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# Design and Development of Automatic Scissor Type Car Jack

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**ABSTRACT**

Having an emergency, especially on the roadside, is not a pleasant experience for every driver. The most common problem that could happen to a car while driving is a tire puncture. When there is no car workshop nearby, the only way that a driver can do is to replace the punctured tyre with a spare tyre which is usually placed under the car's trunk. To replace a tyre, the car needs to be elevated until the tyre is not touching the ground. Hence, a car jack is the most important tool needed for this job. The main objective of this project is to design and develop an automatic scissor-type car jack that can operate automatically without requiring any strength from its user. A 12V DC Motor is used to rotate the power screw of the scissor jack. An automated system that uses sensors is developed so that the user no longer has to bend their body to find the jacking point under the car. The automated system also enables the scissor jack to automatically stop lifting the car when a certain height is reached. The design is constructed using Catia V5, and stress analysis has been done to determine the factor of the critical parts. Motor selection analysis is done to find the best motor suitable for this project. Fabrication of the prototype involves mechanical work such as welding, grinding, and soldering. The electric and electronic circuit is configured to enable the scissor jack's automation. The results of the testing have proven that the mechanism is able to operate as programmed.

***Keywords:***
Automatic scissor jack, motorized car jack, motor selection, Arduino, ultrasonic sensor, infrared sensor

## 1. Introduction

Changing a flat tyre is an unpleasant activity. There are currently a number of car jacks available for elevating vehicles off the ground. However, available car jacks are often manually operated, necessitating great physical effort on the part of the user [1]. These jacks are particularly inconvenient in adverse weather conditions and for the elderly and the physically disabled.

Therefore, the main objective of this project is to design and develop a fully automated scissor-type car jack that use a 12V DC motor powered by the internal car battery power connected through the car cigarette power socket. This is to ease the process of lifting the car without using force from the human. Other than that, the other objective is to equip the car jack with sensors powered by Arduino which can detect and give signal when the jacking point on the car has been gripped by the car jack and indicate that it is safe to be lifted up. The third objective is to automatically stop the car's lifting process when a certain amount of height is reached to prevent from over lifting which may

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cause motor failure. The working mechanism of the Automatic Scissor Jack is proven by the fabrication of a fully functional prototype.

During the fabrication phase of this project, cost, size, portability, and technical considerations are taken into account. Since the tools are loaded with multiple functions, a streamlined workflow is necessary to ensure that this project can be completed within the deadline.

## 2. Related Studies

Automatically operating a car jack is much more convenient than using human strength to operate the car jack during the lifting process. Therefore, automation and electrification of every type of car jack is being chased by a lot of manufacturers in the world as we speak

Noor *et al*. [2] have proposed developing the car jack for emergency use with internal cigarette lighter power (12volts). They have used gear ratio to increase the lifting power in order to ensure the power is adequate. The car jack design consists of original scissor jack, screw shaft, power window motor, pinion, gear, frame holder and stabilizer base. The screw will be the mechanism to adjust and hold the height level. The gearing system is used to increase the torque that is applied on the screw mechanism. Metal Inert Gas (MIG) Welding work is done to attach the motor to the gear system. In order to stabilize the scissor jack, the surface area of the support base is increased so that it will increase the stability.

Jayesh Vaghmashi *et al*. [3] proposed the modification of the current mechanical toggle jack to electric jack by incorporating an electric DC motor with the screw in order to make load lifting simple for emergency use of lifting a vehicle using power of car battery. Various fabrication techniques, such as milling for gear manufacturing, cutting plates for gear box, drilling in plates, and welding, are used to fabricate various components of the scissor jack. Connected to the 12V battery of the car, as a first step, the jack will be positioned under the car so that the top plate just clears the underside of the chassis. The clearance gap will be closed by turning the power screw until the upper section of the mount is flush with the car's chassis. When an automobile is contacted, its weight is transferred to the top plate, which then generates forces that are transmitted through the links and the sides. However, the main disadvantages with the design and mechanism proposed by Noor *et al*. and Jayesh *et al*. is that the operator still need to bend or lie down on the floor to check the contact between the car jacking point and the top mount of the car jack.

Gaikwad *et al*. [4] has proposes a novel design of the Reverse Parking Sensor for Electric Vehicles using an Arduino board and an ultrasonic distance sensor. These components together act as an ES that will assist the driver while parking by displaying Light Emitting Diodes (LEDs); thus, human involvement will be greatly reduced. While the car is reversing, the LED will light up when the ultrasonic sensor detects obstacles along its path and can accurately detect the obstacle's distance. This mechanism proposed by Gaikwad *et al*. is used as reference for this project where the ultrasonic sensor detects the car jack's height during the lifting process.

