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Implementation of Ideal Stop and Go Deactivation Logic for Passenger Vehicle

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Abstract - *Global warming and pollution are on the rise. The emission of CO_2 is one of the main reasons for it. Of the total CO_2 emissions, the transportation sector contributes to about 14%. The emission of the CO_2 does not happen only when the car is running, but also when the car is in a standstill (the engine idles). There was a need to implement a system that would stop the engine of the vehicle when it is not running hence reducing emissions. Start - Stop feature (ISG or "Idle Stop and Go") shuts off the engine when the engine idles while the vehicle is at standstill (like, at a traffic). However, since this feature is engine critical, it is of prime importance to design a safety mechanism to deal with system faults. This paper focuses on implementation of start-stop feature with robust deactivation logic. This is done by considering various inputs from the brake, body and interior devices, electrical supply system, and other vehicular systems as well as analyzing all possible error cases. The software developed in Embedded C is flashed into the engine control unit (ECU) via the controller area network (CAN) bus and was simulated in the LABCAR to get results.*

Key Words: **Ideal Stop and Go, Engine control unit, Controller area network, Embedded C, LABCAR**

1. INTRODUCTION

For the increasing air pollution and global warming issue nowadays, it seems urgent to develop a new generation of automotive with low fuel consumption and emission. This can be achieved by using the vehicles with start-stop feature. The start-stop technology save fuel by shutting off the engine when the vehicle is at a stop, such as traffic light and restart engine instantly when the driver accelerates the vehicle to proceed [1]. The start-stop technology helps to both the vehicle manufacturer as well as the vehicle owner. According to available data, the fuel benefit of start and stop application is 4–6%.

The development of vehicles with combustion engine, hybrid vehicles or electrical vehicles leads to an increasing complexity of the power train. In engine start-stop control strategy in series-parallel hybrid system is discussed [2]. The technology helps to reduce emissions to achieve stringent emission norm. The efficacious idle start stop system, which uses mild hybrid technology and intelligent traffic control algorithm, is discussed [3]. Several small electric vehicles have been developed with various features such as autonomous obstacle avoidance systems [4-5]. These technological developments are focused on several features, however not concerned with energy source and efficiency.

In this paper we are implemented the deactivation logic for start-stop featured passenger vehicle using LABCAR model.

2. BLOCK DIAGRAM

Figure 1 shows that system architecture of start-stop system. Start-stop system architecture shows several systems within the car send release and request signals that determine the state of working.

ISG implementation requires a Start / stop coordinator along with several inputs that decide the state of the coordinator.

The start-stop coordinator module is the main part of the system and has interfaces with several systems like thermal, electrical supply, brake, body interior, gear, human machine interface and engine systems.

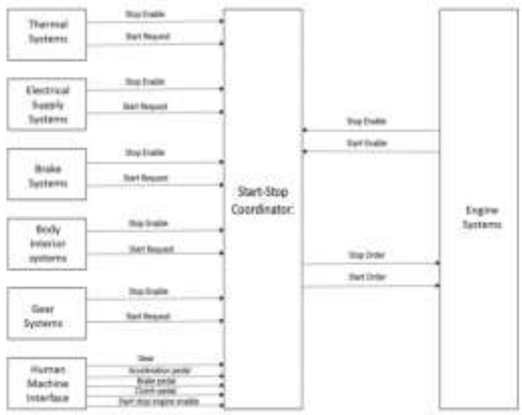

Fig-1: System architecture of start-stop system

Engine coordinator – Engine coordinator provides the current and previous states of the engine and monitors the start and stop states as well as the engine speed signal. Various states like the standby, ready, starting, auto stop, running stopping and finish are distinguished. Sometimes the engine will be stalled due to an unsuccessful attempt to start or due to start / stop functionality or some driver error.

Body and interior devices - In this component door status signal and seat belt status signal are acquired via CAN interface

Thermal system - This component coordinates the demands to the thermal system. It provides the desired relative air mass flow to the engine compartment originated by the powertrain and the coolant temperature of the power terminated by the powertrain.

Brake system - This provides the brake status. There are three different states, which are considered: brake pressing, brake pressed and brake releasing.

While performing analysis for determining the set of all system faults that affect ISG in order to determine what are the possible error cases that lead to ISG deactivation, the inputs from all the above-mentioned systems have to be considered.

