1. **Title:** Hybrid e-CVT Power Split Drivelines

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3. **Abstract**

Hybrid vehicles are the most promising technology that can lead to significant improvements in vehicle efficiency and global performance. The need to manage several sources of mechanical power in hybrid vehicles, led to the development of drivetrain architectures with multiple modes. In this context, efficiency and optimal control models of these transmissions are of great importance. The main objective of the Research Project will be the development of theoretical models to analyze the power flows and the efficiency of Compound Split Transmissions. The aim is to optimize the architecture of compound PS e-CVT and the control strategy for Vehicles, Tractors and Wind Energy Conversion System.

4. **Background**

In recent years most of automotive research is spent towards fuel consumption and emissions reduction. Hybrid vehicles are the most promising technologies that can lead to significant improvements in vehicle efficiency and performance through several drive train architectures [1, 2]. In this context, efficiency and optimal control models of these transmissions are of great importance [3, 4].

An electrical continuously variable power split transmission consists of two motor/generators which work as a variator (Electrical Continuously Variable Transmission or e-CVT) as well as one or several planetary gear sets as a power split device. They can be classified into three different types, namely “Input Split”, “Output Split” and “Compound Split”.

Hybrid vehicles work in several operating conditions: full electric, battery charging, cruising, regenerative braking [6]. As a consequence, Power Split (PS) and Compound PS e-CVT have been introduced to improve the global efficiency in all operating conditions [7-13]. For example Toyota Hybrid Synergy (THS) drive system is a leading integrated electro-mechanical hybrid transmission system which was mass-produced and commercialized since 1997 [14]; Ford Hybrid System (FHS) has been working on its power split system for more than 8 years, and more than 10 years with the aim of improving fuel economy.

PS CVTs have been studied in many works focusing on efficiency [15, 17], functional design, and development of original types of PS CVT [17-20]. It has been demonstrated that a fuel economy improvement can be obtained through a PS CVT in vehicles with internal combustion engine [21]. In hybrid vehicles during regenerative braking, the transmission works in reverse mode and it has been shown [22-24] that the efficiency in reverse mode is lower than the efficiency in direct mode.
Compound Split Transmission consists of two motor/generators as a variator as well as one or several planetary gear sets as a power split device. These architectures can work in two different modes [25-27] by looking for the best global efficiency in the different operating conditions. In recent surveys [26], according to different architectures, many approaches have been proposed to evaluate the efficiency.

A simple approach to determine the performance of Compound e-CVT would be useful to optimize the control strategy and, hence, the global performance of the hybrid vehicle. Through this analysis it would be possible to predict the power flows of the transmission and its efficiency.

Optimal control strategies of hybrid vehicles are a key point for the proficient use of hybrid electric vehicles. Several studies were carried out in [29-35] aimed at identifying the guide lines of optimal control strategies. The focus of these researches is the fuel consumption and the performance of the hybrid vehicle. In [36] a particular architecture is proposed which combines the e-CVT with a fixed gear mode. This combination can improve the regulation of output torque and vehicle speed by controlling the global speed ratio. The design methods are treated in [37] in which a procedure to define the technical requirements and the optimal design of a power split is presented.

5. Research proposal

The project will be split in the following activities:

1) Development of theoretical models to analyze the power flows and the efficiency of Compound Split Transmissions.
2) Development of theoretical models to analyze the fuel consumption in Hybrid Electric Vehicles.
3) Development of models to analyze the Compound PS e-CVT control strategy.
4) Optimization of Compound PS e-CVT for vehicles.
5) Optimization of Hybrid e-CVT power split driveline for tractors.
6) Optimization of Power split e-CVT driveline for Wind Energy Conversion System

6. References