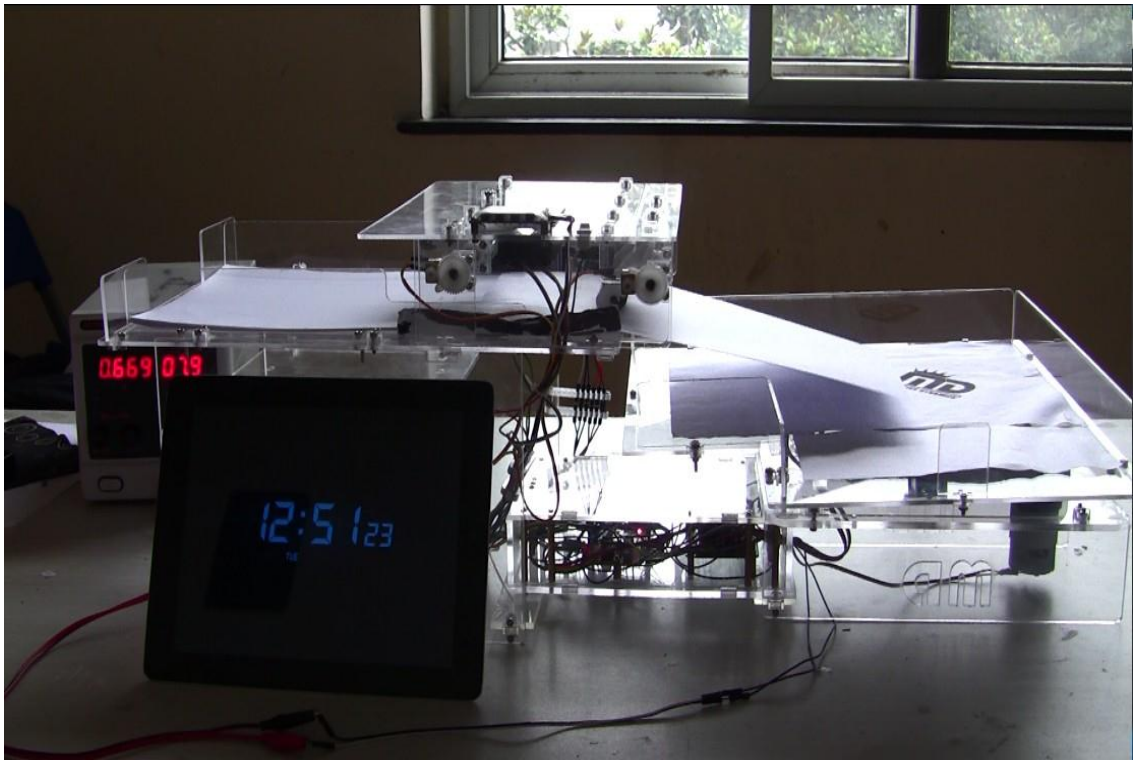


Figure K-2: 12:50 Day Light Test

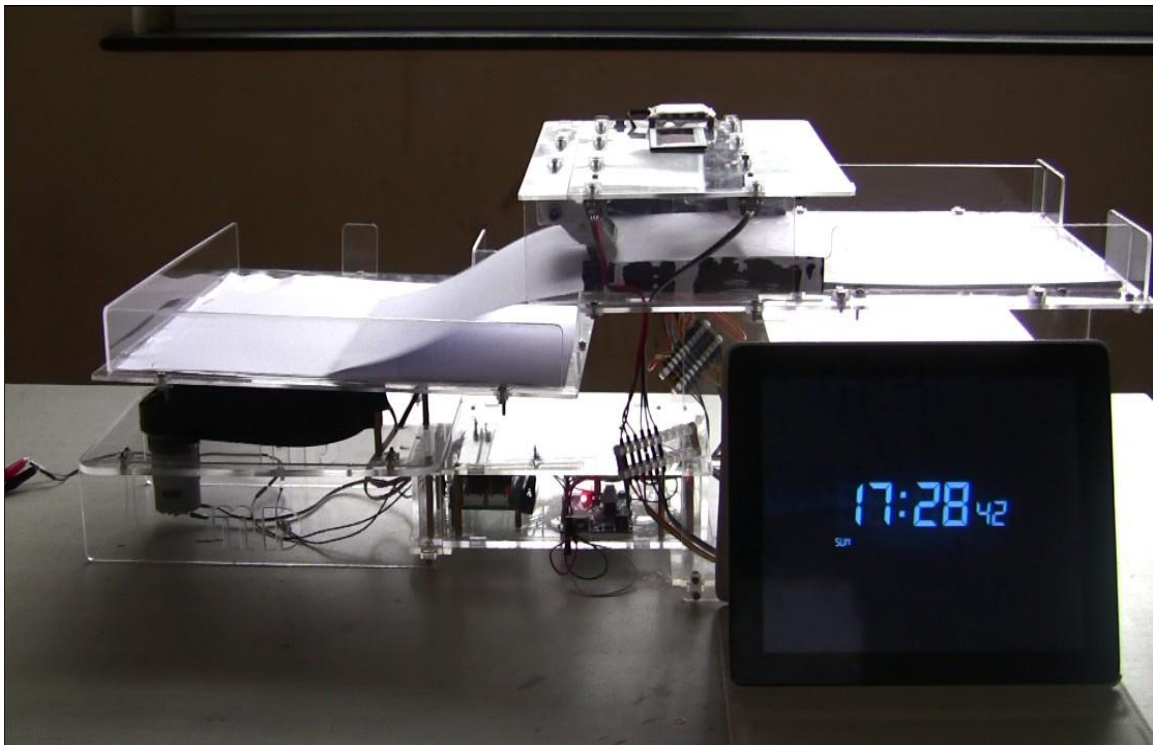


Figure K-3: 17:28 Day Light Test

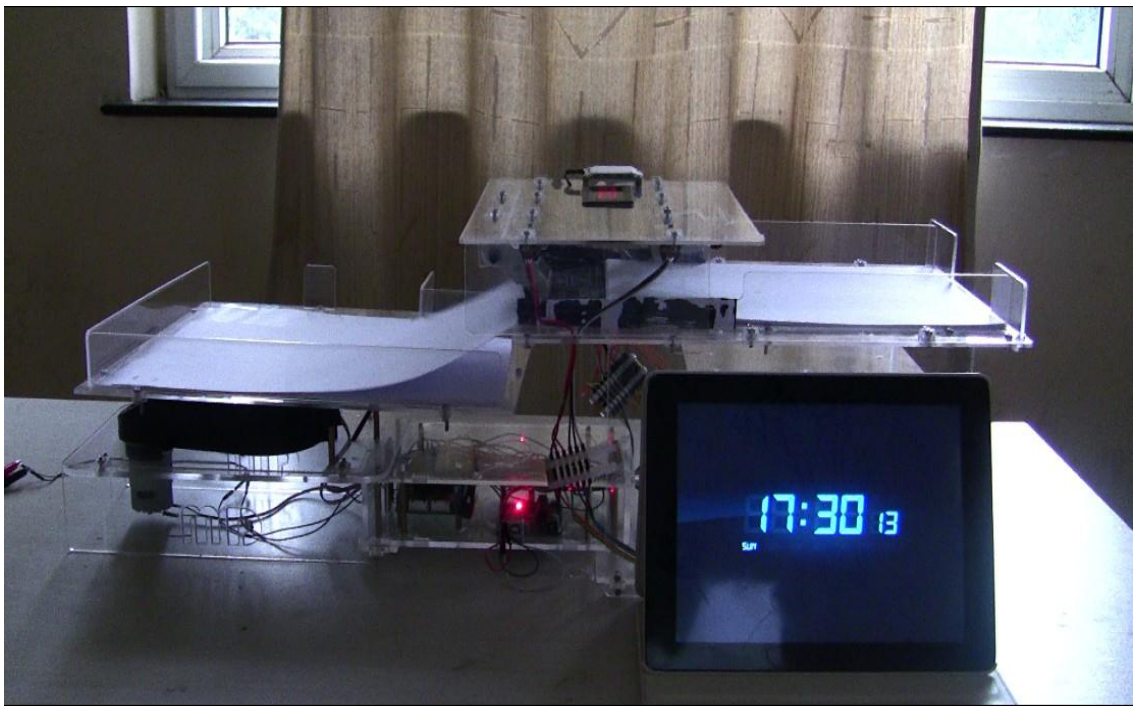


Figure K-4: 17:30 Room Light Test (With Closed Curtain)

Appendix K.3 Voltage Conditions Test

The purpose of this test is to find out the range of voltage for our design. It is more convenient if using a voltage transmitter to test. The procedure is as follows:

1. Turn off the switch of our design.
2. Connect the voltage transmitter with our design correctly.
3. Choose a certain output voltage. (It is better to start with a low output voltage and slowly raise it.)
4. Put some paper into our design.
5. Turn on the switch and separate the paper.
6. Check if our design can work normally.
7. Turn off the switch.
8. Change the output voltage slightly.
9. Repeat step 4-8.

