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Retrofitting of Existing Scooter into Hybrid Electric Scooter

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Abstract

In India, the usage of two-wheelers for daily activities is high. Thus, consumption of petrol is on the rise. If the spending of a country is considered then 80−90% spending is done to pay import bills on petroleum products, which are counted as the country's expenditure. The final result is a hike in the price of petrol and hence rising inflation. India is now the fourth largest emitter of greenhouse gases in the world. The transport sector accounts for 13% of India's related CO_2 emission which is mainly high in the traffic. Deployment of electric vehicles in large numbers is hindered by a variety of barriers. Scaling up electric vehicle's penetration and realizing their full potential would be required. For this situation, now one of the solutions is retrofitting of existing scooters into hybrid electric scooters. Instead of turning existing petrol vehicles into scrap, this can be utilized as hybrid electric vehicles, as nowadays, focus of government is on "National Electric Mobility Mission Plan 2020" (NEMMP 2020). Thus, the aim of our project is to enhance the capacity of cities to improve mobility with lower CO_2 emission. It can be a valuable contribution to achieve NEMMP 2020. The system proposes a solution by retrofitting existing scooters into hybrid electric which runs on Internal Combustion Engine. Here, by using scooter that has 80cc petrol combustion engine. The front wheel is replaced by an electric hub motor. It becomes a 2-wheel drive scooter with the hub motor driving the front wheel and conventional engine powering the rear wheel. Our main aim is to increase mobility and to improve the performance efficiency of existing vehicles. System proposes three switching modes here; Economy mode (Propulsion using motor only), power drive mode (propulsion using engine only) and hybrid mode.

***Keywords:** Controller, drivetrain, engine, hybrid, retrofit*

INTRODUCTION

To cope up with the problems of conventional vehicles, system proposes implementing front and rear wheel independent type drivetrain (FRID).

In this type of drivetrain arrangements, important factors to be considered are:

- Engine Power
- Electric Traction Motor
- Energy Sources
- The control strategy of drive-train.

With the following factors in mind, the parallel FRID design is being carried to satisfy out the

- Grade ability, acceleration, and maximum speed
- Overall high efficient hybrid electric vehicle.

In the case of FRID type vehicles, engine controller, motor controller and electric motor are the main components present in this drivetrain arrangement. By controlling the propulsion of sources present in this drivetrain configuration, ICE, electric motor, the torque has to be controlled independently [1]. Working on the parallel hybrid drive train for a scooter with

simulation data [2]. The efficiency of Hybrid electric vehicle is greater than the conventional engine due to optimization of engine operation. Also, due to ever fluctuating oil prices, there is a fast-growing interest in electric vehicles globally but the deployment of electric vehicles in large numbers is hindered by a variety of barriers. Hence, Hybrid Electric Vechile is the best option [3]. The advantages of replacing front wheel of two-wheeler with electric wheel hub motor and the rear wheel are driven by continuously variable transmission (CVT) as it originally is that both of them are able to provide propulsion torque separately [4]. The control strategy for the hybrid electric scooter is different from conventional type scooters. It includes a separate motor controller which has an inverter unit [5]. There is also an important energy management system for obtaining the desired performance.

PROPOSED WORK METHODOLOGY

System propose a solution by retrofitting existing scooters into hybrid electric which runs on ICE. Here scooter with with engine capacity of 80cc petrol internal combustion engine is used. Also, the front wheel gets an electric hub motor. It becomes a 2-wheel drive scooter with the conventional engine powering the rear wheel and the electric motor driving the front wheel.

A conventional engine is pretty inefficient during start-stop traffic. The engine uses a lot of fuel during such situations and reduces the mileage significantly. Byusing economy mode for these in which scooter will start and run on front wheeled electric motor. Hub mounted electric motor works during crawling traffic and does not need the fuel. Electric motors are much more efficient as they do not draw any power from the battery while waiting in traffic and idling.

Second mode is power drive mode. In this case, scooter will start and run on conventional ICE, which is coupled with the rear wheel. This mode can be used for emergency condition when batteries are completely discharged or if there is any problem in motor. The third mode is hybrid mode.

In proposed system BLDC motor with 746 watt capacity and 4 lithium-ion batteries in series are used. Each has capacity of 12 volts, 9Amph. For controlling acceleration of ICE as well as motor same controller is used. Heretwo control units are used. One is BLDC motor controller which acts as a mediator for motor, accelerator, brake system and battery. Another control unit acts as a mediator for BLDC motor controller, IC engine and battery. One MCB is used for protection purpose.

