

MULTI-MICROCONTROLLER EVALUATION TOOL FOR EDUCATION IN EMBEDDED CONTROL TECHNOLOGY: THE UMP-EVT

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Abstract: In traditional Embedded Control Technology courses, students learn to develop assembly language programs to control peripherals, handle interrupts, and perform I/O operations. Designing and programming of embedded systems require skills that need training and practice. The main problem of such approach is its focus on only one device type with other microcontroller families requires other development boards. This aspect becomes important in a university laboratory, where students have to work with different types of embedded systems. For example, in our Faculty of Electrical & Electronics Engineering, three 8-bit are used in different projects. Each microcontroller type requires its own development board with its own set of peripheral devices; this is a waste of resources and so came the idea to use the same set of peripherals on a mainboard and to plug in an application board with a specific microcontroller and its associated circuitry. A new laboratory evaluation tool (UMP-EVT) specifically will be designed to be as a learning tool for those who intend to learn microcontroller and for use in the academic environment. One mainboard and three application boards were designed and tests were performed. In this respect, this UMP-EVT would be applicable for education and expose the electrical engineering students to the understanding fundamental of microcontroller in electronic design field.

Keywords: Educational, MCS51 microcontroller, HC11 microcontroller, PIC microcontroller

I. INTRODUCTION

Research and education activities at Faculty of Electrical & Electronics Engineering, Universiti Malaysia Pahang involve embedded systems design and development. There are currently running around 30 research projects and student courses ranging from semester 3 to semester 7^[1]. Every year, there are Embedded Control Technology course available for third year diploma and degree and also for students from our faculty who taking

final year projects^[2]. All these activities require different microcontroller types, each with its own development board, but structure of such boards is very similar, only microcontroller and its associated circuitry being different^[8].

The aim of presented work is to design a development board for embedded systems suitable for different microcontrollers that are connected through several types of application board^[4]. Experience gained in last research projects (MCS51 Educational Development System^[1] and MC68HC11A1 Microcontroller Laboratory Hardware Platform – MINI11^[2]) lead to a new design – the UMP-EVT for 8 bit microcontrollers, Freescale HC11, MCS51, and Microchip PIC 16 Series.

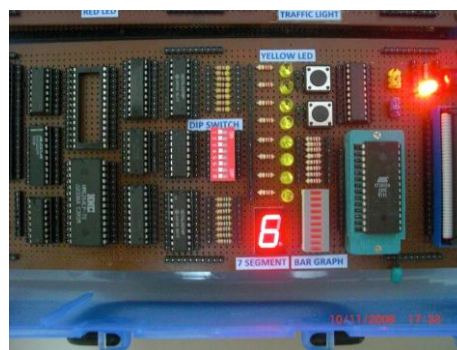


Fig 1: MCS51 Educational Development System

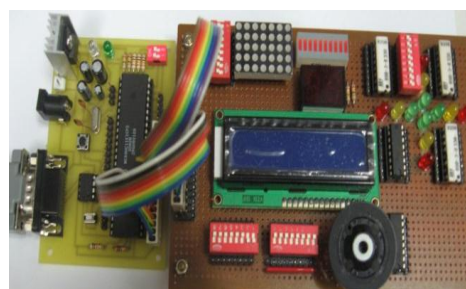


Fig 2: MC68HC11A1 Microcontroller Laboratory Hardware Platform – MINI11

The idea of many available peripherals from first project was combined with flexibility of application board plug in second design^[8]. The resulted system is expected to have 2 qualities: cheap (no more than RM 300 per mainboard plus one application board) and flexible (open structure for application board, future expandable for easy to handle new types of application devices).

In this paper, we are going to propose such a systematic approach for hardware implementation and discuss how it could be used successfully in embedded system education of this UMP-EVT in ECT class. This paper presents the importance of microcontrollers course in education syllabus and the design of UMP-EVT that is based on 8-bit microcontroller Atmel® AT89C51, Microchip® PIC 16F877 and Freescale® MC68HC11. It begins with the discussion of the hardware implementation of the system. It proceeds then with software implementation of the system to be interfaced with the PC creating a user-friendly environment, followed by a discussion. Finally, a conclusion is given in section 6.

II. SYSTEM ARCHITECTURE

The UMP-EVT development board should contain all required peripherals for standard embedded systems applications – 5 Volt power supply, RS232 interfaces, open drain power outputs, analogue buffered inputs and outputs, LEDs, input and output interface. Each application board contains remaining parts – obviously the microcontroller, its external memory circuits, as well as its input and output interface.

