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Automatic electromagnetic retardation braking using ultrasonic waves

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ABSTRACT

Currently, vehicles are often equipped with active safety systems to reduce the risk of accidents, many of which occur in the urban environments. This approach uses ultrasonic sensors in safety systems for controlling the speed of a vehicle is proposed. An intelligent system includes an ultrasonic wave emitter and receiver provided on the front portion of a car producing and emitting ultrasonic waves frontward in a predetermined distance and operatively receiving a reflective ultrasonic wave signal. The reflected wave (detected pulse) gives the information about the distance between the obstacle and the vehicle, apparently PIC 16F877A microcontroller controls the speed of the vehicle based on the detection pulse information by triggering the electromechanical relay and sends a signal to the electromagnetic plunger to apply brake constantly. This approach solves the problem where drivers may not be able to brake manually exactly at the required time, before imminent forward collision with another vehicle or an obstacle.

KEYWORDS: Ultrasonic sensors, Microcontroller, Electromagnetic plunger.

1. INTRODUCTION

The automobile technology has arrived with new enhancement most frequently uses drum and disc brakes. The most popular braking system includes Antilock Braking Systems (ABS), Traction Control and Stability Control, all these systems employing with different types of sensors to constantly monitor the conditions of the vehicle, and respond in an emergency situation. The principle of frictional and electromagnetic retarder system involves the conversion of energy kinetic to heat. In recent days, customers are at odds over a collision while activating autopilot where it is designed to provide a hands-on experience to give drivers more confidence behind the wheel, increase their safety on the road, and make highway driving more enjoyable. The use of the brake also apparently disengaged the automatic emergency braking system during the collision. Autopilot is by far the most advanced system on the road, but it does not turn into an autonomous vehicle and does not allow the driver to abdicate responsibility. Ultrasonic systems are widely used in many applications, whose strength lies in its wide range of detection and anti-interference. This sound normally lies beyond human hearing. In this work with the help of ultrasonic waves the braking system in automobile enhanced and it was analysed during the test. The principle of ultrasonic sensors is used here to control the motion of car by determining the distance before car hits the obstacle or other vehicle. Its weakness lies in the valid radius of detection that is rather limited and in its accuracy in obstacle detection. Ultrasonic systems can generally be used in middle and low end cars. Electromagnetic braking system achieves approximately 75% better than the regular friction brakes. Electromagnetic braking system consistently used in addition to the regular brake pads to precisely control the braking on vehicles.

2. MATERIALS AND METHOD

Electromagnetic Retarder system: The electric retarder uses electromagnetic induction to induce retardation force. An electric retardation unit can be placed on an axle of vehicle, a rotor is mounted to the axle, and a stator securely attached to the vehicle chassis. When retardation is required, the electrical windings in the stator are powered up from the vehicle battery, producing magnetic fields alternating in polarity. This induces eddy currents in the rotor, the generation of eddy currents in the mass of the rotor leads to the appearance of Laplace forces that respond with the rotation of the rotor. The braking torque is thus produced and applied to the axle, to which it is attached. The induction brakes known as electrical or electromagnetic retarder offers an endurance braking system, they disperse a large part of the braking energy, thus relieving conventional braking systems.

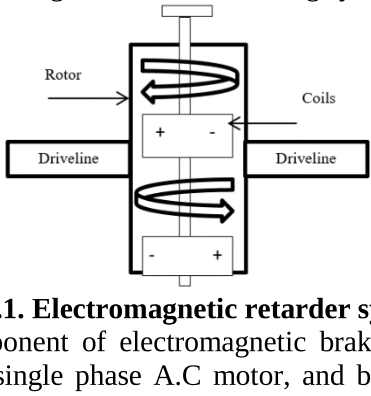

Figure.1. Electromagnetic retarder system

Construction: The main hardware component of electromagnetic braking system includes an electromagnetic plunger, wheel and pulley arrangement, single phase A.C motor, and battery. The mechanical structure for the braking assembly was designed using CATIA 6, and the hardware component was assembled. Programming software MikroC is used here to run the system, and the programs and algorithm were developed for testing.

Mechanical structure: The mechanical frame for the system was planned with the goal of making the structure compact which contains angle beams to make a hard durable structure. The structure is designed to support the parts of the braking system which comprises all the components such as the control panel, electromagnetic plunger and the wheel arrangement. The motor and battery is placed on the top of the frame with proper positioning. The Catia software tools are used for modelling and analysis and the frame has height (30cm), length (80cm), breadth (30cm).

