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Electronic Power Assisted Steering System

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Abstract*— Electric power steering offers greater vehicle safety by adapting variable steering ratios to human needs, filtering drive train influences and even adjusting active steering torque in critical situations. In addition, it can make cars even lighter and more fuel efficient when compared to those using hydraulic steering systems. The central electronic elements of today's power steering systems are modern 32-bit microcontrollers, ARM controllers (MCUs). Only high-performance MCUs can provide sufficient computing power and specialized peripherals for complex motor control functions. Since power steering is a safety-critical function, it also requires new MCU elements that support the functional safety of the overall system.

***Keywords* – EPS (Electronic Power Steering System), ECU-Electronic Control Unit.**

I. INTRODUCTION

The central electronic elements of today's power steering systems are modern 32-bit microcontrollers, ARM controllers (MCUs). Only high-performance MCUs can provide sufficient computing power and specialized peripherals for complex motor control functions. Since power steering is a safety-critical function and requires new MCU elements that support the functional safety of the overall system Only high-performance MCUs can provide sufficient computing power and specialized peripherals for complex motor control functions. Since power steering is a safety-critical function and requires new MCU elements that support the functional safety of the overall system.

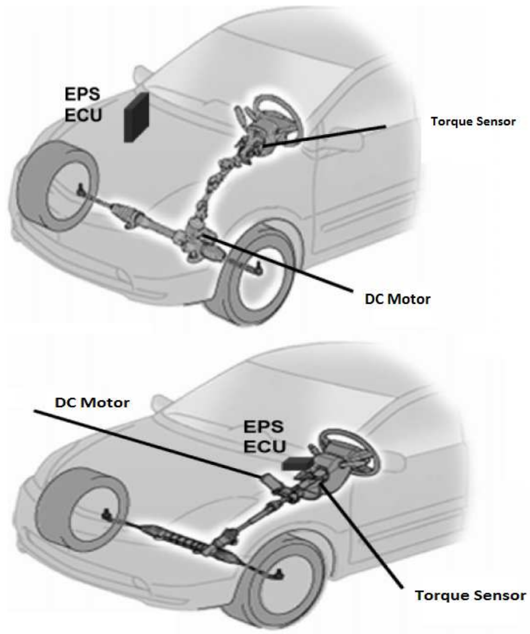

Fig.1. Streeing Control Mechanism

A. *Steering Mechanism*

The topic discusses the steering control mechanism and components involved in it.

B. *Steering Gear*

Turning the steering wheel transmits the torque to the pinion, which causes input shaft to rotate. The input shaft and pinion bar are linked through torsion bar, which twists until torque and reaction force are equal. The twist in the torsion bar is detected by torque sensor which converts the applied torque into electrical signals.

C. *DC Motor*

A worm gear assembly is used in combination with DC motor to transmit the torque to column shaft.

D. *Reduction Mechanism*

Reduction mechanism transfers the motor power assist to the pinion shaft. It consists of ring gear that is connected to pinion shaft and pinion gear which is in turn integrated with motor shaft.

E. *Torque Sensor*

It determines the amount of torque applied to the steering and converts it into electrical signal. EPS ECU uses this signal to determine the amount of power assist that motor should provide.

F. *EPS CPU*

It receives signals from various sensors and determines the assist current to be applied to the DC Motor on the basis of current vehicle condition.

G. *Malfunction Detection*

It is one of the tasks performed by the EPS CPU, by detecting malfunction and alerting the driver by warning light signal.

II. BASIC PRINCIPLE OF EPS

Compared with the traditional hydraulic steering system (HPS), Electric Power Steering (EPS) system adopts motor to offer the driver assistance directly and has the advantages of economy, handiness, easy adjustment, less noise and waste ,oil pollution and so on the composition and working principle of EPS system . EPS system is mainly composed of speed sensors, steering wheel rotation sensors (including torque sensor and speed sensor), electronic control unit (ECU), power drive circuit, clutch, DC motor and so on. ECU decides the rotational direction and suitable assistant torque of motor according to the sensors output signals, sending control signals to motor, clutch and then controlling motor's rotation through power drive circuit. The output of motor from the decelerating gearbox drives rack-and-pinion mechanism to produce the corresponding steering power.

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The magnitude of the motor torque can be changed arbitrarily by control algorithms to offer the necessary transmission power value to transmission mechanism

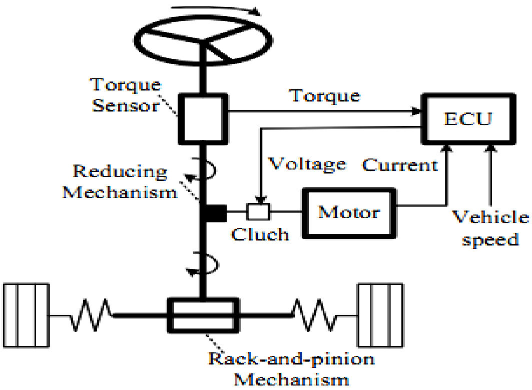

Fig .2.Electronic Power System

III. ELECTRONIC CONTROL UNIT (ECU) DESIGN

EPS ECU consists of microcontrollers, A/D converters, motor drive circuitry (H-Bridge and n-channel mosfet Drive) and regulated power supply with force cooling system. Following diagram makes it clear.

