Internship Report

For

A synchronised vibrational short fibres alignment method (SVSA) device to align discontinuous fibre composites

Prepared by

Wo Yew Ben

Supervised by

Dr Khong Wui Gan

September 9, 2018

1 TABLE OF CONTENT

2 ABSTRACT

The report reviews on a machine which the synchronized vibrational short fibre alignment (SVSA) method which aligns fibres on a platform which can move in four directions along a horizontal plane. This allows fibres to be deposited on a larger area compared to the previous machine made. The functions of every mechanism of the machine, electronic circuit configuration and machine operation are being discussed. Results such as quality of fibre alignment for various carbon fibre length and machine requirements are also obtained from numerous tests and further discussed.

3 INTRODUCTION

The SVSA device as shown in Figure 1 functions to deposit and align carbon fibres on a glass plate of area 30cm × 30cm. The fibres are aligned using a vibration mechanism through a number of slits to obtain a vertical fibre alignment.

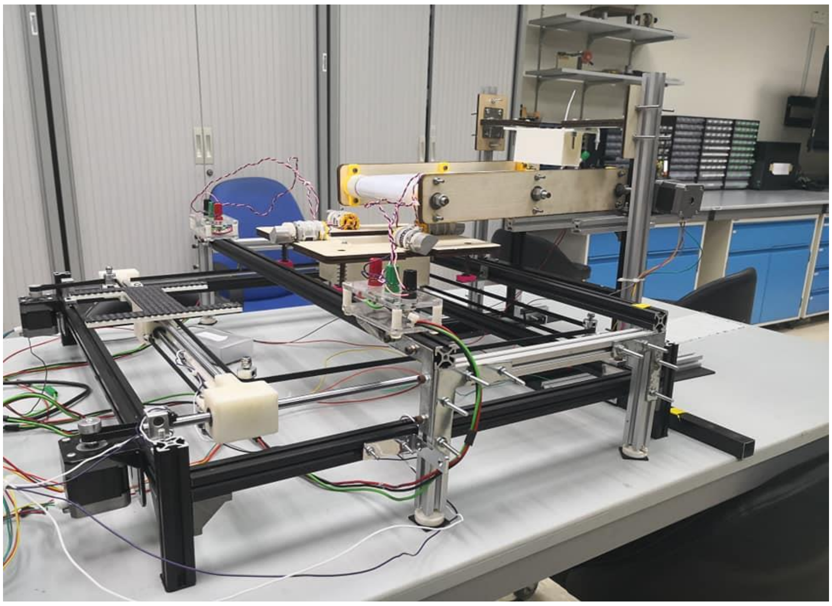


Figure 1: The SVSA device.

The device comprises of 4 parts, as shown in Figure 2.

