

Development of Intelligent USB Interface Circuit for Education and Application in Practice

Yasushi NIITSU¹, Takashi KOHAMA² and Hirohito SAITOH³

School of Information Environment, Tokyo Denki University, 2-1200 Muzai-Gakuen, Inzai, Chiba, Japan,
yniitsu@sie.dendai.ac.jp¹, kohama@sie.dendai.ac.jp², saitoh@sie.dendai.ac.jp³

Abstract: The Intelligent USB universal Input/Output device was developed for the education of the electronics and its practice. This equipment has 24 bits digital I/O, 6 channel high speed A/D, 2 channel D/A and two channel serial interfaces. The special software system in order to control the USB equipment was also developed. This system includes Interpreter, Cross-C compiler and Monitor Programs. At first, the students of the class designed and made the simple LED circuits. After that, they made the advance circuits and software, for example, 7 segment display timer, arm-robot controller and so on. The developed software and circuits were presented and evaluated at the contest of the class room.

Keywords: USB, Electronics, Embedded System, Practice, Education

1. INTRODUCTION

Our faculty has a class of the practical education for the electronics circuits and embedded small computer applications. The educations for the embedded computer practice, we needed to develop the useful (easy to use) electronics-system with a small computer. The almost commercial electronics-circuits adopted RS232C communication interface and the programming needed to be written on the Flash-ROM in MPU or use EP-ROM devices. We had to design the educational program for the embedded computer practices for second degree of student who had not enough experiences on the electronics circuits. Therefore, we planned to develop the special practical circuits and programming system with USB interface and RAM and MPU with the flash memory. The practical class used them and the students designed and made a simple circuit of LEDs output for the digital parallel port applications, at first. After learning the digital port output applications, the students designed and made the circuits by their own ideas. The teachers prepared the materials like the arm-robots, the several electronics devices, the several kind of input and output devices, and help them to realize their ideas.

2. STRUCTURE OF “USB-Computer”

The concept and the target points of the development of MPU system were as followings,

- (1) Strong for the electric surge.
- (2) Avoidable from the trouble of the electric power.
- (3) The target program worked on RAM on the circuit.
- (4) USB interface adopted and automatic driver

installation.

- (5) Adopt high performance MPU and it widely used in the industrial applications.

The MPU circuit was designed with H8MPU made by Renesas Technology (Hitachi) [1]. This MPU equipped many parallel ports, 6-channel 10bits A/D, two-channel 8bits D/A, two-channel serial interface, DMA, many timer components and so on. The families of H8MPU are popular in the embedded controller and similar MPU of Super-H series are used in many kind of Japanese automobiles.

Figure 1 shows the photograph of the developed “USB-Computer”. MPU is H8-3048, and it equips USB1.1 interface, 128KB-RAM, and I/O-ports interfaces. The data and program code in RAM is kept for about one month by 0.22F super-capacitor without 5V power source. Figure 2 shows the signals of I/O pins. There are three universal parallel ports, 6-channel A/D, two channel D/A, two channel RS232C and NMI interrupt. All In/Out ports through EM-filter to protect from the dielectric surge damage. Even if a student touches the circuit, the circuit is not broken.

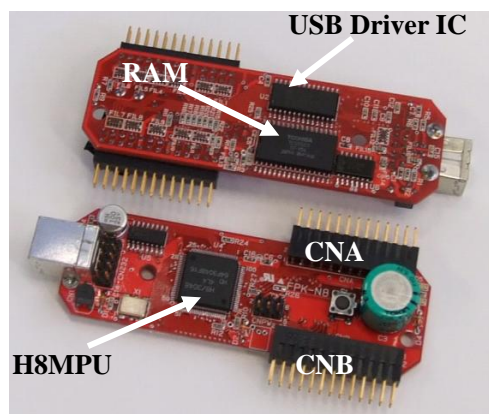


Figure1: The photograph of the developed “USB-Computer”