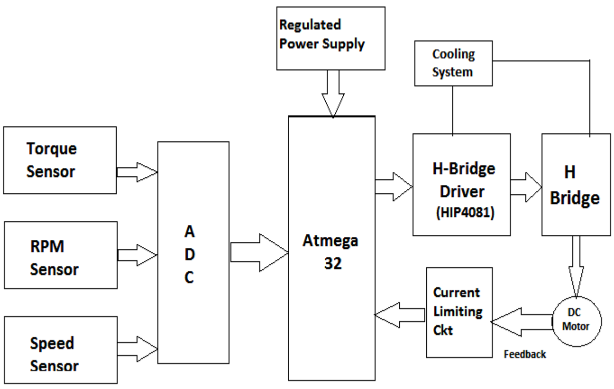

Fig.3. Block Diagram of ECU

The three analog information obtained from the three sensors are converted using an ADC an ATMEGA-32 microcontroller is used to process the data obtained from ADC.**ALGORITHM** used to drive the ESP

1. When the output of RMP sensor is at high level then EPS is enabled and if low it is disabled.
2. When speed of the vehicle determined by speed sensor exceeds 40km/hr, EPS turns off and the steering is derived by mechanical assistance.
3. When the voltage ratings of the Torque sensor is 2.5v then PWM=0, when Torque sensors voltage>2.5, the wheels are rotated in right direction. When Torque sensors voltage<2.5 the wheels are rotated in left direction.
4. When the current rating of current limiting circuit exceeds 51Amps, output of this circuit becomes high and H-bridge is disabled.

Here the H bridge consist of 4 N channel mosfets IRF3205 having current ratings of 110 Amps. It requires a mosfet driver which we have used is HIP4081 its circuit diagram can be shown by following diagram.

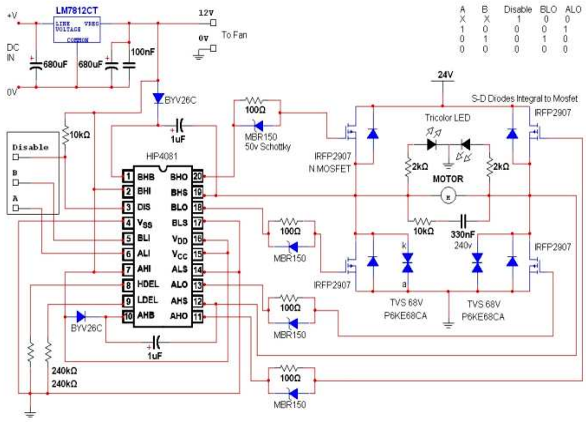

Fig.4. Circuit Diagram

The schematic is fairly self explanatory in the way of parts and values. If we need higher current abilities, simply parallel 2 or 3 Mosfets together on each leg of the H Bridge. We may also need to up-rate the Transient Voltage Suppressors (TVS) to more than 68V.

Simply connect the A, B and Disable lines to your chosen microcontroller, or even switches if you don't want variable speed control. The HIP will accept 5v Logic. By using a microcontroller, you can send a PWM signal to either the A or B inputs to make the motor spin forward or back at any speed desired. Make both inputs low to enter the brake mode. The disable pin is an active low and makes all outputs enabled. We must make sure that A and B are never on at the same time. For a failsafe, you can use a relay in-between your microcontroller and the HIP to switch the PWM signal to either A or B. This has some big advantages in that you only need 1 PWM output from your microcontroller and only 1 input can be on, at any particular time. Simply toggle the relay with your microcontroller and a transistor. This is the method I we use.

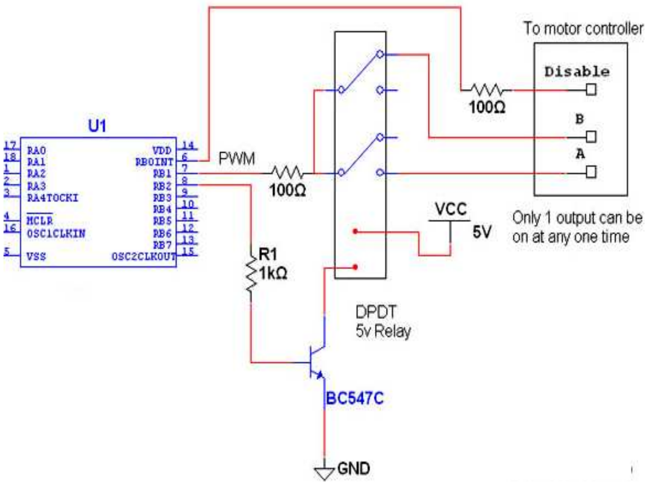

Fig. 5. Electronic Diagram

A. Current Limiting

The output of a current sensor could be fed to one side of a comparator, with the other side being set by a fixed (or variable) voltage reference. When the current draw rises

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above acceptable limits, the comparator's output can be used to turn off the circuit.

