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Enhancement of Mobile Scissor Lifting System for Windy Environments

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Abstract

This paper focuses on the enhancement of mobile scissor lifting system for windy environments. This study was necessitated in order to address the lack of support arm problem on the mobile scissor lifting system for the strong wind environment such as Minna in Niger State Nigeria. The outstation broadcasting operations in Minna metropolis are usually challenging during windy days as wind often affects the stability and efficiency of the outstation broadcasting platforms. This research employs electronic control circuit to control mechanical hydraulic actuated scissor lifting system in response to variations in wind speed. The mechanical components were designed using solidworks software. The control unit was remodeled using Proteus 8.0 software with the code written in Arduino integrated development environment (IDE). The model simulation results for both electronic and mechanical system reveal the possibility of achieving system stability with the resultant signal fidelity in outstation telecommunication broadcast within windy areas. The experiment result shows that the system was capable of lifting the telecommunication platform 2 meters high within 20 seconds considering the load range of 500 to 1000 kg. An overload alert mechanism was incorporated to signal the operators of excessive loading. Then, the system automatically deploys its support arms to counter the attendant consequences of the strong wind thereby restoring the stability of the mobile scissor lift. Therefore, the authors conclude that the enhanced mobile scissor lifting system would be deployed in the windy environment for the maximum attainment of stability objectives while physical model from this design should be subsequently fabricated in the near future.

Keywords: mobile Scissors lift, enhanced model, telecommunication applications, outstation broadcasting, windy environment, stability

1. INTRODUCTION

Mobile scissor lifts are mechanical helical lifting system used as vertical load conveying equipment. This mechanical device aids in raising several equipment up depending on the applications which includes high rise building construction work, super-high-tension electrical installation works and telecommunications works.

The practice of outstation broadcasting over the years has been successful with the use of the several mobile scissor lifting approaches (Pneumatic, Rough Terrain, Electric, Diesel and Hydraulic) for its operations. These operations include carrying of the broadcasting antennas, cameras and Satellite dishes, etc. as in the case of Minna metropolitan city in Niger State is known for its strong wind which poses several challenges to physical

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structures such as broadcasting platforms and the likes. One of the widely used mobile scissor lifting approaches is the electric mobile scissor lifting system. This is electrically driven whereas some are driven by fluid, air and others.

In telecommunication engineering, items of equipment are transferred from the ground level to a certain height for different purposes. Task undertaken by the mobile scissor lifting system depends on the designed maximum load, height and minimum efforts [1–3]. Telecommunication outstation broadcasting operations in a windy environment like Minna Metropolis with mobile scissor lifting system requires a stability-enhanced platform under load condition. When the mobile scissor lifting system is above the ground to a certain height, the centre of gravity seems to shift from its original position introducing a little instability which can be translated to imbalances when strong wind blows [4].

Figure 1 demonstrates the effect of wind on mobile scissor lifting system. This model proposes an enhanced stability support for telecommunication outstation broadcasting operations in Minna Metropolis.

Figure 1: Effect of wind on mobile Scissor lifting system [5].

This is expected to serve as a strong wind suction device which is aimed at enhancing stability for its outstation broadcasting equipments and services.

In view of the above therefore, these could be replicated elsewhere for similiar wind conditions. Chaturvedi [6] analyses and validates that dynamic and static mobile lift stability are some of the basic requrirements for maintenance work using platform lifting system. This model proposes multi-facet Aerial Lift in order to prevent mobile scissor lift collapse as a result of strong wind effect.

Telecommunication outstation broadcasting podium in Minna Metropolis may witness a setback due to the windy nature of the environment. The high level of instability witnessed by the outstation broadcasting platforms resulting from heavy rainfall with strong wind and large wind storm during windy days often affects the telecommunication signal quality. The windy characteristics of Minna metroplitan city necesitates the improvement of existing mobile lifting system by incoprating intelligent load detection and balance maintenance capabilities through an alternative support. The prime task in this work is to develop an improved intelligent mobile scissor lifting system for outstation telecommunication broadcasting applications in respect of Minna metropolitan city. The specific tasks are to:1.design an electrical remotely controlled microcontroller-based mobile scissor lifting system for outstation broadcasting applications,2.design a mobile and wind tolerable scissor lifting system, 3.design an overload alert mechanism for system safe load lifting and 4.to carry out simulation analysis of the system model.

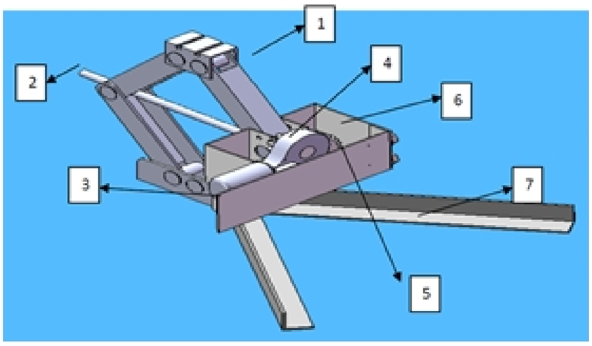
Advancements in technology have continued to play vital roles in improving the safety and efficiency of the mobile lifting equipment. Manual scissor lifting system which was developed for miniature car lifting operation was further enhanced to provide an automated system to undertake the same task.

The prototype was developed for field application for emergency conditions such as tyre replacement on the road [7].

Figure 2 shows a car lifting jack system which deploys the mechanism of mobile scissor lifting to raise vehicle up for maintenance work [8–10].

Mechanical system used in lifting heavy loads with greater amount of applied forces is known as Jack lift. This system deploys a square thread technique for its lifting operation because heavy equipment are involved and their system uses battery [11]. Senthil [12] developed an automated mobile scissor lifting system for the purpose of cleaning ceiling fan with Atmega microcontroller. Dileepan [3] reviews mobile scissor lifting system and confirms that the mobile scissor lift is purposely defined, and proposed a motorized lifting system for human convenience. The design uses PIC16F877 microcontroller for automobile workshop lifting services with load easy lifting capability. Dengiz [2] developed mobile scissor lifting system for industrial purpose with finite element approach, this design supports services such as cleaning, repairs and maintenance within 500kg load capacity and 2m working height. The model was designed with soildWorks design software and the structural investigation was also carried out for its safety, stress and deflection. The system was demonstrated under load and no loads conditions. Rana [13] further worked on advanced technological approach to scissor lifting system which led to the development of an integrated motorized automated jack system with four wheels for mobile services.

