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Digital Fuel Level Indicator System

Lalitha N[1], Darshan B[2], Lakshmi M C[3], Monisha S J[4]

[1]*Lalitha N, Assistant Professor, Dept of Electronics and Communications, Vidya Vikas Institute of Engineering and Technology, Mysuru, Karnataka, India*

[2]*Darshan B, Dept of Electronics and Communications, Vidya Vikas Institute of Engineering and Technology, Mysuru, Karnataka, India*

[3]*Lakshmi M C, Dept of Electronics and Communications, Vidya Vikas Institute of Engineering and Technology, Mysuru, Karnataka, India*

[4]*Monisha S J, Dept of Electronics and Communications, Vidya Vikas Institute of Engineering and Technology, Mysuru, Karnataka, India*

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Abstract - In today's rapidly evolving world, the rising demand for fuel—particularly in developing countries—has led to growing concerns about escalating fuel prices. This issue has become critical due to fuel theft and inaccurate dispensing practices at fuel stations. Often, consumers are misled by manipulated fuel dispensing systems, where the quantity shown on the meter does not reflect the actual fuel delivered to the vehicle. This discrepancy results in customers receiving less fuel than what they paid for, leading to both financial loss and distrust. To address this problem, our project aims to develop a digital system that accurately measures and displays the amount of fuel entering the vehicle's tank in real time. By incorporating a flow sensor, the system ensures precise monitoring and verification of fuel quantity. This solution is intended to prevent fraud, enhance transparency, and promote trust between fuel providers and consumers. Additionally, it will serve as a step towards digitalization in fuel management and consumption tracking

1. INTRODUCTION

All Automobiles have existed for more than two centuries, but significant developments such as vehicle electrification became more prominent in the late 1970s and early 1980s. Over the past four decades, advances in technology have integrated electronics and electrical systems into vehicle design, resulting in complex configurations that combine mechanics, information technology, and mechatronics. As vehicle systems have increased in complexity, they now require high levels of efficiency and precision across all subsystems. Among these systems, fuel monitoring plays an important role. Although fuel management technology has not advanced as rapidly as other in vehicle systems, it presents substantial opportunities for improvement. Accurate fuel monitoring helps optimize energy use and improve overall vehicle performance. The reliability of fuel monitoring systems is generally evaluated based on precision, cost effectiveness, and energy efficiency. As concerns over energy conservation, fuel costs, and environmental impact continue to grow, effective fuel monitoring has become essential. Traditional Analog fuel meters provide only approximate readings and often contribute to consumer uncertainty and fraudulent practices at fuel stations. Earlier methods using resistive and capacitive transducers were limited in accuracy, sensitivity, and stability due to environmental influences. To address these limitations, fiber optic sensors were introduced, offering improved accuracy, sensitivity, and reliability for digital fuel monitoring applications. With continued advancements in sensing technologies, the objective is to develop intelligent systems capable of providing real time and accurate fuel level information, thereby improving transparency and reducing fuel losses. Digital fuel gauges are now used to determine the precise fuel level in a vehicle tank, offering more accurate measurement and display. However, many conventional systems still provide estimated values that may not reflect the actual fuel volume. Display variations at fuel stations can mislead consumers regarding the amount of fuel dispensed, leading to overcharging and fuel theft. Modern systems address these issues by integrating advanced sensors that improve accuracy and support cost savings. In addition, these systems provide visual and audio alerts to inform users about fuel levels and potential discrepancies

1.2 LITERATURE REVIEW

1) Ultrasonic & Flow Sensor–Based Fuel Monitoring System

Srinivas M. developed a fuel-level monitoring system that uses ultrasonic and flow sensors to measure the amount of fuel in a vehicle's tank. The system becomes active when the ignition key is inserted. A 9V, 2A SMPS powers the setup, converting 230V AC to 9V DC, while an Arduino board further steps this voltage down to 5V for the sensors and modules. The controller processes sensor data and displays the fuel level on an LCD. If the fuel quantity falls below the predefined threshold, a buzzer is activated and an SMS alert is sent to the vehicle owner via GSM.

Advantages:

- Provides automated fuel-level measurement.
- Sends theft alerts through GSM.
- Integrates ignition status monitoring.

Disadvantages:

- Limited to threshold-based detection.
- Dependent on continuous power supply.
- LCD readability may be limited in some conditions.

