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Microcontroller-Based Speed and Overload Detection System for Public Vehicles

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Abstract: The entry speed sensor functions to calculate the speed of a public vehicle, and the Driver LCD display functions to confirm the information that occurs in the system, so the display and the buzzer work together so that if the buzzer sounds the information is on the display All components of the Overload and Detection System can run according to plan. The implementation of a microcontroller-based speed and overload detection system on public vehicles makes it easier for drivers to detect excess speed and overload. This tool uses an Arduino ATmega328 which functions as the main controller of the entire system so that it becomes more efficient. Effectively, this tool is also based on IoT which can emit a beep sound if the specified speed and load exceeds. This tool will convey information in the form of a warning sound produced by the Driver Buzzer.

Keywords: Microcontroller Atmega328; Speed Sensor; Load Sensor; Arduino; Buzzer.

INTRODUCTION

Transportation is often considered a prerequisite for economic development because economic growth requires transportation and infrastructure development (Mahmudah et al., 2011). Thus, economic development will also increase the amount of goods transportation load. As noted by the Directorate General of Land Transportation of the Republic of Indonesia (2006), goods vehicles using roads are estimated to reach 91.25%. This figure is much higher than those using rail transportation (0.63%), river transportation (1.01%), and sea transportation (7%)(Rinaldi et al., 2022).

The origin of the word system comes from the Latin system and the Greek system. Definition of a system is a group consisting of components or elements that are connected together to facilitate the flow of information, material, or energy to achieve a goal. It can also be said that the Definition of a System is a collection of elements that are interrelated and influence each other in carrying out joint activities to achieve a goal. So, in general, the definition of a system is a collection of elements that are interconnected in an orderly manner so as to form a unity.

Another definition for a system is an arrangement of views, theories, principles, and so on (Effendy et al., 2023). Overload avoidance efforts are carried out from various aspects. To prevent overloading, the government has issued regulations such as Law Number 22 of 2009 which limits the maximum carrying capacity of vehicles using scales. Efforts to manage excess loads using weighing equipment and weighbridges are ineffective because many drivers still do not comply with vehicle load regulations(Rinaldi et al., 2022).

Traffic accidents are inseparable from accidents on highways that are unexpected or intentional and involve motorcyclists themselves and other road users. Accidents can also cause fatalities, or from research. or even result in property losses. Many factors influence the occurrence of accidents. One factor that can influence the occurrence of accidents, for example, is motorcyclists who drive recklessly and exceed the speed limit in urban areas(Sholihin et al., 2021).

The inspiration for this research or from previous research, one of which is a journal taken from the "Surabaya Aviation Polytechnic Research Journal entitled MICROCONTROLLER-BASED SPEED MEASUREMENT TO SUPPORT DRIVING SAFETY" which explains that the Experiment was carried out with the Vehicle Speed detection Method is an image reduction method that detects the movement of colored objects in the video(Satura et al., 2021).

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Another journal that is also a source of inspiration for the author is a journal taken from the Faculty of Electrical Engineering entitled "And the implementation of a speed detector on an electric vehicle based on the Internet of Things using the HC-SR 04 sensor" states that IoT itself can operate by providing an IP address to an object that is connected to the Internet and also has a sensor.

I am installed on the object. The sensor itself functions as a regulator of information on objects and also communicates with objects that have an IP address connected to the internet. After the data provision is complete, the tool will be able to function by itself(FIRMANSYAH et al., 2023).

The system that will be created will detect the amount of load and speed on 6-wheeled public vehicles, which displays an LCD reading that exceeds the limit and the speed of public vehicles that have been set.

LITERATURE REVIEW

Detection

Detection is a tool or system that functions to track the existence or condition of something. Detection can be done in various ways, depending on the object being detected. The speed and load detection system of 6-wheeled public vehicles can be used to develop an early warning system for accidents. This system can provide a sign to the driver if the vehicle is traveling at a dangerous speed or is overloaded (Muttaqin & Santoso, 2021).

Purpose of Detection

The purpose of a detection system is to identify, monitor, or detect a particular phenomenon or event with high accuracy and consistency. The purpose of the detector varies, depending on the context, but in general. The following are the purposes of the detector, among others:

1. Identifying events or objects
   To control and identify specific events, objects, or conditions that are relevant in a system or environment.
2. Observing changes or behavior
   To monitor changes or behavior from the unspecified and provide alerts or responses if there are significant changes.
3. Detecting Anomalies or Disturbances
   To detect anomalies, disturbances, or abnormal or unwanted events in a system or process.
4. Improving Security.
   To improve the level of security by detecting threats or for better decision-making and rapid response in situations that require action.

