Electrical Braking System Simulation and Control based on Force to Voltage Conversion using Servo Motor

Mohammad A Obeidat

Abstract—In this paper an electrical braking system is proposed. The force on the pedal of the mechanical brake is converted to a voltage using Flexi force sensor. The electrical voltage signal is processed using Arduino uno microcontroller to drive a servomotor at a certain phase angle, which allows the oil to flow in the cylindrical pipe brake.
Hardware implementation of the system has been built and tested. This system can be applied for vehicle to vehicle communication which helps in accident reduction.

Keywords— braking system,. Microcontroller, vehicle, communication, servomotor.

I. Introduction

An Electric braking system is a very important project and it can have many benefits in terms of safety in order to protect people's lives in a better and more developed manner and it saves cost and provides a high efficiency .

The classical Hydraulic braking system depends on pressurized oil, pistons, and an applied force on the pedal, which consumes a lot of time and may come across a lot of issues therefor we tried to develop a controlled process which can come in handy. Developers then created the abs system which added the ability of controlling the amount of braking fluid supplied to the brushes of tires making it possible to turn on and off breaking for each tire which enhanced the prohibition of skidding, and allowed for a partial control of braking of tires which made the drive control in turning and sudden stopping of the vehicle much better.

The normal development is using our knowledge of control systems and electrical devices as mechatronics engineers and apply this knowledge to develop a braking system that is based on the previous mentioned braking types with the addition of a control system to improve the operation and response of the braking process.

The author is with Tafila Technical University, Jordan

II. System design and Implementation

In a hydraulic braking system, when the brake pedal is pressed, a pushrod exerts force on the piston(s) in the master cylinder, causing fluid from the brake fluid reservoir to flow into a pressure chamber through a compensating port. This results in an increase in the pressure of the entire hydraulic system, forcing fluid through the hydraulic lines toward one or more calipers where it acts upon one or more caliper pistons sealed by one or more seated O-rings (which prevent leakage of the fluid).

The brake caliper pistons then apply force to the brake pads, pushing them against the spinning rotor, and the friction between the pads and the rotor causes a braking torque to be generated, slowing the vehicle. Heat generated by this friction is either dissipated through vents and channels in the rotor or is conducted through the pads, which are made of specialized heat-tolerant materials such as kevlar or sintered glass.

Alternatively, in a drum brake, the fluid enters a wheel cylinder and presses one or two brake shoes against the inside of the spinning drum. The brake shoes use a similar heat-tolerant friction material to the pads used in disc brakes.

Subsequent release of the brake pedal/lever allows the spring(s) in the master cylinder assembly to return the master piston(s) back into position. This action first relieves the hydraulic pressure on the caliper, then applies suction to the brake piston in the caliper assembly, moving it back into its housing and allowing the brake pads to release the rotor.

The hydraulic braking system is designed as a closed system: unless there is a leak in the system, none of the brake fluid enters or leaves it, nor does the fluid get consumed through use. Leakage may happen, however, from cracks in the O-rings or from a puncture in the brake line. Cracks can form if two types of brake fluid are mixed or if the brake fluid becomes contaminated with water, alcohol, antifreeze, or any number of other liquids.

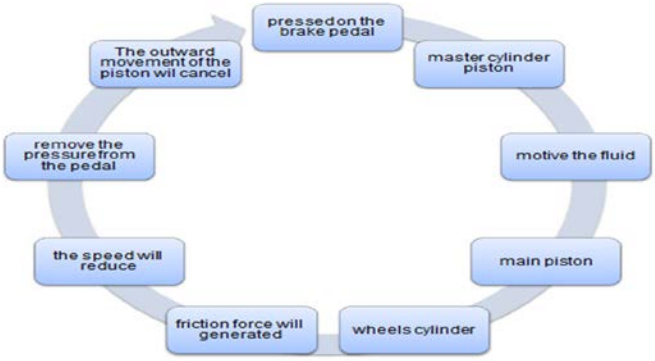

Fig.1: The principle of work for Hydraulic braking system

A more sophisticated breaking system which is the abs system uses a more advanced methodology to enhance breaking capability the following is an explanatory of abs system.

Anti-skid braking system (ABS) is an automobile safety system that allows the wheels on a motor vehicle to maintain tractive contact with the road surface, preventing the wheels from locking up (ceasing rotation) and avoiding uncontrolled skidding. It is an automated system that uses the principles of threshold braking, and cadence braking which were practiced by skillful drivers with previous generation braking systems. It does this at a much faster rate and with better control than many drivers could manage. ABS generally offers improved vehicle control and decreases stopping distances on dry and slippery surfaces.

However, on loose gravel or snow-covered surfaces, ABS can significantly increase braking distance, although still improving vehicle steering control. Since initial widespread use in production cars, anti-lock braking systems have been improved considerably. Recent versions not only prevent wheel lock under braking, but also electronically control the front-to-rear brake bias. This function, depending on its specific capabilities and implementation, is known as electronic brake force. Distribution (EBD), traction control system, emergency brake assist, or electronic stability control (ESC)

When the gyroscopic sensor detects that the direction taken by the car does not coincide with what the steering wheel sensor reports, the (ESC) software will break the necessary individual wheel(s) (up to three with the most sophisticated systems so that the vehicle goes the way the driver intends.

