Low Cost AVR Microcontroller Development Kit for Undergraduate Laboratory and Take-home Pedagogies

Chao Ma, Qingli Li*, Zhongyuan Liu, Yu Jin
School of Information Science & Technology
East China Normal University
Shanghai 200241, China
*E-mail: qlli@cs.ecnu.edu.cn

***Abstract*—Microcontrollers study is an important course in the major of measurement control technology and instrument. Development tools, such as full-speed emulators and software simulators for microcontrollers, are either too expensive or too complicated to be used in laboratory classes for teaching purposes. In this paper, a low cost development kit based on AVR microcontroller suitable for laboratory and take-home pedagogies is developed. The development kit consists of system power, microcontroller socket, and fifteen peripheral function modules. The hardware configuration and usage of each unit in the development kit were introduced. Practical applications show that the low cost development kit can improve the level of the microcontroller education.**

Keywords- microcontroller; development kit; laboratory; educational tools

I. INTRODUCTION

The use of embedded microcontrollers or microprocessors to develop some intelligent products has increased tremendously in the last few years [1, 2]. So teaching microcontrollers to mechanical engineering students has become part of the new curriculum in some university. One important aspect of embedded microprocessors education is the need to provide students with practical hands on programming exercises, typically carried out in the form of laboratory experiments or mini projects. These exercises can stimulates students to participate in their learning process, thus obtaining a deeper and more lasting body of knowledge [3]. Then availability of resources and equipments for practical exercise becomes a very important aspect that decides whether effective education in embedded systems can be achieved. With the progress of microprocessors, more and more embedded microprocessors development kits have been developed and used in the design practice sessions [4-7]. However, most of the developments kits are based on in circuit emulate (ICE) technology which makes them more expensive and not suitable for take-home learning.

In the microprocessors development field, ATMEL Corporation has put forward a series of AVR microcontrollers. AVR combines the most code-efficient architecture for C and assembly programming with the ability to tune system parameters throughout the entire life cycle of key products [8]. These AVR microcontrollers are based on a RISC architecture that combines a rich instruction set with 32 general-purpose working registers. It is fast enough to execute powerful instructions in a single clock cycle and provide the latitude we need to optimize power consumption. It also can support the in-system programming (ISP) mode by on-chip boot program. ISP is the ability of some programmable logic devices, microcontrollers, and other programmable electronic chips to be programmed while installed in a complete system, rather than requiring the chip to be programmed prior to installing it into the system. The primary advantage of this feature is that it allows manufacturers of electronic devices to integrate programming and testing into a single production phase, rather than requiring a separate programming stage prior to assembling the system. This may allow manufacturers to program the chips in their own system's production line instead of buying preprogrammed chips from a manufacturer or distributor, making it feasible to apply code or design changes in the middle of a production run [9, 10]. This characteristic makes it possible to develop a low cost development kit which is different from the in circuit emulate (ICE) commonly used in on board debug. In this paper we developed a low cost AVR microcontroller development kits suitable for both undergraduate laboratory and take-home self-practice pedagogies.

II. DEVELOPMENT PLATFORMS

Our purpose to develop the low cost AVR microcontroller development kit is mainly to adopt the laboratory and take-home condition whereby each student is issued an embedded development kit. With this new development kit, students can work on their assignments at laboratory or on their own time and at a place of their own convenience. The low cost AVR microcontroller development kit includes system power, microcontroller socket, and fifteen peripheral function modules. Figure 1 show the real AVR microcontroller development platform. From the figure it can be seen that most of the peripheral function modules such as the LED light emission diodes module, the LED lattice module, and the matrix keyboard module are mutually independent. This feature makes it possible for students to construct their own mini projects flexibly.

A. System power

The AVR microcontroller development kit can work normally with the input voltage range 8-12V. The system

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power module includes several light emitting diodes, polarity protection circuit, and a power switch. In addition, a 7805 chip was used to supply the 5V/1A power. To keep the stability of the system power, some high frequency and low frequency filter capacitors were used. Figure 2 shows the schematic diagram of the system power.