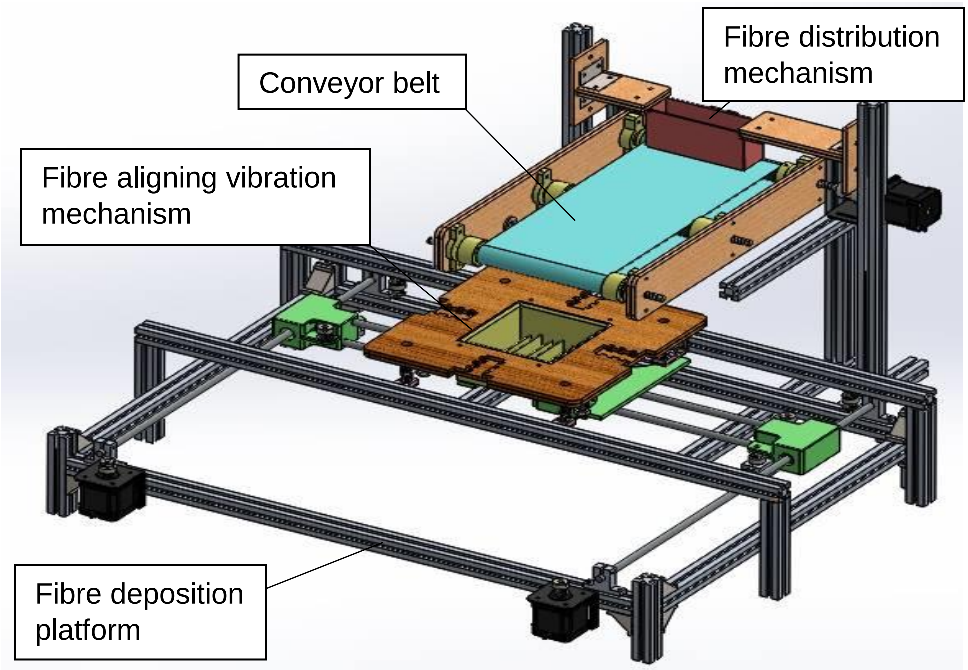


Figure 2: Drawing of the SVSA device using Solidworks 2017.

4.1 DEVICE DESIGN AND ACTUATION

The total effective area of carbon fibre deposited on the glass plate is 26.2 cm × 24.9 cm. During the deposition, the plate is divided into 3 strips of equal width of 83 cm. The fibre is deposited on the glass plate strip by strip to fill the effective area fully.

4.1.1 Fibre deposition platform

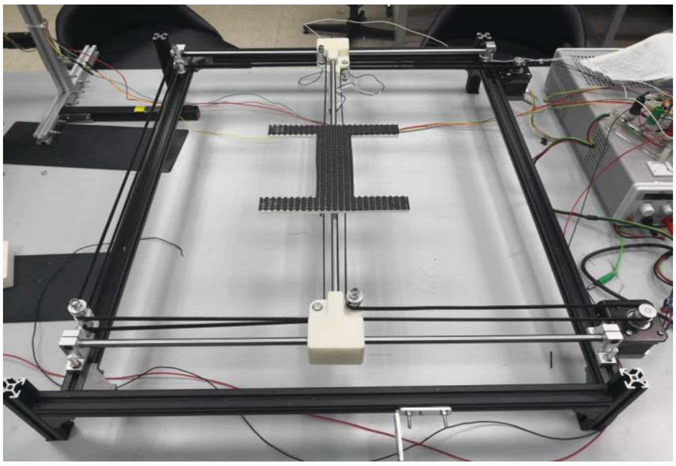


Figure 3: Fibre deposition platform.

The platform, as shown in Figure 3 can maneuver forward, backward, left and right. The platform movement is controlled by 2 Nema-17 bipolar stepper motors, which runs a pulley system, as shown in Figure 4 with a precision of 1/32 of a step of the stepper motors.

