Experimental Study of Automated Car Power Window with "Preset" Position

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Abstract:

In today's automotive industry, many features are added in power window system. For instance, *Anti Trap System*, with immediate reversal of the window in the event of entrapment. Thus, it gives full and reliable protection for children's hand, neck and any obstacles as well. The aim of this paper is to develop an innovative mechanism to enable the user to control the degree of opening power window position with preset position. This experiment involved design and development of PIC program, electronic circuit design and modification on existing power window mechanism. In this experiment, microcontroller PIC16F877A is applied as a medium to achieve the goal. Generally, it will control the degree opening window whenever the user or motorist required, plus anti-entrapment features on window lifting control system. Therefore the user will be able to open and close the power window within the selected position and feel free while maneuvering their vehicles.

Key words: Car power window, anti trap mechanism, innovation

1. Introduction

There are a lot of innovative mechanisms which related to the power window system where initially introduced by Pakard in 1940 [1]. For instance the innovation, pioneered by Nissan at about the same time, is the *express-down* window which allows the window to be fully lowered with one tap on the switch, as opposed to holding the switch down until the window retracts [2]. Since that, the safety has taken into account to avoid someone unintentionally stuck within the power window and the frame which may cause fatal accident. Therefore, several methods are invented on the anti-trap mechanism. Based on Kurihara et al. ideas, the power window is adapted to become operative when the ignition switch off [3] and it is followed by Chen et al. where the window glass will stop moving when an obstacle detected [4]. Another mechanism which studied by Luebke et al. and Miller et al. are based on deformation of sensing edges when obstruction occurred [5], [6]. For Butler et al., he studied the anti-trap on the trunk lid [8] but still used the Luebke et al. [5] weather-strip design. Instead of locating the anti-trap sensor at weather-strip, Shank et al. allocate the infrared sensor as an anti-trap system just next to the rear mirror [9].

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From the review, it shows that most of the research studies focus on the anti-trap mechanism. Therefore in this study, the power window positioning system is added to be a part of innovative idea. As shown in Figure 1.0, the power window system controlled by microcontroller [10] unit divided into two modes; manual and auto. In 'manual mode', opening and closing of power window is just like the usual passenger car. In common 'auto mode' the power window operates to be fully opened or fully closed. Whereas in 'auto mode' with preset button, the user is able to set the degree of window opening at any desired position.

In both common 'manual' and 'auto' modes, the upper and lower limit of power window was set in default position in order to prevent the over current flow on the motor coil which might ruin the motor itself and window regulator.

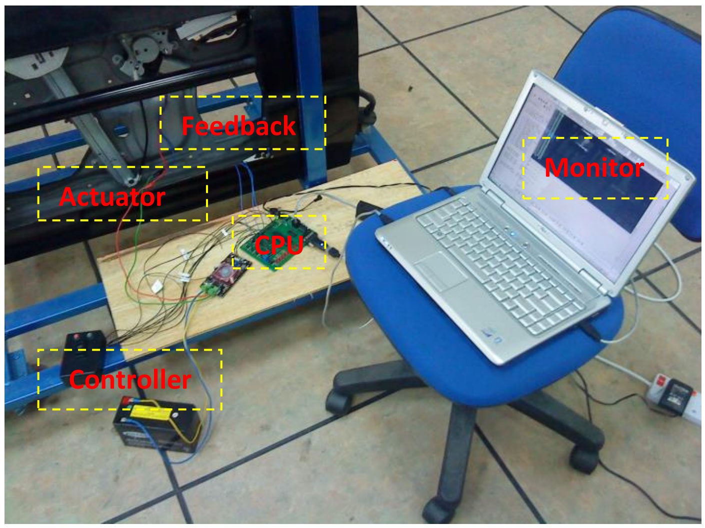


Figure 1.0: Overall project overview

2. Materials and Method

The methodologies for the system development are divided into hardware and software development. The development of hardware and software comprises the modification on existing power window (Malaysia national car), circuit design development and program development. After all hardware and software developments are completed, the circuit integration was done. Finally the analysis of result and measurement data was taken.

