Teaching Platform for Lessons of Embedded Systems Programming

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Abstract: - This paper presents platform for lessons of embedded-systems programming. The platform consists of a several devices which allow students to develop real-time applications with various tools. These devices include a microcontroller learning kit, panel PC with Windows operating system, Advantech I/O modules ADAM and several models of real processes, such as wash machine or heating plant. The advantage of this platform is mainly in the unified hardware for several study subjects which shortens the time needed to understand the interface and allows students to concentrate on programming problems. For teachers it brings the advantage of single learning hardware unit which does not need to be disconnected and rearranged for different lessons.

Key-Words: - Programming lessons, embedded system, Advantech Adam, panel PC, microcontroller programming, RS485

1 Introduction

Embedded computer systems can be found literally all around us and their number increases rapidly. Even simple devices which would be made of discrete parts several years ago are now using microcontrollers and other highly integrated circuits. With the increasing usage of microcontrollers, or generally embedded computers, the need for qualified programmers also increases. Universities and colleges must prepare such experts, who will be able to design and program embedded systems efficiently and appropriately. Obviously, the subject is wide and the teaching process is more or less focused on certain parts of the field, based on experience and tradition of the department, etc. In general, it seems desirable to shift the focus from learning about the microcontroller itself to learning about how the microcontroller can be used as a tool to solve practical problems. The student should preferably be exposed to real-world engineering applications, not only to simpler applications [1].

In our courses we also consider it important to allow students to try their skills on a real hardware. In our experience using real devices, such as models of technological processes, real sensors and actuators and so on, makes the lessons much more attractive for students and also their results are better than when using only simulators and/or computer models. We also try to make it possible for the students to work with microcontrollers at home by providing materials and tools for developing their own embedded designs [2], [3].

At our department we teach microcontroller programming and also programming of embedded systems with the help of real-time operating systems. For these lessons we use several teaching aids (models, development kits, etc.), which will be described later, but the common problem we have is that these tools are not unified or compatible. Basically, there are some tools for microcontroller programming and different tools for real-time OS programming and most of these tools have different interfaces and different programming approaches. Last but not least reason is also the physical arrangement of these tools which are just placed on the table and connected to the computer and if there is another lesson of a different course in the classroom, the tools must be put away and later again prepared – which is time consuming. As a better solution we see to put the tools on a stand, which can be permanently connected to the table. The stand should hold all the required devices and prevent discomfort such as mixed cables or even damage of the devices. The content of the platform does not necessarily have to be invariable; it is better if there is option to change some components (e.g. model of a technological process), but the platform should provide common basic functions, such us connection to power supply and the programming interface and allow easy placement of variable components.

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2 Situation and requirements

During the years that we teach microcontroller programming and real-time programming courses we have used and developed many teaching aids, some of which are now obsolete and some of which are still used. At the beginning we used Motorola 68HC11 microcontroller in a kit containing keyboard, display and programming interface. This kit was also connected to a model of a technological process – a heating plant, which allowed students to develop some real-world applications for measuring and controlling the temperature. This kit was a good tool, but as the 68HC11 was aging we decided to move to newer hardware. However, we found no commercially available ready-to-use device equivalent to the older one. We decided to use M68EVB908GB60 evaluation kit with Freescale HCS08 microcontroller. The kit is equipped with LCD display, push switches, LED diodes and a buzzer. We also developed several extension modules which can be attached to this kit, for example, 7-segment, 4 digit multiplexed display and keyboard, DC motor drive and simple heating plant [4].

The kit together with modules allows developing of wide range of applications but it also has some limitations such as that each of the extension modules has more or less original design and software interface, the connection of the module to the kit is fragile and the kit itself is not well protected from damage when just lying on the table. With the experience from using this kit we formulated the following requirements on a new platform for our courses:

- Single robust stand to hold all the components
- Possibility to attach different models of real-world systems through the same interface
- Option to use either microcontroller system or a panel PC to control the models
- Preferably use only commercially available parts for the design; avoid custom-made components

With these requirements in mind the system described in the following chapter was designed.

3 Proposed platform

This chapter describes the proposed system for teaching courses of real-time programming both on microcontrollers and on PC-based devices (panel PC).

All the devices should be organized on a stand which can be placed on the table and replace the bunch of cables and boards used now. The requirements on the stands are relatively simple – good stability, enough space for the devices and low price. Prototype stand can be seen in fig. 2, but there may be changes to this design later. The contents of the stand are described in the following sections.