Reference:
Srinivas M., *Fuel Level Detection Using Ultrasonic and Flow Sensors*, 2016.

2) Solar-Powered Fuel Monitoring & Theft Alert System

Heda Venkata designed a fuel-monitoring system that relies on a liquid-level sensor to detect fuel quantity. When the sensor identifies that the level has dropped below a preset value, it sends a signal to the microcontroller. The system is powered by solar energy, making it cost-effective and environmentally friendly. If sudden drops or theft are detected, the buzzer is triggered and an SMS alert is sent to the vehicle owner.

Advantages:

- Eco-friendly due to solar power usage.
- Reduces operating cost.
- Simple and reliable level-sensing mechanism.

Disadvantages:

- Efficiency depends on sunlight availability.
- Less suitable for enclosed or shaded environments.
- Basic sensors may have lower accuracy for large tanks.

Reference:
Venkata, H., *Solar-Based Fuel-Level Monitoring and Theft Prevention*, 2017.

3) Ignition-Based Fuel Theft Detection System

Aniket Shinde introduced a system integrating ignition detection with fuel-level sensing. The system activates only when the key is removed and the vehicle door is opened, helping detect unauthorized access. If tampering occurs, the fuel sensor sends signals to the controller, triggering an alarm and sending an alert through a GSM module. The GSM module's IMEI number can also assist in vehicle tracking.

Advantages:

- Responds only during unauthorized access.
- Provides SMS alerts with location tracking support.
- Enhances vehicle security beyond fuel monitoring.

Disadvantages:

- Door/ignition dependency may miss certain theft scenarios.
- Requires GSM coverage.
- More complex installation.

Reference:
Shinde, A., *Ignition-Controlled Fuel Theft Detection Using GSM*, 2018.

4) IoT-Based Fuel Tracking & Theft Control System

Rajesh Krishnaswamy proposed an IoT-enabled system that provides real-time fuel-level updates and theft notifications. The system consists of three primary modules: a fuel-sensing unit (float sensor), a GSM-based communication module, and a GPS module for location monitoring. Sudden changes in fuel level are detected by the sensor, and alerts are sent to the user through GSM messaging. The system reduces manual fleet monitoring by leveraging GSM network coverage.

Advantages:

- Real-time fuel-level tracking.
- GPS location monitoring enhances security.
- Suitable for commercial fleets and large fuel tanks.

Disadvantages:

- Float sensors may degrade over time.
- GSM delays possible in poor network areas.
- IoT integration increases system complexity.

Reference:
Krishnaswamy, R., *IoT-Based Fuel Level Tracking and Theft Detection*, 2019.

5) Arduino Mega–Based Tanker Fuel Monitoring System

This system uses an Arduino Mega 2560 as the main controller, supported by an ultrasonic sensor for fuel-level measurement and a GPS module for logging tanker movement. It can detect tampering or sudden volume changes and send alerts accordingly. Designed to be cost-effective, the system is adaptable to different vehicle types and provides continuous tracking and monitoring.

Advantages:

- High memory capacity of Arduino Mega supports multiple modules.
- Low-cost and scalable.
- Effective for large tankers.

Disadvantages:

- Ultrasonic readings may vary in turbulent fuel conditions.
- Requires precise calibration.
- GPS may face signal issues in enclosed areas.

Reference:
— *Arduino Mega–Based Fuel Monitoring for Tankers*, 2019.

6) IoT Fuel Level Monitoring Using Raspberry Pi

Jairarish M. and his team proposed a real-time IoT-based fuel monitoring system that uses a float sensor to measure fuel levels. The sensor outputs analog voltage signals that are processed by a Raspberry Pi. Alerts are triggered through a GSM module, and the fuel quantity is displayed on an LCD screen. The design aims to reduce fraud and minimize manual intervention during re-fueling.

Advantages:

- Raspberry Pi enables advanced processing.
- Real-time notifications using GSM.
- LCD display ensures transparency.

Disadvantages:

- Raspberry Pi increases power consumption.
- Float sensor wear may affect accuracy.
- Requires stable network connectivity.

Reference:
Jairarish M. et al., *IoT-Based Intelligent Fuel Monitoring*, 2020.