Detection Stages

The following are the monitoring stages, including:

1. Data Collection
   The initial step is to collect relevant information or information from the environment or data source. This can involve the use of sensors, Cameras, Microphones, or other measuring devices, depending on the type of detection being performed. The data generated will be the basis for further examination.
2. Data Processing
   Once the data is collected, the next stage is data processing. This involves data processing which can include filtering, feature selection, normalization, or other data transformations. The goal is to remove noise, prepare the data for further analysis, and produce relevant information.
3. Detection and Decision
   The final stage is detection and decision-making. Here, the data that has been processed to recognize or detect the event or object being searched for. Certain algorithms or methods are used to compare the data with certain predetermined criteria or rules. If an event or object is detected, the system can provide an alert, take action, or produce output that is in accordance with the purpose of the detection.

Public transport

Public transportation is a vehicle used to transport passengers or goods commercially or to serve the general public. These vehicles are usually operated by transportation companies or government agencies that aim to provide public transportation services. Public transportation can be of various types, including:

1. Bus: This public vehicle is designed to transport a large number of passengers in one trip. Buses are generally used in urban, intercity, and interstate services.
2. Train: Trains are a form of public transportation that operates on railroad tracks. They are used to transport people and goods in large numbers.
3. Mass Transportation: This includes public transportation systems such as subways, trams, monorails, and others that operate in certain cities.

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4. Passenger Ship: For water transportation, passenger ships are used to transport people on trips to the sea, rivers, or lakes.
5. Taxi: Taxis are public vehicles that can be ordered to transport passengers from one place to another within a city or a certain area.
6. Airplane: in air transportation, passenger aircraft are used to transport people on domestic and international air travel.

Public transportation plays a vital role in people's mobility, providing accessibility to various locations, workplaces, education, and recreation. They also have a significant role in minimizing traffic congestion and environmental impacts, especially when used efficiently and sustainably.

Microcontroller

A microcontroller is a small computer ("special purpose computer") in one IC that contains a CPU, memory, timer, serial and parallel communication channels, input/output ports, and ADC. Microcontrollers are used for a task and run a program(Perdana et al., 2021).

Arduino

Arduino is a platform consisting of software and hardware. Arduino hardware is generally the same as the Atmega328 microcontroller, except that Arduino has additional pin names to make it easier to remember. Arduino software is open-source software, so you can download it for free. This software is used to create programs and enter them into Arduino(Arifin et al., 2021). Arduino programming does not have as many stages as conventional Atmega328 Microcontroller open source because Arduino has been designed to be easy to learn.

Arduino is a single-board microcontroller designed to facilitate the use of electronic devices in various fields. The hardware is supported by the Atmel AVR processor, and the software includes a proprietary programming language. Arduino is an open-source solution for anyone who wants to create interactive electronic device prototypes based on flexible and easy-to-use hardware or software (Firmawati et al., 2019).

The Atmega328 microcontroller is programmed using the Arduino programming language which has a syntax similar to the C programming language. It is open, so anyone can download the Arduino hardware schematics and create their own Arduino. The Atmega328 microcontroller Arduino uses the Atmega328 microcontroller from the ATMega family released by Atmel, but there are also individuals/companies that make Arduino clones using other Atmega328 microcontrollers and are still compatible with the Arduino IDE software. This is for flexibility. The program is injected through the bootloader. However, there is an option to bypass the bootloader and use the ..hex file downloader to program the Atmega328 microcontroller directly through the ISP port. An example of an Arduino image can be seen in Figure 1 below.

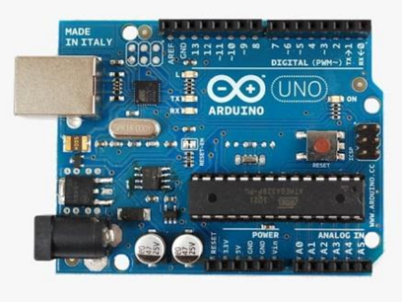

Figure 1. Arduino board

Arduino UNO is a board that uses the Atmega328 Microcontroller. Arduino UNO has 14 digital pins (6 pins can be used as PWM outputs), 6 analog inputs, a 16 MHz crystal oscillator, a USB connection, a power source connector, an ICSP header, and a reset button.