2.1. Method of Control

The method for controlling the power window defined as below:

2.1.1 Manual Mode

The controller button is able to control the power window up or down as the user desired.

2.1.2 Automatic Mode

i. Without preset position mode: The user is able to fully open and fully close the power window. When an obstruction occurred during the window is moving up, the anti-trap is activated to reverse the window's motor.

ii. With Preset position mode: The user is able to open the window to their desired position. The user is required to:

- Set the limit as to where the window glass need to be opened as shown in Figure 2.0

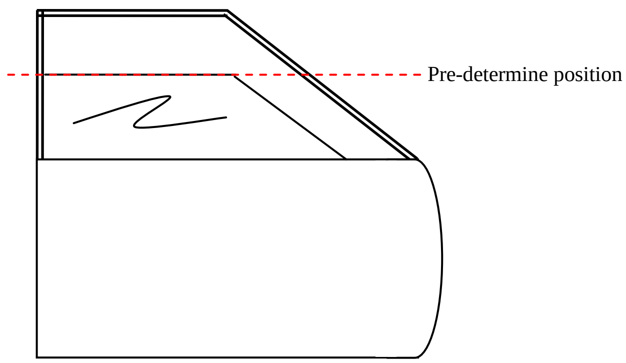


Figure 2.0: Pre-determined positions

- Now, the power window will go up and down within that desired position only as in Figure 2.1. Hence, the user will be able to focus on maneuvering the vehicle without worrying about the power window position anymore.

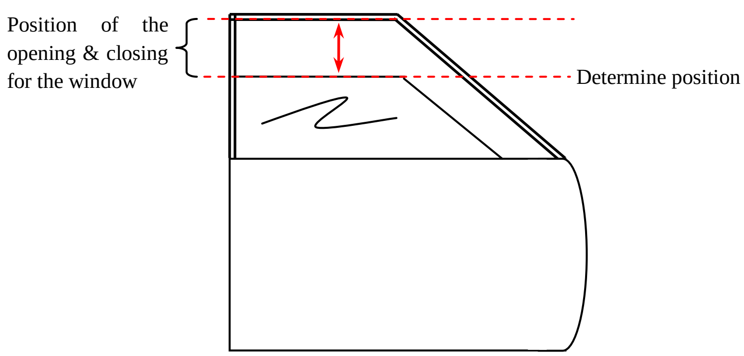


Figure 2.1: Positioning for the window opening and closing

2.2. Anti-trap deformation force

The anti-trap or anti-pinch sensor is embedded in the weather strip. This sensor is made by two conducting materials and embedded in the profile of the thermo-plastic deflectable casing. When an obstruction occurs while the glass window is moving up, the two conductive materials are contacted *see* Figure 2.2. Therefore electrical control signal is activated and sent the signal to the controller to lower the window. This form of thermo-plastic will deform when the force applied within 60N to 100N.

According to the formula: $F = mg$ where; $g = 9.81\ \frac{m}{s^2}$ and $m = mass$

Since;

$$1N = 1kg\frac{m}{s^2}$$

Therefore;

$$60\ kg\ \frac{m}{s^2} = m * 9.81\ \frac{m}{s^2}$$

$$mass = \frac{60}{9.81}\ kg \qquad \therefore mass = 6.12kg$$

When the force is converted to mass, the pinching weight is within 6.12kg up to 10.2kg for the sensor to detect and response to the present of the obstacles.