## 3. Methodology

This section explains the methodology of this project.

### *3.1 Engineering requirements*

In order to get the precise design requirements, a survey was undertaken to collect pertinent information from a group of individuals of varying ages and with varying viewpoints. The purpose of the survey question was to determine market awareness of the existing product and the significance of the product's existence in assisting car consumers. The design of a product must satisfy and meet customer requirements by establishing precise engineering standards and specifications. Customer requirements will be transformed into engineering specifications for the product design process. All engineering requirements are enumerated and presented in tabular format, together with technical parameters for the product's specifications. Table 1 displays the engineering requirement required for product design

**Table 1**
Engineering requirements specification

| Requirements | Details |
|---|---|
| **Automatic lifting** | - 12V DC motor (car wiper motor) is used to automatically rotates the screw jack which will elevate the car |
| **Power source** | - 12V car battery which is connected directly through the car cigarette socket |
| **Switch** | - Double Pole Double Throw (DPDT) switch as a two-way switch |
| **Sensors** | - Infrared sensor is used to detect when the jacking point of the car has enter the grip on top of the car jack<br>- Ultrasonic sensor is used to detect the height of the car from the ground during lifting |
| **Control system** | - Microcontroller (Arduino Uno) is being used to control the operation of the sensors |
| **Automatically stop the lifting** | - Single channel 5V relay module is used to stop the motor from rotating when ultrasonic sensor detects the maximum lifting height is reached |
| **Portable** | - Overall weight below 7kg<br>- Lighter weight for higher portability |

### *3.2 Motorized system*

The motor that is used for this project is a 12V DC Car Wiper Motor. The motor is powered by the internal car battery power connected through the car cigarette socket inside the car. The DPDT switch is used as the two-way circuit for the motor. It controls the rotation of the motor. Generally, DPDT has six terminals, whereas DC motor has two terminals. DPDT switch is used to make a two-way circuit in order to allow the motor to rotate clockwise and counter-clockwise.

Figure 1 shows the circuit diagram for the motorized system of the automatic scissor jack. The circuit diagram was constructed by using Circuit Diagram Web Editor. When the DPDT switch 'O' button is pressed, current will flow and enter the motor from the positive pole and exit from the negative pole. This will make the motor shaft rotate clockwise, thus lifting the car. However, when the DPDT switch '-' button is pressed, the current will flow and enter the motor from the negative pole and exit from the positive pole. This will trigger the motor to rotate its shaft to opposite direction which is counter clockwise and will lower the car. This explains the two way circuit by using the DPDT switch.

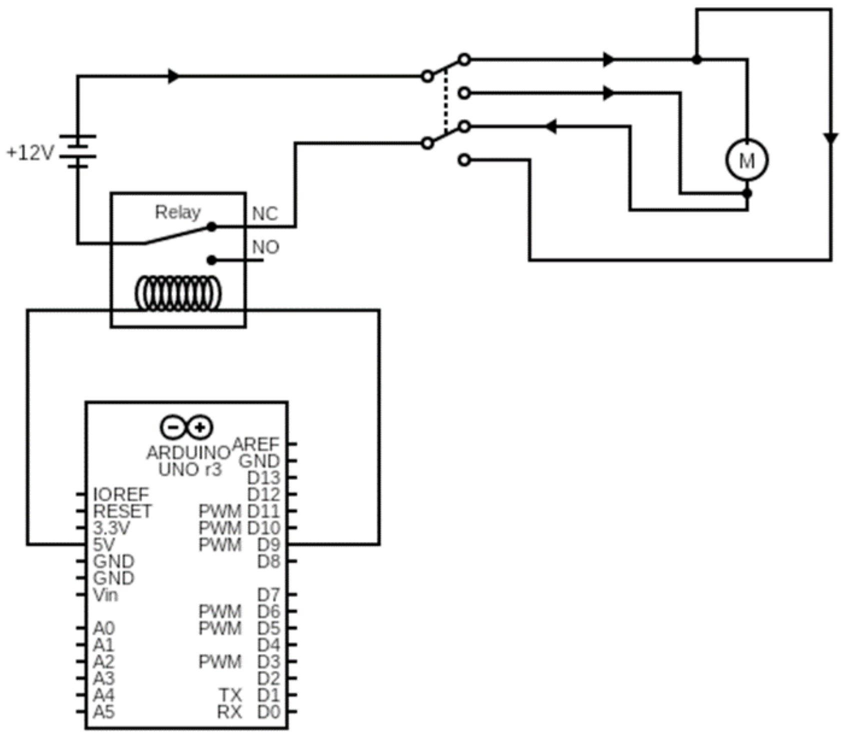


**Fig. 1.** Electrical system circuit diagram

Single Channel Relay Module 5VDC is used to break the circuit when the ultrasonic sensor detects that the height of the lifted car is already at desired height. The relay is connected through the Normally Closed (NO) connector, which the relay will allow the current to flow the entire time. When the ultrasonic sensor detects, the signal will be sent to the Arduino uno, and the signal will be sent to the relay. The relay will break the circuit, cutting the flow of current. This will automatically stops the lifting operation of the car jack.

