DEVELOPMENT OF USER-CENTERED SMART CHILD SEAT FOR NCAP REQUIREMENTS VIA IOT PLATFORM

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DEVELOPMENT OF USER-CENTERED SMART CHILD SEAT FOR NCAP REQUIREMENTS VIA IOT PLATFORM

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This report is submitted in partial fulfilment of the requirements for the degree of Bachelor of Electronic Engineering with Honours

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DECLARATION

I declare that this report entitled "DEVELOPMENT OF USER-CENTERED SMART CHILD SEAT FOR NCAP REQUIREMENTS VIA IOT PLATFORM" is the result of my own work except for quotes as cited in the references.

Signature :

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Date : 22 June 2021

APPROVAL

I hereby declare that I have read this thesis and in my opinion this thesis is sufficient in terms of scope and quality for the award of Bachelor of Electronic Engineering with Honours.

Signature :

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Date : 23 June 2021

DEDICATION

My humble effort I dedicated to Allah the All Mighty for granting me my sweet and loving parent, Norman Bin Darobi and Siti Aishah Binti Kaderi, siblings and my loved one who's their affection, love, patient, encouragement and prays of days and nights make me able to get such success and honour. Alhamdulillah.

ABSTRACT

Recently, the ‘forgotten baby syndrome’ term has become a regular headline in the newspaper. The syndrome is referred to a scenario of a child dying from a heat stroke after being accidentally left in a car. Herein, the Smart Child Seat (SCS) has been designed with real-time monitoring-based system that consists of temperature, humidity, heartbeat, sound, ultrasonic and carbon monoxide sensor to monitor and measure the condition of the child left inside the car. The system’s requirement is designed based on the market survey to provide direction for the optimized Smart Child Seat system. The system will send the notification alert via the Blynk IoT application to the parents if there are an abnormal reading from the sensors.

ABSTRAK

Kebelakangan ini, istilah 'sindrom terlupa bayi' menjadi tajuk utama di keratan akhbar. Sindrom ini merujuk kepada situasi kanak-kanak yang mati akibat strok haba setelah ditinggalkan di dalam kereta secara tidak sengaja. Oleh itu, Smart Child Seat (SCS) telah dirancang dengan sistem berasaskan pemantauan masa nyata yang terdiri daripada sensor suhu, sensor kelembapan udara, sensor degupan jantung, sensor suara, sensor ultrasonik dan sensor karbon monoksida untuk memantau dan mengukur keadaan kanak-kanak yang ditinggalkan di dalam kereta. Keperluan sistem ini dirancang berdasarkan tinjauan pasaran untuk memberikan arahan kepada sistem Smart Child Seat yang dioptimumkan. Sistem akan menghantar makluman pemberitahuan melalui aplikasi Blynk IoT kepada ibu bapa sekiranya terdapat bacaan yang tidak normal dari sensor.

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LIST OF SYMBOLS AND ABBREVIATIONS

NCAP	: New Car Assessment Program
LED	: Light Emitting Diode
LCD	: Liquid Crystal Display
LDR	: Light dependent resistor
IR	: Infrared
Wi-Fi	: Wireless Fidelity
GPRS	: General Packet Radio Service
IoT	: Internet of Things
LAN	: Local Area Network
PAN	: Personal Area Network
RFID	: Radio Frequency Identification
WAN	: Wide Area Network
RF	: Radio Frequency
SMS	: Short Message Service
ECG	: Electrocardiography
CO2	: Carbon Dioxide
CO	: Carbon Monoxide
NICU	: Neonatal Intensive Care Units
ISM	: Industrial, Scientific and Medical
PWM	: Pulse Width Modulation

SPI : Serial Peripheral Interfaces

SD : Secure Digital

IDE : Integrated Development Environment

IEEE : Institute of Electrical and Electronics Engineers

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CHAPTER 1

INTRODUCTION

This chapter introduces this project, following the project's background study, problem statement, and research question. For the project background, an explanation about the main topic, which is SCS, has been described. Then the discovery about the problem statement of the current issues is done and come out with the research question related to the field. Project objectives, scopes and expected results from this project also discussed in this chapter. All the details for each section of the project have been discussed in this chapter.

1.1 Background of Project

The increasing number of cases of a child dying from a heat stroke after being accidentally left in a car needs to be taken. To improve vehicle safety standards, increase consumer awareness, and enhance a market for safer vehicles, New Car Assessment Program (NCAP) launched the new roadmap for 2021-2030, which includes a child occupant safety assessment to ensure that manufacturers take responsibility for the children travelling in their vehicles [1]. One crucial remark is to include a child's presence detection as a preventive measure for a child being accidentally left in a car. Thus, the proposed project aims to design an SCS embedded with multi-sensors to support the NCAP requirements. The prototype will be incorporated with the monitoring and control system via IoT. The analysis of the system will be carried out at the end of the project.

1.2 Problem Statement

Car-related injury and death is a massive problem for the overall health of global society. This refers to the human body’s response to excessive heat, which can lead to heat-related death. Heatstroke is characterized by when a body at rest, the temperature exceeds 40 (°C). Brain death would occur when the body temperature reaches 41 (°C) and when at 45 (°C), a person will be critically injured [2]. Based on safety organization Kids and Cars reporting, each year, an average of 37 children dies due to the entrapment in vehicles. The situation includes cases where children have been forgotten left inside vehicles, who accidentally lock themselves inside the vehicle. Although the adults leave their child just for a minute, they are exposed to such dangers. The study of unattended child presence detection systems for the NCAP safety rating concludes that the preferences system indicator for child’s presence detection and reminder systems should be in audio indicators emanating from the vehicle and phone notification system [3]. Typically air-condition and refrigerator is using carbon monoxide in the compressor. The leakage of gas carbon monoxide inside the car can cause poisoning by inhalation of raw illuminating. The poison gas will also be contributing to the sudden death of a child left in the car [4]. The most child seat with a monitoring system used in today's world operates offline [5]. While current child safety systems mainly focus on detecting the presence of the baby, real-time monitoring via IoT has not yet been explored in depth. Hence, the SCS developed in this study which embedded with multi-sensors and incorporated with the monitoring and control system via the Blynk- IoT platform.

To sum it up, the significant problem statement that we need to counter in this project is an injury that would occur when the vehicle's surrounding temperature exceeds 40°C. So, we need to provide the notification system to the parent if the temperature exceeds this value. Next, an average human cannot detect the presence of combustion gas with their five senses. Thus, sudden death will occur if a person inhales a certain amount of combustion gas. The lack of oxygen will cause heart failure, which increases heartbeat as the oxygen is not well transported to the organs. The role of oxygen in the heart is complex either it can be beneficial or cause cardiac dysfunction, which can result in death [6]. Finally, no real-time monitoring system to measure the instantaneous baby's condition in the vehicle.

1.3 Research question

Over the last 20 years, several projects have been done to counter the child dying after left inside the car. Based on the study to the field about SCS, more research must be performed on highlighting possible security threats that may harm the child being left inside the car. From the research, there are many gaps in the functionality and effectiveness of the product thus, introduce the following research questions:

i. How to prevent infants from being left in the car?
ii. How the effectiveness the used of ultrasonic, sound, heartbeat, temperature, humidity, and combustion sensors in the system?
iii. Do our IoT based SCS smart system can prevent the infant's death?

We acknowledged the importance of an alternative solution regarding the 'forgotten baby syndrome' issue from the above-stated research question. Thus, we can derive the main objectives of this project.

1.4 Objectives

In order to answer above- stated research questions, we envisioned three main objectives. The objectives of this area as follows:

i. To develop a prototype of SCS that is able to detect and measure the presence of the baby, baby's sound, baby's heartbeat, surrounding's humidity, surrounding's temperature and combustion gas leakage inside the vehicle using IoT system.
ii. To analyze the performance of the SCS using the IoT system.

iii. To investigate the market of SCS including analysis of consumer's needs and preferences.

1.5 Scope of work

Several related topics need to be addressed if we want to make some progress in a safer and smarter baby car seat. The topics range from medical aspects via physics to engineering aspects. Figure 1.1 shows the preliminary overview of the overall topics which seems relevant to the project.

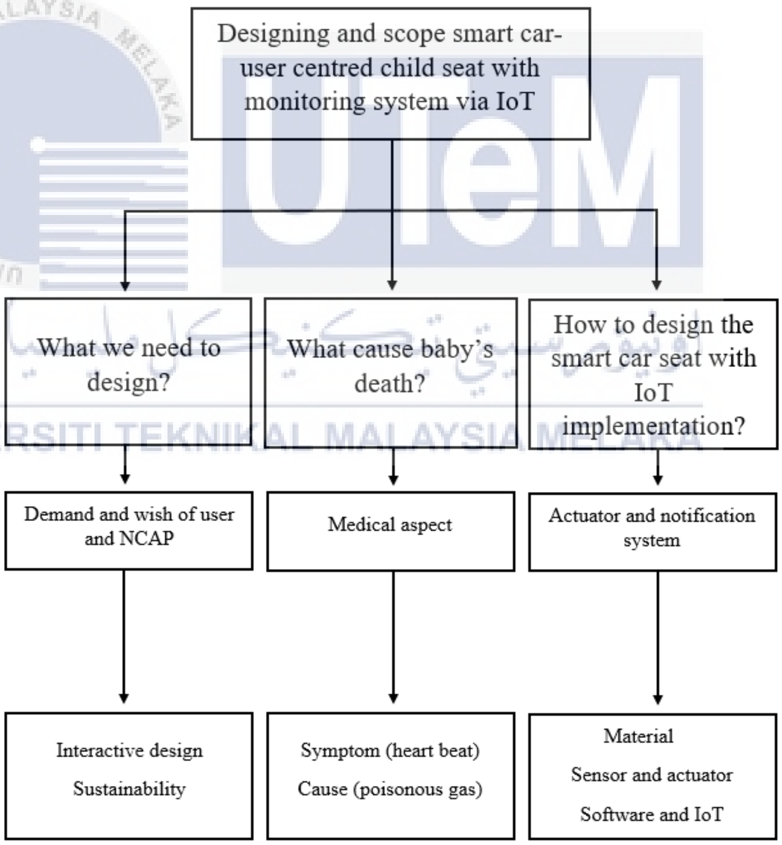


Figure 1. 1 Preliminary overview of the overall topics

At the root of the tree is the thesis's overall aim in developing a User-Centered Smart Child Seat for NCAP Via IoT Platform. The main branches are:

1. What we need to design?
2. What cause baby's death? (In the context of baby being left in the car)
3. How to design the smart car seat with IoT implementation?

In the diagram, many topics are meant to improve the understanding of the medical aspect that plays a role. These are important for making contributions to the third branch, "How to design the prototype?" (Engineering aspects). The thesis focuses primarily on the technical part, in line with "demands and wishes" from NCAP. In order to answer all the above questions, there are three stages for the scope of the project: user requirement, prototype testing, and software integration.

1.5.1 Stage 1: User requirement

- Distribution of market survey to get the preferences from the user about SCS.
- The design of attractive prototype by using CATIA software.
- Design the type of product sensor and several actuators are based on the user demand.
- Calculating dimension to minimize the error when developing the final product.
- Simulate the design circuit by using NI Multisim software and fabricate the PCB board using Proteus software.

1.5.2 Stage 2: Prototype testing

- Design the concept or working principle of the entire project.
- Use Arduino Uno as a microcontroller to interact with the IoT platform.
- Write the programming for the microcontroller using Arduino IDE software.

- Insert the program in order to monitor the condition of the baby infant.

1.5.3 Stage 3: Software integration

- Develop the monitoring system in Blynk application and use the ESP 8266 Wi-Fi Shield to communicate and receive the information from the sensor.
- Develop the program to run the task by following the system's flowchart sequence.
- Evaluating the product or prototype by the inspection of the actuator as the output.
- Prototype testing to evaluate the input-output response time that gives comfort to the user.

1.6 Thesis Outline

Generally, this thesis consists of five chapters. The first part is about the project introduction that will explain the project summary, problem statement, objectives and scope of works. Chapter 2 focuses more on literature reviews related to this project based on any reference books, internet, journal, or other sources of information. An introduction to IoT was explained based on their applications towards monitoring features. Chapter 3 mainly discussed and explain the methodology for the development of the SCS via the IoT Platform. Chapter 4 presents the results and discussion of the project. The result of the project is mainly based on the finished application and the feature's ability in fulfilling the objectives of this project. Chapter 5 concludes the project as a whole. The recommendation for future works was also suggested in this.

CHAPTER 2

BACKGROUND STUDY

This chapter aims to assess the scientific significance of the research problem by illustrating previous research in the field, developing the understanding of the field, identifying a gap in the literature and the need for this review. Publications on SCS from various academic publishers, such as Elsevier’s Science Direct, Springer, IEEE, were identified. The publications from various scholars from the last two decades from 2000 through 2020 were identified through three search engines which are Google Scholar, Scopus and IEEE Xplore Digital Library. The keywords that used to search were ‘user centered child seat’, ‘forgotten baby syndrome’, ‘dying child’, ‘heatstroke’, ‘IoT’, ‘sensors’, ‘NCAP’, ‘child monitoring’, ‘child seat’, ‘heatstroke detection system’, ‘child presence detection system’, ‘child monitoring system’, ‘heartbeat and temperature monitoring system’ and ‘IoT system’, resulted in more than 200 different sources. The sources were filtered, and most interest sources were selected and sorted by year from 2000 until 2020. This chapter firstly presents the introduction to IoT. Next, the literature survey from previous works about SCS via IoT platform has been done. The literature survey focuses mainly on monitoring system issues related to this technology. After that, the sensor used and the analysis obtained in this project will be explained. From this chapter, identifying the research gap can be found, and the options and solutions to fulfil the research gap was succeeded. Finally, the summary of the literature review was discussed at the end of the chapter.

2.1 Internet of things (IoT)

Internet of Things is a pioneering topic with significant technical, social, and economic implications. It describes a network of physical objects or things embedded in sensors, software and other technologies to connect and exchange data over the internet with other devices and systems without human intervention [7]. Nowadays, the use of the internet for communication between users and other systems has rapidly increased in the global network of smart devices. The technology is used to make users feel and respond to their environment. Rapid changes in information and communication technologies have assisted to the wider usage of IoT in areas. IoT brings the digital and physical worlds together to make the world around us more competent and more responsive.

2.1.1 Why implement IoT on the project?

The whole concept behind creating the smart car's child seat is to enable parents to check up on their infants and monitor their activities from afar. The IoT-based system includes the real-time monitoring system on a cry detecting mechanism and the other sensors to check the combustion gas leakage, humidity and temperature inside the vehicle. The data generated by the sensors is stored in the cloud. Nowadays, the IoT is like a giant network connecting things and people [8]. Implementing the IoT technology welcomes us to a world where we can use the internet to connect, interact, and command any device.

