ELECTRIC MOTORCYCLE WITH CLUTCHLESS MULTI-SPEED GEAR REDUCTION SYSTEM

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Abstract - *The fossil fuels are widely consumed all over the globe and it is depleting at a faster rate. These petrol, diesel and gas undergo combustion in the engine to produce mechanical power. During the combustion the carbon form the petroleum product combined with oxygen and thus produce carbon dioxide, carbon monoxide, nitrous oxide and particulates. These pollutants cause air pollution which affects the living beings in numerous ways. These problems can be prevented by using electric motor- cycle that uses electric motor and battery pack. The existing electric motorcycle uses direct drive mechanism with single gear and one big battery pack. The problem is that this drive mechanism need more power from the motor itself to accelerate the motorcycle, this lead to lot of power consumption, high watt-hour battery, battery heating, short range per charge, minimal performance and short battery life. Also the over cost of the electric motor cycle is high. The proposed model contrast the existing model by affordable, more range, good performance by using small wattage motor with multi-speed gear system, small battery packs and battery switching module which reduces the battery heating, increases the battery life and range per charge. This model also has charging from renewable energy. This further enhances the range and economy.*

***Key Words*: Electric motorcycle, gear reduction, clutch less, Emission control, Future bike, high range.**

1. INTRODUCTION

The world is moving towards the cleaner and sustainable energies for a better and brighter future. The electric vehicles are the one best alternative for the conventional vehicles which used petroleum fuels. The motorcycles are more common around the world than the cars. These conventional motorcycles use the petroleum fuels for combustion to produce mechanical energy. The combustion process gives additional product of unnecessary pollutants and noises which are harmful for livings. On other hand the electric vehicles uses cleaner energy that is stored on the battery to drive the electric motor which gives the mechanical energy to accelerate the vehicles. Since there is no exhaust fumes, pollutants and noises from complex mechanical structure and all obtained is the quieter and smoother energy to drive to the vehicle, the electric motorcycle will change the future of competitive events.

The electric motorcycle has the same frame structure as of the conventional motorcycle. Instead of the combustion engine it uses electric motor. The electric motor used in electric motorcycle is brushless DC motor (BLDC). The BLDC motors are more efficient than the brushed DC motor or the PM motors. This means for the same input power the BLDC motor convert more electrical power into mechanical power than a brushed DC motor because of the lack of friction due to the carbon brushes in the BLDC motor. The BLDC motor is controlled by the BLDC motor controller. The motor controller provides commutation to the BLDC motor according to the encoder data from the motor. The encoder data provides the position of the stator which data is used for commutation. The motor controller also provides the speed control of the BLDC motor by using the PWM signal. The PWM is adjusted by using throttle which is in correspondence to the speed of the motorcycle. The electric motorcycle uses the battery as the source to store the electrical energy. The amount of the electrical energy stored in the battery and the current consumed by the motor to accelerate the motorcycle decides the overall range of the motorcycle.

Therefore battery pack of large capacity is used to provide more range per charge to the motorcycle. The most commonly used batteries in the electric vehicles are the lithium ion (Li) batteries. These batteries have voltage potential of 3.7 V. So the serial and parallel combinations of these batteries are used to achieve the necessary voltage rating and capacity (Ah) that is required to drive the motor. LI-ion batteries are also capable of delivering current with high c-rate. They are light weight and larger capacity can be achieved with parallel combinations of cells since the energy density of these batteries are high. On other hand lead acid batteries are heavy and occupy large space comparing to the lithium ion battery. For higher voltage rated motor lead acid battery cannot be used since lead acid batteries are available for lower voltage levels. Therefore Li-ion batteries are most preferred battery to store electrical energy in the electric vehicles.

1.1 Definition of Problem

The existing electric motorcycle's cost is very higher and the performance of the motorcycle is very less. They will give a less kilometer range per charge. People can't take that motorcycle for a long drive or daily usage. Due to the large motor and battery pack, the costs of the motorcycle will increase and the weight of the motorcycle will also increase.

