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Key Technologies of Hybrid Solar Electric Midibus Development

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Abstract

The solar and lithium-ion hybrid electric midibus is a new energy vehicles.According to the 21 low-speed integrated Li-ion power midibus's design and development requirements,this paper introduces some key Technologies need to be[2] resolved,such as vehicle dynamic parameter matching technology, Lightweight design, high efficiency motor and controler technology, solar panels and charger technology, Battery management technology and advanced vehicle control technology. Based on the analysis of the key technologies, this paper put forward the corresponding solutions and implementation plan, and the midibus prototype is also developed. Through the vehicle and some components testing and experiments, which verify the correctness of such Key Techniques.

Keywords: Solar energy, Lithium-ion battery, Lightweight, electric midibus

1 Introduction

Electric Vehicles are using batteries as the power source Vehicles. Solar electric car is the most clean, most promising green vehicles, which are transform the solar light energy into electricity stored in high-energy batteries, used to drive permanent magnet motor rotation, thereby driving vehicles to move. As a new green transport, it has zero emissions, low noise, wide source of energy, and many additional advantages. At present, because the conversion efficiency of solar cells can not very satisfactory, solar power is more suitable for short distance transport of vehicles or low speed situations [1], Such as attractions, schools, large communities, small towns, suburbs, etc. And now at home and abroad most ferry bus under 14 seats are Low energy density, low power system efficiency whose Power system adopts DC motor, the battery used lead-acid batteries. At the same time such ferry bus use fiberglass body, leading to lower load, and thus the energy utilization efficiency is low. Base on the market demand of 21-midibus, the lightweight, high energy efficiency of a new generation of lithium-ion battery integrated solar electric midibus are developed.

2 Design Requirements of Integrated Solar Li-Ion Energy Midibus

2.1 Vehicle Design Parameters Requirements

Capacity: 21 people (including driver);
Curb weight: 1300kg;
Maximum weight (fully loaded): 2700kg;
Speed: 20Km / h;
Maximum speed: 30km / h;
Maximum Grade ability: 20%;
Driving range: 80Km;
Solar auxiliary power supply;

2.2 Application Scope

The vehicle can be used under light rainfall condition. It is also suitable for campus, spots, and large communities such as regional vehicle.

3 Key Techniques of Solar and Lithium-ion Hybrid Electric Midibus Development

3.1 Vehicle dynamic matching technology

The design parameters of electric vehicle power train components, Such like motor power and torque, transmission gear ratio, And a reasonable matching between them , etc, have significant impact on electric vehicle power, economy, driving range. As the vehicle speed is low, taking into account the motor's constant torque and high-speed low-speed characteristics, considering reduce the mass of transmission, improve the transmission efficiency and reduce the difficulty of driving, the fixed ratio transmission solution is adopted. Taking into account the load capacity and vehicle style, the Rear-wheel drive solution is used. Reference to the current light vehicle buses or similar loading vehicle transmission parameters, we select 4.55 as final reduction ratio, 3.652 or 2.39 as fixed-gear ratio. Combining vehicle model parameters, the electric speed, power and torque matching calculation can be carried out. Using the Independent development software EVSIM of electric automobile power matching technology to carry on Simulation calculation, and get the required curve shown in Figure 1.

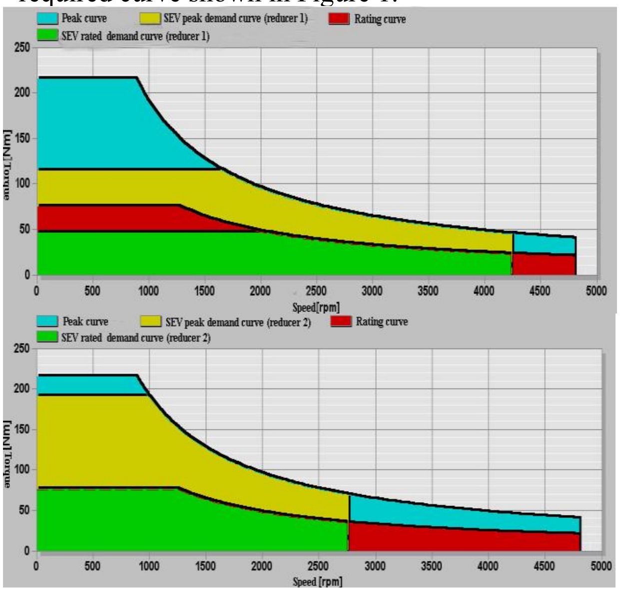

Figure 1: Vehicle power demand curve

3.2 High-efficiency Motors and Drive Systems Development

Motor and Drive System is the one of the electric vehicle core development. There are currently DC motor drive system, AC induction motor drive control system, Switched reluctance motor drive system(SRM), and Permanent magnet synchronous motor (PMSM) drive control system, etc. the permanent magnet synchronous motor with permanent magnet excitation is high power density, large starting torque, smooth torque, low vibration and noise, easy to form a new magnetic circuit. It is very well satisfy the demands such like the electric vehicle load, wide speed range, low-speed high torque, high-speed low-torque, high Instantaneous Power, etc. It is the direction of development of electric vehicle motors [3].