2.1.2 What is the implication of using IoT?

The concept of combining software, hardware and networks to monitor and control devices has existed for decades [8]. It is too relevant that the SCS needs to implement with the IoT based system. There is some favorable implication of IoT, which are faster and better in decision making, meaning that some decision can faster be made by programmed or automated based on sensor's inputs received at the edge. The second implication of using IoT is risk avoidance. With the networking of machines, data and people triangulated analysis and prediction can be near reality before a problem occurs. IoT-based systems can also manage entities, environments, and products at a lower cost and with greater efficiency. It allows for a faster and better quality of monitoring, processing and controlling when needed.

2.2 Related works and previous study

Unfortunately, many children are left unattended in a car each year that often to devastating consequences. Most parents do not realize the tendency of death to their child [9]. Charles J. Cole proposed a system that detects the presence of the child in a vehicle. As the child is detected, the system will disable the vehicle's door locks, thus telling the parents by turning on the alarm system. When the child is sitting in the right place, the pressure sensor on the back seat is used to determine the child's presence. When the sensor's reading is above the threshold level, it shows that a child is present and vice versa. The presence detection also measured by using the motion sensor. The system also detects the temperature inside the vehicle. When the temperature rises above or falls below a certain amount while there is the child's presence, the alarm will sound. There are some disadvantages to this system, such as no real-time monitoring device incorporated in the system. The project can be improvised by implementing the IoT system to the notification alarm.

On a hot day, when parents leave their child in a vehicle, the child tends to be heatstroke. The invention by Victor H. is directed to a system for detecting the presence of a child, when there is nobody else inside the vehicle. [10]. The invention includes a sensor connected to the baby's car seat belt to detect the child's presence. The system also detects the driver's presence. The alarm circuit will be activated when the driver exits the car and deactivate when the driver enters the car. A delay timer is included in the system that gives time to the driver to enter and exit the vehicle without triggering the alarm system. A timer for the time delay will begin as the alarm circuit is activated. If the driver did not disable the alarm circuit by re-entering the vehicle or removing the child from the child's seat, the alarm circuit would trigger, switch off the warning signals and remain energized until the vehicle is disabled. The main disadvantages to this system are that there is no monitoring system embedded in the system.

The pediatrics academy in America changed the policy statement on infant death. In order to cut down on the number of cases regarding deaths of infants and children, Annouri was designed the system with some features which wireless baby monitors embedded with a full sensor located on top of the baby's bed [11]. The temperature sensor, a motion sensor, an audio sensor was embedded in the system to prevent accidental choking and in-bed suffocation. The monitoring system will be accessible to the user through the smartphone. There are three major components in the system which are the monitoring part, the alarm part, and the smartphone device. The system has some disadvantages, such as the fact that it is only suitable for babies aged one year or younger. The following limitation in this project is that it does not provide a cry detection feature, thus not support the wake up or sleeping baby's condition.

Patil S. P. invented a smart baby monitor system based on GSM. The project aims to provide children with better care [12]. The significant parameters in the project were monitoring the condition of the child, such as temperature, humidity, pulse rate, infant movement, and its use of the GSM network. The collected data and information about the child will be sent to the parents with an alarm system. All part of the system was controlled by one microcontroller. There are some disadvantages to the system which it cannot communicate with the mobile application. The notification alert not transferred through any application on the phone. The next disadvantage of the project is that it does not have a real-time monitoring system. This system also does not provide a cry detection feature and does not support awake or sleep feature detection.

Sad facts but true that is many children being left without company in vehicle lead to the death of the children every year. A child can often be forgotten or neglected by a car driver [13]. Rhonda Borgne et al. introduces an alarm system that can help to remind or give an alert to an adult of a child's presence in a car. The project includes the child detector that can detect the presence of children on the child safety seat using a weight sensor with a weight activating circuit. This project integrated the child detector coupled to a child safety seat. The whole system can be operated when a key is not in the ignition. The coordination with the vehicle alarm system, the child detector is used to give a reminder to the driver that a child is conquering a child safety seat. The limitation of this project is that there is no monitoring system thus, no IoT platform used embedded in the system. The warning system limited only to alarm produced by the car.

A recent Internet of Things (IoT) developments has led to renewed attention in the child safety division. By incorporating the IoT technology into the child safety division, K. N. Khamil proposed research on the Baby Care Alert System for Prevention of Child Left in A Parked Vehicle [14]. This system was designed to provide parents with a notification or alert using the essential tools that most people have, such as smartphones. Two key components were included in the design, which are the safety pad and the keychain alarm device. For the first part, a load sensor used to sense the child's presence was placed in a safety pad inside the child's car seat and alert parents through a smartphone. The second part is keychain alarm devices that will work as a backup security feature for users in case of an emergency where the smartphone's battery has been used up or missing. This feature use RF transceivers. A warning alarm will be activated on the device as soon as parents walk outside the RF signal range. The limitation in this project was that the IoT platform used to transmit the data uses an RF signal. The range of coverage for the RF signal is too small. The system also did not provide the real-time monitoring system of the child.

The traditional technique for monitoring the vital signs of an infant requires the parent's direct supervision. Sometimes, specific physiological changes that may be of concern are difficult to identify. Gupta S invented the baby health monitoring system by using detectors located within baby clothes and linked via wireless connectivity [15]. This system includes fully integrated sensors for electrocardiography, temperature and carbon dioxide placed around the baby's bed. A real-time signal is provided in this health monitoring system for any variations in the status of the infant. Sudden death generally occurs during sleep without any alarm and warning, which is why it is hard to identify and foresee. Therefore, this monitoring system will be an efficient way to predict the occurrence of sudden death. However, the system does have some cons, such as it is not compatible with the mobile application. The system also does not include with a cry detection feature.

Patel P. B invented the system that uses motors and infrared sensors to make the Raspberry Pi connected to the static camera with the dynamic motion of the camera [16]. In order to cover all directions, the camera needs to be put in the center of the room. The system can stream the captured video online. All the information and updates can be access by parents. In addition, Raspberry Pi is linked to a GSM module that sends alert notifications whenever the camera rotates. The disadvantage of the system is that it only provides audio and video for monitoring purpose.

Despite the awareness campaign raised by the government on the safety of children in the non-moving car, the cases of children being trapped and suffocated in unattended vehicles continue to grow [17]. Sulaiman N. proposed that the voice, odor, motion and temperature detectors help the system to recognize any signal generated from the vehicle's cabin. Parents will receive a short message due to an efficient feedback system. If no response is given within the specified assignment time, the system will trigger the vehicle's horn. In this instance, the system will lower the vehicle's window to release all toxic gas, reducing the temperature. The limitation of the project is the lack of a real-time monitoring system so that the parents only get the notification only if a bad thing already happen to the child.

The design of the advanced Raspberry Pi baby monitoring system is proposed by Pereira S. C. [18]. The product provides a reliable and effective baby monitor system that can play a vital role in providing any infant with better protection. Parameters such as air moisture, temperature, infant movements are also monitored using the sensor. The sleep sequences of the baby are recorded, which means the baby can be monitor in real-time by parents. The parameter details are sent by the alarm to the parents to take any action if it occurs. This system only limited to observe the child that’s mean no actuator will take action if bad things already happen.

Preterm birth, more commonly referred to as premature birth, is a baby below the gestational age of thirty-seven weeks or less than two kilograms in weight [19]. Ishak D. N. F. M. introduces the project that can record, store, and transmit any observed information related to premature birth to a computer. The data recorded will be transmitted by personnel in the NICU for diagnostic or research studies. This project uses an incubator containing sensors to measure the amount of humidity and heart rate. Both sensors embedded with the observation system. In particular, to monitor the heartbeat, the sensor needs to link with the baby. The measured results, such as humidity level and pulse rate, are sent to the computer via the interface of the

Arduino device. This system has some disadvantages, such as it is not compatible with a mobile application. The following disadvantages of the system are that it does not implement the IoT technology.

Body temperature is crucial physiological data to track in monitoring systems. Aktas F. proposed a project that uses mobile devices based on Android operating systems with sensors such as finger heartbeat, body temperature, humidity and sound detection [20]. The system presented a real-time infant monitoring system. In particular, children's physiological information will be monitored and will produce alarms in any abnormal situations. One of the Arduino boards is dependent on the implementation of this system. Smartwatches and smartphones were used to report alarms based on the Android operating system. The data collected from the implementation results were observed and sensed by the appropriate sensors, showing any abnormal conditions, and the alarms will be turned on. This system can only be linked to a mobile application via Bluetooth, which has less range in the coverage area.

Once a car is turned off and parked with the entire windows closed, there will be a rapid increase in temperature. This condition can lead to heatstroke or hyperthermia, which can be fatal [21]. Baid invented the system based on an optical detector, a mechanical switch and a temperature sensor. The system provides the vehicle ignition monitor to confirm the presence of a driver in the car. A temperature sensor inside the car helps to keep track of the current temperature in the car. As soon as a child on a baby seat left in a turned-off car is detected, the GSM module is used to alert the driver or parents. This system has some limitations: the optical or thermal sensors are bad in detecting child in a blanket or thick cloth.

A car parked under the sun will make temperatures increase very quickly and reach a dangerous level in less than 20 minutes. The project uses RF signals to detect the vital signs by integrating a sensor behind the headliner of the vehicle was proposed by Mousel [22]. The sensing unit emits signals in the 24 GHz ISM band, and the reflected signal is evaluated. The system is sensitive to the movement of a sleeping baby and even able to detect the child under tough circumstances. Once a baby's presence is detected, it will initiate different alerts or countermeasures. The most significant function in the project was the vehicle-based sensing approach, as it can potentially use the entire available infrastructure of the vehicle to initiate cautions and countermeasures. However, the IoT technology is not implemented in this project.

In order to avoid the deaths of in-car infants, Pires proposed a project that is capitalizing on low-cost technologies that can be easily integrated into the vehicle [23]. The idea of the system is to integrate two approaches as inputs, a motion sensor and a camera, while notifying the driver via SMS. A division was created to study the benefits, resulting in an affordable approach that uses the motion sensor and others expected to be more trustworthy, consisting of human detection through vision algorithms. While the integrated system is idealized to recognize the children inside the vehicle optimally, a potential standalone application based on the studies carried out. The disadvantage of the system is that the notification system limited to SMS.

2.3 Literature Review Matrix

Table 2.1 shows the literature matrices of gathered information regarding the baby's presence detection system from the previous studies.

Table 2. 1 Literature matrix of the previous study

No.	Author (Year)	Title	Description	Sensor used
1	Victor H. Rams Jr. (2006)	Child occupancy detection system	Activate the alarm system when the child seat strap is inserted into the belt buckle	Load
2	Charles J. Cole (2014)	System to detect the presence of child in a vehicle	Detect the unattended child in a vehicle and give alarm warning	Pressure Temperature
3	Annouri J. (2014)	Knight's Wireless Baby Monitor	Baby monitoring system with full sensors that located on top of the baby's bed.	Temperature, motion, sound
4	Patil S. P. (2014)	Intelligent Baby Monitoring System	Monitor parameters such as temperature, humidity status, pulse rate, movement of an infant.	Temperature, humidity, motion
5	Rhonda Borgne et. Al. (2015)	Child safety seat alarm	Seat alarm for child safety if unwanted thing happens	Pressure
6	K. N. Khamil (2015)	Baby care alert system for	Reminder system that includes a safety pad fixed into a child car	Load

		prevention of child left in a vehicle.	seat, and a keychain alarm device for the driver.	
7	Gupta S. (2016)	Infant Monitoring System using Multiple Sensors	Health monitoring system that provides a real-time signal of any variations in the infant's status.	Heartbeat, temperature, CO_2
8	Patel P. B. (2016)	Automated Child Monitoring System	Real time monitoring system to the baby condition.	Motion, infrared
9	Sulaiman et al. (2017)	Development of comprehensive unattended child warning and feedback system in vehicle.	System to detect the presence of children in an unmanned vehicle.	Voice, motion, temperature
10	Pereira S. C. (2017)	Advanced Baby Monitor	Monitor and record the activities of infant.	Humidity, temperature
11	Ishak D. N. F. M. (2017)	Arduino Based Infant Monitoring System	Record and save any information about the infant, and then send it to a computer	Humidity, heartbeat
12	Aktas F. (2017)	A Real-Time Infant Health Monitoring System for tough Hearing Parents	Using Android-based mobile devices, a real time monitoring system for hard-of-hearing parents	Heartbeat, temperature, humidity

13	Baid (2017)	Implementation of child presence detector in an unmanned car.	System will trigger the alarm system when it detects child presence when the engine is off	Temperature, sound, infrared
14	Mousel et al. (2017)	Radiofrequency-based detection to reduce heat stroke fatalities.	Reduce the risk of children's heatstroke fatalities using the radiofrequency	Radio frequency
15	Pires, R. (2018)	Vehicle's interior presence detection and notification system	Motion sensor for presence detection and provides alert to the driver.	Motion
16	Mohamad Faiz Bin Norman	Development of User-Centered Smart Child Seat for NCAP Via IoT Platform	Real-time monitoring system integrated with multi-sensor to check the baby's condition that left in a vehicle and provide notification alarm to the parents if abnormal reading detected.	Ultrasonic, temperature, humidity, sound, carbon oxide, heartbeat

2.4 Comparison between previous work and the proposed project

From the literature survey, the comparison is made based on the specific parameter. Table 2.2 shows the comparison between previous work and the proposed work in term of presence detection, real-time monitoring system, warning alarm system, implementation of IoT technology, mobile application and the actuator.

Table 2. 2 Comparison between previous work and the proposed work

System	Features and Characteristic					
	Presence detection	Real time	Warning alarm	IoT platform	Mobile apps	Actuator
[9]	✓	X	✓	X	X	✓
[10]	✓	X	✓	X	X	✓
[11]	✓	✓	✓	✓	✓	X
[12]	✓	X	✓	X	X	✓
[13]	✓	X	✓	X	X	✓
[14]	✓	✓	✓	X	✓	✓
[15]	✓	✓	✓	✓	X	X
[16]	X	✓	X	✓	X	X
[17]	✓	X	✓	X	X	✓
[18]	✓	✓	✓	✓	✓	X

[19]	✓	✓	✓	X	X	X
[20]	✓	✓	✓	X	✓	X
[21]	X	✓	✓	X	✓	X
[22]	✓	X	✓	X	X	X
[23]	✓	✓	✓	X	✓	X
User-Centered SCS	✓	✓	✓	✓	✓	✓

CHAPTER 3

METHODOLOGY

This chapter will cover the procedure and overall approach that is required to complete the project. This project focus on the analysis of user-centered smart child seat through IoT platform. There are two types of data needed to complete this project which is by conducting a Market Survey on SCS and the Product or Prototype Analysis.