The following photos (see Figure K-5 and Figure K-6) show the minimum and maximum working voltage of our prototype.

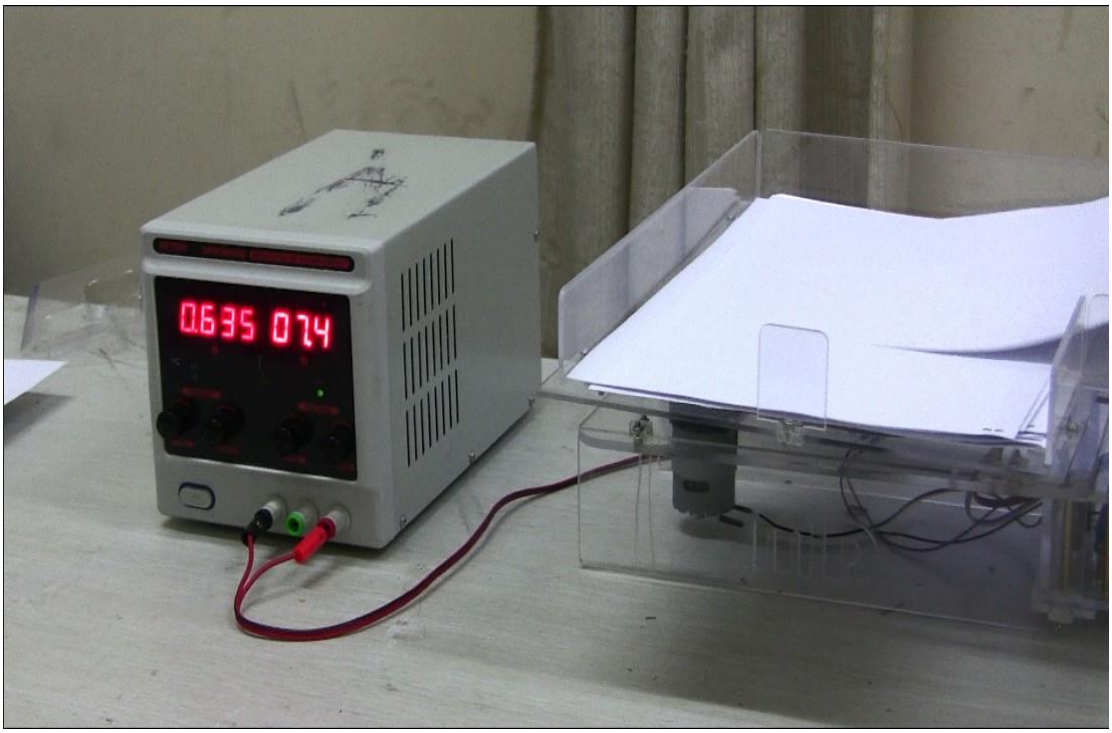


Figure K-5: Minimum Working Voltage

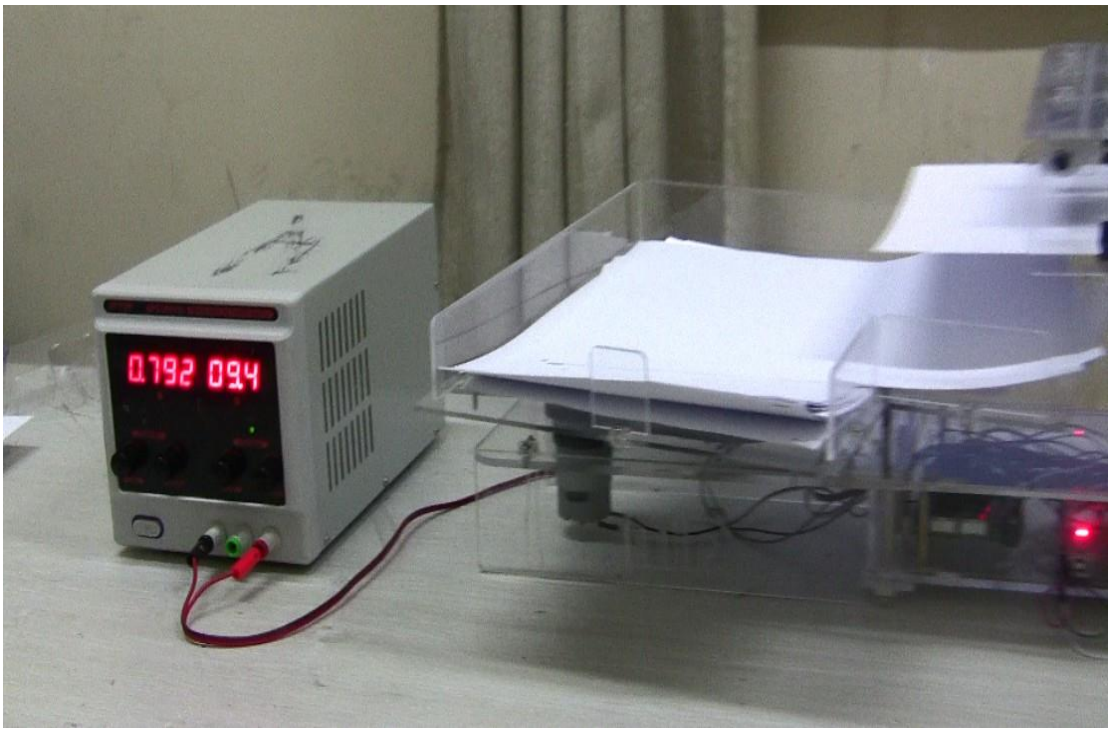


Figure K-6: Maximum Working Voltage

Appendix K.4 Humidity Condition Test

The purpose of this test is to check if our design can work in different humidity conditions (see Figure K-7 and Figure K-8). Since it is hard to change the humidity condition, we recommend that users should test in different days. The procedure is as follows:

1. Measure the air humidity using a hygrometer and record it.
2. Put the paper into our design.
3. Use our design to separate it.
4. Check whether our design can work normally.
5. Repeat step 3-5.
6. Record the results.
7. Repeat step 1-8.

The results are shown in the following table.

Table K-1: Data of Humidity Condition Test

Humidity	Number of sheets of paper	Total error sheets of paper (3 trials)	Error Index (%)
54%	30	1	1.11
	50	2	1.33
	100	6	2.00
83%	30	5	5.56
	50	11	7.33
	100	33	11.00
89%	30	5	5.56
	50	13	8.67
	100	37	12.33

Figure K-7: Humidity Condition Test

Figure K-8: Humidity Condition Test

Appendix K.5 Accuracy Test

The purpose of this test is to find out the accuracy of our design since sometimes our design might feed two sheets of paper in one time. The procedure is as follows:

1. Prepare a certain number of sheets of paper and record it. (It is better if the number is easy for calculating.)
2. Put the paper into our design.
3. Use our design to separate it.
4. Record the number of sheets of paper counted by our design.
5. Calculate the error paper using the equation $N_{error}=N_{total}-N_{counted}$ and record it.
6. Repeat step 2-5.
7. Change the number of sheets of paper and record it. (Also it had better be easy for calculating.)
8. Repeat step 2-7.

In this test, we tested for three times and recorded the result for each number of sheets of paper. By summing them up we got the total error sheets of paper. According to the equation $A_{error}\%=(N_{total\ error}/3)/N_{total}\times100\%$, we calculated the error index and made the following table.

Table K-2: Data of Accuracy Test

Number of sheets of paper	Total error sheets of paper (3 trials)	Error Index (%)
20	0	0.00
30	1	1.11
40	1	0.83
50	2	1.33
60	3	1.67
70	4	1.90
80	4	1.67
90	6	2.22
100	6	2.00
150	14	3.11
200	29	4.83
300	61	6.78

Appendix K.6 Efficiency Test

The purpose of this test is to find out the efficiency of our design and to prove that our design can save users' time. The procedure of this test is as follows:

1. Prepare a certain number of sheets of paper and record it. (It is better if the number is easy for calculating.)
2. Put the paper into our design.
3. Start the stopwatch at the beginning of step 3.
4. Use our design to separate it.
5. Stop the stopwatch when all the paper is separated.
6. Record the time used.
7. Repeat step 2-6.

