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BMS and Motor Controls for Range Extended Electric Vehicle (REEV)

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***Abstract:* - Hybrid electric vehicles (HEVs) combine an internal combustion engine with an electric motor to improve fuel efficiency and reduce emissions. A Battery Management System (BMS) and Motor Controls are pivotal components in Hybrid Electric Vehicles (HEVs) that play a crucial role in optimizing performance, efficiency, and safety. It monitors individual cell voltages, temperatures, and state of charge, thermal management, and fault detection. On the other hand, Motor Controls in HEVs regulate the power distribution between the internal combustion engine and electric motor(s), maintaining a balance. These controls manage torque, speed, and regenerative braking, seamlessly transitioning between electric and gasoline power sources**

***Keywords*- Hybrid electric vehicles, Battery Management system, Motor Controls.**

INTRODUCTION

Range Extended Electric Vehicles (REEVs) have emerged as a promising solution to address the limitations of traditional electric vehicles (EVs) regarding range anxiety and infrastructure constraints. These vehicles integrate an internal combustion engine (ICE) generator, alongside an electric drivetrain and a battery pack, to extend their driving range beyond what is achievable with a pure battery-electric vehicle. Central to the operation of REEVs are Battery Management Systems (BMS) and Motor Controls, which play pivotal roles in managing the energy flow, ensuring operational efficiency, and optimizing performance.

The BMS in a REEV is responsible for monitoring the state of the battery pack, including its voltage, current, and temperature. It manages the charging and discharging processes to maintain the battery within its safe operating limits, maximizing its lifespan and ensuring its reliability. Additionally, the BMS communicates with the vehicle's motor control system to provide real-time data and optimize power delivery based on driving conditions, enhancing efficiency and performance. It also gives the information about the voltage and current flowing through it and sends back the information if there is any kind of fault in the system.

Motor controls in a REEV regulate the power flow between the battery, the electric motor, and the generator, ensuring smooth operation and maximizing energy efficiency. These systems employ sophisticated algorithms to manage torque delivery, speed control, and regenerative braking, enhancing overall vehicle dynamics and driving experience. By effectively coordinating the battery management system and motor controls, REEVs can achieve optimal performance, extended range, and reduced environmental impact, making them a compelling choice for sustainable transportation solutions.

LITERATURE REVIEW

1. This paper deals with battery management systems (BMS) which monitor and control charging and discharging of batteries in electric vehicles to optimize performance and lifespan.
2. The paper presents the design and performance analysis of a PMDC motor for electric vehicles application through modeling, simulation and experimental validation.
3. The document discusses the development and control of hybrid electric vehicles, emphasizing the need for efficient and eco-friendly propulsion in the automotive industry, as well as the integration of various electrical systems and control strategies to achieve optimal performance.
4. The document discusses the importance of battery management systems (BMS) in electric vehicles, focusing on the need for high-power batteries and suitable BMS technologies for safe and reliable operations, as well as comparing lithium-ion (Li-ion) and Nickel-Metal Hydride (NiMH) batteries in terms of aging and the effect of temperature using state of charge (SOC) and open circuit voltage (OCV).

NEED OF PROJECT

1. Battery management systems (BMS) are important for hybrid electric vehicles (HEVs) because they monitor and control the performance of the vehicle's battery pack.
2. BMS ensures the battery's health, safety, and efficiency by managing charging and discharging processes, balancing individual cell voltages, and protecting the battery from overcharging or over-discharging.
3. Together, the battery management system (BMS) and PMDC motor control play a serious role in enhancing the efficiency, reliability, and longevity of hybrid electric vehicles (HEVs), and making them an integral part of modern HEV Technology.

PROPOSED METHODOLOGY

The proposed methodology for battery management and motor controls for range extended electric vehicles involves integrating advanced battery management systems (BMS) to monitor and optimize battery performance. This includes

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implementing algorithms for real-time battery state estimation, thermal management, and cell balancing. Additionally, sophisticated motor control strategies are employed to maximize efficiency and range, such as field-oriented control (FOC) for the motor drive and regenerative braking systems. The overall approach aims to enhance the vehicle's performance, extend its range, and ensure the longevity of the battery pack.