### 3.3 Microcontroller system

The microcontroller that is used for this project is Arduino Uno. The Arduino that will be used to control the entire operation of the mechanism will be configured beforehand so that it can respond appropriately. Arduino is a free and open-source microcontroller that can be easily programmed by translating input to output. It is an open-source platform for constructing and programming electrical devices. Arduino is programmed using the Arduino Integrated Development Environment (IDE) software for writing code.

For this project, a few components are used in the microcontroller system. The components that are used are the Arduino uno R3, Infrared sensor, Ultrasonic sensor HC-SR04, Buzzer 3-24VDC, RGB LED, Resistor, Transistor and Breadboard. For the prototype, the breadboard is used for easy configuration of the circuit as shown in Figure 2. It allows components to be removed and replaced easily without the need for soldering. Jumper wire cable is used to extend the connection from the breadboard to the sensors.

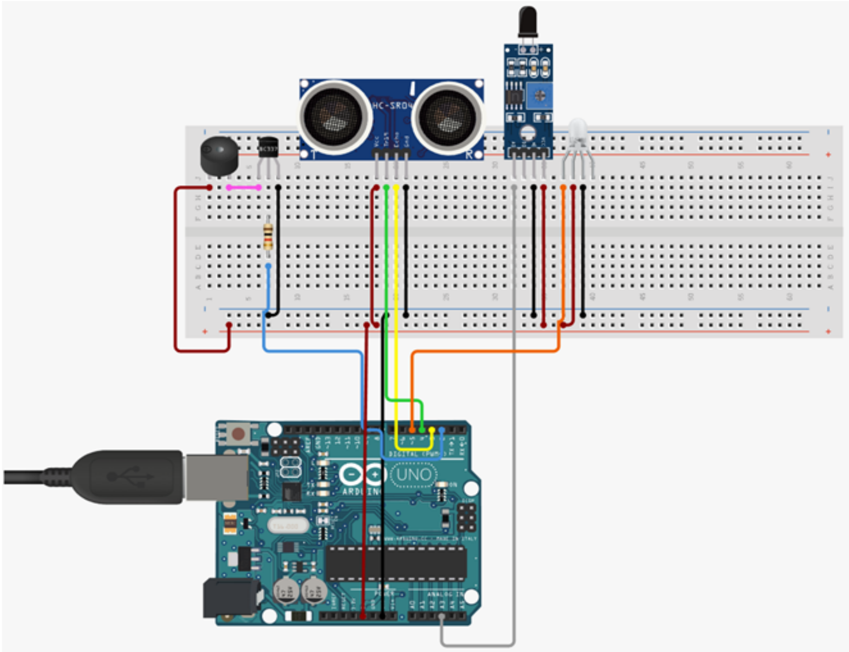


**Fig. 2.** Microcontroller system's connection circuit

### *3.4 Sensor system*

The sensors that are used for this project are the Infrared sensor and the Ultrasonic sensor. Ultrasonic sensors function analogously to sonar detectors in that they send out pulses of sound outside the audible range of human beings. This pulse leaves the range finder in the shape of a cone and moves at the speed of sound, which is 340 metres per second. The range finder receives the sound after it has been reflected off an object. The sensor recognises this as an echo and then computes the amount of time that has passed between the transmission of the signal and the reception of the echo. A controller will then compute this interval in order to determine the distance between itself and the object. To measure the distance the sound has travelled, the time taken for the sound to travel will be multiplied by the velocity of the sound and then divided by 2 because the sound has to travel back and forth. First, the sound travels away from the sensor, bouncing off a surface and returning. The use of ultrasonic sensor to detect the distance or height is becoming an important and widely used component in most electronic devices. The ultrasonic distance sensor attached to the Arduino board works on the principle of sonar. The transmitter transmits a pulse which is received by the receiver after being reflected from an obstacle. This is how the ultrasonic distance sensor measures the distance of it with any approaching obstacle [5].

