

A SELF-POWERED EMBEDDED SYSTEM FOR SHOCK ABSORBER DIAGNOSIS DURING VEHICLE MOTION

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ABSTRACT

Shock absorbers (or dampers) are key components in a vehicle suspension system and play an important role in braking performance, manoeuvring stability and onboard comfort. However they are subject to wear and suffer damages like oil leak, affecting vehicle comfort, drivability, safety and increasing the braking distances. Dampers are difficult to visually inspect, and common examinations on ground suspension platforms give inaccurate results regarding the shock absorber condition. More precise testing can be performed on a dynamometer, where a shock absorber velocity-force diagram can be collected, but because shock absorbers must be removed from the vehicle in order to be tested, these examinations are seldom used.

A theoretical analysis of the vehicle suspension and of dampers internal working principles was used to confirm the possibility of determining damper condition during normal vehicle operation. By knowing unsprung mass acceleration, and damper internal pressure, or alternatively, sprung and unsprung mass acceleration, damper status can be computed in order to alert when dampers replacement is necessary. In order to increase the accuracy, also the oil temperature should be monitored.

A wireless solution can reduce wiring cost and reduce weight, but requires the use of internal energy sources. Harvesting available energy and converting it into electricity, makes the system independent in terms of power supply, becoming a maintenance free device. A piezoelectric generator is proposed as an energy harvesting device for this application, its energy being stored in an external energy reservoir. The proposed system can be fabricated using low cost technologies (CMOS and MEMS) allowing batch fabrication of small dimensions and high reliability systems, that are suitable for embedding in the shock absorber. A monolithic micro-sensor for measuring acceleration, pressure and temperature was fabricated with the SensoNor MultiMEMS process.

Multi road experiments done with instrumented dampers, under various conditions, validated the proposed methods. A piezoelectric cantilever tuned to resonate at 12 Hz (unsprung mass resonance frequency) was installed in the vehicle suspension and energy obtained confirmed the feasibility of a self-powered system. The experimental results validate the possibility of deciding the need for shock absorber service or replacement, by comparison with reference parameters, even in a random multi-road scenario. The proposed self powered embedded system, with measurement, signal conditioning and wireless communication capabilities, can easily be integrated in a shock absorber to enhance vehicle diagnosis. Such device can be a major improvement in vehicle safety without significant added complexity and cost.