Design & Development of a "Drive-By-Wire" System for an Automobile

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Abstract---Nowadays the centre of attention in vehicular technology, we can understand that electrical vehicles are playing a crucial role in automobile field and gained a lot of importance in the previous decade. The drive by wire technology integrated to replace the traditional mechanical system by electronic controller system using joystick, battery, sensors, microcontrollers & electric motors. The purpose is to eliminate traditional machineries such as steering wheel, brake pedal, &accelerator pedal from the vehicle. In this field more than a few control methods have previously been proposed using the motor wheel drive virtues, but that controllers are very hard to estimate the slip angle, vehicle velocity and all. This has the merits of effortlessness and good performance in controlling nonlinear systems. The aim of the present research is to propose a less cost, simply designed electrical vehicle with a new simple microcontroller and electric motors.

Keywords: Drive-by-wire, haptic impact, PIC 16F877A,stepper motor, DC PM Motor.

I. INTRODUCTION

In this study, drive-by-wire technology will be investigated, to replace the traditional mechanical system for vehicle navigation with electronic control system using electro-mechanical actuators, haptic sensors, joystick and electronic controller. The objective is to eliminate traditional components such as steering wheel, brake pedal and accelerator pedal from the vehicle. The integrated system will effectively reduce the amount of force and range of movement required by the driver. Therefore, the vehicle can be operated effortlessly. This paper M. Bertoluzzo.P.Bolognesi and others *et al*.[2] provided an over-view of the key components of by -wire systems, i.e. the electric actuators and the communication networ-ks, especially for steering and braking operations. Antonio Frisoli, Carlo A. Avizzano, Massimo Eergamasco*et al*.[1] investigated *a* 2 dof force-feedback joystick was employed to simulate the force response of a manual gearshift of car during drive. The control law is based on a hybrid model. A state machine determines the active state of the system.The operator can move the gearshift lever whether such a movement would be allowed in an actual transmission under similar circumstances.

The steering system is a group of parts that transmit the movement of the steering wheel to the front, sometimes the rear, wheels and controlling the acceleration part also. The primary purpose of the steering system is to allow the driver to guide the vehicle. When a vehicle is being driven straight ahead, the steering system must keep it from wandering without requiring the driver to make constant corrections. The steering system must also allow the driver to have some road feel (feedback through the steering wheel about road surface conditions). The steering system must help maintain proper tire-to-road contact. For maximum tire life, the steering system should maintain the proper angle between the tires both during turns and straight-ahead driving. The driver should be able to turn the vehicle with little effort, but not so easily that it is hard to control.

II. VEHICLE MODEL

The vehicle model consist of several interconnected parts.

- The joystick system
- Wheel motor
- Steering system
- Power controller

Using energy stored in batteries, the motor system embedded in the wheel produces torque, which is transmitted as a force to the ground on tire-ground contact surface. Force acting on the ground produces counter force acting on the wheel. A force acting on wheels act together on vehicle'sCOG(fig 1) as linear forces creating longitudinal and lateral motion, as well as rotational forces creating yaw motion and also roll and pitchmotions which are limited by the suspension system. Height of the ground under each wheel and roll and pitch motion influence the car's vertical motion.

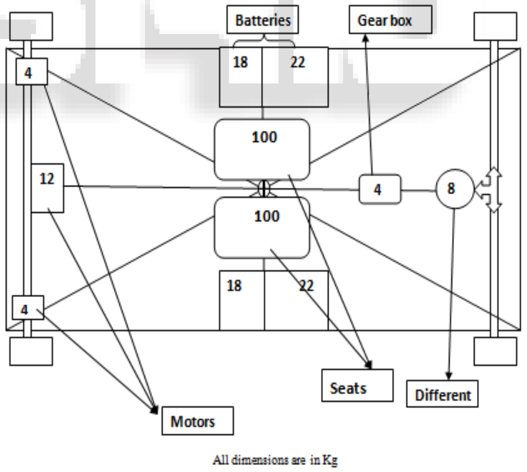

Fig.1: centre of gravity diagram

A. *The Joystick system*

Joystick is an input device consisting of a stick pivots on a base and reports its angle or direction to the device it is controlling. A joystick is actually moves in all directions and controls the movement of some other display control. The simplest joystick design , used in many early game controls, is just a specialized electrical switch. When we push down one of the buttons electricity can flow down a wire from the supply unit. For the part of analyzing ,took one joystick as shown in fig 2. Investigated the voltage according to the position of the axis of the joystick. The voltage & angle values of both y-axis & x-axis are shown below.