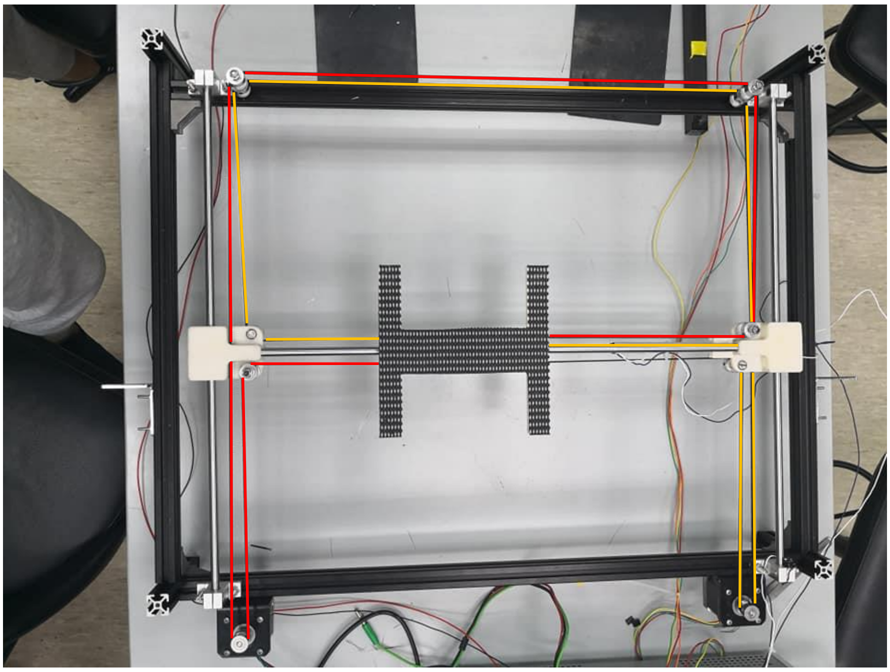


Figure 4: Pulley system of the fibre deposition platform. Blue and green lines denote pulley paths.

Referring to Section 4.2, S3 and S4 are placed on the part to position the platform to its starting position, as shown in Figure 5. When both buttons are pressed by the platform, the devices senses the location of the platform as the origin.

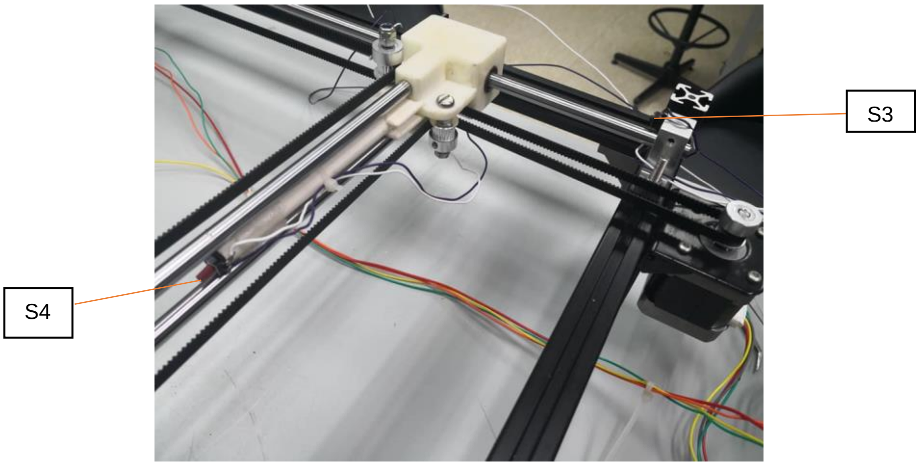


Figure 5: Section of the fibre deposition platform, showing S3 and S4.

By having two bipolar stepper motors which move at the same precision, the four directions for the movement of the platform can be achieved by changing the rotation direction of the stepper motors, as shown in Table 1.

Direction of Stepper Motor A	Direction of Stepper Motor B	Direction of Fibre Deposition Platform
Clockwise	Anticlockwise	Backward

Anticlockwise	Clockwise	Forward
Clockwise	Clockwise	Left
Anticlockwise	Anticlockwise	Right

Table 1: Movement of the fibre deposition platform in relation to direction of rotation of stepper motors A and B.

The deposition platform moves 3.7 cm per revolution, which became the basis to calculate the distance from the origin.

4.1.2 Fibre aligning vibration mechanism

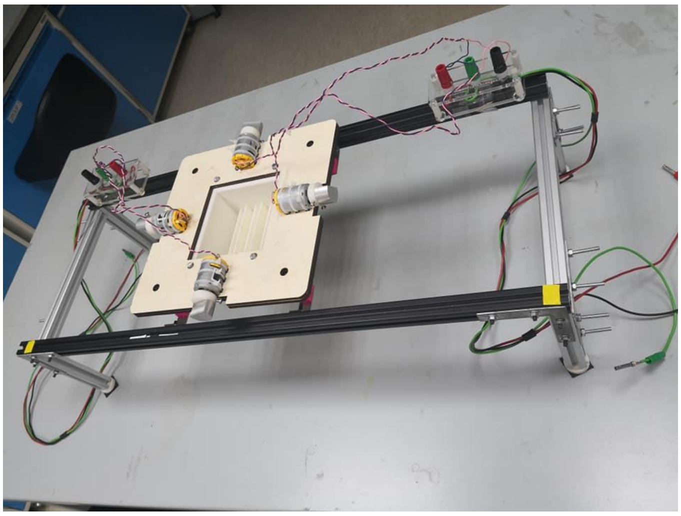


Figure 6: Fibre alignment vibration mechanism.