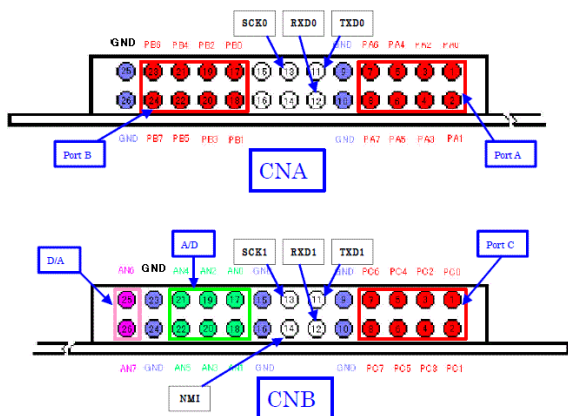


Figure 2: The functions of I/O pins

3. SOFTWARE FOR H8MPU AND TOOLS FOR MS-Windows

3-1. System software

We developed the USB interface code for H8MPU and the driver/tools for MS-Windows. Figure 3 shows the schematics of the Host computer and USB-Computer system. The USB interface code in H8MPU receives the command-data from Host, and replies the acknowledge-signal and data. USB-Computer sends I/O ports status, timer and A/D data to Host at every 1/500 second by Interrupt Mode (like mouse interface). The driver software in Host (MS-Windows) establishes the interface between the tool-software and H8MPU in USB-Computer. The driver software works in Plug-And-Play mode.

3-2. Software-Tools for MS-Windows

There are two software-developing tools for USB-Computer. One is a special interpreter with the command in/out functions. This interpreter is developed based on the solid modeling software “Solid Interpreter” which developed by authors. Table 1 shows the commands in the interpreter-software. Three commands have some kind of optional sub-commands. PA (pa) means Port-A and CHA (cha) means Channel A. Three parallel ports are denoted as PA, PB and PC. Two D/A channels are denoted as CHA and CHB. Six A/D channels are denoted as CHA to CHF. The following Text means a simple program.

```

Init -u cnt          # Connect with USB
Init -p pa 255      # Set Port-A to Output-All
X=0                 # Variable X into Zero
repeat 255 {        # repeat 255 times { to }
    Output -p pa X  # Output X to Port-A
    X=X+1           # Increment X
    wait 0.1        # Wait 0.1 second
}
Init -u ext         # Release USB
  
```

where “repeat” and “wait” are the interpreter’s commands. The notation of “#” means the comment. Figure 4 shows the programming environment on the computer desktop.

Another software-developing tool is the cross-C compiling tool. The cross-C compiler is made by Hitachi Corporation. We developed the monitor program for USB-Computer, which can transfer data, check data in USB-Computer and control the execution of USB-Computer. The monitor can send the compiled MOT files in RAM-memory of USB-Computer. Figure 5 shows the tools-dialog.

Table 1: I/O commands of the interpreter

Command	Option	Function
Init	-u cnt	The USB is connected.
	-u ext	The USB is released.
	-p pa 255	The port A is set to output mode.
	-a single	The A/D is set to single mode.
	-a scan	The A/D is set to scan mode.
	-d cha	The channel A of D/A is set to output mode.
Output	-p pa 255	The numerical value 255 is outputted to Port A.
	-d cha 255	The numerical value 255 is outputted to channel A of D/A.
Input	-p X pc	The data of the port C is put in the variable X.
	-a X cha	The data of the channel A of A/D is put in the variable X.