1.2 Objectives

- To reduce the pollution and global warming.
- To increase the range per charge of the electric vehicle.
- To use lower battery capacity and give best range.
- To give the rider the same feeling as driving the IC engine powered vehicle.
- To implement run time charging by using renewable energy.

2. PROPOSED SYSTEM

Our proposed electric motorcycle will have a small battery pack and motor unit. We integrated a gear reduction system to make the motorcycle produce high torque. This gear reduction system will reduce the load to the motor from the wheel and hence it will reduce the heating of the motor. This motorcycle uses two small battery packs and a switching module to increase the range of the motorcycle. Battery pack 1 used to drive the motor and the battery pack 2 is used as a backup battery pack charging while driving the motorcycle.

3. COMPARISON OF EXISTING SYSTEM

NAME:	Revolt RV 400
MOTOR POWER:	3000 W
BATTERY:	3240 Wh
TOP SPEED:	80 km/hr
RANGE PER CHARGE:	150 km/charge

NAME:	I - ON
MOTOR POWER:	500 W
BATTERY:	720 Wh
TOP SPEED:	90 km/hr
RANGE PER CHARGE:	80-90 km/charge

Fig -1: Comparison

4. BLOCK DIAGRAM

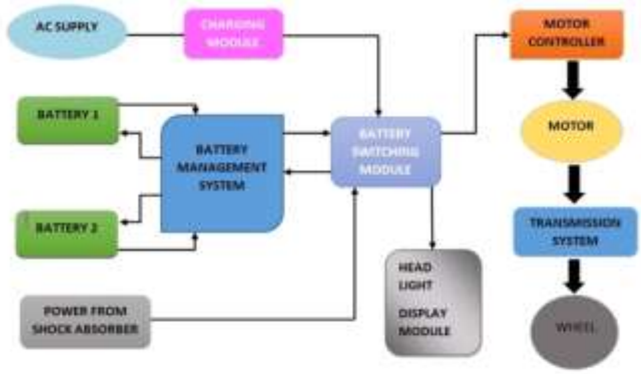

Fig -2:Block Diagram

4.1 Battery Switching Module

A lithium ion battery pack has many small 3.7V lithium ion cells in series and parallel combination to meet the required voltage and current. For large capacity of lithium ion pack, large number of cells is arranged in parallel. This pack can be used to power up the electric motor and many electronics in the electric motorcycle. The problem is that when single cell give up, the whole battery pack will be affected. This will affect the effective voltage and discharge current. Also the cost of replacing the whole battery pack is expensive. Since more cells are closely arranged with or without spacers in large capacity battery pack, the space for heat dissipation is low. The heating of a particular cell with dissipate the heat to the near battery and the overall battery take more time or more air ventilation to cool down or to maintain in the recommended safety temperature. The solution for the better temperature control and cost saving. It is better to use two or three battery of same capacity rather than a whole big battery pack and spiting the discharging and charging work phases. The block diagram of the battery switching module is shown below in the figure.

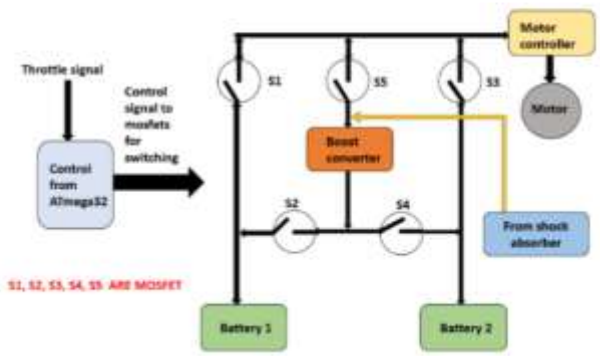

Fig -3: Battery switching module stage1

The working phase of the battery switching module is tabulated below.