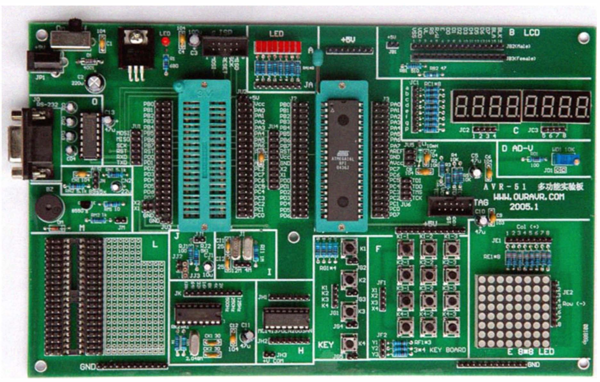

Figure 1. AVR microcontroller development platform

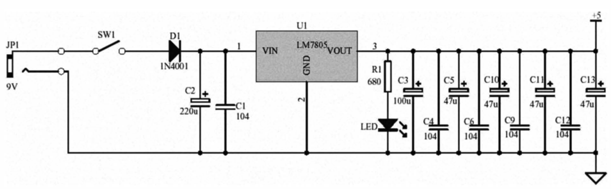

Figure 2. Schematic diagram of system power

B. Microcontroller socket

There are two microcontroller sockets in the development kit on which the AVR microcontroller can be fixed. All of the pins of the two sockets are open except some necessary connection such as the system power, ISP interface, and JTAG interface. There are also some jumpers which can be used to select different working mode of the development kit. Figure 3 shows the schematic diagram of the microcontroller socket. The left microcontroller socket can be used to fix the MSC-51 microcontroller chip with the jumpers such as JU1, X1, and X2. The right socket with jumpers such as JU4, JU7, and JU8 is suitable for ATmega16, ATmega8535, and ATmega32. In practical applications, if one socket is fixed with a microcontroller, the other one can be used as extend socket. For example, it can be used to fix the EEPROM chip 24C256 for I^2C experiment. In addition, a 2×5 ISP interface is reserved in order to make it is compatible with the STK200/300 ISP download cable. A 2×5 JTAG interface is also designed and connected to the microcontroller socket. This JTAG interface can be used to connect the JTAG emulator to perform the real-time program debug process which is very helpful for beginners.

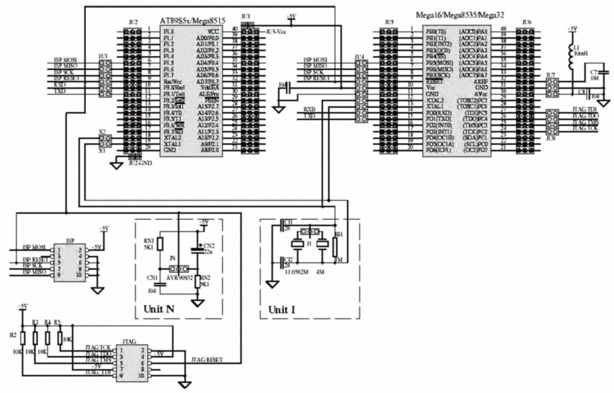

Figure 3. Schematic diagram of microcontroller socket

C. Peripheral function modules

The new low cost development kit has 15 peripheral function modules named as unit A-O, respectively. As shown in figure 4, unit A is an 8-channel LED light emission diodes which can be used to display some output results. Unit B has a standard interface of 2×6 characters liquid crystal display (LCD). This unit can also compatible with the 3310 graphics LCD which can display both characters and graphics. In unit C, eight common cathode 8-segments of numerical code tubes are configured. All these numerical code tubes can be light by dynamic scanning. Unit D is an adjustable DC voltage source composed of precise potentiometer and system power supply. The output voltage range of unit D is 0-5V which can be used as the input voltage source of ADC, or simulate the output of some sensors. Unit E is an 8×8 LED lattice display and unit F is a 4×3 matrix keyboard. Four mutually independent keys are placed in unit G which can be used to simulate the switch signal input. Unit H is a 7-channel 300mA power driver commonly used to drive mini step motor, relays, and so on. Unit I is the system clock circuit and unit J is a RC filter circuit. Unit K can supply ten types of square-wave pulses from 125 Hz to 128 kHz. These signals can be used as the input in the experiment of frequency and cycle measurement. Unit L has a 40-pin narrow extended socket and a standard PCB board. This unit can be used to extend some other circuits according to different design requirements. Unit M, N, and O are passive buzzer, reset circuit, and RS232 interface, respectively. To make the study with the development kit more flexibly, all the peripheral function modules are mutually independent. Then students can complete some course projects by using these peripheral function modules.