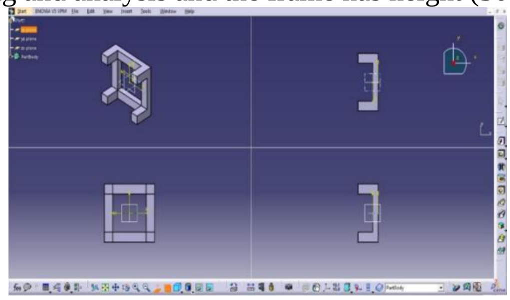

Figure.2. Representation of the mechanical frame using Catia software

Battery: The storage of electricity needs a battery with high reliability, efficiency, long life available at low cost and the overall system optimized by the available energy. The lead acid wet cell with 12V battery is used to control the electromagnetic plunger. The battery unit is mounted indirectly to the control panel consisting of PIC, sensors, and relays.

Single phase A.C. motor: The typical household supply of 220 volts can drive the single phase A.C. Motor. This power supply is limited to the motor; it does not power up any other part of the circuit. The single phase A.C. motor drives the wheel and pulley arrangement and rotates at a speed of 1400 RPM. Since the motor is connected directly to the control unit circuit, the motor will be turned off or stopped whenever electromagnetic plunger hits the brake, which will prevent any internal damage to the motor.

Ultrasonic Sensor: Ultrasonic transducers convert ultrasound waves to electrical signals or vice versa. The ultrasonic sensor HC-SR04 is used which has range of 2cm to 400cm with 4 pins:

VCC – 5V, positive terminal of the power supply
TRIG – Trigger Pin
ECHO – Echo Pin
GND – Negative terminal of the power supply

TRIG and ECHO pins can be used to interface this module with a microcontroller unit.

Electromechanical Relay: Electromechanical relays are electrically operated switches used to separate circuits or batteries, detect faults on transmission and distribution lines, and regulate a high powered circuit using a low power signal. Simple relays consist of a magnetic core bound in a wire coil, a transferable armature attached to an iron yoke, and one or more set of contacts. When an electric current passes through the coil it creates a magnetic field that triggers the armature, therefore touching the contacts to make or break a connection. This relay is switched on only when the sensor detects the obstacle and moves to Normally Open condition. Otherwise the relay will be in Normally Close state.

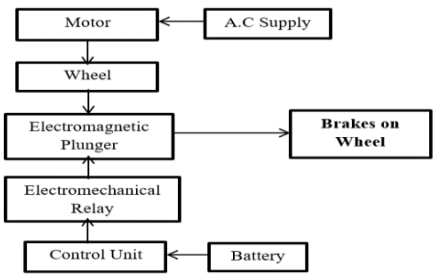

Figure.3. Electromagnetic Retardation braking integration

Electromagnetic Plunger: Linear pull type electromagnetic solenoid designed for proportional motion control thus the plunger position is proportional to the power input. The plunger is mounted underneath the control panel, and the iron wire is attached to it when the plunger is magnetized it pulls the iron wire which will apply the brakes to the moving wheel.

Wheel and pulley: The wheel and pulley arrangement are made to demonstrate the purpose of this approach. The brake will be actuated and applied to the wheel when the detection of obstacle or another vehicle and the wheel is mostly playing a vital role of the entire car, which will be brought to a halt in a real scenario.

Design calculation of wheel and pulley:

Centre distance between the pulleys (x) = 0.31 m

Diameter of the driving pulley (D) = 0.065 m (r_1= 0.0325 m)

Diameter of the driven pulley (d) = 0.05 m (r_2 = 0.025 m)

The Speed of the driving pulley (N_1) = 1400 r.p.m.

Bansal (2006), Velocity ratio $\frac{N_2}{N_1} = \frac{D}{d}$

Therefore, speed of the driven pulley $N_2 = \frac{D}{d} \times N_1$ = 1820 r.p.m

Length of the belt: $L = \pi(r_1 + r_2) + \frac{(r_1 - r_2)^2}{x} + 2x$ (for open belt)

L = 0.8008 m

Installation and Integration of Hardware & Software: The integral components of the braking system are assembled on to the mechanical frame with proper positioning, and the integration is done by using PIC16F877A microcontroller to which it is programmed. The microcontrollers are further connected to the electromechanical relay which in turn actuates the braking system and helps in achieving the purpose. The integrated system is tested, and results are seemed favourable to the vehicle.