The Atmega328 microcontroller is a chip that functions as a controller or controller of electronic circuits and can generally store programs in it, programs in the Atmega328 microcontroller can be erased and rewritten, and an example of an Atmega328 can be seen in the following Figure 2:

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Figure 2. Atmega328

The Atmega328 Microcontroller that the author uses is the Atmega328 Microcontroller which has 14 digital input output pins (6 PWM outputs), 6 analog inputs, a 16 MHz crystal oscillator, serial connection, ICSP header, and a reset button. It contains all the features needed to support the Atmega328 Microcontroller, simply connect it to a computer with a USB to serial cable or AC power to a DC/Battery adapter to get started. The Atmega328 has 28 pins and each pin has a different function as a port or other function(Wicaksono, 2019). The Atmega328 is an ATMEL Atmega328 Microcontroller version which is a RISC (Reduce instruction set computer) that has a faster data execution process compared to those with a CISC (Completed Instructor Set Computer) architecture.

Power Supply

The power supply is a tool or hardware that is able to supply power or electrical voltage directly from another source of electrical voltage. This device provides direct current (DC) voltage needed by computer hardware (such as devices). Fan, hard disk, motherboard, and so on. Power Power supply also has a connector in the form of a cable, and each cable connector has different functions and capabilities that are needed by the computer, and an example of a power supply can be seen in Figure 3 below.

Figure 3. Power Supply

Load Sensor

A load sensor, also known as a strain sensor, is a device used to measure or detect deformation or change in shape in an object caused by a physical load applied to it. These sensors are used to measure or monitor force or pressure in a variety of applications, from industrial equipment to medical devices(Fahmizal et al., 2022), an example of a load sensor can be seen in Figure 4 below.

Figure 4. Load Sensor

Here are some important points related to load sensors:

1. Working Principle: Load sensors work on the principle that changes in the voltage or resistance of a semiconductor or special material attached to the sensor occur when a load is applied. This change is caused by changes in the length or geometry of the sensor material
2. Applications: Load sensors are used in a variety of applications, including digital scales, motor vehicles to measure the weight of loads, industrial process control, medical devices (such as blood pressure monitors), sports equipment, and more.
3. Sensor Types: There are various types of load sensors, including foil strain gauge sensors, resistive sensors, piezoelectric sensors, capacitive sensors, and others. Each type has specific characteristics and applications.
4. Calibration: Load sensors need to be calibrated in order to produce accurate measurement results. This usually involves measuring the sensor's response to a known load and mapping the characteristics of that response.
5. Output: Load sensors provide an analog signal that usually must be converted to digital form for further processing. Some load sensors also have an integrated digital output option.
6. Precision and Sensitivity: Load sensor precision (the degree of accuracy of the measurement) and sensitivity (how well the sensor detects small changes in load) are important factors in selecting the appropriate sensor for a particular application.
7. Reliability: Load sensor reliability is an important factor in applications that require consistent, accurate measurements over time.

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8. Protection: Some load sensors require protection from environmental elements such as dust, moisture, or corrosion that can affect their performance.

Speed Sensor

A speed sensor is an electronic device used to measure or detect the speed of an object in motion. This sensor can measure linear velocity (as movement in a straight line) or angular velocity (as rotational movement). Speed sensors are essential in a variety of applications, including transportation, manufacturing, automation, and many other fields, and an example of a speed sensor can be seen in Figure 5 below.

Figure 5. Speed Sensor

Here are some important points regarding speed sensors:

1. Working Principle: Speed sensors operate on various principles, including measuring the change in distance or the change in position of an object over time. Some sensors use technologies such as magnetic, optical, or ultrasonic to measure speed.
2. Applications: Speed sensors are used in a variety of applications, such as measuring the speed of motor vehicles, monitoring engine speed, measuring wind speed, controlling speed in robotics, and in navigation systems.
3. Sensor Types: There are many different types of speed sensors, including optical rotation sensors, Hall-effect sensors, ultrasonic speed sensors, and others. The choice of sensor type depends on the application and its specific requirements.
4. Output: Speed sensors provide an output signal that reflects the speed of the object being measured. This signal can be an analog signal, such as a voltage or current that changes with speed, or a digital signal that provides a directly readable speed value.
5. Calibration: Speed sensors need to be calibrated in order to produce accurate measurement results. This involves comparing the sensor's measurement results with known speed values.
6. Precision and Sensitivity: Speed sensor precision (accuracy of measurement) and sensitivity (how well the sensor detects changes in speed) are important factors in selecting the appropriate sensor for a particular application.
7. Reliability: Speed sensor reliability is an important factor in applications that require consistent, accurate measurements over time.
8. Protection: Some speed sensors require protection from environmental elements such as dust, moisture, or corrosion that can affect their performance.