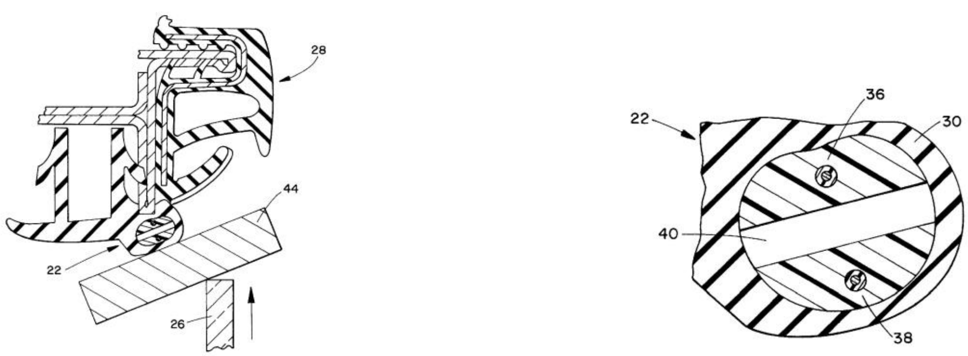
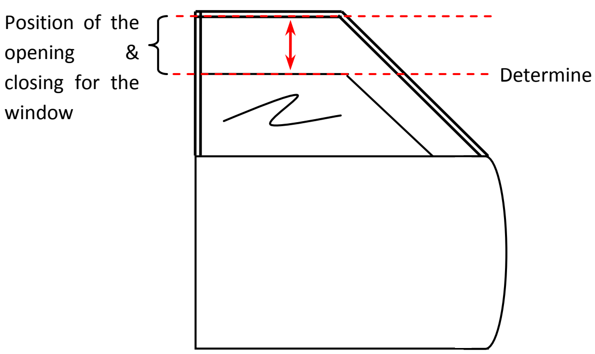


Figure 2.2: Obstruction graphical simulation and sensing element closed-up [5].

2.3 Design Mechanism

These systems is illustrated in Figure 2.3 and divided into 4 major elements; where monitoring process used CCS software under Serial Input/Output Monitor display, controller part for control and program of the power window motor, feedback for distance measurement sensor and anti-trap function and actuator i.e. power window moving mechanism.



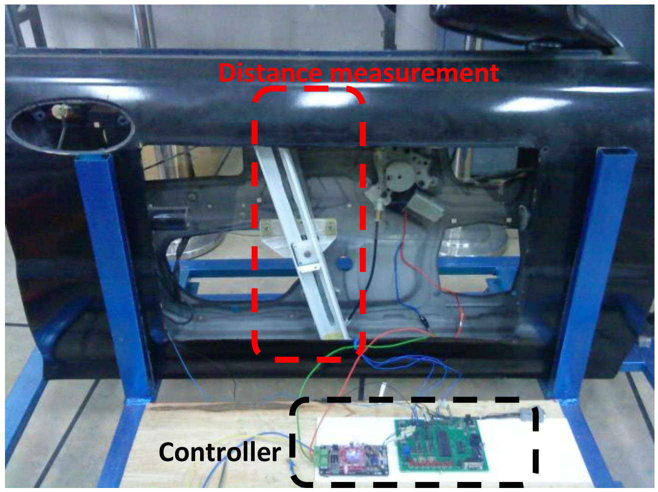
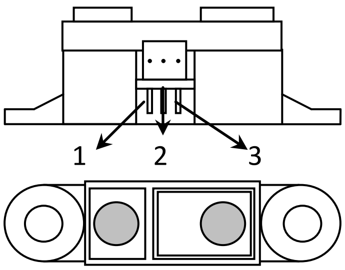


Figure 2.3: Graphical illustration and actual project assembly

2.3.1 Distance Measurement Sensor

To avoid the unnecessary problem, the General Purpose Type Distance measuring sensors GPD12 Figure 2.4 and Figure 2.5 has been chosen to be an appropriate sensing element to be applied to this project. This sensor consist of several features which are; less influence on the color of reflective objects, input voltage is 5V where producing an analogue voltage output from 2.4V to 0.4V proportionally with the distance measured, high accuracy measuring by sequential position detection and mean processing data output, detecting distance from 10cm to 80cm, with low voltage applied and also low cost in price; see Figure 2.6.



