

# MCS51® Educational Development System with IDE Approach

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*Abstract* — According to the latest survey, more than half of the total student in Faculty of Electrical & Electronics Engineering are having problem in understanding program structure and developing hardware. For this reason, the MCS51® microcontroller development project is designed to be as a learning tool for those who intend to learn microcontroller. With an extensive a development board, it could let the user to get start with their microcontroller application efficiently. Without wasting too much time in preparing prototype circuit is one of the advantages by using a development board. In addition, the MCS51® Microcontroller Educational Development System teaches the general applications of development board. Therefore, the users could just get start with their software development if their applications are found in The MCS51® Microcontroller Educational Development System. As a learning tool, it could let the student to test their software on MCS51® Educational Development System. By using The MCS51® Microcontroller Educational Development System, the users will be able to learn from this practical experience. In this respect, the MCS51® Microcontroller Educational Development System would be applicable for education and expose the electrical engineering students to the understanding of microcontroller in electronic design field.

**Keywords:** microcontroller, MCS51, 8051

## INTRODUCTION

Presently, Microcontroller (MCU) is one of the final year course taught as part of Diploma in Industrial Electronics curriculum at the Faculty of Electrical & Electronics Engineering, Universiti Malaysia Pahang (UMP). The Diploma in Industrial Electronics is a three year program for technician level qualification in Malaysia. In this microcontroller technology course, students are required to build an application system based on the Intel 8051 microcontroller to fulfil course requirement. In doing so, students are required to build a basic system development board before proceeding to build the application board for the system being developed. This resulted in too much time spend on developing the development board rather than on developing the application system. One way of

overcoming this problem is to use standard development board available in the market. However, this standard board is usually microcontroller centric and come with a limited expandability [1]. Students feedback indicate that they have difficulty not only in developing an application system due to limited expendability but also in understanding the programming structure and development system hardware due to insufficient documentation [2].

For this reason, the Faculty has taken the initiative to develop in-house microcontroller educational development system based on the Intel 8051 microcontroller. The system consists of a system board as base system and an application board incorporating ten application systems. More importantly, the system board has open I/O ports to allow for future expansion and for students to develop their own application system. In addition to the hardware based system, a GUI application for Windows operating system has also been developed to assist students learning process. Using IDE approach, the interfacing software allows users to not only download Intel executable (.HEX) file to the MCU board but also compile users' developed assembly code to Intel HEX file.

This paper present, firstly the hardware features of the MCS51® Educational Development system. Secondly, the built-in application modules for teaching purposes are discussed. Discussion on interfacing software for Windows operating system follows. The paper concludes with conclusions and future works.

## HARDWARE

The MCS51® Educational Development system hardware components consist of a system board and an application board. System board includes an 8051 microcontroller, external RAM and ROM for expandability, and an RS232 interfacing circuit. The application board, on the other hand, consists of two input devices and eight output devices. The output devices include LEDs, Bar Graph, 7-Segment Displays, 8x8 Tri-Color Dot Matrix, Liquid Crystal Display (LCD), Stepper Motor, Direct Current (DC) Motor and Traffic Light system, while the input devices are an 8-ways Dual-In-Line Package (DIP) switches, and a 4x4 Keypad.

## System Board

The system board uses the generic 8051 microcontroller as the heart of the system. Additional 64k each of code and data memory space is made available via external ROM and RAM devices connected to port 0 and port 2 of the microcontroller using de-multiplexing latches. Availability of de-multiplexing latches also allow for further I/O ports expansion [3]. As such the two I/O ports (port 0 and port 2) are also configured as data bus for selected application modules. In addition to ports expandability, the system board also include a serial communication interface (SCI) that allows the microcontroller to communicate with or to transmit/receive data between other devices. MAX233 provides the necessary drive for serial RS232 transmission. Simplified block diagram of system board in shown in Figure 1.

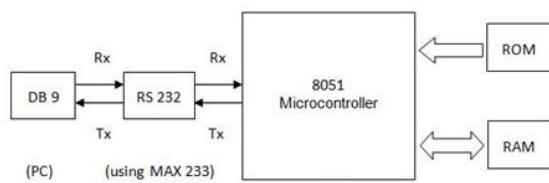


Figure 1: Block Diagram of System Board

## Application Board

The application board is one of the key features of the MCS51® Educational Development board. There are ten application modules incorporated on to the application board. The modular approach used in developing the application modules provides flexibility for instructor to use the development system either as laboratory training tool or as platform for students' design project [5]. Due to the limited number of I/O ports, address decoder is used with latches and buffers to select some of the application devices. The most important application modules are discussed in this section.

