

Design Issues Paper

Rapid Prototyping Environment for Climate Control Development

Team 4

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Introduction:

Understanding in detail the capabilities and limitations of the teams design ensures a well maintained product that yields to any potential failures that could occur. Knowing where the system faults ensures quality, reliability, and efficiency which fall under the Product Life-Cycle Management. While designing a Rapid Prototyping Environment for a Climate Control system, many issues can be encountered such as faulty connections, improper signal transmission, or reaching the limits on the hardware in the system. The challenge in evaluating these issues is vital which outlines an effective approach of determining faults or potential errors that could occur throughout the lifecycle of the teams design. From the prototype to the final design, the upcoming topics in this paper will target those major design issues examined. Addressing these issues early in the prototyping phase of a climate control system reduces the risk of any faults re-surfacing in the final design.

Product Lifecycle Management

The Product Lifecycle Management (PLM) is an important task of the design issues, where the most of issues could occur. Since the project is for the control system in vehicles, it is designed not only for short-term work, but rather for a stable long-term product. The sensors, actuators, and Electrical Control Unit (ECU) are the leading variables that need to be accounted for to maintain the smooth operation through a long time and harsh environment. In addition, the design must confront the development of technology in the future.

Local Interconnect Network (LIN) permits the system to transition from analog to digital communication which allows for the advanced processing of signals sent from the ECU and delivered to the actuators and sensors. It enhances the performance and provides a longer lifecycle of the system.

Design

Designing and implementing a Rapid Control Prototyping (RCP) environment is an extremely complex task but allows for developing and testing several iterations of a new design at a single upfront cost. The total cost for this design experiment is roughly \$11,500 so the benefit of a single upfront cost is very helpful in staying on a budget. General Motors (GM) and dSPACE have generously provided the hardware and software which will allow the team to design sensor and actuator LIN drivers to be used in GM's climate control systems.

Setting up LIN drivers is the first step in developing a digital climate control system. These drivers provide the foundation of signal transmission from the ECU in a vehicle to the actuators and sensors used to control the vehicle interior climate. Simulink is the software that allows for the development of said drivers. dSPACE provided a Simulink library that is compatible with the GM hardware and is used to delegate signal transmission for each component. The Simulink model created can then be used in Control Desk which is the prototyping software that has the capability of performing test edge cases of the LIN driver and the GM Hardware.

Intellectual Property

Intellectual property, is commonly known, and has two essentials. One is the right to own and sell ideas. The other is the right to control the use of those ideas after a sale. As for the team's partnership with General Motors, the team has to consider all intellectual property rights when concluding the team's final design. The team has to account for all products, processes, methods, designs, strategic material, data, software and any information that is or possibly patent protected. The team's climate control system, although a prototype, has classified information regarding licensing agreements with dSPACE, and any other parties dealing with General Motors. When preparing the reports and test data, the team has to ensure the final

product is in compliance with General Motors. In perspective, this is a vital step in order to avoid any possible complications. This could not only affect us as a team, but any other parties in association with the climate control system. Confirming all intellectual property rights will assure the absence of any negative externalities.

Environmental Issues

The actuators and sensors used in the prototyping environment are tested by General Motors in various weather conditions. However, there are limits to the measurement readings of the sensors and the actuators degrade with time. The environment itself also degrades the actuators and sensors with time. Since the actuators and sensors are installed in the vehicle, the change in temperature from the outside environment can affect how they function.

When the actuators and sensors degrade, they can be easily recycled on account they are made of plastic. The lifetime of the actuators and sensors, under normal use, usually lasts the lifetime of the vehicle. In extreme weather environments, this is not true since the actuators would be used heavily for keeping the vehicle at a reasonable temperature when it is in use. Furthermore, extreme weather conditions such as below zero freezing temperatures can cause the actuators to malfunction if snow or rain reaches them. Similarly, the sensors may not be able to read certain temperatures outside the boundary of the design. The surrounding environment has an impact on how long the sensors and actuators will last in addition to the life of the vehicle.

Product Liability

Since the product is a climate control system with multiple sensitive components, which are ECU, sensors and actuators, users shall be careful when they install and implement it. For the MicroAutoBox, it needs to be powered by a 12 volts vehicle battery which provides a current limit of 5 Amps, or applied by power supply with similar current and voltage for testing purposes. The ILLS sensor should work under the condition of maximum current 15 mA and maximum voltage 12 volts. Also, the measured

temperature range for the ILLS sensor is -40 to 87.5 centigrade. The RLHM sensor should work under current less than 200 mA and voltage between 9 to 16 volts, and its measured temperature range is -40 to 85 centigrade. The team's actuators' working voltage range is 9 to 16 volts as well. Moreover, when users physically connect or disconnect the sensors and actuators, the connector insertion force of the wiring harness connector shall not exceed 45 N. The connector removal force for each wiring harness connector shall not exceed 75 N in order to preserve the integrity of the product.

Since the MicroAutoBox working voltage is much lower than the common safety voltage (around 40V), users are not considered in danger if the system is implemented correctly because of the high threshold tolerance of the hardware. Thus, users are considered to be responsible for any injury and components breakdown caused by operations that do not follow product hardware specifications and the basic work environments as previously mentioned.

Standards

LIN 2.0 is a company standard. It was firstly founded by five automakers (BMW, Volkswagen Audi Group, Volvo Cars, Mercedes-Benz), with the technologies supported from Volcano Automotive Group and Motorola in 1999. For background compatibility, it is compatible with LIN 1.3, and nodes designed for LIN2.0 and LIN 1.3 are able to communicate with each other with a few exceptions. (A LIN 2.0 master node can handle clusters consisting of both LIN 1.3 slaves and/or LIN 2.0 slaves. The master will then avoid requesting the new LIN 2.0 features from a LIN 1.3 slave: Enhanced checksum, Reconfiguration and diagnostics, automatic baud rate detection, response error status monitoring). LIN 2.0 is voluntary consensus standard used by GM and this design team. For operations, LIN is able to work with MicroAutoBox, and it is written in Simulink. This technology is copyright protected.

To verify their reliability under realistic operating conditions, all the standard MicroAutoBox variants were exposed to extreme shock and vibration tests according to ISO 16750-3:2007. During this test, MicroAutoBox continuously executed a program without any failures. It is also shock and vibration tested

up to 50 g's. This is written by international Organization for standardization and is a mandatory standard used by dSPACE in the production of the MicroAutoBox.

Conclusion

Accounting for all of these major design factors early in the design addresses all failure possibilities in the teams' prototyping phase, which results in proper functionality of the climate control system in its final phase. From a possible failures point of view, this gives improvements for alternative configurations for a preeminent design. The team's main goal is to not only to identify, but also to avoid all risks and possible injuries within or caused by the teams design. In addition, outlining all negative aspects gives an approach that drives towards higher quality, reliability, safety, and efficiency.