8051 Architecture Microcontroller Learning Kit

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Abstract
The demand and popularity of microcontroller based system has reached the zenith in the last few years. So it is the best time for the engineering students and professionals to learn how to use micro-controllers and how to program them. Microcontroller learning kits can be used for educational purpose. But they are expensive and sometimes it becomes difficult for schools or universities to manage them. In this paper we will introduce a low cost 8051 architecture based micro-controller kit. It can be programmed using personal computer (PC) with the help of our machine code downloading software. Using this kit, we can display characters and numbers in LCD, play sound of different frequencies, drive relay, keep track of current date and time, store data permanently in EEPROM . To interact with human there is a keyboard and it can also talk with external devices through RS232 serial communication protocol.

Keywords: Microcontroller, RS232, I2C, Hex Code, Download, RTOS.

INTRODUCTION

In this paper we will discuss about the construction and programming method of an 8051 architecture based micro-controller kit. We will program it using Personal Computer (PC) through the LPT port.

8051 MICROCONTROLLER

The 8051 is an 8 bit microcontroller originally developed by Intel in 1980. It is one of the most popular microcontrollers in the world for its high performance, rich instruction set (MCS-51®), and low cost.
A typical 8051 contains:

- CPU
- Clock frequency: Its frequency range varies with its different family members. In most cases its maximum Crystal frequency is 24MHz-33MHz. The actual clock Frequency is $Freq_{(crystal)}/12$
- Ports: It has four 8 bit ports, total 32 I/O lines. Each port can be used as Input or Output port. Each I/O lines are individually accessible.
- Memory: 8051 has Program Memory or ROM, RAM, and EEPROM in some models (AT89S8252). Its Program memory can be erased and reprogrammed using conventional memory programmer or by In System Programming (ISP) method. In our kit we will use the 8051 which supports ISP Programming like AT89S51, AT89S52, AT89S53 etc. models.

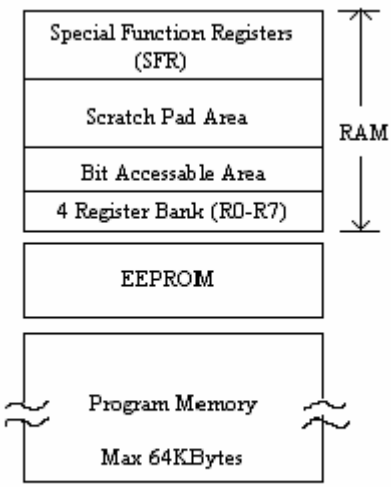

Figure 1. 8051 Memory Architecture

THE 8051 MICROCONTROLLER KIT

Modes of Operation

The kit will operate in 2 modes. We can select these modes from our downloader software. We used 5 output pins of LPT port named as LPT_DATA, LPT_CLK, LPT_PGM, LPT_RUN, LPT_RST and 1 input pin LPT_READ.

Programming Mode

In this mode the LPT_PGM goes high, and LPT_RUN goes to low. In this way tri-state switches connects the 8051 to the PCs LPT Programming pins and separates the peripherals connected with those pins so that connected peripherals will not be disturbed at the time of programming.

Run Mode

In this mode the LPT_RUN goes high and LPT_PGM goes to low. The tri-state switches connects the associated peripherals to 8051 and separates PCs LPT Programming pins from it so that PCs LPT port is not disturbed when we run our downloaded program in the kit. To start running the downloaded program, we can send a signal to LPT_RST using software, also we can restart the program by the external "Reset" switch from the hardware.

Description of Peripherals

Power Supply Unit (PSU)

+5V Regulated DC power supply is required to operate the kit. Here Voltage regulator IC 7805 is used. Its input voltage should be >= 7V for its proper operation. So it is possible to run the kit using 9V DC battery also. A voltage comparator circuit is constructed there which will notify the microcontroller if the battery voltage drops lower than 7V.

Liquid Crystal Display (LCD)

A 16x4 Character LCD (HD44780) is interfaced with the kit using 4 data wire mode. The Contrast Adjust voltage is supplied by a voltage divider circuit.