The steering wheel sensor also helps in the operation of Cornering Brake Control (CBC), since this will tell the ABS that wheels on the inside of the curve should brake more than wheels on the outside, and by how much.

ABS equipment may also be used to implement a traction control system (TCS) on acceleration of the vehicle. If, when accelerating, the tire loses traction, the ABS controller can detect the situation and take suitable action so that traction is regained. More sophisticated versions of this
Can also control throttle levels and brakes simultaneously.

There are four main components of ABS:

•Wheel speed sensors
•Valves, a pump
•Controller
•Speed sensors

A speed sensor is used to determine the acceleration or deceleration of the wheel. These sensors use a magnet and a Hall effect sensor, or a toothed wheel and an electromagnetic coil to generate a signal. The rotation of the wheel or differential induces a magnetic field around the sensor. The fluctuations of this magnetic field generate a voltage in the sensor. Since the voltage induced in the Sensor is a result of the rotating wheel; this sensor can become inaccurate at slow speeds. The slower rotation of the wheel can cause inaccurate fluctuations in the Magnetic field and thus cause inaccurate readings to the controller Valves. There is a valve in the brake line of each brake controlled by the ABS. On some systems, the valve has three positions:

In position one, The valve is open; pressure from the master cylinder is passed right through to the brake. In position two, The valve blocks the line, isolating that brake from the master cylinder. This prevents the pressure from rising further should the driver push the brake pedal harder. In position three, The valve releases some of the pressure from the brake.

Advantages of abs system.
•Reduced the risk of multiple vehicle crashes by 18 percent
•Decreased the risk of run-off-road crashes by 35%.
•ABS-equipped cars are able to attain braking distances better than those that would be possible without the benefit of ABS.
•ABS reduces chances of crashing, and/or the severity of impact.
• ABS will significantly reduce the chances of a skid and subsequent loss of control.
•ABS tends to increase braking distances in gravel, sand and deep snow.

Arduino uno is used as a microcontroller. Arduino is an open-source electronics platform based on easy-to-use hardware and software. It's intended for anyone making interactive projects; it is also the brain of this paper. A servomotor is a rotary actuator that allows for precise control of angular position, velocity and acceleration. Here; the servo will change the angle of the mixer to mix hot and cold water. This sensor will be abide on the bread board then its output will be send to the aurduino after fumbles the strength, then by depending on the sensors reading the aurduino will shoes the suitable value of voltage by depending on the code which had been loaded on the aurduino .

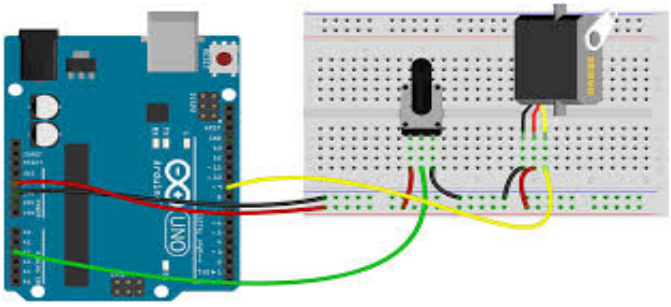

Fig.2: connection diagram of Aurdino

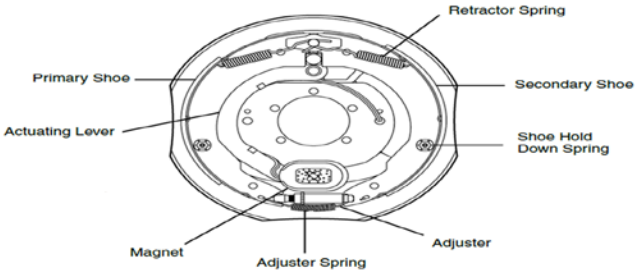

Fig.3: FRONT OF BRAKE

The electric brakes are similar to the drum brakes; the basic difference is that the drum brakes are actuated by hydraulic pressure while electric brakes are actuated by an electromagnet, with the entire brake component connected to the system.

When the electrical current is fed into the system by the controller, it flows through the electromagnet in the brakes.
The high capacity electromagnets are energized and then attracted to the rotating armature surface of the drums which move the actuating levers in the direction of the drum turning.

The resulting force causes the actuating cam block at the shoe end of the lever to push the primary shoe out against the inside surface of the brake drum. The force generated by the primary shoe acting through the adjuster moves the secondary shoe out in to contact with the brake drum. Increasing the current flow to the electromagnet causes the magnet to harden the grip on the armature surface of the brake drum. The result in increasing the pressure against the shoes and then the brake drum is to accomplish the desired stop.