To obtain good average, Lithium-ion batteries are required. To obtain good speed and torque, high wattage BLDC motors are required to be used.

As per our datum in problem statement, our main aim is to increase mobility and to improve performance efficiency of existing vehicles. As per mentioned in solution, three switching modes are used here. Economy mode (Propulsion using motor only), power drive mode (propulsion using engine only) and hybrid mode.

In hybrid mode, while starting, to overcome the starting torque, scooter will start on conventional IC Engine. After time delay of 12 seconds, propulsion of wheel is done by using hub motor. Here, main aim is to increase overall running efficiency up to 90%, thus in this mode running scooter on hub motor after certain speed. When the battery has less charging, to increase the overall mileage is achieved by combining power of both that is IC engine and hub motor. During starting, as batteries are not used hence, life and performance of battery will improve.

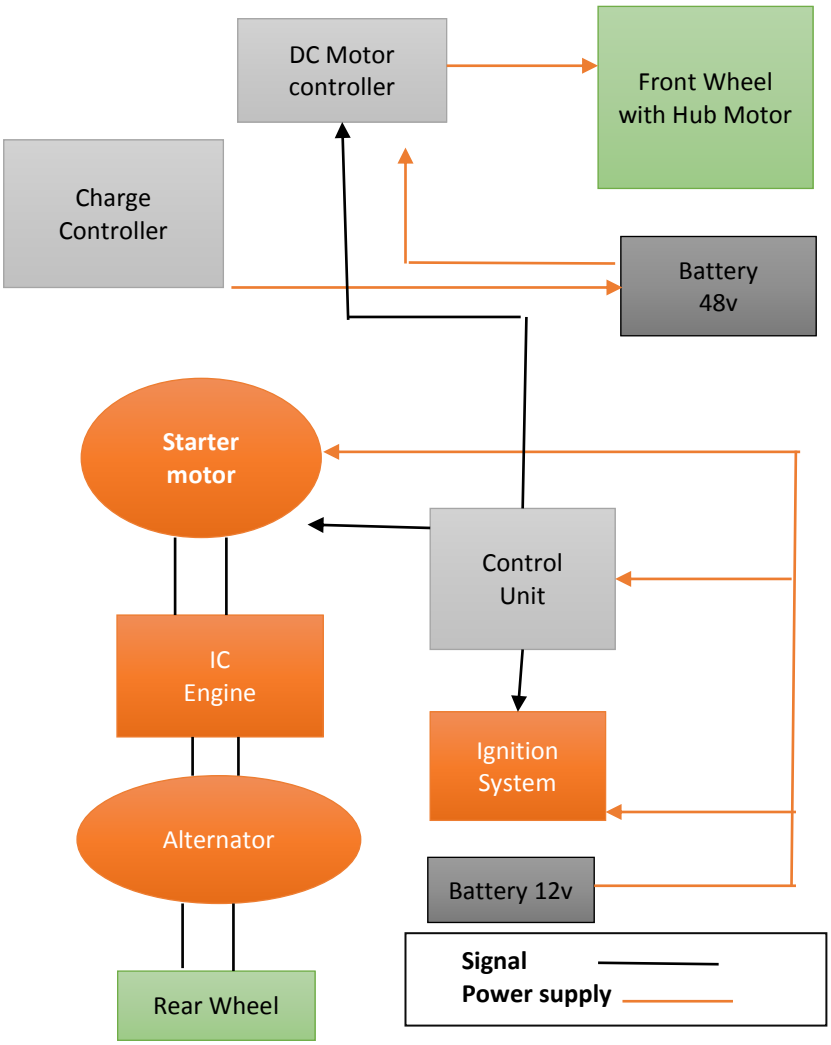

Figure 1: *Block diagram.*

The above Fig. 1 shows the block diagram of FRID type vehicles. This hybrid powertrain uses 746W driven front wheel and the rear wheel is driven by a conventional engine. Four Li-ion battery having a rating of 12V, 9Amph each are connected in series to deliver power to the motor. The batteries can be charged through an external electric source. The control strategy is developed such as both the wheels can drive the scooter individually or simultaneously depending on the requirements of the scooter.