Refs. [14–16] developed a work-podium for aerial services with cross support pattern and



(a)

(b)

Figure 2: Simple Automated Car Jack lifting system [8].

two hydraulic cylinders without wind tolerance device. Yimer [17] designed and implemented a movable dual mobile scissor lifting system for industrial usage with the load limit of 280kg and 1m height, the functionality was validated with the following weight ranges : 102, 153, 204, and 272kg at every stage of the demonstration , the design was made to attain the height of 1m without failure sign. Bao [18] studied a hydraulic lifting system with technology that enables load weight detection and control. Similarly, [19, 20] evaluated the mobile scissor lift stability using AMESim, ADAMS and LifeMOD model and the fall at rest systems were used to illustrate the system effectiveness considering the operators risk. Thorat [21] developed a hydraulic scissor lifting system with selected mild steel with the design load limit ranges of 3000kg to 4000kg load capacity with the height of 2.1336m. Tian [22] developed a scissor lifting system model with 3D software Pro/E , the simulated design was 8m high and platform was 1.8m by 0.9m wide for indoor and outdoor applications. In another development, [23, 24] used ASTM A36 steel to fabricate single stage scissor lifting system and the platform dimension was 0.508m by 0.813m, the design height was 0.811m above the ground, the electrically-driven design was optimized, the test results validate that it was mobile, rigid, stable, versatile and safe for both indoor and outdoor operations. The work considered a load limit of 500kg for a safe operation. Shrivastava [25] proposed an embedded scissor lifting system with current control device, signal conditioning criteria was formulated to validate the design functionality. The reliability assessment of the system was carried out with the MPU6050 software. In the work of Shi [26], three degree of freedom system hydraulic scissor lifting device was developed with artificial agent actuation for vehicle maintenance work. Also, one degree of freedom scissor lift was proposed and the design was developed to transport only the load without human. The system was modeled using 20 sim commercial software package. Gonzalez [27] proposed novel six degree of freedom system robots for scissor lifting operations. This work proposed an intelligent mobile scissor lifting model for telecommunication outstation broadcasting operations in windy environments like Minna Metropolis.

2. DESIGN METHODOLOGY

Materials and methods for the enhancement of the intelligent mobile scissor lifting model are as presented.

2.1. *Materials/Resources*

Scissor lift: Mild Steel Blade, Screws, Nuts and bolts; Actuator: Hydraulic type; Transformer: Stepdown Transformer with 220V to 12V, 4A; AC Motor: Servomotor type; Motor Driver: L293D, Microcontroller: ATMEGA328P; Voltage Regulator: LM 7805 and LM 7812; Diodes: Light emitting diode, bridge diode and crystal diode (IN4001); Resistors: Fixed type; 20Ω, 1kΩ, 10kΩ and variable 10kΩ; Capacitors: 100μF and 1000μF; Switch: Mechanical switch, transistors and relay ; Liquid crystal display: 16 by 16, Ultrasonic sensor: HS SR04; Arduino development board and Keypad.

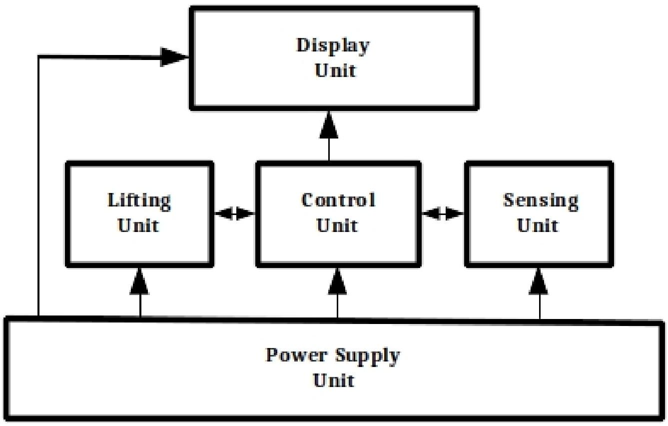


Figure 3: The block representation of the intelligent mobile scissor lifting model.

2.2. *Methods*

2.2.1. *The system architecture*

Figure 3 shows the block diagram for the enhanced intelligent mobile scissor lifting system. The system is divided into six units: power supply unit which provides power to the motor and the

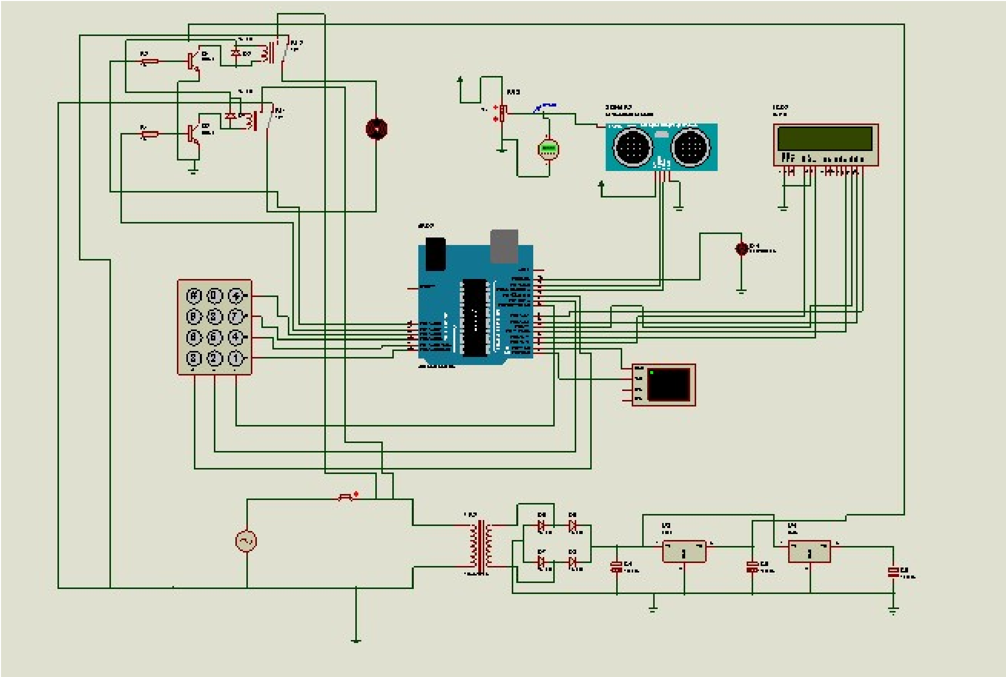


Figure 4: The electronic circuit for the intelligent mobile scissor lifting system .

electronic circuitries; the lifting unit aids in moving the system up or down; the control unit regulates the overall operation of the system, sensing unit aids in the deployment of the support to the mobile scissor mechanism when activated by strong wind and the display unit gives information on the status of the system.

2.2.2. The system design

The intelligent mobile scissor lifting system is made up of an automated system which oversees the electronic and electrical control. Then, a mechanical system is incorporated with hydraulic systems which uses the hydraulic actuators for its control actions.

2.2.3. Electronic system design

Figure 4 shows the electronic circuit configuration for the intelligent mobile scissor lifting model, where the microcontroller is programmed to intelligently manage the stability of the mobile scissor lifting system. The feedback system enables it to detect and react appropriately to varying wind conditions for stability maintenance as depicted in the flow chart of Fig. 5. Whenever the system experiences fluctuation in the signal which is caused by the wind storm, the control initiates support deployment to keep the system stable.

