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Implementation of Drive by Wire Technology Replacing the Conventional Vehicle Control System

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Abstract

*Drive by Wire technology is one important step of taking the car's mechanical control to a computerized one. This technology will take driving to the next level where driving will be a very less complicated task. This paper will concentrate on cars with automatic transmission only. Here we will discuss about converting the mechanical controlled car to a car with Drive by Wire technology. This will include micro-controllers, actuators, sensors etc. Nowadays the combustion engines are totally microcomputer controlled. This paper will focus on controlling steering, acceleration, deceleration and brake. Gear shifting and Hand brake are considered as secondary control and are out of the concern of this paper. The total driving system is operated by a simple 4*4 matrix keypad. The complete functionality is also explained. A Steer by Wire system has been constructed, which is without mechanical backup while acceleration and brake system is mechanically backed up.*

Keywords: *Drive-by-wire, Steering control, Break and acceleration control*

1. Introduction

Drive-by-wire is a catch-all term that can refer to a number of electronic systems that take the place of old mechanical controls. Instead of using cables, hydraulic pressure, and other things that provide the driver with direct, physical control over the speed or direction of a vehicle, drive-by-wire technology uses electronic controls to activate the brakes, control the steering, and operate other systems [1]. There are many people who can't drive correctly, find it hard and thus doesn't get a driving license either. Drive by Wire is a possible and simple solution for them as, this makes driving a lot easier. It is like, holding a keypad and pushing up, down, right, left and the car responses. It's like playing a game where you need to drive. This technology can give the car very good maneuverability, much easier control and confidence. Multi-button presses give the ability of driving the car almost as you wish. Accelerate or decelerate the car along with turning, even drifting all is possible. Hydraulic pressure is needed in the power steering system nowadays which is responsible for more power consumption. But here a Steer by Wire technology is enabled which doesn't require hydraulic power.

A good free control response refers to a well damped return-to-center of steering wheel from an off-center release, or due to an impulsive (jerk& release) excitation from on-center [2]. Here, IR sensors are used to determine the center of the wheel which maintains free control.

2. Steering Control

Steer-by-wire (SBW) systems allow the amount of steering wheel operation to be transmitted in the form of electric signals to the vehicle wheels. These systems help improve control performance for vehicle safety while increasing vehicle design freedom. Thus, this type of system seems to have promise as a next generation automotive steering system [3]. Here a DC gear motor is mounted on a steering box (rack and pinion type). The DC motor is controlled by a microcontroller.

This Steer by Wire system eliminates the need of hydraulic power for the steering system and replaces this with a rotary actuator. This is how the power consumption is greatly reduced. There are two limit sensors at the end points of the rack to send feedback to the control unit that the end point has reached and the motor will not turn further. The response from the keypad will lead the car. This is explained in the following tabular form.

Table 01: Car Direction according to the response from Keypad

Keypad Button	Motor Direction	Rack Direction	Car Direction
4	Clockwise	Left	Left
6	Counter-clockwise	Right	Right

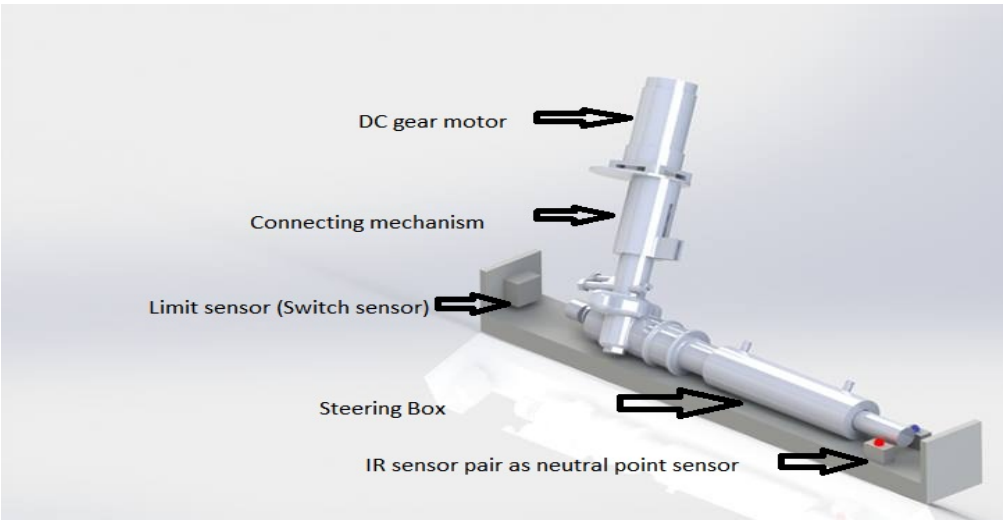


Fig. 2.1: Construction of the Steering Control system in order to imply Steer-by-wire (Rendered from Solidworks 2013 premium)

