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Throttle Valve Control using Regenerative Electromagnetic Suspensions

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Abstract—*This paper presents the idea of using the Electromagnetic Regenerative Suspensions to control the opening of throttle valve in the automobile and hence control the power output of the engine by taking the feedback from the EM (Electromagnetic) suspensions about its extent of movement and rate of movement. The Regenerative Suspensions also lessen the energy wastage of the fuel which otherwise is dissipated as vibrational energy and heat energy. The Regenerative suspensions contract and relax depending upon the pressure applied on it and the extent of contraction and relaxation depends on the unevenness of the road, the more the road is uneven, more is the movement of the suspensions and vice versa. Thus the e.m.f. (electromotive force) is generated by the EM suspensions. The voltage generated is noted and depending upon those values, threshold and peak values are set and fed to microprocessor to control the throttle valve.*

Keywords: Electromagnetic, Regenerative Suspensions, throttle valve, energy wastage.

1. INTRODUCTION

Increase in vehicle traffic and careless driving has led to increase in vehicle collisions and other mishaps. According to Ministry of Road Transport and Highways the number of road accidents has increased in recent years. An intelligent system that takes in input about an automobile's surroundings and accordingly influences the vehicle motion is one of the solutions to the above problem. This system also greatly improves vehicle efficiency and reduces the stress on the driver. It also further improves the vehicle comfort, since Electromagnetic Suspension Systems perform better than the presently widely used Hydraulic Suspension Systems. According to Gysen [7], hydraulic damper contributes to environmental pollution due to hose leaks and ruptures, where hydraulic fluids are toxic. Then, the hydraulic systems are considered inefficient due to the required continuously pressurized system. On the contrary, electromagnetic suspension systems (EMS) not require hydraulic fluid. It consists of sets of permanent magnet and series of current coil.

Vehicles are widely used all around the world and cause a lot of energy and environmental issues. In the United States, transportation accounts for over 70% OF environmental pollution. In addition to thermal efficiency and braking energy, one important loss is kinetic energy dissipated by shock absorbers. An Electromagnetic suspension is a type of shock absorber that converts parasitic intermittent linear motion and vibration into useful energy, such as electricity. It works on the principle of Faraday's law of electromagnetic induction.

2. LITERATURE SURVEY

Recently a number of attempts have been made by various automobile manufacturers in implementing the electro-magnetic suspensions in place of normal suspensions. This paper gives an idea of how these suspensions could further be used as a part of driver assistance system. Various studies regarding the performance and characteristics of such suspension systems have been a worthy motivation for us.

Zhongjie Li and Lei Zuo [1] provided the data regarding the voltage generated with respect to the displacement of the suspensions for different speeds of an Automobile.

An electromagnetic suspension system has an edge over other active suspension systems due to the relatively high bandwidth (tens of hertz), and there is no need for continuous power, ease of control, and absence of fluids. Linear motion can be achieved by an electric rotary motor with a ball screw or other transducers to transform rotary motion to linear translation. However, the mechanism required to make this conversion introduces significant complications to the system. These complications include backlash and increased mass of the moving part due to connecting transducers or gears that convert rotary motion to linear motion (enabling active suspension). More important, they also introduce infinite inertia, and therefore, a series suspension, e.g., where electromagnetic actuation is represented by a rotary motor connected to a ball screw bearing, is preferable. These direct-drive electromagnetic systems are more suited to a parallel suspension, where the inertia of the Actuator is minimized [5].

The Hydraulic Electromagnetic Suspensions require less time to reach stability from vibration compared to the traditional suspensions which directly influences the passenger comfort. The simulation results reveal that under step response stimulus, the hydraulic electromagnetic energy-regenerative suspension has a stronger capability of reducing the body vibration than the traditional suspension, and the vibration of corresponding wheels will increase, which gives a potential of improving the driving comfort [6].

3. SYSTEM ARCHITECTURE

A. Methodology

Here, we have designed a system that controls the throttle valve using Electromagnetic Regenerative suspensions. Electromagnetic Suspension are a combination of normal suspension and strong magnet that produces e.m.f when there is any motion in the suspensions. Based on this generated e.m.f the angle of opening of the throttle valve is controlled SO THAT as the e.m.f increases, the power generated by the Engine is reduced. Hence using this design we can control the power of an engine depending on surfaces of the road.

This paper puts forward the design of driver assistance using Embed LPC1768 arm board.

B. Block Diagram

The figure one shows the functional block diagram of how the system works. In this we have used an arm processor which controls the whole circuitry. The blocks to the left of the microprocessor represent inputs and to the right represent output.