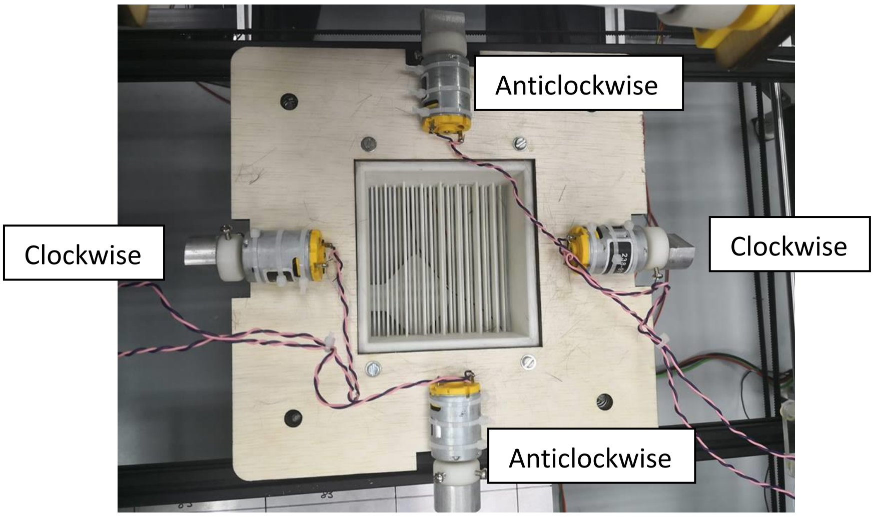


Figure 7: Top view and direction of rotation of DC Motors

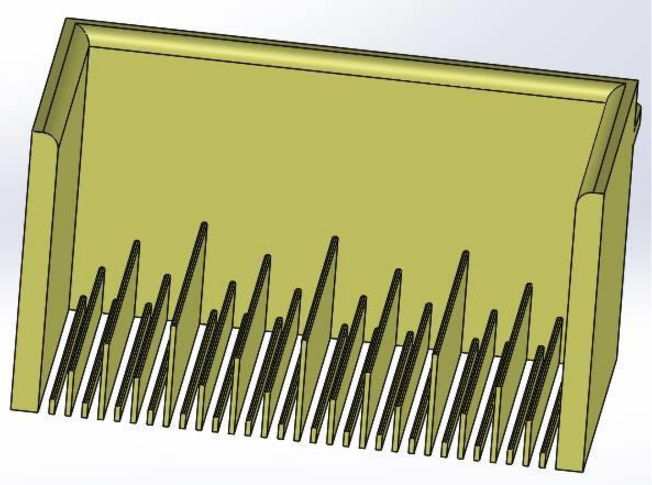


Figure 8: Cross section of fibre aligning slits. Length of slit opening is 3mm.

Each DC motors are connected to a mass of 11g on the shaft of the motor. The attached weight are offset from the centroid of the shaft so the weight is unbalanced force to vibrate the system.

The function of the 4 DC motors with a specific position and direction of the rotation is to produce a high frequency and stable vertical oscillation. This is done by adjusting the direction of rotation of the motors to oppose each other as shown in Figure 7 to cancel the moments generated by the motors. The voltage of the DC motors are supplied by two power sources.

The slits are designed to allow the fibres to be well distributed among the slits to spread the fibres deposited.

The height of the part can be altered by adjusting the stand at the bottom of the part. This can be used to calibrate the height based on the length of the carbon fibre deposited and also to add layers of fibre deposited.