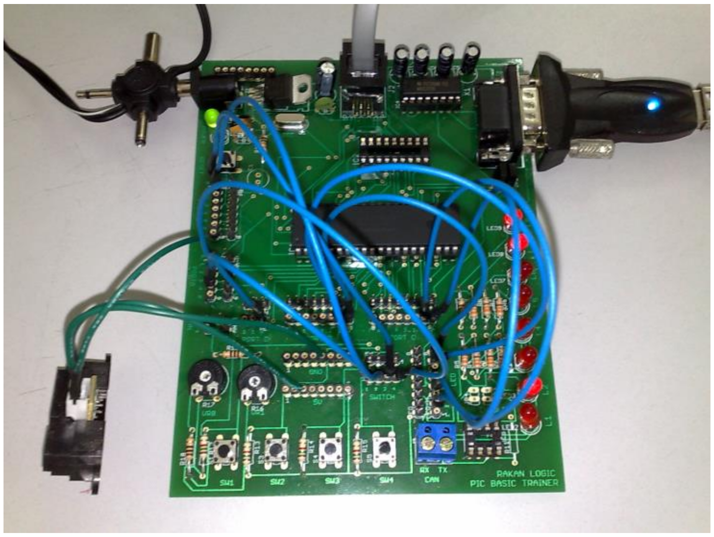
Legend:

1 – V output = 5V

2 – Ground

3 – Vcc = 5V

Figure 2.4: GP2D12 sensor



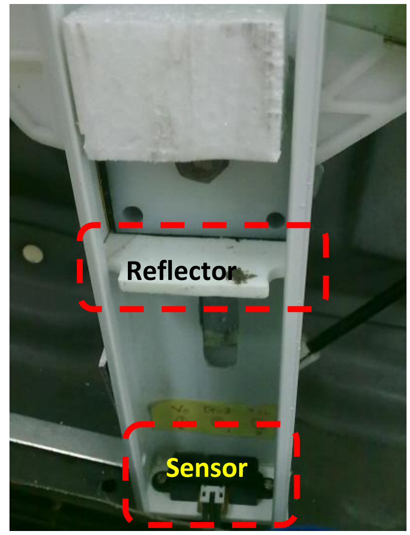


Figure 2.5: GP2D12 tested on the PIC board and power window regulator

2.3.2 Measurement data & plotted graph

Point	A	B	C	D	E	F	G	H
cm	10	13.89	16.67	23.94	31.25	43.82	60	80
voltage	2.4	1.83	1.57	1.17	0.92	0.68	0.53	0.41

Table 1**:** Measurement data

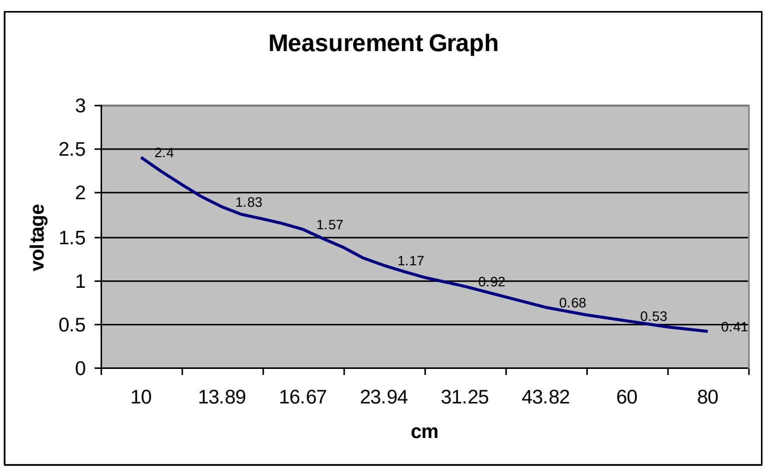


Figure 2.6: Experimental result

2.4 Schematic Diagram Development

To develop the schematic diagram, the ExpressSCH CAD software has been used in Windows application for drawing schematics Figure 2.7 and the integrated control system block diagram shown in Figure 2.8. This circuit directly applied 12 Volt DC.

