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# Implementation of Digital Fuel Gauge and Central Monitoring Station for Fuel Tankers

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***Abstract:*** ***Remote monitoring of fuel level in fuel tankers can be implemented with a solution based on single board computers and to expose it to scalability, it would be given Internet Access to connect it to more sensors in case of multiple fuel tankers in a train or monitoring multiple trains in an Integrated Web page. Arduino UNO acts as a microcontroller, which collects the information from the average of multiple HC-SR04 Ultrasonic sensors set up in a single tanker, calculate the required data such as volume in liters and forwards them to the database server, Raspberry Pi through a serial communication. When the fuel level decreases below a threshold level, the system alarms the administrator. The Data can be accessed from the Central Monitoring Station (CMS) which comprises of a personal computer with data monitoring software tools such as MySQL, Workbench and web services including a web page to display the fuel level data. The Central Monitoring Station (CMS) connects to the Raspberry Pi setup in different locations i.e. tankers or trains provides the data to the administrator, helping the user to view the fuel level on a time-based system and makes daily management easier and less time consuming. The administrator is also notified about the rate of consumption of fuel on a timely basis and issued an alarm if the fuel quantity in a tanker goes down the specified level.***

***Keywords: CMS, MySQL, HC-SR04, Arduino UNO, Raspberry Pi***

## I. INTRODUCTION

Fuel gauge is a device used to indicate the level of fuel available in the container or a tank of an automobile or an aircraft [1]. Traditional Fuel meters consist of a sending unit and the gauge. The fuel level is indicated with an analog indicator i.e. maximum to minimum level with a needle or with a digital indicator which shows the fuel level in bars from maximum to minimum level.

### *A. Existing Methods*

In a resistive type fuel gauge, the sending unit contains a float, whose one end is mounted to the potentiometer i.e. variable resistor and the other end in the fuel [2]. The potentiometer value is varied according to the level of fuel present in the tank. The fuel gauge consists of a bimetallic strip i.e. a temperature sensitive electrical contact made of two different metals with varying physical and thermal quantities like thermal co-efficient of expansion and are joined together lengthwise [3]. When resistance decreases, current increases and thus the strip is heated during which the rate of expansion of one metal is less than the other. This variation in expansion rates of the metals causes a bending action and thus leads to indication of the fuel level. The Fuel gauge displays the level of fuel varying from the minimum level to the maximum according to the potentiometer. The traditional system is notoriously inaccurate and often leads to misconceptions about the amount of fuel left in the tank. In a capacitive type fuel gauge, variable capacitors which have two conducting plates and the factors which decide the height of the fuel in the tank are distance between the two conducting plates and the dielectric of the fuel between the conducting plates of the capacitor. The value of the capacitance is a function of the fuel height. When the fuel level increases or decreases, there is a change in the dielectric constant and thus the capacitance value changes.

### *B. Need for Digital Fuel Gauge*

Digital fuel gauge displays the amount of fuel left in the tanker by measuring its quantity in terms of liters or gallons instead of indicating the level which leads to better accuracy and mileage calculations of the user [4]. If the sending unit has any issues, it causes the full gauge to behave erratically. Some examples are where the fuel level indicator remains either on maximum i.e. full or on minimum i.e. low.

### *C. Proposed Solution*

The sending unit consists of multiple ultrasonic sensors fixed at various positions inside the fuel tank according to the dimensions of the tank. Fuel levels are sensed by the sensors and are sent to the Arduino UNO R3 Microcontroller and the average fuel level is calculated. The Calculations of level of volume remaining in the tanker depend upon the dimensions of the tank. For Example, A

rectangular tank's volume depends on its length, width and height whereas the volume of a cylindrical tank depends on the diameter of its base and height of the body. The data is then transferred to a Single board computer acting as a server to upload the calculated data to a web interface where the administrator is notified about the fuel levels in a tank. The fuel tankers are differentiated with a unique identification number and the location [5] of the tank. The administrator will be alarmed through the web interface if the fuel level drops down the threshold level.

