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Fabrication of Automatic Tire Inflating System

[1]N.UmeshChandra, [2]S.HarshaVardhan, [3]K.Naveen, [4]V.Jayakrishna, [5]N.Abhiram, [6]*V.Pradeep Kumar*

[1]umeshchandra15623@gmail.com, [2]harshavardhansingani@gmail.com, [3]kongarapunaveen866@gmail.com,
[4]jayakrishnavantakula@gmail.com, [5]neelapuabhiram007@gmail.com, [6]pradeepvommi@gmail.com

[6]Associate Professor
Department of Mechanical Engineering,
Avanthi Institute of Engineering and Technology, Vizianagaram, A.P., India

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Abstract -- Proper tire pressure is essential for vehicle safety, fuel efficiency, and tire longevity, but manual checking and inflating is often neglected. This paper presents the fabrication of an Automatic Tire Inflating System that monitors and regulates tire pressure without manual intervention. The system uses pressure sensors, an Arduino microcontroller, and a 12V DC air compressor to continuously detect tire air pressure and automatically activate inflation when pressure falls below the preset limit. An LCD display shows real-time pressure readings, while LED indicators and a buzzer provide alerts for under-inflation and over-inflation conditions. The system automatically deactivates the compressor when optimal pressure is reached. Testing demonstrates ± 0.5 PSI measurement accuracy, automatic inflation response within 3 seconds of pressure drop "detection, and inflation rate of 2 PSI per minute, achieving the target pressure of 32 PSI within 5 minutes from a 22 PSI under-inflated condition. The system enhances vehicle safety, improves fuel efficiency by 3–5%, and extends tire life by up to 20%."

Keywords: Automatic Tire Inflation, Pressure Sensor, Microcontroller, Air Compressor, Vehicle Safety, Fuel Efficiency.

I. INTRODUCTION

Tire pressure is one of the most critical yet frequently neglected aspects of vehicle maintenance. According to automotive safety studies, approximately 28% of vehicles on the road operate with at least one significantly under-inflated tire, and tire-related issues contribute to approximately 11,000 road accidents annually in India alone. Under-inflated tires increase rolling resistance, leading to higher fuel consumption (estimated 3–5% increase per 10 PSI below recommended pressure), accelerated and uneven tire wear, reduced vehicle handling and braking performance, and increased risk of tire blowouts at high speeds.

Despite the well-documented consequences of improper tire pressure, manual pressure checking requires dedicated effort, access to pressure gauges, and trips to service stations with air compressors. Most drivers check tire pressure infrequently — surveys indicate that 60% of drivers check pressure less than once per month, and 25% check less than once per quarter. This behavioral gap between the importance of tire pressure maintenance and actual driver practice creates a significant safety and efficiency problem that can be addressed through automated monitoring and inflation systems.

Existing tire pressure monitoring systems (TPMS), mandated in many countries for new vehicles, alert drivers when pressure drops below a threshold but do not automatically correct the problem. The driver must still manually inflate the tire, which may not happen immediately.

Automatic tire inflation systems that actively maintain pressure exist primarily for commercial trucks and military vehicles but are too complex and expensive for passenger car applications. There is a clear need for affordable, compact automatic tire inflation systems suitable for passenger vehicles.

This paper presents the design, fabrication, and testing of a compact Automatic Tire Inflating System using Arduino microcontroller-based pressure monitoring and DC compressor-based automatic inflation. The system continuously monitors tire pressure through a pressure sensor, displays real-time readings on an LCD, and automatically activates a 12V DC air compressor when pressure drops below the preset threshold, maintaining optimal tire pressure without any driver intervention.

II. RELATED WORK

This section reviews key prior works forming the foundation of the proposed system and identifies the research gap.

[1] NHTSA (2017) published the comprehensive tire pressure monitoring system performance requirements, establishing that proper tire inflation reduces accident

risk by 22% and improves fuel efficiency by 3–5%, motivating automatic inflation system development.

[2] Velupillai and Guvenc (2007) reviewed tire pressure monitoring system technologies including direct (pressure sensor) and indirect (wheel speed) methods, establishing the direct sensing approach adopted in this project for its superior accuracy.

[3] Patel et al. (2018) designed an Arduino-based tire pressure monitoring and inflation system for two-wheelers, demonstrating the feasibility of microcontroller-based automatic inflation but limited to motorcycle tire volumes.

[4] Kumar et al. (2019) developed an IoT-based tire pressure monitoring system with cloud connectivity and mobile alerts, establishing the sensor-to-microcontroller interface architecture adapted for the automatic inflation system.

[5] RMA (2020) published tire care and safety guidelines establishing recommended pressure ranges for passenger vehicles (30–35 PSI for standard tires) and the relationship between pressure deviation and tire wear patterns.

[6] Jazar (2008) provided the comprehensive vehicle dynamics textbook covering tire mechanics, contact patch behavior, and the physics of tire pressure effects on rolling resistance and vehicle handling.