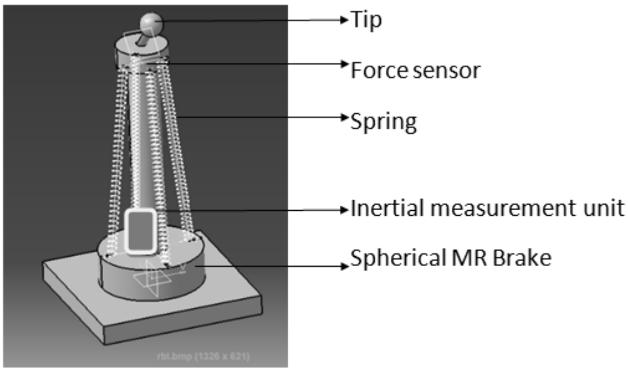

Fig. 2: Haptic joystick

Haptic joystick involves of a spherical MR-brake at its base sustainedby air muscles (Fig. 1). The device is axi-symmetric around the joystick handle in terms of actuation. The MR-brake is mostly a ball-and-socket joint, where friction torque can be modified. A tension nut on the joystick handle is used to bring the muscles to the apt length. Although the MR-brake has 3-DOF, in the current style rotations around the joystick lever can neither be generated nor slow, making the haptic joystick really a 2-DOF device. The joystick has an inertial measurement unit (IMU) tangled to its lever to measure its orientation and a 6-DOF force sensor to measure forces at the tip.While bearing in mind the above calibrations, unwritten that it'sthinkable to set a desired voltage variation with respect to the angle for drive an electrical car. Preferred another joystick for getting a desired angle movementand easycalibration.

B. *Wheel Motor*

Selecting a motor for steer the vehicle is very difficult. While integrating stepper and servo motors characteristics we can understand that stepper motors have a great number of poles. In judgment, servo motors have very little poles.The greater number of poles allows a stepper motor to move correctly and specifically between each pole and allows a stepper to be operated without any position feedback for vehicle steering system.Driving a stepper motor to aexact position is much simpler than driving a servo motor. With a stepper motor, a solitary drive pulse will move the motor shaft one step, from one pole to the subsequently.

Fig. 3: stepper motor

Since the step size of a given motor is permanent at a certain amount of rotation, moving to a exact position is purely a matter of sending the right number of pulses. In compare servo motors read the difference between the current encoder location and the position they were commanded to and just the current required moving to the correct position. With today's digital electronics, stepper motors are much easier to control than servo motors. For the purpose of driving, we can use permanent magnetic DC motors. The drive used in the experiment is variable speed DC motor (0.5 hp) with speed up to 3000 rpm.

C. *Steering System*

Tires are playing important roles as an automobile component. Usually many parts may make up a car but one part is limited to one function. Tire has numerous functions. Thus the tire having a roll to support the weight of the car transmits vehicle propulsion and braking, softness impact from the road and maintains or changes the car's direction. So considering all these part we want to be bothered about tire width, aspect ratio, radial, wheel diameter, load index, speed rating and mud and snow of tire while designing a vehicle. The size of a tire is an important factor. When the size is increasing then it can cover more area. Considered all the factors I preferred this as the tire shown fig 4.