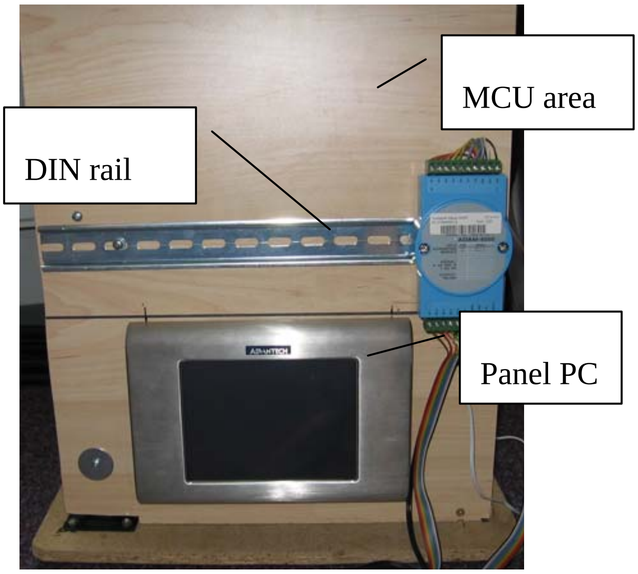

Fig. 2 – Prototype of the stand

3.1 Devices and their arrangement

The proposed layout of the devices can be seen in fig. 2. The most visible device is the panel PC which takes up the bottom part of the stand. Above there should be the microcontroller unit (for now, M68EVB908GB60 evaluation kit, but with possible replacement in future). Besides the MCU unit there is DIN rail for placing models of technological processes and I/O modules Advantech ADAM (used for interfacing the models from panel PC).

The microcontroller kit was described in the previous section. The panel PC is Advantech PPC-L60T, which was available at our department. This device has 6.4” LCD touch screen, Via Eden CPU running at 400 MHz, 128 MB of RAM and hard-drive 80GB, one RS232 port, one RS232/RS422/RS485 port, 1 USB port, 1 VGA port and 1 Ethernet 10/100Base-T port. In fact, the choice of the PC is rather arbitrary; it could be a different device from different manufacturer. Our requirement was only to have a PC-based device for courses where multitasking real-time programing on such systems is taught and to be able to control the models of technological processes by this device.

In place of the models of technological processes we intend to use commercially manufactured models intended primarily for teaching PLC programming but usable also for control from microcontroller. These models actually simulate the

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controlled object (such as wash machine or mixing unit) and provide feedback by their output and also visually by LEDs). Besides these models we plan to also develop our own models, in the first place a simple heating plant similar to the one described in [4], possibly also some more attractive models such as servo motor control etc.

3.2 Connection of the devices

The connections can be divided into two main parts: connection to the computer and connection between the models and the control units (panel PC or MCU unit).

For connecting with the development PC on each workplace the MCU unit uses its standard programming interface. This is RS232 line for the M68EVB908GB60 evaluation kit. The panel PC will be connected via LAN. For interfacing the panel PC with the technological processes there are analog and digital I/O modules Advantech. The following modules are used:

ADAM 4050 - 7 digital inputs and 8 digital outputs.

ADAM 4017 – 8 analog inputs (10V maximum, 16-bit A/D converter)

These modules are interconnected into RS485 bus together with the panel PC. There is software library for accessing the I/O modules from a student's programs written in C/C++ which was developed in a diploma thesis [5].

The other side of the ADAM modules is then connected to a unified connector which allows connection to the modules itself. This connector is the same as the output connector from the MCU unit, so that it is easy to control the real-world models by either the panel PC or by the MCU unit by simply plugging the appropriate connector from the computer system into the connector of the controlled model.

3.4 Software support

There are also software components of the educational platform which should make it easier for students to create their own program. So far a library was created for communicating with the ADAM modules from program running on the Panel PC and also several helper functions for controlling the models from MCU evaluation kit. However, these libraries still need to be improved and tested before they can be utilized in the course.

4 Conclusion

In this paper we describe teaching aid – platform for courses of embedded systems programming. This platform should make it easier to teach these courses by organizing all needed devices on one stand and unifying the connection between the control device (computer system) and the controlled device (e.g. model of a real process).

The platform consists of a microcontroller unit (evaluation kit), an industrial computer (panel PC), several models of real-world processes and I/O modules and other supporting circuitry for connecting the computer systems to the models.

Currently the platform is in the process of creating a prototype with the basic structure and components defined but still much work left on finalizing both the hardware and software tools for using the platform.

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