### Keypad Module

A 4x4 keypad is included as one of the two input modules. It can be used as a general HEX input matrix keyboard or, to output low/high TTL output level to trigger interrupts or, as an input to trigger other I/O devices. The keypad is connected to a keypad encoder chip which is connected to the data bus of the microcontroller via an interfacing buffer. Figure 2 shows the interfacing circuitry for keypad module.

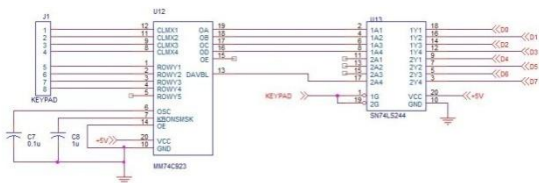


Figure 2: Keypad Module

## LCD Module

While the 4x4 matrix keypad provides advance input module for an application, an LCD module provides the needed complexity for a display device. A 2-by-16 LCD is used for this application. The Data bus from the LCD is connected directly to the microcontroller data bus while the LCD enable input is connected to the address decoder circuit. A Flip-flop and inverter circuits are used to provide interfacing between LCD read/write input and the RD and WR terminals on the microcontroller. A potential meter is provided for adjusting the contrast of LCD. Figure 3 shows a simple LCD circuit connection.

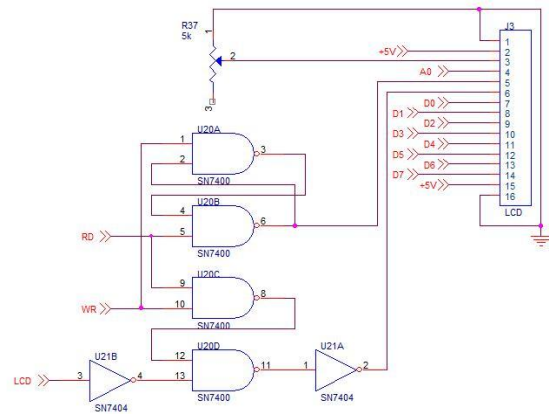


Figure 3: LCD Module

### DC Motor Module

In order to create exciting industrial related application, two electric motors application modules had been added to the MCS51® Educational Development System. The first module is the DC Motor application module. Port P1.0 and P1.1 are connected directly to input terminal of motor driver L293D for motor control application. A simple DC motor circuit connection is shown in Figure 4.

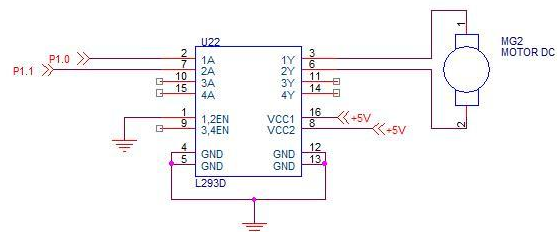


Figure 4: DC Motor Module

### Stepper Motor Module

The other electric motor application included in the application board is the stepper motor module. Similarly, four I/O ports, namely P1.4, P1.5, P1.6 and P1.7, are connected directly to input pins of motor driver ULN2003AN for motor control application. A typical stepper motor circuit connection is shown in Figure 5.

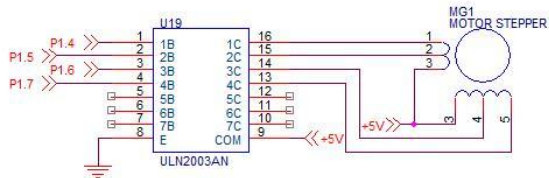


Figure 5: Stepper Motor Module

### Traffic Light Module

To provide students with experience to implement basic digital system on a microcontroller, a 4-way junction traffic light module has been included to the application board. The traffic light system uses I/O Port 1 to control the green lights and the red lights sequence for the 4-way junction. Control of amber lights is achieved by NOR gating the red and the green lights. Figure 6 shows the traffic light connection.