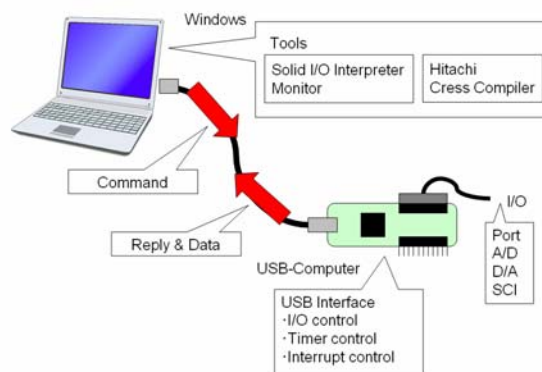


Figure 3: The schematic figure of Host-computer and USB-Slave

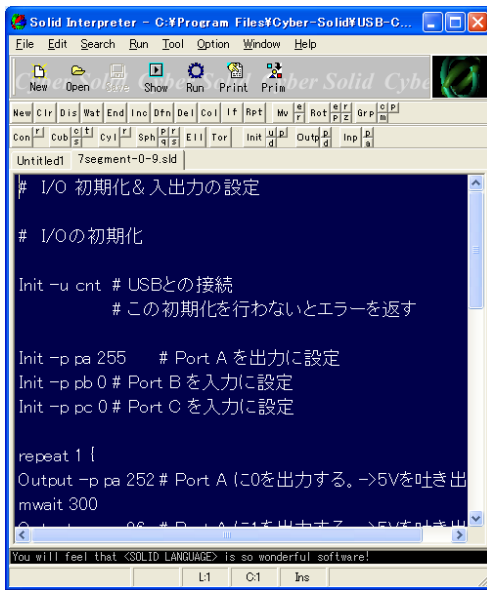


Figure 4: The programming editor of the interpreter.

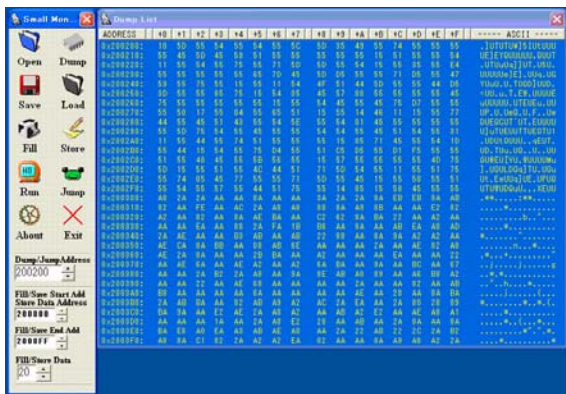


Figure 5: The monitor program.

4. APPLICATIONS FOR PRACTICE

The practical course of the embedded system is planned for second degree of university students. They learned the simple digital circuit (Electronics-A) and the basic JAVA programming before this practice course. 40 set of USB-Computer and the materials were prepared for this class. This practice started at the spring semester in 2002. The number of students was as followings,

- 2002 : 180 students (three classes, basic course)
- 2002 : 43 students (one class, advanced course)
- 2003 : 32 students (one class)
- 2004 : 28 students (one class)
- 2005 : 55 students (one class)
- 2006 : 34 students (one class)
- 2007 : change curriculum / opened in the autumn semester.

This class opened from 10 to 12 times (about 3 hours / day). This class was conducted by two professors, one associate and two or three teaching assistants (graduate students).

At first, the students designed the simple 7-segments LED circuit and made the circuit as shown in Fig. 6 and 7. Next, they learned the interpreter programming and how to use the cross compiling programs. Some students tried to use the cross compiler. Next, they designed and developed the circuits and programs for their own idea as an advanced course. We prepared four arm-robots, one big LED display, several stepping motors, several dots-matrix LED, several character display LCD and so on. The teachers gave advices to the students to realize their idea.

Figures 8 show the examples of the developed works of the students at the advanced course. About half of works were carried out by one student and the other works by two or three students.

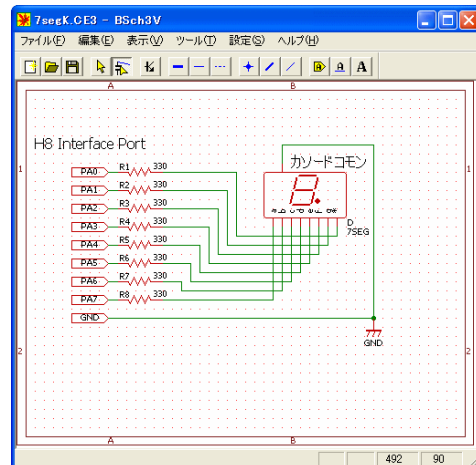


Figure 6: The design of a simple 7-segments LED circuit.

