A Sensorless Control Strategy for IPMSM based Electric Power Steering Systems

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Abstract: - Electric power steering systems are a quite common equipment of modern vehicles. They are based on torque controlled electromechanical actuators assisting the driver in moving the steering wheel. These systems must generate low torque fluctuations and mechanical vibrations, while featuring a low cost and a simple and rugged control system. In order to comply with these requirements an electromechanical actuator based on a sensorless controlled synchronous motor is proposed in this paper. It exploits a sensorless torque control technique based on the injection of high frequency voltage signals and the manipulation of induced high frequency stator current components. A key feature of this technique is a very simple implementation using a low cost mixed (analog/digital) circuitry, requiring a minimal computational power. Implementation issues and experimental results obtained on a laboratory prototype, based on a standard electric power steering system, are presented to confirm the consistence of the proposed approach.

Key-Words: - Sensorless Control; Electric Power Steering systems (EPS); Automotive; Interior Permanent Magnet Synchronous Machine (IPMSM);

1 Introduction

Electric Power Steering (EPS) is today a standard equipment even on low end vehicles, providing better steering feel and higher degrees of adaptability and efficiency in comparison with Hydraulic and Electro-Hydraulic systems [1], [2]. Moreover, traditional components of hydraulic devices, such as pumps, fluids, hoses, pulleys and drive-belts can be eliminated, thus simplifying the design and manufacturing of the steering system [3]. Finally, operations of the EPS and the car engine are made independent, increasing the efficiency and allowing steering assistance even if the engine is off.

An EPS system is basically composed of a torque commanded electric motor drive acting on the steering column. It is tasked to assist the steering by generating a smooth torque on the rack, whilst also providing a sort of torque feedback to the driver. The reference motor torque is determined by a control unit on the basis of the torque applied by the driver to the steering wheel, the angular speed of the steering wheel, the steering angle and the vehicle speed. Different electrical machines can be considered to equip an EPS system, such as PM DC motors, DC Brushless motors, Switched Reluctance motors, Surface Mounted and Interior PM motors. Among them, the Permanent Magnet DC motor is today the most widely used, due to the easy driving and a mature and well accepted technology. However, some alternative solutions have been recently proposed in an attempt to reduce vibrations and torque fluctuations, that are directly transferred through the steering wheel to the hands of the driver. Specifically, in order to contain torque fluctuations above 1~3% of rated torque the Interior Permanent Magnet Synchronous Machine (IPMSM) has been considered. Such an electric motor ensures the highest levels of torque density, thanks to its additional reluctance torque, high efficiency and