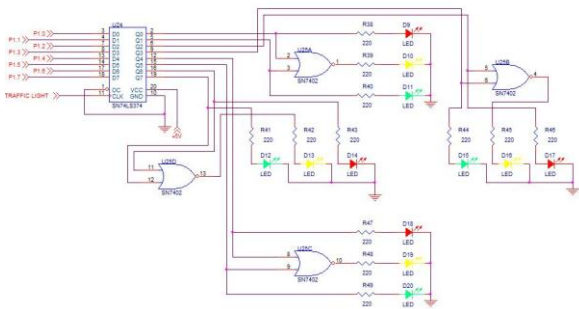


Figure 6: Traffic Light Module

### Expandability option

The other key feature of the MCS51® educational development board is the expansion port. The expansion port in form of 40-pin bus connector is provided to allow for students to develop their own application system board. Furthermore, ZIF socket is used to mount the external code memory (ROM) chip on the system board. This allow for easy placement (replacement) of the memory chip As such students can use the system board as a standalone system for the application modules they'll developing.

### SOFTWARE

A monitor program and sample programs for each of the available application are developed and included as system firmware for the educational development board. In addition to system firmware, PC-to-Board communication software is also developed. Having a monitor program and samples application programs on board helped to facilitate learning and teaching processes.

### Firmware

The MCS51® Educational Development system is equipped with a monitor program to provide a basic system operation and user interaction. The monitor program controls the entire interfacing between a computer and the MCS51® Educational Development System. Written in assembly language and stored in ROM, monitor program is used to perform, among others, object file (.hex file) loading and executing without the hassle of burn-erase-burn method usually associated with EPROM programming.

Additional ten sample applications and testing programs are preloaded into the ROM. They are LED testing, Bar Graph testing, 7-Segment Display testing, Traffic Light testing, Dot Matrix testing, LCD testing, 8-ways DIP Switches testing, Keypad testing, DC Motor testing and Stepper Motor testing. The purpose of those testing program is to test the functionality of each application in the application board.

### PC-to-Board Communication

A GUI based communication terminal for the monitor program to run on Window operating system is developed to replace command-line based HyperTerminal® software commonly used by PCs to communicate with external devices. Using an IDE approach, the communication terminal incorporates an assembler for code assembly, buttons for a 4x4 matrix keypad and command inputs, and a screen display for output. Upon initialization, it communicates with the MCS51® educational development board, uploads the monitor program from system board, and provides virtual display and keypad for user interaction. Figure 7 is a screenshot of the communication terminal.

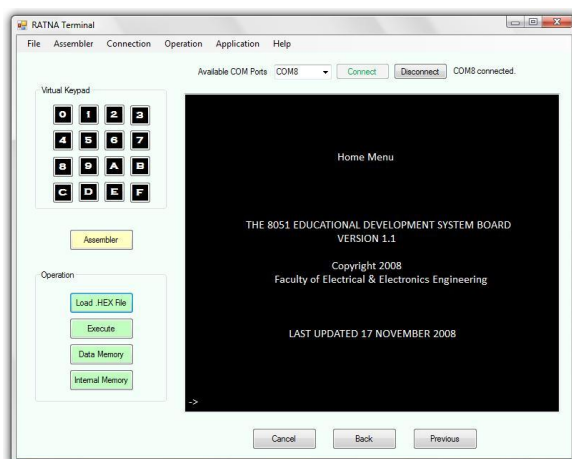


Figure 7: Graphical Oriented Display Mechanisms

## Documentation

The educational development system is useless without proper user manual. As such a comprehensive user manual has been developed to document the system [4]. The user manual includes an extensive description on the application modules, addressing code and memory map of each application and, graphical user guide on how to invoke and use the Program Monitor software.

## CONCLUSION

A prototype MCS51® educational development system has been designed and developed as teaching and learning tools for teaching microcontroller technology for Diploma in Industrial Electronics program at UMP. The onboard application modules and firmware, and the integrated PC-to-Board Communication software provide students with not only a comprehensive learning aids but also flexibility to develop and test new application program efficiently.

Future work will be to develop the prototype system into a user friendly, compact, reliable and cost effective system. The prototype board will be developed onto a PCB while the software will be developed as a full fledged IDE software incorporating a code editor, compiler and monitoring program.

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