Control unit: In automotive electronics Electronic Control Unit (ECU) is a generic term for all embedded system that controls one or more of the electrical system or subsystems in a motor vehicle.

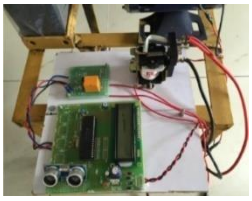

Figure.4.Control unit

Figure.5.Electro magnetic plunger

Figure.6.AC Induction motor

Figure.7.Assembled model

Interfacing of sensor with PIC16F877A: The interfacing is done using the MIKRO C software and a PICKIT burner which is used to write the program into the microcontroller. The codes were generated and executed for the functioning of the system as follows,

a) Provide TRIGGER signal, at least 10µS High Level (5V) pulse.
b) The module will automatically transmit eight 40 KHz ultrasonic burst.
c) If there is a detection of an obstacle in-front of the module, it will reflect the ultrasonic burst.
d) If the signal is back, ECHO output of the sensor will be in HIGH state (5V) for duration of time taken for sending and receiving ultrasonic burst. Pulse width ranges from about 150µS to 25mS and if no obstacle is detected, the echo pulse width will be about 38ms.

PIC16F877A is the core of this circuit. VDD and VSS of PIC Microcontroller is connected to +5V and GND respectively which will provide required power for its operation. An 8MHz crystal is connected to OSC1 and OSC2 pins of PIC, to deliver clock for its operation. 22pF capacitors connected along with the crystal will steady the oscillations generated by the crystal. 16×2 LCD is connected to PORT D which is interfaced using 4 bit mode communication. 10KΩ preset is used to adjust the contrast of the LCD. A 100Ω resistor is used to limit current through the LCD back-light LED. TRIGGER pin of HC-SR04 sensor is connected to RB0 (pin 33) of PIC which is to be configured as an Output PIN (TRIS bit is 0) and ECHO pin is connected to RB4 (pin 37) which is to be configured as an Input PIN (TRIS bit is 1).

The program have written into the microcontroller will work as follows,

- Provide TRIGGER to ultrasonic module- A trigger is provided to the ultrasonic sensor by the RBO/INT terminal of PIC OR the number 33 Pin in the PIC. This helps in producing an echo that is forced out as ultrasonic waves.
- Listen for Echo- Echo is nothing but ultrasonic waves and the second function of the program is to listen to the echo.
- Start Timer when ECHO HIGH is received- When the echo is received the timer is started and a signal is provided to RB4 or the 37th pin in the PIC.
- Stop Timer when ECHO goes LOW- The timer is stopped as soon as the echo goes flat and the connection to the 37th pin is interrupted.
- Read Timer Value- The timer value is read and is used to calculate the distance.
- Convert it to Distance
- Display it- The exact value of the distance between the sensor and the object is displayed.

Calculation of distance from the ultrasonic sensor,

Distance = Speed × Time

Let d be the distance between ultrasonic sensor and target.

Total distance travelled by the ultrasonic burst: 2d (forward and backward)

Speed of sound in air = 340 m/s = 34000 cm/s

$$\text{Thus, } d = \frac{(34000 \times \text{Time})}{2}$$

3. RESULTS AND DISCUSSION

Due to varying temperature exerted by the frequent application of heavy braking results in a reduction in the brake occurs in friction brake drums. This problem is being considered for lighter vehicles by obtaining efficient heat dissipation since electromagnetic braking offers a better thermal dynamic performance and the designed model overcomes such issues. This system will not even rely on oils which are used for the lubrication in friction brakes results in reduction of the cost required for maintenance. But the only problem in using electromagnetic braking requires a battery power which drains rapidly down when it energize the brake. This system will work even better when it is associated with an additional friction braking because the friction force generated by this system is comparatively not greater than disc brakes.

4. CONCLUSION

The existing control system in modern vehicles does not provide a proper interaction with automotive electronics and it will not calculate the relative speed of the vehicle which leads to an error in estimating the distance between vehicles when activating the smart or emergency braking system. The solution developed was feasible and reliable enough to challenge current products available in market in terms of features and support. This approach presents ultrasonic sensors which are cheaper than other types of sensors such as radar and the system consist of a less demanding hardware which facilitates easy mounting. The relative speed of the vehicle with respect to the obstacle is determined using consecutive samples of the distance calculated. Thus the present control system maintains a safe distance by calculating the action on the brakes. If the system is implemented in future with laser sensors which will offer an efficient braking because it keeps a 360˚ watch and consistently will reduce the number of accidents than the present system.

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