BLOCK DIAGRAM

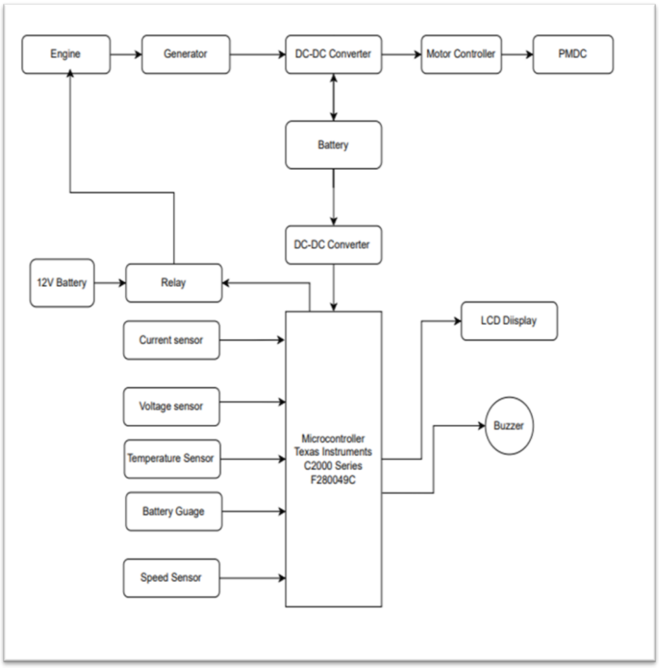

Fig. 1: Block Diagram of The System

1. IC Engine: 4 stroke single cylinder engine of 10 CC.
2. Generator: The generator is used to convert mechanical energy to electrical energy for transmission and distribution over power lines to domestic, commercial, and industrial customers.
3. Controller: Here in this project two controllers are used, the motor controller and main controller to control low voltage designs.
4. PMDC Motor: The motor is used to rotate the shaft and further to the wheels
5. Lithium Ion Battery: Battery is used to power the motor because battery needs electrical power supply.
6. Sensors and output devices: The sensors are used to sense the data accordingly and give to the output devices like LCD Display.

EQUATIONS FOR MOTOR AND BATTERY

1. Motor Equations:

P total= (m∗g∗u) ∗v+(0.5∗c∗a∗d∗v^2) ∗v+ (m∗g∗sin Q) ∗v
where P total= Total Power
m: mass of vehicle= 340kg
g: acceleration due to gravity= 9.81m/s^2
u: rolling resistance= 0.01
c: drag coefficient= 0.30
a: frontal area= 1.1475m^2
d: density of air= 1.2kg/m^3
v: velocity=74kmph= 20.55m/s
Q: inclined angle= 3

Torque=1000∗60∗P/2π∗n
n: RPM

2. Battery Equations

Total force =(m∗g∗u) +(0.5∗c∗a∗d∗v^2) + (m∗g∗sin Q)
Battery capacity = Force(N) ∗range(km)/3600
Force = Total force-gradient force
Energy consumption= P total(kw)/vehicle speed(miles/hr)
Electric range= Battery capacity/Energy consumption

ALGORITHM

algorithm of Hybrid Electric Vehicles
Step 1: Initialize the system:
- Start the HEV.
- Set initial battery percentage.
- Set generator status to OFF.

Step 2: Check Battery Percentage:
- Continuously monitor the battery percentage.

Step 3: Main Loop:
- While the vehicle is running, continue to check the battery percentage and generator status.

Step 4: Battery Percentage Check:
- If battery percentage is below 40%:
- Turn on the generator.
- Set generator status to ON.
- Start recharging the battery.

Step 5: Generator Power Generation:
- When the generator is ON, it generates electricity.
- Convert the generated electricity to the required voltage and current for battery charging.

Step 6: Battery Recharge:
- Channel the generated electricity to the battery for recharging.
- Monitor the battery charging status.

Step 7: Battery Charging Complete:
- When the battery percentage reaches a satisfactory level (e.g., 80%):
- Turn off the generator.
- Set generator status to OFF.
- Stop recharging the battery.

Step 8: Motor Power Check:
- If the generator status is OFF, the motor requires power for propulsion.
- Determine the power requirements of the motor.

Step 9: Power Source Selection
- If the generator status is ON, use the generator as the power source for the motor.
- If the generator status is OFF, use the battery as the power source for the motor.

Step 10: Motor Propulsion:
- Channel the selected power source to the electric motor for propulsion.
- Adjust the power to control the vehicle speed.