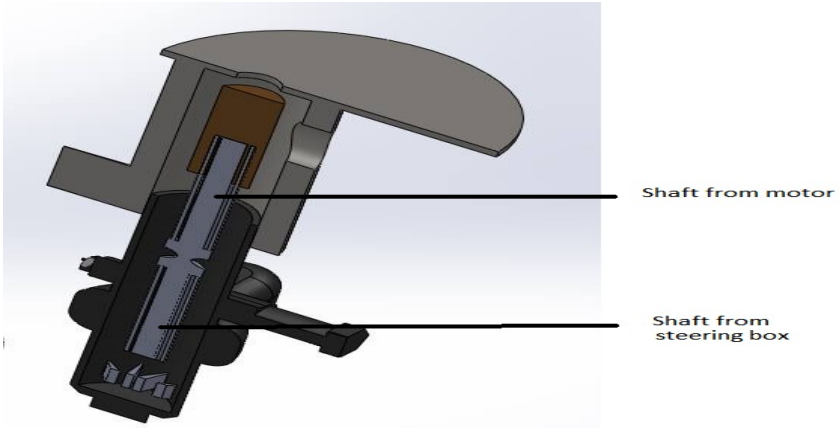


Fig. 2.2: Cross section of the connecting mechanism (Rendered from Solidworks 2013 premium)

Free Control:

For free control of the vehicle (which was previously described), one IR sensing system has been implemented. The rack can go 11.5 cm left from the last limit to the right. An IR transmitter and a receiver is set in across the rack to sense the center point (at 5.75cm from the last limit to the left). The button number 5 in the keypad is used to activate the free control. At full speed of the motor (2A, 12V and defined speed 255 in microcontroller), the rack moves 2.5 cm (average) per click. Holding the buttons pressed is also possible and the rack will move continuously. The performance of the steering can be tuned by changing the input of the microcontroller program. The defined motor speed can vary from 0 to 255.

Performance tuning of the Steer by wire system:

After implying variable power source to the steering control system (while the acceleration and break controls are ineffective), the time required to rotate the steering fully from left to right has been measured along with the variable power.

As stated earlier, the rack can go 11.5 cm left from the last limit to the right. But it is to be noted that the rack takes different amount of time, to reach the sensor placed at right side, due to the variation of power supply. The observation to measure the time variation is presented below.

Table 02: Measurement of required time with variable power source

Observation No.	Current (in mA)	Voltage applied (in volts)	Power (in miliwatts)	Time needed to overcome 11.5 cm (in seconds)
01	78	2	0.156	The Rack does not move
02	870	4	3.48	19.68
03	1010	5	5.2	15.06
04	1150	6	6.9	9.30
05	1500	7	10.5	8.25
06	1800	8	14.4	5.89

After plotting the obtained values (Table 02) of Power along the abscissa and time needed vertically, the following graphical form appears.

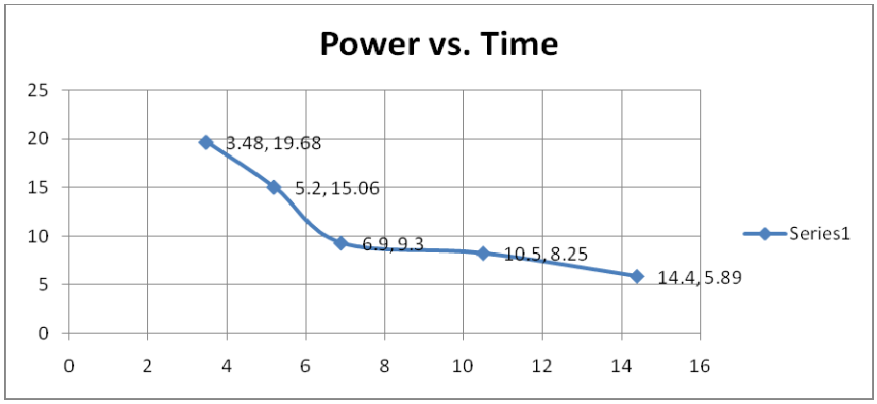


Fig. 2.3: Variation of Time necessary in accordance with Power supply variation

This graph shows us that, without minimum power the motor will not start. Then with the increase in power the required time to reach the end point decreases. That also means the rotation of the motor shaft and speed of rack increases with increasing power input.