The hardware architecture of the UMP-EVT development board is shown in figure 3; architecture of application boards is very simple, mainly microcontroller and some small parts for external memory interfacing circuits. The UMP-EVT development board has a similar layout with MCS51 Educational Development System. Other two more microcontrollers and various associates component were added. The boards contain a Freescale MC68HC11E1 device, ATMEL AT89C51 device and Microchip PIC16F877A device. Each board contain microcontroller, clock circuit with crystal, reset circuit and programming connector. Only flash-type microcontrollers were chosen because the goal is a development system so software changes are often.

These voltages are available on different pins of the connector between boards, so no switch is required for voltage selection. On board voltage regulators are able to supply 1.5A on 5V rail, more than enough for a modern microcontroller.

Programming connector is dependent on microcontroller family. However, all the microcontroller system pre-programmed with monitor program which enable user to load and execute the file using RS232 interface. Every microcontroller has its own monitor program pre-program in internal and external memory.

Final circuitry of the UMP-EVT is designed for interfacing to RS232 serial ports is provided by EIA232 circuit utilizing Dallas Semiconductor's DS275 while power circuit regulates supplied voltage to 5Vdc for TTL application. I/O ports of microcontrollers are connected to connector sockets for ease of interfacing with various I/O devices. Since the development board is designed for on-chip mode, all ports are available to be explored. Figure 3 shows the complete circuit for UMP-EVT development board. This circuit is realized on a single-sided printed circuit board (PCB) for durability.

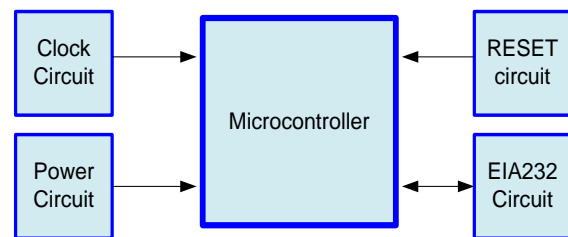


Fig 3: System Block Diagram

III. THE UMP-EVT SOFTWARE IMPLEMENTATION

Development of UMP-EVT software is divided into two i.e. the monitor program development and the IDE program development. Monitor program controls the entire interfacing between a computer and the UMP-EVT development board. Written in assembly language and stored in ROM, monitor program is used to perform object file loading and executing without the hassle of burn-erase-burn method usually associated with EPROM programming. This program will be stored into microcontroller internal EEPROM.

The conceptualization of the monitor program algorithm (used in Freescale HC 11) is shown in the Figure 3. The basic function of a monitor program is to read user's input from keyboard. Based on the input, it determines which procedure, either upload S19 or HEX file or execute program, to be executed. Once selected, the instruction is processed by sending the information to the

development board for execution. Status of execution is feedback to user on a computer screen.

Usually running a monitor program requires the use of communication program such as Hyper-Terminal. Likewise, developing application software for microcontroller requires a text editor and an assembler to write and assemble the code respectively. An IDE program integrating programs such as communication program, cross-assembler and text editor is developed to create user-friendly development environment. This new software is developed to allow users to perform all development activities in the ever familiar window working environment without needing to exit any program. Instead of entering instruction on command line, IDE user interface allows execution of instruction by clicking the appropriate buttons. Figure 5 shows a screenshot of the IDE program.