Fig. 4: Tyre conseptual design

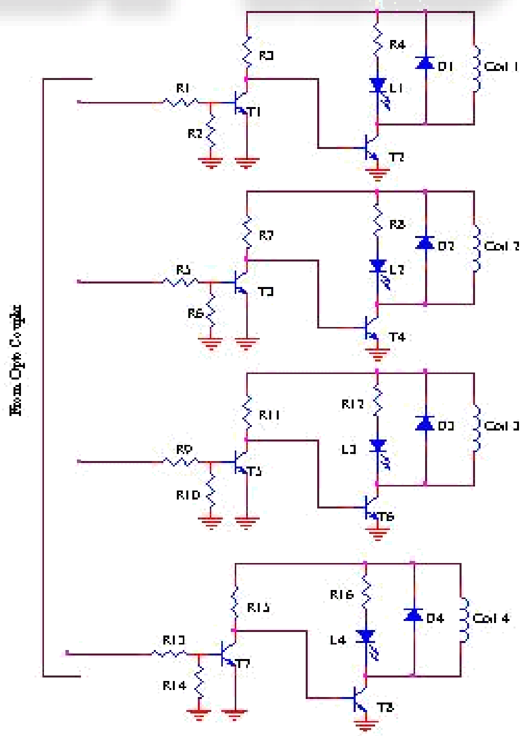

Fig. 5: Steering circuit diagram

To boost the stability and handling characteristics, it is required to utilize an active vehicle dynamics control (VDC) system as well as improved passive systems in the projected electric vehicle. An integrated active steering with a torque haptic system is deliberated for this purpose. Based on using both the by-wire steering structure and in-wheel drive system, the torque vectoring and independent control of each wheel's steering angle can easily be accomplished by the help of this circuit diagram. Figure above shows the driver circuit diagram. Four signals are coming from the PIC 16F877A are, ground, PWM signal, and two direction signals as shown in the above figure. PWM signals given to the lower transistor section. PWM signal is generated by the corresponding movement of the joystick. When the joystick movement is long, then PWM signal width increases. Battery power given to the collector terminal of the below last transistor. When the PWM signal comes from the **,** PIC 16F877A by the variation.

III. Conceptual Design

The conceptual model of the proposed electric vehicle is illustrated in Fig. 6

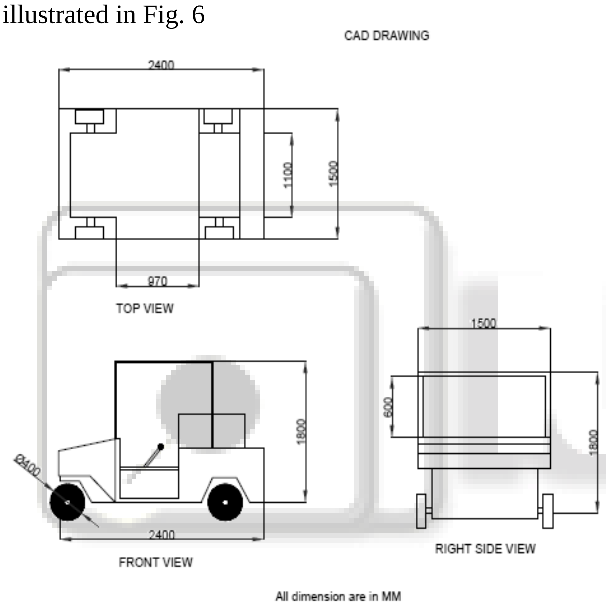

Fig. 6: Conceptual views of vehicle

Performance investigation is the final part of the theoretical design. A vehicle's driving presentation is usually evaluated by its acceleration time, highest speed and maximum range per charge. According to provision of the selected in-wheel motor and batteries and on the whole condition of the vehicle.

IV. Power Controller

In drive by wire system the torque vectoring and autonomous control of each wheel's steering angle can easily be achieved by the help of this circuit diagram shown in fig. The overall goal of the proposed controller can generally be stated as "to minimize the difference between the desired and actual motions of the vehicle". From the circuit it can be seen that the reference analog supply after being regulated by the 9v regulator enters the zener diode through the resistance R4 where it is again regulated to 5v since the zener diode used here has a cut off of 5v. Thus we have a double regulated completely filtered analog reference source. R6 is a potential divider used for setting the dynamic response range of the reference supply.

