

Multi-Sensor Configurable Platform for Automotive Applications

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Abstract

This paper presents a configurable and generic platform architecture suitable to interface several kinds of sensors for automotive applications. A platform-based design approach is pursued to reduce time-to-market. The platform is essentially a library of hardware and software reconfigurable resources. It is based on a microprocessor core plus a set of analog and digital peripherals dedicated to signal acquisition, data processing, storage and transmission. A particular instance of this platform has been developed. The prototype electronic board produced is able to acquire temperature, humidity, pressure and perform voltage/current measurements and settings. The results achieved prove the validity of the proposed approach in terms of system performance and high reconfigurability of the generic platform.

1 Introduction

For an emerging class of automotive applications the actual trend is to increase both safety and comfort levels in modern automobiles. X-by-Wire, Assisted Guidance, Collision Avoidance and Cruising Control are typical advanced facilities based on a continuously growing set of sensors distributed anywhere in the car. A common automotive electronic system gathers environmental data through a set of sensors, processes the data and eventually reacts through a set of actuators. Embedded systems are very suitable for this type of application because they allow the designers to implement complex and low-cost system satisfying high level constraints and reducing development times. Many commercial electronic platforms for embedded systems have been produced by electronic companies for general purpose applications. They offer design and development environments to support the project to all hierarchical levels and obtain an electronic system in a chip (SoC)[6][7]. The commercial environments, such as mentioned, offer platform very interesting but they present two types of disadvantages: they are not optimised for the particular field of application, they don't consider safety and reliability issues and they are expensive. There are good reasons to

design and develop a configurable electronic platform dedicated to particular applications. This paper presents a generic configurable platform able to acquire analog and digital signals from a set of sensors, perform data processing, storage and transmission. The basic idea behind the considered platform is to reduce the development time and increase the system reliability by using a rigorous methodology to design embedded systems.

2 Platform Overview

Embedded products have become so complex and have developed so quickly that the current design methodologies are no longer adequate. To overcome these issues, a platform based design approach [1][3] can be pursued. This methodology is based on design-reuse approach [4], design flexibility and error prevention [1]. Once the architecture has been identified, a suitable verification approach [5] allows fast debugging and gives the platform additional quality degree. This phase is done by inspections of all hierarchy levels of the platform. The configurable platform architecture has been addressed to interface different kind of sensors for a wide range of automotive applications. The platform is essentially a library of HW/SW configurable resources. It is based on a microprocessor plus a set of analog/digital peripherals. The definition of the architecture has produced design standards and rules to connect together all HW/SW platform components. The library can be expanded in the future, new sensors and components can be integrated respecting the standards defined. The microprocessor monitors system activity, commands the actuators and handles communication with external devices. Digital modules perform the conditioning of the sensors, data processing and safety functionalities. The reuse of the platform is obtained guaranteeing high flexibility and portability of the SW/HW components as much as possible on different commercial programmable devices. For a particular project a designer can derive a platform instance from the generic platform by choosing a set of components from the library and setting parameters of the configurable modules.

2.1 Generic Architecture

The analog signal conditioning (front-end) has reduced as little as possible to perform most of the conditioning in the digital domain. Thus the analog section only consists of ADCs, DACs, amplifiers and voltage/current sources, which are essential building blocks for automotive sensors conditioning. All the other platform functions and services are implemented through digital hardware and software, keeping simple and reliable the analog section. The front-end can be designed and customized for different classes of sensors by choosing the most suitable chips for the particular project. The digital peripherals of the platform are configurable IP cores. Dependability modules, such as the watchdog and the reset controller, are present in the generic architecture in order to restore the initial condition when the software running on the processor locks. All IP cores can operate with the interrupt mechanism. The data acquired can be sent via CAN bus (Controller Area Network) toward other devices thanks to a dedicated digital module for high speed serial link. For safety and reliability reasons the IP cores have been designed using triple-voting and redundancy techniques coding the digital state machines in safe mode. A Register-Transfer-Level (RTL) description in VHDL has been preferred in order to have the maximum control on the final synthesized architecture. SW routines have been developed for each IP core in C/assembly. The high level software is hardware-independent and it can manage each peripheral simply using the SW drivers developed. The platform architecture can be configured by means of SW/HW parameters. *System parameters* determine the structure of the platform at high level while *specific parameters* establish the functionality of single HW/SW components. Address of internal registers, size of IP modules, number of generic digital components and bus size are example of system parameters. The platform can be customized setting the actual values of available parameters. This feature allows the designer to reach quickly a certain architecture configuration and eventually to modify it back in short time.

3 An application Case

To tune the generic platform proposed, a prototyping electronic board has been developed as an instance of the generic platform. The board supports the following sensors and components: two digital temperature - humidity sensors, an 12-bit ADC with four channels for voltage and current measurements, an 16-bit Sigma-Delta ADC for accurate temperature measurements, a digital pressure sensor, a Thermistor - to - digital converter for temperature measurements and a 12-bit DAC for voltage settings. Analog front-end has been developed on the

basis of the sensors and chips selected. The system monitors the status of sensors. The data from sensors are acquired, processed, stored and then sent to Personal Computer (PC) for data display (Figure 1).

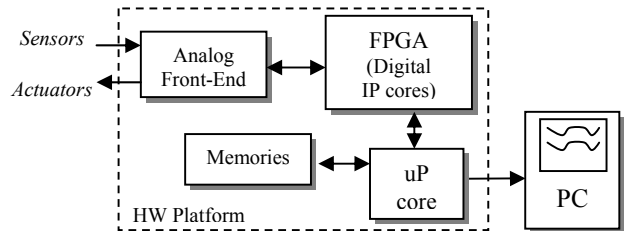


Figure 1: Case study

The board processor is a low-power and general purpose microcontroller of the Silicon Laboratories, based on an 8051 core. The platform IP cores have been mapped in an Actel FPGA of ProASIC Plus family. The digital part has roughly a complexity of 18k gates. The clock frequency of microcontroller and FPGA is 20 MHz. A mass memory of 4M bytes, a RAM memory of 24k bytes and a serial flash of 8k bytes are provided in the board for parameter configuration, data handling and collection.

4 Conclusions

In this paper a multi-sensor configurable platform for automotive applications has been presented. An outline of platform architecture and its customisation for sensor data acquisition has been reported. A platform-based design approach has been adopted to give additional quality degree and to reduce development time. The results achieved prove the validity of the proposed approach in terms of system performance and high reconfigurability of the generic platform architecture.

5 References

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