*D. Applications*

Digital Fuel gauges can be installed in any automobile to measure the level of fuel in a better and accurate manner [6]. Fuel Tankers in trains, ships [7] and oil industries are large scale applications. Fuel Tanks in two wheelers and three wheelers also require digital fuel gauges for calculating efficient mileage provided by the vehicle [8]. Using a Central monitoring station, the fuel levels in every tanker of the train or in an industry is monitored periodically by the administrator.

## II. DATA ACQUISITION AND PROCESSING

The Arduino UNO R3 Microcontroller is used to acquire the data from the ultrasonic sensors and calculate the volume of the fuel left in the tank according to the dimensions of the tank given in the program [9]. The dimensions can be varied according to the design of the tank in the program using Arduino IDE. A maximum of 7 ultrasonic sensors can be connected to a single Arduino Board. The average of all the distances measured by the ultrasonic sensors is taken and fuel level is calculated.

*A. HC-SR04 Ultrasonic Sensor*

The HC-SR04 ultrasonic sensor is used in distance measurement which offers a range up to 400 centimetres. The HC-SR04 module contains 4 pins. The transmitter emits bursts of a directional 40 KHz ultrasonic wave when triggered using the TRIG pin and starts a timer. Ultrasonic pulses travel outward until they encounter an object. The object causes the wave to be reflected and is sent back to the sensor. The ultrasonic receiver would detect the reflected wave and stop the stop timer. The velocity of the ultrasonic burst is 340 m/sec. in air. When the number of counts until the object is detected is obtained, the time interval can be calculated using the number of counts [10].

| Pin | Description |
|---|---|
| VCC | 3.3V Power Supply |
| GND | Ground |
| TRIG | Trigger Input/ Transmitter Pin |
| ECHO | Output Receiver Pin |

TABLE I
PIN DESCRIPTION OF ULTRASONIC SENSOR

The distance D can be calculated by

$$D = \frac{T_h * C}{2} \quad (1)$$

Where,

C – Velocity of light
D – Distance of object from sensor
$T_h$ – high level time of ECHO pin

*B. Arduino UNO R3*

Microcontroller is a small computer on an integrated chip which is used to design real-time systems. Arduino UNO R3 is based on the ATmeg328 microcontroller which can be used for numerous number of real time applications. The board contains 6 analog input pins and 14 digital input pins of which 6 pins provide PWM output and a crystal oscillator of 16 MHz It has a flash memory of 32kB, a RAM of 1kB and ROM of 1kB [11]. Arduino IDE i.e. Integrated Development Environment is used to code and debug the program and upload it to the microcontroller. The ATmega328 Microcontroller contains 23 GPIO lines, 32 general purpose working registers, 3 Timer/Counters, internal and external interrupts on a priority basis, a serial programmable USART, an SPI serial port, a

6-channel 10-bit ADC, a programmable Watchdog Timer with internal Oscillator. It has a Type-A USB Port which is used for serial communication with the Arduino IDE or other devices to upload the program to the microcontroller.

*C. Circuit*

The number of ultrasonic sensors required depends upon the dimensions of the tanker and user's requirement. Here three HC-SR04 Ultrasonic Sensors are interfaced with the Microcontroller. The sensors will be fixed at an equal distance from each other such that the complete width of the tanker is covered irrespective of whether the design is a vertical tanker or a horizontal tanker. The average value of fuel level is calculated from all the distances obtained from the sensors to improve accuracy and precision. The TRIG and ECHO pins of the Sensor is connected to the Digital pins whereas the VCC and GND pins are connected to the 3.3V Power Supply and Ground pin respectively.