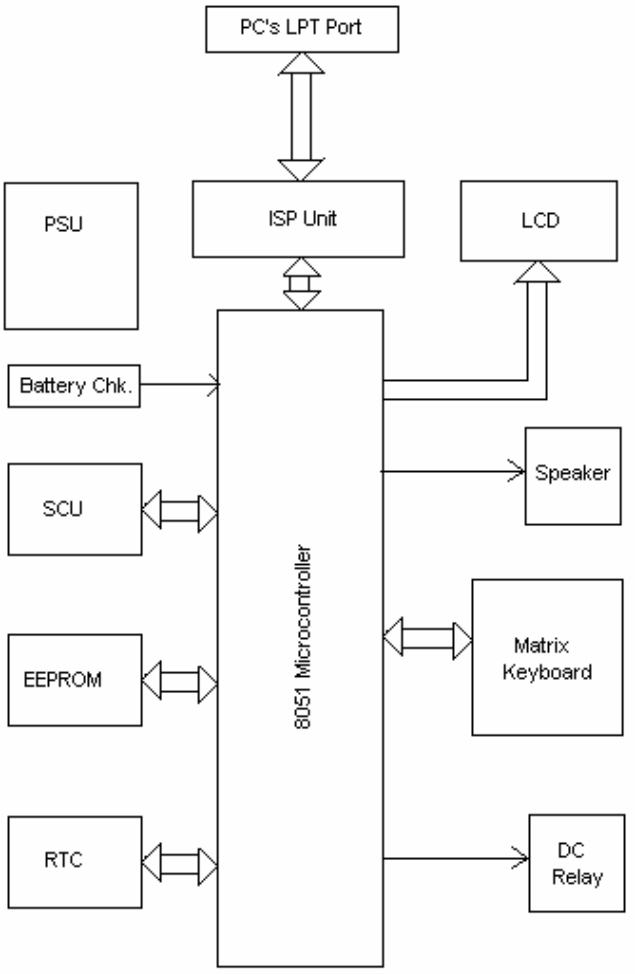

Figure 2. Block Diagram of 8051 Kit

Keyboard

A 4x4 Matrix keyboard is interfaced here in an 8 bit port.

ESC	0	/	*
7	8	9	+
4	5	6	-
1	2	3	Enter

Figure 3. Keyboard Layout

Speaker

An 8Ω speaker is here through a 2N2222 (NPN) transistor based switching circuit. By sending square pulses of different frequencies at the base of transistor we can generate different sounds with it.

DC Relay

A 2N2222 based transistor switching circuit is used here to operate a DC relay. Through its contact pin any high voltage circuit (110/220AC) can be controlled. A free wheeling diode is placed here to protect the circuit from back EMF.

Electrically Erasable Read Only Memory (EEPROM)

To store the contents of RAM even if the power is off or to store some permanent data, an EEPROM is used. Here we used Atmel 24C64 (8KB) EEPROM. It sends and Receives data with Microcontroller using 2 wire I2C protocol. In this I2C Bus more I2C components can also be interfaced.

Real Time Clock (RTC)

RTC is a device which has in built clock and permanent Calendar algorithm implemented inside it. It takes power from a lithium battery when the power is turned off. So it is possible to keep track of current date and time. Here we used DS12887. It has multiplexed address and data bus. It is interfaced with microcontroller using Address Latched philosophy.

Serial Communication Unit (SCU)

Using this unit, the microcontroller can talk with other Devices using RS232 protocol. A Level Converter IC (MAX232) is used here to appropriately convert the Signal levels between other serial peripherals and microcontroller.

	Logic 1	Logic 0
Other Serial Devices	-12V	+12V
Microcontroller	5V	0V

Table 1. RS232 Voltage Level

PROGRAMMING THE KIT

Instruction Set

8051 accepts MCS-51® instruction set. MCS-51® is a rich instruction set. We can write the program in any text editor like Notepad® and save our program as .asm file.

Compilation

We can compile our written program using Asm51 cross assemblers. High level compilers like Keil®, BASCOM® also can be used for writing code and compilation.

After compilation the following files are created:

- List file (.lst)
- Intel® Hex File (.hex)

The Intel® Hex file contains the absolute machine codes.

Downloading Program from PC to Kit

After compilation we will download the machine codes from pc to the kit serially through the LPT port pins. We can write software in Microsoft™ Visual Basic® or in Microsoft™ Visual C++® to do these tasks. The key functions of the software are described below:

Open Hex file

User will be prompt to browse the created hex file to be opened. The software will then dissect the hex file and put the machine codes in the CodeBuffer.

View Buffer

User will be able to see the machine codes in the CodeBuffer in a CodeBuffer Window.