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Step 11: Continue Main Loop:

- Repeat steps 2 through 10 as long as the vehicle is operational.

Step 12: Shutdown:

- When the vehicle is turned off, stop all power generation and propulsion systems

FLOW CHART

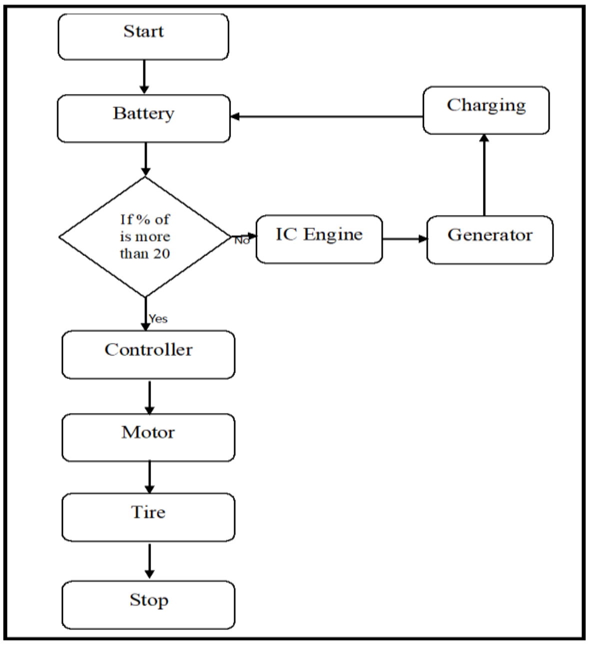

Fig. 2: Flow Chart of the system

POWER FLOW DIAGRAM

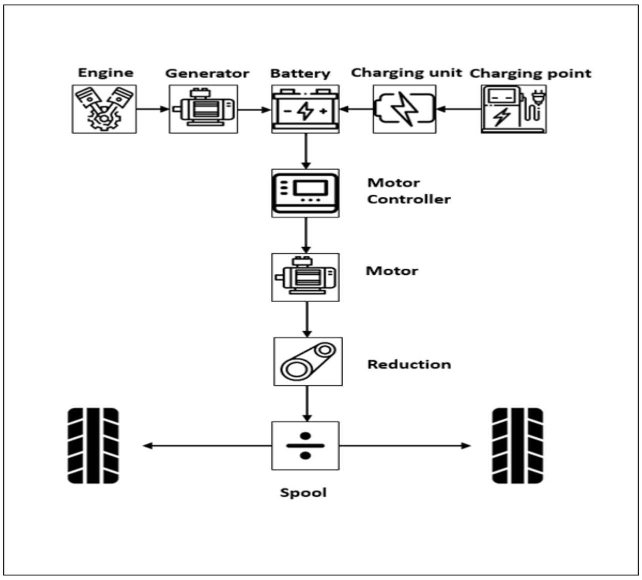

Fig. 3: Power Flow Diagram

The Transmission system ensures that power is efficiently delivered from electric motor to wheels allowing for optimal performance and energy usage. It helps balance the power output from the electric motor and the internal combustion engine to achieve the best compromise between performance and fuel efficiency.

ADVANTAGES

1. HEVs combine an IC engine with an electric motor, allowing them to operate more efficiently, especially in city driving conditions HEVs produce fewer emissions compared to conventional gasoline or diesel vehicles.
2. HEVs produce fewer emissions compared to conventional gasoline vehicles.
3. HEVs use regenerative braking to capture and store energy that is typically lost as heat during braking.
4. Electric motors are quieter than internal combustion engines, leading to reduced noise pollution in urban areas.
5. Many governments offer incentives such as tax credits or rebates to encourage the adoption of HEVs.

DISADVANTAGES

1. HEVs tend to be more expensive upfront compared to traditional gasoline or diesel vehicles due to the dual powertrain components
2. The dual powertrain system in HEVs can be more complex, requiring additional maintenance and potentially higher repair costs.
3. Unlike pure electric vehicles (EVs), HEVs don't benefit from a widespread charging infrastructure, limiting their electric-only capabilities.
4. Over time, the high-voltage battery in HEVs can degrade, reducing the overall efficiency and performance of the vehicle.