Figure 5 shows the procedural flow chart of the improved intelligent Mobile scissor lifting system, the system is initailized and it begins to scan the stability status of the load. This is one of the major contributions of this work.

Nonetheless, on an account of any instability due to wind force, the system deploys its support arms to stabilize the load. Instability results in the loss of signal due to the wind storm. When stability is established again, the system continues its normal operation as the code is provided in Appendix A.

2.2.4. Mechanical system design

The main concept behind the mechanical component of the design is the wind support system incorporated in the scissors arms of the lift to serve as auxiliary and emergency support system. The system is designed to be driven on four tires, which must be deactivated to allow the system rest on a rigid frame during lifting operations. The wind support system is made of four actuator arms that are to be actuated by a sensor linked to the control system, which deploys the wind support arm whenever it senses instability and excessive vibration. The emergency support arms are linked to the overload monitoring device which sends overload signals to an operator and deploys the emergency support arms and actuators to support the entire weight of the system.

Figure 6a shows a side view of the system on full collapse mode, while Fig. 6b depicts the full lifting of the auxiliary lift which is designed to carry personnel and loads up to the platform height.

Fig. 7a shows the front view of the designed model at full lift height while Fig. 7b shows the side view on full lift. Figure 8a and 8b shows the projected view and the plan view of the device, respectively.

Figure 9 shows the designed model on full lift with the emergency support arms fully deployed, while Fig. 10 depicts the full deployment of the wind support arms at full lift. Figure 11 shows the part numbering of the designed model. The part names are presented on Table 1.

Table 1: Part Names

Item number	Part Name	Qty.
1	Base Frame 1	1
2	Base Frame 2	1
3	Hydraulic Actuator 1	4
4	Hydraulic Actuator 2	4
5	Scissors Link Arm 1	2
6	Scissors Link Arm 2	6
7	Scissors Link Arm 3	4
8	Scissors Link Arm Brace 1	2
9	Scissors Link Arm Brace 2	2
10	Scissors Link Arm Brace 3	6
11	Scissors Link Arm Brace 4	6
12	Wind Support Actuator 2	4
13	Wind Support Actuator 3	4
14	Wind Support Actuator 4	8
15	Tyre actuator	4
16	Tyre	4
17	Drive Nut	1
18	Drive Screw	1
19	Drive Nut Hinge	1
20	Top Frame 1	1
21	Top Rail Shaft	2
22	Top Frame 2	1
23	Tyre Shaft	4
24	Door	1
25	Link Joint Pivot	6
26	Electric Motor	1
27	Gear Box	1
28	Hydraulic System Circuit	1
29	E Support Arm	4
30	E Support Actuator	2
31	E Support Actuator 2	2
32	Hinge roller	4
33	Stud	4
34	Frame Bolt	32
35	Barrel cover	2
36	Auxiliary lift actuator 3	1
37	Auxiliary lift actuator 3	1
38	Auxiliary lift actuator 3	1
39	Circuit Box	1

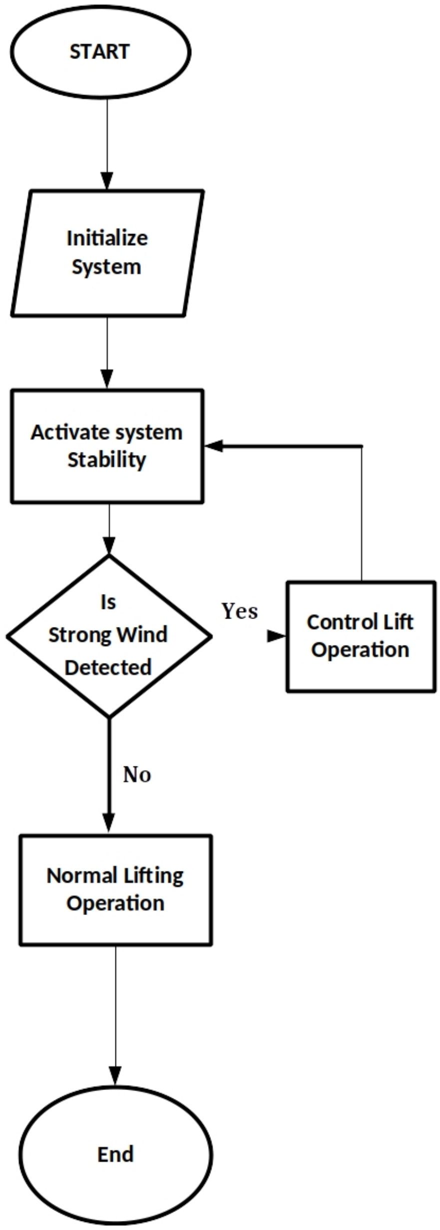


Figure 5: Flow chart for the the enhanced intelligent mobile scissor lifting system.

3. RESULTS AND DISCUSSION

3.1. Electronic System Result

The microcontroller-based system improved intelligent mobile scissor lifting system for telecommunication outstation broadcasting operations in windy environments like Minna metropolis was realized. Table 2 shows resistance-voltage relationship for distance determination.

3.1.1. Simulation results

In this simulation demonstrated, an ultrasonic sensor was connected to the micro controller and the virtual terminal was also connected to give simulation results. The test pin was connected to a variable resistor of 10KΩ such that the voltage-resistance relationship determines the distance covered by the sensor.

The collapsible scissor lifting system on arrival at an event center is positioned, and the # button when pressed lits the light emitting diode to indicate that the system is ON.

Figure 12 shows that the measured distance is proportional to the voltage, this means that as the voltage increases, the distance also increases.

Figure 13 shows that the Resistance is proportional to the measured distance, this means that the resistance increases with increase in distance.

Figure 14 shows that the varying resistance is proportional to its corresponding voltage, this means that the voltage increases with the increase in resistance. But when the variable resistance adjustment is toggled up and down at certain speed, the system with its embedded code activates the wind support arm in Pin A1 and A3 while the LED lit indicator shows the system operational status.