There are three different modes in which scooter can operate:

1) Economy mode (propulsion using motor only)

2) Power drive mode (propulsion using engine only)

3) Hybrid mode (propulsion combining power from motor and engine)

SIMULATION RESULTS

The third mode of operation is hybrid mode. It is shown by simulated data for the hybrid mode operation. For simulation purpose, followings are main components:

- BLDC Motor
- Lamp (Indicates supply to ignition system)
- 555 delayed timer off circuit
- Resistors- 10K, 100K, 2.2K
- Capacitors- 0.1µF, 100 µF
- Transistor(BC547)
- 3 NO. of Relays

Now off delay time of timer can be set as:

Time Period (T) =1.1×R1×C1

= 1.1×100K ×0.1µF
=12 seconds
Hence, for time delay of 10 seconds, after pressing Push Button, the lamp showing supply to ignition system will glow and after 12 seconds, supply to ignition system will cut off and supply to BLDC motor will start.

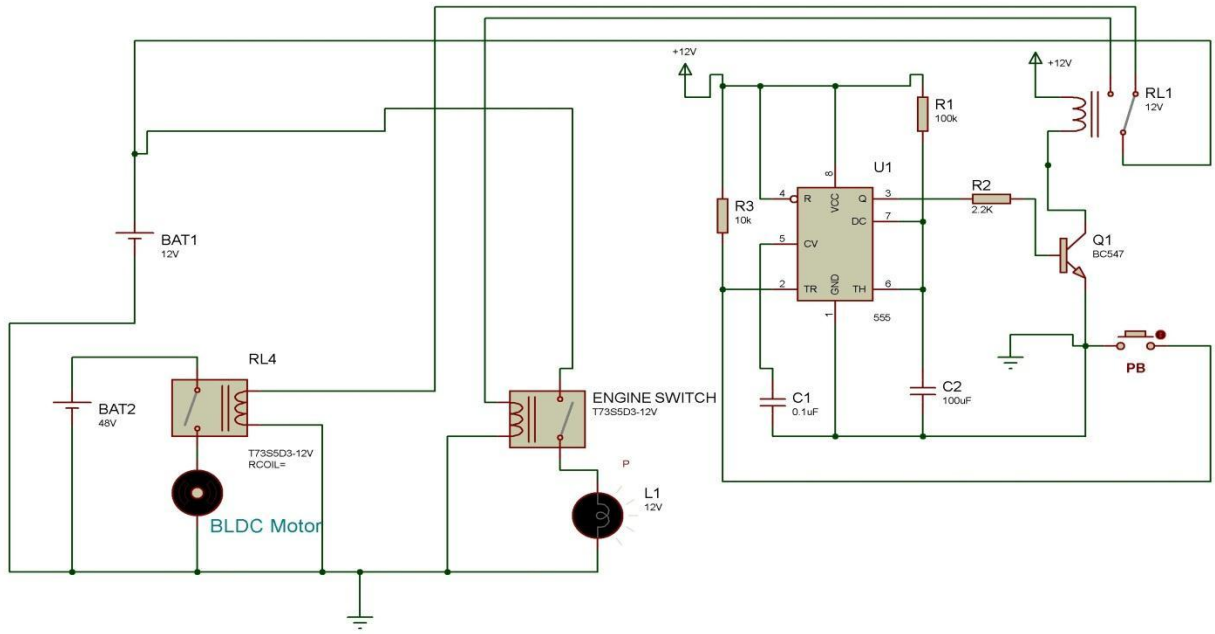

Figure 2: *Circuit before simulation.*

These circuit shows lamp and BLDC motor both are in the off state. As push button is not pressed, the relay is at its normal position.

