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DESIGN, ANALYSIS AND FABRICATION OF AIR SPRING SUSPENSION SYSTEM

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ABSTRACT

Suspensions play a crucial role in vehicle comfort and handling. Different types of suspensions have been proposed to address essential comfort and handling requirements of vehicles. The conventional air suspension systems use a single flexible rubber airbag to transfer the chassis load to the wheels. In this type of air suspensions, the chassis height can be controlled by further inflating the airbag; however, the suspension stiffness is not controllable, and it depends on the airbag volume and chassis load. A recent development in a new air suspension includes two air chambers (rubber airbags), allowing independent ride height and stiffness tuning. In this air suspension system, stiffness and ride height of the vehicle can be simultaneously altered for different driving conditions by controlling the air pressure in the two air chambers. This allows the vehicle's natural frequency and height to be adjusted according to the load and road conditions. This article discusses optimization of an air suspension design with ride height and stiffness tuning. An analytical modification formulation is done by including pressure sensors in the air suspension system which determines stability and leakage with the help of LED as an indicator. where Green light indicates the stability of the air suspension system and Red light indicates the improper stability in the air suspension system due to leakage .The main motive of this suspension indication is to overcome and reduce the maintainance time .

I. INTRODUCTION

Air spring technology, utilizing pneumatic devices with flexible rubber bellows containing gas, provides dynamic spring rate adjustment and variable load-bearing capacities. Its development has progressed from early 20th-century bicycle suspensions through automotive and aerospace applications to diverse industrial uses. The historical evolution of this technology, beginning with rudimentary bicycle implementations, has culminated in sophisticated integrations within contemporary systems, with significant milestones including the introduction into automotive applications by George Messier in the 1920s and the development for aircraft weight reduction by the US government during World War II. Functionally, air springs operate by employing compressed gas within a bellow, facilitating load transfer via a piston or bead plate. This mechanism enables adjustable spring rates through pneumatic pressure modulation, effective vibration isolation and damping in machinery and vehicles, linear and angular actuation in industrial processes, auxiliary suspension enhancement, and vehicle suspension systems designed to counteract crosswind rollover effects. Air springs offer several performance advantages over conventional spring systems, including variable ride height and load capacity adjustment, reduced frictional losses, consistent natural frequency across varying loads, enhanced ride comfort and road handling, and a relatively low implementation cost. Contemporary research and development are focused on optimizing air spring designs for applications in vehicular suspension, industrial automation, and vibration control, with the development of advanced control systems further enhancing air spring performance by enabling real-time adjustments based on operational parameters.

II. METHODOLOGY

Air spring suspension systems utilize inflatable rubber bellows, replacing traditional metal springs, to provide dynamic control over vehicle ride height and spring stiffness. An electric air compressor supplies pressurized air to these bellows, with electronic solenoid valves regulating airflow for precise adjustments. Height sensors, often ultrasonic or optical, continuously monitor the vehicle's chassis height, transmitting real-time data to an