4.1.3 Conveyor belt

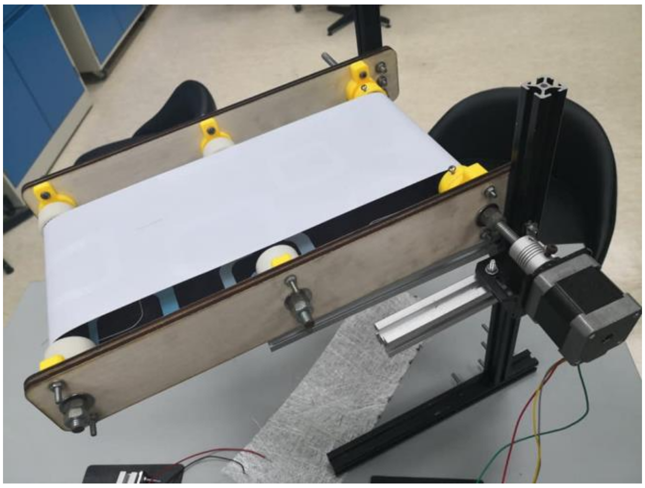


Figure 9: Conveyor belt.

The conveyor belt is powered by a Nema-17 Stepper Motor, which has one of its rollers connected to the motor shaft. A slider mechanism is attached at the base of the part which allows the part to slide back and forth to ease the distribution fibre on the conveyor belt.

The belt is tested using 3 types of materials and the pros and cons between the materials are compared.

Materials tested for conveyor belt	Advantages	Disadvantages
Rubber sheet	• Thick and dampens vibration from the device. • High friction and holds the fibres in place.	• Hardens over time and causes bumps on the sheet.
Plastic sheet	• Cheap and easy to be obtained. • Does not generate electrostatic force when in contact with fibre.	• Thin and causes minor vibration on belt.
Nylon sheet	• Cheap and easily obtained.	• Generates an electrostatic force when in contact with fibre.

Table 2: Comparison between types of materials used as conveyor belt.

From the comparison, plastic sheet is best to be used as the conveyor belt. The vibration does not displace the fibres unnecessarily. However, the durability of the material over a long period of time has not been tested.

4.1.4 Fibre distribution mechanism

Figure 10: Fibre distribution mechanism.

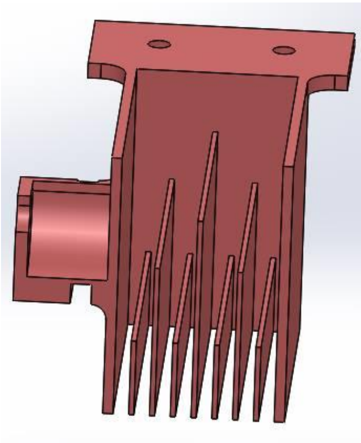


Figure 11: Cross-sectional view of the fibre distribution mechanism slits. Length of slit opening is 3mm.

Fibres are dropped into the vibrating slit. Then, the slit of the mechanism is vibrated using a R300C DC motor to distribute and align the fibres on the conveyor belt in a horizontal position. The DC motor is run at 8.6V.