3. System Design and Implementation for ISG

The requirement for starting or stopping of the engine is generated depending on different conditions that we consider. Primarily, a start / stop request has to be generated. Once there is a request, the coordinator checks whether all other systems affected can release the generated request in order to go for a start / stop order. Requests and releases might be driver related, system related or related to other parameters.

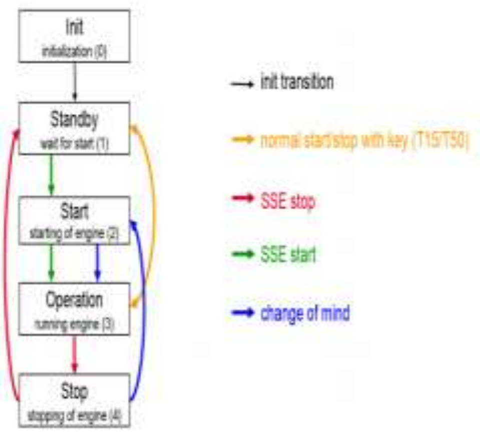

Fig-2: State diagram of ISG

The Figure 2 shows the state machine within the start – stop coordinator. It consists of 5 states, namely:

1. **Init**: The initialization state represents that ISG is inactive. This state is indicative of the presence of system faults (leading to state machine reset) or ignition not being ON or ISG being deactivated by the driver.

2. **Standby**: In this state, the coordinator expects to receive an ISG Start order or waits for the driver to crank the engine (in case first start has not happened).

3. **Start (Transient):** It is the equivalent of cranking phase of the engine. The coordinator monitors for engine cranking failures as well.

4. **Operation:** The combustion engine is operational and the ISG Coordinator waits for a stop order to stop the engine when needed.

5. **Stop (Transient):** It reflects the engine-stopping phase. The coordinator essentially looks for change of mind triggers.

Change of mind means that there is a sudden Start request during engine stopping phase. The engine cannot start suddenly during every stopping phase. For this, there is change of mind threshold speed figure 3 shows the change of mind when engine speed is greater than threshold speed.

If there is a start request before the engine speed goes below the threshold, then it immediately switches to start phase. Figure 4 shows the change of mind when engine speed is less than threshold speed

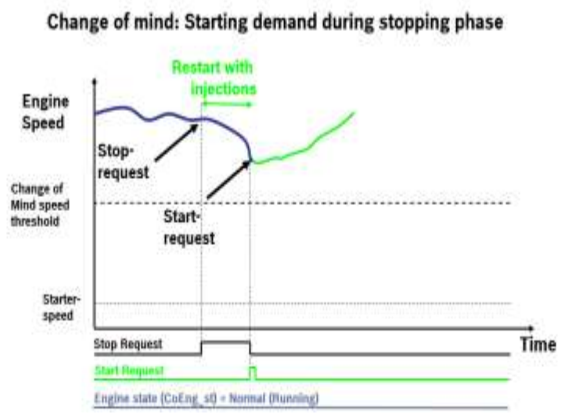

Fig-3: Change of mind when Engine Speed > Threshold

However, if it is below threshold speed, then the engine first completes the stop (Reaches zero rpm) and then starts from there.

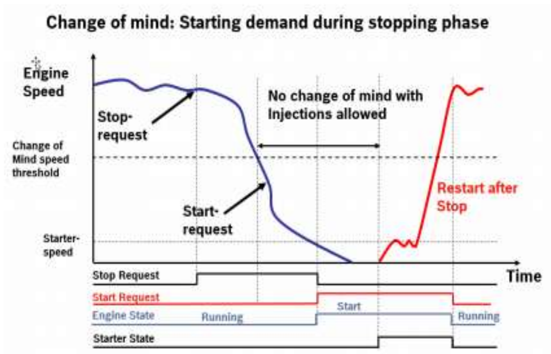

Fig-4: Change of mind when Engine Speed < Threshold

4. DEACTIVATION LOGIC

For designing robust deactivation logic for the ISG system, it is necessary to identify all the possible error cases, both from a system perspective as well as ISG functionality perspective.

The best way to compile a list of all the faults is by looking into all the interfaces that act as inputs to the coordinator as well as considering all the system related faults that affect ISG functionality directly or indirectly. Further, these faults are classified based on the transmission type. Hence, there are AT Faults, MT faults and Common faults (which affect automatic and manual transmission systems alike).Figure.5 shows the deactivation logic block diagram. The presence of a fault resets the State machine as well as indicates to the driver about ISG deactivated status via the display cluster. This ensures that necessary actions can be taken.

