Politecnico di Torino

Department of Electronics and Telecommunications

Master of Science in Mechatronic Engineering

Master Degree Thesis

Hardware design of a motors control module in sensorless approach for memory seats application

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Academic Year 2019-2020

The automotive industry is developed more and more continuously. By virtue of these improvements applications are enhanced. Aim of some of automotive applications is to provide people with ease of driving and comfort. Especially, the driver comfort is more important than other passengers. For this issue, vehicle seats is become significant.

The vehicle seats have different movement capabilities and ergonomic calibrations and each seat can be controlled mechanically and electrically. Also, electric controller has a position memory function, which stores the configuration and comfort settings.

The aim of thesis is to design electronic control of memory seats control module to drive brushed DC motor in sensorless method as a research project of Electronic Division of Bitron Industrie S.p.A. in Grugliasco(TO). This division is specialized in the design of electronic systems and devices for the automotive applications. The idea is to improve and design sensorless method model that should have same or similar capability as a sensored method hence, the sensorless model is an alternative for sensored one. The project is focused on hardware design that are comprised of circuit simulation, testing developed hardware, electrical schematics, characterization of seat motor. Also, there is a software design part that software engineer is responsible.

Sensored method was utilized with hall-effect sensors assembled on the body of the motor to provide a feedback loop to motor control module. Contrary to sensored solution, sensorless method reduced the number of hall-effect sensors and the number of wirings that were required and also it decreased the cost of labour to assembly of sensors. For these reason, the aim of sensorless solution was to obtain convinent results with a cheaper and easily configurable way.

To provide sensorless method followings steps were applied.

- Characterization of several seat motor
- System architecture definition
- Hardware requirements definition
- Electric schematics
- Circuit simulation
- Design book
- Testing developed hardware, ensuring that it’s compliant to the customer requirements

In the thesis, vehicle seat adjustment methods were explained. That were manual and memory seat adjustment. The brushed DC motor working principle was expressed step by step, also components and types were described. The complete electronic system was represented with components and explained.

Position control measurement technics were explained for both sensored and sensorless method. For sensored method, position could be measured by hall-effect sensors and optical encoder. Current ripple and PWM technics could be applied for sensorless position measurement.

The system stages that were consisted of current sense amplifier, band pass filter, differential amplifier, comparator. The first stage, current sense amplifier was connected brushed dc motor and its duty was to convert current to voltage. The second stage, band pass filter was connected output of current sense amplifier and its responsibility was to manage range of working frequency of motor. The third stage was linked to output of band pass filter to provide appropriate biasing for next stage. The fourth stage was linked to output of differential amplifier to generate square waves to follow motor movements. For each system stage to get better results from system, required computational works were applied. Additionally, system stages were modified to reduce cost of the project.

All the system stages electric schematics were represented. The complete system was tested with 3 different voltage levels that were 9 V, 12 V and 16 V. Also, various motions were applied which were upward, downward, forward, backward. Sensored method was tested in laboratory and sensorless method was simulated in the TINA software tool by obtained result from laboratory. The aim of sensorless method test was to acquire same or similar results that were achieved for sensored method.

In test section, there were 3 different motor conditions which were before steady state, steady state, after steady state. Normally, in steady state all the ripples should follow motor movements but before and after steady states it should not be any ripples because at that time motor is not turning.

According to test results, all the motor movements were followed by ripples in steady state whereas there were some unwanted ripples in before and after steady states because low level of input voltage of comparator caused these ripples.

In future, the unwanted ripples could be removed by software design. Also the hardware design structure could be changed and it can be gotten better result.