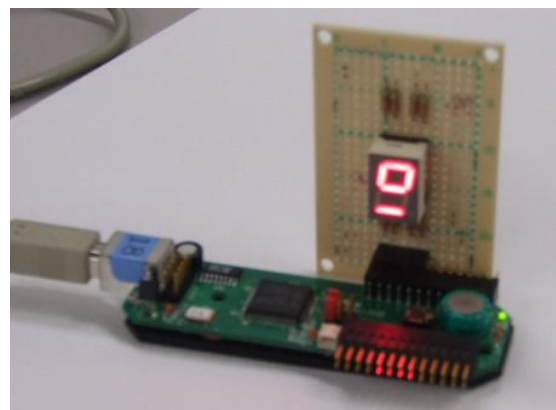
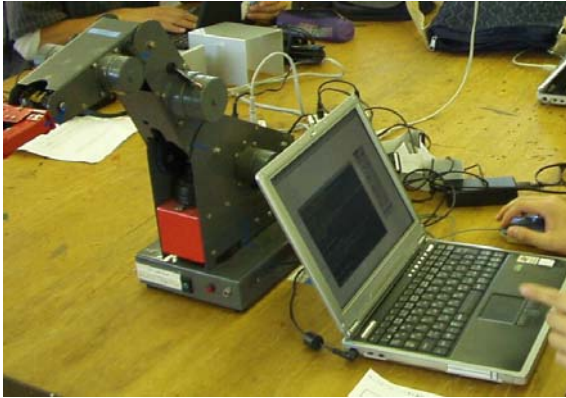
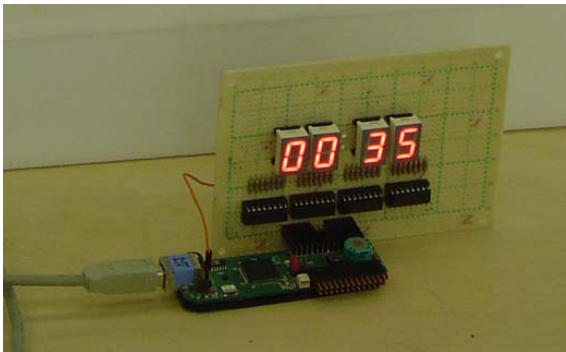


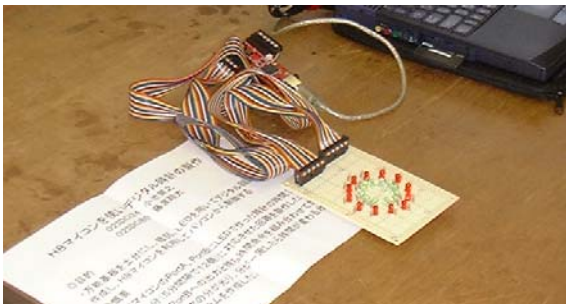
Figure 7: The photograph of the 7-segments LED circuit.



(a) Arm-robot control circuit and control program.



(b) Timer counter circuit and program.



(c) Roulette game circuit and program.



(d) The big LED display control circuit and program.

Figure 8: The examples of developed works at the advances course.

5. CONCLUSIONS

The USB universal Input/Output device was developed for the education of the electronics and its practice. At first, the students of the class designed and made the simple LED circuits. After that, they made the advance circuits and software. The developed circuits and software were presented at the contest of the class room. Almost students were satisfied that they could establish their works. USB-Computer was easy to use for the students, so that they could have experience of embedded system in only less than 12 times lectures.

USB-Computer was developed by the corporation of Tokyo Denki University [2] and Netplus Corporation [3].

REFERENCES

- [1] Renesas Technology Home-Page, www.renesas.com
- [2] Tokyo Denki University Home-Page, www.sie.dendai.ac.jp
- [3] Netplus Co. Home-Page, www.n-plus.co.jp