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Electric propulsion system for electric vehicular technology: A review

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ABSTRACT

In recent decades, factors such as the worldwide growing concern for pollution induced climate changes, increasingly stringent emission norms for vehicles and depleting petroleum resources coupled with volatility in their prices have motivated and accelerated development of sustainable and clean alternatives for transportation systems. Electrification of vehicular technology (EVT) is considered as a promising and sustainable alternative for future transportation systems. In evolution of EVT, instability of fuel price, fuel economy, range, performance and costs are the governing factors and prime concerns for researchers, auto manufacturers and customers. These factors are decided by the design of the electric propulsion system (EPS) for vehicular application and its suitable integration with various electrical and mechanical components. In this paper, a comparative overview of EVT along with a comprehensive analysis of EPS and a brief discussion on power flow control and management algorithms for EVT is presented. The paper also highlights the ongoing technological advancements and future challenges in the roadmap of EPS for the electrification of vehicular technology.

Contents

1. Introduction

In conventional vehicles, petroleum products (viz. petrol, diesel) are used to propel wheels through internal combustion engines (ICEs) as energy conversion units [1]. However, petroleum products are

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exhaustive and it is estimated that, at the present consumption rate, the current global petroleum resources will be used-up within the next 50 years [2]. Use of petroleum products primarily in transportation has also raised growing concerns about environmental pollution and subsequent climate changes. In the United States of America, for example, conventional transportation system accounts for 30–35% of total greenhouse gases (GHG) emission, causing significant global warming [3]. It is projected that world population will increase from the existing 6 billion to around 10 billion in the next 50 years while the number of vehicles in operation is set to increase from 700 million to 2.5 billion [4]. Given this scenario, meeting the worldwide energy demand for the present and future transportation systems with the least impact on the environment is an important developmental challenge.

In order to meet this challenge, novel concepts and innovations are being infused to make transportation systems more energy efficient, reliable and safe with zero or reduced emissions at an affordable cost. Majority of these innovations rely on electrification of conventional vehicular technology and are grouped under the genre of Electric Vehicular Technology (EVT). In EVT, ICE-based propulsion systems are being replaced by electric propulsion system, either partially or fully, to minimize fuel consumption and tailpipe emission. EVT involves specialization in mechanical, electrical, chemical and electronic aspects to achieve a reliable operation of electrified vehicles. Vehicles that employ EVT can be broadly classified as: electric vehicles (EVs), hybrid electric vehicles (HEVs), plug-in hybrid electric vehicles (PHEVs) and fuel cell vehicles (FCVs) [4–21].

In the last decade, successive development in vehicular electrification brought back the electrified vehicles in competition with ICE vehicle in terms of performance and globally emerged as sustainable alternative of conventional ICE based vehicles [13]. In addition automobile industries are shifting towards more fuel efficient, improved performance, higher degree of reliability, durability, safety and added comforts [23,24]. Thus, significant efforts

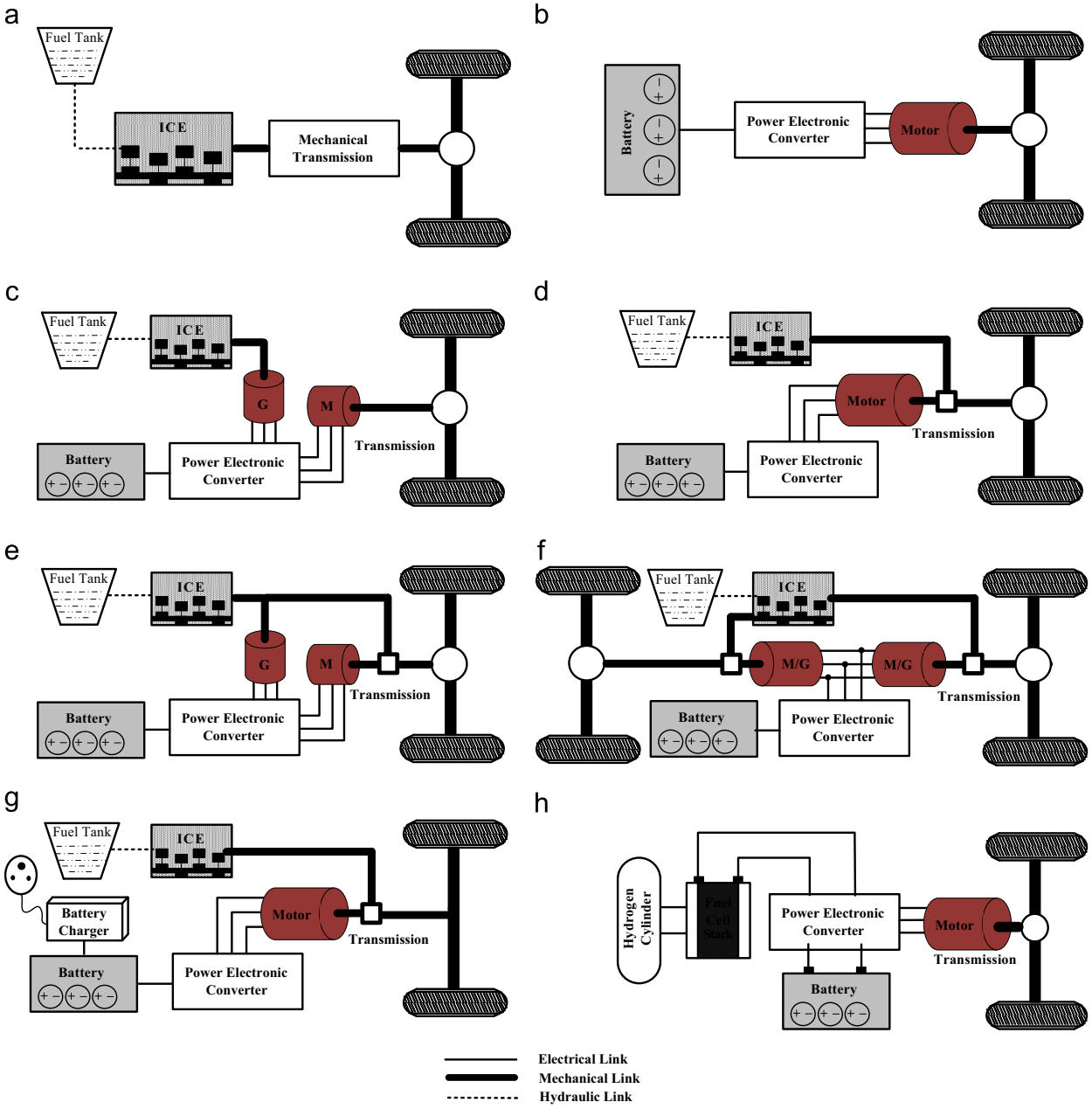

Fig. 1. Architecture and configuration of different vehicles (a) ICE vehicle; (b) battery electric vehicle; (c) series hybrid vehicle; (d) parallel hybrid vehicle; (e) series-parallel hybrid vehicle; (f) complex hybrid vehicle; (g) plug In hybrid vehicle; (h) fuel cell vehicle.