APPLICATIONS

1. HEVs are commonly used in passenger cars and SUVs, providing a balance between fuel efficiency and practicality for daily commuting.
2. Many cities use HEVs for buses and other forms of public transportation to reduce emissions and fuel consumption.
3. HEVs are employed in delivery and logistics vehicles to reduce fuel costs and emissions during frequent stop-and-go driving.
4. HEVs are used in taxi services due to their improved fuel efficiency and lower operating costs.
5. Government agencies and municipalities use HEVs for various purposes, including police cars, maintenance vehicles, and administrative fleets.

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SPECIFICATIONS

1. Battery

Battery pack configuration	6S 6p
Battery nominal voltage	51.2 V
Battery capacity	90 Ah
Battery operating voltage	44.8V to 58V
Life cycle	2000
Casing type	Metal
Battery operating temperature	0ºC - 65ºC
Continuous discharge current	200A (can be change as per bms Rating)
Pulse discharge current	300A

Table 1: Battery pack technical specifications

2. Motor

Parameter	Description
Max RPM	3500
Peak Power	11.5 KW
Weight	20Kg
Rated Torque	22 Nm
Ambient Temperature	32°C
Dimension (L∗B∗H)	(220∗120∗220) (in mm)

Table 2: PMDC Motor technical specifications

3. Motor Controller

Motor Control Type	PMDC
Input Current Rating	152 A
Output Current Rating	145 A
Voltage Rating	48 V
Efficiency	85%
Cooling	Air Cooling
Derating	0.86
Coupling Mechanism	Belt Drive

Table 3: Motor Controller technical specifications

FUTURE SCOPE

1. Develop advanced battery technologies such as solid-state batteries to improve energy density, reduce weight, and increase the range of hybrid vehicles.
2. Establish a widespread network of wireless charging stations to make recharging more convenient and encourage the adoption of hybrid vehicles.
3. Integrate autonomous driving features into hybrid vehicles to improve efficiency and safety, making them more attractive to consumers.
4. Implement Vehicle-To-Grid (V2G) technology in hybrid vehicles, allowing them to store excess energy and feed it back into the grid during peak demand periods.

RESULT

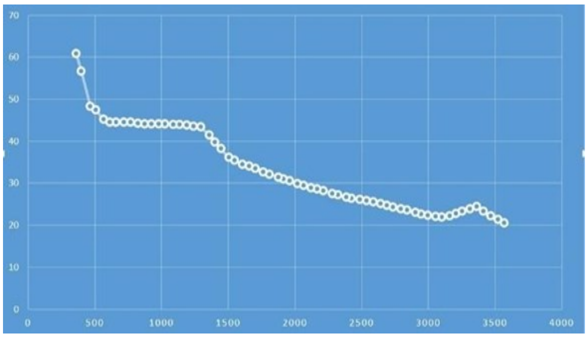

Fig 4: RPM VS Torque

The above graph shows us that, as the RPM increases Torque Decreases. It shows that Torque and RPM are inversely proportional to each other. there is more reduction in the torque in the initial stage and as the RPM increases torque gradually decreases

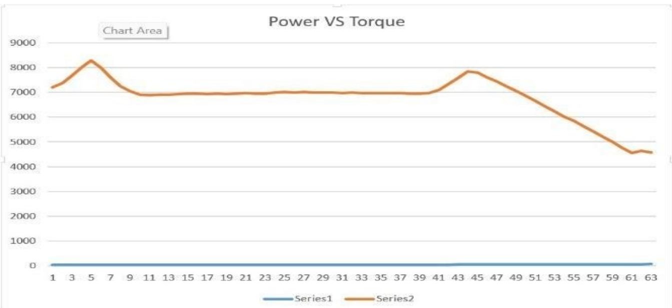

Fig 5: Power Vs Torque

The above graph will give us the different values of torque at different power ratings. This estimates us that what is the power required at various torque.

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CONCLUSION

Hybrid Electric Vehicles has shown that these vehicles offer a promising solution for reducing fuel consumption and emissions. We successfully demonstrated the effectiveness of combining electric and internal combustion engines to improve fuel efficiency and reduce environmental impact. Our findings indicate that hybrid vehicles are a viable and eco-friendly transportation option for the future. Further research and development in this field will likely lead to even more efficient and sustainable hybrid electric vehicles. This project highlights the importance of embracing hybrid technology to address environmental concerns while maintaining practicality and convenience for consumers. Ultimately, hybrid electric vehicles are a step in the right direction towards a cleaner and more sustainable transportation future.

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