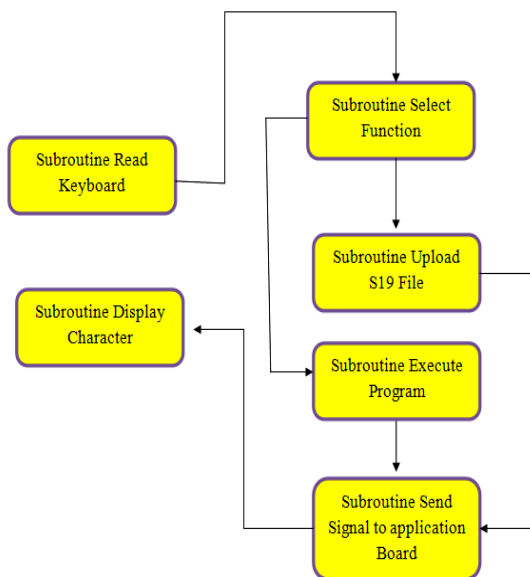


Fig 4: Concept Diagram of Monitor Software

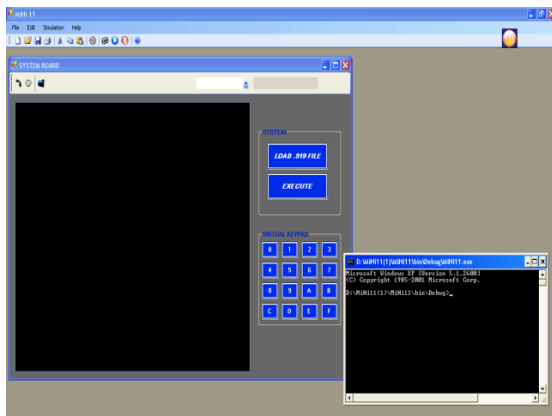


Fig 5: Screenshot of IDE program for UMP-EVT

IV. DISCUSSION

Likewise, a monitor program will be developed, assembled, and downloaded into the EEPROM or NVRAM. Several tests of mini operating system will be tested several times and prove that the system is reliable and sufficiently stable. It will show that the monitor program is able to communicate with the computer and capable of performing several commands issued from the host.

A survey on student's understanding in embedded systems was conducted to detect the level of understanding in this course and the feedback from the students if there are develop in-house microcontroller educational development system based on the MCS51, HC11, and PIC 16 series microcontroller were developed. So far only 21 responses from the students in FKEE who replied the surveys and preliminary results are encouraging. The majority of the students found the UMP-EVT system will helpful in understanding the knowledge in embedded system. The UMP-EVT system will also helped them to better understand how the microcontrollers worked and how hardware and software worked together if the UMP-EVT are build. The instructors teaching this lab noticed that the need of this UMP-EVT system could make a significant improvement in students' performance and understanding of the lab. For more detail on this UMP-EVT system's survey, please log on into this webpage, "http://www.kwiksurveys.com/online-survey.php?surveyID=BIEIM_5d8a6dc9".

V. RESULT AND TESTING

After designing the UMP-EVT, the mainboard and each application board were tested by running simple applications for each of the microcontroller. These programs were elaborated with monitor program of each microcontroller. All boards are functional as well as all devices from mainboard. In this project, students from second to fourth year were involved in manufacturing the boards with soldering the components and hardware and software testing. From this teamwork, some new ideas occurred and they will be implemented in next version of mainboard.

Testing of different microcontroller configurations was helped by the existence of a common set of software modules written in C language ([2]). These modules have a high level of portability and can be easily adapted to new microcontroller families. From the costs point of view, the solution is cheap – about RM 150 for mainboard and RM 10 – RM 50 for each daughter board, depending on microcontroller.

The flexibility of this solution made it very attractive for replacing other more expensive development systems. After a survey on electronic component distributors, development systems with similar peripherals cost more than RM 1000 for all three families of microcontrollers and offer less functionality. Another advantage of presented solution become important in education activities – a flash microcontroller has a limited number of erase cycles for its program memory, catalogue data mentioning usually 10'000 cycles. Unfortunately this number is valid in some special temperature and voltage conditions that can be easily exceeded in an educational environment. If microcontroller becomes damaged, replacing the device is a cheap option compared with replacement of the entire board like in case of single board solution.

During development and testing stages a number of improvement ideas occurred. First, a USB connection is important for working with modern laptops that have no more RS232 interfaces. Second, connector socket on the motherboard is too much for normal applications and consume too much board space. Third, a buzzer or small speaker is a good option for generating sounds and alarms. Fourth, more high-range devices were required for application module, like ZIGBee being considered. Finally, keyboard and LCD display should on the mainboard, not connected using cables. A 2 line LCD display is enough for normal applications. All these new ideas are will be implementing in this UMP-EVT system and results are expected in end of this year 2010. Presented work is a part of a research project of Faculty of Electrical & Electronics Engineering, Universiti Malaysia Pahang.

VI. CONCLUSIONS

Modern system-on-chip microcontrollers offer simple solutions for control applications at affordable prices. Software development tools for different microcontroller families tend to have similar interfaces, especially if coming from the same software house, but hardware tools (development boards) are specific to microcontroller families. General trend presented in software industry towards open architectures and systems is for moment not valid for development boards. This work tries to make a step further in this direction of making development platform independent of selected microcontroller solution. Presented solution for development in the field of embedded systems is a part of an electronic project for evaluation tool systems and has great potential for education – is low cost, flexible and has an

open architecture. It is also worth to mention that was elaborated together with a number of lecturers within same faculty of Universiti Malaysia Pahang.

VII. ACKNOWLEDGEMENT

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