4.15 Fibre alignment operation and methodology

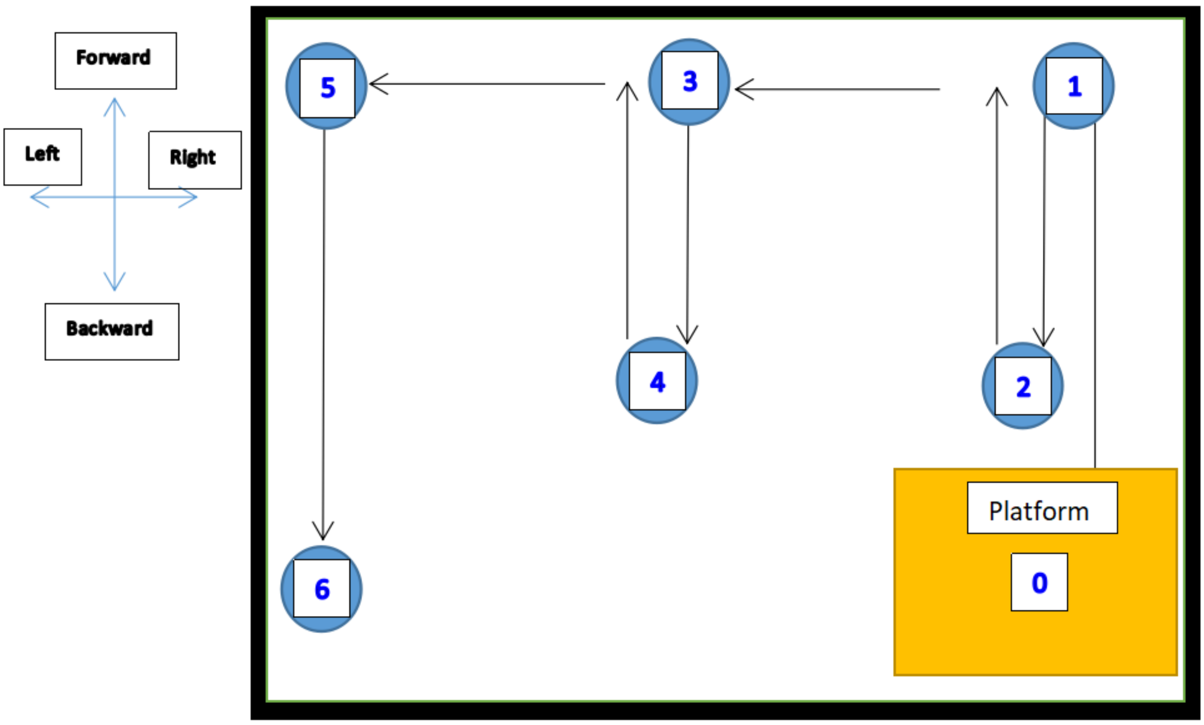


Figure 12: Path and directions taken by the deposition platform for deposition process.

1. Reset button is pressed and platform moves to the origin at position 0.
2. A metal plate of 30cm × 30cm is placed in the middle of the platform.

3. Fibres are aligned on the conveyor belt by moving the conveyor belt on a slider and also by pressing button S1. The fibres are distributed in a horizontal orientation in an area of 270mm × 90mm.
4. Button S2 is pressed and the platform will move in an order as shown in Figure 11 every time the S2 is pressed.
5. The fibres are filled up every time at position 1, 3 and 5 as referred from the picture.
6. Fibres are deposited on the deposition platform when the platform moves from position 1 to 2, position 3 to 4 and position 5 to 6. During the process, both the conveyor belt and platform will move simultaneously.
6. At position 6, the process is completed and the plate is ready to be taken and removed.
7. A picture of the top view of the deposited fibres is taken, and the picture is imported to Solidworks 2018.
8. Lines for the fibres are sketched in Solidworks 2018 and the sketch is exported to an Excel file to be further analysed.