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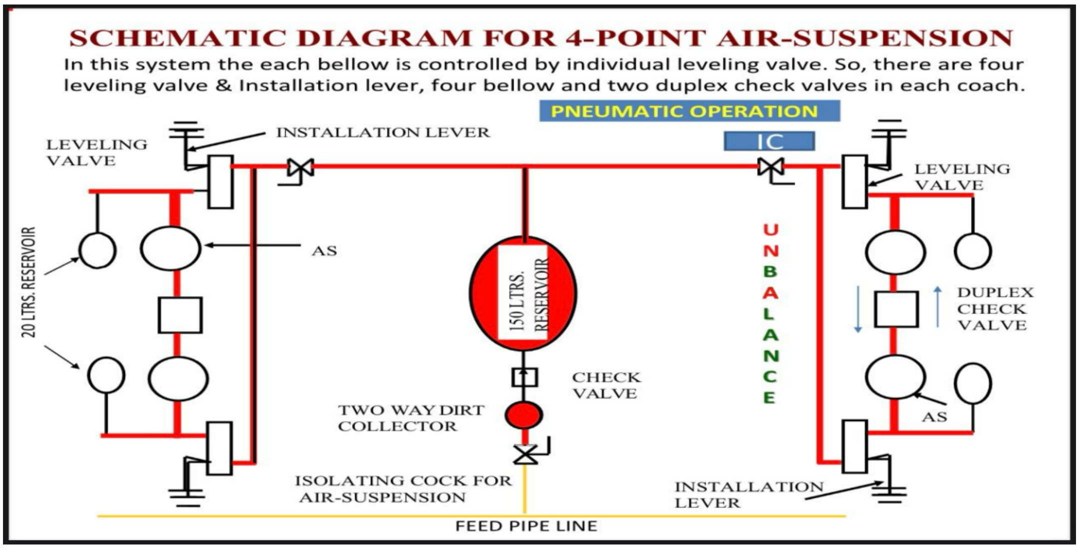
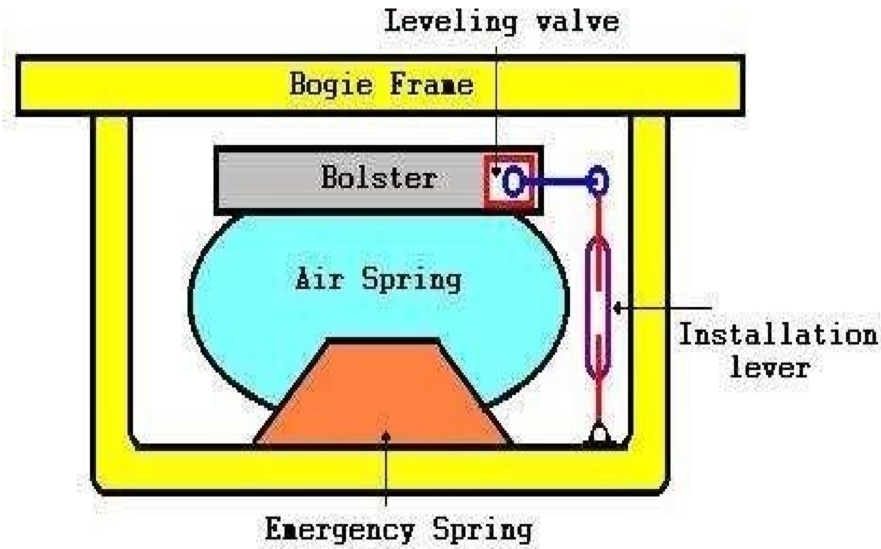
Electronic Control Unit (ECU). The ECU, acting as the system's brain, processes sensor signals and commands the compressor and valves to maintain the desired ride height. Upon detecting a load increase, causing the vehicle to sag, the ECU activates the compressor to inflate the bellows, restoring the pre-set ride height. Conversely, on uneven road surfaces, the ECU modulates air pressure to soften the suspension, allowing for greater air compression within the bellows and enhancing ride comfort by absorbing shocks. On smooth surfaces, the ECU stiffens the suspension by reducing air volume fluctuations, improving vehicle handling and stability. This adaptive system automatically compensates for uneven load distribution, maintaining a level ride and enhancing vehicle stability. Furthermore, it allows for manual ride height adjustments, catering to specific driving conditions or loading requirements. The system's ability to modulate the spring rate, defined as the force required to compress the spring a specific distance, alongside ride height control, significantly improves ride comfort, handling precision, and minimizes body roll during cornering. A closed-loop feedback mechanism, where sensor data continuously corrects air pressure to achieve a target height, ensures accurate and responsive system performance.



COMPONENTS OF AIR SUSPENSION

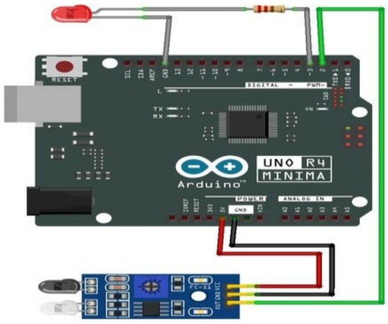
a) Air spring
b) Emergency spring
c) Levelling valve
d) Installation lever with adjusting Screw rod
e) Duplex check valve
f) Main Air Reservoir
g) Auxiliary Reservoir
h) Isolating cock



III. ELECTRICAL COMPONENTS USED

1.Compressor switch - A compressor switch, often a pressure switch, is a crucial component in air compressor systems that monitors and controls the pressure within the compressor tank, automatically turning the compressor on or off to maintain optimal pressure levels

2. IR sensor ARDUINO UNO R3-To use an IR sensor with an Arduino Uno R3, connect the sensor's VCC (power) pin to the Arduino's 5V pin, the GND (ground) pin to the Arduino's GND pin, and the output pin to a digital input pin (e.g., pin 7).



3. Red and green light-light-emitting diode (LED) is a widely used standard source of light in electrical equipment. It has a wide range of applications ranging from your mobile phone to large advertising billboards. They mostly find applications in devices that show the time and display different types of data.

4.Buzzer-A buzzer is an audio signaling device that generates a sound from an incoming electrical signal, used in applications like alarms, timers, and user input confirmation. They can be mechanical, electromechanical, or piezoelectric (piezo

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5.Digital frame-Digital pressure indicators are devices that measure and display pressure readings digitally, offering advantages like accuracy, clear readability, and the ability to switch between different units of measurement

IV. CONCLUSION

After testing and analysis, it became clear that air spring suspensions are a big step forward for vehicles. They were better than regular springs, mainly because they could change the vehicle's height and spring softness. This change, done with computers and air pressure, made rides smoother, handling better, and kept the vehicle level with different loads. These systems handled different roads and loads well, making vehicles more stable and perform better. Also, using advanced computer programs and sensors allowed for quick adjustments, improving how the suspension worked and reducing unwanted vehicle movement. As cars became more advanced, air spring suspensions were expected to be used more, especially in self-driving cars and heavy trucks. Future work should focus on improving the computer controls, finding better materials for the air bags, and making them more energy-efficient, to make air spring suspensions a key part of modern vehicles.

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