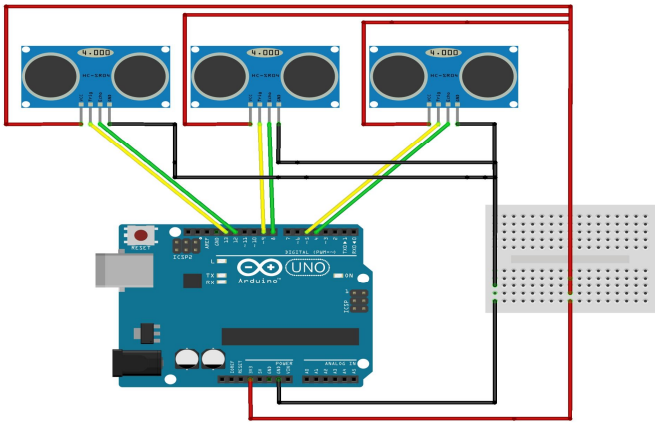

Fig. 1. Interfacing HC-SR04 Ultrasonic sensors with Arduino UNO R3 Microcontroller

TABLE II
MICROCONTROLLER CIRCUIT PIN LAYOUT

| Sensor Pins | Arduino UNO R3 Board |
|---|---|
| Sensor 1 VCC | 3.3V |
| Sensor 1 GND | GND |
| Sensor 1 TRIG | D13 |
| Sensor 1 ECHO | D12 |
| Sensor 2 VCC | 3.3V |
| Sensor 2 GND | GND |
| Sensor 2 TRIG | D9 |
| Sensor 2 ECHO | D8 |
| Sensor 3 VCC | 3.3V |
| Sensor 3 GND | GND |
| Sensor 3 TRIG | D5 |
| Sensor 3 ECHO | D4 |

## III. SERVER

Raspberry Pi 3 Single Board Computer is used as the server here to collect data from the microcontroller and upload it to the Integrated Web Interface [13]. A WPA2 PSK secured Wi-Fi Network is provided to the Raspberry Pi for access to the Internet to communicate with the Central Monitoring Station. Every Raspberry Pi setup in a fuel tanker has a unique static IP address to differentiate it from the other Raspberry Pi servers operating from other tanks located across various locations [14].

### *A. Raspberry Pi SoC*

Raspberry Pi is a single board computer capable of many functions as the desktop PC does. It was initially designed to run on a Linux based Operating System such as Raspbian, Ubuntu MATE, RISC OC, Snappy Ubuntu Core, Fedora Remix, Android Things, Arch Linux, open SUSE, Xbian, Ark OS, Sailfish OS and supported Operating systems which were not Linux based like HelenOS, Haiku, FreeBSD, Net BSD, Plan 9 from Bell Labs, xv6, RISC OS and Windows 10 IoT Core. The Raspberry Pi does not have a built-in data storage device, thus an external SD card with a minimum size of 4 GB is required to boot the Operating System (OS) and run it on the Raspberry Pi. Some packages such as Open CV, Tensor flow require huge amount of space, thus the Raspberry Pi can support external SD cards up to 32GB. The Raspberry Pi 3 contains a Broadcom BCM2837 SoC with a 1.2GHz 64-bit quad-core ARM Cortex A53 processor and a RAM of 1GB [15]. The GPU is capable of 1Gpixel/s, 1.5Gtexel/s or 24 GFLOPs of general-purpose compute performance, and provides the Blue Ray quality video using H.264 at 40MBits/S. The built-in USB ports are used to connect keyboard, mouse and other USB powered devices. A 10/100Mbps Ethernet port is also built-in to provide internet access via LAN built using the SMSC LAN9514 Chip. It consists of 26 General Purpose input/output (GPIO) pins (17 out of them are responsible for input or output functions,17 of which are responsible for input and output functions whereas the rest are power supply and ground pins.

### *B. Serial Communication*

The Arduino UNO R3 has a USB Type-A port and the Raspberry Pi has a USB Type-B port. Connect the boards with a USB Type-A to Type-B cable. Ideally the Arduino UNO connects to the dev/ttyACM0 port of the Raspberry Pi. Install Java-RXTX library using the terminal window to enable serial data transfer between the Arduino UNO and Raspberry Pi. After installation of the RXTX library, to allow data to be read by the Raspberry Pi, pySerial, a Python library for serial communication must be installed in the Raspberry Pi.