In this test, we used our design to separate 100 sheets of paper. The ideal time of feeding paper and rotating are 1.8s and 1s, respectively. According to the equation $T_{total}(N,P)=(N/P-1)\times T_r+N\times T_f$, the estimated time for separating 100 sheets of paper is 186s (see Figure K-9 and Figure K-10).

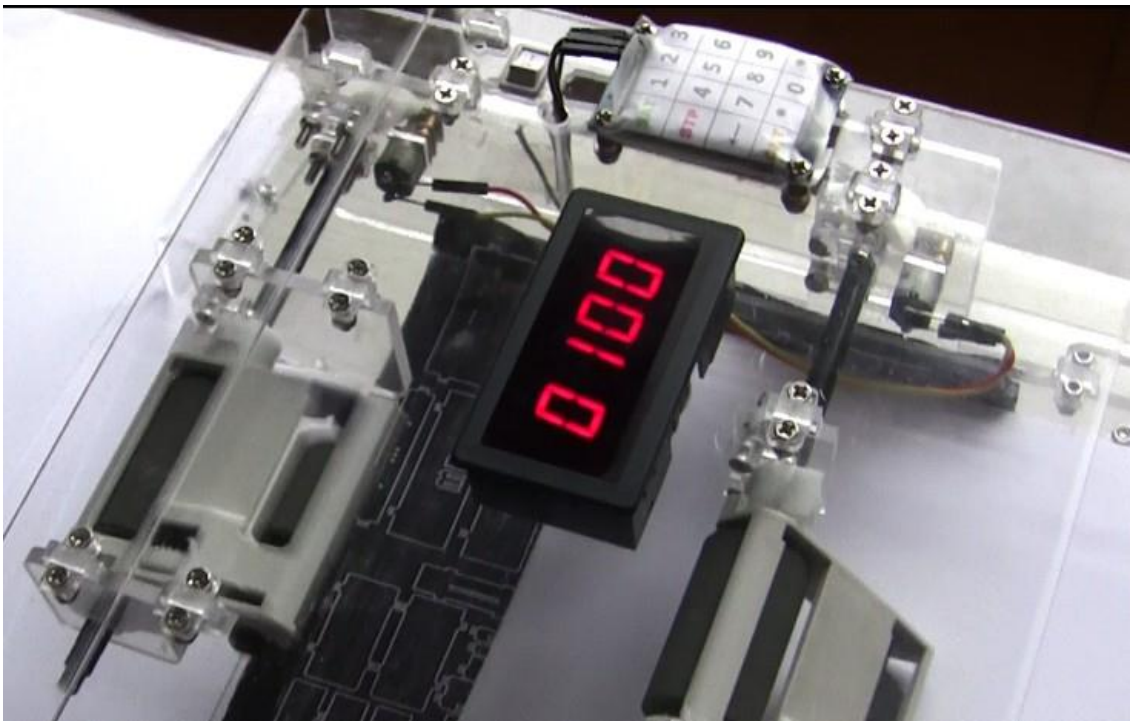


Figure K-9: Separating 100 Sheets of Paper

Figure K-10: Time Used for Separating 100 Sheets of Paper

Appendix K.7 Continuity Test

The purpose of this test is to ensure that our design can work continuously so that our design is able to separate a large number of sheets of paper. The procedure is as follows:

1. Prepare two stacks of paper.
2. Put the first stack into our design.
3. Use our design to separate it.
4. Wait until all the paper is separated.
5. Put the second stack into our design.
6. Press the “CNT” (short for “continue”) button on the matrix keyboard and start separating the second stack of paper.
7. Check if our design can work normally.
8. Repeat step 1-7.

Here are some photos (See Figure K-11 to Figure K-13) showing that our design can work continuously.

