Lab 1 : Airbag Control System

Since 1998, all new cars sold in the United States must have both driver and passenger airbags. According to the latest statistics, the risk of dying in a head-on collision has decreased because of airbags. However, airbags only decrease risk in head-on collisions. Side-impact collisions are also common and can result in serious injury or death.

While carmakers have tried to make car doors stronger to improve vehicle safety, side door airbags are also being designed, tested, and even offered in some cars. Designing side door airbags is significantly more difficult for engineers than front airbags because of the speed the airbag must inflate.

In a head-on crash, energy from the collision is absorbed by the bumper, hood, and engine before it reaches the occupant. This takes approximately 35 to 40 milliseconds and thus the front airbag must be deployed in less than this amount of time. In a side collision there is less material to absorb the energy and thus the airbag must be deployed in about 5 or 6 milliseconds. In recent years some cars, especially in the SUV class have begun to offer curtain airbag to protect passengers in case of side collisions and in case the car rolls over in a crash.

We have been asked to evaluate whether the Zynq chip as configured on the ZYBO board, could be used to implement sensor nodes, actuator nodes and the Airbag Control System. The nodes will be connected in a CAN bus network.

You will design the system according to the specifications given below and derive the exact timing requirements. The following is available for the design:

Sensors:
- Crash sensor, variable sampling freq, set in steps of 1kHz up to 32kHz, 16-bit measurements
- Roll sensor, sampling freq 5kHz, 12-bit measurements

Algorithms:
- Crash detector (20 crash sensor samples are needed to detect collision)
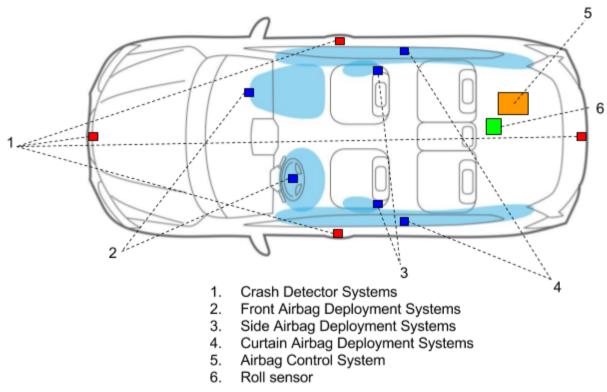- Roll detector (20 roll sensor samples are needed to detect roll)

Network:
- 2MHz CAN bus

Actuators:
- CAN connected igniter (needs 3A for 1 ms to trigger)
- 1.5 liter sodium azide side airbag inflator (inflates in 3ms)
- 6 liter sodium azide curtain airbag inflator (inflates in 10ms)
- 60 liter Sr complex nitrate driver airbag inflator (inflates in 20ms)
- 90 liter Sr complex nitrate passenger airbag inflator (inflates in 24ms)

Furthermore you will set up a test based on the ZYBO board and virtual services for sensors and actuators in order to prove that the timing constraints are actually met. For the test you can assume a maximum wire length of 2m between the nodes on the network. The test will be based on the ZYBO boards. The zybo boards will be connected to the CAN bus via the SN65HVD232D transceiver.

Condition	Deployment	Deadline
Roll detected	All side airbags All curtain airbags	20ms
Front or rear collision	Front airbags	50ms
Left side collision detected	Left side airbags	6ms
Right side collision detected	Right side airbags	6ms

1. Crash Detector Systems
2. Front Airbag Deployment Systems
3. Side Airbag Deployment Systems
4. Curtain Airbag Deployment Systems
5. Airbag Control System
6. Roll sensor