III. FEATURES OF DEVELOPMENT PLATFORM

As the AVR microcontroller development kit is designed for supporting the inside and outside of laboratory environment, it should have the following features. First, the system power supply, the adjustable DC voltage source, and the pulse signal generator can meet the necessary condition and provide methods to different exercises. Second, the development kit has input and output interfaces which can be used as the basic peripheral devices. These interfaces include mutually independent keys, 4×3 matrix keyboard, passive buzzer, 8×8 LED lattice display, 2×6 characters liquid crystal display, 8-channel LED light emission diodes, RS232 interface, etc. At last, the development kit has flexible and extensible ability. There are 40-pin microcontroller socket, extended socket, system clock jumpers, and external reset jumpers which makes the kit extensible for different experiments. For example, in the experiments of learning how to use I^2C and SPI serial bus, the students only need to connect some wires among the system power supply, the clock, and the microcontroller pins. This development kit has all of the basic functions and units of AVR microcontrollers such as the IO interface, ADC, clock, interrupt, PWM, keyboard, LED, 8-segments LED, LCD, frequency and cycle measurement, power driving, and so on. If the students integrate the units organically, they can even design some real electronic products such as the alarm clock with music, frequency meter, voltmeter, etc.

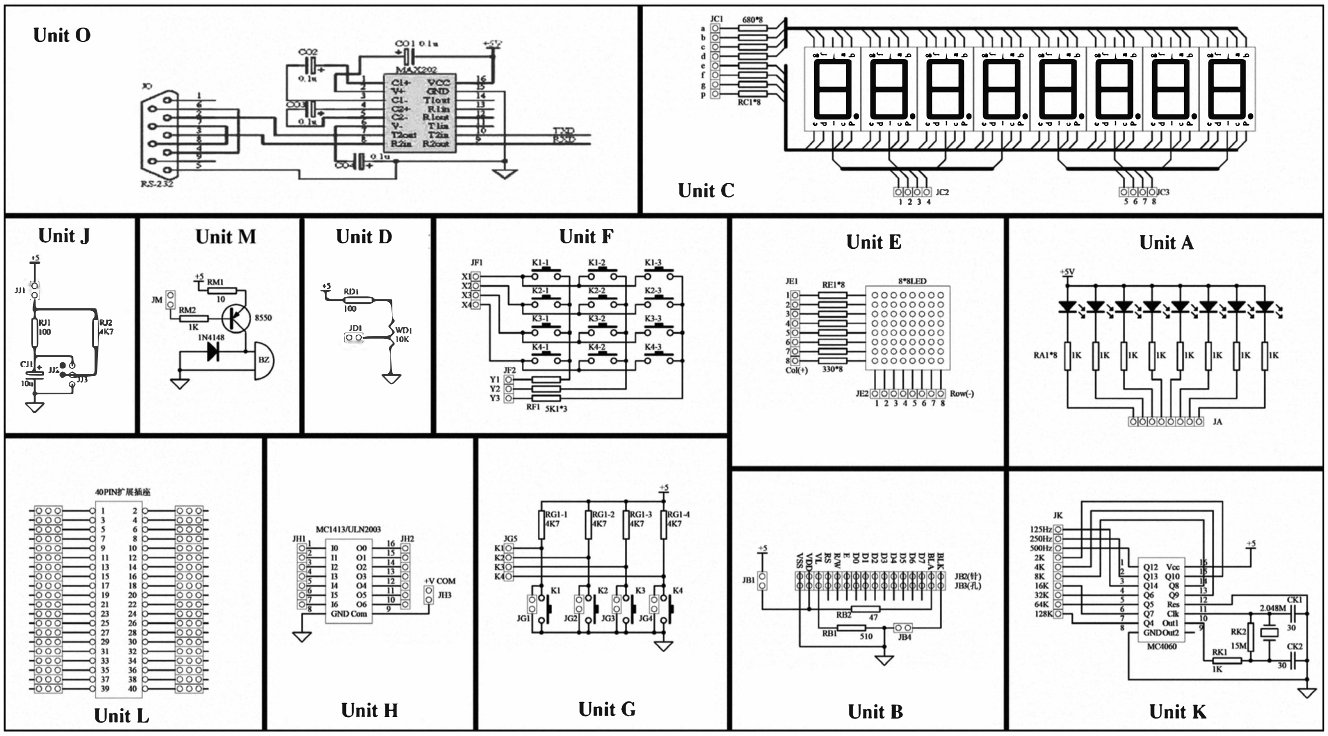

Figure 4. Schematic diagram of peripheral function modules

IV. Conclusions

Our teaching practices indicate that a purely laboratory based arrangement where students practice hands on programming during the schedule laboratory sessions is not an ideal method. In this paper we developed a low cost AVR microcontroller development kit suitable for both the undergraduate laboratory and take-home pedagogies. This new development kit can not only add more designable experiments but also strengthen the training of hardware operation. As most peripheral function modules of the kit are independent, the student can select different types and difficulty degrees exercises according to their own learning demands. With the take-home development platform, simple C language based exercises and applications development assignments can be performed without the space and time constraints of laboratory-based pedagogies. Practical applications show that this new AVR development kit can drive the student from the theory concepts to the practice at any time and any place.

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