MIXED SIGNAL PLATFORM BASED DESIGN FOR AUTOMOTIVE SENSOR INTERFACE

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Summary: A general architecture suitable to interface several kinds of sensors is presented. The platform is composed by an analog front-end and a digital section to perform all the signal processing required for sensor conditioning. A platform based design approach was used to minimize time-to-market and ensure a proper system’s behaviour.

Keywords: platform-based design, sensor interface, system architecture

1. INTRODUCTION

In the last years a rapid growth of the number and complexity of electronic circuits for automotive application has been observed. Main benefits of electronic circuits in automotive industry are the increase of reliability and flexibility (initially Achille’s heel of automotive electronic) compared to the ones provided by predecessor mechanical and electromagnetic devices. Moreover, electronics made possible several new applications in car’s safety (e.g. airbag, ABS, proximity sensor), performances and/or comfort (e.g. driving assistance, air conditioning). This rapid growth has recently lead to the necessity of developing new design methodologies allowing the designers to keep up with the increasing complexity of design and decreasing time-to-market requirements [1]. Trying to deal with these key factors, designers have developed several solutions based on the so called Generic Sensor Interface concept [2]. This approach consists on integrating on a single chip all the analog/digital conditioning resources for the considered range of sensors (capacitive, resistive, inductive, etc.). This way cost and time-to-market are reduced but a sub-optimal architecture is obtained: Indeed, for a given sensor, this generic approach causes an increase in area and power consumption and a reduction of overall performance and safety level (automotive sensors can be very different from each other) [3]. In this paper, to overcome such a limitation while reducing time-to-market, a platform-based approach to for a generic automotive sensor interface is presented. Platform-based methodology defines the electronic system design as sequence of several abstraction layers (each one can be considered as a platform) [4], [5]. Within an embedded system, a platform can be seen as a set of modules, interfaces, services and software: they must be as much as possible configurable, to fit a wide class of automotive sensors. As a matter of fact, the platform is build up taking into account the commonalities of the signal conditioning electronics for the different sensors (more than 100) present in modern automobiles. Starting from this generic platform, the optimum interface for a specific sensor can be easily derived by means of system simulation, verification and possibly prototyping in a short time. Then, only the required analog/digital components will be implemented in silicon resulting in practically zero area and power overheads.

2. PLATFORM BASED DESIGN FLOW

The starting point of our approach is the realization of a MATLAB model for the system, which is made of a set of functional blocks, without any distinction between analog/digital sections and software. A system exploration phase, based on simulation, design iterations and functional blocks refinement, results in a more detail description of the required functionalities. At this point a first partitioning of the system in analog, hardwired and programmable (software) digital building blocks is also derived. Each block is then modeled with the more appropriate description language: VHDL for digital hardware, VHDL-AMS for analog circuitry and C/C++ for software routines. Fig. 1 shows the top-down design flow, moving from the initial behavioral model to lower level of abstraction via synthesis step. The result of a synthesis step is then validated with the previous one through a verification phase. For what concerns the digital section, through an RTL description and a synthesis tool we produce a Gate-Level VHDL for the selected technology.

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3. PLATFORM DESCRIPTION

The proposed generic platform to address the design of the sensor interface for a wide range of automotive application is presented in Fig. 2. It is based on three main parts: analog, hardwired digital and programmable digital (software). The analog part, which is pretty critical in automotive application to meet the required noise, area and power consumption constraints for the wide temperature range (-40°C÷125°C). This is particular true if compared with the digital counterpart, that’s why we try to reduce analog processing to the minimum and to perform most of the conditioning in the digital domain. The resulting analog front-end is based on ADCs, DACs, amplifiers and voltage/current sources which are the building blocks typically needed for automotive sensors. This way all the other platform functions and services are implemented either through digital (hardware or software), keeping as much as possible fixed, simple and thus reliable the analog section. Front-end customization for the different sensors (inductive, capacitive, etc.) is achieved by programming main components parameters (such as amplifier gains, number of ADC bits, etc.) through the digital part. The digital section is in charge of all processing required for sensor conditioning, together with platform activity monitoring and communication control with external devices (such as a PC). The monitoring/control functions are particularly useful for platform customization for the given sensor. Depending on the required processing power two kind of digital resources are present: dedicated IPs for digital signal processing (DSP block in Fig. 2), such as FIR/IIR filters, modulator, demodulator, etc., and a general purpose processor or a microcontroller (8051 CPU core by Oregano in the current development, see Fig. 2) provided with memories, buses and peripherals for communication. The latter being in charge also of the signal processing monitoring through standard interfaces, such as UART and SPI. This partitioning between processing and monitoring functionalities is important to have maximum performances without hardware overhead (only the required blocks for both processing and monitoring will be finally implemented on silicon) and at the same time guarantee fast and accurate platform optimization for the given sensor.

4. CONCLUSIONS

In this paper a mixed signal platform based design methodology for automotive sensor interface has been presented. This approach aims to fast identify and verify a suitable interface analog/digital architecture for a given sensor before integration onto silicon. In the full paper the application of such a methodology to a practical example case will be discussed.

REFERENCES

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