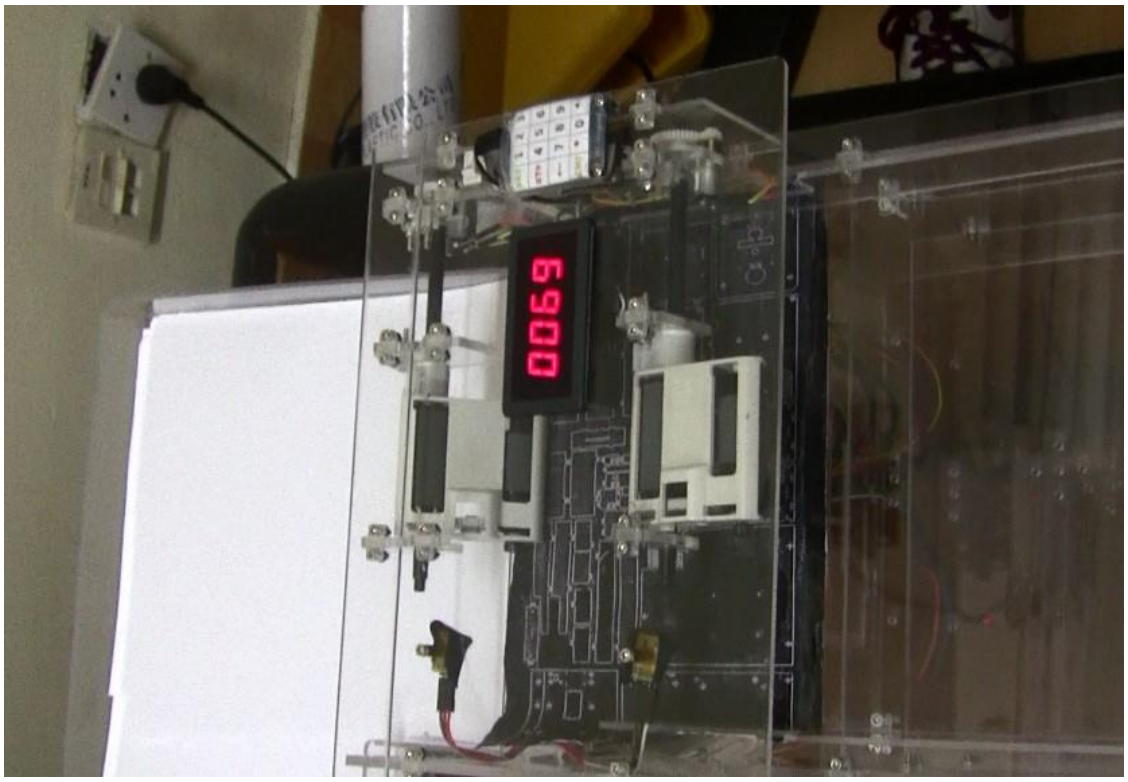


Figure K-11: Separating the First Stack of Paper

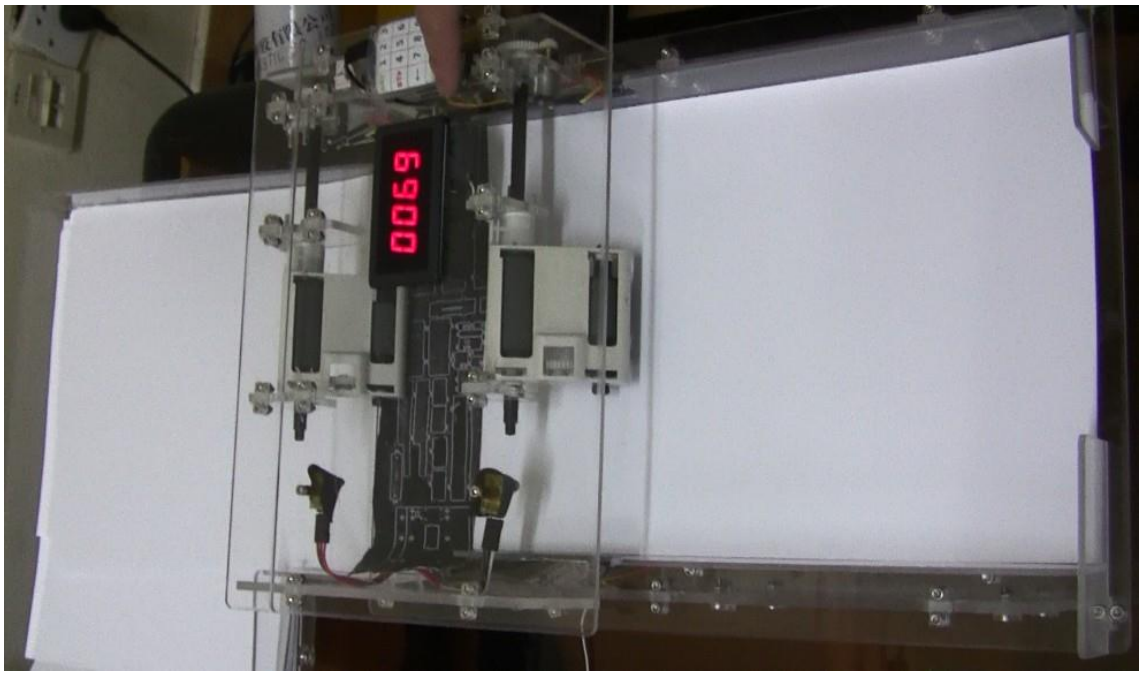


Figure K-12: Putting the Second Stack & Pressing the "CNT" Button

Figure K-13: Separating the Second Stack

Appendix K.8 Alarming System Test

The purpose of this test is to ensure that the alarming system of our design will work if paper is stuck. The procedure of this test is as follows:

1. Prepare a stack of paper.
2. Wrinkle it. (Or you may skip this step and just grasp the paper on purpose in step 5)
3. Put the paper into our design.
4. Use our design to separate them.
5. Wait until paper is stuck. (Or you may just grasp the paper.)
6. Check if the alarming system works normally.
7. Repeat step 3-6.

When the paper got stuck, not only the buzzer beeped but also the display screen indicated that something wrong had happened in the test of our prototype, as the following photo (See Figure K-14) shows.

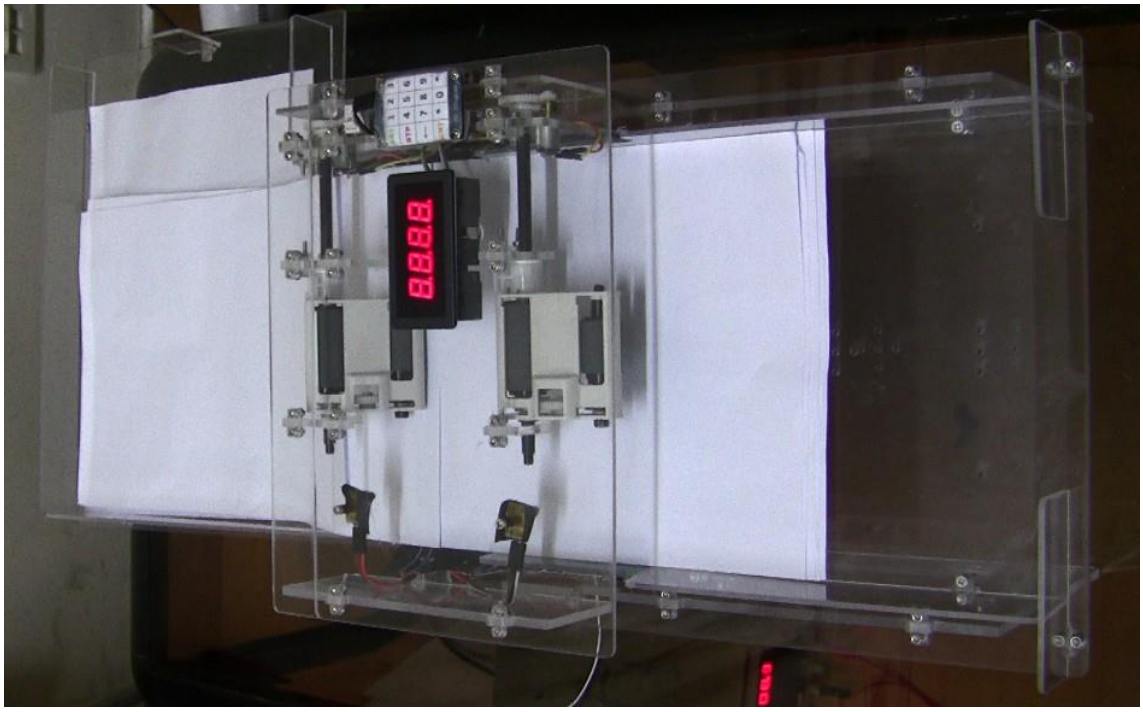
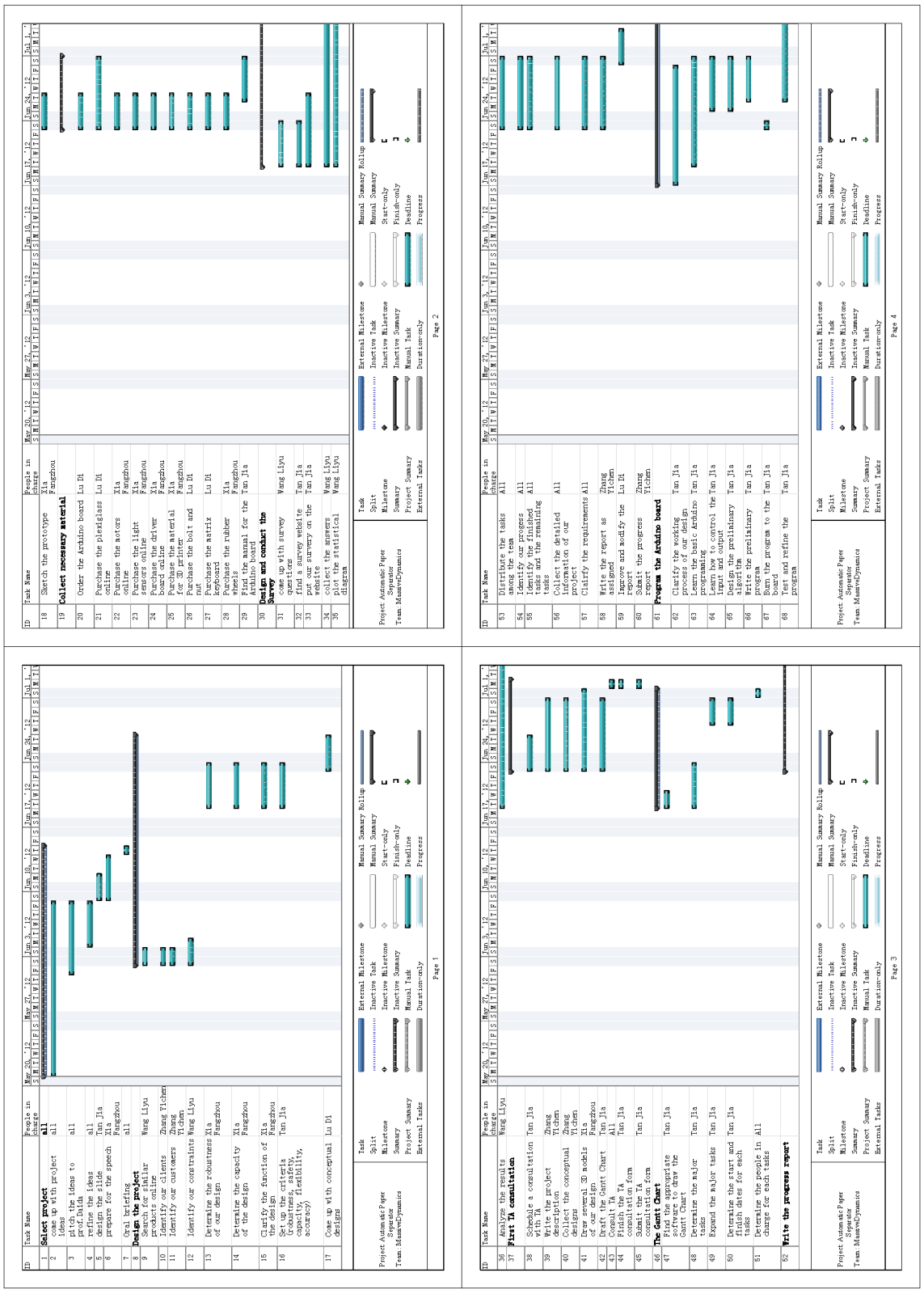
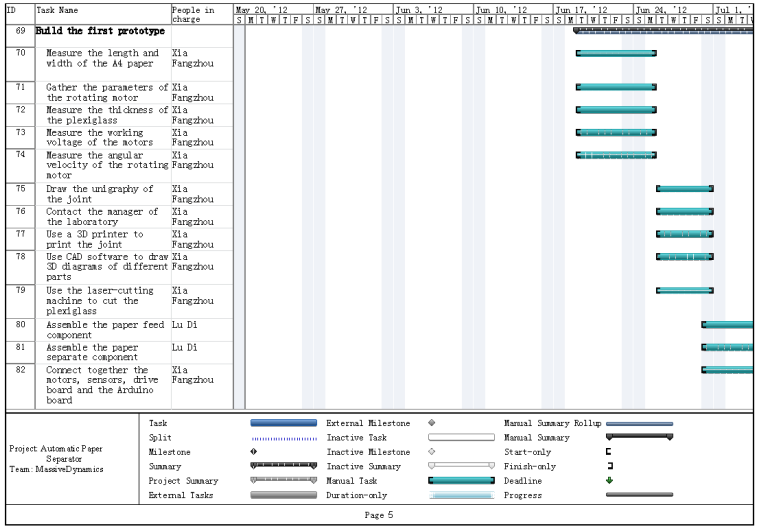