3. Acceleration and Deceleration control

The acceleration and deceleration control is mechanically backed up and the control is directly applied to the acceleration pad. A servo motor is connected to the acceleration pad. The servo motor is controlled by the

micro-controller. Button 2 and 3 controls acceleration and deceleration simultaneously. Holding these buttons will continuously rotate the servo but if buttons are clicked only, 5 degrees rotation will occur per click.

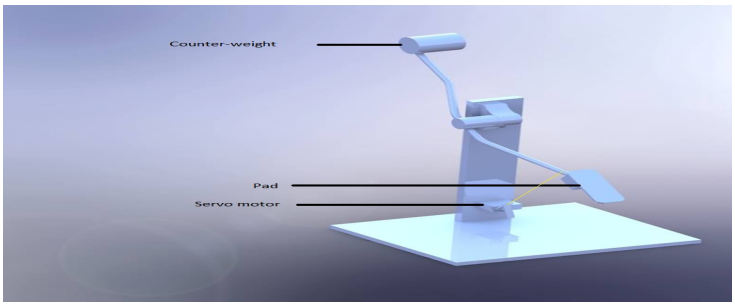


Fig.3.1: Acceleration pad (Rendered from Solidworks 2013 premium)

4. Brake control

The braking system is mechanically backed up and the control is directly applied to the brake pad. This system is same as the Acceleration-deceleration control. Just this is applied on the brake pad. Button 7 and 9 controls brake on and release simultaneously.

5. Control System

The circuit diagram of the control system is illustrated below:

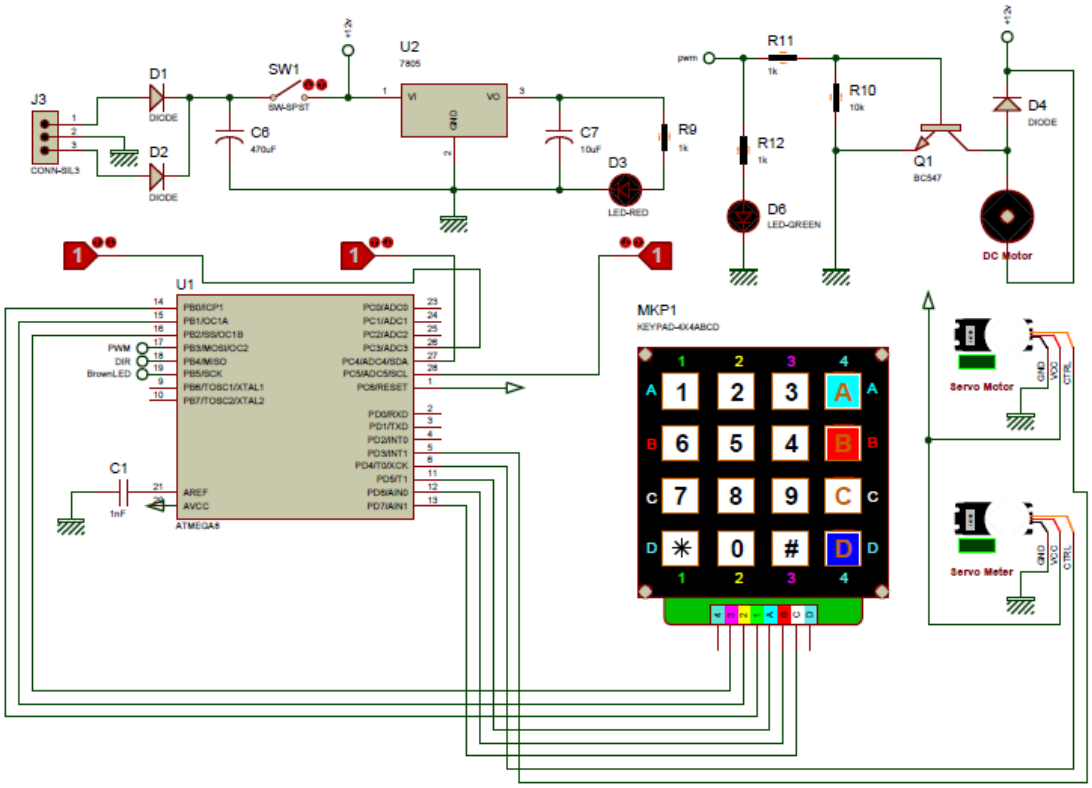
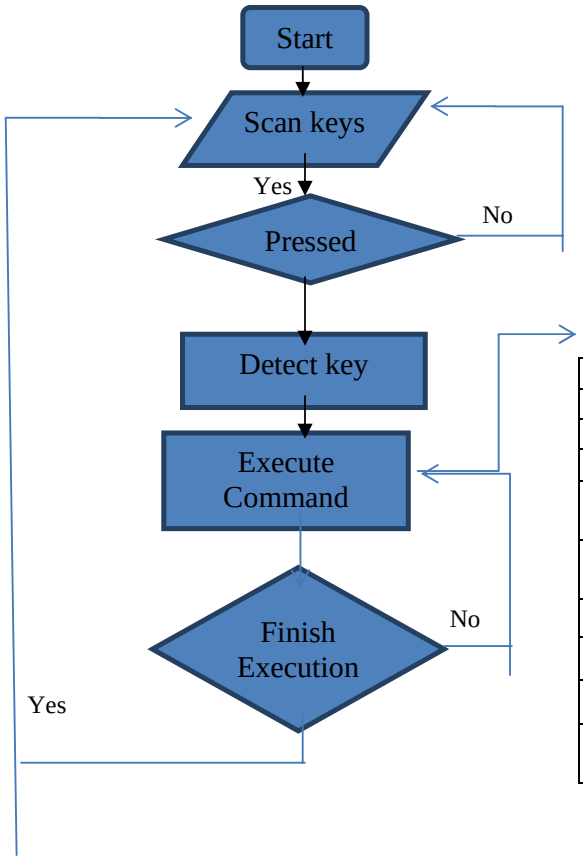