3.1 Analysis of User-Centered Smart Child Seat Market Survey

The technique of collecting the data was performed using the questionnaire. It contains items of different instruments, including demographic, multiple-choice questions, likert-scale questions, and open-ended questions. The study of a population-based on age, race, and sex is known as demographic analysis. Demographic data is a statistical representation of socioeconomic information such as employment, education, income, and marriage. Multiple-choice options questions are to indicate the respondent's most preferred activity. Likert-scale questions are a five-point scale used to allow the student to express how much they agree or disagree with a particular statement. Open-ended questions are phrased in the form of a statement that requires a response. The response can be compared to information that is already known to the questionnaire. This questionnaire is divided into parts A, part B, part C and part D. In part A, the question will ask about the demographic background of the respondents. It consists of three questions which are gender, age, occupation and nationality. In part B, generally, the question is whether respondents agree we need to improve the current type of child seat. In part C, the question will ask about the respondent's preference by introducing the real-time monitoring system to the child seat. Lastly, in part D, the question will ask respondent's opinion about the suitable price for desktop and laptop.

In this project, there are 35 respondents gathered through the online survey by using Google forms. The response rate for our questionnaire is relatively high, which is we need two days to achieve a total of 30 respondents. Before going to the analysis phase, the gathered data was prepared. Missing data and outliers were checked in the dataset. For this condition, the “outlier labelling rule” was used [24]. All values outside the calculated range were considered outliers. Finally, the data was then analyzed using Microsoft Excel.

3.2 The User Centered Smart Child Seat system's flowchart

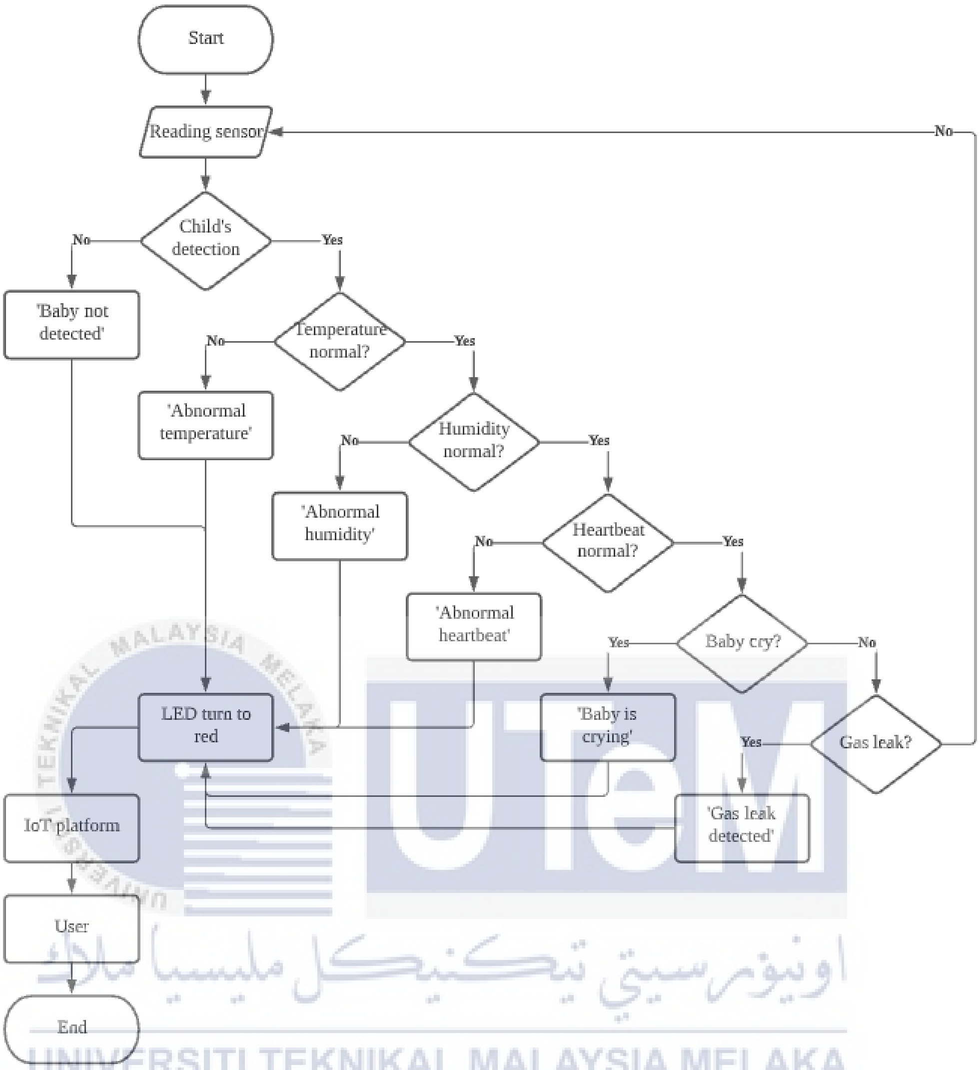


Figure 3. 1 Flow chart of the system

Figure 3.1 shows the flow chart of the system. Based on the flow chart, the process will start if and only if the start button is pressed. In this project's first task, the device will be connected to the internet through a Wi-Fi module. Next, it will start reading all the sensor by following the sequence. Firstly, it will detect the presence of a child in the seat by using infrared sensors. If there is no baby's presence on the child seat, the system will jump to the end-stage, thus send the warning notification to the parents. The following sequence of the parameter detected by the sensor is the temperature sensor to detect the temperature inside the car, gas leak sensor that detects the combustion gas inside the car, heartbeat sensor that checks the BPM of a child and sound sensor that detects whether the child is crying and lastly. For each sensor stage, if an abnormal condition is present, the parents will get the warning notification through the smartphone via the IoT platform. The system also provides a real-time monitoring system, meaning that the parents can know the child's present condition. In addition, there are also notification indicators to the surrounding such as the LED will be blinking. In this project, the car lamp is replaced by using the LED. All of the element is according to the NCAP standard.

3.3 Block diagram

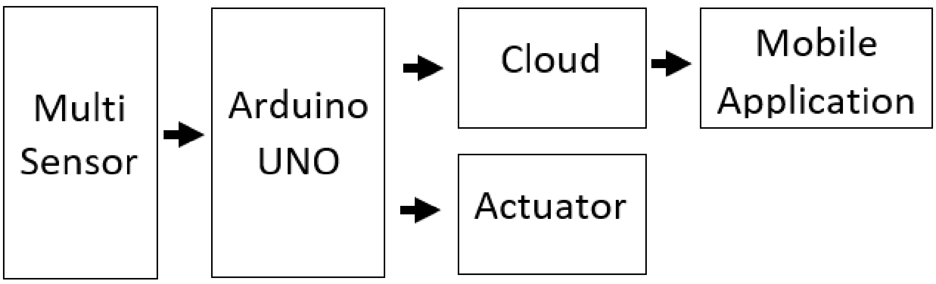


Figure 3. 2 Block diagram of the project

Figure 3.2 shows the block diagram of the system. The system starts with the multi-sensor act as an input indicator to collect the child's condition inside the vehicle. The data next pass to the Arduino UNO microcontroller and then process the data depending on the desired task. The output of the system divided into two-part, which is the actuator and the cloud system. For the proposed project, the actuator will trigger some component to know the action needs to be taken with the vehicle. For the cloud system, the data collected from the microcontroller will be transferred to the mobile application. This output provides a real-time monitoring system regarding the child's current status left inside the car. Parents will get the warning alarm through their smartphone when unwanted things happen to their child.

3.4 Project planning

The concept of smart car will be implemented in this project to provide a safer vehicle. To achieve the objective, several procedures need to be done. Firstly, start with the design of the product that interactive and user friendly. The data from the market survey will be considered to make the finished product. There are many example projects provided in the google search engine as a guideline to design the shape and dimension of this project. The final design is sketch digitally using the CATIA software for 3D printing purpose. Next, the suitable parameter to monitor the child is selected based on the literature review and market survey. Before going to the hardware part, the simulation of the circuit is tested using the NI Multisim software. The designing process and troubleshooting of the circuit can be easily conducted using simulation tools in this software. Next, the coding for the microcontroller is wrote using the Arduino IDE software. Several inputs and output need to be considered depending on the working principle of the entire project. The monitoring and alarm system of the project is using the Blynk interface. Based on the sensor analysis in chapter 2, the selection of the sensor to be used in this project was determined. Next, the circuit design of the project is constructed on the bread board to ensure the functionality and compatibility of the component before the fabrication of PCB. Next, the product will be assembled and ready to test on the user.

3.5 Hardware selection

3.5.1 List of components

Table 3.1 shows the significant list of components used in completing the project.

Table 3. 1 List of components used in the project

Component	Type
3D printing	Ender-3 Pro
Arduino	UNO
Wi-fi shield	ESP 8266
Liquid crystal display	16x2 with I2C
Pulse sensor module	Hw-827
Ultrasonic sensor module	HC-SR04
Temperature and humidity sensor module	DHT11
Gas sensor module	MQ-9
Sound sensor module	KY-038

3.5.2 3D printing

The process of creating three-dimensional solid objects from a digital file is known as 3D printing [25]. The digital file must in STL format. Additive manufacturing processes are used to create 3D printed objects. An object is created in an additive process by laying down successive layers of material until the object is complete. Each of these layers can be viewed as a cross-section of the object that has been thinly sliced. Subtractive manufacturing, which involves cutting a piece of metal or plastic with a milling machine, is the opposite of 3D printing. As a result, 3D printing creates less material wastage.

3.5.3 Arduino

Arduino Uno is a microcontroller board based on the ATmega328 [26]. It has 20 pins that can be programmed as either input or output, 6 of the pins can be used as PWM outputs, and six can be used as analogue inputs. There also have a USB port, a power jack, a programming header for the in-circuit system, and a reset button. To power up the Arduino, connect it to a computer via USB, or use an AC to DC adapter or battery. Programs can be loaded onto it from the computer program Arduino IDE. The Arduino board has several general pin functions: LED, VIN, 5V, 3.3V, GND, IOREF, and Reset. There also have special pin functions such as pin RX, TX, PWM and SPI.

3.5.4 Wi-Fi Shield (ESP 8266)

Arduino Wi-Fi shield allows an Arduino board to connect to the internet, read and write to an SD card using the Wi-Fi and SD libraries [27]. The shield will be stacked on top of an Arduino board to use it. The data and sketch can be uploaded to the board by connecting them to the computer using a USB cable. As the sketch has been uploaded, the board can be powered up using any other type of power supply, such as a battery.

3.5.5 Liquid Crystal Display (LCD) (16x2 with I2C)

The LCD is an electronic display module that produces a visible picture using liquid crystal [28]. It consists of a 16-pin configuration and operates at a power source of about 4.7 (V) to 5.3 (V). The current consumption is also reasonably acceptable at 1 (mA) without a backlight. The LCD allows the device, as long as it is pre-programmed, to display numerals and alphabets. The LCD has two registers which are command and data. The display command is stored in the command register, and the data to be displayed is stored in the data register. The LCD will display various characters and symbols by placing the instructions in the instruction register. There is also a potentiometer that can be used to adjust the contrast of the LCD via the VEE pin. The pin set to 'HIGH' is the bits that are written to a register starting from the D0-D7 data pins.

3.5.6 Pulse sensor module (Hw-827)

A pulse sensor is a device that measures heart rate, and it consumes around 3.3 (V) to 5.0 (V) supply to operate [29]. This sensor has an analogue type signal as the input. The sensor can be worn on the finger. It also comes with an open-source app that can show heart rate in real-time with graphs like the Blynk application. The heart rate sensor is essentially an optical heart rate sensor with an amplifier and noise cancellation circuit built-in. The pulse sensor's operation is straightforward and clear. The light-emitting diode and ambient light sensor are connected on the first surface of this sensor. On the second surface, the circuit is connected, which is accountable for the noise cancellation and amplification. The LED is placed above a vein in the human body, such as an ear tip or a fingertip, but it must be placed directly on top of a layer. Once the LED is positioned on the vein, it begins to emit light. There will be a flow of blood within the veins when the heart is pumping. So, if we check the blood flow, we can also check the heart rates. If blood flow is detected, the ambient light sensor will receive more light because blood flow will reproduce it. This minor variation in obtained light can be examined over time to determine our pulse rates.

3.5.7 Ultrasonic sensor module (HC-SR04)

Ultrasonic sensors operate by emitting sound waves at a frequency that humans cannot hear. This sensor, also known as a transducer, operates on the same principles as a radar system [30]. An ultrasonic sensor can convert electrical energy into acoustic waves and vice versa. The acoustic wave signal is an ultrasonic wave with a frequency greater than 18 (kHz). A microcontroller is typically used to communicate with an ultrasonic sensor. The microcontroller sends a trigger signal to the ultrasonic sensor to begin measuring the distance. When activated, the ultrasonic sensor emits ultrasonic wave bursts and starts a timer. The timer stops as soon as the reflected signal is received. The ultrasonic sensor produces a high pulse with the same duration as the time difference between the transmitted ultrasonic bursts and the received echo signal.

3.5.8 Temperature and humidity sensor module (DHT11)

Humidity is referred to the amount of water in the surrounding air. The DHT11 sensor is made up of a capacitive humidity sensing element and a thermistor for temperature sensing [31]. A moisture-holding substrate serves as a dielectric between the two electrodes of the humidity sensing capacitor. The capacitance value changes as the humidity level changes. This sensor uses a negative temperature coefficient thermistor to measure the temperature, which causes its resistance value to decrease as the temperature rises. This sensor is typically made of semiconductor ceramics or polymers to achieve higher resistance values even with minor temperature changes. The temperature range of DHT11 is from 0 (°C) to 50 (°C) with a 2 (°C) accuracy and for humidity range of this sensor is from 20 (%RH) to 80 (%RH) with 5 (%RH) accuracy. DHT11 is a small device with an operating voltage range of 3 (V) to 5 (V). DHT11 sensor has four pins which are VCC, GND, Data Pin and an idle pin. A pull-up resistor of 5 (kΩ) to 10 (kΩ) is provided for communication between the sensor and the microcontroller.

3.5.9 Gas sensor module (MQ-9)

The MQ-9 gas sensor has a high sensitivity to carbon monoxide, methane, and other combustible gases, despite having a low conductivity in clean air [32]. The sensor uses silicon dioxide as a semiconductor. When the surrounding is clean air, there is no free electron means no current flow. When the combustible gas present, the sensor will detect the free-electron thus, the current can flow. It makes detection by cycling high and low-temperature method, and detect carbon oxide gases when the low temperature. The conductivity of the sensor increases as the gas concentration increases. When high temperature, it will detect methane, propane, butane and other combustible gas.