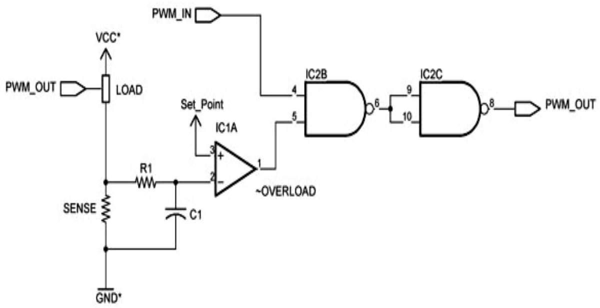

Fig. 6. Block Diagram of Comparator's Output

B. Power and heat

The power that the MOSFET will have to contend with is one of the major deciding factors. The power dissipated in a MOSFET is the voltage across it times the current going through it. Even though it is switching large amounts of power, this should be fairly small because either the voltage across it is very small (switch is closed - MOSFET is on), or the current going through it is very small (switch is open - MOSFET is off). The voltage across the MOSFET when it is on will be the resistance of the MOSFET, Rds (on) times the current going through it. This resistance, RDSon, for good power MOSFETs will be less than 0.02 Ohms. Then the power dissipated in the MOSFET is:

$$P = i_a^2 R_{DSO_n}$$

For a current of 40 Amps, Rds on is of 0.02 Ohms, this power is 32 Watts. Without a heat sink, the MOSFET would burn out dissipating this much power. Choosing a heat sink is a subject in itself.The on-resistance isn't the only cause of power dissipation in the MOSFET. Another source occurs when the MOSFET is switching between states. For a short period of time, the MOSFET is half on and half off. Using the same example figures as above, the current may be at half value 20 Amps, and the voltage may be at half value, 6 Volts at the same time.

Now the power dissipated is 20 × 6 = 120 Watts. However, the MOSFET is only dissipating this for the short period of time that the MOSFET is switching between states. The average power dissipation caused by this is therefore a lot less, and depends on the relative times that the MOSFET is switching and not switching. The average dissipation is given by the equation

$$480W \times \frac{time_{to_{switchover}}}{time_{between_{switchings}}}$$

The algorithm for the circuit

- The values that is in analog format is obtained from the non contact Hall effect sensor and the 10 bit ADC of the ATMEGA32 accepts the value, the value ranges from 0.8-2.5-4.2
- The controller after sensing the value from ADC PORT produces a PWM wave.
- The condition is such that the value of PWM is maximum at the two extremes 4.2 and 0.8
- The value of PWM is 0 i.e. when value of ADC obtained is 2.5 it corresponds to zero PWM
- This PWM signal is activated and the PORT D0 and D1 of the controller is used to switch the relay.
- When one port is on the relay will be on to provide an appropriate PWM according to the value obtained from ADC i.e. PIN D5
- This PWM signal is given to the pin of HIP4081 which switches the two mosfets on and off according to the requirement.

Heat sinks are used for extra protection of the mosfets , a fan is also used in order to provide a forced cooling to the entire system.

C. Proteus simulation for the circuit

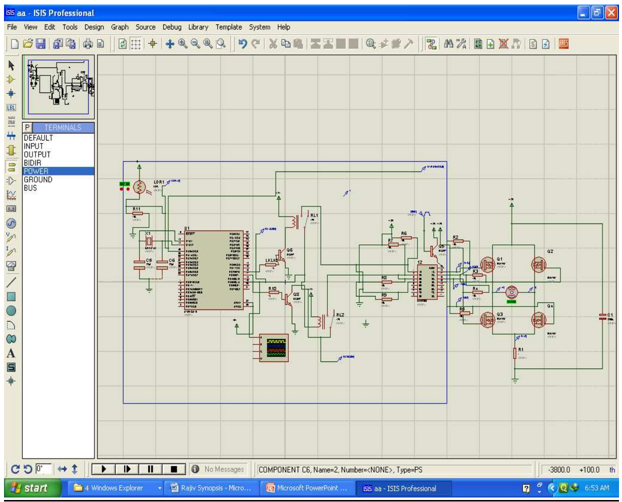

Fig. 7. Graphical User Interface

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