Buzzer

A buzzer is an electronic component that converts electrical vibrations into sound vibrations. Buzzer has an electromagnetic coil mounted on an electronic component that is classified as a simple transducer. Buzzer has two legs, one positive and one negative. Can be used as is. buzzer is an electronic component that is classified as a simple transducer buzzer that has 2 legs, namely positive and negative. To use it simply we can provide positive or negative voltage, an example of a buzzer image can be seen in the following figure 6.

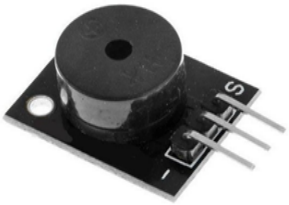

Figure 6. Buzzer

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METHOD

In this writing, the author analyzes two systems as a reference that can help the author, namely analyzing the system that is currently running and analyzing the system that will be designed. The following is a description of the two analyses that the author carried out, namely:

Analysis of the running system

In the analysis of the system currently running, the author observed that, still uses a manual system, namely to detect speed, still look at the speedometer, and for weight, usually the weight of an object is weighed first using a manual scale.

Analysis of the system to be built

The design that will be made is a design using an automatic system that can detect the speed and load on 6-wheeled public vehicles, this helps drivers or company owners to know whether their vehicles exceed the speed and load of their vehicles exceed the predetermined limits.

Design

System design is the stage after the analysis process for system development or construction, defining functional requirements and describing the implementation design requirements.

Computer Hardware Design

In designing this hardware system, it will be described using a block diagram which is a basic description of the hardware design of the system in the form of a series of system work that is designed. Each block diagram has a different function. The block diagram of the designed system is shown in Figure 7 below:

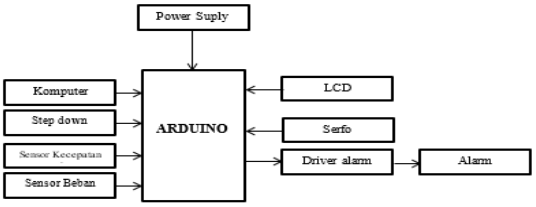

Figure 7. Block Diagram

Keterangan Diagram Blok :

1. The load sensor functions to measure or detect the weight of an object or load by converting it into an electrical signal that can be used for measurement or control purposes.
2. The speed sensor functions to measure the speed of movement.
3. The Esp8266 functions to send data via the internet and this internet is to activate the Esp8266.
4. Arduino functions to control and process data from input devices and then forward it to the Output device.
5. The Power Supply functions to meet the current voltage for the needs of the designed system.
6. The 16x2 character LCD functions as a microcontroller interface with its user,
7. The buzzer functions if the speed and load exceed the limit, the user or user can find out from the sound whether the load and speed exceed the specified limit.

Manufacturing Flow

The design stage is a step in determining the course of a system that has been built. The manufacturing flow of the designed system is shown in Figure 8 below.

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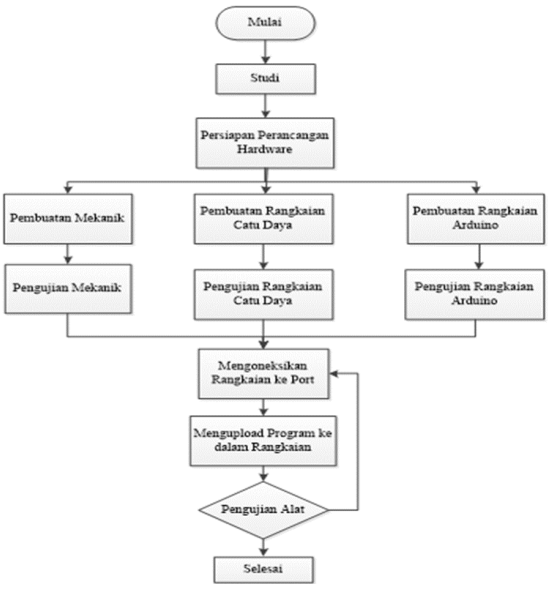

Figure 8. Flowchart Flow Diagram

Sampling in this study used the Observation method where the speed and load of the vehicle were directly monitored in the field so that the samples taken were based on certain considerations.