3.5.10 Sound sensor module (KY-038)

The working principle of a sound sensor is similar to human ears. Because human ears contain a diaphragm, the primary function of this diaphragm is to convert vibrations into signals. At the same time, this sensor employs a microphone whose primary function is to convert vibrations into current and voltage. When sound waves strike the sound sensor, a thin piece of material called a diaphragm would vibrate. The vibration of the diaphragm is measured in frequency. It will be converted to the electrical signal by the sensor [33].

3.6 Software selection

3.6.1 CATIA drawing tools

CATIA is a computer-aided design software to simulate, analyze, and manufacture products in various industries [34]. It allows the user to draw and edit digital 2D and 3D designs faster and easier than by hand. The files can also be easily saved and stored in the cloud, where they can be accessed anytime and from any location. The STL file format of the drawing can feed into a 3D printer or a machine for a prototype to be created.

3.6.2 Arduino IDE

Arduino IDE is a platform application for several operating systems such as Windows, macOS and Linux. This application supports the programming languages C and C++ by employing special code structuring rules [35]. The software is used as a platform to write and upload programs to Arduino compatible boards. The Arduino IDE includes a software library from the wiring project that includes various common input and output procedures. User-written code only requires two primary functions, which is setup and the main program loop.

3.6.3 Blynk mobile application

Blynk is an iOS and Android app that allows users to create interfaces for controlling and monitoring hardware projects quickly [36]. By using the widgets, the user can control the output from sensors. Blynk supports most Arduino boards, Raspberry Pi models, the ESP8266, Particle Core, and a few other popular microcontrollers.

3.7 Software development

3.7.1 Declaration

In the root of programming language, there must be a declaration variable of some parameter. This including the library and data type. The purpose of the declaration is to make the program understand the particular command provided by the library. Table 3.2 shows the declaration of all library used in the program.

Table 3. 2 Declaration of all library used in the program

Coding	Description

`#include <SPI.h>`
`#include <SoftwareSerial.h>`
`#include <ESP8266_Lib.h>`
`#include <BlynkSimpleShieldEsp8266.h>`
`#include <DHT.h>`
`#include <Wire.h>`
`#include <LiquidCrystal_I2C.h>`
`#define USE_ARDUINO_INTERRUPTS true`
`#define DHTPin A1`
`#define DHTType DHT11`
`#define ESP8266_BAUD 9600`
`#define EspSerial Serial1`
`#define BLYNK_PRINT Serial`
	#include is use to put the data from the other library source into the program, while #define is use to declare a particular value from the library

`const int presentledred = 13;`
`const int presentledgreen = 12;`
`const int temperatureledred = 11;`
`const int temperatureledgreen = 10;`
`const int humidityledred  = 9;`
`const int humidityledgreen  = 8;`
`const int gasledred = 7;`
`const int gasledgreen = 6;`
`const int echoPin = 4;`
`const int trigPin = 5;`
`int beat;`
`int BPM=0;`
`int soundreading = 0;`
`int sensorValue;`
`float humidity;`
`float temperature;`
`int distance;`
`float sensor_volt;`
`float RS_gas;`
`float ratio;`
`float R0 = 1.38;`
`long duration;`
	All the variable has the specific data type such as const int, int, float and long. For example, 'presentledred' is declare as 13 with the const int data type. When the 'presentledred' is called in the loop function, it means the function call the value of 13. The different of the data type may cause the different number of decimal when performing the mathematical task.

3.7.2 Void setup

The void setup function usually placed at the top of the program. This function will run once since the program start. The void setup used to declare all the pin mode of the microcontroller and start the external source such as LCD, sensors and Wi-Fi. Figure 3.3 shows the coding of the void setup in the entire program.

Table 3. 3 Void setup in the full program

Coding	Description

Serial.begin(9600);
EspSerial.begin(ESP8266_BAUD);
delay(10);
Blynk.begin(auth, wifi, ssid, pass);
dht.begin();
lcd.init();
lcd.backlight();
lcd.clear();
pinMode(trigPin, OUTPUT);
pinMode(echoPin, INPUT);
pinMode(presentledred, OUTPUT);
pinMode(presentledgreen, OUTPUT);
pinMode(temperatureledred, OUTPUT);
pinMode(temperatureledgreen, OUTPUT);
pinMode(humidityledred, OUTPUT);
pinMode(humidityledgreen, OUTPUT);
pinMode(gasledred, OUTPUT);
pinMode(gasledgreen, OUTPUT);
	There is the setup of the serial monitor, Wi-Fi connection, Blynk application, LCD display and the pin mode of the Arduino.

3.7.3 Void loop

Void loop is the program that starts directly after the opening curly bracket and runs until it sees the closing curly bracket. The code is read line by line and jumps back up to the first line in the loop. The loop function will run over and over until the reset button in Arduino is pressed. Table 3.4 showed the void loop with the description in the entire program.

Table 3. 4 Void loop in the full program

Coding	Description

Blynk.run();
beat= analogRead(A3);
soundreading=analogRead(A0);
humidity = dht.readHumidity();
temperature = dht.readTemperature();
digitalWrite(trigPin, LOW);
delayMicroseconds(2);
digitalWrite(trigPin, HIGH);
delayMicroseconds(10);
digitalWrite(trigPin, LOW);
duration = pulseIn(echoPin, HIGH);
distance = duration * 0.034 / 2;
sensorValue = analogRead(A2);
sensor_volt = ((float)sensorValue / 1024) * 5.0;
RS_gas = (5.0 - sensor_volt) / sensor_volt;
ratio = RS_gas / R0;
	Blynk.run is use to connect the microcontroller to the Blynk application. The rest is the command for read all the sensor which are heartbeat, sound, humidity, temperature, ultrasonic and gas ratio.

if(beat>=120)
{
Blynk.setProperty(V0,"color","#FF0000");
}
else if(beat>=55)
{
Blynk.setProperty(V0,"color","#00FF00");
}
else
{
Blynk.setProperty(V0,"color","#FF0000");
}
	The 'if else' loop for the heartbeat measurement. The command used to write some output in Blynk application. The normal reading of heartbeat is set at the range of 55 BPM to 120 BPM.

if (soundreading >=550)
{
Blynk.setProperty(V5,"color","#FF0000");
}
else
{
Blynk.setProperty(V5,"color","#00FF00");
}
	The 'if else' loop for the sound measurement. The command used to write some output in Blynk application. The threshold of sound reading is set at 550 Hz.

if (distance <= 10)
{
digitalWrite(presentledred, HIGH);
digitalWrite(presentledgreen, LOW);
Blynk.setProperty(V4,"color","#00FF00");
}
else
{
digitalWrite(presentledred, LOW);
digitalWrite(presentledgreen, HIGH);
Blynk.setProperty(V4,"color","#FF0000");
}
	The 'if else' loop for the present detection. The command used to write some output in the prototype and Blynk application. The threshold of the distance is set at 10 cm.

if (temperature >= 34)
{
digitalWrite(temperatureledred, LOW);
digitalWrite(temperatureledgreen, HIGH);
Blynk.setProperty(V2,"color","#FF0000");
}
else if(temperature >= 25)
{
digitalWrite(temperatureledred, HIGH);
digitalWrite(temperatureledgreen, LOW);
Blynk.setProperty(V2,"color","#00FF00");
}
else
{
digitalWrite(temperatureledred, LOW);
digitalWrite(temperatureledgreen, HIGH);
Blynk.setProperty(V2,"color","#FF0000");
}
	The 'if else' loop for the temperature reading. The command used to write some output in Blynk application. The normal reading of temperature is set at the range of 25 ℃ to 34 ℃.

<table>
<tr>
<td><pre><code>if (humidity >= 80)
{
    digitalWrite(humidityledred, LOW);
    digitalWrite(humidityledgreen, HIGH);
    Blynk.setProperty(V3,"color","#FF0000");
}
else if (humidity >= 40)
{
    digitalWrite(humidityledred, HIGH);
    digitalWrite(humidityledgreen, LOW);
    Blynk.setProperty(V3,"color","#00FF00");
}
else
{
    digitalWrite(humidityledred, LOW);
    digitalWrite(humidityledgreen, HIGH);
    Blynk.setProperty(V3,"color","#FF0000");
}</code></pre></td>
<td>The ‘if else’ loop for the humidity reading. The command used write some output in Blynk application. The normal reading of humidity is set at the range of 40 %RH to 80% RH.</td>
</tr>
<tr>
<td><pre><code>if (ratio<4)
{
    digitalWrite(gasledred, LOW);
    digitalWrite(gasledgreen, HIGH);
    Blynk.setProperty(V1,"color","#FF0000");
}
else
{
    digitalWrite(gasledred, HIGH);
    digitalWrite(gasledgreen, LOW);
    Blynk.setProperty(V1,"color","#00FF00");
}</code></pre></td>
<td>The ‘if else’ loop for the gas ratio level. The command used to write some output in Blynk application. The threshold of the gas ratio level is set at 4.</td>
</tr>
</table>

3.8 Circuit design

This project is divided into two parts which are the hardware part to measure and control the desired parameter and the software part to monitor and store the specific data. Figure 3.3 shows the raw element and component in both parts. The significant component in the hardware part is the gas sensor, ultrasonic sensor, temperature sensor, humidity sensor, heartbeat sensor, sound sensor, Wi-Fi shield, Arduino UNO, LCD and RGB LED. At the same time, the significant component in the software part is the cloud system and mobile phone application. The Arduino UNO will act as a microcontroller to control all the program in the hardware part. Wi-Fi shield is used to enable the connection of the microcontroller to the W-Fi. All the sensor are used to measure the specific parameter of the child left inside the car. The RGB LED used as an indicator if unnecessary things happen. LCD is used to display important parameters such as current temperature and humidity level. For the software part, the cloud system is used as the data storage medium. The Blynk mobile application is used for monitoring system purpose. All the data transferred to the mobile application via the IoT platform.

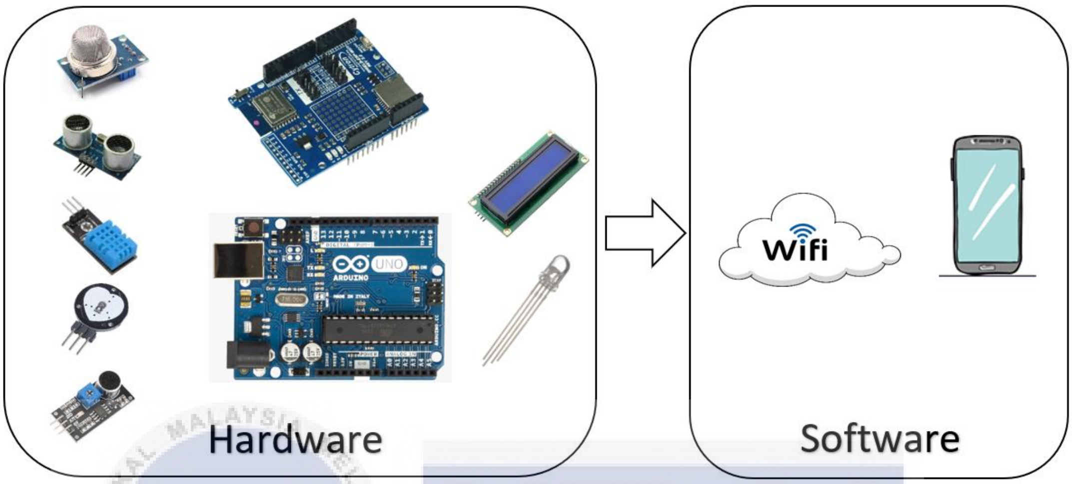


Figure 3. 3 Element in hardware and software

This project uses six pins of Arduino UNO to act as an analogue input, and ten pin acts as a digital output. All the measurement of the sensor is in analogue type and for the output is in digital type. Figure 3.4 shows the circuit design for the overall project. Initially, RGB LED has four pins which are red, green, blue and VCC. However, the output needs to turn the LED in red and green light thus, the blue pin is not to be used. So, one LED will use two pins from the Arduino pinout. All the sensor has three pins which are VCC, GND and signal, so each of them will use one pin from Arduino pinout except the ultrasonic sensor. It has four pins which are VCC, GND, echo and trig. Therefore, the ultrasonic sensor will use two pins from Arduino. For the LCD, it will use two pins of the Arduino. Therefore, all pin in the Arduino will be used for the overall project. Table 3.5 is the detailed pin configuration of Arduino UNO.

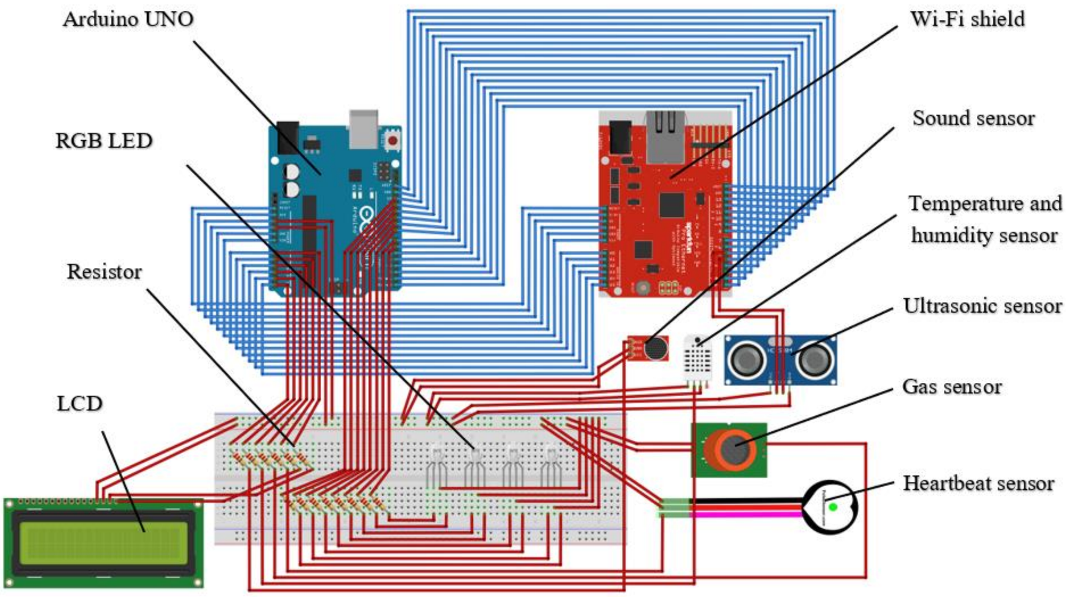


Figure 3. 4 The overall circuit connection sketch in Fritzing software

Table 3. 5 Pin configuration for Arduino UNO

Pin	Destination
A0	Sound sensor
A1	Temperature and humidity sensor
A2	Gas sensor
A3	Heartbeat sensor
A4	SDA LCD display
A5	SCL LCD display
D0	RX Wi-Fi
D1	TX Wi-Fi
D2	Wi-Fi shield
D3	Wi-Fi shield
D4	Echo ultrasonic sensor

D5	Trig ultrasonic sensor
D6	Green LED for gas sensor
D7	Red LED for gas sensor
D8	Green LED for humidity sensor
D9	Red LED for humidity sensor
D10	Green LED for temperature sensor
D11	Red LED for temperature sensor
D12	Green LED for ultrasonic sensor
D13	Red LED for ultrasonic sensor

CHAPTER 4

RESULTS AND DISCUSSION

This chapter will discuss the results obtained from the experiment. Then, to achieve the project's objective, we will analyze the gatherer's results. Finally, all the data and figures are recorded with some discussion and explanation.