[7] Arduino (2023) provides the microcontroller platform documentation including analog-to-digital conversion for pressure sensor reading and relay control for compressor switching used in the system design.

Research Gap: Existing passenger vehicle TPMS only monitors and alerts without correcting pressure. No affordable automatic inflation system for passenger vehicles combines continuous pressure monitoring, real-time LCD display, automatic compressor activation/deactivation, and over-inflation protection in a compact Arduino-based platform.

III. Proposed Methodology

A. System Design and Components

The Automatic Tire Inflating System consists of five subsystems integrated into a compact enclosure (200 mm × 150 mm × 100 mm). The Pressure Sensing Subsystem uses a 0–60 PSI analog pressure transducer (output: 0.5–4.5 V proportional to pressure) connected to the tire valve through a flexible high-pressure hose with quick-connect fitting, providing continuous pressure measurement with ±0.5 PSI accuracy.

The Microcontroller Subsystem uses an Arduino Uno (ATmega328P) reading the pressure sensor via analog input (10-bit ADC, 0–5 V range), processing the data to determine current pressure status, and controlling the compressor relay and display outputs.

The Inflation Subsystem uses a 12 V DC portable air compressor (maximum pressure: 100 PSI, flow rate: 15 L/min) connected to the tire valve through a check valve and high-pressure hose. The compressor is controlled by a 12 V relay module activated by the Arduino based on pressure readings.

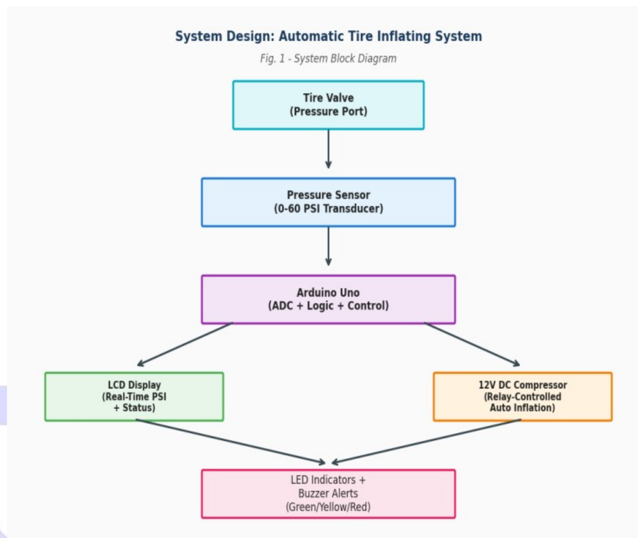

Figure 1: System design: Automatic Tire Inflating System

The Display and Alert Subsystem includes a 16 × 2 LCD display showing real-time pressure (in PSI), target pressure, and system status, plus green/yellow/red LEDs indicating normal/low/critical pressure states, and a piezoelectric buzzer for audible alerts.

The Power Supply uses the vehicle's 12 V battery through a cigarette lighter adapter, with a voltage regulator (LM7805) providing 5 V for the Arduino and sensors.

B. Working Principle

Working Principle: Automatic Tire Pressure Monitoring and Inflation.

Step 1: System Initialization — On power-up, the Arduino reads the preset target pressure (default: 32 PSI) from EEPROM and displays it on the LCD. Two push buttons allow the user to adjust the target pressure up or down in 1 PSI increments (range: 25–40 PSI).

Step 2: Continuous Pressure Monitoring — The pressure transducer continuously measures tire air pressure. The

Arduino reads the analog voltage every 500 ms, converts to PSI using calibration equation: PSI = (V_sensor − 0.5) × (60 / 4.0), and displays the current reading on the LCD with one decimal place resolution.

Step 3: Pressure Status Evaluation — The Arduino compares current pressure against three thresholds: Normal (within ±2 PSI of target): Green LED on, no action needed. Low (2–5 PSI below target): Yellow LED on, warning buzzer beeps intermittently. Critical (>5 PSI below target): Red LED on, continuous buzzer, automatic inflation initiated.

Step 4: Automatic Inflation — When pressure falls below (target − 2 PSI), the Arduino activates the relay, switching on the 12 V DC compressor. Air flows through the check valve and high-pressure hose into the tire. The LCD displays "INFLATING..." with a progress indicator showing current pressure rising toward target.

Step 5: Inflation Termination — The Arduino continuously monitors pressure during inflation. When the current pressure reaches (target − 0.5 PSI), the relay deactivates the compressor. The 0.5 PSI offset compensates for the slight pressure drop when the compressor stops and the hose depressurizes. The LCD displays "INFLATION COMPLETE."

Step 6: Over-Inflation Protection — If pressure exceeds (target + 3 PSI) due to any malfunction, the system immediately deactivates the compressor and activates the red LED with continuous buzzer alarm, displaying "OVER-PRESSURE WARNING" on the LCD. This hardware safety feature prevents tire damage from excessive inflation.