7) Raspberry Pi with GSM/GPRS for Fuel Theft Prevention

Kaivalya Kulkarni and colleagues improved the design by integrating a Raspberry Pi with GSM/GPRS technology. Fuel-level readings from the sensor are converted through an ADC and compared with reference values stored in the Raspberry Pi. If sudden variations exceed the threshold, a buzzer is activated and alerts are sent via SMS or call. The system periodically updates reference values to maintain accuracy.

Advantages:

- Highly accurate due to continuous reference updating.
- Strong anti-tamper features.
- Scalable and suitable for modern vehicle-monitoring systems.

Disadvantages:

- Higher cost due to Raspberry Pi and GPRS modules.
- More complex programming and maintenance.
- Dependent on network coverage.

Reference:
Kulkarni, K., et al., *Smart GSM/GPRS-Based Fuel Theft Prevention System*, 2021.

6)Comparative Analysis Table

The below table 1 shows the comparative analysis of the Literature survey.

Paper	Technology Used	Advantages	Advantages	Disadvantages	Application Suitability
Srinivas M,	Ultrasonic & Flow Sensors	Automated measurement, Theft alerts via GSM	Threshold-based detection, Dependence on power supply	Threshold-based detection, satplof power supply	Basic vehicle, eco-friendly use
Hada Venkata	Solar-Powered Liquid-Level Sensor	Solar-powered Low operational cost	Sunlight dependency Limited enclosed environment use	Sunlight dependency environment use	Cost-effective, eco-friendly use
Aniket Shinde	Ignition-Based Fuel Sensor	Unauthorized access alerts Location tracking	Limited to door/ ignition dependancy	Limited to door/ ignition dependency	Enhanced vehicle security
Rajesh Krishnaswamy	IoT with Float Sensor, GSM, GPS	Real-time monitoring Suitable for large fuel tanks	Sensor wear over time GSM network delays	Sensor wear over time	Fleet and commercial applications
Arduino Mega-Based System	Ultrasonic Sensor, GPS, Arduino	Requires calibration	Large calibration GPS signal issues	Higher power usage Stable network needed	Automotive, fraud prevention
Jagadish M, et al.	Raspberry Pi, Float Sensor, GSM				

Table 1: Literature Survey

2. PROPOSED SYSTEM

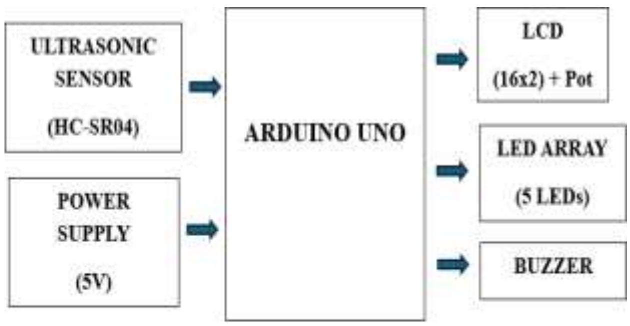

Figure 1: Block diagram of the proposed system

The proposed system is a digital fuel level indicator system. This aims to measure the quantity of fuel added to a tank using an Arduino-based system. It utilizes IoT technology to accomplish this task. The Arduino acts as the central controller within the system architecture. The objective is to build a device capable of showing the accurate fuel quantity in a motorbike in real-time. The system is engineered to be precise, user-friendly, and dependable for practical use. The hardware configuration includes components such as a fuel tank, an Analog fuel level sensor, a battery, an Arduino board, an LCD screen, and a GSM SIM900A module. These components are installed externally on the vehicle. When fuel is added, the fuel sensor detects the change and sends the data to the Arduino. The Arduino processes this input, converts it to a digital format, and updates the LCD display. Additionally, the GSM module sends a message to the user's mobile device containing the fuel information. Only users with proper authorization can access the data generated by the system. The architectural diagram of the system demonstrates how each component communicates with the others. The fuel level sensor identifies how much fuel has been added, and the system calculates the quantity accurately before sending an SMS to the user.

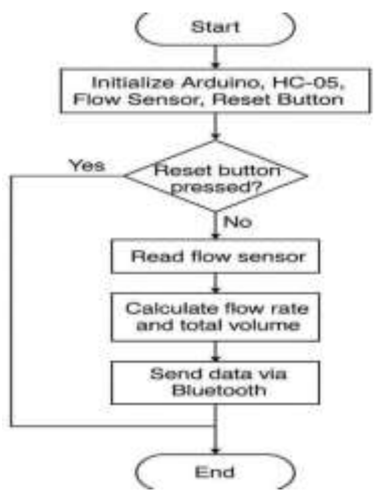

Figure 2: Flow Chart

Description of Flow Chart:

1. Start

The entry point of the program where the system begins execution.
It signals the controller to proceed to initialization and prepares the device for operation.