4.1 Market survey analysis

The market survey has been done by developing the questionnaires about the user requirement of the project. The data from 35 respondents have successfully been collected to support the finding in this project.

4.1.1 Part A: Demographic

In the distributed questionnaire, the first part type of instruments is about the demographic data of the respondent. The target user of SCS is for the parents that have a child. So, the most relevant question in this part is gender and age. The data should be balance thus, there will be no bias in the next part. Figure 4.1 shows the gender and the age of the respondent. 60% of them are male, and the rest are female. Meanwhile, the distribution age of the respondent is 61.8% is 20-25 years old, 32.4% is 26-30 years old, and the rest is around 30-35 years old. The collected data in both sections show that the questionnaire is balanced distributed to the respondent. No bias would occur in the next section.

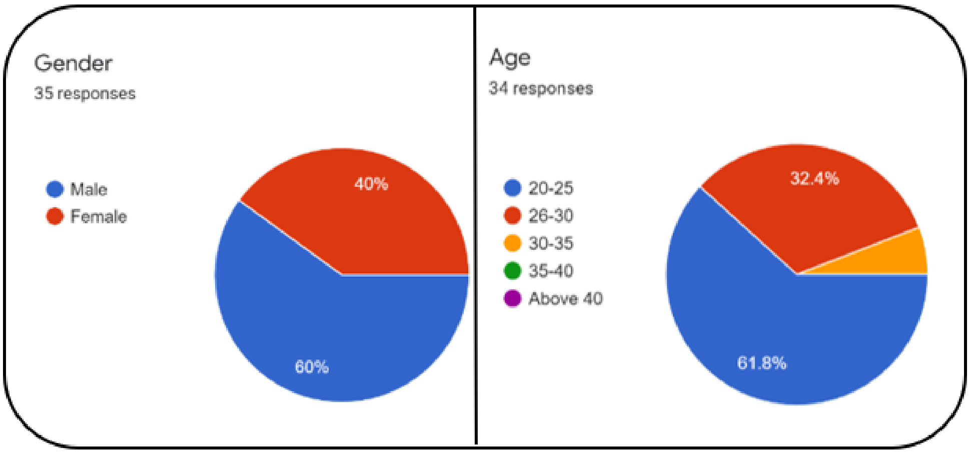


Figure 4. 1 Gender and age of the respondent

4.1.2 Part B: Close-ended questions

Table 4. 1 Part B of the market survey

No.	Question	Yes (%)	No (%)
1.	Does baby car seat can prevent the unnecessary incident?	100	0
2.	Does introducing a monitoring system for baby car seat will give a good impact?	100	0
3.	Does implementing IoT into the baby car seat will improve the child monitoring system?	100	0
4.	Does IoT system will make the child monitoring system user-friendly?	97.1	2.9
5.	Does car seat need a temperature sensor to measure temperature inside the car?	97.1	2.9
6.	Does car seat need a heartbeat sensor to measure the heart rate of the baby inside the car?	74.3	25.7
7.	Does car seat need a carbon monoxide sensor to detect harmful gas leak inside the car?	100	0

Table 4.1 shows the part B question in the market survey. From the distribution data, all respondents agree that baby car seats can prevent unnecessary incidents. The respondent also agrees that introducing a monitoring system for a baby in the car seat can positively impact the user. By implementing IoT into the baby car seat, the respondent believes it will improve the child monitoring system. The majority of the respondents agree that the system will become user-friendly by implementing an IoT

system to the baby car seat. Next, majority of the respondent agrees that baby car seat need a temperature sensor to measure the temperature inside the car. Most respondents agree that the baby car seat needs a heartbeat sensor to measure the baby's heart rate inside the vehicle. Finally, all respondents agree that baby car seats need a carbon monoxide sensor to detect harmful gas leaks inside the car.

4.1.3 Part C: Likert scale

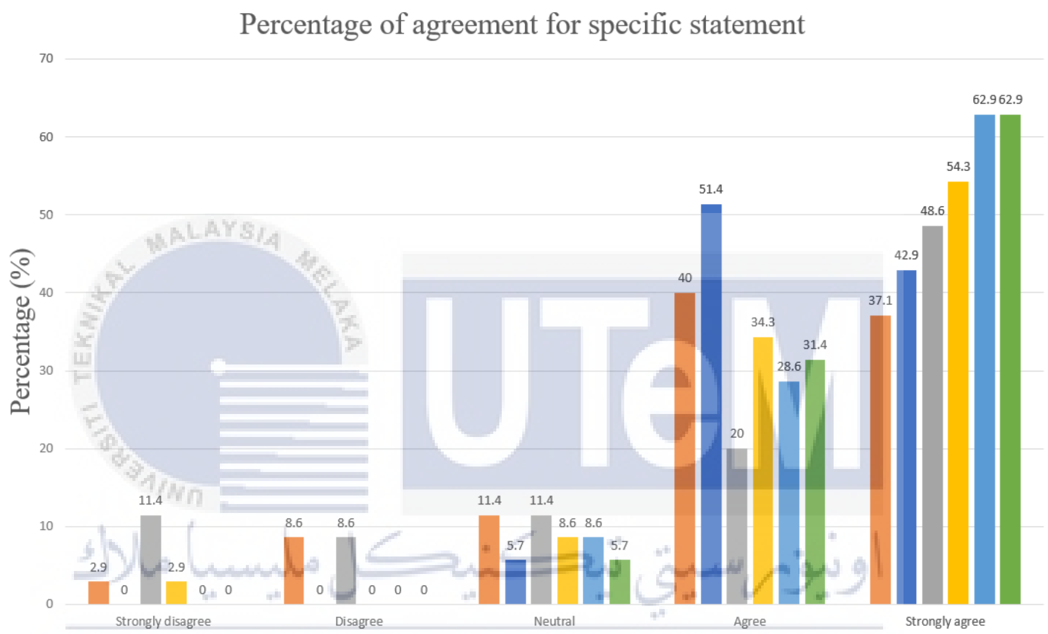


Figure 4. 2 Percentage of agreement of particular statement

- Current baby car seat is user friendly
- Current system for baby's car seat provides user interface to monitor baby's condition
- Current baby's car seat can prevent heat stroke if the baby left inside the car
- Smart Child Seat are easy to monitor the baby's condition by using the temperature, humidity, heartbeat, and gas leak sensor
- If a IoT is implemented in this project, baby monitoring process would be easier
- Smart child seat is unique and can be commercialized

Figure 4.2 shows the percentage of agreement from the respondent on a particular statement. For the first statement, which is 'current baby car seat is user friendly', the graph shows 0% of respondents strongly disagree, 0% choose to disagree, 5.7% are neutral, 51.4% choose to agree, and 42.9% strongly agrees with the statement. From the data distribution in the bar graph, our respondent tends to agree with this statement. For the second statement, ' current system for car seat baby monitoring can provide a user interface to monitor baby's condition' gives the result 2.9% of respondent strongly disagree, 8.6% choose to disagree, 11.4% is neutral, 40.0% choose and 37.1% strongly agrees. From the data distribution in the bar graph, our respondent tends to agree with the statement. Third, the statement' current baby car seat can prevent heat stroke if the baby left inside the car' gives the result 11.4% of respondent strongly disagree, 8.6% choose to disagree, 11.4% is neutral, 20.0% choose to agree, and 48.6% is strongly agreed as shown in Figure 4.2. From the data distribution for this statement, our respondent tends to agree with it. For the following statement, which is 'Smart child seat is easy to monitor the baby's condition by using the temperature, humidity, heartbeat, and gas leak sensor', 2.9% of respondent strongly disagree, 0% choose to disagree, 8.6% is neutral, 34.3% choose to agree, and 54.3% strongly agrees with the statement. The data shows that the respondent tends to agree with the statement. Furthermore, 0% of respondents strongly disagree, 0% choose to disagree, 8.6% are neutral, 28.6% choose to agree, and 62.9% strongly agrees with the statement 'If IoT is implemented Smart Child Seat, baby monitoring process would be easier'. From the distribution data in the bar graph, most of the respondents also agree with the statement. Finally, the statement 'Smart child seat is unique and can be commercialized' give the result 0% of respondent strongly disagree, 0% choose to disagree, 5.7% is neutral, 31.4% choose to agree, and 62.9% strongly agrees. From the graph, all the data slightly shows the respondent agrees with all the statements. All the given statement is related to the positive side on making of this project. When the result is biased to the agreement of the statement, it shows that by developing the SCS, it will give a good impact to the future.

4.1.4 Part D: Open-ended questions

Do you have any additional comments or suggestions? If YES, please fill in the box below

20 responses

- Good innovation
- Good project
- Superb project
- No need heartbeat detection

Note: There is the top four most repeating answer for this question.

Figure 4. 3 Comment and suggestion from the respondent

In part D, the question is compulsory to the respondent but not mandatory to answer. From 35 of the respondents, only 20 persons answer this question. Figure 4.3 shows the most frequent answer for the question. The majority of the respondent says the project is good. However, some respondents say there is no need for heartbeat detection to the baby left inside the car.

4.2 Prototype Analysis

The project includes the dimension, circuit simulation, serial monitor, circuit board printing, Blynk application, and real-time monitoring system for the prototype testing. The prototype is designed using CATIA software, and it is compliant with the market survey for user-friendly purposes. For the on-board simulation circuit, the critical parameter such as low power consumption which use constant 7 V direct current voltage and minimization of the circuit route is applied to raise user interest in the product, thus making them sustainable in the long term. The sensor was first calibrated in the serial monitor using the Arduino IDE software before the assembling process to the final product. For the IoT application, the Blynk application is being used as the platform. The user interface was designed in two modes which are dark mode and light mode, so the user can choose the interface depending on their preferences. The alarm and notification system is also included in the Blynk application. Users or parents can monitor the baby's condition in real-time using by using this system. Besides that, the monitoring system also provides the data in others timeframes to the user. All the data is collected and saved using the Blynk cloud system. It also can be exported to Microsoft excel for tracing data purposes.

4.2.1 CATIA drawing

The digital sketch of the final product is made in CATIA software tools. The drawing is divided into the bottom casing and the top casing, as shown in Figure 4.4 and Figure 4.5, respectively. For both parts, the sketch of the top view, front view, right view, an isometric view using the scale of 1:2. The dimension of the product is 116 mm in length, and the width is 184 mm. When the product is assembled, the total height is 71 mm.

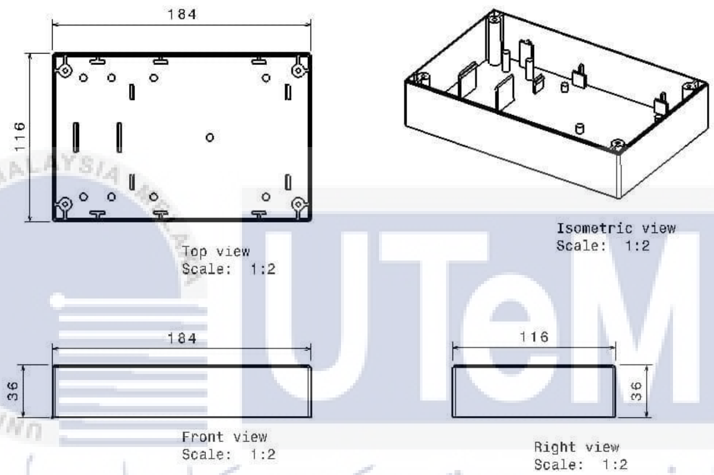


Figure 4. 4 Dimension of bottom casing

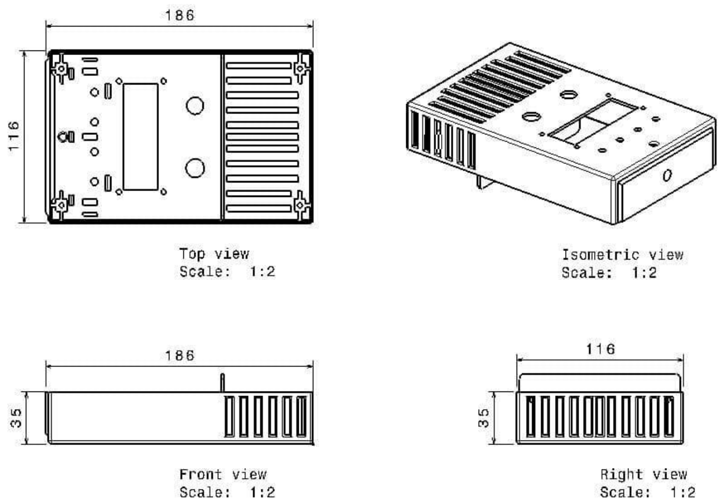
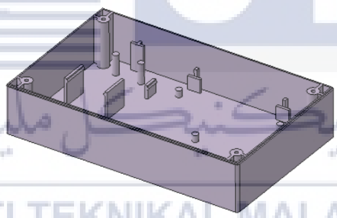
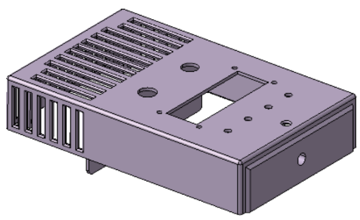
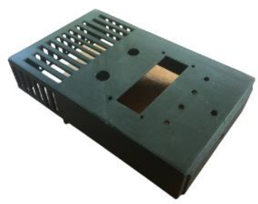


Figure 4. 5 Dimension of top casing

4.2.2 Digital sketch vs 3D printing

Table 4.2 shows the digital sketch and 3D printing results. The digital sketch is made in CATIA software tools, while the sketch is print using the Ender-3 Pro. The file format for the digital drawing is an STL file thus, enable it for the printing purpose. The printing process is done by laying down successive layers of material until the object is complete. Each of these layers can be viewed as a cross-section of the object that has been thinly sliced. The printed object is using the PLA material with a wall thickness of 2 mm. As a result, the casing is tough enough to hold all the components inside.