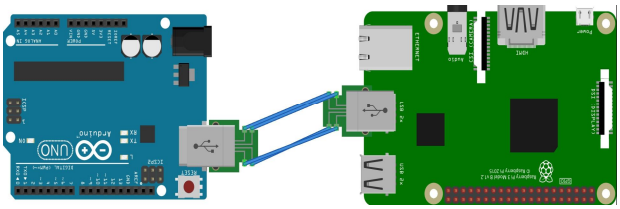

Fig. 2. Serial Communication between Arduino UNO and Raspberry Pi with a USB Type-A to Type-B Cable

### *C. MySQL Database*

To store the data received from the microcontroller, a database is required. MySQL server [16], an open source database server compatible with the Linux based Operating system must be installed using terminal commands. A database named ‘Fuel’ is created to store data. Inside the database, a tables is created to store the value of Volume left in Litres with the time and date at which the data was recorded and location of the fuel tanker. Data received from the microcontroller is inserted into the database using Python Scripts.

## IV. CENTRAL MONITORING STATION

The Central Monitoring Station (CMS) is a personal computer setup for the administrator to view the database through the Integrated Web Interface [17]. The CMS consists of MySQL Workbench to connect to the database. It also consists of a Web browser to access the Integrated Web Interface. The Databases from different locations can be accessed by the CMS with the help of MySQL Workbench. C# is a multi-paradigm programming language encompassing strong typing, imperative, declarative, functional, generic, object-oriented, and component-oriented programming disciplines.

### *A. Database Server*

MySQL Workbench is an open source tool to access databases and manage them remotely. It is a visual tool for Database Administrator (DBAs), and Database Designers creating and managing databases. MySQL Workbench provides all the comprehensive tools as a single package such as Data modeling, SQL development and server configuration. It also provides prolific features of database administration features like local and remote server control, setting up the MySQL server, and the server diagnostic information, including network traffic, server status and memory consumption. It has a user and session management system, which provides the special features for creating, deleting, viewing MySQL users and controlling the user privilege. Thus, MySQL Workbench is a complete software package for designing and developing the database system.

### *B. Web Interface*

The Integrated Web Interface is be designed using ASP.NET and C Sharp (C#). ASP.NET is an open source server-side framework tool designed to create dynamic web interfaces. C# is an object-oriented programming language encompassing declarative used to create dynamic websites. Hyper Text Mark-up Language (HTML) is a programming language to design web interfaces The Interface displays data being uploaded from the servers on a time basis from different locations, each location specifying a different fuel tanker [18]. The Web Interface is accessible over the Internet and restricted to only administrator and authorized users [19]. The user information is stored in the database system to provide access to the Web Interface. The Web Interface provides the details of the identification of fuel tanker and its location along with the volume of fuel left in liters and gallons. The administrator and authorized users are alarmed if the fuel level drops down below a predefined value [20].