For this project, the ultrasonic sensor as shown in Figure 3 will be attached to the side surface of the top saddle of the scissor jack. This emitter which will send out the sound wave will be facing downwards towards the ground. This will enable the ultrasonic sensor to detect the height that is reached during lifting operation. The ultrasonic sensor will be powered and controlled by Arduino, which takes power from the internal car battery.

**Fig. 3.** Ultrasonic Sensor

Infrared sensor is an electronic device, that emits the light in order to sense some object of the surroundings. An infrared sensor can measure the heat of an object as well as detects the motion. Usually, in the infrared spectrum, all the objects radiate some form of thermal radiation. These types of radiations are invisible to human eyes, but infrared sensor can detect these radiation [6].

For this project, the infrared sensor as in Figure 4 will be used to detect the presence of the car jacking point inside the grip hole on top of the scissor jack. This is crucial to enhance the safety during lifting operation, ensuring that the car will not slip and the car jack can firmly hold the car. When the sensor detects that the jacking point of the car has been gripped and locked into place by the car jack, it will send the signal to the Arduino, and the buzzer will beep with faster beeping sound to give the indication.

**Fig. 4.** Infrared Proximity Sensor

The proportional coefficient, β is still the same as in the default Taguchi's T-Method in Equation 2. The LTB SNR was used in the third model by replacing the dynamic SNR. The equation for η is the same as in Equation 19 for the second model. The model was developed as in Equation 10 after the proportional coefficient, β and SN ratios η were computed. The model was then optimised using the OA type $L_{12}$, similar to the default Taguchi's T-Method. The results before and after optimisation were recorded.

## 4. Results Analysis

### *4.1 Motor Selection*

For an electric power system to work well, the secret lies in properly sizing and selecting important components. Sizing and properly selecting an electric motor goes a long way to improve reliability and performance while making equipment cost-effective. Therefore, motor selection is an important step in this project.

Based on the design of this automatic scissor jack, a 12V DC motor is attached to the power screw of the scissor jack by welding. The motor is installed to enable the scissor jack to operate automatically without needing any strength or force from human to rotate the power screw.

A suitable motor is vital to prevent from consuming too much electricity that may affect the performance of the car jack, as well as to ensure that the motor is capable of rotating to power screw for the car jack to elevate the car. Thus, engineering calculations will be incorporated into the motor selection procedure to guarantee that the motor's specific attributes are suitable for the mechanism.

First and foremost, the torque that is required to rotate the screw jack needs to be calculated. Based on the car's weight, which is assumed to be 9000 Newton, the torque required by the motor can be calculated by taking the coefficient of friction, screw pitch radius and the pitch of the screw jack of the automatic scissor jack. For this project, the data of the screw jack are taken from the scissor jack that is used as the prototype. The calculation for the torque require to rotate the power screw of the automatic scissor jack is shown below :

$$Torque\ required\ = Q\ \times\ \frac{[(2\pi \times \mu \times r) - p]}{[(2\pi \times r) + (\mu \times p)]} \times (r)$$

where,
$Q$ = Load of the car
$\mu$ = Coefficient of friction
$r$ = Screw pitch radius
$p$ = Pitch

Summary of the data for this project :

Weight of car, Q = 9000 N
Coefficient of friction, $\mu$ = 0.25
Screw pitch radius, *r* = 0.006 m *(as illustrated in Figure 5)*
Pitch, *p* = 0.0025 m

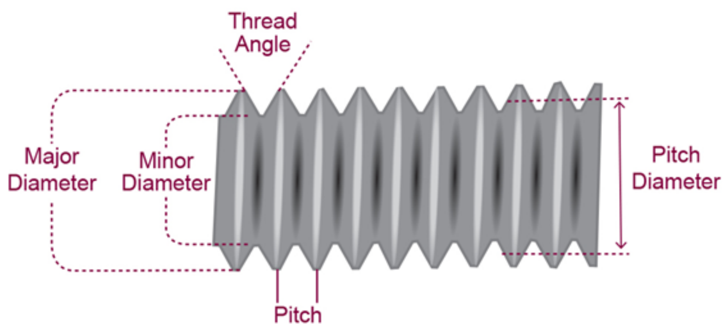


**Fig. 5.** Screw pitch and pitch diameter of the power screw

Substituting the value,

$$Torque\ required = 9000 \times \frac{[(2\pi \times 0.25 \times 0.006) - 0.0025]}{[(2\pi \times 0.006) + (0.25 \times 0.0025)]} \times (0.006)$$
$$= 9.7\ N/m$$

The minimum torque required to rotate the power screw of the automatic scissor jack is determined to be 9.7 N/m. For this project, a 12V DC Car Wiper Motor was chosen to be used as the motor which will rotate the power screw of the car jack. The reason why this motor is chosen is because of the torque that it can produce which is 40 N/m. The value is more than the minimum torque value required, making it the most suitable motor. Moreover, since it is the motor which is equipped to the car, it makes the procurement process much easier and cheaper.