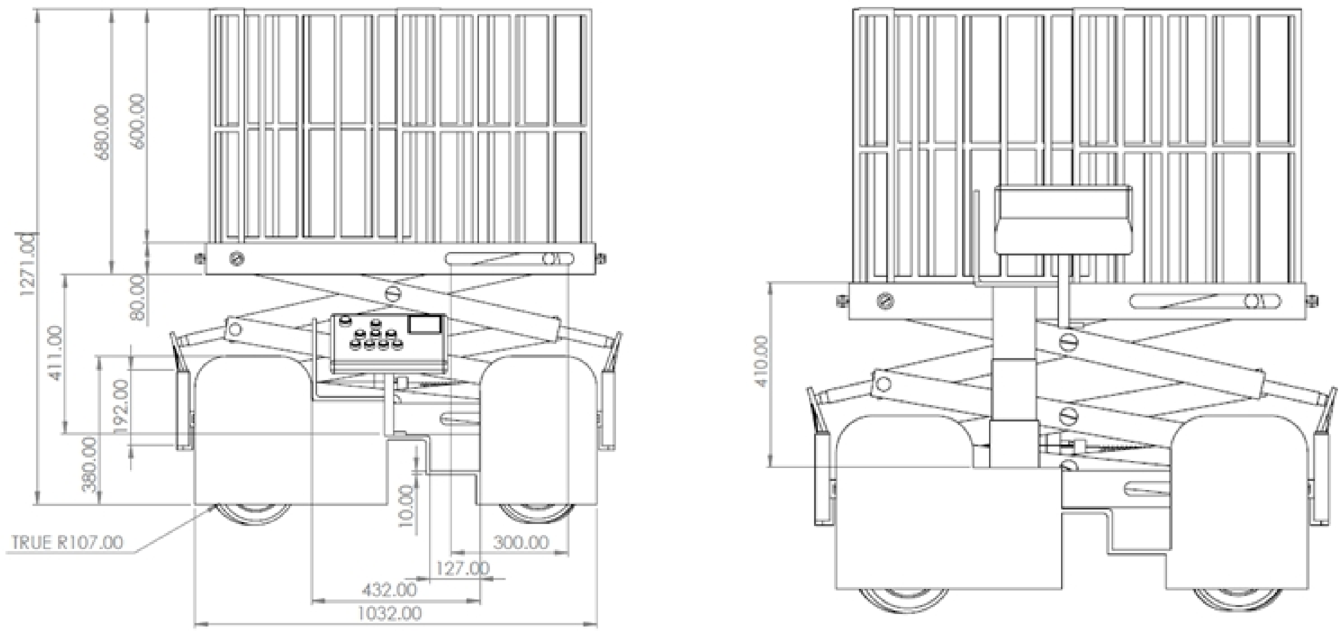


Figure 6: Front and side elevation of the improved intelligent mobile scissor lifting system on full collapse mode.

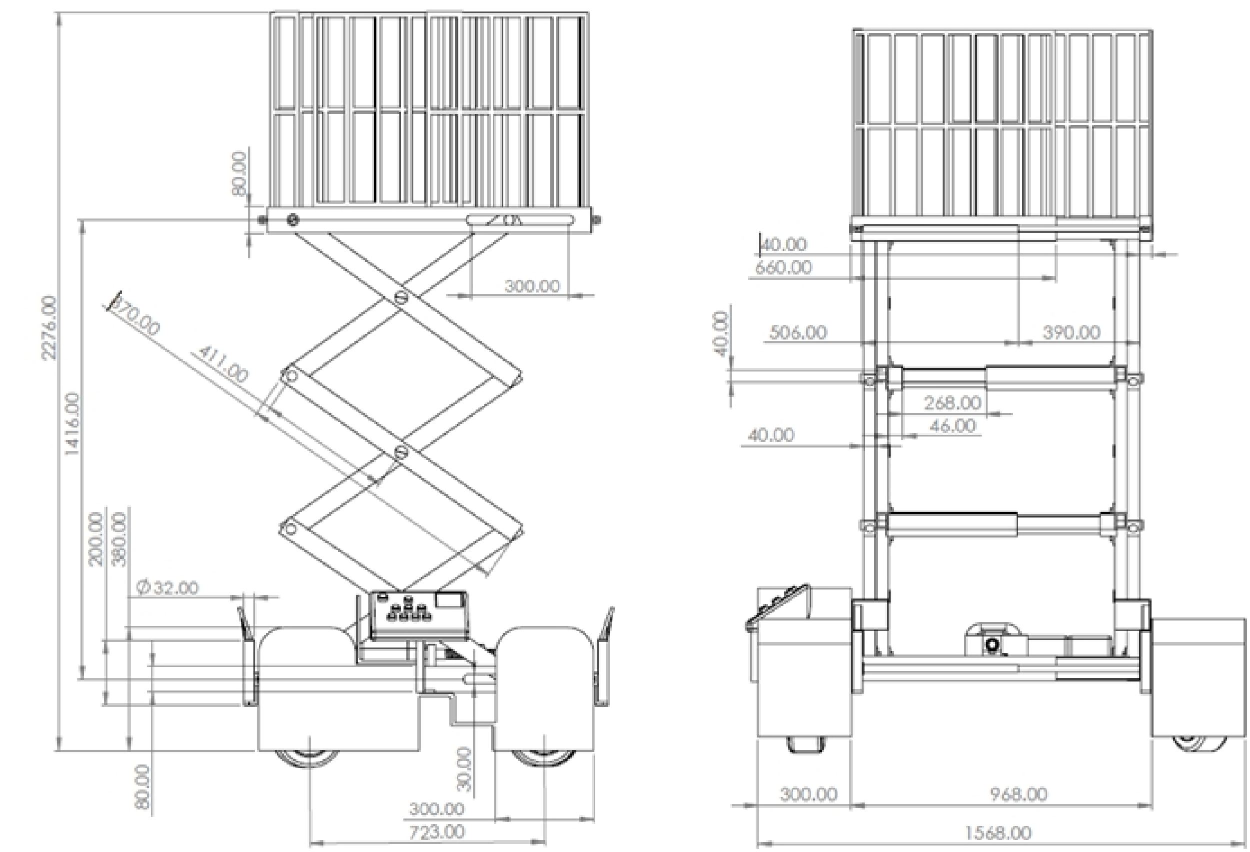
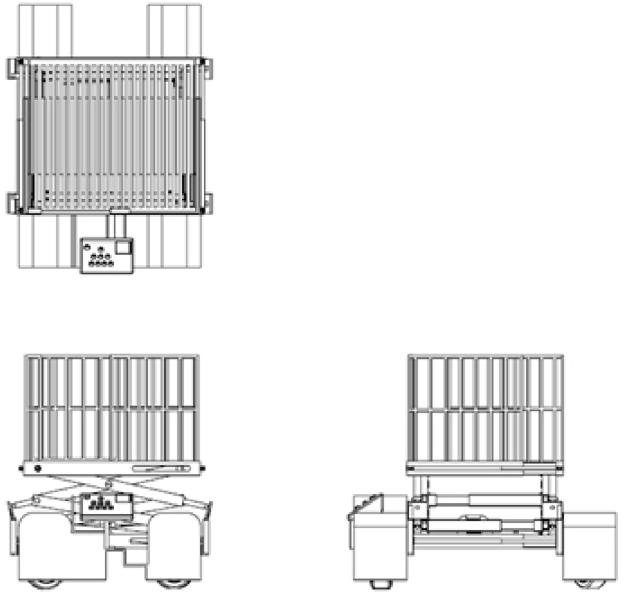