Table -1: Battery switching module working1

BATTERY1 = DISCHARGE AND BATTERY2 = CHARGING					
THROTTLE STATUS	MOSFET /SWITCH				
	S1	S2	S3	S4	S5
ON	ON	OFF	OFF	ON	OFF
OFF	OFF	OFF	OFF	ON	ON

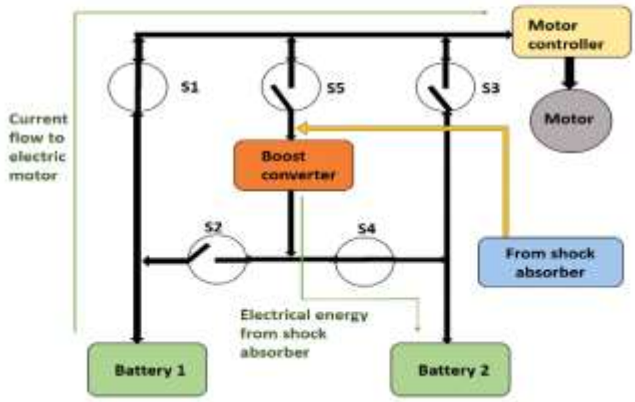

Fig -4: Battery switching module stage2

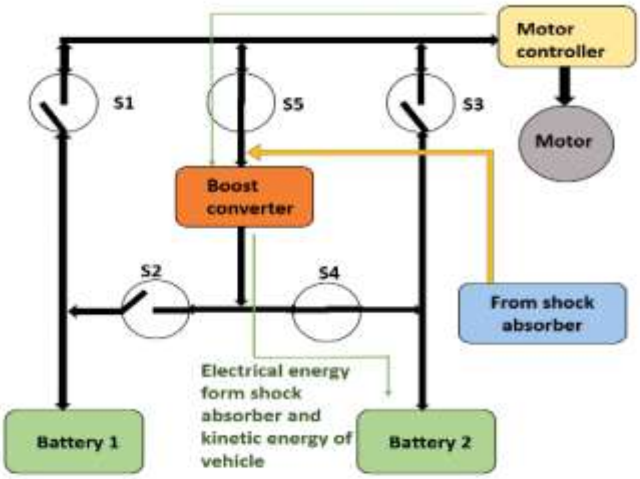

Fig -5: Battery switching module stage3

Table -2: Battery switching module working2

BATTERY1 = CHARGING AND BATTERY2 = DISCHARGING					
THROTTLE STATUS	MOSFET /SWITCH				
	S1	S2	S3	S4	S5
ON	OFF	ON	ON	OFF	OFF
OFF	OFF	ON	OFF	OFF	ON