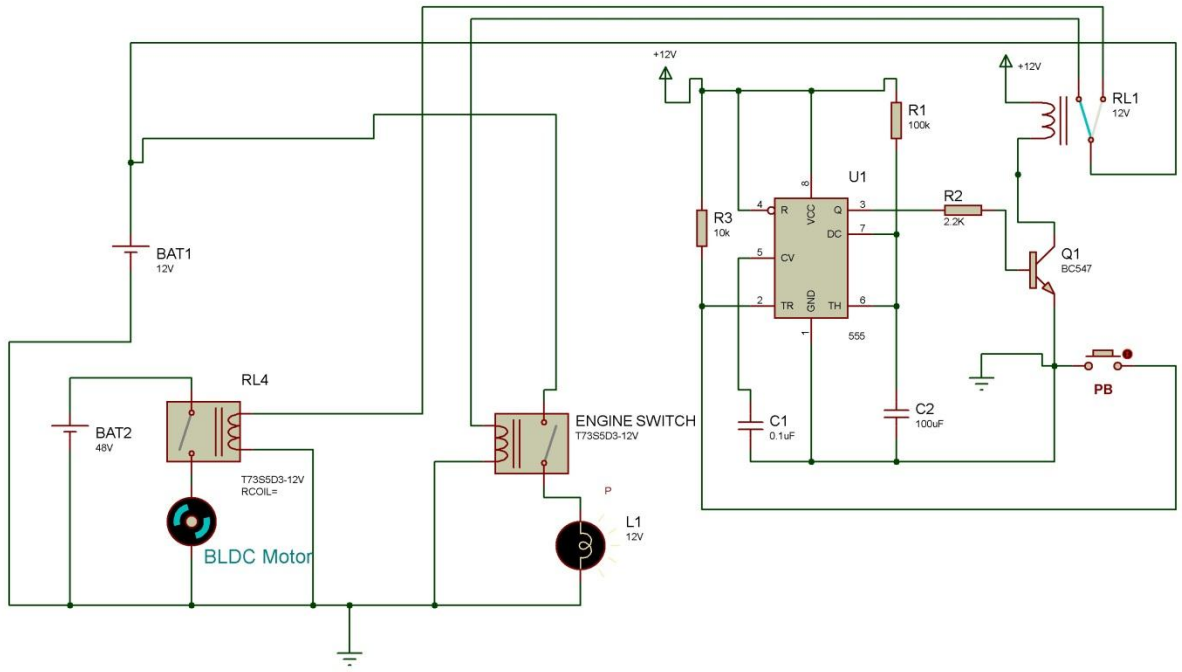

Figure 3: *Circuit showing supply to ignition system.*

As push button is pressed, the relay is switched from its normal position. These circuit shows that lamp is in the on state hence, there is supply to ignition system and scooter will start on the engine.

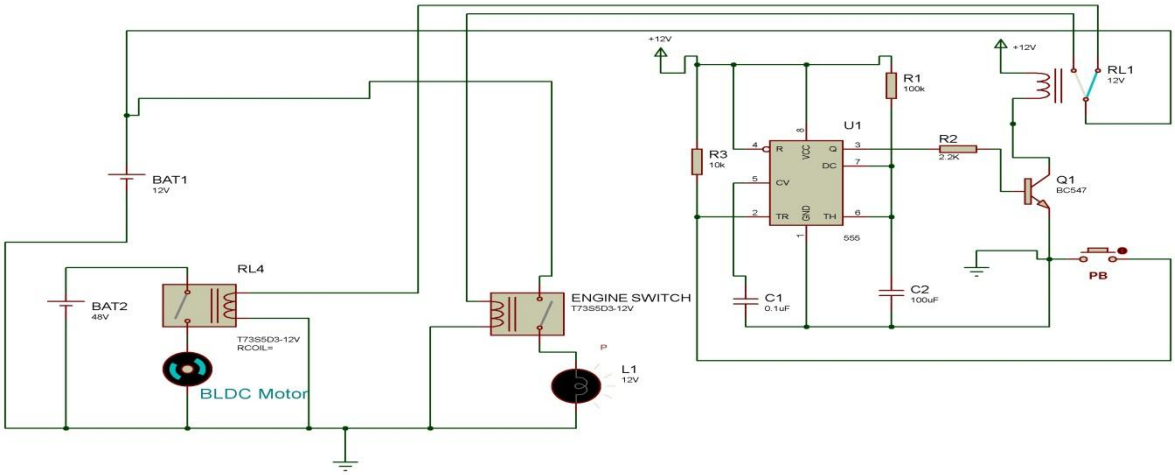

Figure 4: *Circuit showing supply to BLDC Motor.*

After delay of 12 seconds, main relay will come back to its original position. Hence, supply to ignition system will cut off and supply to BLDC motor will start. Hence, system will be switched on the electric mode operation.