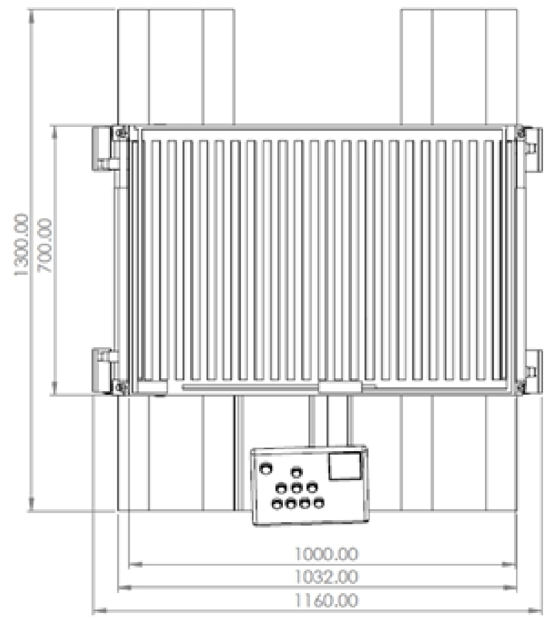
Figure 7: Front and side elevation of the improved intelligent mobile scissor lifting system on full lift mode.

Table 2: The resistance-voltage relationship for distance determination.

Resistance (Ω)	0	10	20	30	40	50	60	70	80	90	100
Voltage (v)	0	0.5	1	1.5	2	2.5	3	3.5	4	4.5	5
Distance (cm)	4	111	224	336	448	560	673	789	897	1010	1122



(a)



(b)

Figure 8: Projected view of the improved intelligent mobile scissor lifting system in a full collapse mode.

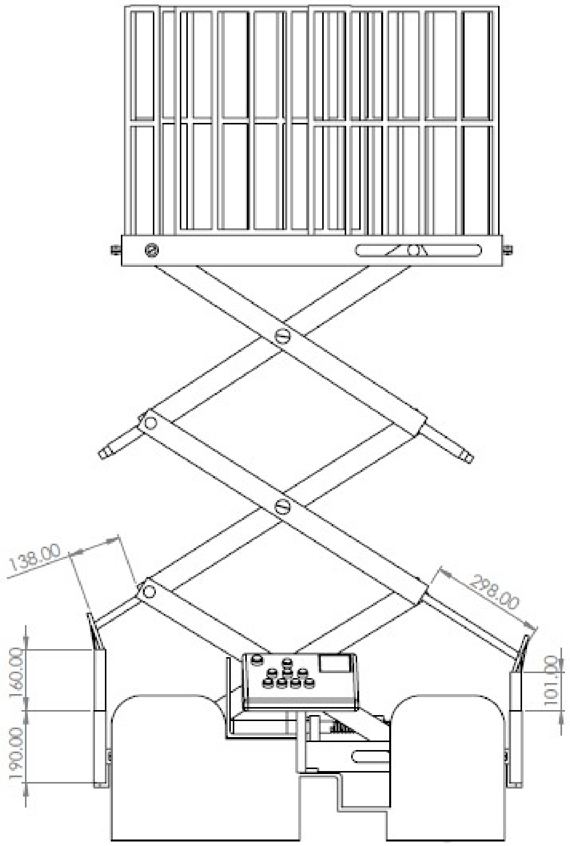


Figure 9: The full lift mode of the device on emergency support.

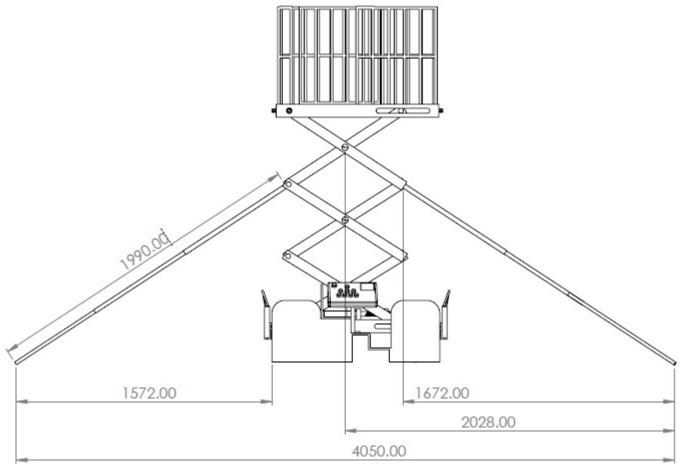


Figure 10: The full lift mode of the developed device with wind support arms deployed.

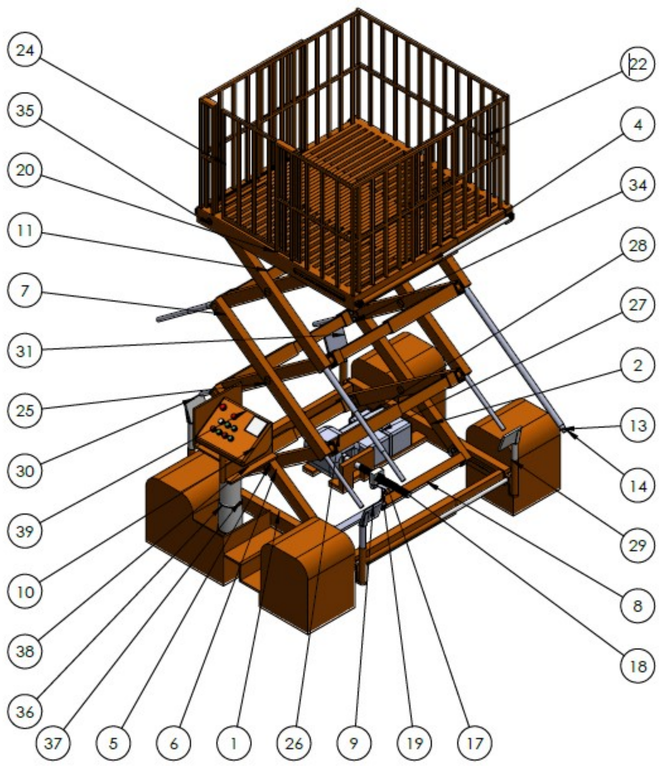


Figure 11: The part numbering of the designed scissor lifting model.

3.1.2. *Experiment results*

The model was demonstrated by placing the ultrasonic sensor in the mobile scissor lift at 2m (200cm) facing down with the normal wind or breeze scenario and the reading was taken at first instance, at second instance, the rushing wind scenario was created by varying the speed of the standing fan to blow the model and the reading was recorded using Pc Communication port from the Arduino IDE program platform. This demonstration is in line with the opinion of [28] which defined wind as a three-dimensional vector that can easily affect the signal transmitted by ultrasonic sensor. This formed the basis of the design concept of which the study is hinged.