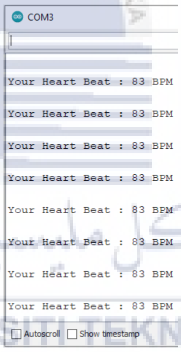
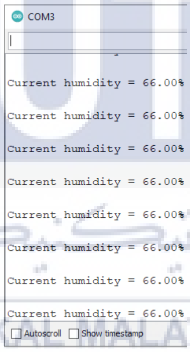
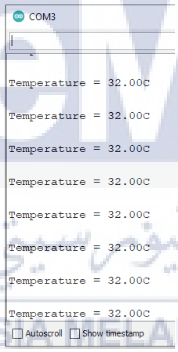
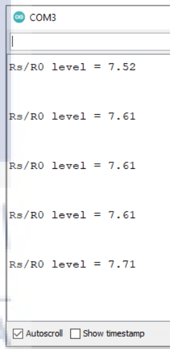
Table 4. 2 Digital sketch versus 3D printing results

	Drawing	Printing
Bottom casing		
Top casing		

4.2.3 Serial Monitor testing

The programming for the microcontroller is done in Arduino IDE software. All the sensors first were calibrated and get the reading using the serial monitor. Table 4.3 shows the serial monitor's results of all sensors in Arduino IDE software. The serial monitor shows the heartbeat reading is 83 (BPM), the humidity level is 66 (%RH), the temperature level is 32 (°C), and the gas ratio is 7.52. All the readings are tally with the onboard testing and Blynk application testing that will be discussed later.

Table 4. 3 Serial monitor of all sensors in Arduino IDE software

Parameter	Heartbeat	Humidity	Temperature	Gas ratio
Serial monitor				

4.2.4 On board testing

Figure 4.6 shows the result initial state of when a child is in good condition. All the LED is green in color meaning that all the sensor's reading is normal. The LED will turn red if the particular sensor's reading reaches the threshold value.

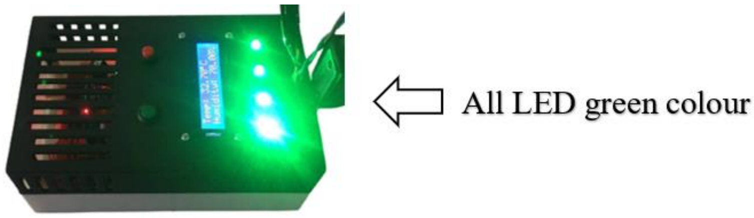


Figure 4. 6 Initial states when child's condition is good

Figure 4.7 shows the result when there is no presence of baby inside the child seat. LED 1 represents the baby detection inside the child seat. This LED will turn red as there is no presence of a baby inside the child seat.

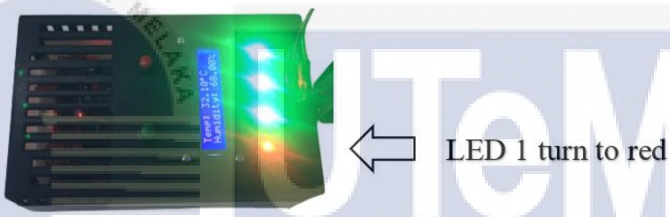


Figure 4. 7 Output when the child's presence not detected

Figure 4.8 showed the result when the abnormal temperature is detected. LED 2 represents the temperature status inside the vehicle. The range of normal temperature inside the vehicle is from 25 (̊C) to 34 (̊C). When LED 2 turns red, the temperature inside the vehicle is either higher or lower than the threshold value that can lead to death.

Figure 4. 8 Output when abnormal temperature detected

Figure 4.9 showed the result when abnormal humidity was detected. LED 3 represents the humidity status inside the vehicle. The range of normal humidity for humans in a close room is from 40-80 (%RH). The outnumber of the humidity level led the LED 3 to turn red.

Figure 4. 9 Output when abnormal humidity detected

Figure 4.10 shows the result when the combustion gas is detected. LED 4 represents the gas level status inside the vehicle. The combustion gas measured using the ratio particle per minute of carbon oxide. The higher ratio represents the clean air which around 4 to 12. When the gas sensor's reading is out from the normal range, LED 4 will turn red.

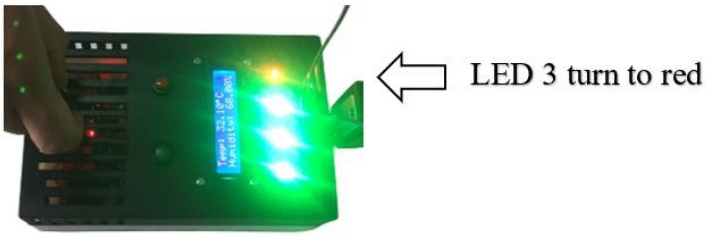


Figure 4. 10 Output when combustion gas detected

4.2.5 Blynk application testing

This project provides a monitoring system for the child that is left in a car. Figure 4.11 shows the user interface in the Blynk mobile application. There are four parameters displayed in a meter form, while two parameters are displayed in the light form. The two lights represent the presence and cry detection. The meter form represents the heartbeat, gas level, temperature, and humidity reading. For the heartbeat measurement, the meter range is from 0 (BPM) up to 150 (BPM), and the normal reading is around 55 to 120 (BPM). Next, the meter for the gas ratio is from 0 to 10, and the clean air is defined as the ratio higher than 4. For the temperature sensing, the meter range is set from 0 to 100 (°C). The normal reading for temperature should be 25 (°C) to 34 (°C). Finally, the humidity meter sensor is programmed from 0 (%RH) to 100 (%RH), and the normal range is around 40 (%RH) to (80%RH). The concept is simple where there is an abnormal reading by the sensor, the green color will turn red. Table 4.4 shows the result and description when the sensor reaches the threshold value.

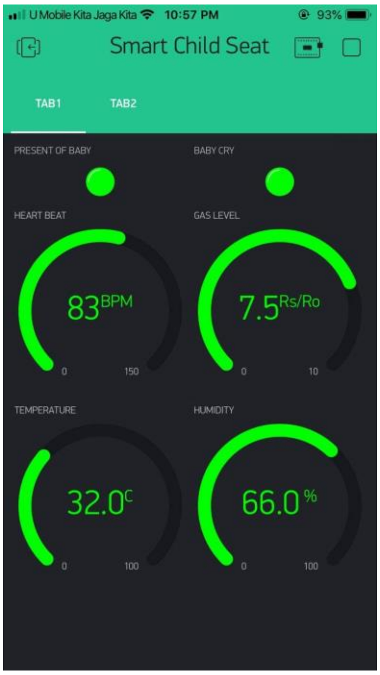
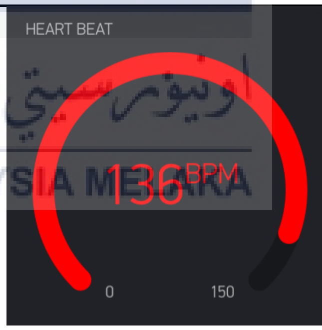
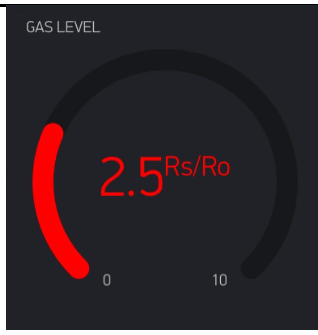
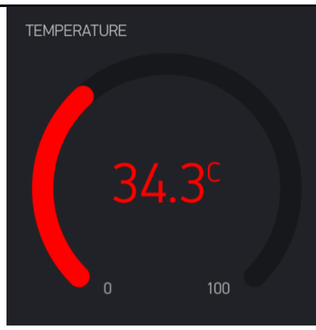
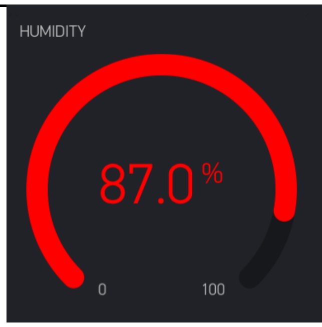


Figure 4. 11 User interface in the Blynk mobile application

Table 4. 4 Result and description when the sensor reaches the threshold value

Description	Monitoring alert
Heartbeat is 136 (BPM) and it is higher than the threshold value	
Gas ratio level is 2.5 and it is lower than the threshold value	

Temperature reading is 34.3 (̊C) and it is higher than the threshold value	
Humidity level is 87 (%RH) and it is higher than the threshold value.	

4.2.6 Monitoring system

In the Blynk application, the system provides the data of the monitoring system in real-time. In simple words, parents or users can monitor the child's condition in a live timeline. The graph represents the four most important parameters in monitoring purposes which are heartbeat, gas, temperature, and humidity level, as shown in Figure 4.12. The data gathered for all the sensors almost stays at the same point, such as heartbeat reading stays around 70 (BPM), gas ratio level stays around 80, the temperature stays around 30̊C and humidity level stays around 75 (%RH). The situation happens due to the live monitoring system where the timeframes are too short. At the bottom left of the interface, users or parents can change the timeframes into 15 minutes, 30 minutes, one hour, one day, one week, and one month as shown in Figure 4.13. It means that they can track and trace the previous data for up to 1 month.

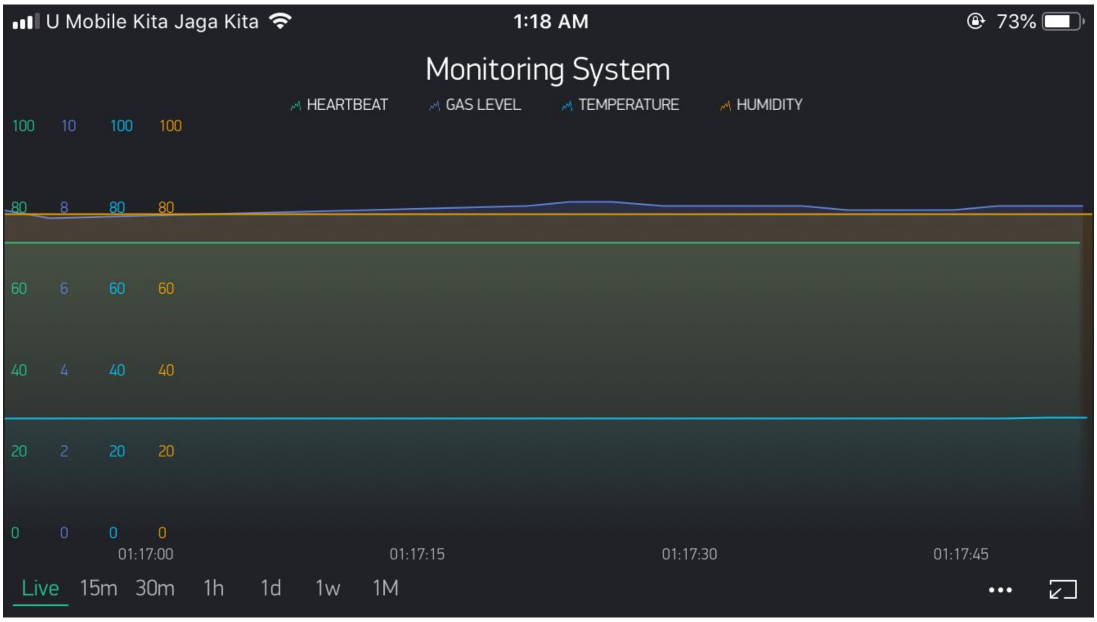


Figure 4. 12 Real time monitoring system represent by line graph

Figure 4. 13 Different timeframes in the user interface

4.2.7 Analysis

Initially, this system uses the Blynk cloud to store the data. With the modification of the program, all the data is transferred to Microsoft Excel for analysis purposes. With Microsoft excel, parents or users can trace and track the instantaneous value of a particular sensor. Figure 4.14 shows the data in Microsoft excel that have been converted to the line graph. The data is collected based on the given situation:

I. Hot day

II. Air conditioner is turn on

III. Combustion gas applied

The constructed graph is based on the 20 minutes of the data. In the graph, the red color represents the heartbeat reading, the blue color represents the humidity level, the black color represents the temperature level, and the green color represents the gas ratio level. Table 4.5 shows the summarization of sensor reading at a particular time.

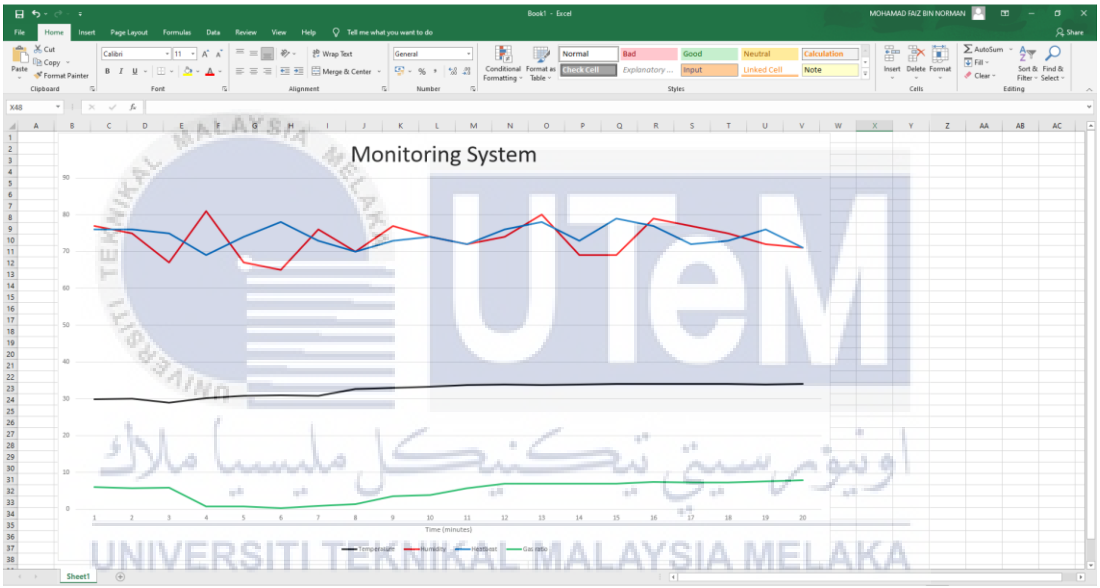


Figure 4. 14 Monitoring system in Microsoft excel

Table 4. 5 Summarization of sensor reading in a particular time

Time (minute)	Temperature (̊C)	Humidity (%RH)	Heartbeat (BPM)	Gas ratio (RS/RO)
1	29.9	77	76	6.0
2	30.0	75	76	5.7
3	29.0	67	75	5.9
4	30.2	81	69	0.7
5	30.8	67	74	0.7
6	30.9	65	78	0.3
7	30.8	76	73	0.9
8	32.6	70	70	1.4
9	33.0	77	73	3.6
10	33.2	74	74	3.9
11	33.8	72	72	5.7
12	33.9	74	76	6.9
13	33.7	80	78	6.9
14	33.9	69	73	7.0
15	34.0	69	79	7.0
16	34.0	79	77	7.4
17	34.0	77	72	7.2
18	34.0	75	73	7.2
19	33.9	72	76	7.5
20	34.0	71	71	7.8

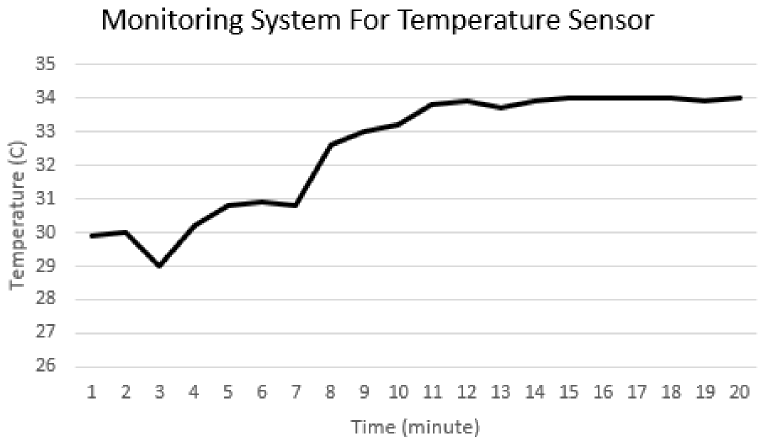


Figure 4. 15 Graph of temperature level for 20 minutes

Figure 4.15 shows the graph of temperature level for 20 minutes. The graph initially shows that the temperature reading is below 30 (̊C) and keeps increasing until 34 (̊C). It means that the temperature inside the car will increase on a hot day although the air conditioner is turned on.