Figure K-14: Alarming System

Appendix L Gantt Chart



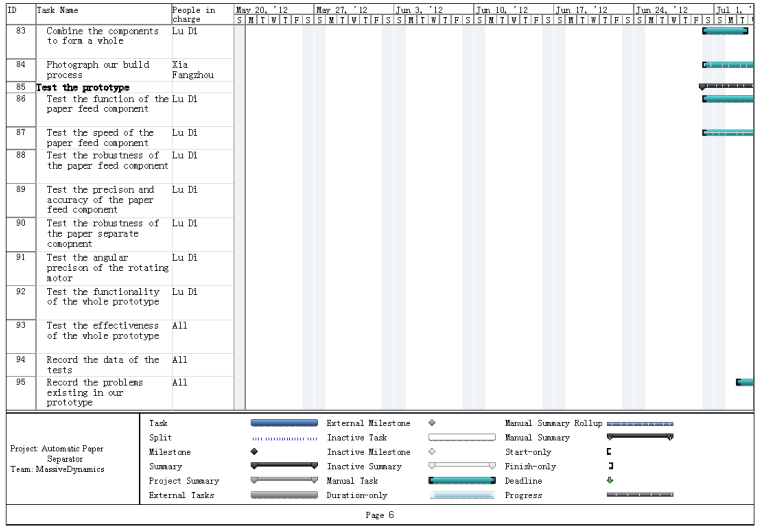


ID	Task Name	People in charge
69	**Build the first prototype**	
70	Measure the length and width of the A4 paper	Xia Fangzhou
71	Gather the parameters of the rotating motor	Xia Fangzhou
72	Measure the thickness of the plexiglass	Xia Fangzhou
73	Measure the working voltage of the motors	Xia Fangzhou
74	Measure the angular velocity of the rotating motor	Xia Fangzhou
75	Draw the unigraphy of the joint	Xia Fangzhou
76	Contact the manager of the laboratory	Xia Fangzhou
77	Use a 3D printer to print the joint	Xia Fangzhou
78	Use CAD software to draw 3D diagrams of different parts	Xia Fangzhou
79	Use the laser-cutting machine to cut the plexiglass	Xia Fangzhou
80	Assemble the paper feed component	Lu Di
81	Assemble the paper separate component	Lu Di
82	Connect together the motors, sensors, drive board and the Arduino board	Xia Fangzhou

Project: Automatic Paper Separator
Team: MassiveDynamics

Task, Split, Milestone, Summary, Project Summary, External Tasks, External Milestone, Inactive Task, Inactive Milestone, Inactive Summary, Manual Task, Duration-only, Manual Summary Rollup, Manual Summary, Start-only, Finish-only, Deadline, Progress

Page 5

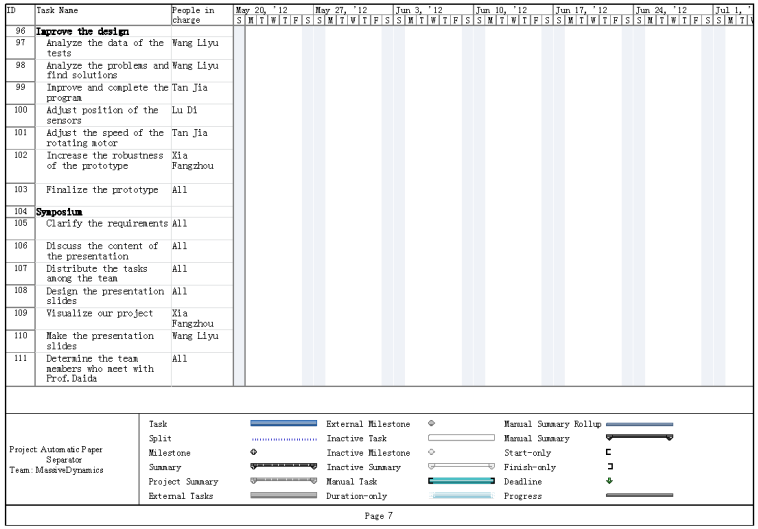


ID	Task Name	People in charge
83	Combine the components to form a whole	Lu Di
84	Photograph our build process	Xia Fangzhou
85	**Test the prototype**	
86	Test the function of the paper feed component	Lu Di
87	Test the speed of the paper feed component	Lu Di
88	Test the robustness of the paper feed component	Lu Di
89	Test the precison and accuracy of the paper feed component	Lu Di
90	Test the robustness of the paper separate comopnent	Lu Di
91	Test the angular precison of the rotating motor	Lu Di
92	Test the functionality of the whole prototype	Lu Di
93	Test the effectiveness of the whole prototype	All
94	Record the data of the tests	All
95	Record the problems existing in our prototype	All

Project: Automatic Paper Separator
Team: MassiveDynamics

Task, Split, Milestone, Summary, Project Summary, External Tasks, External Milestone, Inactive Task, Inactive Milestone, Inactive Summary, Manual Task, Duration-only, Manual Summary Rollup, Manual Summary, Start-only, Finish-only, Deadline, Progress

Page 6



ID	Task Name	People in charge
96	**Improve the design**	
97	Analyze the data of the tests	Wang Liyu
98	Analyze the problems and find solutions	Wang Liyu
99	Improve and complete the program	Tan Jia
100	Adjust position of the sensors	Lu Di
101	Adjust the speed of the rotating motor	Tan Jia
102	Increase the robustness of the prototype	Xia Fangzhou
103	Finalize the prototype	All
104	**Symposium**	
105	Clarify the requirements	All
106	Discuss the content of the presentation	All
107	Distribute the tasks among the team	All
108	Design the presentation slides	All
109	Visualize our project	Xia Fangzhou
110	Make the presentation slides	Wang Liyu
111	Determine the team members who meet with Prof. Daida	All

Project: Automatic Paper Separator
Team: MassiveDynamics

Task, Split, Milestone, Summary, Project Summary, External Tasks, External Milestone, Inactive Task, Inactive Milestone, Inactive Summary, Manual Task, Duration-only, Manual Summary Rollup, Manual Summary, Start-only, Finish-only, Deadline, Progress

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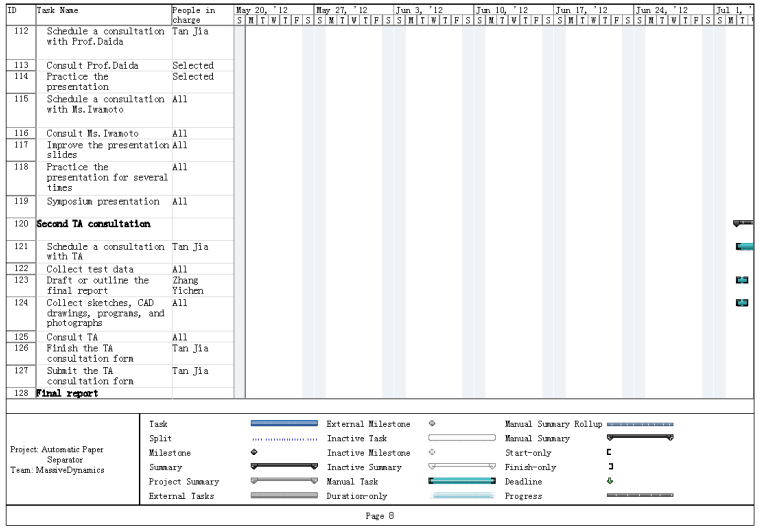