With the experimented sample size of 20, the enhanced scissor lifting system on attaining its design height of 2m (200cm) with non-rushing wind distortion, recorded that the sensor reads exactly 2m(200cm) value within 38:18.0 through 38:23:0seconds.

Table 3 and Fig. 15 shows that within this considerable time, the system was stable with a constant height attainment of 200cm, this implies that there was no rushing or strong wind interference with the mobile scissor lifting system model as the height value remains unchanged throughout the experimented period.

In Table 4, with the experimented sample size of 20, the enhanced mobile scissor lifting system on attaining its design height of 2m (200cm) experiences non-rushing wind distortion and the recorded ultrasonic sensor reading was

Table 3: Data from the enhanced scissor lifting system without strong wind effect.

	Distance (CM)	**Time(sec)**
1	200	38:15.0
2	200	38:19.0
3	200	38:19.2
4	200	38:19.4
5	200	38:19.6
6	200	38:19.8
7	200	38:20.1
8	200	38:20.0
9	200	38:20.5
10	200	38:20.7
11	200	38:20.9
12	200	38:21.2
13	200	38:21.4
14	200	38:21.6
15	200	38:21.8
16	200	38:22.0
17	200	38:22.3
18	200	38:22.5
19	200	38:22.7
20	200	38:23.0

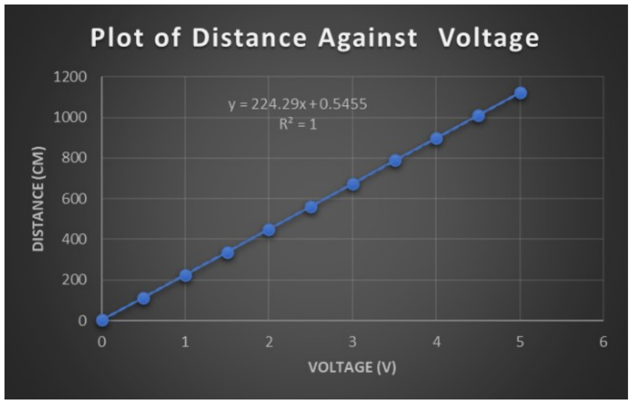


Figure 12: The simulation plot of the distance against voltage for the enhanced mobile scissor lifting system.

2m (200cm) within sample 1 to 5 and the time reading from 39:15.0 through 39:20:6 but the rushing wind distortion slightly distorted the signal between sample 6 to 9 giving the time lag of 39:20.8 through 39:21.5 with the height reducing to 155.844cm(1.55844m); more so, at sample 10 the height reads 129.871cm(1.29871m) corresponding to 39:21.7 seconds, whereas from sample 11 to 14 strong wind erupted and exceeded the design threshold which is 103.896cm (1.03896m) within the time 39:21.0 through 39:22.6 thereby activating the model to deploy the mobile scissor lifting support arms to cushion the effect of the strong wind for stability attainment.

Also, within sample 15 to 17, the rushing wind distortion was gradually restored to 181.1818 cm (1.811818 m) within 39:22.8 to 39:22.3 seconds. However, within the sample of 18 to 20, the wild rushing wind was not experienced again and the height was restored back to 200cm(2m) corresponding to 39:22.5 through 39:23.0 seconds.

Table 4 and Fig. 16 show that within this con-

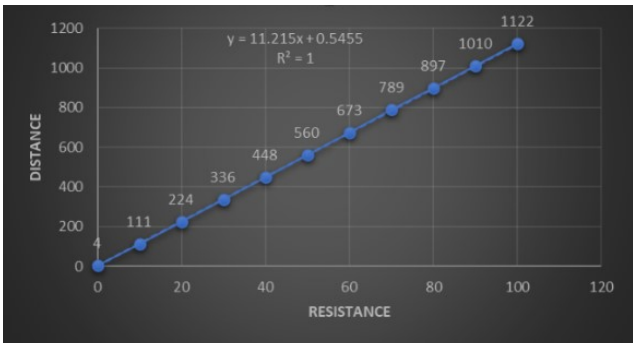


Figure 13: The simulation plot of distance against resistance for the enhanced mobile scissor lifting system.

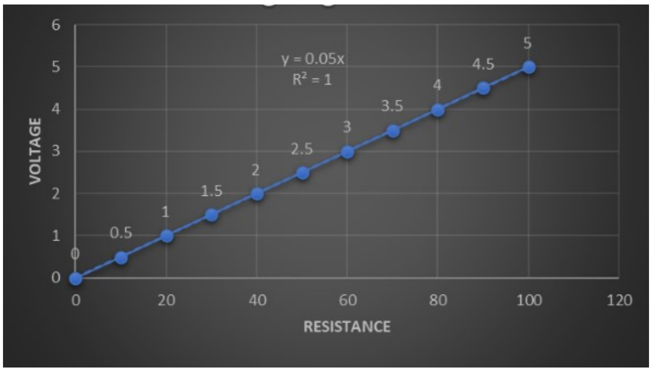


Figure 14: The simulation plot of distance against Resistance for the enhanced scissor lifting system.

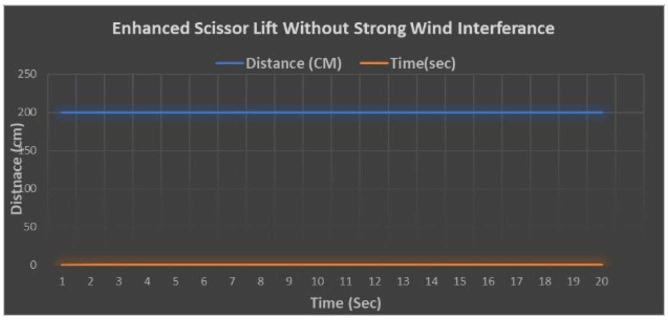


Figure 15: The plot of the distance against the time of the enhanced scissor lifting system without strong wind effect.

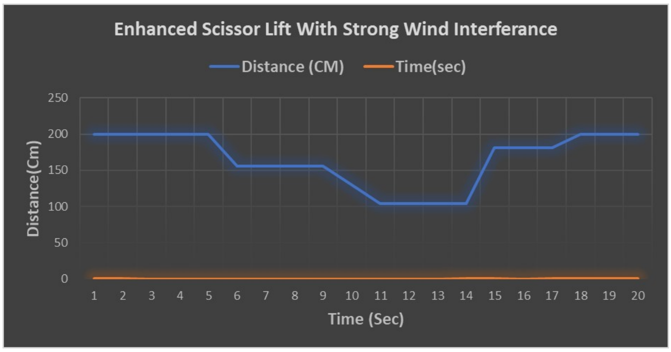


Figure 16: Results from the enhanced mobile scissor lifting system with strong wind effect.

sidered time, the system was stable with a constant height attainment of 200cm.