## V. RESULTS

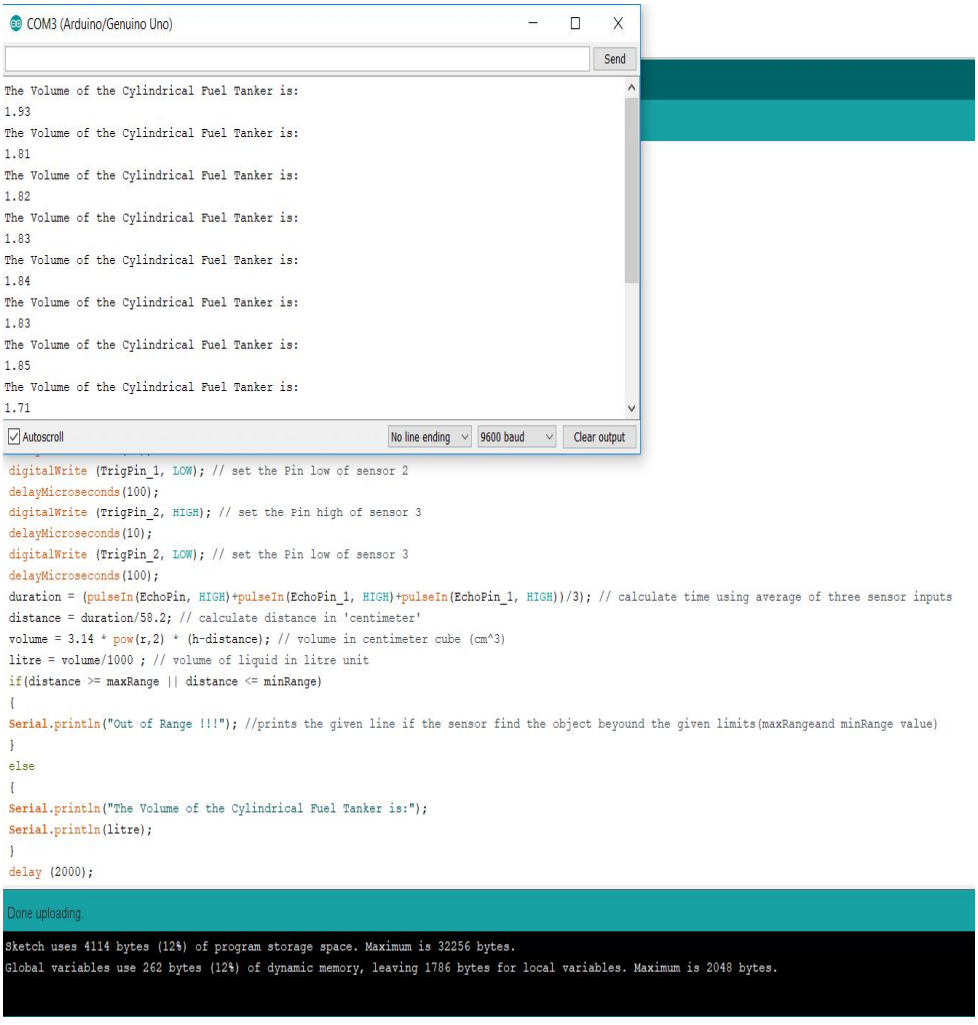


Fig. 3. Output Display in Serial Monitor of Arduino IDE

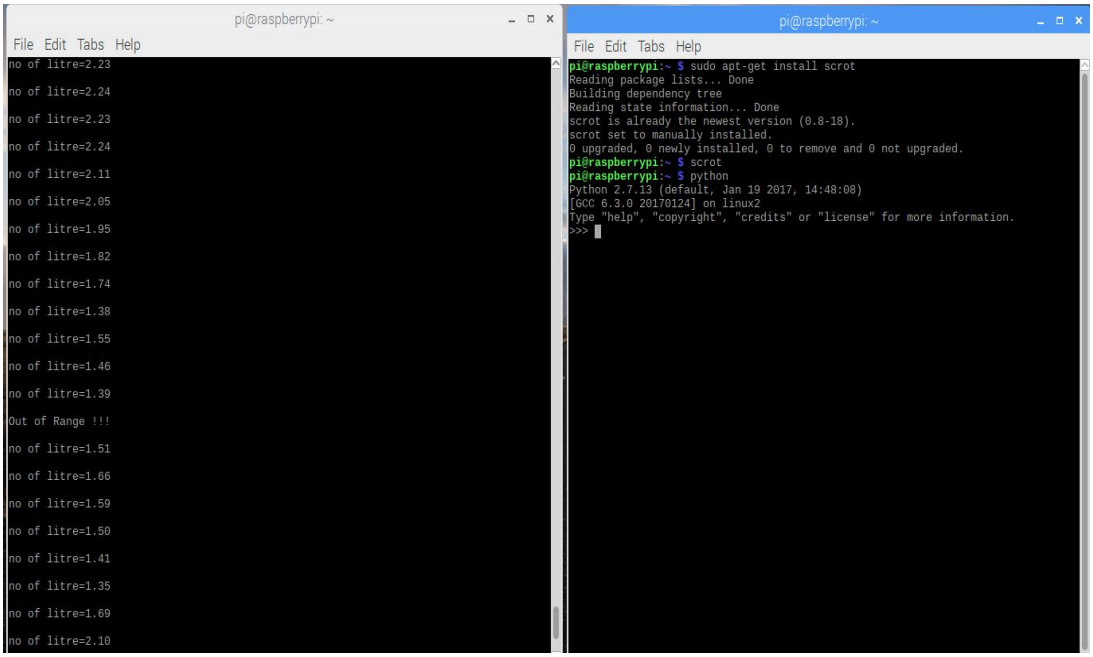


Fig. 4. Output Display in Raspberry Pi Terminal using Arduino-Raspberry Pi Serial Connection