The next step is to calculate the time taken for the motor to lift the car from the ground until the maximum height (the height that ultrasonic sensor detects). Ideally, the time that should be taken for the car jack to lift the car has to be lower than 60 seconds. Anything above that time can cause inconvenience and not efficient. Therefore, in order to calculate the time taken, the power of the motor needs to be determined first. Based on the specification of the DC Car Wiper Motor, the voltage is 12 Volt and the Current is 5 Ampere. The power can now be calculated

Specification of the DC Motor :
Voltage = 12V
Current = 5A

To calculate Power :
*Power* = Voltage x Current
= 12V x 5A
= 60W

The power of the 12V DC Car Wiper Motor is calculated to be 60 Watts. Assuming that the force exerted to car jack is 9000 N, which is the weight of an average sedan car, the velocity of the lifting can be calculated. The calculation is shown below :

$$Velocity = \frac{\text{Power}}{\text{Force}}$$
$$= \frac{60}{9000}$$
= 0.0066 m/s

The velocity of lifting is calculated to be 0.0066 m/s. With the parameters set to the ultrasonic sensor, the displacement that the car jack needs to lift from the ground is 0.27 metre. Therefore, the time taken for the car jack to lift the car from the ground until desired height is shown below :

$$Time\ taken = \frac{0.27\ m}{9000\ N}$$
= 41 seconds

The time taken for the car jack to lift the car from the ground until maximum height is calculated to be 41 seconds. This is an ideal duration since the duration is below 60 seconds. Therefore, the 12V DC Car Wiper Motor is proven to be the most suitable motor for this project.

*4.2 Prototype*

A working prototype of the automatic scissor jack has been built and the building process is explained in details. The scissor jack that is used for this project is taken from the trunk of author's car and development and automation on the scissor jack has been done. The DC motor is welded to the scissor jack. There are a few manufacturing works that have been done before the welding process takes place such as grinding. The configuration and wiring of the circuit has been done by following the steps. After that, Arduino Uno is programmed to control the mechanism of the machine and also controls the sensors that is installed on the prototype. Soldering work has been done to connect the power source to the Arduino through the car socket adapter. The objective of this project is achieved and successfully demonstrated by the prototype.

There are a few electronic components that are used in this project. Each of them has its own function and are connected to each other to work according to what the programme tells them to do. The electronic components that are used in this project are the Arduino uno R3, Infrared proximity sensor, Ultrasonic sensor HC-SR04, Single channel relay module 5V, Car cigarette socket adapter, Buzzer 3-24VDC, RGB LED, Resistor and Transistor.

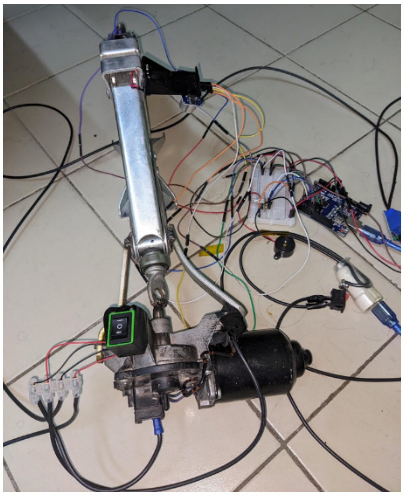

**Fig. 6.** Prototype of the Automatic Scissor Jack

## 5. Conclusions

This project aims to design and develop a fully automated scissor type car jack that uses a 12V DC motor powered by the internal car battery power connected through the car cigarette power socket. This is to ease the process of lifting the car without using the force from human. The other objective of this project are to equip the car jack with sensors powered by Arduino which can detect and give signal when the jacking point on the car has been gripped by the car jack and indicate that it is safe to be lifted up and also to automatically stop the lifting process of the car when certain amount of height is reached to prevent from over lifting which may cause failure of the motor . The most important part of this project is to build a working prototype of the automatic scissor jack to prove its functionality

There are a few recommendations about how to effectively fully automate the car jack system. The first one is to design and develop the scissor jack to be a built-in function inside the automobile. This can enhance the automation of the car jack system. If the scissor jack is installed inside the automobile, the user no longer needs to take out the car jack from the car's trunk. A switch can be installed inside the vehicle dashboard compartment which makes it convenient for the user to lift up their car

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