This reveals that there was neither rushing nor strong wind interference in the mobile scissor lifting system between sample 1 to 5, a slight instability was witnessed in the model functionality between sample 6 to 9 which reduced the height reading to 155.844cm but until the drop in the sensor value got to the threshold of about 100cm(1m) , the system automatically deploys the support arms to cushion the effect of strong wind for the designed broadcasting platform.

3.1.3. Manual operation

Table 5 shows the lift height at different positions during operation, but during smart operations when the button is pressed, the second time the lift begins to release and mount the accessory for operations. The height attended at a particular time is displayed on the liquid crystal display, this is as a result of the sensors corresponding feedback. When the motor rotates, the lift continues to move up or down depending on the control action.

If the load limit is exceeded, the LED light begins to blink thereby initiating an overriding action to bring down the platform but in the case of system instability as a result of strong wind, the system automatically releases more auxiliary stability sub-structures to balance the effect of the wind. This emergency support action is one of the outstanding aspects of this proposed design. At the end of the event, the operator then presses the * button to stop the operation while the system is automatically lowered and folded back.

3.2. Computer Aided Design Drawing for Improved Scissor Lifting System

Figure 17a shows the designed intelligent mobile scissor lifting system in full collapsed mode. This is when the system could be moved to service site either on its drive system or another vehicle.

Figure 18 depicts the designed model in its full lift height in service. At this point the system rests on its base frame while the tyres are deactuated with the aid of a hydraulic system.

Figure 19 depicts the side view of the device in full lift mode with the emergency support actuators fully deployed. An overload alert system was incorporated to signal the operators when the system is exceeding its bearing capacity limit while the system automatically deploys its support arms to stabilize the platform for safe operations.

Figure 20 depicts the isometric view of the designed model with the wind support actuators fully deployed. The wind support actuators are deployed intelligently after stability assessment by the control system is completed. It then, senses any imbalance above the design threshold caused by any destabilizing forces. This emergency support action is one of the outstanding aspects of this design which can as well be initiated by an operator using a remote device.

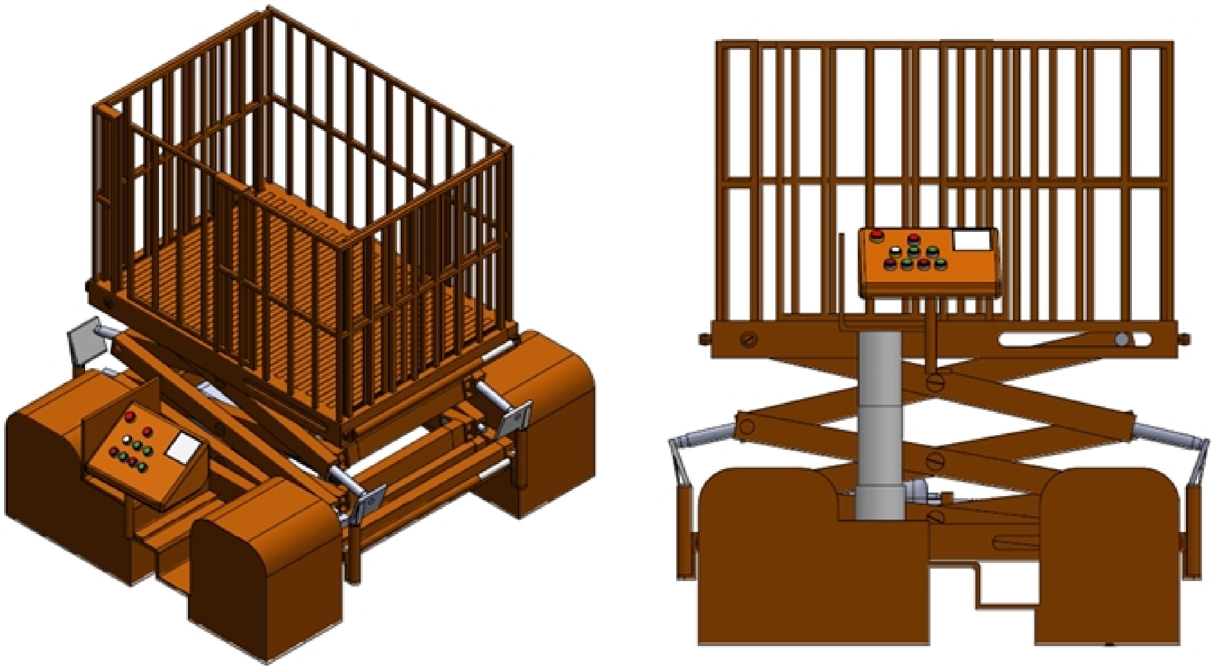


Figure 17: Isometric view of the designed intelligent mobile scissor lifting system in full collapsed mode.

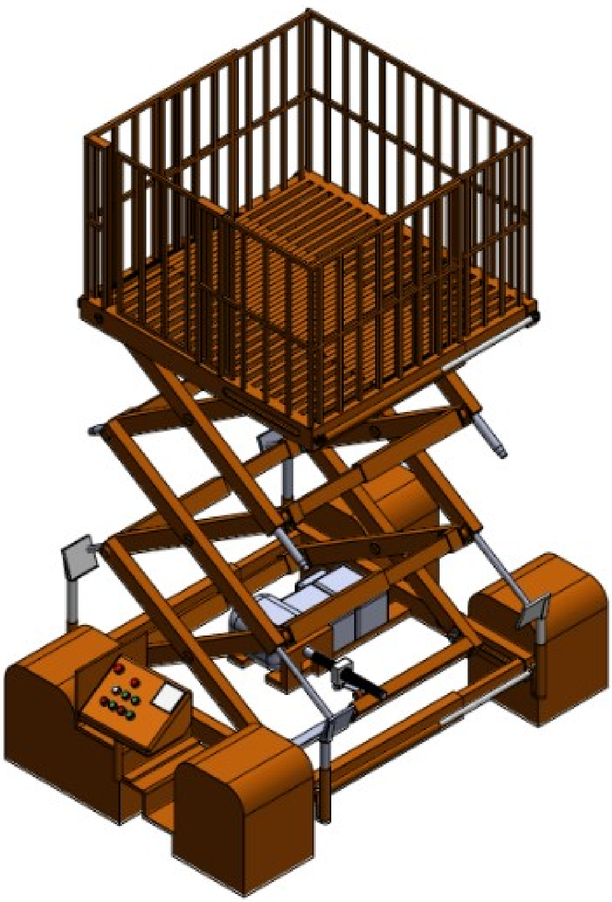


Figure 18: Isometric view of the designed enhanced intelligent mobile scissor lifting system in full lift position.

