A functional safety concept and design method for Hybrid Electric Vehicle powertrain

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Consumers are demanding it, regulations are tightening it, and hence automotive industry are very fast evolving on Advanced Propulsion Technology Strategy. The objectives of this strategy is– reduced fuel consumption, reduced emissions and increased energy diversification. A key element of 'Advanced Propulsion Technology Strategy' includes electrification of the automobile. The introduction of hybrid vehicles was one of the first steps as a result of this strategy.

A Hybrid Electric Vehicle (HEV) powered by (typically) two power sources, require an 'Electronic Control Unit' (ECU) like 'Powertrain Control Module' (PCM) to ensure that torque required for vehicle acceleration is provided by one of the power source/ both power sources together such that the driving experience is maintained while optimizing 'fuel economy', 'emissions' and 'safety'. PCM ECU is designed with control strategy that takes into account various inputs like braking, Acceleration, Gear position, fuel level, SOC of Battery etc. to ensure power is drawn from right fuel source/sources and in right amount to provide smooth driving experience to driver while maintaining vehicle drivability, stability and fuel economy.

To support ever increasing complex functionalities, PCM system architecture is also expanding with multiple critical and complex functions. While building these complex structures it is important to ensure malfunction of such systems do not lead to undue 'Hazard' for driver or road participants. Hence it is necessary to factor, in these scenarios in system design and use appropriate 'Safety Analysis' method to avoid malfunction due to 'Systematic Failures' or 'Random HW failures'. Functional safety, defined as absence of unacceptable risk due to the hazards caused by mal-function in the electric or electronic systems is becoming a key factor in the development of hybrid electric vehicles.

The aim of this paper is to briefly explain the functional safety concept as per ISO 26262 guidelines for the specific hazards associated with powertrain control units of hybrid vehicles. The paper will highlight how, well established, safe architecture of traditional internal combustion engine (ICE) PCM has changed by vehicle hybridization and how 'Safety' is can be by following ISO 26262 guidelines. It also presents how functional safety is achieved in PCM controller based on Continuous Torque Monitoring (CTM) concept of the E-GAS architecture. This paper would also provide details on how CTM can detect critical failures in Hybrid ECUs, leading to unintended acceleration , loss of vehicle stability etc. using various safety mechanisms like multiple level plausibilisation of signals and variables, torque distribution monitor, adequate diagnostics, Shut off path test and trigger appropriate system reactions to allow the each source to enter into a safe state, within pre-defined time to ensure safety of human life (driver and traffic participants).

Keywords: Hybrid Electric Vehicles (HEV), Powertrain Control Module, Functional Safety Concept, ISO 26262, Continuous Torque Monitoring