# ABSTRACT

In spite of the current tendency towards the electrification of the road transport, internal combustion engines have been essential in this sector and it is expected to continue being a technology with a noticeable presence during next decades. Current passenger cars based on internal combustion engines are greener than those used years ago, although it is still a developing process.

Aftertreatment systems are aimed to minimize as much a possible the impact of internal combustion engines in terms of pollutant emissions. In case of spark-ignited engines, three-way catalytic converters represent the most widespread technology during last decades, due to their compactness and cost-performance. These converters are capable to oxidise hydrocarbons and carbon monoxide while simultaneously reducing nitrogen oxide. Nonetheless, to achieve their best efficiency, the air-to-fuel ratio must be accurately controlled close to stoichiometric conditions.

In this sense, electronic engine management systems are essential to take advantage of the features of these converters. In particular, control and diagnosis strategies play a key role to achieve an effective emissions reduction under the wide range of operating conditions that arise in real driving conditions. The further development of this strategies is fundamental, especially taking into account the low emissions level allowed by current regulatory procedures and the trend towards zero emissions. The purpose of this dissertation is to analyse the behaviour of the aftertreatment system under very specific but at the same time very common conditions, and developing strategies that provide a further emissions reduction for systems based on three-way catalyst.

With the popularization of small turbocharged spark-ignited engines, the use of scavenging strategies to solve the typical low-end torque issues has increased. This dissertation analyses the impact of the short-circuit pulses on both three-way catalyst and $\lambda$ sensors. The short-circuit process has an important effect on the in-cycle dynamics of the exhaust gas composition. In particular, the carbon monoxide and hydrogen pulses followed by fresh air pulses cause a sensor bias. Thus a new method to on-line estimate the short-circuit rate has been proposed. This method allows to correct the sensor bias and, therefore, help to reduce the emissions penalty.

To improve the TWC efficiency under transient conditions, not only an accurate air-to-fuel ratio control upstream of the converter is required, but also to consider the dynamic behaviour of the converter itself. For example, the oxygen storage is the main responsible for the converter dynamics, and thus, a good indicator of the catalyst state, but it cannot be directly measured. Hence the development of models is key in current control strategies, to on-line track different parameters related with the state of the converter. Several models have been derived in this dissertation in order to fulfil different requirements, from the prediction of water condensation effects on the temperature evolution inside the converter just after cold-start, to the quantification of the ageing level, through the optimal catalyst purge control, or the air-to-fuel ratio disturbances rejection.