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Electric Bike

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Abstract: *Since, there is a growing demand for the use of domestic vehicles and the world is facing crisis for petroleum to drive them, thus, this project draws light on the above problem and comes with a solution of replacing the current internal combustion trend by electric drives. The main objective of this project is to implement the electric drive technology concept for two-wheeler by proposing a control strategy and the benefits of all electric range and fuel economy improvements. The work also focuses on the investigation to evaluate the energy requirements, its mass and initial cost of the battery pack for daily average travel needs of electric drive two-wheelers in India. This project also investigated the influence of driving cycle and all-electric range on battery parameters. The current project will make city commute much convenient. E-bike represents natural progression in the development of urban transportation. It will serve as a turning point since it will minimize the pollution and the running expenses. The increasing prices of fossil fuel will provide a gateway to the E-bike use and thus reducing pollution i.e. Global Warming.*

I. Introduction

Problem & Previous Research:

The current market of electric bikes faces the difficulty of slow charging time and low top speed due to the insufficient powered motors as per the load variations. Also, the mass decentralization due to small wheel-base of the current electric scooters makes the vehicle unstable at high speeds. Previous research highlights the point of easy of commute with moderate range and charging time due to economic constraints. Research is carried out to improve the commutation of the Sensor Brushless DC Motor in order to improve the efficiency by providing more steps of PWM Signal and thus, having better jerk-free operation. With high frequency switching Power MOSFETs, the driver output ensures a smooth, hassle free operation of the motor.

Purpose& Contribution:

For accounting the above mentioned problems, the primary idea of the paper is to encounter the slow recharging time of the battery pack by providing an arrangement of a removable battery through sliding mechanism and the battery contacts will be held by magnetic connectors. Swapping of the discharged battery with a charged one will consume time same as a same as a standard motorcycle. To centralize the mass, the concept of converting a standard motorcycle with electric driven one and thus the prolonged wheelbase helps for stability of the motorcycle ensuring higher top-speed at low drag co-efficient and thus improving the efficiency and range. The PI controller is operating with open loop feedback control and with the human feedback control, the motor speed is monitored continuously and the PWM is modified according to the variable input and ensuring better starting of the motor initially.

II. Indentations And Equations

Range of Mass:

In order to propel the motorcycle, the motor has to overcome the dead weight of the motor and thus, the range of mass has to be calculated

Sr. No.	Components	Mass (Kg)
1.	Bike Assembly	75
2.	Motor and Gear	9.5
3.	Battery Pack	35
4.	Controller and circuitry	1.5
5.	Rider	75
6.	Total Weight	196

To propel the bike on an inclined surface having6% gradient, the force to be developed by the motor will be,
$F_{wf} = windage\ and\ friction\ drag,$
$F_d = downhill\ force\ from\ gravity = m \sin x = 196 \times 0.06 \times 9.8 = 115\ N$
$F_p = Propelsion\ Force = F_{wf} + F_d$
$V_b = motorcycle\ speed = 20\ km/hr$
$P_d = F \times V_b = 115 \times 5.56\ m/sec^2 = 640\ W \pm 65\ W\ for\ accounting\ windspeed$
Thus, the required motor will be for 700W in order to propel the motorcycle. For attaining higher top speed, a 2000W Sensor Brushless DC Motor is selected.

Motor Specifications:
The motor is a sensor brushless DC motor having the following data:
1. Power – 2000W
2. Rated Voltage-48V
3. Peak current - 120A
4. Rated Current - 90A
5. Rated Speed – 3000 RPM
6. No. of stator poles – 6
7. Rated Torque – 6.6 N-m
8. Peak Torque – 20 N-m
9. Shaft mounted fan.

$$T_L = T_{em} - \omega B - J_m \frac{d\omega}{dt}$$
$$T_{em} = k_t i_a$$

Where,
$T_{em} = developed\ electromagnetic\ torque\ (Nm)$
$\omega = rotor\ angular\ velocity\ \left(\frac{rad}{\sec}\right)$
$B = viscous\ friction\ constant\ \left(\frac{\frac{Nm}{rad}}{\sec}\right)$
$J_m = Rotor\ moment\ of\ inertia\ (kg - m^2)$
$T_L = load\ torque\ (Nm)$

