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Research on the Possibility of Using a Hybrid Electric Vehicle Powertrain in V2X Applications

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Abstract

The article presents the results of an experimental analysis of the possibility of gaining electricity to external loads from the Hybrid Electric Vehicle powertrain. The tests were carried out on a vehicle with a series-parallel hybrid drive system, where a mode of charging a battery at standstill is possible. The analysis was aimed at determining the feasibility of using a hybrid vehicle as a stationary source of electricity in the Vehicle-to-Load, Vehicle-to-Home, and in emergency applications even as Vehicle-to-Grid application. The tests consisted in loading the High-Voltage battery of the car with an external load of several different values. In the first approach, receivers intended for 230V AC power were used, but also tolerant to DC power supply with a voltage in the range of 200-250V. The operating parameters of the vehicle's hybrid drive system were recorded, as well as the amount of energy supplied to the receivers from the system. Particular attention was paid to the behavior of the cooling system of the vehicle systems. The analysis showed that without interfering with the operation of the vehicle's electronic controllers, it is possible to deliver energy to an external energy receiver. In the analyzed range of load changes, no malfunction of the hybrid system was recorded. As a result of the work carried out, the directions for further work on the system were defined.

Introduction

Humanity is constantly faced with countless problems. In the last few decades, one of the most important problems of the world is climate change, caused largely by the rapidly growing CO_2 emission [1]. Climate change manifests itself in the form of, inter alia, global warming, but also weather anomalies, such as droughts, resulting from insufficient rainfall, floods caused by too intense rainfall, or tornadoes and hurricanes destroying large areas of land [2]. Humanity itself has certainly contributed to the exacerbation of adverse climatic events in many ways. The dynamic development of virtually all branches of world economies, especially in the last 150 years, has had an impact on the natural environment. One of the areas of a developed economy that is clearly harmful to nature is transport [3].

Various types of initiatives aimed at reducing the nuisance of transport to the natural environment apply to all modes of transport: road, rail, sea and air [4, 5, 6, 7, 8]. Due to the universality, road transport plays a significant role here. In the field of pro-ecological legislation for road transport, one of the leading roles in the world in recent years has been played by the European Commission [9]. However, apart from ecological issues, the sustainable development of road safety is also important [10, 11].

In the European Union countries, very strict emission limits are already in force for vehicles powered by internal combustion engines, while in the coming years a complete departure from internal combustion engines in cars in favor of electric drives is assumed [12, 13]. Another developed alternative technology to ICE, eliminating the emission of CO_2 and toxic gases, is the use of hydrogen-powered fuel cells [14].

The shifting away from internal combustion engines to drive cars is a great challenge for manufacturers, energy suppliers, governments, but also for the users of zero-emission cars themselves. The still unresolved problem is the high purchase price of such a vehicle, its usually small range, long battery charging time, or the low availability of charging stations [15] or hydrogen refueling stations.

The development of electric and hydrogen mobility also offers possibilities that were by no means available in the case of classic cars powered by internal combustion engines. One of such possibilities is the possibility of obtaining electricity from a car battery or a fuel cell and using it after appropriate processing in external receivers [16]. In this case, it is about receivers with a power clearly exceeding 1 kW. There are solutions where the use of an inverter on board a car powered by an internal combustion engine allows the vehicle to be connected to an electrical device that requires AC power supply, but these are low-power devices, between 150 and 200W [17].

last part of the test. The electrical components operated within the safe temperature range, but no temperature stabilization was achieved at the end of the trial due to an energy aspect-oriented rather than thermal aspects-oriented test procedure. A clear assessment of the thermal aspects of the system will require a longer high-load testing.

Summing up, it can be stated that the obtained results give positive premises as to the final result of the work aimed at developing the V2X system for HEV. Further development will include the selection and adaptation of the inverter, testing the overall efficiency of the system and testing the environmental impacts (exhaust emissions), which are the crucial points [30]. Nevertheless, other important directions of the further development are also cybersecurity, especially of the V2G systems [31], verification of the possibility of cooperation with other car models and the selection of favorable conditions for the external use of energy from the HEV vehicle.

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Definitions/Abbreviations

DLC - Data Link Connector
HEV - Hybrid Electric Vehicle
SI - Spark Ignition
SOC - State of Charge
Temp. - Temperature
V2G - Vehicle-to-Grid
V2H - Vehicle-to-Home
V2L - Vehicle-to-Load

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