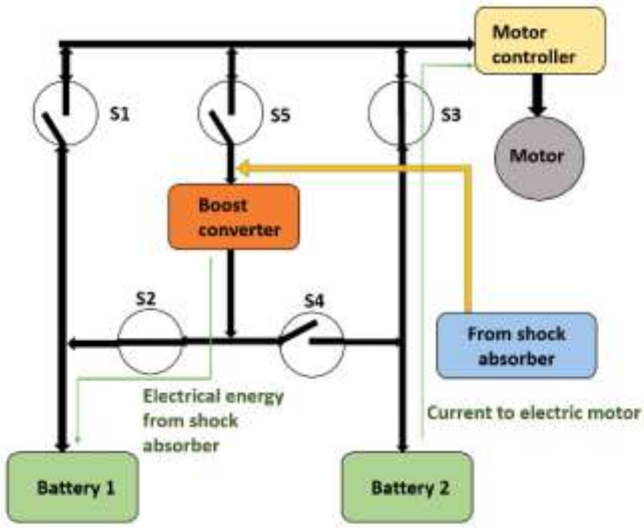

Fig -6: Battery switching module stage4

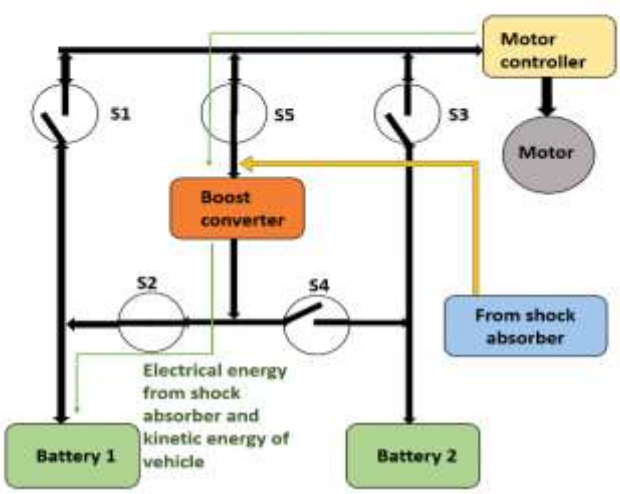

Fig -7: Battery switching module stage5

Splitting the charging and discharging work phases between the lithium ion battery packs will keep the battery in optimum temperature because both the work phases use high current charging and discharging.

4.2 Charging module

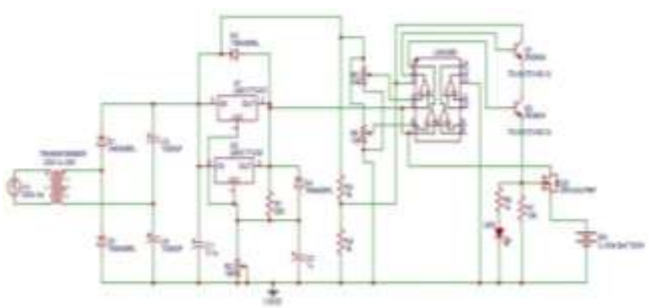

Fig -8: charging module circuit

The charging module is used to charge the lithium ion battery pack. This charging module offers charging the battery directly from AC mains by regulating the voltage using voltage regulator. The lithium ion battery pack used is 36V and 10 Ah capacity. The configuration of the battery pack is 9s4p. Each lithium ion cell has a nominal voltage of 3.7v and max voltage of 4.20v. To charge a cell 4.20v is required. Therefore for a 9s4p battery pack 37.8v is required. Due to safety concern and long life of lithium ion battery pack the charging cut off is set at 36.9v internally in the battery management system (BMS).

4.3 BLDC motor controller

Motor controller is used to control the motor activity like speed and torque. These controllers have microcontroller, power mosfet, transistor, voltage regulators and many other active and passive components. The BLDC motors have no brushes and slip rings for commutation. So the commutation is given by the motor controller. The commutation is the process of switching the direction of the current in the phases to continue the rotation of the motor. The basic block diagram of the motor controller is shown in the figure below.

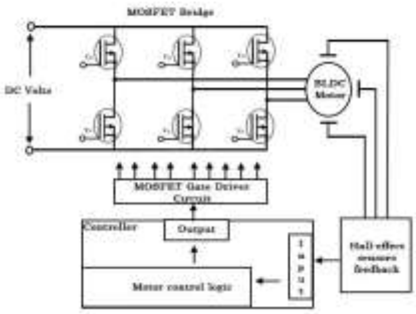

Fig -9: Motor controller

4.4 Motor specification

Fig -10: Motor

RATED POWER	500 W
RATED VOLTAGE	36 V
RATED CURRENT	18.5 A
RATED RPM	2800
RATED TORQUE	1.7 Nm

Table -3: Motor specification

4.5 Gears

A gear is rotating mechanical part used to deliver force from prime mover in different proportion. Gear gives the mechanical advantage of multiplying torque and maintaining appropriate rpm.

The torque is multiplied when gears that have different number of teeth are brought into contact. The gear ratio decides the amount of torque multiplication. Gear ratio is the fraction of number of teeth in the driven gear (N1) by driver gear (N2).

Gear ratio = N1/N2 (NO UNIT).