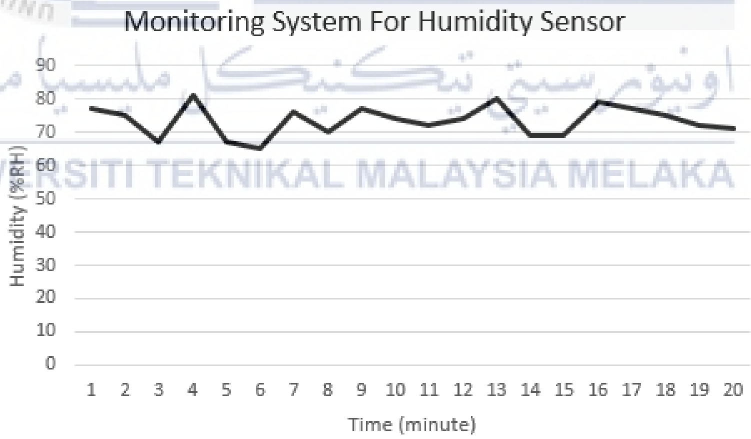


Figure 4. 16 Graph of humidity level for 20 minutes

Figure 4.16 shows the graph of humidity level in 20 minutes. From the graph, the lowest and highest humidity level is around 60 (%RH) and 82 (%RH) respectively. The reading is in the normal range, meaning that it does not affect the humidity level inside the car with the three-situation stated earlier.

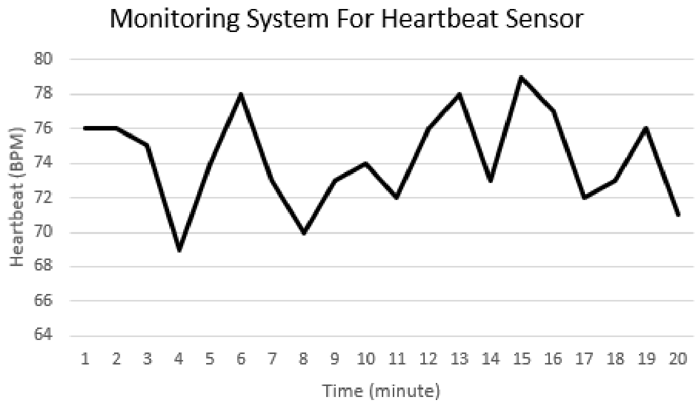


Figure 4. 17 Graph of heartbeat reading for 20 minutes

Figure 4.17 shows the graph of heart rate in 20 minutes. The heart rate is measured in BPM, meaning that it is not a constant reading. From the graph, the heart rate shows the normal reading of around 65 (BPM) to 80 (BPM), thus telling the user their child is safe.

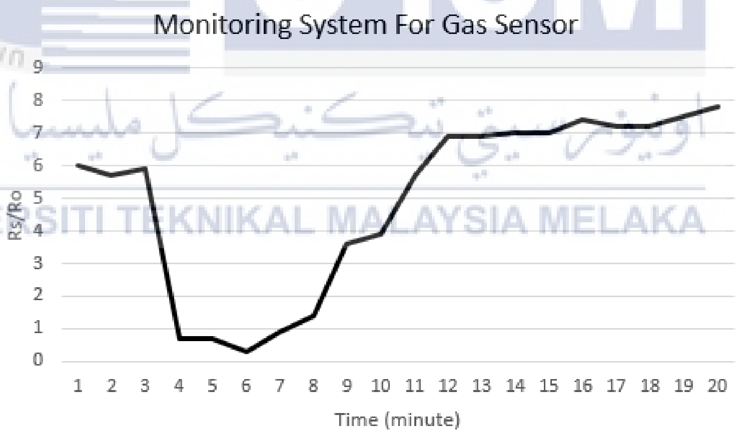


Figure 4. 18 Graph of gas ratio level for 20 minutes

Figure 4.18 shows the graph of gas ratio level in the 20 minutes. One of the situations given for the testing is combustion gas is applied. From the graph, at 4^{th} minutes to 6^{th} minutes, the ratio almost reaches zero, meaning a high amount of combustion gas is detected. From the 7^{th} minutes onwards, the ratio shows the increasing pattern, meaning that the amount of combustion gas slowly decreases with time.

CHAPTER 5

CONCLUSION AND FUTURE WORKS

In this chapter, the conclusions are derived from the study on developing a user-centered smart child seat for NCAP requirements via IoT platform. The conclusions were based on the purpose, research questions and results of the study. The implications of these findings, recommendations and future suggestion will also be explained. Recommendations were based on the conclusions and purpose of the study.

5.1 Conclusion

The car-related death keeps increasing each year, referring to a child's situation that left inside the car. We need to raise awareness among the parents of their child regarding the danger they will face. In this research, most respondents showed positive findings on questions concerning child safety in vehicles and the development of SCS systems. It can be shown that child's condition detection systems are suitable for implementation in the automotive field. According to the results, some of the respondents suggest that the heartbeat measurement is not compulsory to the system. In conclusion, the study's primary goal is to develop a prototype of SCS that can measure the presence of the baby, baby's sound, baby's heartbeat, surrounding's humidity, surrounding's temperature, and combustion gas leakage inside the vehicle using IoT system was achieved. By applying technical knowledge related in this field and conducting several tests, this project receives the desired results. The most suitable sensor was selected and been used for fabricating process in the research. The best placement locations of the sensors were determined, and the interactive design concept is applied to raise the interest in the product. Finally, the design of SCS holds the promise of constant real time monitoring system for the infant and prompt notification through the visual and mobile application of an emergency scenario.

5.2 Future work and recommendation

There are still many rooms for improvement for this project. For greater accuracy of sensor reading, the measurement should consider the average value, not the instantaneous value. In term of power consumption, use the USB port to power up the Arduino UNO because it will drive the constant 5 (V) rather than 7 (V) if using the barrel connector. The power circuit design should include the charging port to charge the battery. For the heartbeat measurement, the sensor should not attach directly to the baby and the suitable approach by placing on the backrest of the child seat. The connectivity to mobile apps should not be limited to the IoT. It is preferred to add both Bluetooth and RF connection to the system.

Awareness programs for parents about road safety must be conducted and relevant literature must be provided. This includes knowledge regarding the possible dangers of heat-related incidents. The use of a system for the detection of a child's condition can be the key to reduce the risks of children being left unattended in a car. Therefore, immediate actions should be taken by vehicle manufacturers and automotive suppliers to speed up the availability of these systems in the commercial market.

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APPENDICES

Appendix A: Arduino Standard Data Sheet

Overview

The Arduino Uno is a microcontroller board based on the ATmega328 (datasheet). It has 14 digital input/output pins (of which 6 can be used as PWM outputs), 6 analog inputs, a 16 MHz ceramic resonator, a USB connection, a power jack, an ICSP header, and a reset button. It contains everything needed to support the microcontroller; simply connect it to a computer with a USB cable or power it with a AC-to-DC adapter or battery to get started.
The Uno differs from all preceding boards in that it does not use the FTDI USB-to-serial driver chip. Instead, it features the Atmega16U2 (Atmega8U2 up to version R2) programmed as a USB-to-serial converter.
Revision 2 of the Uno board has a resistor pulling the 8U2 HWB line to ground, making it easier to put into DFU mode.
Revision 3 of the board has the following new features:

- 1.0 pinout: added SDA and SCL pins that are near to the AREF pin and two other new pins placed near to the RESET pin, the IOREF that allow the shields to adapt to the voltage provided from the board. In future, shields will be compatible both with the board that use the AVR, which operate with 5V and with the Arduino Due that operate with 3.3V. The second one is a not connected pin, that is reserved for future purposes.
- Stronger RESET circuit.
- Atmega 16U2 replace the 8U2.

"Uno" means one in Italian and is named to mark the upcoming release of Arduino 1.0. The Uno and version 1.0 will be the reference versions of Arduino, moving forward. The Uno is the latest in a series of USB Arduino boards, and the reference model for the Arduino platform; for a comparison with previous versions, see the index of Arduino boards.

Summary

Microcontroller	ATmega328
Operating Voltage	5V
Input Voltage (recommended)	7-12V

Input Voltage (limits)	6-20V
Digital I/O Pins	14 (of which 6 provide PWM output)
Analog Input Pins	6
DC Current per I/O Pin	40 mA
DC Current for 3.3V Pin	50 mA
Flash Memory	32 KB (ATmega328) of which 0.5 KB used by bootloader
SRAM	2 KB (ATmega328)
EEPROM	1 KB (ATmega328)
Clock Speed	16 MHz

Schematic & Reference Design

EAGLE files: arduino-uno-Rev3-reference-design.zip (NOTE: works with Eagle 6.0 and newer)
Schematic: arduino-uno-Rev3-schematic.pdf
Note: The Arduino reference design can use an Atmega8, 168, or 328, Current models use an ATmega328, but an Atmega8 is shown in the schematic for reference. The pin configuration is identical on all three processors.

Power

The Arduino Uno can be powered via the USB connection or with an external power supply. The power source is selected automatically.
External (non-USB) power can come either from an AC-to-DC adapter (wall-wart) or battery. The adapter can be connected by plugging a 2.1mm center-positive plug into the board's power jack. Leads from a battery can be inserted in the Gnd and Vin pin headers of the POWER connector.
The board can operate on an external supply of 6 to 20 volts. If supplied with less than 7V, however, the 5V pin may supply less than five volts and the board may be unstable. If using more than 12V, the voltage regulator may overheat and damage the board. The recommended range is 7 to 12 volts.
The power pins are as follows:

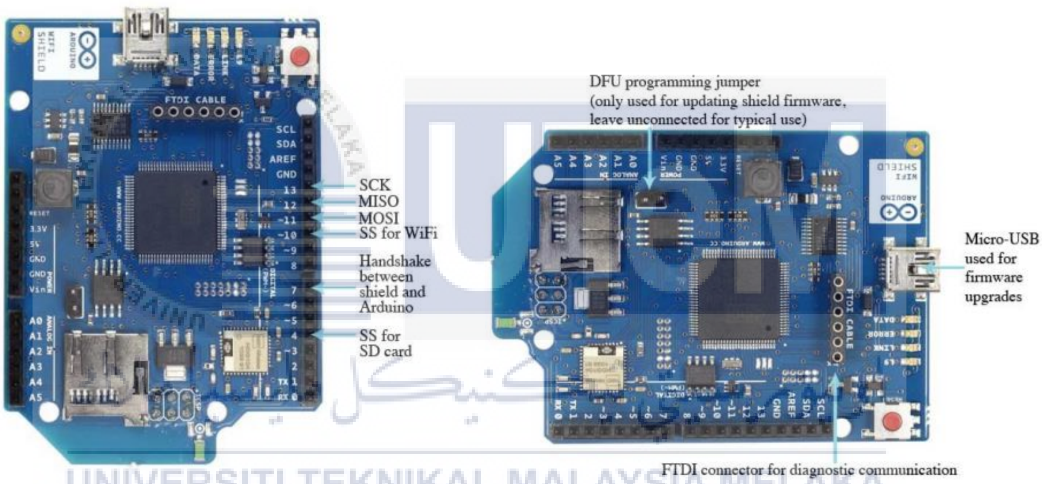
- **VIN.** The input voltage to the Arduino board when it's using an external power source (as opposed to 5 volts from the USB connection or other regulated power source). You can supply voltage through this pin, or, if supplying voltage via the power jack, access it through this pin.
- **5V.**This pin outputs a regulated 5V from the regulator on the board. The board can be supplied with power either from the DC power jack (7 - 12V), the USB connector (5V), or the VIN pin of the board (7-12V). Supplying voltage via the 5V or 3.3V pins bypasses the regulator, and can damage your board. We don't advise it.
- **3V3.** A 3.3 volt supply generated by the on-board regulator. Maximum current draw is 50 mA.
- **GND.** Ground pins.

Appendix B: Wi-Fi Shield Standard Data Sheet

Overview

The Arduino WiFi Shield connects your Arduino to the internet wirelessly. Connect it to your wireless network by following a few simple instructions to start controlling your world through the internet. As always with Arduino, every element of the platform – hardware, software and documentation – is freely available and open-source. This means you can learn exactly how it's made and use its design as the starting point for your own circuits.

Requires and Arduino board (not included)
Operating voltage 5V (supplied from the Arduino Board)
Connection via: 802.11b/g networks
Encryption types: WEP and WPA2 Persoanl
Connection with Arduino on SPI port
on-board micro SD slot
ICSP headers
FTDI connection for serial debugging of WiFi shield
Mini-USB for updating WiFi shield firmware



Appendix C: 16x2 with I2C Standard Data Sheet

Datasheet

I2C 1602 Serial LCD Module

Product features:

The I2C 1602 LCD module is a 2 line by 16 character display interfaced to an I2C daughter board. The I2C interface only requires 2 data connections, +5 VDC and GND to operate

For in depth information on I2C interface and history, visit: http://www.wikipedia/wiki/i2c

Specifications:

	2 lines by 16 character
I2C Address Range	0x20 to 0x27 (Default=0x27, addressable)
Operating Voltage	5 Vdc
Backlight	White
Contrast	Adjustable by potentiometer on I2c interface
Size	80mm x 36mm x 20 mm
Viewable area	66mm x 16mm

Power:

The device is powered by a single 5Vdc connection.