Table 1: *Ratings of components.*

Make – TVS
Model: Scooty pep +
Maximum Power: 3.5BHP
Displacement: 87.8cc
MaximumTorque:5.8Nm@4000rpm
Number of gears: Automatic
Net Weight: 79.50KG
Fuel Tank Capacity: 3.5liters
Motor Ratings:
Motor Type: Brushless DC motor
Power: 746 Watts
Voltage: 48Volts
Rated Current: 15.54A
Wheel Motor diameter-12inches=12*2.5=30cm
Controller Ratings:
Voltage: 48V
Current: 5-6 Ampere
Battery Ratings:
Battery Type: Lead acid Battery
Voltage: 12 V
Ampere hour rating: 9
Tested Parameters:
Speed (RPM) = 900Ampere
No load current=3Ampere
Full load current=13.20Ampere

Table 2: *Calculations.*

For BLDC Motor:
$\boldsymbol{Torque} = \frac{(\text{power} \times 60)}{(2 \times \pi \times \text{speed})}$
$= \frac{(746 \times 60)}{(2 \times 3.14 \times 900)}$
= 7.91N-m
$\boldsymbol{Efficiency} = \frac{\text{output power} \times 100}{input\ power}$
$= \frac{48 \times 13.20 \times 100}{48 \times 15.54}$
= 85%
Speed in kmph $= \text{D} \times \text{RPM} \times 0.001885$
$= 30 * 900 * 0.001885$
=50.89 Km/hour
Battery Km/charge:
Rating of battery: 12V, 9Ah
No of batteries used: 4
Let average current drawn: 6A
$\boldsymbol{In\ one\ charge\ it\ can\ complete} = \frac{50.89 \times 9}{6}$ =75Kms

Table 3: *Calculations for saving.*

Assumptions:
Price of petrol/ liter= 78Rs.
Price of Electricity / Unit= 5Rs.
E-bike Energy/ Charge= 0.432 Kwh
Annual driving distance= 12000Km
Duration of ownership= 3 years
Price of battery pack= 8000Rs.
3 years driving distance= 36000Km

Table 4: *Cost calculations for three years comparatively for electric scooter, engine operated scooter, hybrid scooter.*

For Electric Scooter:
Cost of Vehicle= 50,000Rs.
Range of Charge= 75 Km/Charge
Maintenance cost= 3000Rs.
Battery Cost= 8000Rs.
Units of power consumed considering 612 charges=
612×0.432×5=1321.92Rs.
Total Cost= 50,000+3000+8000+1321.92
=62321.92Rs ~ 62,330Rs.
For Engine operated Scooter:
Cost of Vehicle= 50,000Rs.
Mileage/Km/liter = 50 Km/Charge
Maintenance cost= 10,000Rs.
Liters of petrol consumed= 720
Cost of petrol consumed= 720×78
=56,160Rs.
Total Cost= 50,000+10,000+56,160
=1, 16,160Rs.

CONCLUSION

From this project, it can beconcluded that hybrid scooter has more advantages than full electric and full engine operated scooter.

Advantages are as follows:

- Scooter can be operated on both engine mode and electric mode independently. Hence, it has advantages of both engines operated and electric scooter.
- Hybrid scooter consumes less fuel than full engine operated scooter.
- There is less emission of pollutant gaseous that tends to rise in an environment-friendly system.
- In hybrid mode operation, starting of scooter is done by engine and after a certain delay, the system is switched on electric mode. Due to these, life of batteries improves as batteries get protected from the initial starting current of the motor.
- The efficiency of hybrid scooter is higher than full engine operated scooter as the duty cycle of this scooter is more on electric mode operation.
- In emergency conditions, scooter is operated in engine mode operation.
- Maintenance cost of hybrid scooter is more than that of engine operated scooter.
- Hybrid scooter can be operated at higher torque while electric scooter has less torque.

  By considering these advantages, it can be conclude that hybrid scooter is more portable than full engine operated and full electric scooters.

Nowadays, it is very essential to use electric system vehicles as the cost of crude oil are raising. Such a change cannot be accepted by common people easily. To make this solution affordable to common people, it is the option that instead of turning existing petrol vehicles into scrap, we can utilize it as hybrid electric vehicles. Recently, two-wheelers sales in India in 2017/18 is up to 2Cr. and out of which, 40% are scooters. Hence, we are focusing on retrofitting of existing scooters into hybrid electric scooter.

This project gives modified product of the existing system by making changes in the existing system, it will give a more enhanced outcome. It can overcome problems in existing electric scooters such as low speeds, unavailability of charging stations when batteries are getting to be discharged. This will also reduce Co_2 emission, import cost of crude oil. It is a cost-effective solution. Thus, it gives good contribution to a society.

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