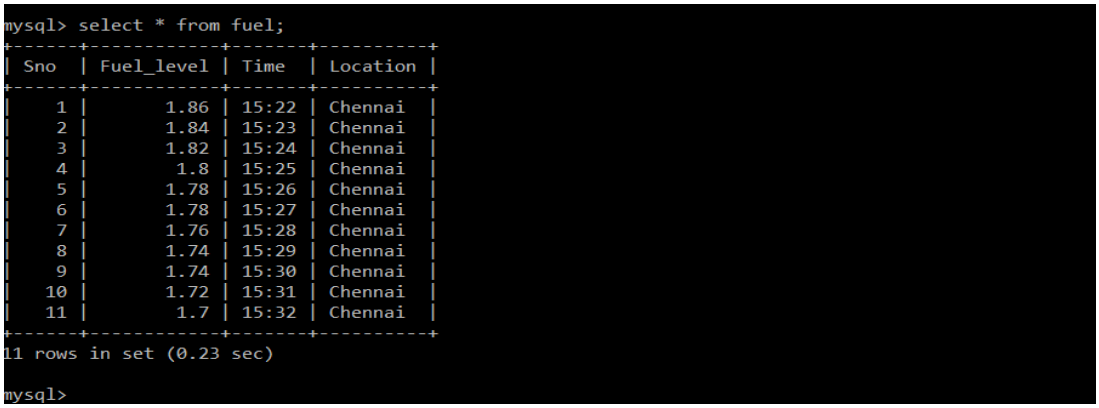


Fig. 5. MySQL Database updated as the Fuel Level is updated on a real-time basis by the Microcontroller

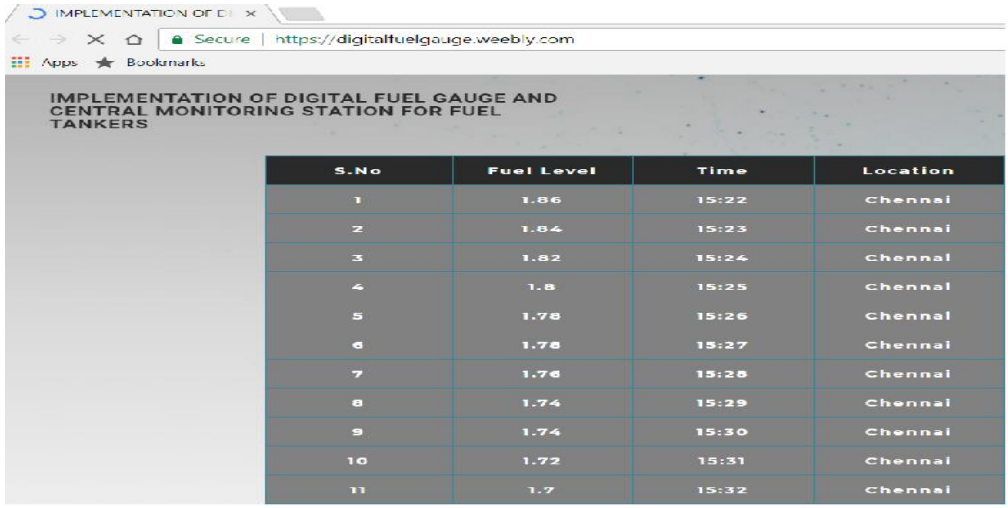


Fig. 5. Data of Fuel Tanker Level displayed in Integrated Web Interface

## VI. CONCLUSIONS

Digital Fuel Meters have a higher precision and accuracy compared to the traditional and analog fuel gauges. Malfunction in the variable resistor, capacitor or the sending unit might lead to inaccurate fuel level measurement and generally leads to misconceptions by the consumer. Thus, a Digital Fuel Gauge is designed to provide a better result to the consumer. Central Monitoring Station is designed to provide the consumer an option of accessing the fuel levels of tankers in various locations in an Integrated Web Interface.