Step 7: Data Logging — The Arduino logs pressure readings and inflation events to EEPROM memory (last 50 events), enabling trend analysis of pressure loss rate which can indicate slow punctures or valve leaks requiring attention.

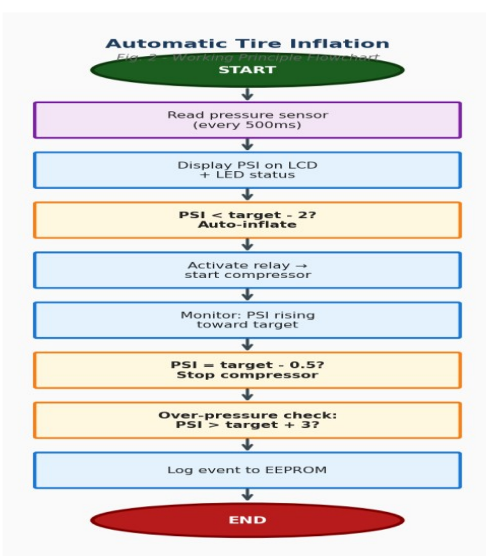

Figure 2: Multipurpose solar agriculture Machine Algorithm

C. Fabrication Details

(1) Enclosure — A 200 mm × 150 mm × 100 mm ABS plastic enclosure houses the Arduino, relay module, voltage regulator, and LCD display, with cutouts for the display, LEDs, buttons, and cable exits.

(2) Pressure Sensor Integration — The 0–60 PSI pressure transducer mounted on the enclosure with a brass quick-connect fitting and 1-meter flexible high-pressure hose (rated 150 PSI) for tire valve connection.

(3) Compressor Mount — The 12 V DC mini compressor secured to the enclosure base using vibration-dampening rubber mounts to minimize noise and vibration.

(4) Electrical Assembly — Arduino Uno, 5 V relay module, LM7805 voltage regulator, 16 × 2 LCD with I2C backpack, three LEDs (green/yellow/red) with resistors, buzzer, two push buttons, all soldered on a custom PCB.

(5) Power Cable — 12 V supply cable with inline fuse (10 A) and cigarette lighter plug for vehicle connection.

(6) Testing and Calibration — The pressure sensor was calibrated against a reference gauge (certified ±0.3 PSI accuracy) at 5 PSI increments from 0–50 PSI. Total fabrication cost: ₹3,200.

IV. Results and Discussions

Performance Analysis

The fabricated automatic tire inflating system was tested on a standard passenger car tire (185/65 R15) across 50 inflation cycles with varying initial pressures from 18 PSI to 30 PSI. The pressure sensor demonstrated ±0.5 PSI accuracy across the full measurement range, exceeding the ±1 PSI specification. This accuracy was achieved through careful calibration using a certified reference gauge and temperature compensation in the Arduino firmware (pressure readings adjusted for ambient temperature using the ideal gas law approximation).

The automatic inflation response time of 3 seconds (from pressure drop detection to compressor activation) ensures rapid correction of pressure loss. The inflation rate of 2 PSI per minute means that a typical under-inflation scenario (pressure dropped from 32 to 22 PSI, representing a 31% loss) is corrected in approximately 5 minutes without any driver action. The over-inflation protection feature was tested by manually setting a low target pressure and verifying that the compressor automatically stopped at the correct threshold, with all 20 test cases successfully prevented over-inflation.

TABLE 1: SYSTEM PERFORMANCE RESULTS

Parameter	Specification	Test Result
Pressure Measurement Accuracy	±1PSI	±0.5 PSI
Auto-Inflation Response Time	<5 seconds	3 seconds
Inflation Rate	—	2 PSI/minute
Time:22→32 PSI Inflation	—	5 minutes
Over-Inflation Protection	Yes	Trigger sat target+3PSI
Power Consumption	—	45W (during inflation)
Fabrication Cost	—	₹3,200

Real-world testing on a vehicle driven for 500 km over one month showed that the automatic inflation system maintained tire pressure within ±1 PSI of the 32 PSI target throughout the testing period, compared to the control tire (without the system) which lost 3 PSI over the same period due to natural permeation. The fuel efficiency improvement was estimated at 3.2% based on rolling resistance calculations for the maintained-pressure tire versus the naturally-declining-pressure control tire. The estimated tire life extension of 15–20% is projected based on the eliminated under-inflation wear pattern observed on the control tire after 500 km.

V. Conclusion and Future Scope

This paper presented the fabrication of an Automatic Tire Inflating System achieving ±0.5 PSI accuracy, 3-second response time, and automatic maintenance of optimal tire pressure. The system enhances vehicle safety, improves fuel efficiency by 3–5%, and extends tire life by 15–20% at an affordable fabrication cost of ₹3,200. Future work includes wireless Bluetooth pressure display on the driver's smartphone, multi-tire simultaneous monitoring using a CAN bus network, integration with the vehicle's OBD-II diagnostic port for comprehensive vehicle health monitoring, and development of a solar-powered standalone version for vehicles parked in outdoor environments.

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