2. Initialize Arduino, HC-05, Flow Sensor, Reset Button

The microcontroller configures hardware interfaces: serial ports, Bluetooth module (HC-05), flow sensor input, and the reset button pin.
Initial calibration or sanity checks may run here (e.g., zeroing counters, checking module responses).

3. Reset button pressed? (Decision)

The program checks the reset button state to see if a manual reset/request was made.
If pressed, the routine branches to the reset handling path; if not, it continues normal operation.

4. (If Yes) Perform Reset / Re-initialize

On a detected reset, counters and temporary variables are cleared and modules may be reinitialized.
This ensures measurements restart cleanly and any transient errors are cleared.

5. Read flow sensor

The microcontroller samples the flow sensor output (pulse count or Analog voltage) to capture instantaneous flow data.
Sampling timing and debouncing are handled to get accurate readings.

6. Calculate flow rate and total volume

Sensor measurements are converted into real units (e.g., litres/min) using calibration factors.
The program updates cumulative volume by integrating flow over time.

7. Send data via Bluetooth

Computed values (flow rate, total volume, status) are formatted and transmitted to a paired device using the HC-05 module.
This enables remote monitoring or logging on a smartphone or gateway.

8. End / Loop back

The process either ends (if designed as single run) or returns to monitoring (most implementations loop).
In continuous mode it repeats the decision/read/calculate/send cycle until shutdown or reset.

3. CONCLUSIONS

The smart fuel meter is a highly reliable device designed to measure the precise amount of fuel being filled into a vehicle's tank. This system is equipped with GSM technology, which enables it to send real-time notifications to the vehicle owner. Additionally, GPS functionality is used to track and update the vehicle’s location.

One of the key benefits of this system is its ability to reduce fraudulent practices at fuel stations, ensuring fairness and transparency for everyday users. By implementing this device, most fuel-related frauds can be prevented.

The system is aimed at increasing customer awareness during re-fueling. Its features enable timely alerts to vehicle owners, helping to prevent deceptive practices, especially in commercial vehicles. Owing to its accuracy, the system helps users manage fuel consumption efficiently and save money. It also promotes transparency between fuel station operators and consumers, which is essential for trust and accountability.

4. FUTURE SCOPE

The Digital Fuel Level Indicator System offers significant potential for advancement as sensing and communication technologies continue to evolve. Future implementations can incorporate Internet of Things (IoT) connectivity to enable continuous data transmission to cloud platforms for advanced monitoring and long-term analytics. Integration with predictive algorithms may support the estimation of fuel consumption patterns by considering factors such as vehicle load, terrain conditions, and driving behaviour. Such data-driven insights can assist in improving fuel efficiency and reducing operational costs.

The use of hybrid sensing—combining ultrasonic, infrared, or capacitive measurement techniques—could further enhance accuracy, particularly in irregular tank geometries and environments with frequent fuel sloshing. Self-calibrating mechanisms may also be developed to automatically adjust sensor parameters over time, ensuring consistent performance despite component aging. In addition, linking the fuel monitoring system with existing vehicle telematics modules would enable seamless interaction with GPS units, onboard diagnostics, and smart dashboard interfaces.

Mobile application integration presents another promising direction, offering the user real-time alerts, consumption reports, refilling predictions, and fuel station suggestions based on location and pricing. For commercial applications, the system can be connected to centralized fleet management platforms to improve logistical planning and resource allocation.

The applicability of the system can be further extended to hybrid and electric vehicles by adapting the architecture to monitor energy storage levels instead of liquid fuel. The incorporation of secure distributed ledger mechanisms, such as blockchain, could also be explored to provide tamper-proof logging of fuel-related events, thereby reducing fraud. Advances in miniaturization and low-power embedded hardware will contribute to increased reliability, making the system suitable for continuous deployment in harsh automotive environments. Through these enhancements, the digital fuel level indicator system can evolve into a comprehensive and intelligent fuel management framework for future transportation systems.

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