To meet the requirements of Matching vehicle dynamic parameters， Considering the vehicle driving range, 192V ,100AH lithium-ion battery is used as power supply. Corresponding permanent magnet synchronous motor and its controller are also designed and developed. The motor and controller parameters are shown in table 1.

Table 1: Motor design parameters

Motor design parameters				
Rated speed	w	1200	rpm	
Rated current	In	94	Arms	
Electric poles		8	Poles	
Rated frequency	Fn	80	Hz	
Rated torque	Tn	82.5	Nm	
Rated power	Pn	10.3	kW	
Rated voltage	Vn	84	Vrms	
Locked current	Io	96	Arms	
Locked torque	To	84	Nm	
Phase back-EMF	EMF	0.55	v/s	
Torque constant	Kt	0.96	Nm/Arms	
Rotor inertia	Jort	0.0124	Kgm2	
Maximum speed	W1	4800	rpm	
Maximum frequency	Fn1	320	Hz	
Maximum current	Imax	234	Arms	S6,10%
Maximum torque	Tmax	213	Nm	S6,10%
Peak power	Pmax	33	kW	<1min
Efficiency		0.9		
Insulation Class		F		
Protection class		IP54		
Working standard		S1		
Lead wire		50	mm²	PTFE red、blue、yellow
20 ℃, the winding wire resistance Rw		0.0658	Ohm	
Inductance Lw (1000Hz)		0.8	mH	
Equipped with feedback components factory		Resolver		

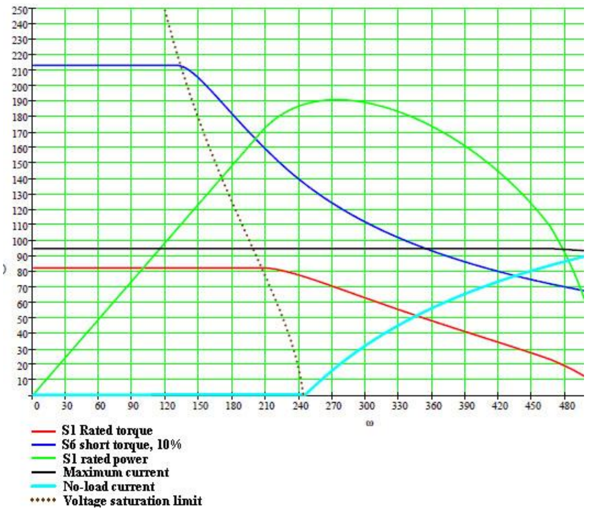

Figure 2: Electrical Motor Characteristics Curves

3.3 Distributed Battery Management System

Electric vehicles usually use lead-acid battery, nickel metal hydride batteries or lithium ion battery as power source. Lithium-ion batteries because of its high energy density, high number times of rechargeable are considered the best battery for electric vehicles at present. Electric vehicles' batteries are generally composed by the battery packs which are making up by dozens or even hundreds of single cells in series or in parallel. During using it will cause the battery to the inconsistent, and affect the battery life and battery energy storage and so on. All these will bang inconvenience for battery performance, and security management and cause impact on the application of vehicle. For this reason, electric vehicles are typically equipped with battery power management system to achieve the estimated battery state of charge, and vehicle safety management and communication functions [4].

The solar and lithium-ion hybrid electric midibus Utilizes 55 100AH square lithium-ion batteries which are divided into 5 groups, each composed of 11 cells in series into smart battery pack as shown in figure 3. Smart battery packs include lithium-ion battery and Intelligent Manager, which include smart sensors, thermal management and equalization functionality. Distributed battery management system which developed based on embedded hardware, includes battery management parameters setting module, battery dynamic database module, battery statistical analysis module, battery equalization charging algorithm module, the battery state of charge (SOC) module, the battery state of health (SOH) module, an alarm warning module, heat balance management module, display module and control and communication module.