Based on sources from the Police, the increase in traffic accidents from 2018 to 2019 increased by 3% and the number of traffic accidents in 2019 reached 109,215 incidents with the number of victims reaching 23,530 people, the incident occurred due to human factors (related to the skills and character of the driver) 61%, vehicle factors (related to the fulfillment of technical requirements and roadworthiness) 9% and infrastructure and weather factors 30%(Khakim, 2023).

We can see that the number of accidents always increases every year, the table description showing the information on accidents that increase every year can be seen in Table 1 below.

Table 1. Information on the increasing number of traffic accidents each year

Tahun / Jenis korban	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Meninggal	882	1.060	1.497	1.648	1.922	1.996	2.042	2.099	2.299	2.162
Luka Berat	1.749	2.320	2.824	3.198	3.361	3.036	3.166	3.025	3.236	2.682
Luka Ringan	3.808	4.136	5.328	5.115	4.343	4.266	4.218	3.588	3.648	3.027
Jumlah	6.439	7.516	9.649	9.961	9.626	9.298	9.426	8.712	9.183	7.871

So, to reduce the number of accidents, a system was created. In reviewing a system, there are types of systems that can be classified in several ways, namely(YOGASARA, 2023):

1. Systems are classified as physical systems and abstract systems.
   A physical system is a system whose components are real objects that can be seen. For example, hardware systems, memory, monitors, keyboards, CPUs (central processing units), and others.
2. While abstract systems are systems whose components cannot be seen. For example, a computer operating system (OS) consisting of a set of instructions in a language understood by a computer machine
3. Systems are classified as natural systems and human-made systems.
   Natural systems are systems whose conditions occur naturally without human intervention. For example, the solar system consists of a group of planets.
4. Classification systems as certain systems (deterministic systems) and uncertain systems (probabilistic systems) certain systems are systems whose behavior cannot be determined/predicted in advance. For example, a computer application system Deterministic systems are systems whose behavior cannot be determined/predicted in advance.
5. Classification systems into closed and open systems.
   A closed system is a system whose operation is not influenced by the external environment. For example, a computer application system. An open system is a functioning system. For example, a computer application system will stop if a computer's power is interrupted/outage.

RESULT

Based on the analysis of the system detecting excess speed and overload, the level of speed and load design for the system design/system design, and system testing and overall tool function system, both hardware and

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software have been tested at the Indonesian Institute of Technology and Business (ITBI) Lab and can function as desired, with the following results:

1. The load sensor is designed as a sensor that detects the load level in a public vehicle.
2. The Entry speed sensor functions to calculate the amount of speed in public vehicles.
3. The servo functions to open the doors of public vehicles automatically.
4. The LCD display driver functions to confirm the information that occurs in the system, so the display and buzzer work together so that if the buzzer sounds the information is on the display.
5. The Buzzer Driver functions if the speed and load are too high, we give a warning sound alarm meaning that something needs to be checked so that the system works.

The results of the tests carried out on the speed sensor and load sensor can be seen in Tables 2 and 3 below.

Table 2. Table of speed sensor test results

NO	The speed determined	Speed detected in the App (km/h)	Speed read by the speed sensor
1	<20km/jam	21	21
2	20km/jam	21	20
3	25km/jam	22	22
4	15km/jam	16	16
5	10km/jam	12	12
6	<30km/jam	30	30
7	50km/jam	40	40
8	5km/jam	6	6
9	40km/jam	40	40

Table 3. Table of weight sensor test results

NO	Specified load (kg)	Load read by LCD	The load read by the load sensor	Buzzer
1	2 kg	2,1 kg	2,1kg	Ringing
2	3 kg	2,5 kg	2,5 kg	Not
3	>3 kg	1 kg	1 kg	Ringing
4	4 kg	4,3 kg	4.3 kg	Ringing
5	1 kg	3 kg	3 kg	Ringing
6	4,5 kg	4 kg	4 kg	Not
7	2,5 kg	2 kg	2 kg	Not
8	3,1 kg	3,3 kg	3,3 kg	Ringing
9	<4 kg	4,5 kg	4,5 kg	Ringing

Based on the design results above, for more details on the test results and overall design of "Speed and Overload Detection System on Public Vehicles Based on Integrated Microcontroller Internet Of Things". The front view of the miniature truck can be seen in Figure 9 below.