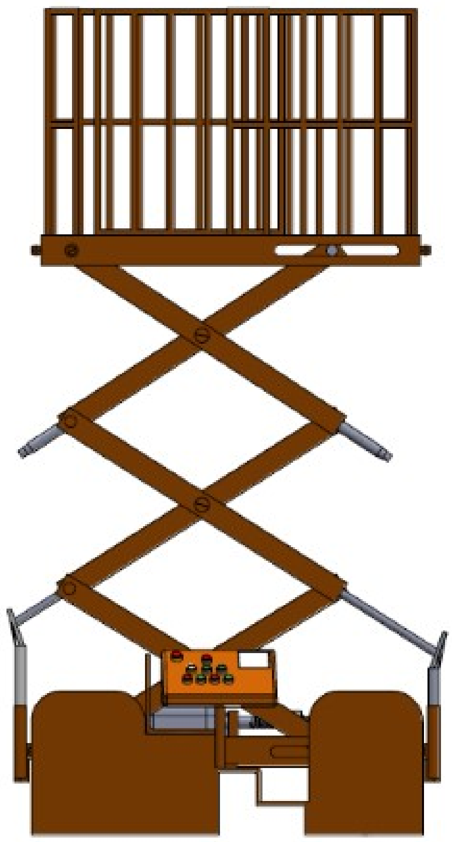


Figure 19: Side view of the designed improved intelligent mobile scissor lifting system.

Table 4: Data from the enhanced scissor lifting system with strong wind effect.

	Distance (CM)	Time(sec)
1	200	39:15.0
2	200	39:19.0
3	200	39:19.2
4	200	39:19.4
5	200	39:20.6
6	155.844	39:20.8
7	155.844	39:20.1
8	155.844	39:20.3
9	155.844	39:21.5
10	129.871	39:21.7
11	103.896	39:21.9
12	103.896	39:21.2
13	103.896	39:21.4
14	103.896	39:22.6
15	181.182	39:22.8
16	181.182	39:22.0
17	181.182	39:22.3
18	200	39:22.5
19	200	39:24.0
20	200	39:23.0

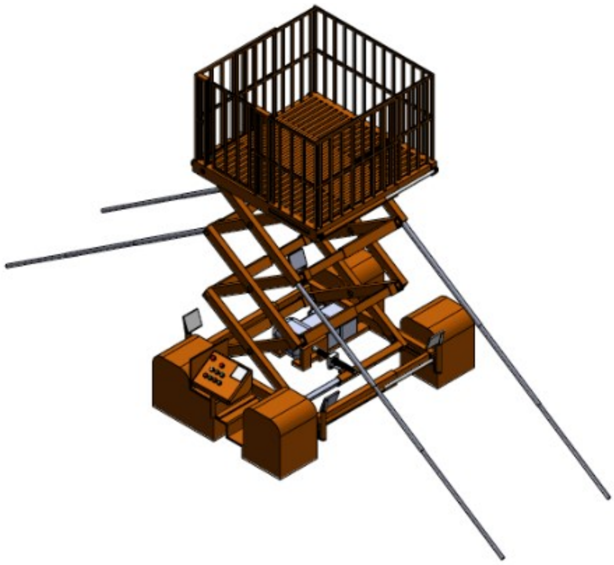


Figure 20: Isometric view of the designed enhanced intelligent mobile scissor lifting model on wind support system.

4. CONCLUSION

The designed intelligent mobile scissor lifting system for outstation telecommunication broadcasting applications within Minna metropolitan city was remodeled. The instability of broadcasting platforms arising from strong wind during outstation broadcasting operations in Minna metropolis could be curtailed thereby providing a stable and rigid outstation broadcasting platform for its operation. This designed intelligent scissor lifting system model mitigates the effects of excessive wind on mobile broadcasting platform using mechanical and electronic system model. The mechanical and hydraulic actuated scissor lifting system was developed using solidworks software, and the microcontroller-based electronic system was modeled using Proteus 8.0 software with its programme written in Arduino integrated development environment. The model simulation for both electronic and mechanical system reveals the possibility of managing outstation telecommunication broadcast within Minna metropolis with this intelligent, mobile and stability enhanced scissor lifting system prototype. The design was experimented and was capable of lifting the telecommunication platform up to the height of 2m at the speed of 20 seconds considering the load ranges from 500 to 1000kg. The overload alert system was incorporated to signal the operators when the system is exceeding its load limit while the system automatically folds its support arms and lowers the platform for safe operations. The transformation of this simulated model to physical system would be the next research work, hence the study concludes that the enhanced mobile scissor lifting system would be deployed in the windy environment for stability attainment.

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Table 5: Lifting position on manual operation.

Machine Interface key	0	1	2	3	4	5	6	7	8	9	10
Lift Height (m)	0.2	0.4	0.6	0.8	1	1.2	1.4	1.6	1.8	2	2.2

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Appendix A. Program Code for the enhanced scissor lifting System

```
#include <LiquidCrystal.h>
LiquidCrystallcd(2, 3, 4, 5, 6, 7);
const int trigPin = 12;
const int echoPin = 11;
void setup ()
{
Serial.begin(9600);
lcd.begin(16,2);
pinMode(trigPin, OUTPUT);
pinMode(echoPin, INPUT);
lcd.setCursor(0,0);
lcd.print("Distance");
Serial.print("Distance");
lcd.setCursor(0,1);
lcd.print("  Measurement  ");
Serial.print(" Measurement ");
delay(1000);
lcd.clear();
lcd.setCursor(0,0);
lcd.print("Jack: ");
delay(1000);
Serial.print("Jack:");
lcd.setCursor(0,0);
lcd.print("Improved Scissor Lift");
lcd.setCursor(0,1);
lcd.print("Scissor Enhanced Simulation Model");
Serial.print(" Jack Scissor Lift Result ");
delay(2000);
lcd.clear();
}
void loop ()
{
Int dis =digitalRead (11,12);
If (dis >=40) //deploy wind support arms
{
digitalWrite(A1,HIGH);
digitalWrite(A2,HIGH);
digitalWrite(13,HIGH);
}
Else if (dis< 40)//do not deploy wind support arms
{
long duration, inches, cm;
pinMode(trigPin, OUTPUT);
digitalWrite(trigPin, LOW);
delayMicroseconds(2);
digitalWrite(trigPin, HIGH);
delayMicroseconds(10);
digitalWrite(trigPin, LOW);
pinMode(echoPin, INPUT);
  duration = pulseIn(echoPin, HIGH);
  inches = microsecondsToInches(duration);
  cm = microsecondsToCentimeters(duration);
Serial.print("Distance:");
Serial.print(cm);
Serial.print("cm");
delay(100);
Serial.println();
lcd.setCursor(0,0);
lcd.print("");
delay(10);
lcd.setCursor(0,1);
lcd.print("Distance:");
lcd.print(cm);
lcd.print("cm");
delay(100);
}
long microsecondsToInches(long microseconds)
{
 return microseconds / 74 / 2;
}
long microsecondsToCentimeters(long microseconds)
{
  return microseconds / 29 / 2;
}
```