ID	Task Name	People in charge
112	Schedule a consultation with Prof. Daida	Tan Jia
113	Consult Prof. Daida	Selected
114	Practice the presentation	Selected
115	Schedule a consultation with Ms. Iwamoto	All
116	Consult Ms. Iwamoto	All
117	Improve the presentation slides	All
118	Practice the presentation for several times	All
119	Symposium presentation	All
120	**Second TA consultation**	
121	Schedule a consultation with TA	Tan Jia
122	Collect test data	All
123	Draft or outline the final report	Zhang Yichen
124	Collect sketches, CAD drawings, programs, and photographs	All
125	Consult TA	All
126	Finish the TA consultation form	Tan Jia
127	Submit the TA consultation form	Tan Jia
128	**Final report**	

Project: Automatic Paper Separator
Team: MassiveDynamics

Task, Split, Milestone, Summary, Project Summary, External Tasks, External Milestone, Inactive Task, Inactive Milestone, Inactive Summary, Manual Task, Duration-only, Manual Summary Rollup, Manual Summary, Start-only, Finish-only, Deadline, Progress

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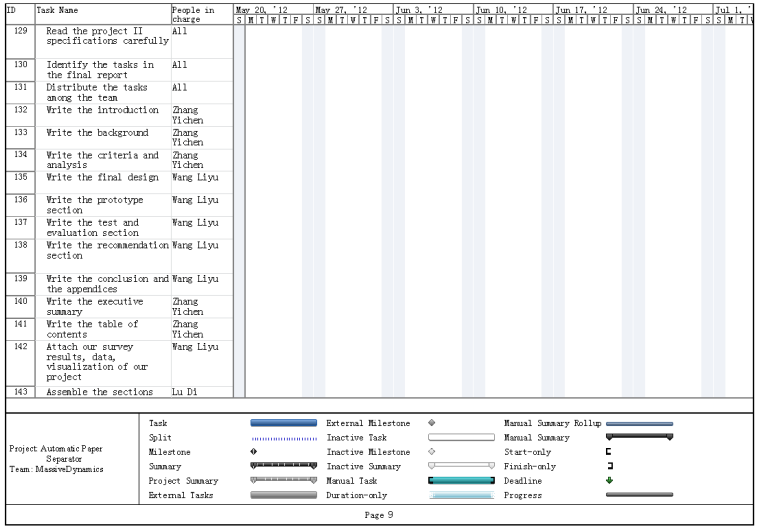

ID	Task Name	People in charge
129	Read the project II specifications carefully	All
130	Identify the tasks in the final report	All
131	Distribute the tasks among the team	All
132	Write the introduction	Zhang Yichen
133	Write the background	Zhang Yichen
134	Write the criteria and analysis	Zhang Yichen
135	Write the final design	Wang Liyu
136	Write the prototype section	Wang Liyu
137	Write the test and evaluation section	Wang Liyu
138	Write the recommendation section	Wang Liyu
139	Write the conclusion and the appendices	Wang Liyu
140	Write the executive summary	Zhang Yichen
141	Write the table of contents	Zhang Yichen
142	Attach our survey results, data, visualization of our project	Wang Liyu
143	Assemble the sections	Lu Di

May 20, '12 | May 27, '12 | Jun 3, '12 | Jun 10, '12 | Jun 17, '12 | Jun 24, '12 | Jul 1, '

Project: Automatic Paper Separator
Team: MassiveDynamics

Task | External Milestone | Manual Summary Rollup
Split | Inactive Task | Manual Summary
Milestone | Inactive Milestone | Start-only
Summary | Inactive Summary | Finish-only
Project Summary | Manual Task | Deadline
External Tasks | Duration-only | Progress

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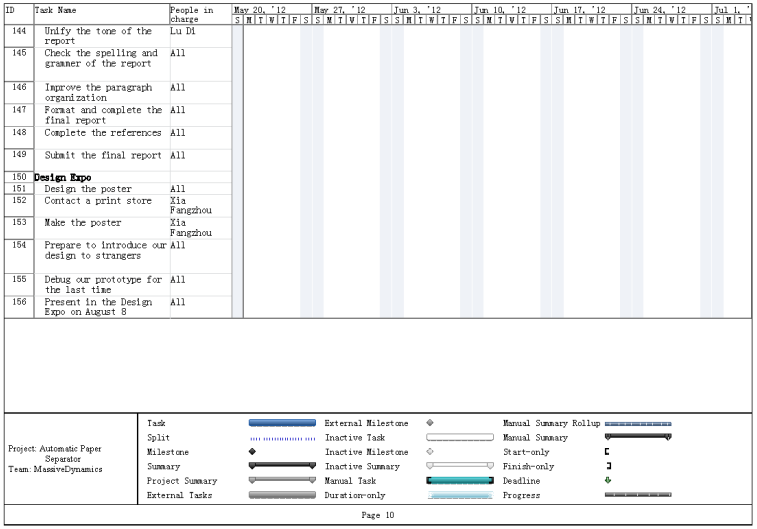

ID	Task Name	People in charge
144	Unify the tone of the report	Lu Di
145	Check the spelling and grammer of the report	All
146	Improve the paragraph organization	All
147	Format and complete the final report	All
148	Complete the references	All
149	Submit the final report	All
150	**Design Expo**	
151	Design the poster	All
152	Contact a print store	Xia Fangzhou
153	Make the poster	Xia Fangzhou
154	Prepare to introduce our design to strangers	All
155	Debug our prototype for the last time	All
156	Present in the Design Expo on August 8	All

May 20, '12 | May 27, '12 | Jun 3, '12 | Jun 10, '12 | Jun 17, '12 | Jun 24, '12 | Jul 1, '

Project: Automatic Paper Separator
Team: MassiveDynamics

Task | External Milestone | Manual Summary Rollup
Split | Inactive Task | Manual Summary
Milestone | Inactive Milestone | Start-only
Summary | Inactive Summary | Finish-only
Project Summary | Manual Task | Deadline
External Tasks | Duration-only | Progress

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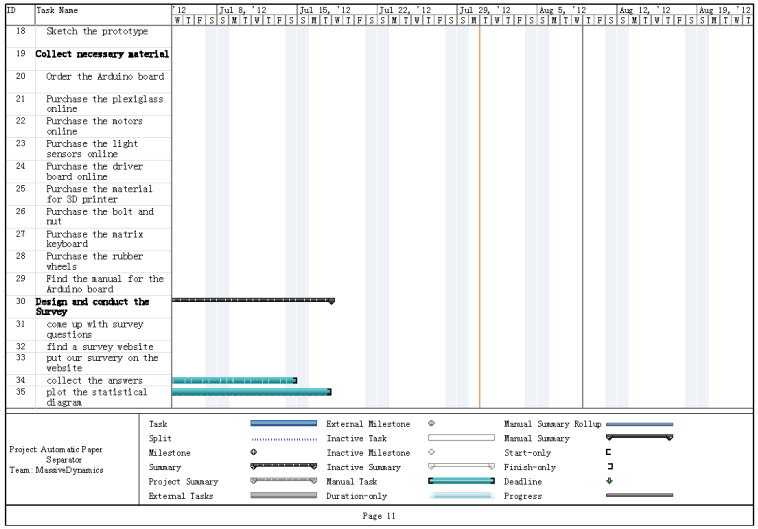

ID	Task Name
18	Sketch the prototype
19	**Collect necessary material**
20	Order the Arduino board
21	Purchase the plexiglass online
22	Purchase the motors online
23	Purchase the light sensors online
24	Purchase the driver board online
25	Purchase the material for 3D printer
26	Purchase the bolt and nut
27	Purchase the matrix keyboard
28	Purchase the rubber wheels
29	Find the manual for the Arduino board
30	**Design and conduct the Survey**
31	come up with survey questions
32	find a survey website
33	put our survery on the website
34	collect the answers
35	plot the statistical diagram

'12 | Jul 8, '12 | Jul 15, '12 | Jul 22, '12 | Jul 29, '12 | Aug 5, '12 | Aug 12, '12 | Aug 19, '12

Project: Automatic Paper Separator
Team: MassiveDynamics

Task | External Milestone | Manual Summary Rollup
Split | Inactive Task | Manual Summary
Milestone | Inactive Milestone | Start-only
Summary | Inactive Summary | Finish-only
Project Summary | Manual Task | Deadline
External Tasks | Duration-only | Progress