4.2 ELECTRONIC COMPONENTS CONFIGURATION

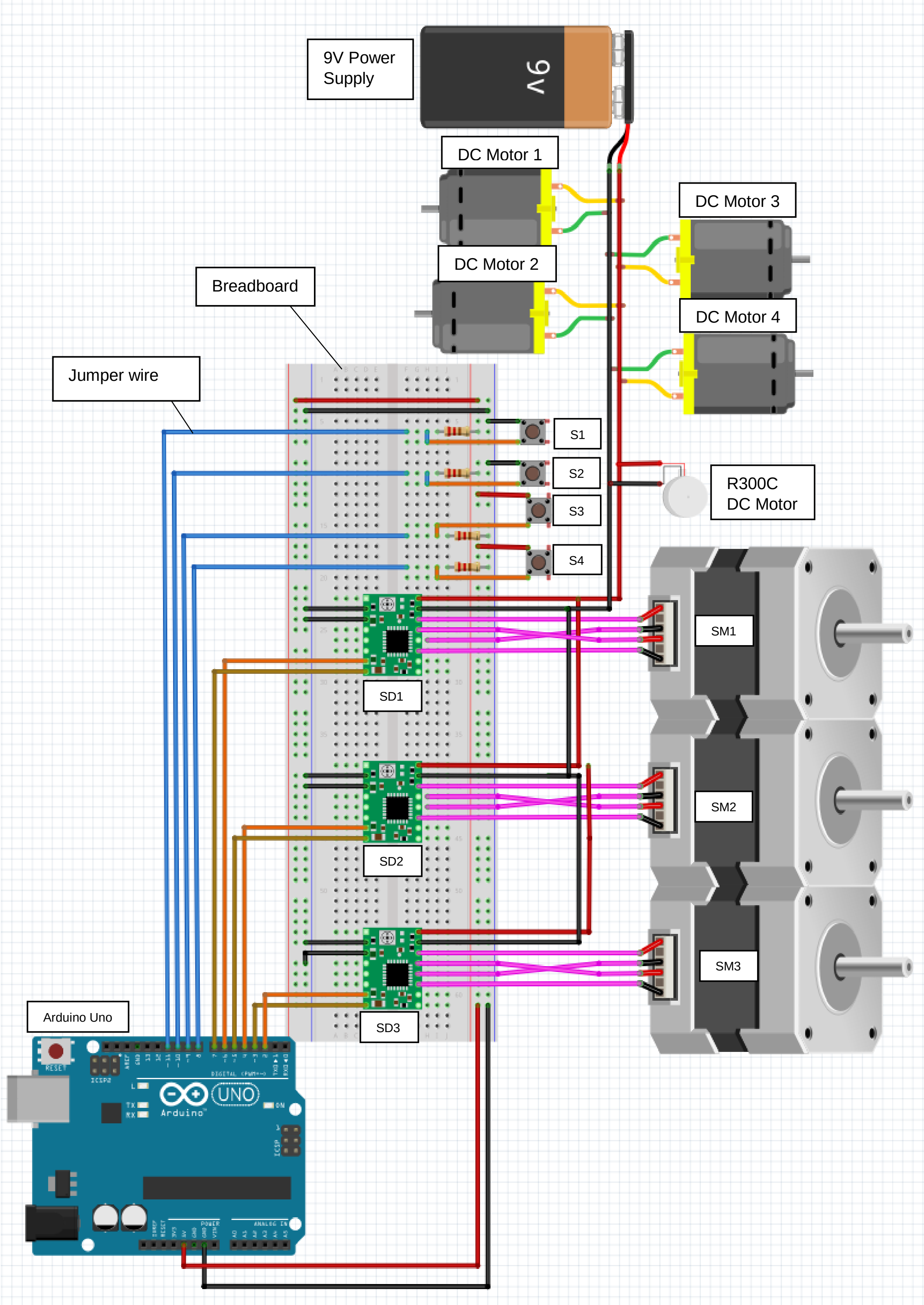


Figure 13: SVSA Device electronics circuit schematic drawing using Fritzing.

Legend	Component
S[number]	Limit Switch
SM[number]	Nema-17 Stepper Motor
DC Motor[number]	238-9737 RS Pro DC Motor
SD[number]	TMC2100 Stepper Motor Driver

Table 3: Electronics components and their legends according to Figure 11.

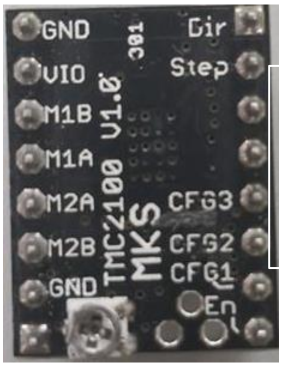
<table>
<tr><th>No.</th><th>Component</th><th>Description</th></tr>
<tr><td>1</td><td>Arduino Uno</td><td>Microcontroller to programme and actuate the machine.
USB port is connected to a laptop.</td></tr>
<tr><td>2</td><td>SD 1, 2, 3</td><td>