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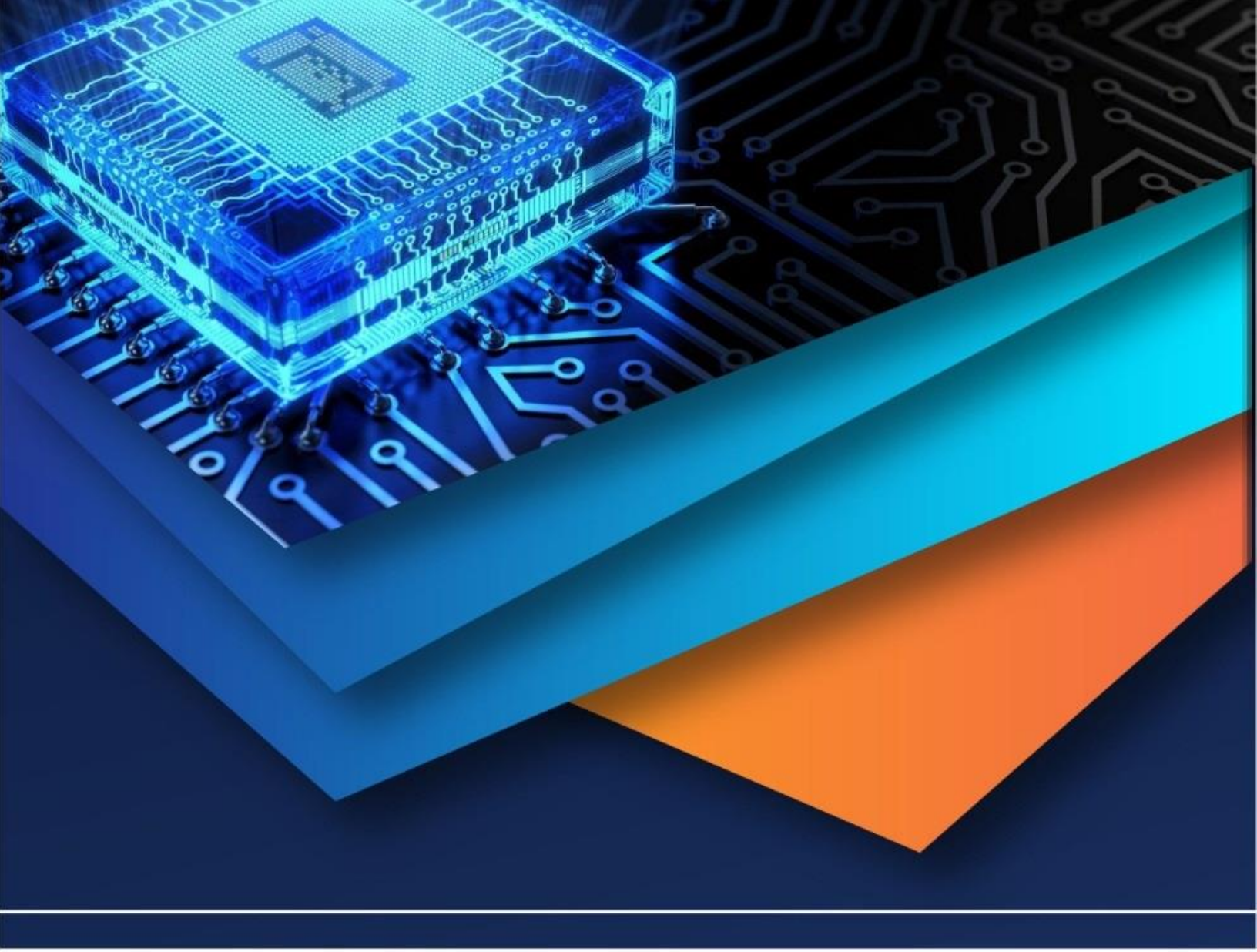

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