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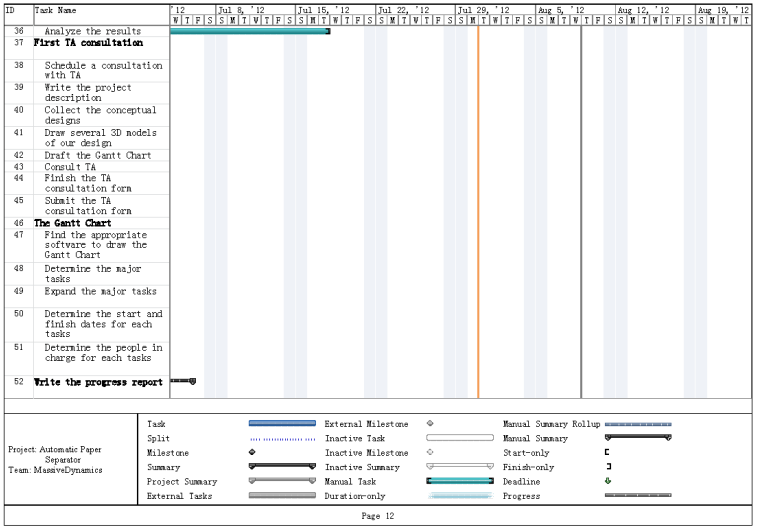

ID	Task Name
36	Analyze the results
37	**First TA consultation**
38	Schedule a consultation with TA
39	Write the project description
40	Collect the conceptual designs
41	Draw several 3D models of our design
42	Draft the Gantt Chart
43	Consult TA
44	Finish the TA consultation form
45	Submit the TA consultation form
46	**The Gantt Chart**
47	Find the appropriate software to draw the Gantt Chart
48	Determine the major tasks
49	Expand the major tasks
50	Determine the start and finish dates for each tasks
51	Determine the people in charge for each tasks
52	**Write the progress report**

'12 | Jul 8, '12 | Jul 15, '12 | Jul 22, '12 | Jul 29, '12 | Aug 5, '12 | Aug 12, '12 | Aug 19, '12

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Milestone | Inactive Milestone | Start-only
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Project Summary | Manual Task | Deadline
External Tasks | Duration-only | Progress