Figure 14: Top view of the TMC2100 Stepper Motor Driver.
GND : Connect to ground.
VIO : Connect to 5V.
M1B, M1A, M2A, M2B : Connect to Stepper Motor.
Dir : For stepper motor direction, connect to Arduino Uno Digital pin.
Step: For stepper motor stepping, connect to Arduino Uno Digital pin.
CFG1 & CFG2: Connect to ground to microstep the steps to 1/32.</td></tr>
<tr><td>4</td><td>SM1</td><td>Connected to the stepper motor holder on the conveyor belt.</td></tr>
<tr><td>5</td><td>SM2</td><td>Connected to the right stepper motor holder on the fibre deposition platform.</td></tr>
<tr><td>6</td><td>SM3</td><td>Connected to the left stepper motor holder on the fibre deposition platform.</td></tr>
<tr><td>7</td><td>S1</td><td>To run conveyor belt to fill the belt with fibre.
NC connected to Arduino Uno Digital Pin.
COM connected to ground.</td></tr>
<tr><td>8</td><td>S2</td><td>To run deposition platform and conveyor belt to align fibre on the platform.
NC connected to Arduino Uno Digital Pin.
COM connected to ground.</td></tr>
</table>

9	S3	To align initial position of the platform vertically. NO connected to Arduino Uno Digital Pin. COM connected to ground.
10	S4	To align initial position of the platform horizontally. NO connected to Arduino Uno Digital Pin. COM connected to ground.
11	DC Motor 1, 2, 3, 4	To generate vibration for fibre aligning vibration mechanism. Connected to power supply.
12	R300C DC Motor	To generate vibration for fibre distribution mechanism. Connected to power supply.
13	Jumper wire	Wires of different colours to connect between components.
14	Breadboard	Base to develop the electronic circuit.

Table 4: Description on electronic components in Figure 11.

4.2 TEST RESULTS

For all of the tests, the DC motor for the fibre distribution mechanism is set to 8.6V. As for the fibre aligning vibration mechanism, a range of voltage supplied is obtained via a few trials. The suitable voltage from both power source which provided a stable vibration for the vibrating mechanism is around 4.50V – 4.80V. In most of the tests, 4.80V and 4.60V are used.

Two different ratio of mass of carbon fibres are used in the deposition process, which are m_1, 180g/m^2 and m_2, 360g/m^2 of carbon fibres are used in the deposition process. Since the total area for deposition is 0.0675m^2, the total mass of fibres used are $m_{1,total}$, 12.09g and $m_{2,total}$, 24.18 g.

The factors affecting the success rate of the alignment are speed of deposition platform and conveyor belt, position and distance moved by deposition platform, height of the fibre aligning vibration part and size of slit used. Since the size of slit is fixed, the other factors are calibrated to optimize the performance of the machine. The values for position, speed and distance covered are given variable names as in the Arduino code and does not use a generic measuring system.

In the final results, speed and position and distance travelled by the deposition platform are fixed. However, the height of the slit to ground level, *h* is varied according to the fibre length.

Length of fibre (mm)	Height between slits and ground level, *h* (mm)
12	12.5
18	14.5
24	16.5

Table 5: Length of fibre deposited corresponding with the height between slits and ground level

From the results, *h* increases when length of fibre used increases. The increase *h* is necessary to allow space for the fibres to rotate itself when it falls vertically on the deposition platform, even though the increased *h* might cause slight misalignment of the fibre.

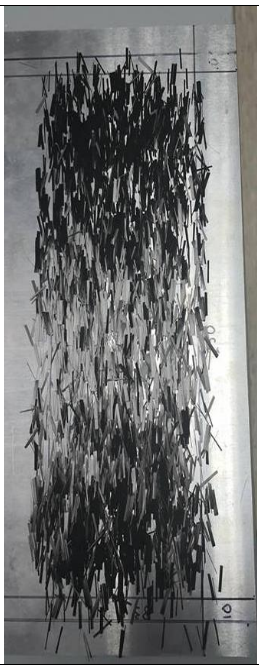
Fibre length	12mm	18mm	24mm
Deposition result			

Table 6 Result of fibre deposition using various fibre length.