An e.m.f is generated by Electromagnetic Regenerative suspensions when there is unevenness or bumps in the road and the e.m.f generated by the EM Suspensions is directly proportional to unevenness of the road, if the road has more bumps or potholes then e.m.f generated by the Suspensions is more and vice versa. According to the value of e.m.f generated by the suspensions, the processor controls the throttle valve i.e. the opening and closing of a throttle valve is controlled using servo motor. On the other hand, in a normal vehicle, as the driver depresses the accelerator pedal more air/fuel mixture will be sucked into the engine and hence the power is also high irrespective of the condition of the road.

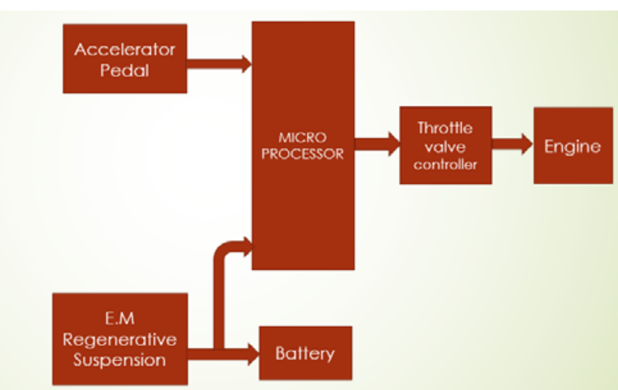

Fig. 1: Block diagram of system

The current generated by the electromagnetic suspension can also be used to charge the battery of the vehicle. The arm processor is the heart of the system which controls the whole circuitry. It uses LPC1768 microcontroller.

4. DETAILED DESIGN

A. Board Used

Mbed LPC1768

It is Rapid Prototyping for general microcontroller applications, Ethernet, USB and 32-bit ARM Cortex-M3 based designs. The mbed Microcontrollers are a series of ARM microcontroller development boards designed for rapid prototyping. The mbed NXP LPC1768 Microcontroller in particular is designed for prototyping all sorts of devices, especially those including Ethernet, USB and the flexibility of lots of peripheral interfaces and FLASH memory. It is packaged as a small DIP form-factor for prototyping with through-hole PCBs, strip board and breadboard, and includes a built-in USB FLASH programmer. It is based on the NXP LPC1768, with a 32-bit ARM Cortex-M3 core running at 96MHz. It includes 512KB FLASH, 32KB RAM and lots of interfaces including built-in Ethernet, USB Host and Device, CAN, SPI, I2C, ADC, DAC, PWM and other I/O interfaces. The pinout below shows the commonly used interfaces and their locations. Note that all the numbered pins (p5-p30) can also be used as DigitalIn and DigitalOut interfaces. The different pins of the embed board is shown in figure3.