Battery Specifications:
Powering the motor is a lead-acid battery pack. The pack contains four batteries 12V each connected in series and thus the total voltage available at the battery terminals is 48V (same as that of Motor). The low manufacturing cost and ease of replacement draws attention on the use of lead-acid battery.
$$Rating = Ah \times V = 26 \times 48 = 1248\ W$$
Controller Specifications:
The motor commutation in BLDC motor is implemented by an electronic controller and determines the rotor position and to know when to commutate, the hall sensors are used. The controller is having MSP430 micro-controller and driver DRV8323 from Texas Instruments.
1. Rated Voltage of MSP430 – 3.6V – 15V
2. Rated Voltage of DRV8283 = 6-60 V
3. Peak current capacity of DRV8283 = 120A
4. Operating Temperature - $-15℃ - 80℃$
5. Auto cutoff voltage = $\pm 8V$ of 48V
6. Commutation angle = $120°\ Electrical$
7. Throttle Voltage – 1V – 4.7V
8. Aluminum Alloy Heat sink
9. PWM Frequency = 15640 Hz
10. System Frequency = 16000 KHz

11. Timer PWM Period $= \frac{System\ \ freq}{PWM\ freq} = \frac{16\ MHz}{15.64\ KHz} = 1023\ steps$
12. Speed PWM Factor $= \frac{2^{12}}{Timer\ \ PWM\ period} = \frac{2^{12}}{1023} = 4$
13. Duty Cycle = 4
14. Min. PWM Duty cycle = Timer PWM period x duty cycle = 1023x0.05=51 counts
15. Motor Startup Time = 100 msec
16. Duty Cycle Change Periods = 10 PWM periods
17. PWM duty cycle update steps during starting

$$= \frac{pwm\ freq \times motor\ startup\ time}{duty\ cycle\ change\ period} = \frac{15.64K \times 100m}{10} = 15$$

18. PWM bucket Percent = 0.20%
19. Bucket step resolution in PWM duty cycle periods

$$= timer\ pwm\ period\ \times\ pwm\ bucket\ = \left(1023 \times \frac{0.2}{100}\right) = 2\ counts$$

III. Figures And Tables

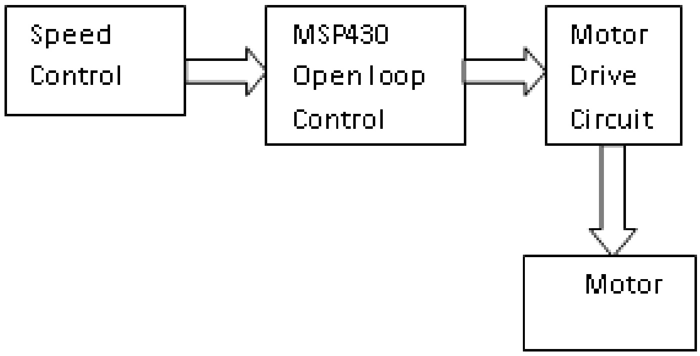

Fig. 1. Block Diagram for Open Loop Control of Sensor Brushless DC Motor.

Here, the feedback is provided by the human as to increase or decrease the throttle similar to a conventional vehicle.

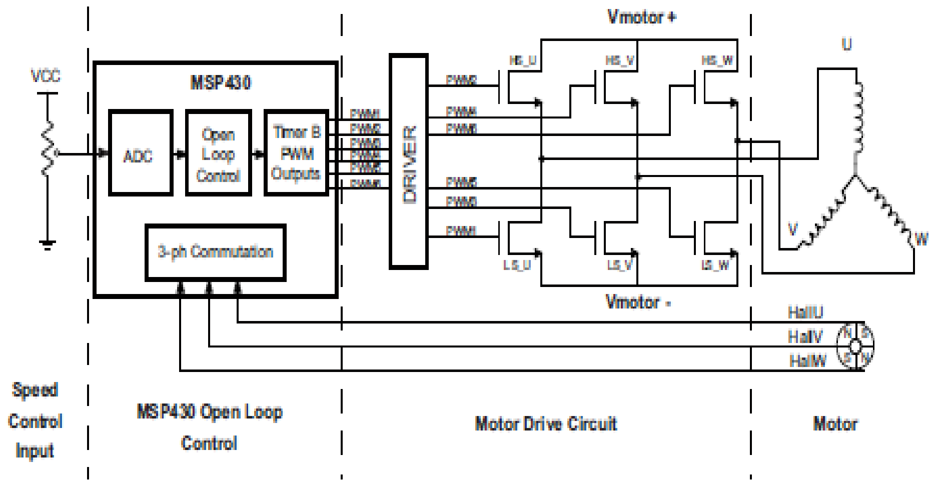

Fig 2. Block Diagram for open loop control implementation

Considering the motor direction in Counter Clockwise, the commutation sequence of the three phases is given as.