Appendix D: Hw-827 Standard Data Sheet

Features

- Biometric Pulse Rate or Heart Rate detecting sensor
- Plug and Play type sensor
- Operating Voltage: +5V or +3.3V
- Current Consumption: 4mA
- Inbuilt Amplification and Noise cancellation circuit.
- Diameter: 0.625"
- Thickness: 0.125" Thick

Warning: This sensor is not medical or FDA approved. It is purely intended for hobby projects/demos and should not be use for health critical applications.

Pin Configuration

Pin Number	Pin Name	Wire Colour	Description
1	Ground	Black	Connected to the ground of the system
2	Vcc	Red	Connect to +5V or +3.3V supply voltage
3	Signal	Purple	Pulsating output signal.

Appendix E: HC-SR04 Standard Data Sheet

Product features:

Ultrasonic ranging module HC - SR04 provides 2cm - 400cm non-contact measurement function, the ranging accuracy can reach to 3mm. The modules includes ultrasonic transmitters, receiver and control circuit. The basic principle of work:

(1) Using IO trigger for at least 10us high level signal,

(2) The Module automatically sends eight 40 kHz and detect whether there is a pulse signal back.

(3) IF the signal back, through high level , time of high output IO duration is the time from sending ultrasonic to returning.

Test distance = (high level time×velocity of sound (340M/S) / 2,

Wire connecting direct as following:

- 5V Supply
- Trigger Pulse Input
- Echo Pulse Output
- 0V Ground

Electric Parameter

Working Voltage	**DC 5 V**
Working Current	**15mA**
Working Frequency	**40Hz**
Max Range	**4m**
Min Range	**2cm**
MeasuringAngle	**15 degree**
Trigger Input Signal	**10uS TTL pulse**
Echo Output Signal	**Input TTL lever signal and the range in proportion**
Dimension	**45*20*15mm**

Appendix F: DHT11 Standard Data Sheet

Each DHT11 element is strictly calibrated in the laboratory that is extremely accurate on humidity calibration. The calibration coefficients are stored as programmes in the OTP memory, which are used by the sensor's internal signal detecting process. The single-wire serial interface makes system integration quick and easy. Its small size, low power consumption and up-to-20 meter signal transmission making it the best choice for various applications, including those most demanding ones. The component is 4-pin single row pin package. It is convenient to connect and special packages can be provided according to users' request.

2. Technical Specifications:

Overview:

Item	Measurement Range	Humidity Accuracy	Temperature Accuracy	Resolution	Package
DHT11	20-90%RH 0-50 ℃	±5%RH	±2℃	1	4 Pin Single Row

Detailed Specifications:

Parameters	Conditions	Minimum	Typical	Maximum
Humidity				
Resolution		1%RH	1%RH	1%RH
			8 Bit	
Repeatability			±1%RH	
Accuracy	25℃		±4%RH	
	0-50℃			±5%RH
Interchangeability	Fully Interchangeable			
Measurement Range	0℃	30%RH		90%RH
	25℃	20%RH		90%RH
	50℃	20%RH		80%RH
Response Time (Seconds)	1/e(63%)25℃, 1m/s Air	6 S	10 S	15 S
Hysteresis			±1%RH	
Long-Term Stability	Typical		±1%RH/year	
Temperature				
Resolution		1℃	1℃	1℃
		8 Bit	8 Bit	8 Bit
Repeatability			±1℃	
Accuracy		±1℃		±2℃
Measurement Range		0℃		50℃
Response Time (Seconds)	1/e(63%)	6 S		30 S

Appendix G: MQ-9 Standard Data Sheet

MQ-9 Semiconductor Sensor for CO/Combustible Gas

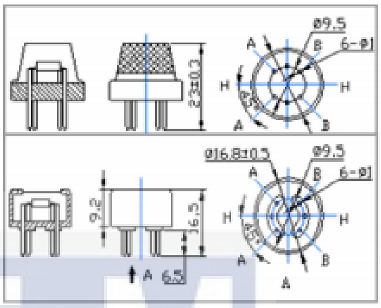
Sensitive material of MQ-9 gas sensor is SnO_2, which with lower conductivity in clean air. It make detection by method of cycle high and low temperature, and detect CO when low temperature (heated by 1.5V). The sensor's conductivity is more higher along with the gas concentration rising. When high temperature (heated by 5.0V), it detects Methane, Propane etc combustible gas and cleans the other gases adsorbed under low temperature. Please use simple electrocircuit, Convert change of conductivity to correspond output signal of gas concentration.

MQ-9 gas sensor has high sensitity to Carbon Monoxide, Methane and LPG. The sensor could be used to detect different gases contains CO and combustible gases, it is with low cost and suitable for different application.

Character

* Good sensitivity to CO/Combustible gas
* High sensitivity to Methane, Propane and CO
* Long life and low cost
* Simple drive circuit

Configuration



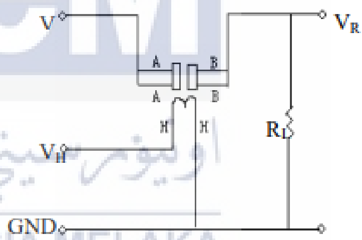
Application

* Domestic gas leakage detector
* Industrial gas detector
* Portable gas detector

Technical Data

Model No.			MQ-9
Sensor Type			Semiconductor
Standard Encapsulation			Bakelite
Detection Gas			CO and combustible gas
Concentration			10-1000ppm CO 100-10000ppm combustible gas
Circuit	Loop Voltage	V_c	≤10V DC
	Heater Voltage	V_H	5.0V±0.2V ACorDC（High） 1.5V±0.1V ACorDC（Low）
	Heater Time	T_L	60±1S（High）90±1S（Low）
	Load Resistance	R_L	Adjustable
Character	Heater Resistance	R_H	31Ω±3Ω（Room Tem.）
	Heater consumption	P_H	≤350mW
	Sensing Resistance	R_s	2KΩ-20KΩ(in 100ppm CO)
	Sensitivity	S	Rs(in air)/Rs(100ppm CO)≥5
	Slope	α	≤0.6(R_{300ppm}/R_{100ppm} CO)
Condition	Tem. Humidity		20℃±2℃; 65%±5%RH
	Standard test circuit		Vc:5.0V±0.1V; V_H（High）: 5.0V±0.1V; V_H（Low）: 1.5V±0.1V
	Preheat time		Over 48 hours

Basic test loop



The above is basic test circuit of the sensor. The sensor need to be put 2 voltage, heater voltage（VH） and test voltage（VC）. VH used to supply certified working temperature to the sensor, while VC used to detect voltage (VRL) on load resistance（RL）whom is in series with sensor. The sensor has light polarity, Vc need DC power. VC and VH could use same power circuit with precondition to assure performance of sensor. In order to make the sensor with better

Appendix H: KY-038 Standard Data Sheet

Technical data / Short description

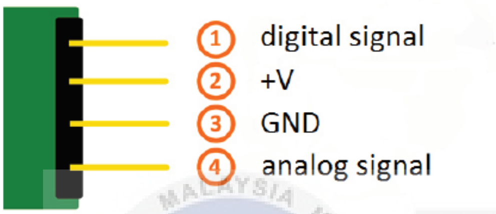
Digital Out: You can use a potentiometer to configure an extreme value for the sonic. IF the value exceeds the extreme value it will send a signal via digital out.

Analog Out: Direct microphone signal as voltage value

LED1: Shows that the sensor is supplied with voltage

LED2: Shows that a magnetic field was detected

Pinout



Functionality of the sensor

The sensor has 3 main components on its circuit board. First, the sensor unit at the front of the module which measures the area physically and sends an analog signal to the second unit, the amplifier. The amplifier amplifies the signal, according to the resistant value of the potentiometer, and sends the signal to the analog output of the module.
The third component is a comparator which switches the digital out and the LED if the signal falls under a specific value.
You can control the sensitivity by adjusting the potentiometer.

Please notice: The signal will be inverted; that means that if you measure a high value, it is shown as a low voltage value at the analog output.

Appendix I: Coding for SCS System

```
#include <SPI.h>
#include <SoftwareSerial.h>
#include <ESP8266_Lib.h>
#include <BlynkSimpleShieldEsp8266.h>
#include <DHT.h>
#include <Wire.h>
#include <LiquidCrystal_I2C.h>
#define USE_ARDUINO_INTERRUPTS true
#define DHTPin A1
#define DHTType DHT11
#define ESP8266_BAUD 9600
#define EspSerial Serial1
#define BLYNK_PRINT Serial

LiquidCrystal_I2C lcd = LiquidCrystal_I2C(0x27,20,4);
char auth[] = "X6GLoif4d9cM7itvBJKNyJg8bWDy3FhC";
char ssid[] = "madijao";
char pass[] = "lembugoreng012";

SoftwareSerial EspSerial(2,3);
ESP8266 wifi(&EspSerial);
DHT dht = DHT(DHTPin,DHTType);
const int presentledred = 13;
const int presentledgreen = 12;
const int temperatureledred = 11;
const int temperatureledgreen = 10;
const int humidityledred  = 9;          // output pin ultrasonic
const int humidityledgreen  = 8;        // output pin temperature
const int gasledred = 7;                // output pin humidity
const int gasledgreen = 6;              // output pin gas
const int echoPin = 4;
const int trigPin = 5;
int beat;
int BPM=0;
int soundreading = 0;
int sensorValue;
float humidity;
float temperature;
int distance;
float sensor_volt;
float RS_gas;
float ratio;
float R0 = 1.38;
long duration;
```

```
void setup()
{
    Serial.begin(9600);
    EspSerial.begin(ESP8266_BAUD);
    delay(10);
    Blynk.begin(auth, wifi, ssid, pass);
    dht.begin();
    lcd.init();
    lcd.backlight();
    lcd.clear();
    pinMode(trigPin, OUTPUT);                //ultrasonic
    pinMode(echoPin, INPUT);                 //ultrasonic
    pinMode(presentledred, OUTPUT);          //ultrasonic
    pinMode(presentledgreen, OUTPUT);        //ultrasonic
    pinMode(temperatureledred, OUTPUT);      //dht
    pinMode(temperatureledgreen, OUTPUT);    //dht
    pinMode(humidityledred, OUTPUT);         //dht
    pinMode(humidityledgreen, OUTPUT);       //dht
    pinMode(gasledred, OUTPUT);              //gas
    pinMode(gasledgreen, OUTPUT);            //gas
}

void loop() {

   Blynk.run();
   beat= analogRead(A3);
   soundreading=analogRead(A0);                 //sound
   humidity = dht.readHumidity();               //dht
   temperature = dht.readTemperature();
   digitalWrite(trigPin, LOW);                  //ultrasonic
   delayMicroseconds(2);
   digitalWrite(trigPin, HIGH);
   delayMicroseconds(10);
   digitalWrite(trigPin, LOW);
   duration = pulseIn(echoPin, HIGH);
   distance = duration * 0.034 / 2;
   sensorValue = analogRead(A2);                //gas
   sensor_volt = ((float)sensorValue / 1024) * 5.0;
   RS_gas = (5.0 - sensor_volt) / sensor_volt;
   ratio = RS_gas / R0;
```

```
lcd.setCursor(0,0);                        //temperature lcd
lcd.print("Temp: ");
lcd.setCursor(6,0);
lcd.print(temperature);
lcd.setCursor(11,0);
lcd.print(char(223));
lcd.setCursor(12,0);
lcd.print("C");

lcd.setCursor(0,1);                        //humidity lcd
lcd.print("Humidity: ");
lcd.setCursor(10,1);
lcd.print(humidity);
lcd.setCursor(15,1);
lcd.print("%");


Blynk.virtualWrite(V0,BPM);
Blynk.virtualWrite(V1,ratio);
Blynk.virtualWrite(V2,temperature);
Blynk.virtualWrite(V3,humidity);
WidgetLED led4(V4);
WidgetLED led5(V5);
led4.on();
led5.on();



if(beat>=120)
  {
      Blynk.setProperty(V0,"color","#FF0000");
  }
else if(beat>=55)
  {
      Blynk.setProperty(V0,"color","#00FF00");
  }
else
  {
      Blynk.setProperty(V0,"color","#FF0000");
  }
```

```
if (soundreading >=550 )                                //sound threshold
{
    Blynk.setProperty(V5,"color","#FF0000");
}
else
{
    Blynk.setProperty(V5,"color","#00FF00");
}


if (distance <= 10 )                                  //distance threshold
{
    digitalWrite(presentledred, HIGH);
    digitalWrite(presentledgreen, LOW);
    Blynk.setProperty(V4,"color","#00FF00");
}
else
{
    digitalWrite(presentledred, LOW);
    digitalWrite(presentledgreen, HIGH);
    Blynk.setProperty(V4,"color","#FF0000");
}


if (temperature >= 34 )                                //temperature threshold
{
    digitalWrite(temperatureledred, LOW);
    digitalWrite(temperatureledgreen, HIGH);
    Blynk.setProperty(V2,"color","#FF0000");
}
else if(temperature >= 25 )
{
    digitalWrite(temperatureledred, HIGH);
    digitalWrite(temperatureledgreen, LOW);
    Blynk.setProperty(V2,"color","#00FF00");
}
else
{
    digitalWrite(temperatureledred, LOW);
    digitalWrite(temperatureledgreen, HIGH);
    Blynk.setProperty(V2,"color","#FF0000");
}
```

```
if (humidity >= 80)                          //humidity threshold
{
    digitalWrite(humidityledred, LOW);
    digitalWrite(humidityledgreen, HIGH);
    Blynk.setProperty(V3,"color","#FF0000");
}
else if (humidity >= 40)
{
    digitalWrite(humidityledred, HIGH);
    digitalWrite(humidityledgreen, LOW);
    Blynk.setProperty(V3,"color","#00FF00");
}
else
{
    digitalWrite(humidityledred, LOW);
    digitalWrite(humidityledgreen, HIGH);
    Blynk.setProperty(V3,"color","#FF0000");
}



if (ratio<4)                                  //clean air threshold
{
    digitalWrite(gasledred, LOW);
    digitalWrite(gasledgreen, HIGH);
    Blynk.setProperty(V1,"color","#FF0000");
}
else
{
    digitalWrite(gasledred, HIGH);
    digitalWrite(gasledgreen, LOW);
    Blynk.setProperty(V1,"color","#00FF00");
}

}
```