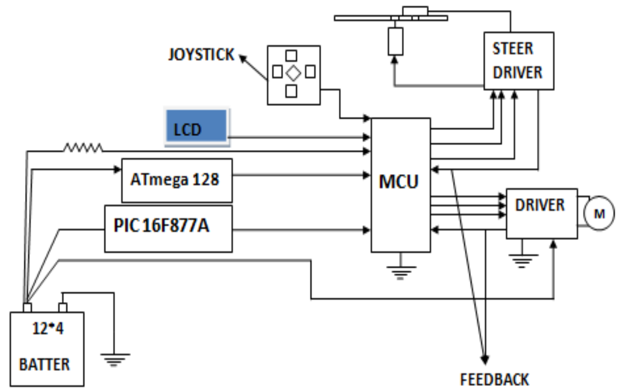

Fig. 7: Power controller diagram

Battery gives the power to drive the electric motor. Automotive battery is using here to drive the electric motor. 36v automotive battery using here. Because of the size, weight, and cost, three 12v battery is taken

The battery gives the power to operate the microcontroller unit and to the driver unit. Automotive battery is using here to drive the electric motor. The voltage regulator unit regulates the voltage from the battery and the regulated voltage given to the microcontroller unit. Then the microcontroller unit operated by the regulated voltage from the voltage regulator. The signal from the joystick given to the microcontroller unit. Joystick is a two axis four quadrant joystick.

X-axis for the direction movement and Y-axis for the speed movement. Microcontroller unit ATmega16 has inbuilt ADC. The ADC in the ATmega16 converts the analog signal from the corresponding movement of joystick to the digital voltage. When the joystick moves forward, then the corresponding analog movement converted in to digital by the ADC in the microcontroller unit. The program written in the ATmega16 by the atmel studio and the program burned by the extreme Burner – AVR. Program downloaded to the ISP(In system programmer) and connected with microcontroller. The battery power given to the speed driver and to the steer driver. Two drivers are operated by the battery power and by the program in the microcontroller unit. The motor driver takes power from the battery and allocate the power to drive the motor. ATmega16 gives the direction signal and PWM signal to the motor drivers. Direction signal gives the motor forward and reverse direction. For the steer driver, direction signal is right or left. For the speed driver directional signal is acceleration and deceleration. PWM signal and direction signal generated from the microcontroller unit with respect to the joystick movement. When joystick moves long distance, the PWM signal width will be higher and motor moves faster. When the joystick moves little bit, the motor runs slowly.

Steer driver drives the steering motor and speed driver drives the speed motor with respect to the direction signal from the microcontroller unit. In steering motor section, the steering driver rotates the motor in right or left with respect to the direction signal. In speed motor section, the speed driver rotates the motor in forward or backward direction. There is a feedback signal from the driver to microcontroller unit to know about the operation. A high value of resistor connected between the battery and microcontroller unit. Actually it is a battery level indicator. When the battery charge is less, the motor stops slowly and it avoids the motor damage. LCD shows the motor direction and speed levels.