Fig. 2: Arm Embed LPC1768

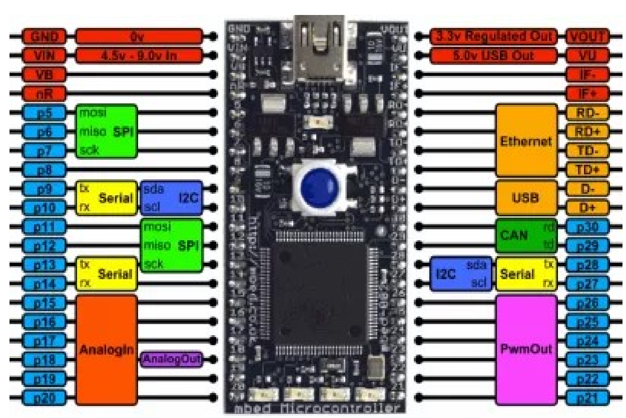

Fig. 3: Pin configuration of embed LPC1768

B. Working of system

In this a throttle body and servo motor are employed to achieve the desired results. Electromagnetic suspensions generates currents when there is a movement or vibrations in the suspensions and this works on the principle of Faraday's Law of Electromagnetic Induction. The generated current or voltage is given as input to processor and also simultaneously is used to charge the battery. Another input to the processor comes from the Accelerator Pedal Position Sensor in the form of a voltage. The output voltage of the sensor varies with the depression of the accelerator pedal. This sensor consists of a Potentiometer whose wiper terminal is wired to the accelerator pedal. The change in desired acceleration is given out as a particular voltage level which is sent to the processor. The Processor reads both these inputs i.e. from the Electromagnetic Suspensions and the accelerator pedal position sensor and then the software compares these inputs to the values stored in the processor's memory and then gives out signals in the form of voltage to the servo motor which in turn controls the movement of the Throttle Valve. For example, if a large voltage is generated by the electromagnetic suspension which indicates the presence of excessive bumps in the road, the processor rotates the servo motor in such a way that the valve is only partially opened. This causes less air-fuel mixture to enter into the engine and hence the power generated by engine is less which causes the vehicle to move with less speed. On the other hand if voltage generated by suspensions is very less which indicates the road is smooth, so the processor rotates the servo motor in such a way that the throttle valve is completely opened which results in an air and fuel mixture of higher air to fuel ratio entering into the engine and thus increasing the engine's output power which in turn accelerates the vehicle. Thus depending upon voltage generated by EM suspensions along with the acceleration desired by the driver, the movement of throttle valve is controlled. In our project we have used a potentiometer in place of EM suspensions and when we vary the voltage from 0 to 5 volts the servo motor attached to valve also rotates according to required conditions.

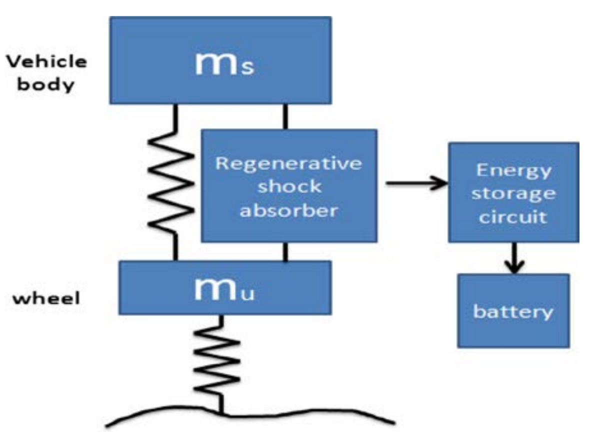

Fig. 4: Typical EM Suspension Model

5. IMPLEMENTATION RESULTS

This research work emphasized the idea of controlling the power output of a gasoline engine depending on the linear movement of the electromagnetic suspensions. A model was also designed to realize the system. The model was designed such that angle of opening of the throttle valve is directly proportional to the value of acceleration pedal position sensor at a particular value of voltage output of the suspensions.

EM suspension output in volts	Position sensor output voltage	Angle of opening
1	1	17.1^0
	3	49.5^0
	5	81.9^0
3	1	13.5^0
	2	22.5^0
	3	31.5^0
5	3	13.5^0
	4	15.3^0
	5	17.1^0

It is observable from the above table that, lesser output voltage of the EM suspensions corresponds to smoother roads and hence opening angle increases significantly with increase in acceleration. Larger output voltage from EM suspensions means the road is uneven and hence the throttle valve opens to a smaller extent and thus controls the power output from the engine even if the driver tries to accelerate.

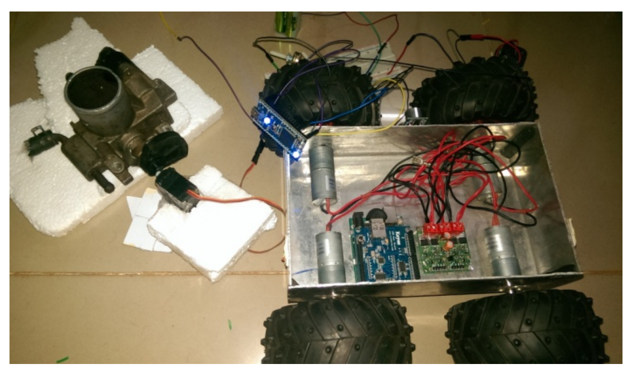

Fig. 8: Throttle valve control

6. CONCLUSION

This paper concludes that the power output of an automobile engine, gasoline engine in particular, can be automatically controlled by taking in feedback information from the electromagnetic suspensions about the surface of the road and thus avoid or reduce unwanted acceleration of the automobile due to reckless or irresponsible driving.

This work also includes a basic design model of the proposed system and shows the tabulated data of the resulting opening angle of the throttle valve for a particular output voltage from the electromagnetic suspensions and accelerator pedal position sensor. For greater output voltages from the suspensions the opening angle reduces for a particular acceleration, thus achieving the primary objective of this work that is, controlling the unnecessary acceleration of the car ON bumpy roads. This system can further be integrated with other available driver assistance systems in cars, particularly for reducing the reckless or irresponsible driving in cases where the driver is under the influence of alcohol or in any other similar scenarios.

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