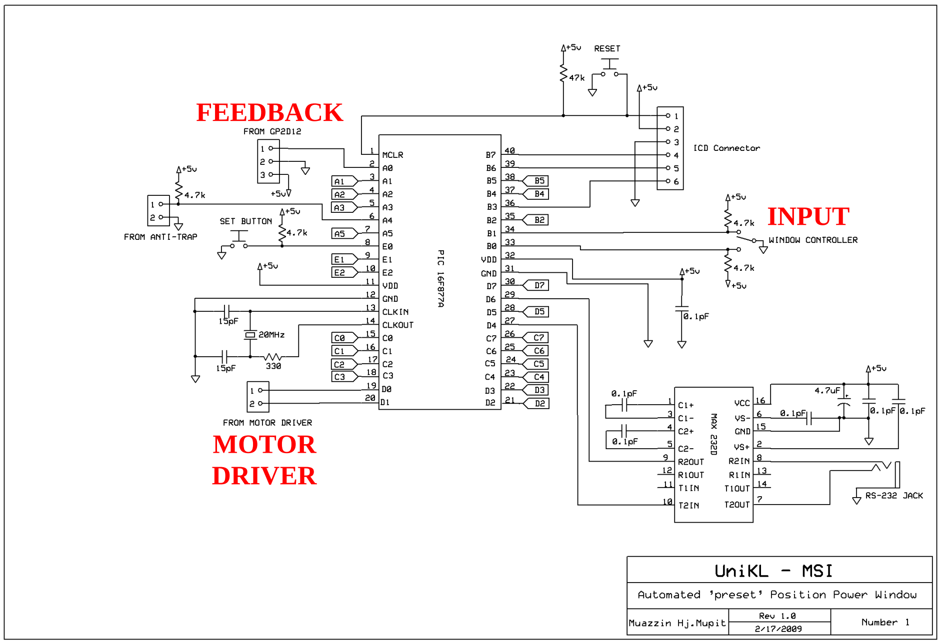


Figure 2.7: Schematics diagrams and integrated block diagram

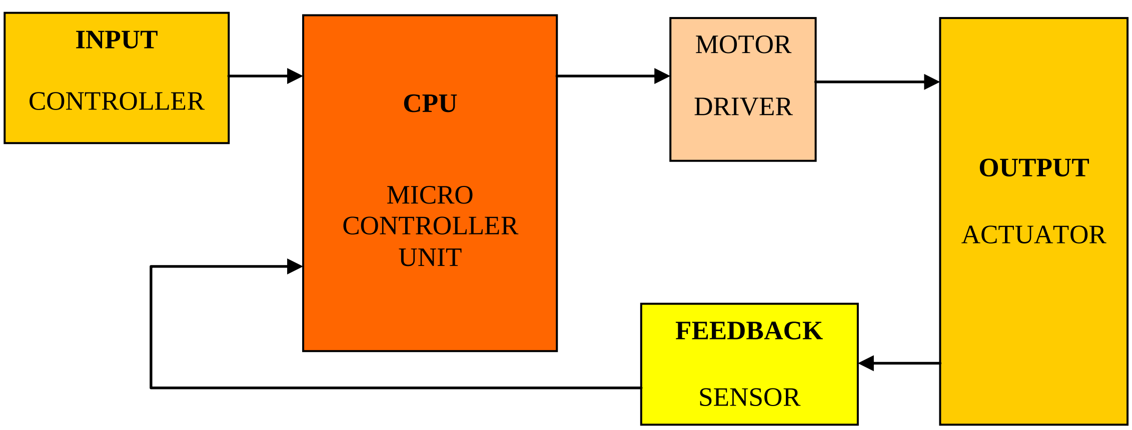


Figure 2.8: Integrated control system block diagram

3. Results

To identify the performance of this system, the Kaptoris Data Acquisition System (DAQ) is used to monitor the movement and variation of each signal in term of sensor, button up and button down movement. Kaptoris DAQ system displayed the data input from sensor and both button up and down. Shown in Figure 3.0 and Figure 3.1, is the integration of power window regulator and Kaptoris DAQ system.