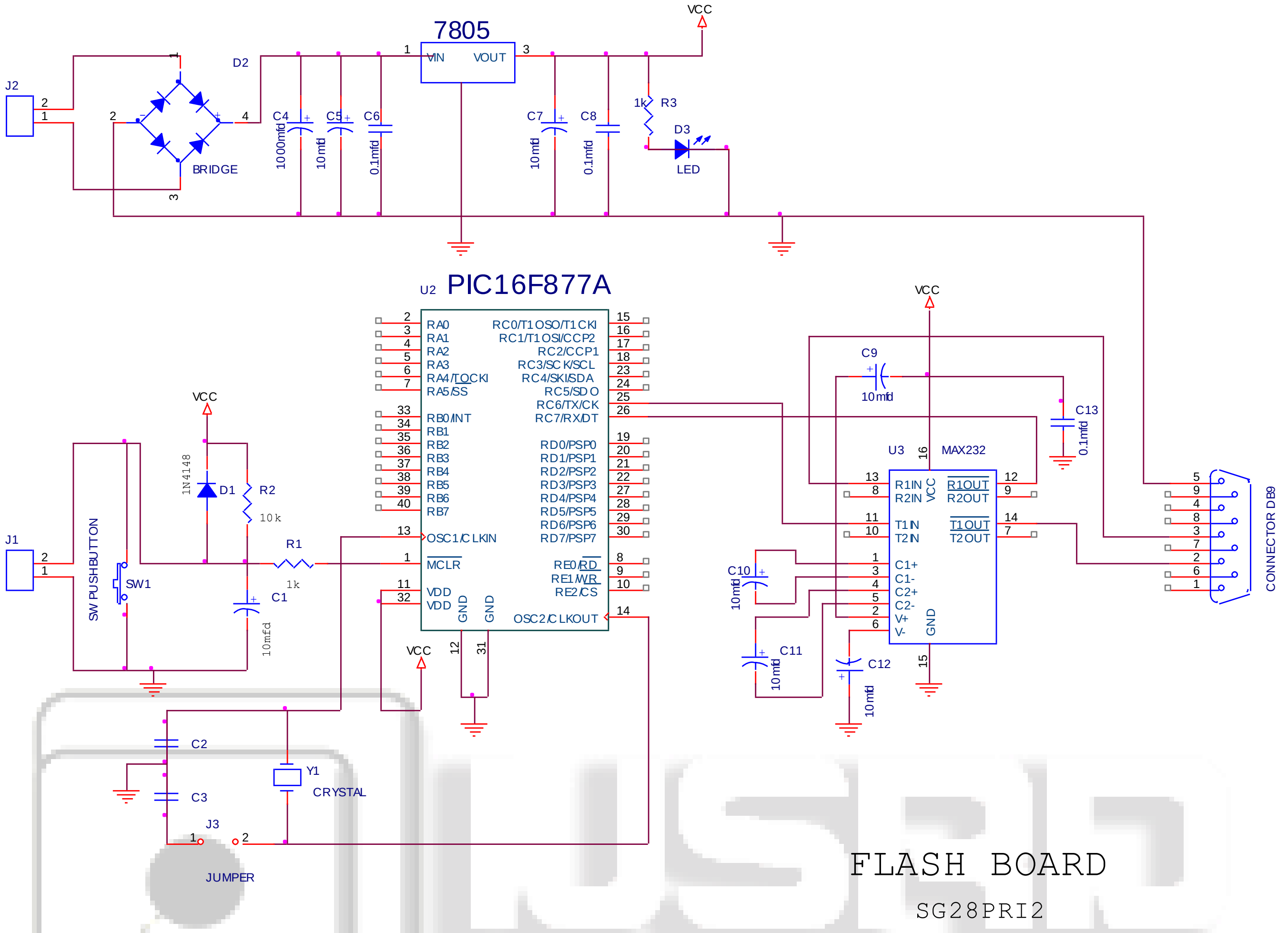

Fig. 8: PIC circuit diagram

From the circuit it can be seen that the reference analog supply after being regulated by the 9v regulator enters the zener diode through the resistance R4 where it is again regulated to 5v since the zener diode used here has a cut off of 5v. Thus we have a double regulated completely filtered analog reference source. R6 is a potential divider used for setting the dynamic response range of the reference supply. This means that the reference 5v can be used as it is or it can be made into a fraction of the 5v for example 1v so that readings in this range can be read with more precision. This is because the ADC has 10 bit resolution which can be totally used for representing the 1v rather than 5v. The pins 2-5, 7-10, 35 and 36 are used as the 10 channels of the ADC. To these pins the analog inputs to be processed by the ADC are given. Y1 is the crystal oscillator used. It is of 10 MHz and gives a baud rate of 9600 bits/s. The capacitors C2 and C3 are used as decoupling capacitors to remove the high frequency noise signals. The capacitor C1 is in the off condition when power is switched off. When the power is switched on or reset then this capacitor gets charged through the resistor R2 and then through R1 this appears at the MCLR pin of the PIC. This is the memory clear pin and thus the memory is cleared and is ready for use as soon as power is switched on. S1 is the synchronous switch which is also used for the same operation and for PC and PIC synchronous operation.