Fig. 5.1: Circuit diagram of the control system

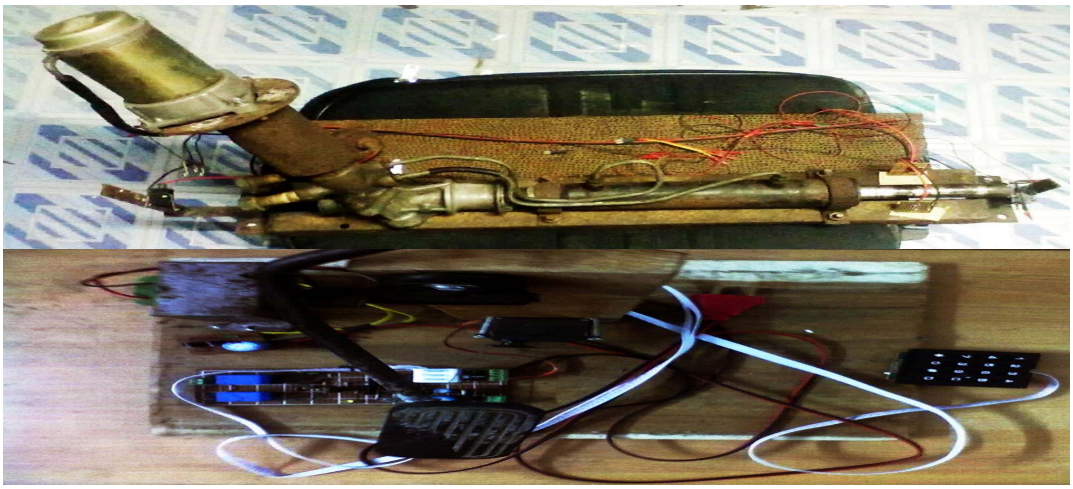
Here the DC gear motor has been used to control the steering box. The servo motors are for acceleration and brake control. The keypad is used as the input. This sends signals to the microcontroller and the controller performs the action. The microcontroller sends the necessary signals to the motors and they perform the pre-programmed task.



Button	Function
1	-------
2	Accelerate
3	-------
4	Turn Right
5	Straight Drive
6	Turn Left
7	Brake On
8	Decelerate
9	Release Brake

The flow diagram of the algorithm is as shown above.

7. The Final Construction:



8. Conclusion

Drive by wire technology has been developed here but hydraulics still plays a vital part in acceleration and brake control. Hopefully it will be taken care of in near future. The steer by wire system works perfectly as was expected. Light, horn and other indicative systems will be controlled by the same keypad in the future. A nice thing is, a car does not have to be made with this technology. Any car with automatic transmission can be converted to have this marvelous technology.

9. References:

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