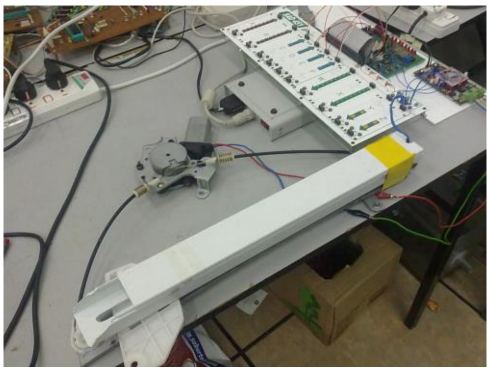


Figure 3.0: Overview of Kaptoris DAQ system and power window regulator

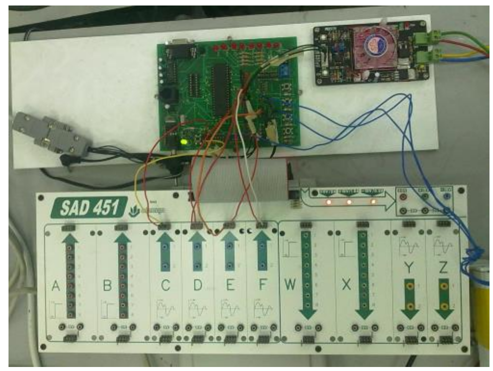


Figure 3.1: Kyptoris DAQ systems

In Figure 3.2, it shows the combination of these three modes with respect to the button up and button down in duration of 30 seconds. It shows that in:-

Manual mode : Windows move according to the button pressed.

Preset mode : Constant variation of upper limit 1.05v and lower limit 2.00v

Auto mode : Constant variation of maximum upper limit 0.6v and maximum lower limit 2.20v

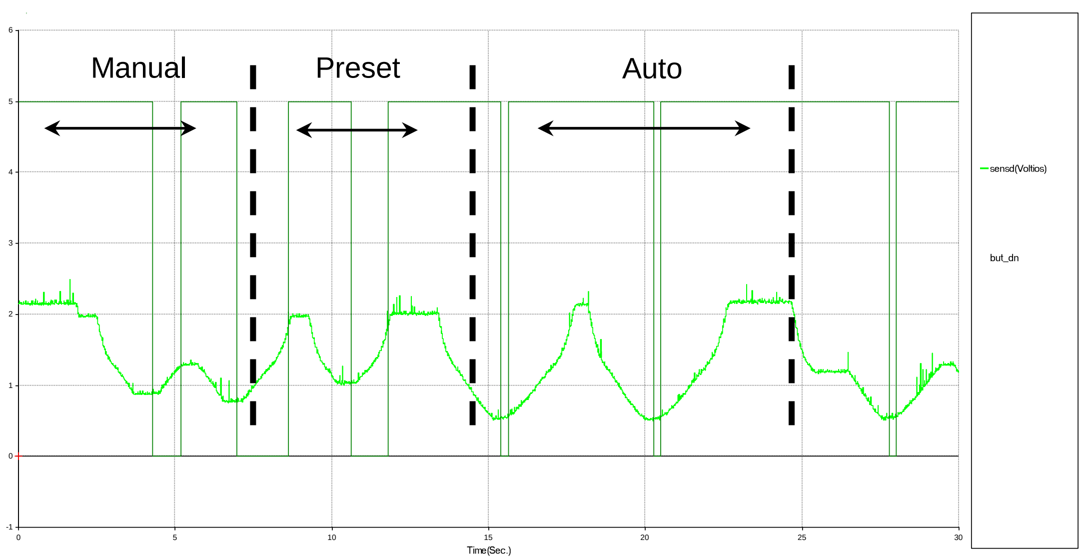


Figure 3.2: Manual – preset –Auto modes graphical simulation

4. Discussion

During the full experiment, it is observed that the power window motor is unable to fully close and an intermittent gap occur due to the alignment of sensor and reflector. The problem encounter on the reflector’s position itself, where it is not perpendicular with the sensor due to the reflector’s position which only attached at the window glass.

As a solution, the sensor needs to be placed in one casing where the reflector will move accordingly with the track i.e. linear guide. Therefore the linear guide was fabricated to ensure that the sensor position perpendicular with the reflector. After it is tested, the repeatability is good based on repeated experiment. But unfortunately when the window is closed, it left a gap about 5cm but much better than previous experiment. This occurred due to severe consequences where either the reflector’s angle is $> 90^0$ or $< 90^0$ as shown in Figure 4.0.

