Open hardware platform helps students getting started in analog and digital design

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Abstract

A common multidisciplinary platform can improve and fine-tune the collaboration between several courses like data communication, software engineering, analog electronics and digital design. Therefore, De Nayer Instituut developed a platform that consists of two low-cost boards. An interface experimentation board featuring an analog experimentation area and various in- and outputs. The second board is built around a microcontroller that can be used to control the experimentation board. Both boards can be used without the need for expensive hardware allowing the students to prepare or finish their assignments at home.

1 Introduction

During the last two decades students at De Nayer Instituut were provided with in-house developed microcontroller kits. Most of these kits were 8051 based. Because these boards are available at a low price they inspire the students to develop their own applications. This allows students to work and experiment with the boards at their own pace in the classroom or at home. This approach provides a lot of benefits and already delivered some promising results for both professors and students. Based on this experience other courses, like data communications and software engineering also started using the microcontroller kit. To extend this success even further to courses like analog electronics and project based design, there was a need for a new board with more interfacing features. Taking into consideration all possible parameters the decision was made to develop two interconnectable boards:

- interface experimentation board
- snap-on microcontroller board.

The paper is organised as follows. Section 2 describes the microcontroller board. Section 3 gives an overview of the interface experimentation board. Section 4 discusses the different course objectives that can be achieved with these boards.

2 Microcontroller board

The microcontroller used on the board is an ADuC832 [1] from Analog Devices. It is a 8051 compatible microcontroller and has 64Kbytes of flash program memory and 4Kbytes of EEPROM for non-volatile data retention. Data and variables can be stored in the 2304 bytes on-chip RAM. The microcontroller also features an extended range of peripherals: AD/DA converters, timers, real-time clock, I²C, UART and SPI.

![Figure 1. Microcontroller board](image)

A bootloader is preloaded and allows students to program their application into the microcontroller with a standard serial connection. A cross-platform graphical user interface was developed by a student to simplify the programming process [2].

The board [3], shown in Fig. 1, contains an 2×20 character LCD display, eight LEDs, four push buttons and eight dip switches. All I/Os are mapped onto various connectors which enable easy interfacing with the interface experimentation board.
3 Interface experimentation board

The interface experimentation board can be divided logically in three parts:

- Analog experimentation area.
- High-Voltage, High-Current outputs.
- Isolated inputs.

![Figure 2. Interface experimentation board](image)

The analog experimentation area consists of op-amps, transistors, resistors, capacitors and diodes that can be interconnected in various ways by adding or removing components and wires. Possible circuits that can be implemented include:

- (Non-)Inverting amplifiers
- Differential amplifiers
- Summing amplifiers
- Instrumentation amplifiers
- Voltage followers
- Comparators
- Current sources

All circuits built on the experimentation area can be interfaced with the microcontroller, discussed in section II, as input or output. The board also features twelve High-Voltage, High-Current outputs:

- A seven-output Darlington array with freewheeling diodes.
- One MOSFET output.
- Four outputs connected to two H-bridges.

All outputs are driven by the microcontroller. The H-bridges are part of an integrated circuit and enable the student to connect one stepper motor or two DC-motors. The third part of the board consists of three isolated inputs which are connected to the microcontroller.

4 Course objectives

The boards are used in multiple courses spread over three years. The goal in the first year is to learn basic soldering techniques, function and properties of each component and hardware troubleshooting. Courses like software engineering use the board to interface to the real world. In the course analog electronics the controller board is used to visualize the results or to generate a signal. This way the students can easily check their analog circuit. During the second year the prime objective is teaching the students microcontroller hardware and programming in assembly or C [4]. This is done by starting with simple programs (e.g. moving patterns on the led bar) and finishes with complex applications (e.g. speed regulation for DC motors, 12bit ADC data acquisition). In the third year, students learn about more complex microcontrollers. With all knowledge acquired in the different courses they have to design a custom board.

5 Conclusion

Both boards were introduced approximately one year ago. After a recent evaluation the following conclusions were made:

- Students reach a higher level of understanding in a shorter period for all courses.
- Theory and practice for both hardware and software are integrated into one complete package.
- Lab exercises do not end when a lab session is finished. Most, if not all, students keep on experimenting at home.
- The boards are low-cost, allowing each student to purchase his own embedded system.

A poll among the students showed us that this initiative was highly appreciated. Therefore this approach will be continued next year.

Acknowledgment

We would like to thank Analog Device Belgium for supporting this project. This project was partly realized with PWO [5] funding.

References