State	Direction = CCW	Active PWM & Power MOSFETs	
1	110	PWM4, PWM5	High-V, Low-W
2	100	PWM2, PWM5	High-U, Low-W
3	101	PWM2, PWM3	High-U, Low-V
4	001	PWM6, PWM3	High-W, Low-V
5	011	PWM6, PWM1	High-W, Low-U
6	010	PWM4, PWM1	High-V, Low-U

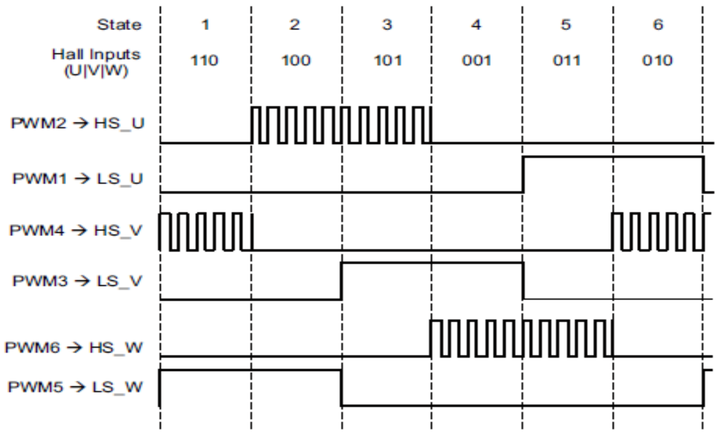

Fig 3. Hall Sensor based commutation for one electrical cycle.

The stepped PWM signal helps in achieving three phase controlled input to the stator terminals of the motor and thus, by feeding the hall sensor data to the controller, the motor operates as a conventional three phase ac synchronous motor.

Sr. No.	Voltage (V)	Current (A)	Speed (RPM)	Torque (Nm)	Power (W)
1.	50.5	6.8	3000	0.07	35.7
2.	49.6	14.2	2971	2.56	732.6
3.	48.1	26.8	2948	3.58	1127
4.	46.9	36.3	2927	5.06	1577
5.	45.4	53.3	2918	7.22	2139

The above table shows the motor parameters during testing. By considering the average load of 195 Kg, the acceleration by the motor by giving 100% throttle is given.

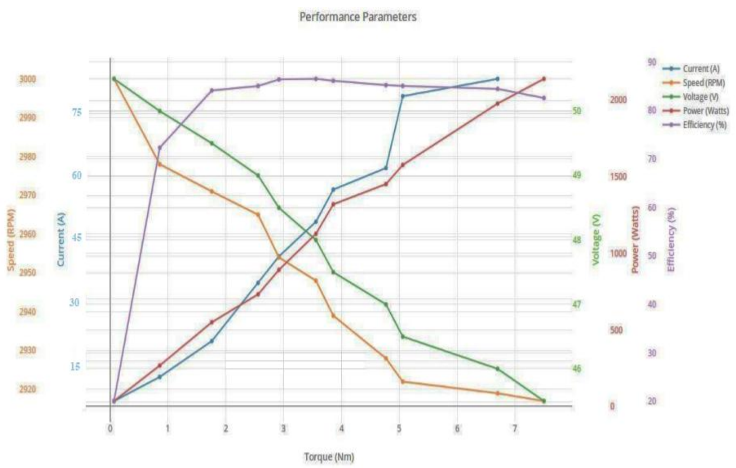

Fig 4. Performance Parameters of BLDC Motor

IV. Conclusion

In this paper, the components for hardware testing has been selected for the making of an electric motorcycle as the BLDC motor has 80% of its rated torque initially which translates into rapid acceleration. Electric bike are particularly useful in city riding because they don't blench smoke into city air. There is no use of fuel hence it has low maintenance as well as it is eco-friendly in nature .Limitations of electric bike is as follows: Power delivery is so linear that there is no 'surge' feeling which many riders experience in conventional fuel powered engines .Sometimes, battery has short life and long charging time. But this problem is solved with the adaption of the modular battery pack concept. It can be used by any urban citizen. Electric bikes requires no license so anyone can travel long distance in short period of time.

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