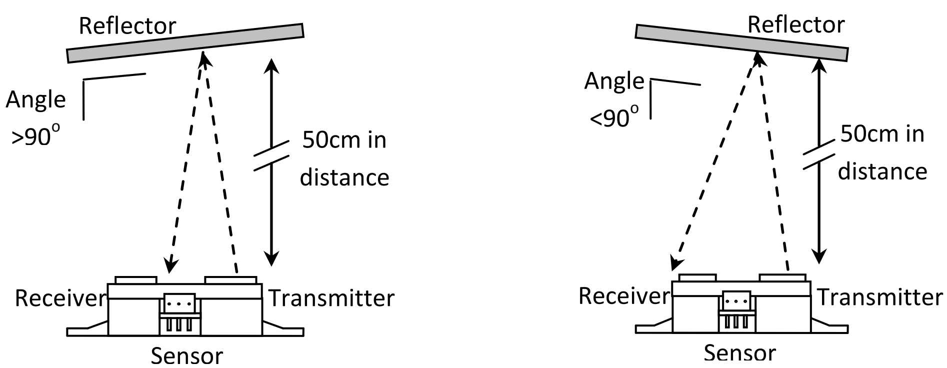


Figure 4.0: Reflector’s illustration due to manual fabrication on the reflector’s track in a farthest distance

On the downward position, it is unable to make it fully open due to the sensor GP2D12 characteristic which only can detect as close as 10cm [11] of distance as shown in Figure 4.1

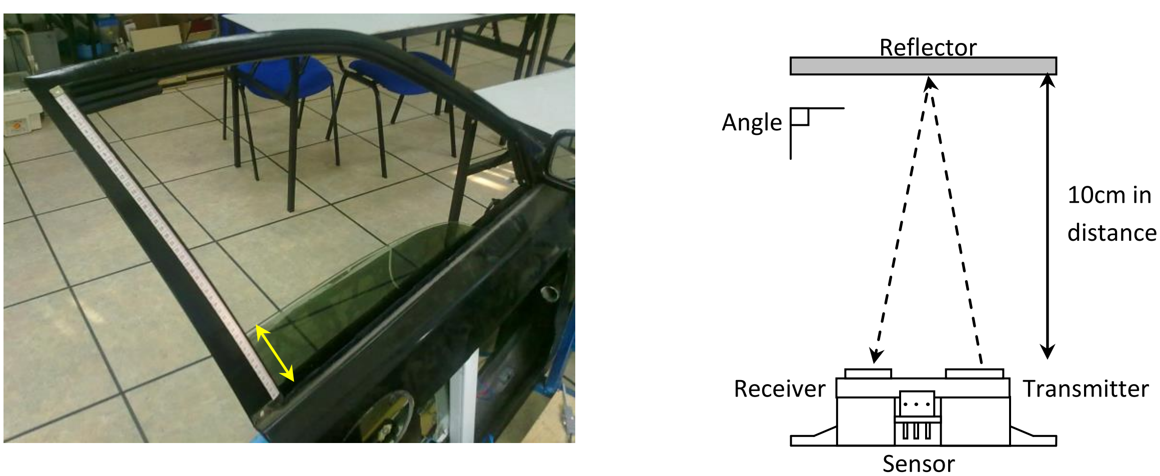


Figure 4.1: Power window fully opened and graphic illustration

5. Conclusions

In term of repeatability, the system mechanism is able to get to the same position after some modification and alignment made to the experimental rig. In AUTO MODE the up and down window is move accordingly to the degree of opening window. This is because the sensors detect the incoming reflective signal accurately, but not on the closing window. This is occurred because the reflective signal diffused when the reflector panel is farther away from the sensor. This error occurred mostly during the MANUAL MODE, where the signal in closing window is intermittent. Therefore with this innovative idea, I hope it will contribute to so many upcoming innovations in the future.

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