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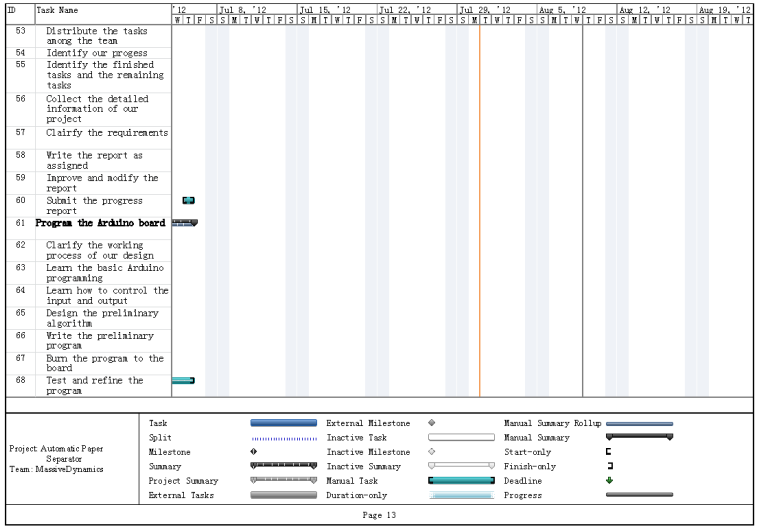
ID
Task Name
'12
Jul 8, '12
Jul 15, '12
Jul 22, '12
Jul 29, '12
Aug 5, '12
Aug 12, '12
Aug 19, '12
53 Distribute the tasks among the team
54 Identify our progess
55 Identify the finished tasks and the remaining tasks
56 Collect the detailed information of our project
57 Clairfy the requirements
58 Write the report as assigned
59 Improve and modify the report
60 Submit the progress report
61 Program the Arduino board
62 Clarify the working process of our design
63 Learn the basic Arduino programming
64 Learn how to control the input and output
65 Design the prelimilnary algorithm
66 Write the prelimilnary program
67 Burn the program to the board
68 Test and refine the program
Project: Automatic Paper Separator
Team: MassiveDynamics
Task
Split
Milestone
Summary
Project Summary
External Tasks
External Milestone
Inactive Task
Inactive Milestone
Inactive Summary
Manual Task
Duration-only
Manual Summary Rollup
Manual Summary
Start-only
Finish-only
Deadline
Progress
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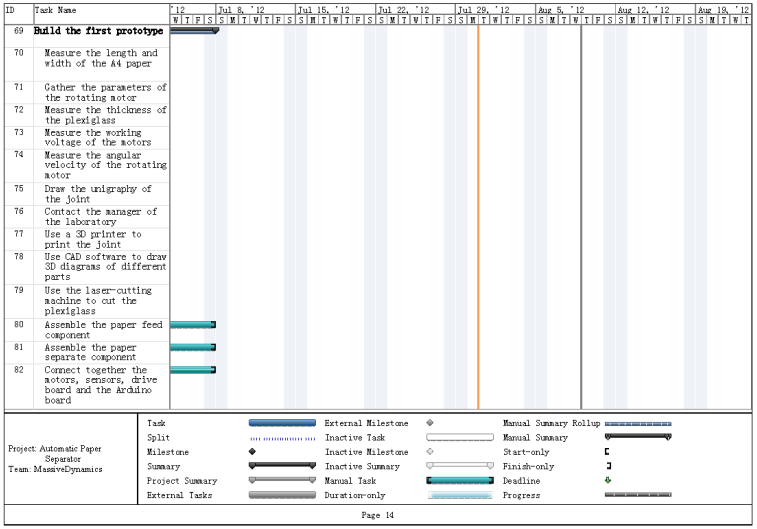
ID
Task Name
'12
Jul 8, '12
Jul 15, '12
Jul 22, '12
Jul 29, '12
Aug 5, '12
Aug 12, '12
Aug 19, '12
69 Build the first prototype
70 Measure the length and width of the A4 paper
71 Gather the parameters of the rotating motor
72 Measure the thickness of the plexiglass
73 Measure the working voltage of the motors
74 Measure the angular velocity of the rotating motor
75 Draw the unigraphy of the joint
76 Contact the manager of the laboratory
77 Use a 3D printer to print the joint
78 Use CAD software to draw 3D diagrams of different parts
79 Use the laser-cutting machine to cut the plexiglass
80 Assemble the paper feed component
81 Assemble the paper separate component
82 Connect together the motors, sensors, drive board and the Arduino board
Project: Automatic Paper Separator
Team: MassiveDynamics
Task
Split
Milestone
Summary
Project Summary
External Tasks
External Milestone
Inactive Task
Inactive Milestone
Inactive Summary
Manual Task
Duration-only
Manual Summary Rollup
Manual Summary
Start-only
Finish-only
Deadline
Progress
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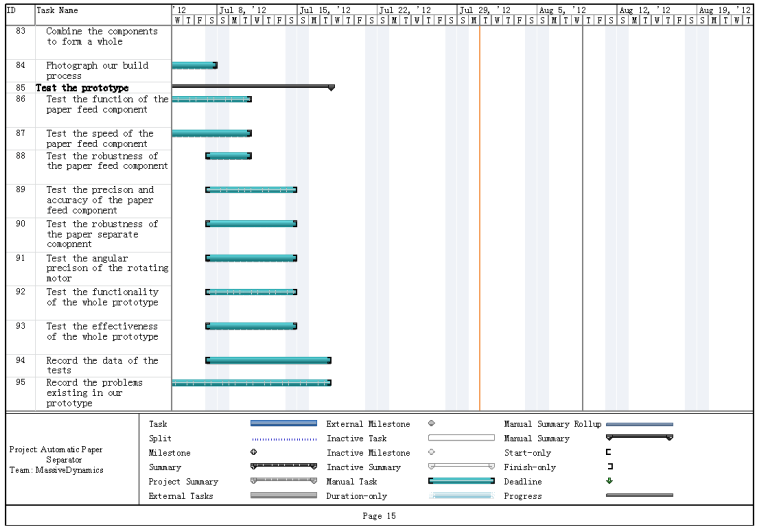
ID
Task Name
'12
Jul 8, '12
Jul 15, '12
Jul 22, '12
Jul 29, '12
Aug 5, '12
Aug 12, '12
Aug 19, '12
83 Combine the components to form a whole
84 Photograph our build process
85 Test the prototype
86 Test the function of the paper feed component
87 Test the speed of the paper feed component
88 Test the robustness of the paper feed component
89 Test the precison and accuracy of the paper feed component
90 Test the robustness of the paper separate comopnent
91 Test the angular precison of the rotating motor
92 Test the functionality of the whole prototype
93 Test the effectiveness of the whole prototype
94 Record the data of the tests
95 Record the problems existing in our prototype
Project: Automatic Paper Separator
Team: MassiveDynamics
Task
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Milestone
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Project Summary
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External Milestone
Inactive Task
Inactive Milestone
Inactive Summary
Manual Task
Duration-only
Manual Summary Rollup
Manual Summary
Start-only
Finish-only
Deadline
Progress
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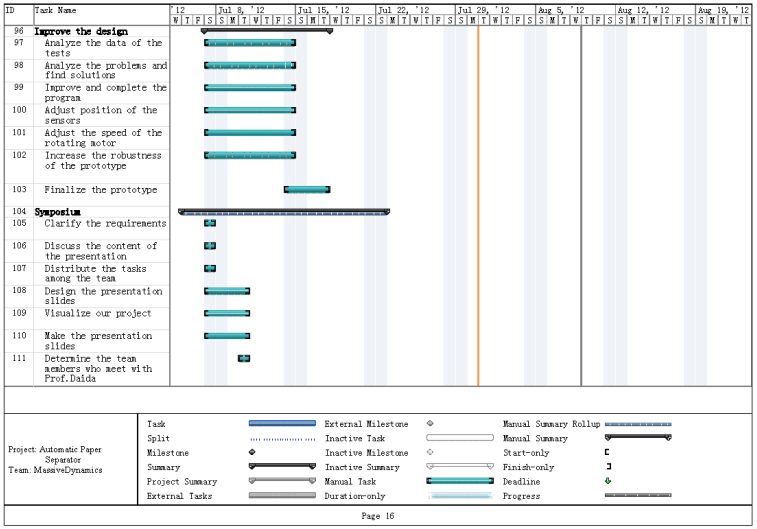
ID
Task Name
'12
Jul 8, '12
Jul 15, '12
Jul 22, '12
Jul 29, '12
Aug 5, '12
Aug 12, '12
Aug 19, '12
96 Improve the design
97 Analyze the data of the tests
98 Analyze the problems and find solutions
99 Improve and complete the program
100 Adjust position of the sensors
101 Adjust the speed of the rotating motor
102 Increase the robustness of the prototype
103 Finalize the prototype
104 Symposium
105 Clarify the requirements
106 Discuss the content of the presentation
107 Distribute the tasks among the team
108 Design the presentation slides
109 Visualize our project
110 Make the presentation slides
111 Determine the team members who meet with Prof.Daida
Project: Automatic Paper Separator
Team: MassiveDynamics
Task
Split
Milestone
Summary
Project Summary
External Tasks
External Milestone
Inactive Task
Inactive Milestone
Inactive Summary
Manual Task
Duration-only
Manual Summary Rollup
Manual Summary
Start-only
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Deadline
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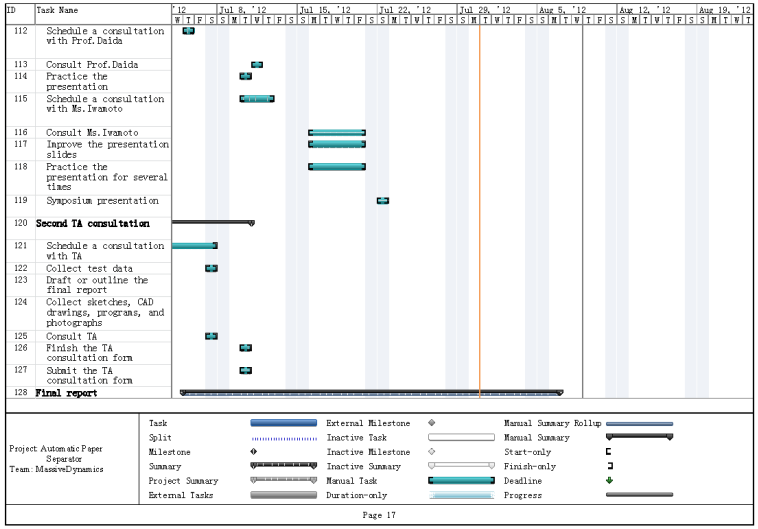
ID
Task Name
'12
Jul 8, '12
Jul 15, '12
Jul 22, '12
Jul 29, '12
Aug 5, '12
Aug 12, '12
Aug 19, '12
112 Schedule a consultation with Prof.Daida
113 Consult Prof.Daida
114 Practice the presentation
115 Schedule a consultation with Ms.Iwamoto
116 Consult Ms.Iwamoto
117 Improve the presentation slides
118 Practice the presentation for several times
119 Symposium presentation
120 Second TA consultation
121 Schedule a consultation with TA
122 Collect test data
123 Draft or outline the final report
124 Collect sketches, CAD drawings, programs, and photographs
125 Consult TA
126 Finish the TA consultation form
127 Submit the TA consultation form
128 Final report
Project: Automatic Paper Separator
Team: MassiveDynamics
Task
Split
Milestone
Summary
Project Summary
External Tasks
External Milestone
Inactive Task
Inactive Milestone
Inactive Summary
Manual Task
Duration-only
Manual Summary Rollup
Manual Summary
Start-only
Finish-only
Deadline
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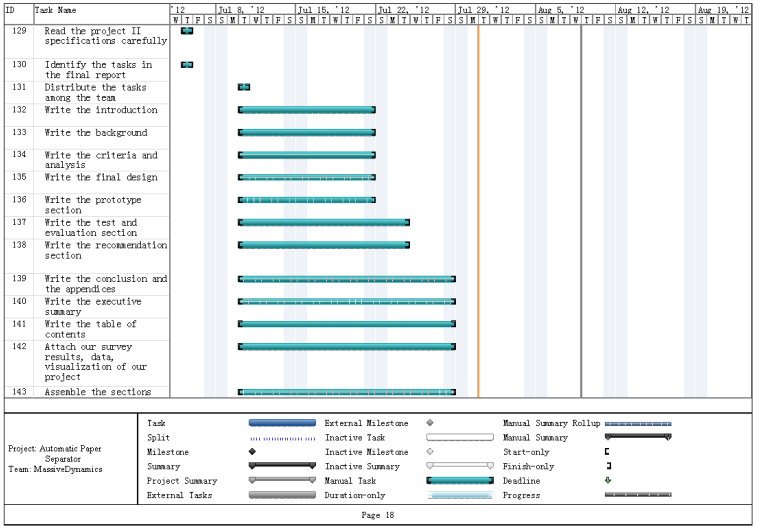
ID
Task Name
'12
Jul 8, '12
Jul 15, '12
Jul 22, '12
Jul 29, '12
Aug 5, '12
Aug 12, '12
Aug 19, '12
129 Read the project II specifications carefully
130 Identify the tasks in the final report
131 Distribute the tasks among the team
132 Write the introduction
133 Write the background
134 Write the criteria and analysis
135 Write the final design
136 Write the prototype section
137 Write the test and evaluation section
138 Write the recommendation section
139 Write the conclusion and the appendices
140 Write the executive summary
141 Write the table of contents
142 Attach our survey results, data, visualization of our project
143 Assemble the sections
Project: Automatic Paper Separator
Team: MassiveDynamics
Task
Split
Milestone
Summary
Project Summary
External Tasks
External Milestone
Inactive Task
Inactive Milestone
Inactive Summary
Manual Task
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Manual Summary Rollup
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'12
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Aug 5, '12
Aug 12, '12
Aug 19, '12
144 Unify the tone of the report
145 Check the spelling and grammer of the report
146 Improve the paragraph organization
147 Format and complete the final report
148 Complete the references
149 Submit the final report
150 Design Expo
151 Design the poster
152 Contact a print store
153 Make the poster
154 Prepare to introduce our design to strangers
155 Debug our prototype for the last time
156 Present in the Design Expo on August 8
Project: Automatic Paper Separator
Team: MassiveDynamics
Task
Split
Milestone
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Project Summary
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External Milestone
Inactive Task
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