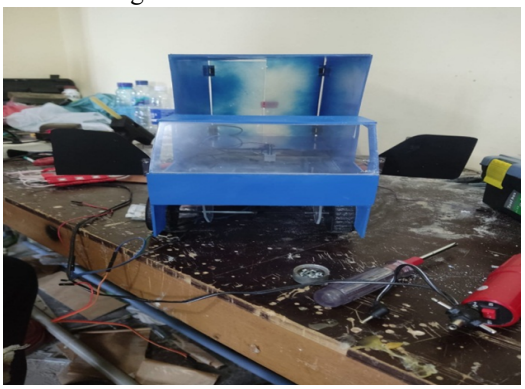

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Figure 9. Front View of Speed and Overload Detection System

The side view of the miniature truck can be seen in Figure 10 below.

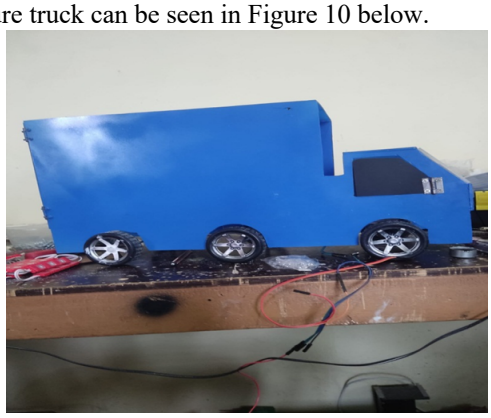

Figure 10. Side View of Speed and Load Detection System

The display image for the miniature truck speed sensor can be seen in Figure 11 below.

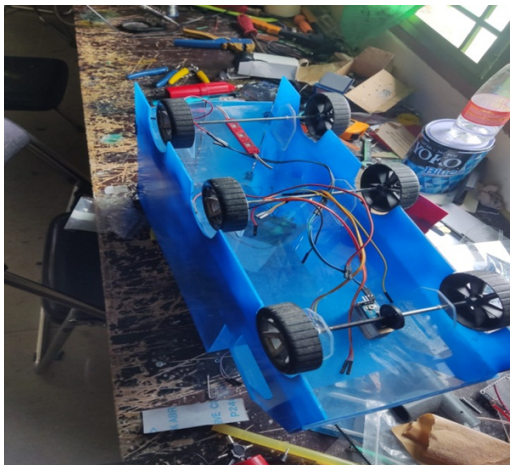

Figure 11. Speed Sensor

The display image for the miniature truck load sensor can be seen in Figure 12 below.

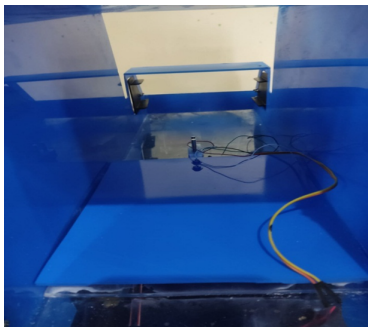

Figure 12. Load Sensor

DISCUSSIONS

At this stage, a discussion is carried out on the working process of the Speed and Overload Detection System, which is as follows:

1. Arduino is used to control and process data from input devices and then forward it to the output. In this process, this sensor can be used to process work, so it will be able to read data from all inputs which then process the data and then make decisions about which devices (outputs) should be controlled.
2. Smartphones function to receive wifi and send data via wifi.
3. Wifi / Internet functions to control, both for monitoring, and viewing data all using the internet.

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4. Esp8266 functions to send data via the internet and this internet is to activate Esp8266.
5. Power Supply functions to meet the electrical voltage for the needs of the designed system.
6. Ultrasonic sensors function to detect sound sensors from rotating wheels from public vehicles.
7. Weight Sensors function to calculate the amount of weight entering public vehicles.
8. Servo functions to open the door automatically.
9. The LCD display driver functions to confirm the information that occurs in the system, so the display and buzzer work together so that if the buzzer sounds the information is on the display.
10. The Buzzer Driver can act if the noise is too high, the light information is too low and the number of visitors is too many so we give a warning sound indicator meaning that something needs to be checked so that the system works.

CONCLUSION

The conclusions obtained during the work and creation of the speed and overload detection system on public vehicles based on microcontrollers are as follows: (1) All components of the Overload Detection and Overload System can run according to plan. (2) The application of the speed and overload detection system on public vehicles based on microcontrollers makes it easier for drivers to find excess speed and overload. (3) This tool uses Arduino ATmega328 which functions as the main controller of the entire system to make it more effective. (4) This tool is also based on IOT which can emit a beep sound if the speed and load are exceeded as determined.

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