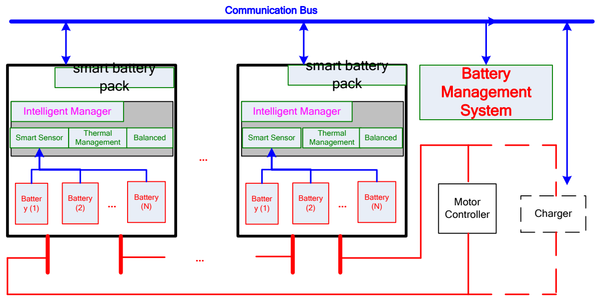

Figure 3: Distributed battery management system

3.4 Distributed Development of Solar Cell and Charge System

The design of solar module includes the size and performance parameters design. The former depends on the structure and size of the roof, and its Layout is shown in figure 4. To reduce weight, battery components' substrate use lightweight, high toughness resin material. The performance parameters design is based on characteristics of vehicle and Battery characteristics [5] and the rated voltage of 192V, the maximum voltage of 212V. Design parameters of the battery components can be shown in table 2, maximum power Pm is 60W, component efficiency is17.5%, open circuit voltage Voc is 20.1V, Isc short circuit electrical current is 4.01A, the best operating voltage Vm is 16.9V, the best work of the current Im is 3.57A, components color is white. 16 battery module in series to achieve the total open circuit voltage 321.6V. The total voltage of the best 270.4V. 16 battery components in series achieve the total open circuit voltage to 321.6V. The best working total voltage is 270.4V.

Table 1: battery component performance parameters

Item	Pm	Efficiency	Cell Cutting Size	
1	60W	17.5%	125x93(116.3)	
Voc	Isc	Vm	Im	Color
20.1V	4.01A	16.9V	3.57A	White

Solar charger use step-down charging way, that using Assisted in the maximum power point tracking technology to achieve the ultimate objective of charge. Charger circuit diagram is shown in Figure 4. Main DC / DC circuit is buck circuit model, the control circuit use efficient and practical C8051F330 microcontroller to handle solar module and the sampling signal from battery pack, to achieve MPPT (maximum power point tracking), Modulate PWM waveforms, through the drive circuit driving MOSFET, and sent solar voltage and current signals to the host computer.

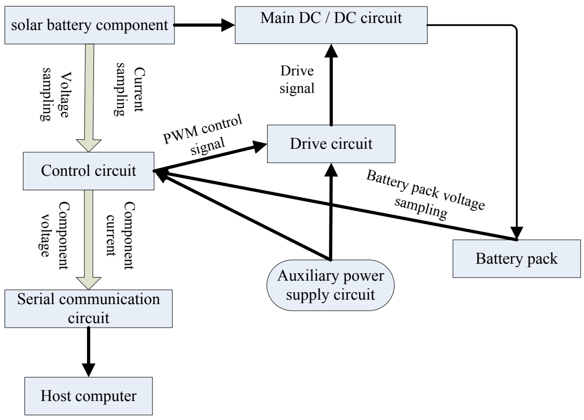

Figure 4: charger circuit diagram

3.5 Optimization of Vehicle Structural and Lightweight Design

Under the condition of high energy density, high-performance battery did not come out currently, the lightweight design technology is particularly important for electric vehicle [6]. The solar and lithium-ion hybrid electric midibus can take 21 passengers, Equivalent to the traditional midibus. The midibus most use multi-parallel double-beam chassis structure, and the weight is close to 1800kg, leading to the much more mass of vehicle, load ratio decreases, reducing energy efficiency. Project team considering the low vehicle speed and the operating environment condition, select the chassis whose size and weight and structure similar to the midibus' chassis, to optimize design of the chassis structure, and analysis the dynamic and structural strength, for achieving optimization of the chassis structure. Body, seat frame, handrails and other accessories are used aluminum; seats are made of wood, to reduce vehicle weight. The vehicle is shown in figure 5.


Figure5: The solar and lithium-ion hybrid electric midibus

4 Prototype and Test

The following is the integration of solar electric vehicle parameters:
Basic parameters of vehicle
Capacity: 21 people (including driver)
Maximum weight (fully loaded): 2800kg
Curb weight: 1361kg
Geometric dimensions (length / width / height): 5.52m × 1.82m × 2.08m
Wheelbase: 3015 mm
Wheelbase: 1506 mm / 1496 mm
Drive: rear-wheel drive
Ground clearance: 175mm
Minimum turning radius <13m
Speed: 20Km / h
Maximum speed: 35km / h
Maximum climbing degree: 25%
Driving range: 80Km (20km / h constant speed)
Solar power: 960WP
Electric power steering system;
Brake Assist System.


Figure 6: The appearance of solar and lithium-ion hybrid electric midibus


Figure 7: road test of solar and lithium-ion hybrid electric midibus

5 Conclusion

The low speed and large capacity electric bus in the city plays roads, slip roads to public transport, small and medium sized cities and urban public transport and large factories, mines, businesses, schools and tourist spots have a broad application space. The modified traditional bus program reduce energy use efficiency, is higher production costs, difficult to use solar energy and other clean energy as Auxiliary energy. This paper according to the characteristics of electric vehicles, design a new electric vehicle model having fashionable appearance, Develop a new motor and drive system, solar battery and charge system and lithium-ion battery management system, apply lightweight design. And these greatly improve the energy efficiency of electric vehicle, achieve to better operating results. Based on the prototype in operation, we will further design and develop closed electric midibus, and achieve industrialization as soon as possible.

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