The advantages for electrical braking actuator system:

•They can be manually adjusted by the controller to provide the correct braking capability for varying road and load conditions.
•They can be modulated to provide more or less braking force, thus easing the brake load on the towing vehicle.
•In an emergency situation, they can provide some independent braking.

The application is monitored using a flexi force sensor.This sensor will fumble the pressure strength on the pedal which the arduino will read as an analog signal. After that a signal will send to a linear actuator, and depending on the code which saved on the arduino and the relation between the pressure range on the pedal which the sensor will fumble, and the space which the linear actuator should cross.

Then a piston which connected with that linear actuator will move, so the braking oil will be pressured, and depending on the pressured force on the piston the oil will move toward the brake so the pistons in the brake will be pressured. So a friction will be induced between the moving part of the brake and the wheel, so the speed will be reduced.
And when the pressure force on the pedal move, the linear actuator will back to its normal state In the next semester we are going to implement this search on hard ware, depend on the range of the voltage which the arduino will read.

We will select a range of voltage, and depend on the read value, the brake force will act in, medium, heavy, or other mode.

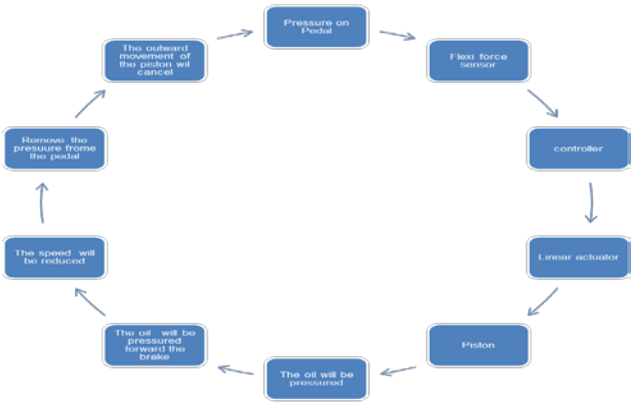

Fig.4: Principle of operation

III. RESULTS

Table 1: Principle of Operation Results

Pedal angle	The arduino reading	Piston angle
0	600	0
1	610	6
2	620	12
3	630	18
4	640	24
5	650	30
6	660	36
7	670	42
8	680	48
9	690	54
10	700	60
11	710	66
12	720	72
13	730	78
14	740	84
15	750	90
16	760	96
17	770	102
18	780	108
19	790	114
20	800	120
21	810	126
22	820	132
23	830	138
24	840	144
25	850	150
26	860	156
27	870	162
28	880	168
29	890	174
30	900	180

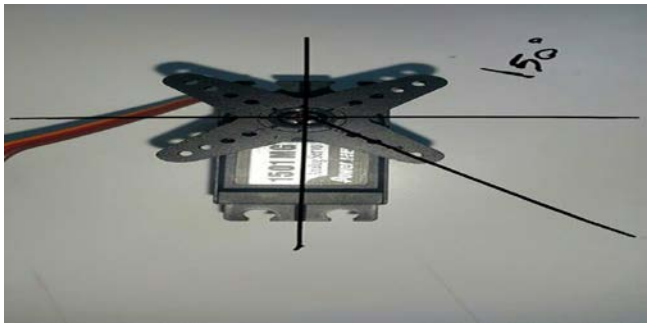

Fig.5: Servo motor with angle 150 degrees.

CONCLUSION

We are so excited to apply what we learned in the courses, and we had new experiences about the electrical devices.
The process of designing a control system from the scratch and programming the arduino to fulfil the purpose of our project formed a challenge but by team work and the help of our instructor we managed to finish and operate the system successfully.

We faced a few problems such as finding the right sensor for the application choosing from various types of sensors and at last we chose the flexible force sensor because of it's high sensitivity and accuracy and it has the ability of providing a varying signal (analog).

Another problem was choosing a motor that gives a linear movement so we had to choose between servo motor and linear motor, the better choice was the linear motor but because it wasn't available in the market we had to go with the servo motor and by manipulating it's principle of operation by connecting the piston to it's arm converting the circular motion of the servo motor to a linear motion.

Dealing with this project and solving it's problems improved our understanding of control systems and the selection of the right devices and programming methodology to achieve the goals of our application.

In the end we want to thank our university and our faculty and our department for making it possible for us to achieve success in this project and last but not least we want to thank our instructor for his continuous help and guidance.

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Mohammad A Obeidat is assistant professor in power and mechatronics department at Tafila Technical University. He received his PhD in Electrical Engineering, Wayne State University, in 2013. his M.Sc degree in Electrical Engineering, Yarmouk University, Jordan, in 2006, and his B.Sc degree in Electrical Engineering, Jordan University of Science & Technology, Jordan, in 1999; and He is a member of IEEE, Tau Beta PI Honor Society, Golden Key Honor Society. He was given the honor to be a Sigma Xi member from the Board of Governor, in 2012. He was a reviewer for the 25th Chinese Control and Decision Conference 2013 CCDC.