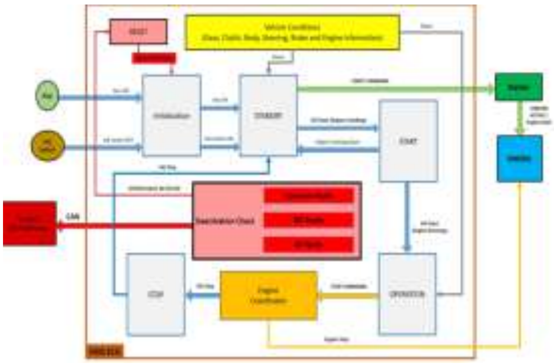

Fig-5: Deactivation logic

5. METHOD OF TESTING

As per the V – Model, different test methods are used in each level to validate the design.

Testing in Lab car: Lab car is a compact real time testing system for automotive embedded control units. It contain electrical loads to simulate different types of loads in a vehicle

Closed loop systems: Closed Loop systems are used for Hardware in the Loop Testing, it is also called LCPT (Closed Loop Power Train). It consists of a LABCAR, ECU and test PC. It differs from open loop systems in the sense that there is feedback from the systems is shown in Figure 6

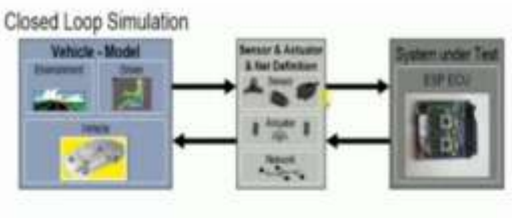

Fig 6.Closed Loop Testing

In closed loop testing system, Software is generated using ASCET and ECU is flashed with Hex and A2L generated by software build using INCA tool. The ECU is also connected to a break out box that can be used to tap the ECU signals to take measurements. INCA tools are used for development of ECU and testing the ECU

6. SIMULATION RESULTS

If there are no faults in the vehicle, ISG will be activated. If any fault occurs then ISG will be deactivated. The figure 7 shows the presence of a starter relay counter error. If starter relay counter value exceeds the counter threshold, then starter counter error will set. ISG Deactivation occurs and this message is conveyed to the driver via Inhibition or fault display signal, which is transmitted to the display panel via CAN.

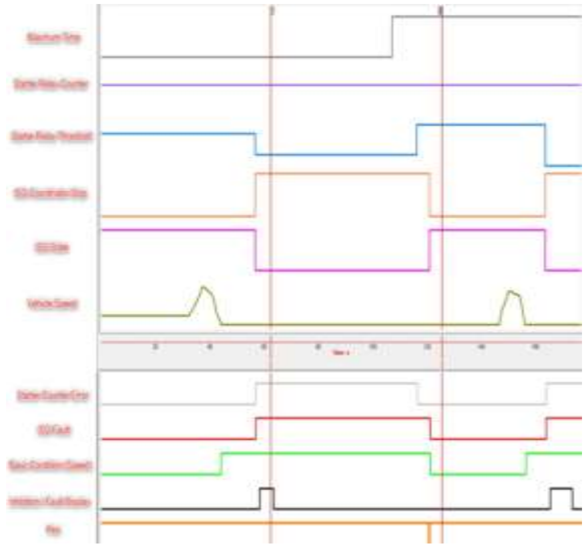

Fig-7: Simulation result

7. CONCLUSION

The design of deactivation logic is completely met by taking into consideration of all possible fault or error cases with respect to ISG system. Different categories of faults were analyzed. Some of which are engine relevant, driver detection, hardware dependent faults and transmission relevant. If any fault occurs then ISG will be deactivated and this message is conveyed to the driver via inhibition or fault display signal, which is transmitted to the display via CAN. The software developed in embedded C was flashed into the ECU via the CAN bus and was simulated in the LABCAR to get the results.

In this paper we are implemented a deactivation logic in a start-stop featured vehicle. The deactivation logic is designed using ASCET tool and simulated the through LABCAR, if any fault occurred in the vehicle then ISG will be deactivated and displayed to driver through LED.

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