V. CONCLUSION

In this paper a detailed design and development of a model based integration of a small, electric vehicle is presented. Simulation results have confirmed that the modeled vehicle behaves in a physically spontaneous way under various simulated conditions. Thus, the presented model can be the basis for the development of electronic differential and belonging subsystems like traction control system, haptic controlling, electronic stability control system and others. A further useful feature is the ability ofthe joystick. while movingthe joystick it can give a haptic impact.

REFERENCES

[1] Antonio Frisoli, Carlo A. Avizzano, Massimo Eergamasco, "Simulation of a manual gearshiftwith a 2 DOF force feedback joystick" PERCRO, ScuolaSuperiore S. Anna, Pisa, Italy 561.27,antony.@sssup.it carlo@sssup.it, bergamasco@sssup.it.

[2] M. Bertoluzzo.P. Bolognesi, Member. IEEE, 0. Bruno-, G. Buja', Fellow.. IEEE, A. LandF, Memnber. IEEE and A. by-Wire Systems for Ground Vehicles",Department

of Electrical Engineering - Univ\ersit-, of Pado-a – Via Gradenigo 6/a. 35131 Padova

[3] Li Feiqiang, Wang Jun, Liu Zhaodu, "Motor Torque Based Vehicle Stability Control for Four-wheel-drive Electric Vehicle", School of Mechanical and Vehicular Engineering Beijing Institute of Technology Beijing, China.

[4] Yongli Zhao, Yuhong Zhang, Yane Zhao, "Stability Control System for Four-In-Wheel-Motor Drive Electric Vehicle", 1) Hebei University of Technology, 300130，Tianjin, P. R. China,2) Tianjin key laboratory of Advanced Mechatronics Equipment Technology, School ofMechanical and Electronic Engineering,Tianjin Polytechnic University, 300160, P. R. China.3) Institute of Automotive Engineering, School of Mechanical Engineering, Shanghai Jiao TongUniversity, 200240, Shanghai, P. R. China.

[5] GoranVasiljevic, ZoranVrhovskiy, StjepanBogdan, "Dynamic Modeling and Simulation of a Three-wheeled Electric Car",Faculty of Electrical Engineering and Computing ,University of Zagreb Unska 3, 10000 Zagreb, CROATIA Bjelovar Technical College TrgEugenaKvaternika 4, 43000 Bjelovar, CROATIA.

[6] SoheilMohagheghiFard, AvestaGoodarzi, Amir Khajepour, EbrahimEsmailzadeh, "Design and Control of a Narrow ElectricVehicle", Automotive Engineering DepartmentIran University of Science and TechnologyTehran, Iran,soheil.m.fard@gmail.com. Mechanical and Mechatronics Department, University of WaterlooWaterloo, Ontario, Canadaavesta.goodarzi@uwaterloo.caMechanical and Mechatronics Department, University of Waterloo,Waterloo, Ontario, Canadaa, khajepour@uwaterloo.caFaculty of Engineering and Applied ScienceUniversity of Ontario Institute of TechnologyOshawa, Ontario, Canadaezadeh@uoit.ca

[7] Jing Gu, MinggaoOuyang, Jianqiu Li, "Vehicle Dynamic Simulation for Efficiency Optimization ofFour-wheel Independent Driven Electric Vehicle",State Key Laboratory of Automotive Safety and Energy, Tsinghua University, Beijing, 100084, P.R.ChinaEmail:gu j02@mails.tsinghua.edu.cn.

[8] Xiang Liu1 Mian Li, Chengbin Ma, Min Xu, "Kriging Assisted On-line Torque Calculation for Brushless DC Motors Used in Electric Vehicles" Institute of Automotive Engineering, University of Michigan – Shanghai Jiao Tong University Joint Institute Shanghai Jiao Tong University, Shanghai, China 200240