Write to Kit

User can download the machine codes by choosing this option. Here the software will place the CodeBuffer bytes in the format of ISP Programming Instruction set [4]. Then it will send the ISP instructions serially through the LPT_DATA pin. For Writing, the software will first erase the chip and then it will start sending data. We can use the output pins of LPT port (pin 2- pin 9) for LPT_DATA, LPT_CLK, LPT_PGM, LPT_RUN, and LPT_RST.

Read From Kit & Verify

User will also be able to read and verify their downloaded program. Here the software will send the read ISP instructions [4] and we can get the written data in the microcontroller from the LPT_READ pin. We can use LPT input pin (pin 10, Acknowledgment) as LPT_READ pin. The software will gather the bits form that pin and place them in a separate CodeBuffer. By comparing this CodeBuffer with the actual CodeBuffer we can verify whether our program was downloaded correctly or not.

Reset

User will be able to reset and restart the microcontroller. This can be simply done by sending a high value in the LPT_RST pin for at least 2 machine cycles of the kit.

METHODS OF ACCESSING PERIPHERALS

LCD

A LCD Driver chip contains special registers like command register and data register. From LCD Datasheet, we can write different command codes like clear LCD, set cursor Position, cursor on/off in the command register. To display texts (A-Z, a-z, 0-9) ASCII codes are sent to data register.

Keyboard

To detect a key press, the microcontroller send 0 to all row Port pins and 1 to column port pins. If all column port pins are 1 then there is no pressed. If one of them is zero, then a key is pressed at its corresponding column. Now to detect the row, microcontroller set 1 to row port pins one by one and read the column port pins. When all column port all pins are zero then that is the key row. Depending on the Column and Row values a key scan code is calculated and placed in the microcontrollers RAM.

Speaker

By sending 1's and 0's of different interval at the base of the transistor, we can vibrate the speaker diaphragm and generate different tones. The maximum frequency tone can be obtained is $Freq_{(crystal)}$ / 24.

DC Relay

Here by placing 1 and 0 at the relay control port pin, We can connect and disconnect the relay contacts.

EEPROM

The I2C EEPROM's SCL and SDA pins are connected with microcontroller port pins and by giving signals according to I2C protocol, we can read and write different memory locations of EEPROM.

RTC

RTC stores the value of Hour, Minute, Second, Day, Date, Month, Year in different locations of its in-built non-volatile RAM. By reading the proper memory locations through the Address Latch philosophy, we can get the current Date and Time information. We also can configure the current date/time by writing new values in those locations.

SCU

By reading and writing the Serial Buffer Register (s_buf) content we can receive and send data with other serial peripherals.

	ISP	7Segment /LED	LCD	Key-board	Multy tone Speaker	Relay	EEPROM	RTC	RS232 (not for ISP)	I2C Bus	USB	Battery Check	Cost (USD)
MINI-MAX51	yes	no	yes	no	no	no	yes	no	no	yes	no	no	$69.00
Kanda	yes	yes	yes	no	no	no	no	no	no	no	no	no	$94.80
K51	yes	yes	no	yes (4x1)	no (Buzzer only)	no		yes	no	yes	no	no	n/a
Goal Semi coductor	yes	yes	yes	yes	no (Buzzer only)	no	yes	no	no	yes	no	no	$99.00
THIS Paper	yes	no	yes	yes (4x4)	yes	yes	yes	yes	yes	yes	no	yes	$35.00

Table 2. Comparison of Different Commercially available 8051 kit

SOFTWARE UTILITIS

The User/Learner can write their own Operating System for the kit which will be responsible for execution of different application programs. Varity of application programs can be written. Example: Alarm Clock, Calculator, Phone Book, Music generator i.e. Tini piano, Small games etc. Moreover by using its relay control unit, We can write programs which can control High AC voltage peripherals.

DEVELOPMENT

We have successfully developed the hardware and software for the kit. The cost taken for the entire kit is approximately USD $35.00

FUTURE PLANS

It is possible to write codes for microcontroller which will be able to communicate with Internet protocols like TCP/IP. In this way, user will be able to know how to construct and write codes for Internet communicate able Embedded systems.

CONCLUSION

This paper shows a way to construct a cost effective 8051 microcontroller based learning kit covering all the major features. We believe that this paper will be a helpful document for any one who wants to work with microcontroller kit.

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