Many meshed gears of appropriate ratio form a multispeed gear box. These gears are selected by sliding the dog gear to engage a particular gear set. The gear ratio used for the proposed model is tabulated below.

GEARS	RATIO
Gear 1	**9.35**
Gear 2	**5.27**
Gear 3	**3.56**
Gear 4	**2.67**

Table-4: Gear ratios

4.6 Speed

The motorcycle is fitted with a 17 inch diameter wheel. The maximum speed achievable using this gear ratios and BLCD motor is listed below

GEARS	**SPEED** [Km/h]
Gear 1	**24**
Gear 2	**43**
Gear 3	**63**
Gear 4	**85**

Table-5: Speed

4.7 Maximum wheel torque

The maximum wheel torque is the product of the motor rated torque and the gear 1 ratio.

Maximum torque = Gear1 ratio * motor torque

= 9.35 * 1.7

= 15.89 N-m

5. EXPERIMENTAL RESULT

5.1 No load test

This test is conducted without any load to the wheels of the motorcycle.

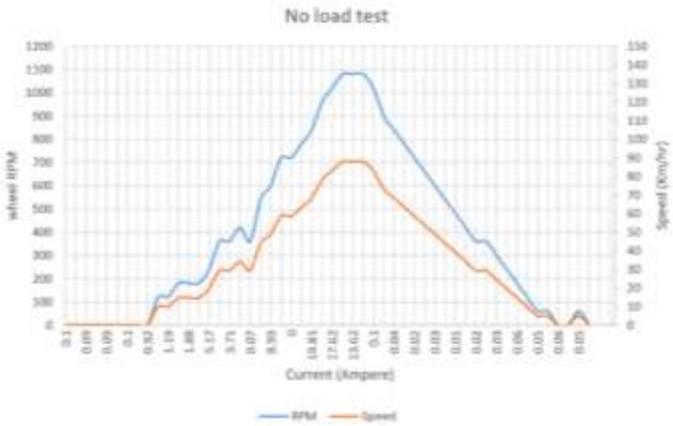

Fig -11: No load graph

Without any load the motorcycle shows a top speed of 88 Km/hr. Due to no load, the motor rpm was above the rate of 2800 rpm. The current consumption increases while high accelerating and reduces to optimum level when the acceleration decreases or vehicles attains a constant wheel rpm.

5.2 Load test

This test is conducted with a driver. The weight of the driver is 60 Kg.

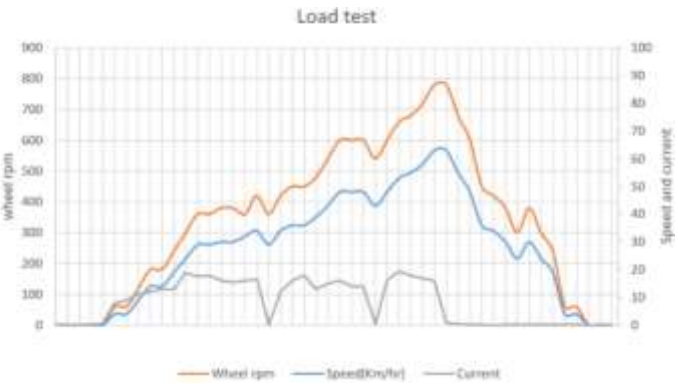

Fig -12: Load graph

The top speed of the motorcycle is not reached in this test. Due to road limitations and traffic the vehicle is speeded to 60 km/hr. The current consumption is optimal and the acceleration is slightly lower in higher gears due to load and limited torque from electric motor. The overall driving exposure is good and it is have good performance comparing to the conventional direct drive method.

6. CONCLUSION

This motorcycle will give high speed and range per charge and good performance by using a low watt motor and low kilowatt hour battery pack at a low price when compared to other existing electric motorcycles. With the multispeed gear reduction system the motorcycle gives better acceleration and gives better driving even at the slope area with huge load without any struggle.

7. REFERNCE

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